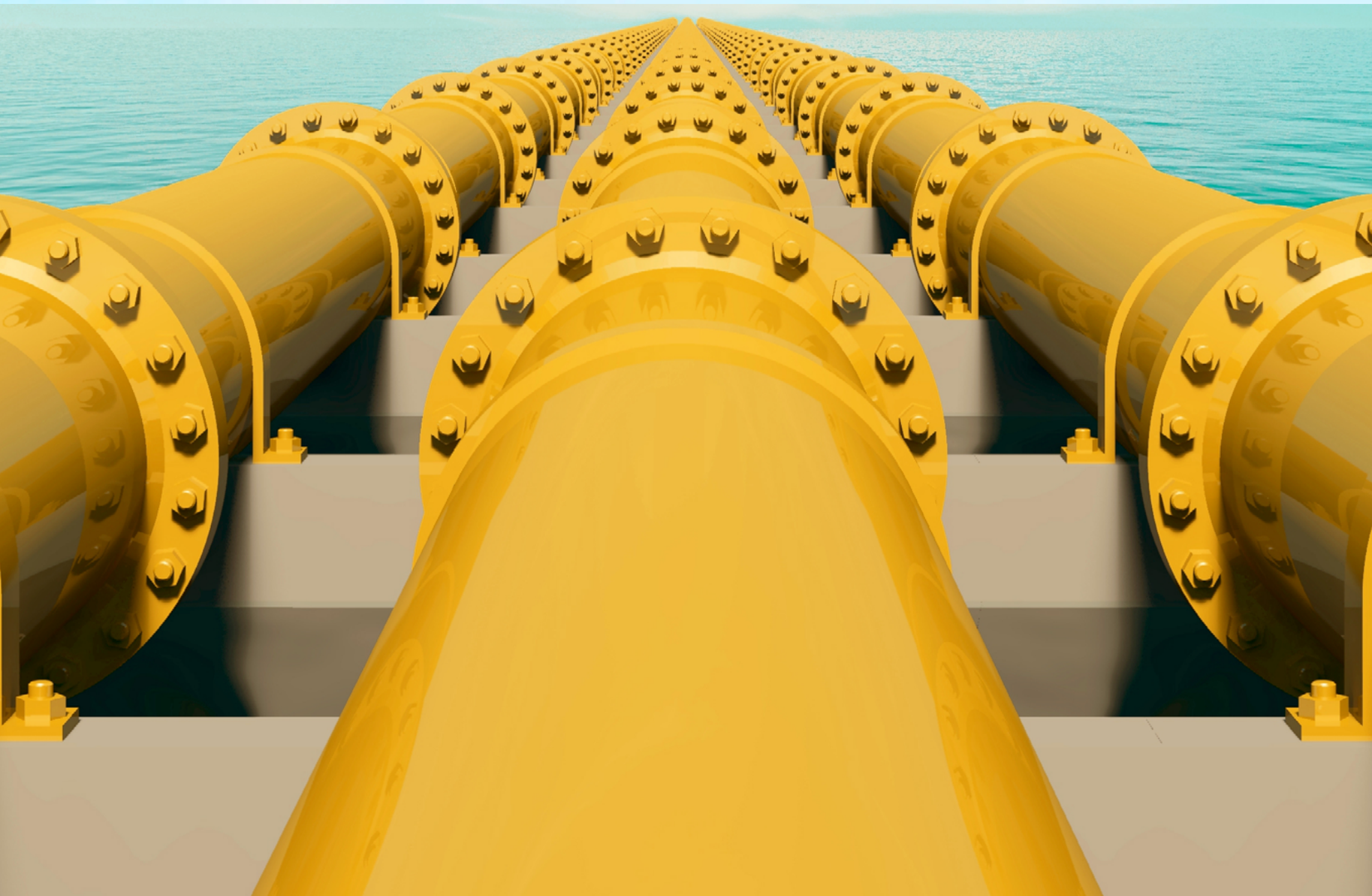
CLIMATE CHANCE

GLOBAL SYNTHESIS REPORT ON CLIMATE ACTION BY SECTOR

2022



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DIRECTOR OF THE PUBLICATION
Ronan Dantec, *President of Climate Chance*

OBSERVATORY TEAM
Antoine Gillod, *Director*
Tania Martha Thomas, *Research Officer*
Ophélie Cuvillard, *Research Assistant*
Mélaine Assè-Wassa Sama, *Africa Observatory Project Manager*

AUTHORS
Anne Barre, Anna Samwell (WECF); Edgardo Bilsky (CGLU); Grégoire Brethome, Amandine Martinet (Construction 21); Yann Briand (IDDRI); Sébastien Delpont (Greenflex); Anna Faucher, Louison Lancon, Jean-Baptiste Wolff (Let's Food); Virginie Hugues (consultant); Julien Joubert, Anousheh Parsaei (Energy Cities); Charlène Kouassi (Movin'On Lab); Samuel Laval (Ministry of Ecological Transition); Nicolás E. Obando Salgado (consultant); Anaïs Padilla, Marie-Noëlle Reboulet (Geres); Aude Valade (CIRAD)

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Émilie Alberola, Anouk Faure, Mathieu Salel (EcoAct); Alexis Chabanne (Ministry of Ecological Transition); Gilles Dufrasnes (Carbon Market Watch); César Dugast and Arthur Pivin (Carbone4); Elizabeth Goldman (Global Forest Watch); Vivian Depoues (I4CE); Stephanie Hagen, Shashwati Shankar (Autonomy); Marie-Ange Kalenga (Fern); Harold Levrel (CIRED, AgroParis Tech); Christine Moro (member of Climate Chance); Florence Palla (Central Africa Forest Observatory); Loïs Panchèvre (Eramet); Amaury Parelle (Transitions-DD); Saverio Ragazzi, Lucas Winkelmann (Geres); Nora Steurer (GlobalABC)

ENGLISH TRANSLATION
Solten Group
Anne-Marie Harper
Tania Martha Thomas

GRAPHICS
Elaine Guillemot LATELIERDELESTUAIRE.COM
Hewan Goethals

DATA PARTNER
Enerdata

PHOTO CREDITS
Shutterstock

CLIMATE CHANCE

Since 2015, Climate Chance has been working to create a favourable environment to strengthen climate action and contribute to the attainment of the goals of the Paris Agreement. It is the only international organisation that aims to bring together all the non-state actors recognized by the United Nations Framework Convention on Climate Change (UNFCCC) – local authorities, companies, NGOs, trade unions, the scientific community, agricultural, youth, indigenous peoples' and women organisations – to develop common priorities and proposals and to strengthen stakeholder dynamics through networking within thematic coalitions, during the Climate Chance Summits and through the action portal.

THE OBSERVATORY AND THE SECTOR-BASED REPORT

In order to strengthen the action of non-state actors and give credibility to climate stabilisation scenarios, the Climate Chance Association launched in 2018 a Global Observatory of Non-State Climate Action, which aims to explain the evolution of greenhouse gas emissions, by crossing national public policies with sectoral dynamics, strategies of private actors, local public policies, and all the actions undertaken by non-state actors at the local level.

The Sector-based report is the flagship publication of the Observatory. It proposes a unique synthesis of the ongoing global trends in actions to explain the evolution of GHG emissions in the energy, transport, building, industry, waste, and land-use sectors.

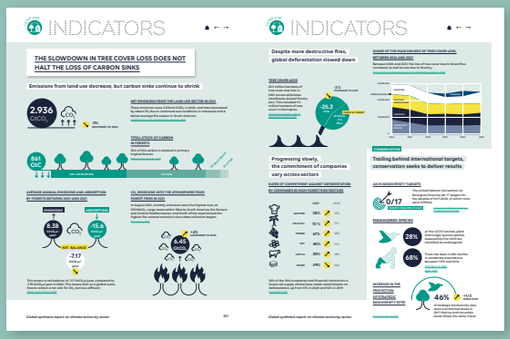
THE CLIMATE CHANCE ASSOCIATION AND ITS OBSERVATORY ARE SUPPORTED BY

5th EDITION

GLOBAL SYNTHESIS REPORT ON CLIMATE ACTION BY SECTOR 2022

The Global Synthesis Report is a comprehensive analysis of available publications on climate action, based on contributions from experts and specialist organisations. This fifth edition traces the evolution of emissions and climate action from 2021 to the first half of 2022. This year, a special feature on carbon offsetting enriches the analyses.

Starting with objective data on emissions and actions taken **[INDICATORS]**, the Observatory analyses recent trends in the actions of companies, local authorities and all civil society organisations that help explain changes in emissions **[TRENDS]**. It highlights remarkable initiatives **[STUDY CASES]** that help identify the most effective levers for moving towards a low-carbon society. Finally, it tracks down the weak signals for action in international news **[SIGNALS]**, which today foreshadow the trends of tomorrow.



INDICATORS
A double-page infographic to understand the evolution of emissions in each sector, and its main drivers of transition.

TRENDS
Detailed analyses of the main trends in climate action led by non-state actors in the last year.

SIGNALS
A round-up of the initiatives, regulation changes, and market transformations of today that signal the climate action trends of tomorrow.

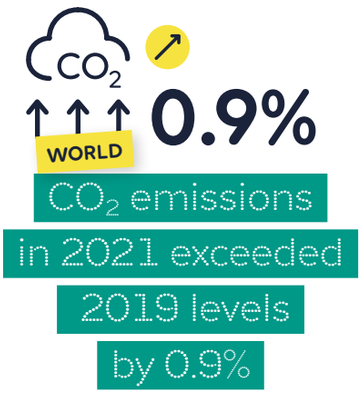
CASE STUDIES
Concrete examples of public policies and on-the-ground projects that have been implemented to reduce emissions, adapt to climate change, and attain the SDGs.

INTRODUCTION

A LOW-CARBON TRANSITION FORCED TO ADAPT TO GEOPOLITICAL AND CLIMATE CONDITIONS

The year 2021 marked a rebound of emissions, more or less rapid depending on the sectors, and with regional variations, to their 2019 levels. Global temperatures have already risen by 1.2 °C compared to the pre-industrial era. The reports of the Sixth Assessment cycle of the Inter-government Panel on Climate Change (IPCC) published from August 2021 to April 2022 are clear about the drastic consequences of this alteration of the planet's climate balance. According to the IPCC, in order to meet the Paris Agreement's goal of limiting temperature increases to below 1.5 °C, GHG emissions must be reduced by 43% by 2030 compared to 2019 levels. The current commitments of the 193 parties to the Agreement will only reduce emissions by 0.3% by 2030, compared to 2019 levels (UNFCCC, 2022a).

But the IPCC also insists on another reality: every tonne of greenhouse gases (GHGs) avoided will contribute to limiting global warming, and for this the authors stress on "*the growing role of non-state and sub-national actors including cities, businesses, Indigenous Peoples, citizens including local communities and youth, transnational initiatives, and public-private entities in the global effort to address climate change*" (IPCC, 2022).



THE DIVERGING RECOVERY TRENDS OF EMISSIONS TRAJECTORIES

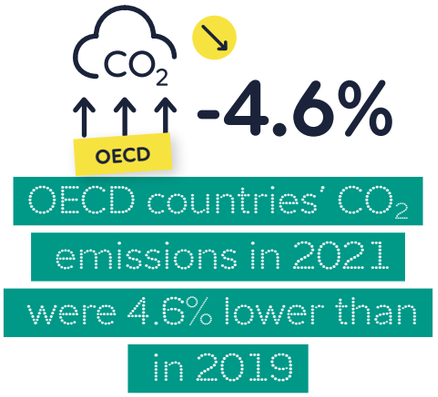
Global emissions are back to 2019 levels following a historic dive in 2020

At 37,061.24 $MtCO_2$[a], global emission levels in 2021 were the highest in history. From 2019 to 2020, emissions had dropped 5% as a result of the pandemic, remaining at 35,137.86 $MtCO_2$, down to the level of 2012-2013. In 2022, emissions are maintaining their momentum. Global emissions observatories — in Hawaii and Australia — evaluated GHG concentrations at between 417 and 420 ppm in May 2022, which is higher than in May 2021 (UNFCCC, 2022b). Prior to 2015, the atmosphere had never exceeded 300 ppm during the 800,000 years observed by palaeoclimatologists (Lüthi et al, 2008). Nevertheless, the level of global emissions per capita (4.22 tCO_2 per cap.) is lower than that of previous years, except for 2020 (4.04 tCO_2 in 2020, compared to 4.27 tCO_2 in 2019 and 4.32 tCO_2 in 2018).

The level of global CO_2 emissions in 2021 therefore cancelled out the reduction observed in 2020. Coal consumption accounted for 40% of the emissions upswing in 2021, which explains why the GHG emissions generated by energy reached their highest level (IEA, 2022).

The Covid-19 crisis was only a hiccup in the emissions trajectory, which was back on an upward track in 2021. However, regional trends differ.

a Unless specified otherwise, the data on economic acitivity and emissions presented in this section are drawn from Enerdata's Global Energy and CO_2 Data.



In advanced economies, emissions picked up but did not touch their 2019 levels

Average emissions generated by OECD countries are still 4.6% below their 2019 levels. The main European and North American countries all saw emissions rise in 2021 compared to 2020, but did not go back to 2019 levels. Global economic output has recovered more strongly than emissions (IEA, 2022) — despite significant differences between countries.

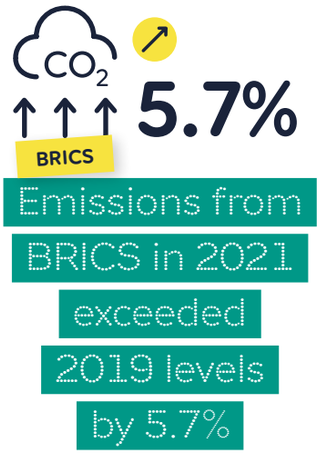
Among European Union countries — which emitted 6% more in 2021 than in 2020 — emissions from France and Italy increased by 9.9% and 8.6%, but without reaching 2019 levels. In the first quarter of 2022, Europe was still at a lower level than at the same period in 2019, and countries like France (Citepa, 2022) — which has changed its target — and the United Kingdom (Climate Change Commitee, 2022) are sticking to their respective carbon budgets. We do not yet measure the consequences of the war in Ukraine initiated by the Russian army in February 2022, which was a huge shock for European energy supplies. The geopolitical decision to go without Russian gas led European States to substitute it with oil, in particular to produce electricity, due to a limited gas supply and a hike in prices. The increased use of oil and the move from gas to oil could slow down European decarbonization efforts.

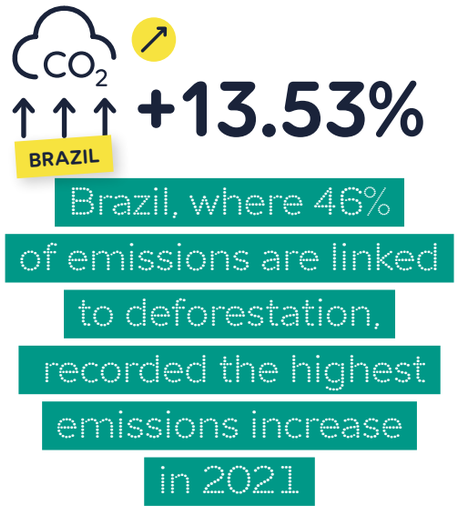
In North America, the United States has seen a similar return to emissions as the European Union (about +6%), while Canada's pick-up is more moderate (+3%), but without returning to 2019 levels. Japan and South Korea recorded a moderate increase from 2020 to 2021 (+0.8% and 2.8% respectively) **(TAB. 1)**. For Australia, updated data (different from Enerdata) from the government indicated that its GHG emissions had increased by 1% compared to 2021, driven by the recovery of transport in particular (Australian Government, 2021).

Emissions exceed 2019 levels for emerging economies

The decrease in emissions during the Covid-19 crisis in 2020 for non-OECD members (-2%), BRICS (-1%) and G20 countries (-4.6%) have been less significant than the drops recorded by advanced economies, and these groups have all returned to or exceeded their 2019 emissions levels (+3.6% for countries outside the OECD, +5.7% for BRICS and +1.1% for G20 countries). Despite disparate trends, the major emitting countries in Asia have overshot their 2019 emissions levels **(TAB. 2)**: Turkey by 11.2%, China by 7.6%, Russia by 4.6%, and India by 0.07%. Russia, whose emissions increased by 9.5%, has returned to a level not seen since 1993. With 470.7 $MtCO_2$, Turkey has reached an unprecedented level of national emissions. A few exceptions exist, such as Indonesia, whose emissions rose by 3.45% in 2021, but remained 10% lower than 2019 levels.

China was one of the only countries to record a growth in emissions in 2020 despite the pandemic (+1.62%). In 2021, its emissions reached 6% growth, exceeding its 2019 level by 7.6%, and continued to grow in early 2022. This increase mostly comes from greater demand for electricity produced from coal, which has significantly compensated for the decline in hydroelectricity and has replaced gas, which has become too expensive (IEA, 2022). The move from gas to coal has also increased demand for coal in the region, stimulated by economic growth in countries like India (whose emissions rose by 7.2% from 2020 to 2021).





In Latin America, whereas the decrease in emissions in 2020 in Brazil and Argentina ranked among the biggest drops of the year, these countries went on to outstrip their 2020 levels by 10% in 2021 **(TAB. 2)**. Argentina has returned to its 2019 level, while Brazil has already exceeded it by 7% — outdoing its 2017 record. Brazil, where 46% of emissions are caused by deforestation (Climate Home News, 10/07/2022) — saw the highest increase in CO_2 emissions in the world in 2021.

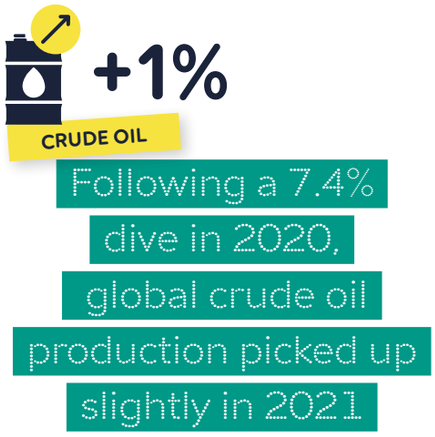
Concerning their carbon footprint[b], the export carbon footprint of these countries is larger than their domestic footprint, unlike countries in Europe and North America. For example, net exports of emissions from China and India are about 10% greater than emissions linked to imports, while the United Kingdom's net imported emissions are 40% higher than its export-related emissions (Global Carbon Budget, 2019). Therefore, China has a higher level of GHG emissions when calculated according to the territorial approach, compared to the consumption approach (footprint), while the opposite will be true for the EU and the US. Taking a domestic approach, emissions per capita in China only just exceeded the EU level in 2018 (about 7 tCO_2 per cap. per year). However, in terms of footprint, China's emissions per capita are 20% lower than those of the EU-27 (6 tCO_2 per cap. per year compared to 8 tCO_2 per cap. per year) (Ministry of Ecological Transition, 2022). But studies converge to indicate that changes in consumption patterns and the expansion of the middle and affluent classes are generating exponential growth in China's carbon footprint and household emissions (Wiedenhofer et al., 2016; Wei, L., et al., 2020) as well as increasing disparities with a large section of rural populations.

Varying upturns in Africa and the Middle East

With 1,493.71 $MtCO_2$ in 2021, the African continent exceeded its 2019 emissions level (1,483.86 $MtCO_2$) but still only constitutes 3.8% of global emissions. The Middle East reached 2,005.29 $MtCO_2$ in 2021, not quite returning to its 2019 level (2,077.27 $MtCO_2$). From 2020 to 2021, different countries saw disparate emissions growth, with a slight stagnation for Qatar, Saudi Arabia and South Africa for example, and an increase of over 11% for Iraq and Kuwait.

In Africa and the Middle East, emissions have shot up since 2015 (+6.6% in Africa from 2015 to 2019, +3.5% in the Middle East), but have diminished when compared to the number of inhabitants (-3.7% in Africa from 2015 to 2019, -3.4% in the Middle East): the population is growing faster than emissions. Economies were strongly impacted by the pandemic due to the oil production cuts organized by OPEC+, which led to large drops in emissions (-6.9% in Africa from 2019 to 2020, -3.6% in the Middle East). However, in 2021, some countries exceeded their 2019 emissions levels: Kuwait (+12.4%), Qatar (+5%), Egypt (+4.5%) and Nigeria (+8.5%) **(TAB. 3)**.

Emissions do not generally include the land use sector, which is a nevertheless major factor in Africa. With an estimated 2,200 $MtCO_2$, it probably makes up about 40% of African and Middle Eastern emissions (Climate Analytics, 2022), mainly due to deforestation for farming.



b The consumption or footprint approach is calculated as follows: territorial emission – exported emissions + imported emissions

CARBON DIOXIDE EMISSIONS (EXCEPT LAND USE), IN $MTCO_2$

For advanced economies, emissions picked up but did not reach their 2019 levels

TABLE 1	2016	2017	2018	2019	2020	2021	*Medium-term trends* Evolution 2016-2019 (%)	*Continuity with pre-pandemic trends* Evolution 2019-2021 (%)	*Post-pandemic upswing* Evolution 2020-2021 (%)
Canada	617.73	627.46	640.74	641.12	579.00	599.80	**3.79%**	**-6.44%**	**3.59%**
France	345.48	351.40	340.16	332.06	294.14	323.50	**-3.88%**	**-2.58%**	**9.98%**
Germany	800.93	781.36	754.27	707.55	648.94	690.25	**-11.66%**	**-2.44%**	**6.37%**
Italy	350.86	347.36	342.16	333.80	297.80	323.52	**-4.86%**	**-3.08%**	**8.64%**
United Kingdom	399.13	385.61	378.63	366.36	316.81	337.79	**-8.21%**	**-7.80%**	**6.62%**
United States	5142.63	5084.83	5210.12	5116.12	4561.21	4843.99	**-0.52%**	**-5.32%**	**6.20%**
Japan	1220.47	1206.81	1168.38	1132.93	1094.45	1103.20	**-7.17%**	**-2.62%**	**0.80%**
South Korea	707.55	717.38	721.81	703.36	644.14	662.49	**-0.59%**	**-5.81%**	**2.85%**
Australia	417.18	423.26	422.68	423.92	411.49	396.59	**1.61%**	**-6.45%**	**-3.62%**
European Union	3160.68	3192.26	3121.46	2976.95	2692.41	2862.32	**-5.81%**	**-3.85%**	**6.31%**

Emissions exceeded their 2019 level in emerging economies

TABLE 2	2016	2017	2018	2019	2020	2021	*Medium-term trends* Evolution 2016-2019 (%)	*Continuity with pre-pandemic trends* Evolution 2019-2021 (%)	*Post-pandemic upswing* Evolution 2020-2021 (%)
China	11129.17	11240.76	11409.11	11562.74	11710.50	12442.76	**3.90%**	**7.61%**	**6.25%**
India	2299.47	2431.76	2557.87	2555.51	2384.78	2557.29	**11.13%**	**0.07%**	**7.23%**
Indonesia	517.23	548.32	611.54	664.36	577.45	597.38	**28.45%**	**-10.08%**	**3.45%**
Russia	1751.66	1802.80	1887.56	1936.60	1848.68	2024.86	**10.56%**	**4.56%**	**9.53%**
Turkey	400.56	442.72	439.75	423.10	421.88	470.67	**5.63%**	**11.24%**	**11.57%**
Brazil	488.41	497.16	471.36	473.34	448.48	509.15	**-3.08%**	**7.57%**	**13.53%**
Argentina	189.39	185.21	182.07	173.81	158.77	174.86	**-8.23%**	**0.60%**	**10.13%**

In Africa and the Middle East, diverging recoveries

TABLE 3	2016	2017	2018	2019	2020	2021	*Medium-term trends* Evolution 2016-2019 (%)	*Continuity with pre-pandemic trends* Evolution 2019-2021 (%)	*Post-pandemic upswing* Evolution 2020-2021 (%)
Iran	655.29	682.95	696.61	692.81	689.14	n.a.	**5.73%**	n.a	n.a
Iraq	138.65	152.34	160.44	174.64	148.78	166.59	**25.96%**	**-5%**	**11.97%**
Kuwait	92.87	92.70	92.85	93.71	94.29	105.28	**0.90%**	**12%**	**11.65%**
Qatar	99.66	100.75	99.74	105.30	110.88	110.63	**5.65%**	**5.07%**	**-0.22%**
Saudi Arabia	573.31	559.66	534.43	540.35	540.98	536.17	**-5.75%**	**-0.77%**	**-0.89%**
United Arab Emirates	207.95	204.18	184.65	197.41	192.34	195.21	**-5.07%**	**-1.12%**	**1.49%**
Algeria	150.30	149.83	160.46	165.50	158.14	160.04	**10.11%**	**-3.30%**	**1.21%**
Egypt	237.87	252.28	268.89	272.01	266.75	284.28	**14.35%**	**4.51%**	**6.57%**
Nigeria	114.98	115.44	115.90	121.78	122.67	132.12	**5.91%**	**8.49%**	**7.70%**
South Africa	444.14	451.43	456.03	464.01	429.80	432.53	**4.47%**	**-6.78%**	**0.64%**

GROWING COMMITMENTS REVEAL DIVERGING NATIONAL PRIORITIES

Many countries have thus already exceeded their 2019 emission levels. The latest NDC Synthesis Report indicates a small decrease in these levels by 2030 and a potential "catastrophic" warming of 2.4 °C by the end of the century. The UN analysis notes that only 39 countries have updated their NDCs since 12 October 2021, of which 24 have been updated since COP26 in Glasgow in November 2021 (UNFCCC, 2022a; UNFCCC, 2022c). Nevertheless, this projected warming figure is less than half of what was predicted five years ago — a result of international mobilisation, increased attention to climate and energy policies, and even of falling renewable energy prices (The New York Times, 26/10/2022).

Announcements of commitments continued before, during and after COP27 in Sharm el-Sheikh this year. Ahead of the conference in Egypt, the EU-27 fast-tracked deals on three important climate laws on the sale of internal combustion engine vehicles, carbon sinks and national emissions targets that, according to European Commission vice-president Frans Timmermans, could reduce net emissions in 2030 by 57% compared to 1990, compared to the announced target of 55% (Reuters, 15/11/2022a). Against the backdrop of divisive mid-term elections domestically, the US announced or renewed commitments to several initiatives on renewable energy, emissions reduction, adaptation and climate finance (White House, 11/11/2022), while the resumption of their climate negotiations with China has raised hopes at COP27 (Financial Times, 14/11/2022). Momentum for commitments is also building in the developing world: India has presented its Long Term Low Emission Development Strategy (LT-LEDS), which outlines how it intends to achieve the Net Zero in 2070, the target it set in 2021 (Economic Times, 15/11/2022). Mexico has announced its intention to add 30 GW of renewable capacity by 2030 (Reuters, 15/11/2022b), while Brazil, fresh from elections, announced a return to stronger climate commitments under the Lula government (Bloomberg, 14/11/2022).

According to the UNFCCC's analysis, long-term strategies (LT-LEDS)[c] the current NDCs cover 83% of global GDP and about 69% of total 2019 total energy consumption, which is a "strong signal" that the world is moving towards net zero emissions. Including NDCs with long-term targets, these figures rise to 90% and 79% respectively (UNFCCC, 2022d). As a barometer of climate action since the Paris Agreement, net zero targets have also progressed — more than 11,000 companies, financial institutions and local governments from 116 countries have committed to net zero emissions by 2050 as part of the Race to Zero initiative (Race to Zero, 2022). A study of national targets compared to policy implementation, economic trends, business expansion plans and changes in citizen behaviour in the world's four largest emitters — the US, EU, China and India — found that the latter three, driven by markets, may well see faster progress in emissions reductions than projected in their NDCs, thanks to advances in renewable energy (ECIU, 2022).

COP27 also saw a number of shorter-term commitments, such as the Egyptian Presidency's African Just and Affordable Energy Transition Initiative (AJAETI), launched with IRENA, the IEA and SE4All, among others, which aims to provide technical and policy support to facilitate access to clean and affordable energy for at least 300 million people in Africa by 2027, increasing the share of renewables in energy production to 25% (Egyptian Presidency, 2022). As last year's declaration on deforestation gets off to a slow start, the three largest rainforest nations, Brazil, Indonesia and the DRC, have formed a new alliance ahead of the G20 talks in Indonesia, to protect forests and put pressure on advanced economies to fund this protection (Reuters, 14/11/2022). In the slow-to-decarbonise maritime transport sector, the COP saw the launch of the Green Shipping Challenge by Canada, the United States and Norway, which aims to keep the sector on a 1.5 °C trajectory, engaging ports, carriers, cargo owners and other stakeholders in the maritime transport value chain (Green Shipping Challenge, 2022).

Despite growing commitments, sectoral indicators of progress do not paint an entirely optimistic picture – in areas such as electricity, buildings, industry, transport, forests, agriculture, carbon capture and finance, progress has been made, but not in line with the changes required to meet the 2030 targets on time. An assessment by the Systems Change Lab estimates that none of the indicators of change in the above sectors are progressing at a pace sufficient to meet 2030 targets (Systems Change Lab, 2022).

Regulatory carbon markets set up by state and local governments have continued their upward trend. According to I4CE, as of August 2022, there were 68 explicit carbon pricing mechanisms (taxes and tradable allowances) worldwide, up from 47 last year. These mechanisms cover more than 70% of global GDP, with more than $100 billion in carbon revenues raised in 2021 — an 80% year-on-year increase from $53.1 billion in 2020 (I4CE, 2021). Rising emissions in the US and EU are expected to provide price support in their carbon markets in 2022, with the energy crisis and conflict in Ukraine driving up EU emissions, while declining nuclear and hydroelectric generation pushes gas-fired power generation in the US (BloombergNEF, 31/10/2022).

c These strategies, included in the Paris Agreement, are policy instruments that place short-term actions within the framework of long-term structural changes needed for a low-carbon economy in 2050. They can also help to explore the consequences of these actions on the socio-economic objectives of countries (IDDRI, 2016).

THE CONVERGENCE OF THE MITIGATION AND ADAPTATION AGENDAS CONFRONTED BY A FUNDING GAP

The focus of COP27 has been on adaptation and loss and damage, which for the first time is on the official agenda of the COP. Whether it is the summer 2022 heat waves and droughts around the world, or devastating floods like the ones in Pakistan and West Africa, the impacts of global warming are already being felt — to the tune of $121 billion in insured losses in 2021 (SwissRE, 2021). Over the past few years, global warming has already had a negative impact on various mitigation measures, in terms of human and agricultural losses, or damage to electricity and transport infrastructure, while short-term adaptation measures such as air conditioning, refrigeration or irrigation have increased the pressure on fossil fuel-based electricity grids. By 2022, 84% of UNFCCC parties had established adaptation plans, strategies, laws and policies, an increase of 5% from the previous year (UNEP, 2022).

Coordinated by the German G7 presidency and developed with the V20 group of 58 most vulnerable economies, the €200 million Global Shield initiative, launched at COP27, aims to provide rapid access to insurance and financing for disaster protection after floods or droughts. Pakistan, Ghana and Bangladesh will be the first to benefit from this (Financial Times, 14/11/2022). In Africa, the signatories of the Nairobi Declaration on Sustainable Insurance have committed to underwrite $14 billion in climate risk coverage by 2030 (Reuters, 10/11/2022). Although up 53% from 2017-2018, financial flows for adaptation in 2019-2020 remain far from the parity with those for mitigation targeted by the Paris Agreement and from the $300 billion in needs before 2030, estimated by the Climate Policy Initiative (Climate Policy Initiative, 2021).

While the existing promise of $100 billion in climate finance by 2020 for all purposes has not been met — $83 billion in climate finance flows were mobilised in 2020 (OECD, 2022) — the debate on financing centred around the creation of a loss and damage fund, which developing countries had demanded from countries with a historical responsibility for emissions. The lengthy negotiations at the COP finally led to the decision to set up a new loss and damage fund (Carbon Brief, 21/11/2022). There are also concerns about the dilution of commitments made in Glasgow, such as doubling adaptation funding (The Guardian, 15/11/2022). The Alliance of Small Island States (AOSIS) proposed at the COP that fossil fuel companies could meet part of their share by paying a tax on their profits, which would then be channelled into these funds (Energy News, 09/11/2022).

COMPETITION INTENSIFIES FOR ACCESS TO RESOURCES THAT ARE STRATEGIC TO THE TRANSITION

The European energy crisis, intensified by the war in Ukraine, has been an excellent example of the geopolitical context driving climate action; in this case, driven by its need for energy independence, Europe is accelerating the deployment of renewable energy. Around the world, competition for strategic resources is shaping the transition in various sectors.

In 2021-22, the recovery of the global economy, extreme weather events and the war in Ukraine have underlined the vulnerability of value chains and the strategic interdependencies of transition industries. Industries such as the automobile sector, in a context of concentrated resources of strategic minerals (lithium, nickel, cobalt), favour long-term supply contracts and vertical integration of value chains. The price index for lithium (x4), cobalt and nickel (x2) have undergone strong inflations since the second half of 2020 (IMF, 2022), under the pressure of growing demand. From the opening of lithium mines to the production of renewable energy, reindustrialisation hovers between cooperation and competition. The trend is also towards the relocation of transition industries, with 1,400 GW of "gigafactories" planned in Europe (Les Echos, 2022). $369 billion in tax credits and energy transition investments have been passed in the US, with these credits promoting the consumption of Made-in-America products (White House, 2022).

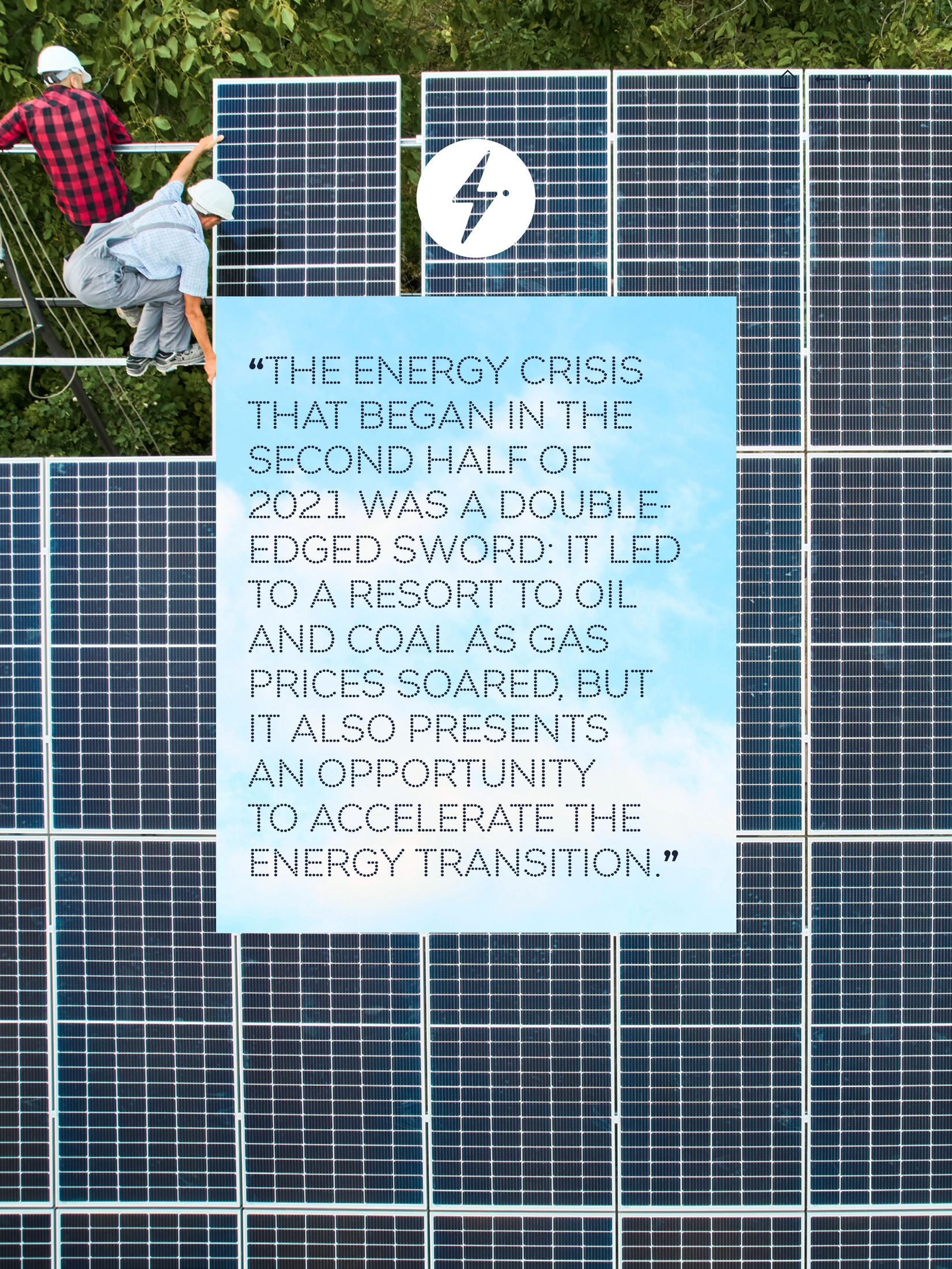
The European Commission concluded agreements with several countries during COP27, including forestry agreements for the protection and restoration of forests and the sustainable supply of wood products with Mongolia, Guyana, Republic of Congo, Zambia and Uganda, (European Commission, 08/11/2022) and agreements on rare minerals or hydrogen with Kazakhstan, Egypt and Namibia (Politico, 08/11/2022). In Europe, the USA and China, and in emerging countries with considerable primary resources, the State is taking control to relocate value chains, or even nationalize domestic champions (EDF, Uniper), in a deteriorating economic environment.

MOUNTING PRESSURE FROM CIVIL SOCIETY ON BUSINESSES AND STATES

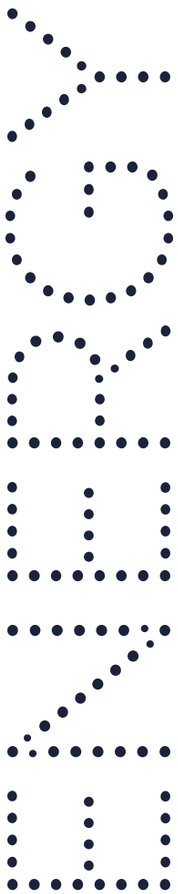
The ongoing energy and climate transition is being met at every stage with various forms of activism aimed at accelerating it: from legal action and shareholder activism to popular and civil society movements. The number of climate-related lawsuits worldwide has doubled since 2015, with more than a quarter of them filed in the last two years (The Guardian, 30/06/2022). While a large proportion of lawsuits target State inaction (70%), the fossil fuel industry is increasingly in the crosshairs, with at least 13 cases filed against European companies and two against Australian companies. 90% of cases are brought by NGOs in the recent period. Six of the eight lawsuits targeting State climate policies handled by the highest national court have received a climate-friendly ruling, out of 73 filed; 54% of rulings in non-US cases since 2000 have a climate-friendly outcome; this is less than in 2020, as eleven German cases were lost against the Länder (LSE, 2022).

Shareholder activism, while largely concentrated in the US, has also been effective in influencing industries' climate action. 172 environmental proposals were filed by shareholders at the AGMs of the 3,000 largest US companies in 2022, representing 18% of ESG proposals and 39% more than in 2021. Of these, 130 were climate-related proposals in 2022 (73%) (Freshfields, 2022). Even while waiting for long-term results on the impacts of legal action and shareholder activism, this dual pressure is causing carbon-intensive industries to re-examine their transition strategies, but at their own pace.

There is also pressure from governments to encourage companies to be transparent about their non-financial performance. In the US, the Biden administration recently announced the Federal Supplier Climate Risks and Resilience Rule, which requires government suppliers to disclose climate-related emissions and financial risk data, and to set science-based emissions reduction targets (ESGToday, 11/11/2022). The EU has also adopted its Corporate Sustainability Reporting Directive (CSRD), which requires around 50,000 large multinational companies to disclose their environmental and social impacts (European Parliament, 11/11/2022).



“THE ENERGY CRISIS THAT BEGAN IN THE SECOND HALF OF 2021 WAS A DOUBLE-EDGED SWORD: IT LED TO A RESORT TO OIL AND COAL AS GAS PRICES SOARED, BUT IT ALSO PRESENTS AN OPPORTUNITY TO ACCELERATE THE ENERGY TRANSITION.”



After its first quarter which was bogged down by Covid-related lockdowns, 2021 saw a return of global energy demand (+5.8%) and energy-related emissions (+7%) to levels even higher than in 2019, breaking with the exceptional pattern of 2020. Emissions from the power sector touched 12.83 $GtCO_2$, due largely to the resort to fossil fuels as the bounding growth in renewables was not enough to sate the power-hungry recovery **[INDICATORS]**.

The energy crisis that began in the second half of 2021 was a double-edged sword: it led to a resort to oil and coal as gas prices soared, but it also presents an opportunity to accelerate the energy transition. While coal, oil and gas all experienced sharp price inflation, the reactions of different countries and energy companies varied depending on the regional and geopolitical contexts **[TRENDS]**. While inflation temporarily pushed up the costs of renewables, renewable capacity additions remain nevertheless cheaper and more profitable in the long term — indeed in 2021, renewables accounted for 81% of new power generation capacities, at 257 GW of capacity added, of which 133 GW of wind and 93 GW of solar **[INDICATORS]**.

With increasing resistance to the expansion of fossil fuels, articulated through student movements, civil society protests, and even judicial action against energy companies **[SIGNALS]**, renewable energies are gaining ground around the world.

The uptake of renewables has also been a particularly strong trend on the African continent, seeking to respond simultaneously to concerns of expanding access to energy and decarbonising the energy sector. As actors in the sector turn to various tools to expand renewable capacity installations — from contractual tools like Power Purchase Agreements on a larger scale, to more physical ones like the deployment of independent mini grids for remote rural areas on a smaller scale, as in the case of Mali **[CASE STUDIES]** — financing remains the key to unlock the vault. Currently, States are implementing reforms, institutional and legislative, to attract more private investments **[TRENDS]**.

While renewables continue their stellar growth, riding the momentum from 2020, 2021 and its trail of climate catastrophes, in addition to energy crisis, has brought a newer concern to light: the vulnerability of energy grid and its infrastructure. Adaptation to these impacts is taking a form shaped by the dual forces of short-term adaptation through fossils, and longer-term reflections on sufficiency and anticipatory planning at the system level **[TRENDS]**. At the local level, the trend is one of combining adaptation and mitigation objectives, by promoting renewable technologies and sustainable production techniques while also ensuring the socio-economic resilience of communities — with energy cooperatives in Georgia working for the emancipation of women, or the development of sustainable wood fuel value chains with the involvement of local populations in Cambodia **[CASE STUDIES]**.

THE ENERGY CRISIS STIFLES AMBITIONS OF TRANSITIONING TO A LOW-CARBON MIX

Energy consumption and emissions revert to their pre-Covid dynamics

EMISSIONS FROM THE POWER SECTOR

12.83 $GtCO_2$

+7%
COMPARED TO 2020

Emissions from the production of electricity went from 11.99 Gt in 2020 to a record 12.83 Gt in 2021. The figures for Europe and North America, however, remained below their 2019 levels. *Enerdata Global Energy and CO_2 data*

GLOBAL ENERGY DEMAND IN 2021

+5.8%
COMPARED TO 2020

Global energy demand has exceeded its pre-pandemic level (+1.3% compared to 2019). The share of fossil fuels (82%) declined compared to 2019 (83%) and 2016 (85%).

BP, 2022

CHANGE IN GLOBAL ELECTRICITY CONSUMPTION IN 2021

+5.4%
COMPARED TO 2020

In 2020, this consumption was 0.6% less than in 2019.

Ember, 2022

Despite the momentum gained by renewables, the electricity mix does not shift

+257 GW

NEW RENEWABLE CAPACITY ADDITIONS IN 2021

+9.1%
COMPARED TO 2020

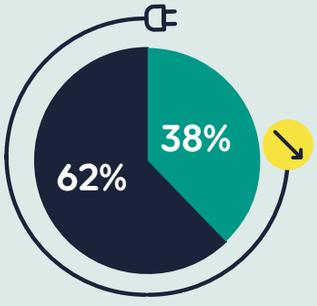
SOLAR ..... +133 GW
WIND..... +93 GW
IN CHINA..... +121 GW

IRENA, 2022

SHARE OF LOW-CARBON ELECTRICITY GENERATION

The share of renewables (including nuclear) in the global electricity mix fell by one point in 2021, but still exceeded coal (36%). Solar and wind account for 10%. The galloping growth of renewables is not enough to shift the electricity mix.

Ember, 2022



$366 bn

+6.8%
COMPARED TO 2020

INVESTMENTS IN RENEWABLE ENERGY IN 2021

This is 6.8% more than in 2020. While solar PV (56%) and wind (40%) dominate investment, the annual dynamics differ: wind is declining in 2021 (-5%), especially offshore (-45%), while solar is rising (+19%).

REN21, 2022

-5%
-45%
+19%

Coal reinvigorated by the gas crisis

COAL-FIRED CAPACITY ADDITION IN 2021

India and China account for 72% of new fossil fuel capacity installations in 2021: a dynamic which slowed down in China compared to 2020 (-35%), but which has exploded in India (+234%) after exceptionally low installations in 2020.

Global Energy Monitor, 2022

+45.55 GW

IN CHINA +26.187 GW

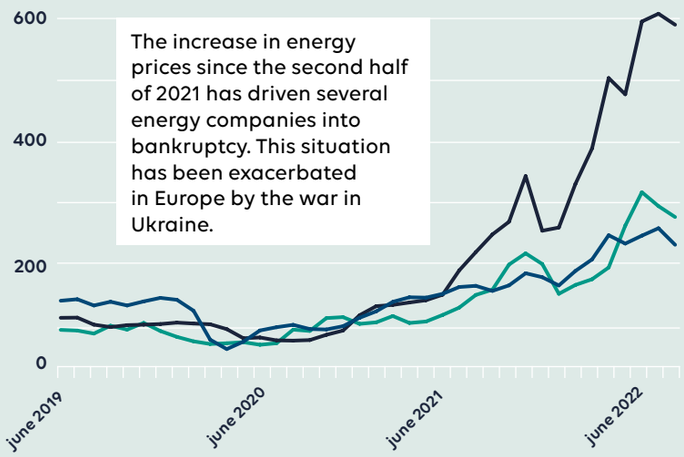
IN INDIA +6.69 GW

+14%

EU coal consumption increased by 14% in 2021, and is expected to increase by a further 7% in 2022, driven by a gas-to-coal switching due to soaring gas prices.

IEA, 2022

Energy inflation puts pressure on the market and on supplies...



International Monetary Fund, 2022

PPA PRICES IN EUROPE

+225%
BETWEEN SEPTEMBER 2021 AND AUGUST 2022

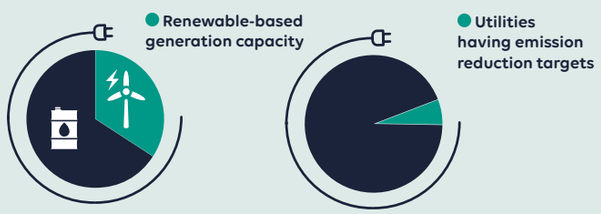
One of the growth drivers for renewables, PPA tariffs rose from €52.77/MWh in September 2021 to €171.4/MWh in August 2022, before falling back to €105.81/MWh in September 2022. Insufficient capacity and regulatory constraints until July 2022 restricted volumes and caused tariffs to peak. *Pexapark, 2022*

...while the dependence on fossils remains strong

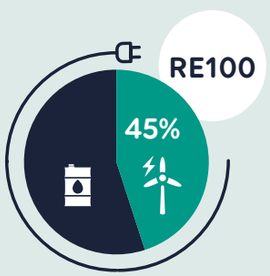
DECARBONISATION OF ELECTRIC UTILITIES

47 of the world's 50 largest utilities do not have emissions reduction targets aligned with a 1.5 °C trajectory. 66% of these utilities' generating capacity is fossil-based.

World Benchmarking Alliance, 2022



RENEWABLE ENERGY SOURCING BY THE PRIVATE SECTOR



This is the share of renewable electricity in the consumption of 315 RE100 members in 2021, i.e. 340 TWh: the equivalent of the annual consumption of the United Kingdom.

RE100, 2022

SHARE OF THE GLOBAL POPULATION COVERED BY RENEWABLE ENERGY TARGETS OR POLICIES

In 2021, about 1,500 cities had renewable energy targets or policies, covering more than 1.3 billion people.

REN21, 2022

TRENDS
FOSSILS

The growth of renewables is still not enough to feed the insatiable energy appetite of the economic recovery

TANIA MARTHA THOMAS • Research officer, Global Observatory of Climate Action, Climate Chance

Breaking from the trend of 2020, 2021 and the first months of 2022 present a varied picture for energy production sector. Renewables, fossils and emissions are all on an upward trend. The energy crisis, which began in the second half of 2021, has been intensified by war in Ukraine, and the hike in energy prices in its wake has spared no actor. Europe, pursuing a target of long-term energy autonomy, is obliged to tackle the short term using coal, oil and LNG to secure supplies and move away from Russian gas. In parallel, Asia has turned to fossils – mainly coal – to fuel its recovery. This is the case for India, and to a certain extent China, which is still dealing with Covid-related lockdowns. In the private sector, differences between large and small actors are widening, while concentration and nationalization are intensifying.

DATA OVERVIEW

The energy crisis offers a reprieve for fossils as renewables continue to grow

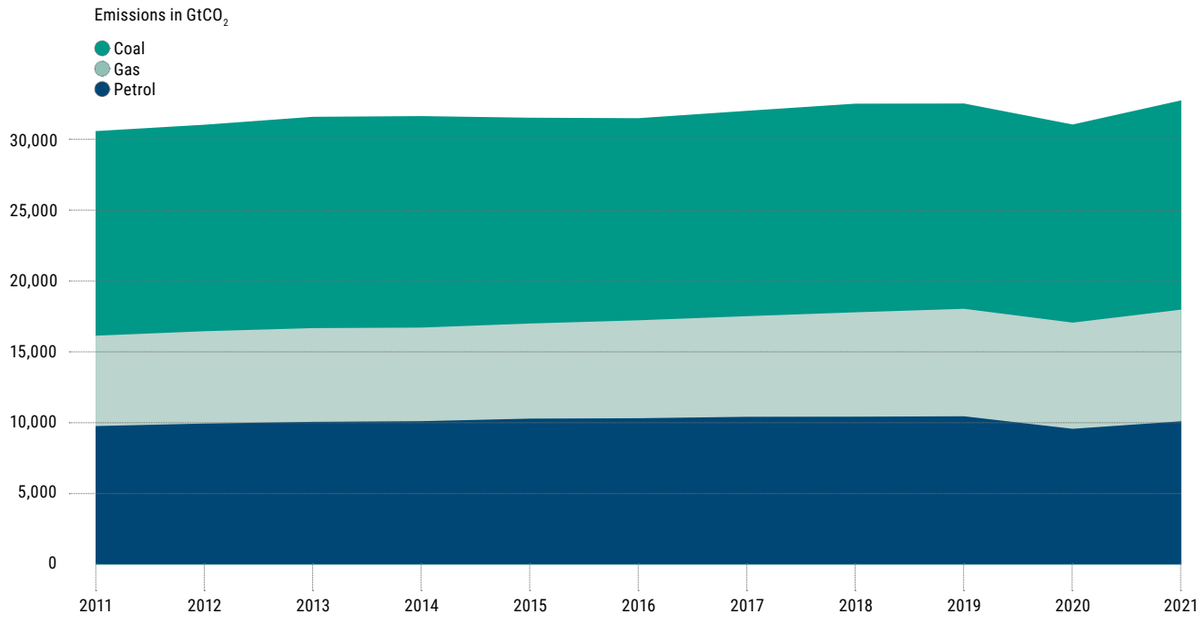
While in 2020 the Covid-19 pandemic saw global CO_2 emissions (apart from land use) take their biggest dive since the second world war (-1,6 $GtCO_2$, a drop of 4.4%), 2021 kicked off with an economic rebound and a sharp rise in emissions of 5.5% compared to 2020 (+1.9 $GtCO_2$). According to initial estimations, driven by the economic recovery and adverse weather conditions, these emissions amounted to 37.1 gigatonnes of CO_2 ($GtCO_2$), and therefore more than made up for the drop in 2020, despite the fact that many countries were still applying movement restrictions in the first quarter of 2021 **(FIG. 1)**.[1]

Demand for oil in 2021 remained lower than pre-pandemic levels, at an average 3.7 million barrels a day (Mb/d). This situation was due to the low demand for fuel in transportation, mainly in the aviation sector.[2] The International Energy Agency (IEA) anticipates that oil demand for vehicles in advanced economies will never return to its pre-2020 levels due to saturated vehicle ownership and demand per capita, while Asian countries continue to drive current growth in demand.[3] Nevertheless, demand for oil has grown in 2022 under the impact of the gas-to-oil shift[4] due to soaring gas prices and a geopolitical situation that has pushed countries to seek energy independence and move away from Russian gas. However, this increase in oil demand is held back to a certain extent by renewed lockdowns in China and sluggish economies in OECD countries.[5] Oil supply slowly picked up again in 2022, and in July OPEC+ recorded its highest monthly crude oil production rate in five months, led by Saudi Arabia and the other countries of the Middle east, along with

FIGURE 1

EVOLUTION OF CO_2 EMISSIONS BY FUEL, 2011-2021

Source: Climate Chance, based Enerdata, Global Energy and CO_2 data, 2022



Kazakhstan. Nevertheless, the objective of increasing production promised by the alliance has not been reached,[6] and analysts remain doubtful about the oil production potential of OPEC+,[7, 8] including leading producers like Saudi Arabia.[9]

Forty percent of the growth in global CO_2 emissions is due to the consumption of coal, emissions of which reached 14.8 $GtCO_2$ in 2021, exceeding their 2019 level **(FIG. 1)**.[10, 11] More precisely in the electricity sector, which makes the biggest contribution to CO_2 emissions, coal-fired power plants met half of the increase in global demand for electricity (a total rise of 1,400 TWh), and their emissions reached 10.5 $GtCO_2$. At the same time, the rise in gas prices also led to a gas-to-coal switch, in particular in Europe and the United States, where competition between coal and gas power plants is highest.[12] Global electricity production from coal reached a record level of 10,042 TWh in 2021, according to analyses by Ember.[13] The gas-to-coal shift had already increased demand for coal in 2022, also stimulated by economic growth in India.[14]

Coal production and consumption in the EU grew in 2021, and anthracite[a] production amounted to 57.2 million tonnes (Mt), while consumption totalled 160 Mt. Lignite consumption totalled 277 Mt in 2021, most of it used to produce electricity.[15] In 2022, the German Bundestag authorized the temporary usage of a large number of coal-fired power plants to produce electricity in reaction to restrictions on gas supply from Russia,[16] with coal representing a third of the country's electricity production[17]. The same trend can be observed across Europe – electricity production from coal has grown 20% in France, Germany, Italy, the Netherlands, Spain and the United Kingdom since last year, according to Rystad Energy statistics.[18] In the United States, coal production amounted to 524 Mt in 2021, while consumption was 494 Mt (455 Mt in the electricity sector).[19] In the first quarter of 2022, US consumption of coal was 3.9% lower than during the same period in 2021.[20]

Most of the increase in emissions related to energy in 2021 originated in China, where electricity demand grew by 10% in 2021, 56% of it met by coal.[21] China's coal production reached a record 4.07 billion tonnes, which is 4.7% more than the previous year.[22] In 2022, raw coal production in China shot up between January and May, resulting in domestic production of 1.81 billion tonnes, which is a 10.4% year-on-year increase. However, according to the Global Energy Monitor, additional new electricity production capacities using coal dropped by 35% from 2020 to 2021 **(SEE INDICATORS)**. During the second quarter of 2022, Chinese emissions saw a record decrease of 8% (230 $MtCO_2$, the largest in a decade), as a result of various factors including factory closures due to strict lockdowns, low growth in electricity demand, and high growth of renewable energy.[23]

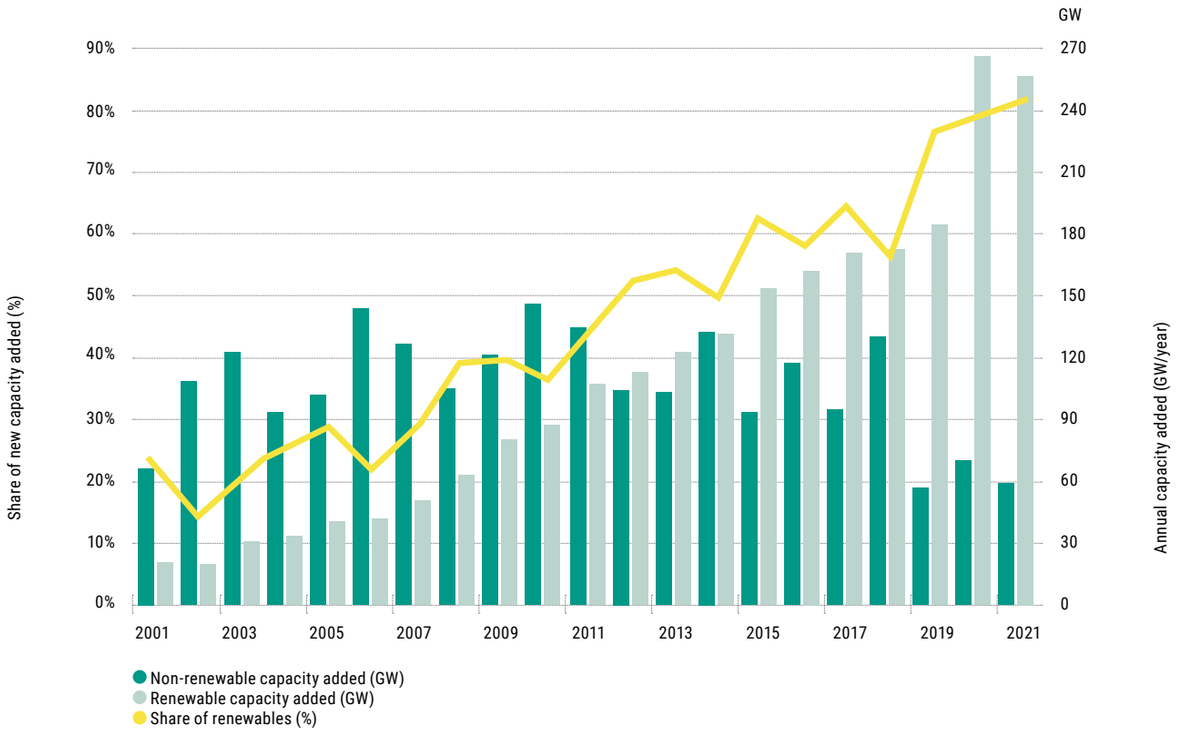
In second place after China, India's coal production reached 777.31 Mt (+8.55%) and its coal imports amounted to 208.93 Mt in 2021-22 (up to April 2022).[24] Additional coal-fired production capacities in the country soared by 234% from 2020 to 2021 **(SEE INDICATORS)**. Japan, South Korea, South Africa, Indonesia,

a Anthracite is dark black coal with a higher carbon content and energy density than other types of coal. Lignite, however, has a lower carbon content and energy density, meaning that it emits more CO_2.

FIGURE 2

RENEWABLE AND NON-RENEWABLE CAPACITIES ADDED FROM 2001 TO 2021

Source: IRENA, 2021



Russia and Australia were also among the countries that used the most coal in 2021. Record electricity production levels from coal were also reached in other Asian countries like Mongolia (+13%), Pakistan (+8%), the Philippines (+8%) and Kazakhstan (+6%).[25]

While in 2020 coal succumbed to the low price of gas, in 2021 the trend bucked – the increase in gas prices at the end of the year led to a move to coal, a trend exacerbated by the conflict in Ukraine.[26] On the whole, gas prices have remained volatile, but LNG prices have surged as a result of reduced European gas imports from Russia via gas pipelines.[27] Nevertheless, gas emissions have exceeded 2019 levels, and demand has increased in all sectors.[28] Global natural gas production has reached 4,036.9 billion cubic metres.[29] Europe and East Asia remain the biggest importers of LNG, and the European Union's REPowerEU plan aims to reduce Europe's dependence on Russian gas by two-thirds before the end of 2022, which increases pressure on LNG supplies,[30] as well as on other sources of energy.

Electricity production from gas rose by 1.3%, moving from 6,017 TWh in 2020 to 6,098 TWh in 2021. Gas production therefore plateaued, while other electricity sources increased significantly. The biggest increases in the relative share of gas in domestic production were recorded in Russia, Turkey, and Brazil, which compensated the lack of hydropower following a year of drought. India and China both produced only 3% of their electricity from gas.[31]

The exceptional growth of renewable energy during the pandemic has slowed down slightly, but additional renewable energy capacities have continued to rise: +260 GW in 2021, for an installed total of 3,068 GW. Renewables represented 81% of new capacities in 2021, compared to 79% in 2020 **(FIG. 2)**.[32]

Solar power (133 GW) and wind power (93 GW) are responsible for 88% of this increase in new capacities, most of it in China (53 GW solar, 47 GW wind). Europe and North America have increased their solar capacities by 39 GW and 38 GW respectively. India (+10.3 GW), Japan (+4.4 GW) and South Korea (+3.6 GW) have also added considerable solar capacities.[33] At the same time, "clean energies" provide jobs for more than 50% of all workers in the energy sector[b], according to the IEA, due to the substantial growth of projects being implemented.[34]

These trends can be found in electricity consumption: in 2021, clean energies (including nuclear) represented 38% of the global energy mix, a one-point drop since 2020.[35] While renewable energies continued to grow, although at a slower

b According to the IEA, "clean energy employment" includes people working in bioenergy supply, nuclear power and renewable energies to produce electricity, storage networks, the manufacture of electric vehicles, and energy efficiency.

pace, the explosion in demand for electricity triggered by the economic recovery, coupled with the current energy crisis, led to the reopening of a number of fossil-fuel power plants. The share of renewables in the global energy mix grew slightly from 2009 (8.7%) to 2019 (11.7%) and 2020 (12.6%).[36] Adding to this impetus, the first half of 2022, marked by war in Ukraine, has highlighted the question of energy security due to restricted supplies and rocketing prices – and a shift in the relative shares of fossil and renewable energy sources.

THE OBSERVATORY'S LENS

The renaissance of fossils: A story in three curves

An explosive situation, even before the war in Ukraine

Oil, gas and coal all saw a resurgence in demand in the second half of 2021. At the end of 2021, the IEA estimated that coal demand had risen by 6% in 2021, posing a threat to zero net emission targets.[37] This is reflected in coal prices, which have considerably increased since May 2021 **(FIG. 3)**. The price hike is mainly due to the incapacity of supply to meet demand from the biggest market, China, and partly due to the rise in natural gas tariffs. Prices peaked in October 2021, with thermal coal imported to Europe reaching up to $298 per tonne, before dropping back down in November 2021 following policy intervention by the Chinese government.[38] Prices then went up again in January 2022 in reaction to an export prohibition on coal by Indonesia[39] and increased tensions in Ukraine.[40]

This price hike is reflected in the profits of mining companies and coal producers (thermal and industrial), whose earnings have rocketed. For example, Peabody, the biggest private coal producer in the world and owner of the world's biggest coal mine, North Antelope Rochelle in Wyoming, which was going bankrupt in 2016, reported its best quarterly results in 20 years, with profits of 513 million dollars in the last half of 2021.[41] The Chinese coal extraction and processing industry saw its profits more than double in 2021,[42] and mining revenues were multiplied by 1.75 from January to May 2022.[43] In 2022, coal profits continued to grow and reached new heights. Glencore Plc increased profits from its coal activity by 900% during the first half of the year. The producer Coal India saw its revenues triple, and Chinese companies doubled their profits during the same period. The value of shares in Thungela Resources, the former coal subsidiary of Anglo American Plc, has grown by 1,000% since the company entered the stock exchange in June 2021.[44]

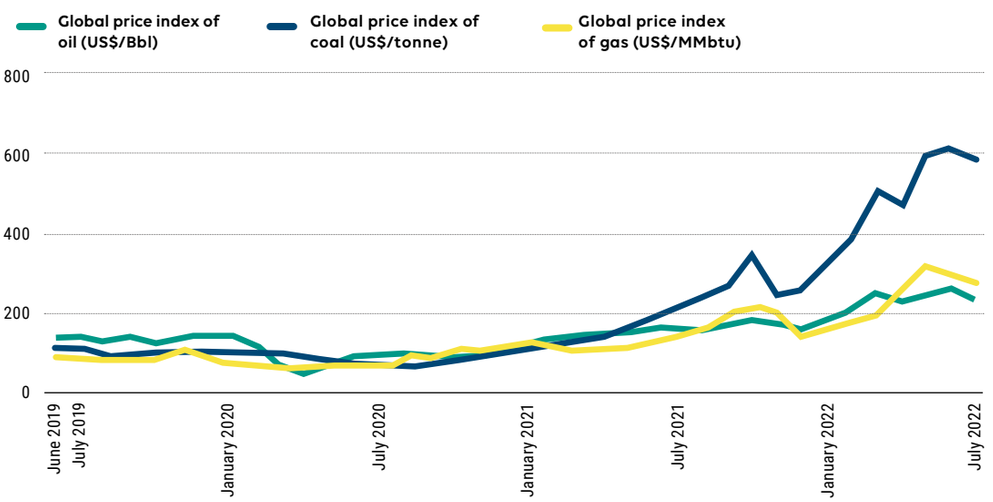
Oil prices were also on the rise in the second half of 2021 (**FIG. 3**), as a result of increased demand generated by the lifting of lockdowns, perturbations related to weather conditions, the limitation of OPEC+ production, and increased gas prices.[45] In early 2022, following geopolitical tensions – conflict in Ukraine, drone attacks in the UAE claimed by Houthi rebels in Yemen[46] – and producers' incapacity to meet demand,[47] oil prices reached their highest level in seven years, and a new peak at the outbreak of the Ukrainian conflict.

The rise in gas prices, which almost takes centre stage, was fuelled by supply and demand factors on global LNG markets and European regional gas markets. Since the start of 2021,

FIGURE 3

GLOBAL PRICE INDEX FOR COAL, GAS, AND OIL, JUNE 2019 – JULY 2022

Source: Climate Chance, base on data from the IMF, 2022



and even during the summer, Asian markets have dominated global LNG demand, closely followed by Central and South American markets. This situation, compounded by a colder autumn and winter, the drop in European gas production, low storage levels, and lower than usual imports via gas pipeline from Russia (in particular along the Yamal-Europe route), pushed up prices.[48]

In late 2021, LNG carriers initially destined for Asia were finally rerouted towards Europe, where the shortage of gas has seen FFT contract prices rocket, and where suppliers are ready to pay higher prices. Throughout the year, the Chinese, Japanese and Korean markets had outbid European demand. According to Platts, the spread between European and Asian prices, expressed in $/mBTU, has never been so high; to the point that Australia sent its first LNG cargo to Europe since 2009.[49] Whereas 2022 started with questions about Russian supply, the invasion of Ukraine confirmed those fears, taking prices to a new peak. Europe found itself in the eye of the storm, largely dependent on Russian gas until that point (in 2021 over 40% of gas imports on the continent came from Russia),[50] and obliged to take measures to secure its energy independence.

Due to surging prices, shares in oil and gas companies have increased in value on stock markets since the rise in oil barrel prices and the war in Ukraine. Some of them, like BP, have come a long way: the price of shares in the British company were at their lowest point for 27 years at the height of the pandemic. ExxonMobil had even been ejected from the Dow Jones Industrial Average. Thanks to the superprofits generated by the rise in the price of a barrel, oil and gas companies are able to distribute high dividends and buy back their own shares at a high price. Illustrating this frenzy on the stock exchange, Saudi Aramco, a state-owned company, overtook Apple as the highest valued company in the world.[51] The Russian company Gazprom recorded record profits of 29 billion dollars in 2021.[52]

Gas is the new coal, with the explosive competition for LNG

According to a Climate Action Tracker[53] analysis of the recovery and resilience policies implemented by States to deal with the successive energy crises triggered by the pandemic and the invasion of Ukraine, we are seeing a new "gold rush" for fossil energies. This rush involves numerous investments directed at opening new fossil gas infrastructures (especially LNG) and oil installations (pipelines in East Africa, like the controversial EACOP project).[54] Measures to compensate energy price increases also contribute to locking consumers into fossil energy systems.[55]

Gas, for a long time presented as a means of transition towards greener energy (i.e., a bridge fuel), still has a large carbon footprint **(SEE BOX 1)**.[56] In 2022, Global Energy Monitor listed 9,578 gas power plants in the world, of which 7,320 are operational and 226 "mothballed", in other words, not in service but maintained in a state ready to operate if needed.[57]

BOX 1 • **KEYS TO UNDERSTANDING**

THE CARBON FOOTPRINT OF GAS

The advantage of natural gas is its relatively low emissions compared to other fossil fuels – it emits 50% less CO_2 than coal, and 30% less than oil per unit of energy produced. However, recent studies have shown that natural gas may not be as green as it seems. Natural gas was the main source behind increased CO_2 emissions from fossil fuels for the period 2010-2019 (42%). It is also responsible for 60% of methane emissions from the production of fossil fuels, including the methane leaked during gas production and transport, and electricity production. The global warming potential of methane over 100 years is 28 to 32 times greater than that of CO_2. Although LNG is increasingly popular, the emissions related to its supply and final usage amounted to 1,25 $GtCO_2e$/year (~17% of natural gas emissions) in 2020.

Sources: C2ES, n.d.; UNECE, n.d.; Hare et al, 2021

In the case of LNG, 6.9 million tonnes per annum (MTPA) of liquefaction capacities were added in 2021, and 12.5 MPTA in the first four months of 2022, which raised global capacity to 472.4 MTPA. At the other end of the chain, global regasification capacity reached 901.9 MTPA.[58] Emissions from supply and final usage of LNG reached an estimated 1.25 $GtCO_2e$/year (~17% of fossil gas emissions) in 2020. LNG represented about 12% of the total use of gas in the world in 2020.[59] While policies decided on in 2021 are likely to increase this share to 16%, the geopolitical situation in 2022 could push it up further still – Europe gives priority to LNG and storage to replace Russian pipeline gas.[60] The continent represents 85% of increased demand in 2022 **(FIG. 4)**.[61]

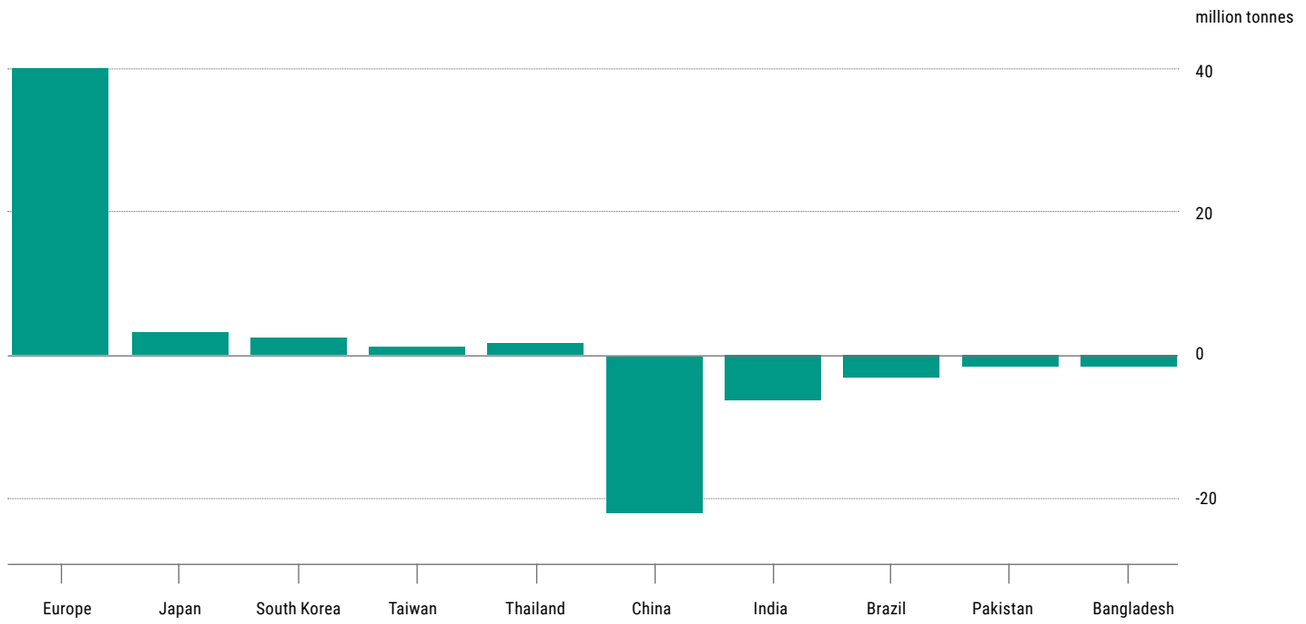
France has not received Russian gas since 15 June 2022 – GRTGaz observed "*the interruption of physical flows between France and Germany*", the transit country for Russian gas imported into France. The previous day, Gazprom announced a 40% reduction in its gas deliveries to Germany via the Nord Stream 1 pipeline. In 2020, Russia accounted for 17% of gas deliveries to France, and Norway made up 36%. The storage level in France was 99% in the month of October, much higher than usual.[62] At the same time, LNG deliveries to four French regasification terminals went up by +66%, or 51 TWh, mostly from the United States.[63] In May, Engie signed an agreement to buy gas from the Texan company NextDecade, a turnaround compared to 2020, when a potential agreement with US suppliers was revoked due to environmental concerns.[64] The law of 16 August 2022 on emergency measures to protect purchasing power establishes the accelerated installation of a floating LNG terminal off Le Havre,[65] in addition to the existing terminals in Dunkerque, Montoir-de-Bretagne, and two in Fos-sur-Mer.

Germany does not possess an LNG regasification terminal, which can take five years to build, and is looking for alternative solutions to avoid dependence on Russian gas, such as floating terminals and "*more adaptable land sites*". The

FIGURE 4

INCREASED DEMAND FOR LNG PER COUNTRY/REGION IN 2022

Source: Financial Times, 2022



country is chartering five Floating, Storage and Regasification Units (FSRU) via the government, and two others will be leased by the private sector.[66] Olaf Lief, minister of energy for Lower Saxony, has announced the installation of an FSRU and a land-based terminal. The first one should be operational in Wilhelmshaven before the end of 2022 to allow imports of 5 bcm/year. A second vessel is due to be operational in early 2023, allowing imports of 10 to 14 bcm, according to RWE. Uniper has announced that it "*will charter two other FSRUs for the German government from the Greek company Dynagas*". With these Greek terminals, Germany will have a regasification capacity of 20 bcm/year, which is the equivalent of 50% of its Russian gas imports. The trend to purchase or lease FSRUs could rise significantly during the year, although only 48 terminals of this type currently exist in the world, according to Bloomberg.[67, 68]

Two FSRUs – the Golar Igloo and the Eemshaven LNG – are being installed in the Dutch port of Eemshaven, where they will operate for five years, together creating what has been called the EemsEnergyTeerminal, whose capacity of eight billion cubic meters has been sold to Engie SA, Shell plc, and the Czech company CEZ AS. The new terminal has received its first delivery from the United States and is set to receive 18 more by the end of the year, providing gas to not just the Netherlands but also landlocked countries like the Czech Republic.[69]

Spain has been developing its capacities to import LNG for some time. Gas represents the largest share of electricity production in the country.[70] As a result, and coupled with its weak interconnections with the rest of the continent, Spain is opposed to the target to reduce energy consumption by 15% put forward by the European Commission.[71]

In the United Kingdom, while in July 2022 Greenpeace took the British government to court for having authorized the Jackdaw gas field in the North Sea off Aberdeen,[72] in September Liz Truss's new government overruled the prohibition on oil and gas fracking as part of measures aimed at curbing the rise in energy bills.[73] Fracking was banned in the country in 2019 following several local demonstrations. The Scotch and Welsh governments have always been opposed to fracking on their territories.[74] The controversial decision was then reversed with the entry into power of Rishi Sunak's government.

Demand for LNG in Europe shot up so quickly in 2022 that European countries outbid China, India, Brazil, Pakistan and Bangladesh **(FIG. 4)**, and these countries will therefore be confronted with the biggest drop in LNG demand, placing them at risk of energy crisis, according to analytics firm ICIS. LNG traders also seem to be out to take advantage of price differences on global markets, because emerging economies often use the spot market to buy LNG.[75]

A frenzy that has not spared renewables

Since 2010, the cost of solar energy has dropped by 85%, and by about 50% for onshore and offshore wind.[76] At the same time, renewable installations have benefited from stable costs, relatively unaffected by the geopolitical situation. A study by the association Transition Zero, which has built an index to "*follow the carbon price needed to encourage the move from coal to onshore wind or photovoltaic solar energy with battery storage in 25 countries*" shows, based on data from 2010 to 2022, that it is more profitable to move from coal to clean energy, than from coal to gas.[77] In 2022, galloping inflation has also led to disruptions in supply chains, which has temporarily increased the cost of new renewable energy installations – nevertheless leaving them cheaper still than fossil alternatives.[78]

For the final consumer, the price of electricity remains high – as pointed out by analysts, gas remains the key factor in electricity prices across Europe, thanks to the marginal pricing system of the EU's single electricity market, where all sellers get the same price for electricity.[79,80] In the United Kingdom, the current energy crisis has pushed up retail prices by 80% and wholesale prices have quadrupled, despite the fact that the country produces over half of its own electricity from non-fossil sources.[81] In August 2022, wholesale prices in Germany and France reached record levels of 850 euros and over 1,000 euros per megawatt hour (MWh) respectively, compared to only about 85 €/MWh in these countries in 2021.[82] Although prices have been high on the entire continent, reactions have varied from one country to the next. Some, like Spain and Portugal,[83] have capped natural gas prices in electric power plants, while the United Kingdom has capped wholesale electricity bills. Several states have offered support or benefits to households, and many have plans to tax energy companies that make superprofits **(SEE BELOW)**.[84]

Another indication of the impact of the renewable energy crisis, the price of power purchase agreements (PPAs), one of the preferred tools of private and local actors[c] to obtain supplies of renewable energy, increased dramatically in 2022 **(SEE INDICATORS)**. PPA tariffs went from €52.77 per MWh in September 2021 to €171.4 per MWh in August 2022, before going back down to €105.81 per MWh in September 2022. Insufficient production capacities and regulation requirements up to July 2022 restricted volumes and triggered the price peak.[85,86]

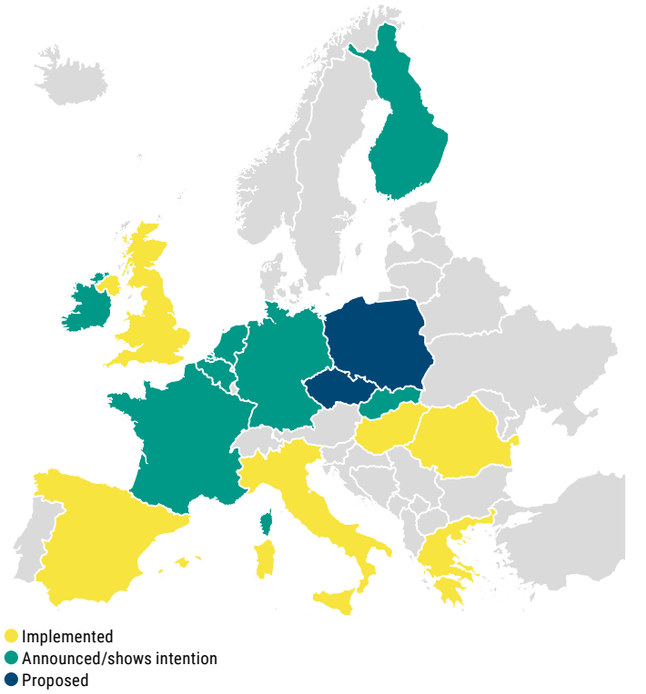
Superprofits, exceptional taxes and the superconcentration of companies

The energy price hike has generated "superprofits" for major energy companies, defined as "*profits considered as much larger than normal and due to external events, generating money for companies that have done nothing to modify their way of operating or strategic methods*".[87] This trend is a point of concern for governments, and Romania and Spain had already implemented temporary mechanisms in late 2021 to limit excessive revenues garnered by energy companies.[88] In its REPowerEU communication dated March 2022, the European Commission recommended taxing these exceptional profits of energy suppliers, while devising these taxes to avoid affecting long-term wholesale electricity price trends, with tax revenues acting to reduce the burden for final consumers. In late September 2022, Greece, Hungary, Italy, Romania, Spain and the United Kingdom had set up taxes on exceptional profits; the Czech Republic and Poland had published proposals aimed to implement such a tax; while Belgium, Finland, Germany, Ireland, the Netherlands and Slovakia had also expressed their intention to do so (**FIG. 5**).[89] Although the idea of a tax on superprofits has been suggested in France (the government added an amendment to the 2023 budget to impose "temporary contributions" of 33% of the income of companies operating in the oil, gas, coal and refining sectors)[90] and even voted by the National Assembly,[91] its definitive implementation remains questionable after the minister of the economy announced that the amendment would not go through after all.[92]

FIGURE 5

LEGISLATIVE STATUS OF TAXES ON EXCEPTIONAL REVENUES

Source: Tax Foundation, 2022



The rates and structures of these taxes vary from one country to the next, which has led to different calculation methods and initial revenues. The tax introduced in Italy has raised issues of constitutionality (on its field of application and the distinction between companies) and has only gathered two billion euros out of an expected eleven billion. In Poland, company associations have warned of a wave of bankruptcies – a concern that seems to also apply to other countries.[93,94] In Romania, the 98% tax on the net revenues of gas and electricity trading companies has worried retailers, with domestic companies preparing for bankruptcy and lawsuits as winter approaches.[95]

Bankruptcy among the smallest and alternative electricity companies marks another trend throughout the continent. In the United Kingdom, 31 energy companies have stopped their activity since early 2021, incapable of dealing with rocketing gas market prices. Many of them went on to be purchased by giants like British Gas, Scottish Power and even EDF.[96] In France, too, the crisis that started with electricity resellers continues, and the number of gas and electricity producers shrank from 39 in summer 2021 to 14 currently. Several sup-

c For more information on PPAs, see the Trend "With PPAs, businesses and cities are making the production and supply of low-carbon electricity safer", p. 24 in Observatory of Non-state Climate Action (2021). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

pliers have opted to make no new offers while retaining their existing clients; others, like Ohm, Mint, Mega and GreenYellow, have had to increase their prices significantly; several clients have been directed towards EDF.[97]

In Germany, municipal electricity companies have been hit by inflation, following on from the crisis that started in 2021 – with the bankruptcy of the midsize electricity company OTIMA and others that used a commercial model supplying energy at fixed tariffs based on "stable, predictable developments" on the market. These small municipal companies feel that they have been ignored, while bigger companies like Uniper and E.ON have been the focus of national attention.[98]

In fact, both Uniper and EDF are the object of nationalization plans by their governments. Along with a concentration of the sector between the hands of the biggest actors which have resisted the crisis better, the other trend is nationalization. In July, France announced its intention to nationalize EDF, with the objectives of more control over price stability and greater independence in the face of Russian gas. EDF currently supplies 70% of the electricity produced in the country, and the State already owned 84% of the company.[99] As for Uniper, the German State has announced its intention to acquire 99% of the shares in this struggling gas company – the biggest nationalization ever in the country.[100] Nationalization, although generally a "last resort", has emerged in the German energy sector with discussions on State participation in VNG, a subsidiary of Energie Baden-Wuerttemberg,[101] and the State purchase of three refineries previously owned by Rosneft.[102]

KEY TAKEAWAYS

Following an exceptional year in 2020, energy demand and electricity consumption picked up again in 2021, driven by the economic recovery. While renewable energy continued its galloping growth, it is fossil energy that has fed the appetite of demand, taking global energy-related emissions to higher levels than before the pandemic. Added to adverse weather conditions, these factors set the stage for a crisis that went on to be intensified by geopolitical tensions in 2022. Although the war in Ukraine has provided an additional motivation for the energy transition under a banner of energy independence, the current dependence on fossil fuels is a setback for greater ambitions.

The price of coal, oil and gas, all of which have risen since the second half of 2021, have had a number of consequences, in particular for Europe. Individual states have looked more closely at their energy mix, switching from gas imported by pipeline from Russia to LNG, while responding to concerns about superprofits and bankruptcies. On the private side, industry giants have benefitted from historically high prices, while small electricity companies have been forced into bankruptcy – leading to a concentration of the sector in the hands of the major players.

REFERENCES

RETURN TO PREVIOUS PAGE

1 Enerdata (2022). Global Energy and CO_2 data. *Enerdata*

2 BP (2022). Statistical Review of World Energy 2022. *BP*

3 IEA (25/01/2022). Oil. *International Energy Agency*

4 IEA (2022). Oil Market Report – August 2022. *International Energy Agency*

5 IEA (2022). Oil Market Report – September 2022. *International Energy Agency*

6 Gupte, E., et al. (09/08/2022). OPEC+ crude oil output makes biggest gain in five months, but gap with quotas grows: Platts survey. *S&P Global*

7 Fanzeres, J. (02/06/2022). Oil Rises as Stockpiles Fall, OPEC+ Supply Hike Disappoints. *Bloomberg*

8 Wilson, T. (12/07/2022). Opec forecasts booming oil demand will test its production capacity. *Financial Times*

9 Watkins, S. (04/07/2022). Is Saudi Arabia Exaggerating Its Oil Production Potential? *Oil Price*

10 IEA (2022). Global Energy Review: CO_2 Emissions in 2021. *International Energy Agency*

11 Enerdata *(2022) Global Energy and* CO_2 *emissions, op. cit.*

12 IEA *(2022). Global Energy Review:* CO_2 *Emissions in 2021, op. cit.*

13 Jones, D. et al. (2022). Global Electricity Review 2022. *Ember*

14 Chestney, N. (28/07/2022). Global coal demand to match record high this year, IEA says. *Reuters*

15 Eurostat (02/05/2022). Coal production and consumption see rebound in 2021. *Commission européenne*

16 FAZ (08/07/2022). Grünes Licht für Kohle als Gas-Ersatz. *Frankfurter Allgemeine Zeitung*

17 Romei, V. & Arnold, M. (07/09/2022). Germany turns to coal for a third of its electricity. *Financial Times*

18 Tayeb, Z. (11/09/2022). Coal is making a comeback in energy-hungry Europe, sending prices soaring. *Market Insider*

19 EIA (12/2021). Quarterly Coal Report, October – December 2021. *U.S. Energy Information Administration*

20 EIA (07/2022). Quarterly Coal Report: Highlights for the first quarter of 2022. *U.S. Energy Information Administration*

21 IEA (2022). Global Energy Review: CO_2 Emissions in 2021, *op. cit.*

22 Reuters (17/01/2022). China coal output hits record in Dec and in 2021 – Stats bureau. *Reuters*

23 Myllyvirta, L. (01/09/2022). Analysis: China's CO_2 emissions fall by record 8% in second quarter of 2022. *Carbon Brief*

24 Ministry of Coal (*s.d.*). Production and Supplies. *Government of India*

25 Jones, D. et al. (2022). Global Electricity Review 2022, *op. cit.*

26 IGU (2022). Global Gas Report 2022. *International Gas Union*

27 Savcenko, K. (27/05/2022). Russian gas phaseout and the future of Europe's power generation. *S&P Global*

28 IEA *(2022). Global Energy Review:* CO_2 *Emissions in 2021, op. cit.*

29 BP (2022). Statistical Review of World Energy 2022, *op. cit.*

30 IGU (2022). Global Gas Report 2022, *op. cit.*

31 Jones, D. et al. (2022). Global Electricity Review 2022, *op. cit.*

32 IRENA (2022). Renewable Energy Statistics 2022. *International Renewable Energy Agency*

33 IRENA (2022). Renewable Energy Statistics 2022, *op. cit.*

34 IEA (2022). World Energy Employment. *International Energy Agency*

35 Jones, D. et al. (2022). Global Electricity Review 2022, *op. cit.*

36 REN21 (2022). Renewables 2022 Global Status Report. *REN21.*

37 Kinch, D. (17/12/2021). Global coal demand to grow 6% in 2021, threatening net-zero goals: IEA. *S&PGlobal*

38 IEA (2021). Coal 2021: Analysis and Forecast upto 2024 *International Energy Agency.*

39 Russell, C. (24/01/2022). Indonesia's coal ban send prices soaring, other exporters fail to step up. *Reuters*

40 Varadhan, S. (28/01/2022). Global coal prices surge as Ukraine tensions worsen supply woes. *Reuters*

41 McCormick, M. (10/02/2022). Coal titan turns round as demand strengthens for dirtiest fossil fuel. *Financial Times*

42 National Bureau of Statistics of China (28/01/2022). The Profit of Industrial Enterprises above Designated Size in 2021. *National Bureau of Statistics of China*

43 China Electric Power News (28/06/2022). Morning Energy News Bulletion (28 June). *China Electric Power News*

44 Bloomberg News (13/08/2022). Coal giants are making mega profits as climate crisis grips the world. *Mining.com*

45 Nagle, P. & Temaj, K. (02/11/2022). Oil market developments – rising price amid broader surge in energy prices. *World Bank Blogs*

46 Wallace, J. (18/01/2022). Oil Prices Hit Seven-Year High on Rising Geopolitical Tensions. *The Wall Street Journal*

47 Reed, S. (14/01/2022). Oil Producers Aren't Keeping Up With Demand, Causing Prices to Stay High. *The New York Times*

48 Fulwood, M. (01/2022). Surging 2021 European Gas Prices – Why and How? *The Oxford Institute for Energy Studies*

49 Wilson, T., Hume, N., Pop, V. (21/12/2021). Ships carrying natural gas head for Europe as prices surge to new high. *Financial Times*

50 Commission européenne (20/04/2022). In focus: Reducing the EU's dependence on imported fossil fuels. *European Commission.*

51 Wilson, T. (10/06/2022). Oil and gas back in vogue for retail investors. *Financial Times*

52 Reuters (27/04/2022). Russia's Gazprom lands record high profit of $29 bln in 2021. *Reuters*

53 CAT, NewClimate Institute, Climate Analytics (2022). Global reaction to energy crisis risks zero carbon transition. *Climate Action Tracker, NewClimate Institute, Climate Analytics*

54 Rosen, J.W. (12/09/2022). Economic lifeline or climate peril? East African pipeline is a new flashpoint. *National Geographic*

55 *CAT, NewClimate Institute, Climate Analytics (2022). Global reaction to energy crisis..., op. cit.*

56 Hare, B., Ganti, G., Maxwell, V., et al. (2021). Why gas is the new coal. *Climate Analytics*

57 Global Energy Monitor (2022). Global Gas Plant Tracker. Consulté le 30/09/2022

58 IGU (07/2022). 2022 World LNG Report. *International Gas Union*

59 *Hare, B., Ganti, G., Maxwell, V., et al. (2021). Why gas is the new coal, op. cit.*

60 European Parliament (2022). Briefing: EU gas storage and LNG capacity as responses to the war in Ukraine. *European Parliament*

61 Tani, S. & Parkin, B. (23/09/2022). Europe's appetite for LNG leaves developing nations starved of gas. *Financial Times*

62 GIE. Aggregated Gas Storage Inventory, *consulté le 20/10/2022.*

63 Pécout, A. (18/06/2022). Guerre en Ukraine : la France ne reçoit plus de gaz russe. *Le Monde*

64 Jacobs, J. & White, S. (02/05/2022). French utility Engie buys US natural gas as Europe looks beyond Russia. *Financial Times.*

65 Vie publique (17/08/2022). Loi du 16 août 2022 portant mesures d'urgence pour la protection du pouvoir d'achat. *Vie publique*

66 Koc, C. & Shiryaevskaya, A. (08/09/2022). New Gas Terminals Arrive to Ease Putin's Grip on Europe. *Bloomberg*

67 Kurmayer, N. J. (06/05/2022). L'Allemagne acquiert quatre terminaux GNL flottants dans une course effrénée pour remplacer le gaz russe. *Euractiv*

68 Delfs, A. & Dezem, V. (05/05/2022). Germany Rents Floating LNG Hubs to Cut Reliance on Russian Gas. *Bloomberg*

69 *Koc, C. & Shiryaevskaya, A. (08/09/2022). New Gas Terminals Arrive..., op. cit.*

70 Observatoire mondial de l'action climat non-étatique (2021). Espagne• Après des années de vents contraires, les renouvelables se font une place au soleil. *Climate Chance*

71 Reuters (21/07/2022). L'Espagne s'oppose à une réduction de la consommation de gaz. *Reuters*

72 Keane, K. (26/07/2022). Greenpeace lodges legal bid to halt Jackdaw gas field in North Sea. *BBC News*

73 BBC (08/09/2022). Fracking ban in England lifted in bid to boost UK gas supply. *BBC News*

74 BBC (24/09/2022). What is fracking and why is it controversial? *BBC News*

75 *Tani, S. & Parkin, B. (23/09/2022). Europe's appetite for LNG..., op. cit.*

76 IRENA (2021). Renewable Power Generation Costs in 2020. *International Renewable Energy Agency*

77 Gray, M. (10/05/2022). Fuel Switching 2.0: Carbon Price Index for Coal-to-Clean Electricity. *TransitionZero*

78 BloombergNEF (30/06/2022). Cost of New Renewables Temporarily Rises as Inflation Starts to Bite. *BloombergNEF*

79 Jaeger, J. et al. (24/01/2022). Renewable Energy Shouldn't Be Blamed for Spiking Energy Prices – It's the Solution. *World Resources Institute*

80 UCL News (06/09/2022). Electricity prices dictates by gas producers who provide less than half of UK electricity. *University College of London*

81 *Ibid.*

82 Le Monde, AFP (26/08/2022). Le prix de gros de l'électricité en France dépasse 1000 euros le mégawattheure, contre 85 euros il y a un an. *Le Monde.*

83 Hancock, A., Fleming, S. & Wilson, T. (01/09/2022). What are the EU's plans to curb electricity prices? *Financial Times.*

84 Carbonaro, G. & Huet, N. (21/09/2022). Energy bills are soaring in Europe. This is what countries are doing to help you pay them. *Euronews.*

85 Pexapark (2022). Pexa Euro Composite. Consulté le 07/09/2022

86 Sanchez Molina, P. (29/06/2022). Ukraine war halting PPAs, driving up prices across Europe. *PV Magazine*

87 Aubert,R. & Deroeux, I. (01/09/2022). D'où vient la notion de « superprofit » et que signifie-t-elle vraiment ? *Le Monde*

88 Enache, C. (04/10/2022). What European Countries Are Doing about Windfall Profit Taxes. *Tax Foundation*

89 *Ibid.*

90 Golla, M. (11/10/2022). Taxer les superprofits : le gouvernement fait volte-face. *Novethic*

91 Boiteau, V. (13/10/2022). Une nuit au Bourbon : A l'Assemblée, le gouvernement débordé par sa majorité sur une taxation des « superdividendes ». *Libération*

92 Farge, B. (17/10/2022). Taxe sur les super-dividendes : Bruno Le Maire annonce que cet ammendement ne sera pas retenu. *BFM TV*

93 *Enache, C. (2022). What European Countries....., op. cit.*

94 Fonte, G. (02/08/2022). Italy faces shortfall of over $9 billion on energy windfall tax – document. *Euronews*

95 Sabadus, A. (02/09/2022). Romania's hefty energy tax to put security of supply at risk – traders. *Independent Commodity Intelligence Services*

96 Cyrus, C. (18/02/2022). Failed UK Energy Suppliers Update. *Forbes*

97 Cessac, M. (28/09/2022). Débâcle chez les fournisseurs d'électricité alternatifs. *Le Monde*

98 Kurmayer, N. J. (06/09/2022). Energy crisis looms large over Germany's local utilities. *Euractiv*

99 Winters, J. (08/07/2022). France will nationalize its biggest energy company. *Grist*

100 Kurmayer, N. J. (21/09/2022). Uniper : l'Allemagne va nationaliser le géant gazier en difficulté. *Euractiv*

101 Geinitz, C. (15/09/2022). Verstaatlichung als letzter Ausweg in der Energiewirtschaft. *Frankfurter Allgemeine Zeitung*

102 Chazan, G. (16/09/2022). Germany seizes control of Rosneft oil refineries. *Financial Times*

TRENDS
RENEWABLES

Africa pursues the development of renewable energy, despite certain obstacles

MÉLAINE ASSÈ-WASSA SAMA • Project Officer, Africa Climate Action Observatory, Climate Chance

Access to energy is one of the great challenges of the African continent, which has one of the lowest electricity access rates in the world. With global warming calling for an energy transition, the continent has chosen to integrate the development of renewables into its energy policy in order to catch up and to reduce its dependence on fossil fuels. While recent reports show an increase in installed renewable energy capacity thanks to identified funding mechanisms, they also reveal the urgent need for investment in order to reach the objectives set.

DATA OVERVIEW

Renewable generation capacities on the rise on the African continent

According to the International Energy Agency (IEA), more than 600 million people lack access to electricity in Africa, and without additional measures, 565 million people will still lack access to electricity in 2030.[1] The West African population is the most affected, with only 8% of the rural population having access to electricity. Electricity demand across Africa is predicted to increase by 75% by 2030 due to population growth and economic development.[2] Africa has 40% of the world's potential for renewable energy production, estimated at 2,431,765 terawatt-hours/year (TWh/year).[3] The continent has 60% of the world's solar energy resources with a solar irradiance varying between 5 and 7 kilowatt-hours/square metre (KWh/m^2) over the course of a year. Yet only 1.3% of the world's photovoltaic generation infrastructure is located on the continent. This industry remains largely untapped but trends show that it is growing, with an increase in infrastructures on the African continent. 22 African countries[4] already use renewable energy as their main source of electricity and eight[a] of them generate more than 90% of their electricity from renewable energy. According to IRENA projections, by 2030 renewable energies could account for about 65% of electricity generation in sub-Saharan Africa.[5]

For solar energy, for example, thirteen countries in sub-Saharan Africa (excluding South Africa) now have more than 50 megawatts (MW) of installed capacity.[6] According to the IEA, solar and wind energy could account for about 27% of electricity generation in 2030.[7] But while solar photovoltaic installations experienced spectacular growth in Africa in 2019, they fell sharply in 2020 before rising again in 2021.[b] While the addition of new renewable capacity continued its global growth in 2020, the health crisis significantly slowed the launch of several large projects in Africa due to increased financial risks.

The continent's wind generation potential is estimated at 978,066 TWh/year.[8] However, according to the Mo Ibrahim Foundation report, wind power is still largely untapped in Africa (at 0.01% of its potential).[9] The regions that are most suited to large-scale wind energy are North Africa, the Sahel, the Horn of Africa and Southwestern Africa. In terms of installed capacity, South Africa has the largest wind energy market in sub-Saharan Africa. In 2021, this capacity was estimated at 2,956 MW,[10] compared to 2,094 MW in 2019, a jump of 29% in two years. South Africa alone accounts for 40% of installed wind power capacity on the African continent.[11]

Behind South Africa is Egypt, whose installed wind energy capacity amounts to 1,640 MW (22% of the continent's total).[12] The country plans to reach a 42% share of renewable energies within the total energy mix by 2035, 14% coming from wind energy. Morocco takes the bronze, with 1,435 MW of installed

a Central African Republic (96.3%), DR Congo (98.9%), Eswatini (99.8%), Ethiopia (100.0%), Lesotho (99.9%), Mozambique (95.4 %), Namibia (91.0%), Uganda (97.7%).

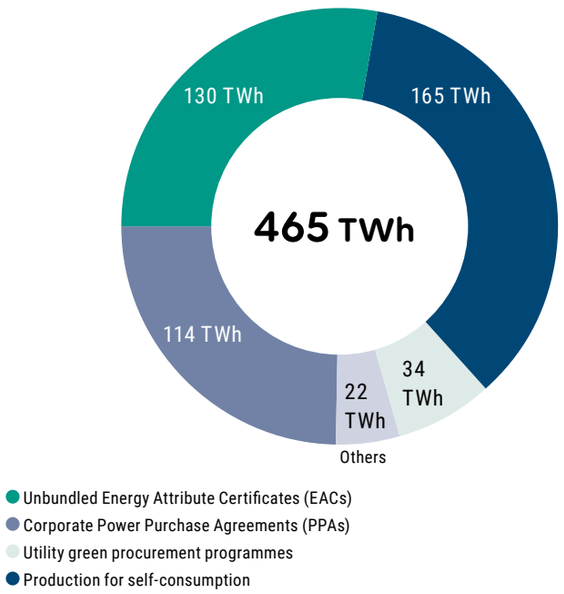
b Worldwide, newly installed photovoltaic capacity has continued to grow, rising from 118 GW in 2019 to 144 GW in 2020 and to 183 GW in 2021. See figures from Bloomberg New Energy Finance (BNEF)

capacity of onshore wind energy in 2021, i.e., nearly 20% of the continent's total. In its voluntary commitments for 2030, Morocco plans to reach 52% installed renewable electricity capacity by 2030, with 20% coming from wind energy.[13] In West Africa, deployment of wind energy capacity is slowly moving ahead and is concentrated in the Niger and especially in Senegal,[14] which currently has the largest wind farm in the sub-region (158 MW).[15] The country has set itself the objective of reaching 350 MW of wind power. In East Africa, Kenya is positioned as the leader in wind energy. With an increase of 102 MW in 2021, its installed capacity is estimated at 440 MW.[16] In the Sahel, optimal exploitation of wind potential would increase the power generation capacity of countries such as Chad, Mauritania, Niger, and Mali by up to 30 times.[17]

FIGURE 1

GLOBAL CORPORATE SOURCING OF RENEWABLE ELECTRICITY BY SOURCING MODEL

Source: IRENA, 2018



Given the prospects it represents for electricity production from renewable sources, Africa is becoming increasingly interested in the production of green hydrogen. In May 2022, six African countries – Egypt, Kenya, Mauritania, Morocco, Namibia, and South Africa – launched the African Green Hydrogen Alliance[18] with the objective of making the continent a key player in the production of green hydrogen. Namibia aims to produce 300,000 tonnes of green hydrogen per year by 2026, while Egypt is planning three green hydrogen production projects with a combined capacity of 300 MW.[19] South Africa is also positioning itself as a future leader of the green hydrogen market with a production target of 500,000 tonnes of green hydrogen per year by 2030. The country could then produce green hydrogen for $1.60/kg, i.e., one of the lowest rates in the world.[20] The South African government is working with the Platinum and ENGIE groups to develop the "Hydrogen Valley" programme[21] with the aim of forming an integrated industrial ecosystem for green hydrogen. According to the IEA, Africa could produce 5,000 Mt of hydrogen at less than $2/ kg, "*equivalent to current global primary energy demand*".[22]

The overall renewable energy landscape in Africa suggests a rather positive trend. This is in part supported by public investments, which are very costly for African countries. Between 2010 and 2019, African governments tripled public investment in renewable energy, up to 47 billion dollars, from 13.4 billion dollars in the preceding decade.[23] Still, these remain largely insufficient to meet the national production targets that have been set. This situation was aggravated by the pandemic, which slowed the launch of projects due to increased financial risks for countries and the private sector. Several tools are already being used to effectively and adequately direct financial mechanisms and flows into Africa.[24] Power Purchase Agreements (PPAs) in particular are attracting much interest in global renewable energy markets (**FIG. 1**), especially to secure the supply of renewable energy or electricity (Green PPAs). In Africa, the use of Green PPAs is boosting the development of new renewable energy capacities, particularly solar and wind.

THE OBSERVATORY'S LENS

Africa structures its renewable energy market thanks to renewable power purchase agreements

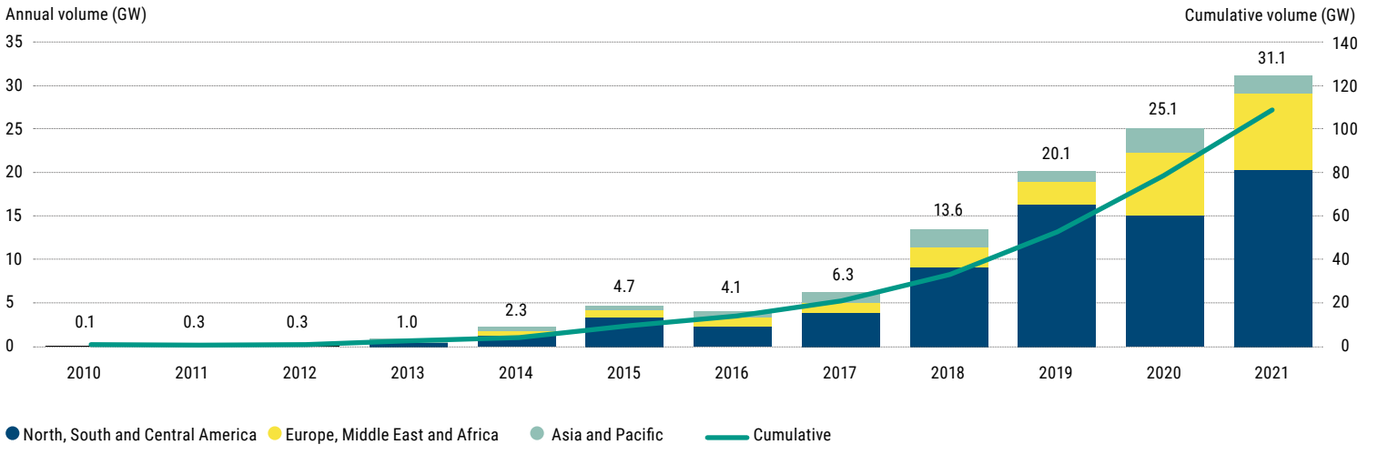
PPAs facilitate the establishment of independent power producers in Africa and the increase in renewable generation

The energy generation sector is the main source of GHG emissions in Africa due to the massive use of fossil fuels. To remedy this, African countries are turning to renewable energies. In most of the NDCs (Nationally Determined Contributions) submitted by African countries within the framework of the Paris Agreement, there are promises of an energy transition that make it possible to achieve both the objectives of reducing emissions and the objectives of universal access to electricity. To achieve this, an increasing number of tools are being developed in Africa that effectively contribute to the achievement of these objectives. This is the case for Green Power Purchase Agreements, electricity purchase contracts binding a producer to a consumer,[25] which are being increasingly used in Africa **(SEE BOX 1)**. According to IRENA, these contracts "*have proven their ability to support the energy transition*"[26] on the continent.

FIGURE 2

GLOBAL CORPORATE PPA VOLUMES, 2010-2021

Source: BloombergNEF, 2022



Onsite PPAs excluded. APAC volume is an estimate. Pre-form PPAs in Mexico and sleeved PPAs in Australia are excluded. Capacity is in MW DC.

BOX 1 • **KEYS TO UNDERSTANDING**

THE DIFFERENT TYPES OF PPAs

The term PPA indicates an electricity purchasing mode which, in reality, covers several types of different contracts, depending on local legislative contexts and the organisation of different electricity markets.

Most PPAs concern off-site installations which are geographically disconnected from the buyer, contrary to on-site installations which can be the subject of PPAs, but are also sometimes quite simply the property of the business or the municipality, and thus count as self-consumption. PPAs can also be cross-border, involving actors that do not operate on the same electricity markets. In that case, an agreement may be reached with the grid operator for the transmission of electricity, but most of the time, cross-border PPAs are "virtual". The producer sells electricity on their domestic market, the consumer continues to buy its electricity from the supplier in its own market, and it compensates for any potential fluctuations in prices on the producer's market via the PPA. In this case, the two markets are not necessarily physically linked.

PPAs can also be drawn up via an intermediary, often the energy service provider who is in charge of bringing together different producers to form an installations portfolio, supplying them with any potential electricity that is lacking, selling surplus electricity or even insuring different risks concerning producers or consumers. This constitutes a sleeved PPA.

Whatever the type of PPA, if it concerns renewable energies (which is more often than not the case these days), the buyer almost systematically couples their contract with the purchase of any corresponding renewable energy certificates. These are either those owned by the PPA production site, or those found elsewhere on the certificate market which are equal to the volume of electricity purchased (fig.2).

Basically, these contracts are nothing new as they have been used for conventional power generation for a long time. However, after the emergence of energy production from renewable energy sources and the increase in their attractiveness, PPAs have experienced renewed interest. Green PPAs denote "*a contract between a commercial or industrial supplier or customer and a green energy producer for the purchase of energy generated by renewable energy assets*".[27] It is usually a contract for a period of five to twenty years. Depending on the renewable energy source used, they are referred to as solar PPAs, wind PPAs, etc. In Africa, solar and wind PPAs are the most common.

Thanks to the new Green PPAs that have been concluded, the number of independent power producers on the continent is increasing.[28] Independent power producers (IPPs) are private entities that own, develop, and operate energy production infrastructures based on long-term PPA contracts concluded with power companies or other buyers. IPPs can be local or foreign producers. With the ever-increasing energy demand in Africa, new IPPs are setting up on the continent through Green PPAs in order to meet the demand. In 2016, IPPs were already operating in 18 African countries "*accounting for 13% of total regional generation capacity*".[29]

South Africa remains the largest market for independent renewable power producers. This success is explained by its regulatory framework (in the energy sector) which is favourable to private investors as well as to the development of Green PPAs. South Africa has therefore developed a significant amount of installed energy capacity thanks to IPPs. For example, since 2011, more than 112 projects led by IPPs were registered in the country.[30] Egypt is developing a wind power market that is very favourable to the private sector, particularly IPPs. In 2019, an international consortium made up of the French ENGIE group, the Japanese Toyota Tsusho Corporation and Orascom Construction in Egypt, was set up to build Africa's largest private wind farm, boasting a capacity of 262.5 MW.[31] In 2021, British renewable energy company Lekela Power, which is behind the 250 MW West Bakr Wind

Farm project, signed a 20-year power purchase agreement with the Egyptian Electricity Transmission Company (EETC), a public operator that supplies electricity to the national grid.

In West Africa, efforts to develop the energy sector require significant investments that the countries cannot afford on their own. Using Green PPAs has become essential for attracting IPPs. Senegal and Nigeria stand out as potential "hubs" in the sub-region. As early as 2016, Nigeria had concluded a solar PPA with a rate considered to be the lowest in West Africa (7.5 ¢/kWh). Both countries have the lowest PPA rates in the sub-region. In 2018, through the World Bank's Scaling Solar programme, which facilitates the development of large-scale solar projects in developing countries, a new benchmark price for electricity generation in Senegal was established. This price was around 5 ¢/kWh. Thanks to PPAs, Senegal developed 100 MW of solar power plants as well as the largest wind farm in West Africa (158 MW), which is run by IPPs.[32]

Legislation on the continent is evolving to facilitate use of Green PPAs and attract private investment

The energy market is still dominated by state enterprises. However, according to some studies, where private sector participation is allowed, private operators outperform public companies in the development of renewables and energy access.[33] Therefore, in order to create a favourable environment for private investors and for the proliferation of Green PPAs, several countries around the world have implemented reforms with positive results. Vietnam, for example, has developed several policies to support the onshore wind sector in recent years. The most emblematic among these is the 39/2018/QD-TTg[c] decision which gave new impetus to the wind energy market. In the wake of this reform, more than 140 wind energy projects have seen the light of day through PPAs concluded with the public EVNP company. Thanks to these reforms, the country now ranks among the leaders of the energy transition in Southeast Asia.[34]

In Africa, countries are gradually moving in this direction. Reforms undertaken by some African governments to establish a legal framework that is suitable and encouraging for the production of renewable energies, are based on a policy framework that stimulates the emergence of the independent energy production sector. Emphasis is particularly placed on attracting IPPs by providing support through specialised structures, tax incentives, and exceptions to the existing regulatory framework. These changes have several primary objectives, such as establishing a legal framework for the development of renewable energies and the diversification of the electricity production mix. They then facilitate the establishment of an incentive framework favourable to the purchase and sale of electricity from renewable energy sources. They also allow the establishment of a remuneration framework for producers of electricity from renewable energy sources.

South Africa was an early adopter of energy sector reforms through the Renewable Energy Independent Power Producer Programme (REIPPP), earning it pioneer status in policy and regulatory reforms for energy efficiency and renewable energy.[35] Thanks to this, it obtained a RISE[d] (Regulatory Indicators for Sustainable Energy) score[36] of 82 in renewable energy,[37] one of the highest scores on the continent.[e] RISE scores place Tunisia as Africa's leading country in terms of policies and regulations for energy access, energy efficiency and renewable energy deployment, indicating an environment that is generally favourable to renewable energy and private investments.[38] It obtained a RISE score of 84 in 2019, higher than that of other developed countries.

Currently, stimulating competition in electricity supply and attracting private investment have been prioritised in several African countries. Some utility companies are being called upon to build new plants through untendered proposals and single-source power purchase agreements, which has sometimes led to excessive purchases and pricing, resulting in suspicions of corruption, as in the case of Ghana.[39] Some governments have thus been compelled to intervene in order to renegotiate certain contracts. Although private participation in production has gradually increased in Africa, Zambia is still the only country where private sector operators are represented in the entire supply chain, from production to transport and distribution. Although the benefits of private sector participation are obvious, public financing, development finance institutions and development banks will be needed to mitigate project risks, especially in their early stages.[40]

Furthermore, auction systems for the distribution of new capacity have proven to be effective in reducing supply costs, especially for large-scale renewable energy projects such as those in Ghana. Other models aimed at introducing competition and private sector participation depend on concessions and the creation of regulatory exceptions that would allow grid or mini-grid operators to build or even operate facilities set up by utility companies, subject to conditions. This model and others have also been studied in Nigeria. Private companies operating grids under concession have already proven successful in Uganda, where Umeme, a private company, concluded an agreement with utility company UEDCL to operate almost the entire grid in the country.[41]

The adoption of PPAs by heavy users, like the mining industry, is nascent in Africa

Green Corporate PPAs make it possible for companies, regardless of their sector of activity, to decarbonise their energy consumption while stabilising their long-term supply costs. There are two types of green energy supply contracts: offsite and onsite **(SEE BOX 1)**. "Offsite" contracts are when energy generation equipment is not installed at the energy consumer's location, in contrast to "onsite" PPAs where the renewable energy production facilities are installed at the

c Decision available online

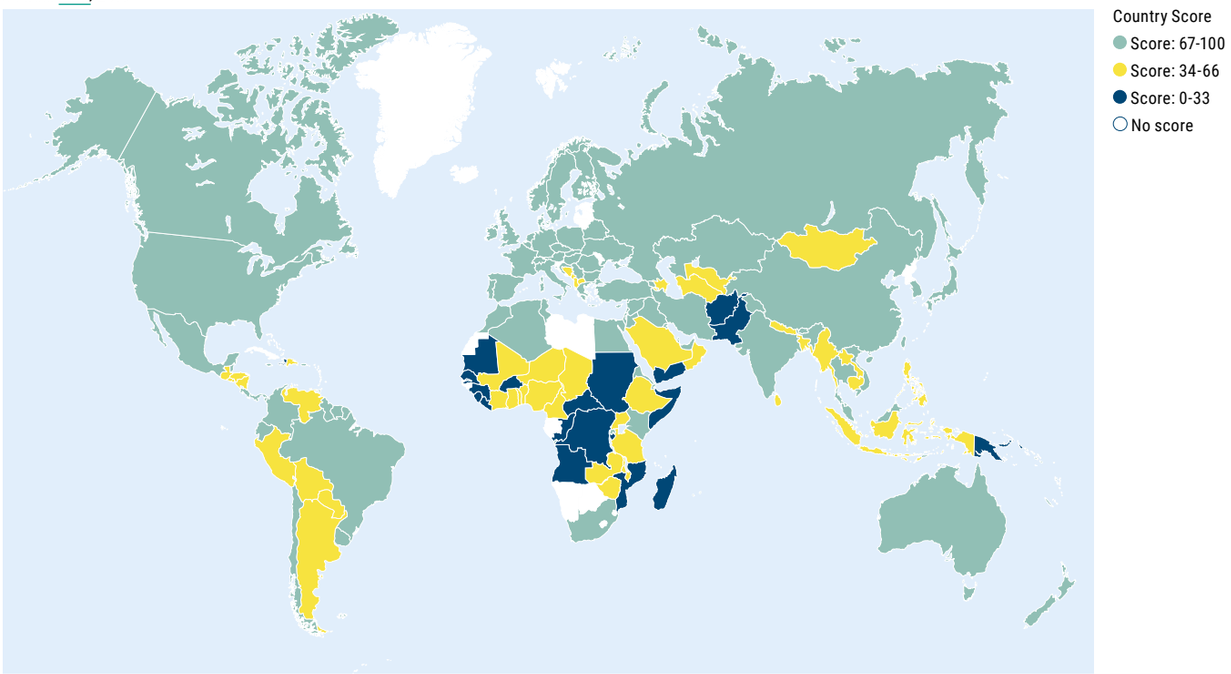
d This is a set of indicators for comparing national sustainable energy policy and regulatory frameworks.

e South Africa's overall score is 71.

FIGURE 3

REGULATORY INDICATORS FOR SUSTAINABLE ENERGY

Source: RISE, 2019



user's location. The advantage of offsite contracts is that they make the development of high capacity wind or solar farms possible, and they benefit from the best locations for the most cost-effective electricity generation.

The PPA market is primarily dominated by large companies, especially those in the digital sector. In 2020 Amazon was identified as the leader in this market **(FIG. 4)**, with 35 declared PPAs amounting to 5.1 GW, bringing the total contracted by the company to 7.5 GW.[f] In 2021, Amazon continued this trend with 44 offsite PPAs announced in nine countries, amounting to 6.2 GW. This brings its total renewable energy PPA capacity to 13.9 GW. Microsoft and Meta complete the list of market-leading companies with 8.9 GW and 8 GW[42] respectively.

In 2021, thanks to Green Corporate PPAs, companies bought 31.1 GW of renewable energy worldwide, an increase of almost 24% compared to the previous year.[43] Supply to businesses in Europe, the Middle East, and Africa have increased by 19% to 8.7 GW.[44] While already common in North America, the Nordic countries and Europe,[45] Green Corporate PPAs are becoming increasingly popular in Africa, mainly due to the fall in the production costs of green energy.[46] In Africa, PPAs are increasingly used by companies to boost their production of renewable energy. This is especially the case for the mining sector in South Africa, where the Richard Bay Minerals (RBM) mining company signed a 20-year solar PPA contract with the Voltalia renewable energy company.[47] The company will supply up to 300 GWh of annual solar PV generation capacity to the RBM smelting and processing facilities in KwaZulu-Natal.

In sub-Saharan Africa where electrical transport and distribution networks are limited, heavy users such as the mining industries habitually generate their own electricity or obtain electricity produced from diesel or heavy fuel oil (HFO), under various forms of corporate PPAs from specialised suppliers. Recently, projects have been developed to replace off-grid production using diesel and HFO with renewable energy or using hybrid solutions combining diesel or gas with renewable energy and battery storage. These solutions reduce fuel and logistics costs as well as carbon emissions from operations.

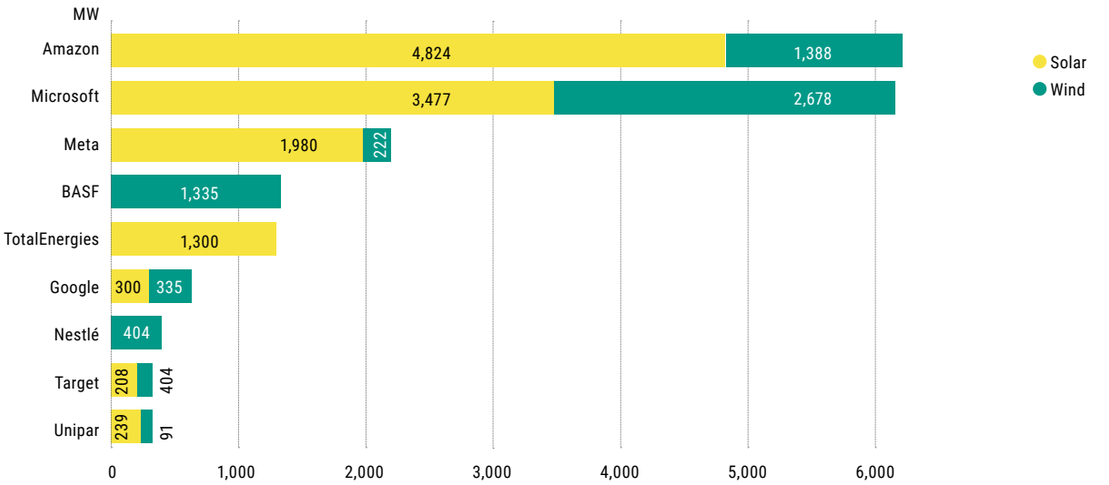
An example of this paradigm shift is the 15 MWp EREN Renewable Energy and African Energy Management Platform solar farm at Burkina Faso, which was commissioned in March 2018[48]. Production from this project will be sold to the IAMGOLD Essakane SA gold mine as part of a fifteen-year PPA. It will complement the mine's already existing heavy fuel power plant. This Green Corporate PPA will enable a reduction in CO_2 emissions of approximately 18,500 tonnes and savings of around six million litres of fuel per year.[49]

f To find out more, see Observatory of Non-State Climate Action (2021). Global report on climate action by sector. *Climate Chance* p. 26

FIGURE 4

TOP CORPORATES BUYER OF CLEAN ENERGY IN 2021

Source: BloombergNEF, 2022



KEY TAKEAWAYS

Installed capacity of renewable electricity production is increasing on the African continent, as it is elsewhere in the world, particularly in the solar and wind energy sectors. These production capacities are nevertheless concentrated in a handful of countries. South Africa, Kenya, Tunisia, Morocco, Senegal and Nigeria stand out as being more open to investment from independent power producers. The increase of renewable energy purchase contracts, made possible by a spate of reforms underway in some African countries, promotes the investment and the establishment of these independent producers on the continent. That being said, the overall rate of investment remains insufficient to meet the energy transition objectives that the continent has set for itself. While reforms have already been initiated by some States to attract investment, these must spread to the entire continent, particularly to West Africa, to create an environment conducive to the accelerated development of installed renewable capacities.

REFERENCES

RETURN TO PREVIOUS PAGE

1 IEA (2022). Africa Energy Outlook 2022. *International Energy Agency*, p. 106.

2 *Ibid.*, p. 75

3 IRENA (2021). La transition vers les énergies renouvelables en Afrique Renforcer l'accès, la résilience et la prospérité. p.38.

4 Mo Ibrahim Foundation (2022). Forum report: Making Africa's Case in the Global Climate Debate. p. 45.

5 IRENA (2018). Planification et perspectives pour les énergies renouvelables : Afrique de l'Ouest. p. 11.

6 IEA (2022). *Op. Cit.*, p.43

7 IEA (2022). *Op. Cit.*, p. 75

8 IRENA (2021). *Op. Cit.*, p.38.

9 Mo Ibrahim Foundation. (2022). *Op. Cit.*, p. 47.

10 GWEC (2022). Global Wind Report 2022, p.131.

11 IRENA (2022). Renewable capacity statistics 2022, p. 13.

12 *Ibid.*

13 *Ibid.*

14 IRENA (2018). *Op. Cit.*, p. 60.

15 IRENA (2021). *Op. Cit.*, p. 98.

16 GWEC (2022). *Op. Cit.*, 114.

17 Mo Ibrahim Foundation. (2022). *Op. Cit.*, p. 47.

18 UNFCCC (n.d.). African Green Hydrogen Alliance. *Climatechampions.unfccc.int*

19 Mo Ibrahim Foundation (2022). *Op. Cit.*, p. 45.

20 See https://gh2.org/countries/south-africa

21 *Ibid.*

22 IEA (2022). Africa Energy Outlook 2022, *Op. Cit.* p. 8.

23 Mo Ibrahim Foundation (2022). *Op. Cit.*, p. 45.

24 IEA (2022). Africa Energy Outlook 2022, *Op. Cit.*

25 Observatoire de l'Industrie Électrique (2019). « Corporate PPA » : fonctionnement et modalités contractuelles. *observatoire-electricite.fr*

26 IRENA, AfDB (2022). Renewable energy market analysis: Africa and its regions. p.162.

27 https://greensolver.net/fr/quest-ce-quun-ppa/

28 IRENA (2021). *Op. Cit.*, p. 28.

29 Blimpo, M. P., Cosgrove-Davies, M. (2020). Accès à l'électricité en Afrique subsaharienne : Adoption, fiabilité et facteurs complémentaires d'impact économique. p.23.

30 Deloitte (2019). Renewable energy in South Africa Valuation insights. p. 5.

31 *Ibid.*

32 IRENA (2021). *Op. Cit.*, 98.

33 Grids4Africa (2021). Private Sector Participation in African Grid Development. *RES4Africa*

34 GWEC (2022).*Op. Cit.*, p. 114.

35 IRENA (2021)., *Op. Cit.*, p.99.

36 https://rise.esmap.org/

37 https://rise.esmap.org/country/south-africa

38 https://rise.esmap.org/country/tunisia.

39 Ackah I., Auth K., Moss T., Kwakye J. (2021). A Case Study of Ghana's Power Purchase Agreements. p. 5.

40 IEA (2022). *Op. Cit.*, p.135.

41 *Ibid.*

42 BloombergNEF (31/01/2022). Corporate Clean Energy Buying Tops 30GW Mark in Record Year.

43 REN21 (2022). Renewables 2022 Global Status Report. p.48.

44 *Idem.*

45 IRENA (2018), Corporate Sourcing of Renewables: Market and Industry Trends – REmade Index 2018. p.46.

46 Baker McKenzie (2015). The rise of corporate PPAs A new driver for renewables. p. 2.

47 Jacobo, J. T. (06/10/2022). Voltalia inks 148MW solar PPA with Rio Tinto in South Africa. *PV-Tech*

48 https://www.total-eren.com/realisation-eren/essakane/.

49 Baker McKenzie (2018). The Rise of Corporate PPAs 2.0 an Update. p. 7.

TRENDS
ADAPTATION

Between the revival of fossil fuels and emergency sufficiency, the difficult process of adapting electricity grids

VIRGINIE HUGUES • Climate Change Adaptation Consultant

The challenges of a changing climate are considerable for energy grids and infrastructure, which encounter difficulties in ensuring enough supply to meet demand during consumption peaks and times of reduced production capacities. In the United States, Europe, India, China and Brazil, the extreme weather events over the last year have highlighted the vulnerability of electricity grids. While gas, oil and coal offer a carbon-intense emergency solution to deal with shortfalls on the grid, the war in Ukraine has illustrated the cost of this dependence on fossil fuels in terms of strategic autonomy. Coupled with mitigation strategies, integrating adaption into transition scenarios and polices is now therefore more vital than ever.

DATA OVERVIEW

From summer 2021 to summer 2022: exceptional meteorological conditions that could become the norm

The 2021 report on the state of the global climate published by the World Meteorological Organization (WMO) shows an intensification of extreme events related to climate change. The average global temperature is 1.11 °C higher that during the pre-industrial era. Record temperatures were reached (54.5 °C in Death Valley, California, USA; 48.8 °C in Syracuse, Italy). In mid-August, Greenland was subject to exceptional glacier melting and, for the first time, rainfall was recorded at its highest point (3,216 m altitude) following several hours of temperatures above zero. Elsewhere in the world, flooding incurred colossal human and economic costs: 17.7 billion dollars for Henan Province in China, 20 billion dollars for Germany; due to drought, wheat and rapeseed production in Canada was 35% to 40% lower than in 2020. The year of 2021 also saw numerous population movements (internal migrations): over 1.5 million people displaced in China, more than 664,000 in Vietnam, and over 600,000 in the Philippines.[1] In Europe, the Copernicus program points out that during the three months of the summer of 2022, "*The average temperature for Europe from June to August 2022 was about 1.34 °C above the 1991-2020 average for the season. This is almost 0.4 °C higher than that recorded for the previous warmest European summer, which occurred just one year earlier, in 2021*". During August in particular, summer temperatures were up to "*1.72 °C higher than the 1991-2020 average*".[2] In France, the summer of 2022 was the second hottest recorded since 1900, with a difference of +2.3 °C compared to 1991-2020 averages. Three successive heatwaves in June, July and August totalled 33 extremely hot days (compared to 22 in 2003).[3] Official figures are not yet available from Santé Publique France on the number of deaths attributed to the heatwave, but the national statistics body INSEE nevertheless identifies an increased number of fatalities during that summer.

Extreme events like forest fires are increasingly frequent. Resulting from a combination of factors (mainly dry vegetation and soil, and higher temperatures), forest fires burn "*nearly twice as much tree cover today than they did 20 years ago*".[4] While the whole of the south of France was affected by numerous wildfires (61,921 hectares in 2022 against an average 9,117 from 2006-2021), the area of Gironde was hit hardest (over 26,000 ha burned). According to the European Forest Fire Information System (EFFIS), "*at least 901,094 hectares have burned in Europe, 750,000 of them in the EU*", with particularly high records exceeding all previous years: 293,155 ha in Spain, 149,278 in Romania, 103,382 in Portugal, etc.[5]

Climate change is destabilizing the natural balances maintained by a particular temperature or rainfall level. These modifications lead to extreme events and latent perturbations, with consequences for natural ecosystems as well as for the socio-economic activities and industries that they support. The energy sector is one of these, and is having to deal with more frequent, extreme, and intense climate events, coupled with energy demand that varies depending on the season and changes in the climate.

TABLE 1

SENSITIVITY OF THE MAIN ELEMENTS OF ELECTRICAL GRIDS TO CLIMATE HAZARDS

Source: Carbone 4, 2021

	Extreme heat Extreme cold Temperature fluctuations	Snow fall, floods	Violent winds/ storms	Forest fires
Power lines	Overheating or contraction (frost) of cables	Damage to pylons and cables	Damages to pylons and cables	Heat, smoke and ashes can cut transmission lines
Transformers	Diminishing capacity, accelerated ageing and rupture	Short circuit (water infiltration) and explosion	Short circuit (fall of objects) and explosion	Destruction (equipment usually scarcely exposed)
Electrical substation (Circuit breakers…)	Rupture, accelerated ageing	Breakdown, weakening and rigidification of insulations	Short circuit (fall of objects)	Destruction (equipment usually scarcely exposed)
Electronic equipment and telecomms	Overheating or frost	Damage linked to humidity or water infiltration	Damage (fall of objects)	Destruction (equipment usually scarcely exposed)

Weak sensitivity · Average sensitivity · Strong sensitivity

THE OBSERVATORY'S LENS

Adapting energy grids is a multiple-choice question

The pressure of climate change on energy infrastructure and grids

The impacts of climate change, which include increasing temperatures, higher sea levels, greater frequency and intensity of precipitation, and extreme events, affect infrastructure and can destabilize all or part of the grid (**TAB. 1**), with a domino effect on: 1) other infrastructure in the energy grid,[a] and 2) other networks, such as transport (**FIG. 1**). These impacts affect production and operating capacities, the integrity and lifespan of infrastructure, and the stability of energy production and supply.

With the aim of improving resilience and adaptation of infrastructures to climate change while taking into account a key point that is rarely considered, i.e., the numerous interdependencies between the different networks (electricity, road and rail transport, and telecommunications, **FIG. 1**), France Stratégie recently suggested working on three focus areas.[6]

Provide shared references
- Make it easier for all actors to use the same set of climate forecasts
- Improve knowledge of the current state of grid infrastructure and their interdependencies

Establish national governance
- Create a working body gathering at least network operators and the State
- Establish in the law the production of a joint roadmap for adapting networks to climate change

Base the national vision on a local approach
- Suggest that local governments experiment with a system to establish a diagnosis and an action plan shared at local level
- Test out a system to bring feedback and capitalize on information within a national decision-making body

Therefore, increasing the resilience of energy infrastructure also involves different levers, as identified by Ouranos[b] in a report: better observe, forecast, and anticipate the impacts of climate change; modify climate norms; review the capacities and characteristics of physical installations; build climate resilience with inhabitants, etc.[7]

a Energy infrastructure concerns all of the physical installations that make up the energy grid. They play several roles: production, transport, supply and storage of energy. The grid thus form a network of more or less interconnected infrastructure.

b Ouranos is a Quebecois consortium on regional climatology and adaption to climate change.

TABLE 2

NON-EXHAUSTIVE TABLE OF CLIMATE CHANGE HAZARDS, POTENTIAL IMPACTS, AND RESILIENCE OPTIONS IN ENERGY SECTOR

Source: IISD, 2021

CLIMATE HAZARDS	EXAMPLES OF POTENTIAL IMPACTS (NON-EXHAUSTIVE)	EXAMPLES OF RESILIENCE OPTIONS (NON-EXHAUSTIVE)
TEMPERATURE INCREASE AND HEATWAVES	• Risk of failure of hydroelectric dams • Decreased efficiency of solar panels, thermal plants • Increased stress on the distribution system infrastructure	• Planning: Incorporate climate scenarios into load forecasts for future demand • Structure: Increase cooling system capacity • Monitoring and maintenance: More frequent maintenance and component replacement to reduce stress on the distribution system Enhanced dam safety monitoring management
CHANGES IN PRECIPITATION PATTERNS	• Water level fluctuations and drier soils can increase internal erosion of embankment dams • Inundation of coastal energy generation plants, substations	• Planning: Use up-to-date flood plain maps to locate new facilities outside high-risk flood zones • Structure: Reinforcing coastal infrastructures, adjust design criteria for transmission lines (height, materials…) • Monitoring and maintenance: Revise asset maintenance and replacement schedules
WINTER STORMS/ ICE STORMS AND HIGH-VELOCITY WINDSTORMS	• Ice build-up can result in snapped power lines, broken or fallen utility poles • Winds can bring down utility poles and transmission lines	• Planning: Install microgrids to enable communities to separate from failed central grids and run on secondary sources • Structure: Bury distribution lines • Monitoring and maintenance: Manage/trim the trees around transmission lines, use of smart grid technology to identify the precise location of failed or upcoming failure in distribution line…

For example, the Agence Parisienne du Climat, as part of its Adaptaville platform,[8] proposes adaptation solutions to deal with the risks of drought, flooding, and heatwaves, which can undermine the resilience of the capital's grid and energy supply. Solutions include producing local energy (micro-methanation of food waste from local communities), self-consumption (installation of green roofs with photovoltaic generation), and passive alternatives to individual air-conditioning (free cooling).

Nuclear power production strained by drought

Nuclear power plants are on the front line when it comes to climate change impacts and could be affected more than anticipated by forecasts.[9,10] The reason is that they require considerable quantities of water to cool down their facilities. Generally, plants withdraw water from rivers close by. The water is used to cool installations, and then discharged back into the river. Regulations limit the maximum temperature of water upstream from the power plant (e.g., 28 °C for the Garonne River at Golfech Power Plant); the maximum heating threshold of the river from upstream to downstream of the plant (e.g., +3 °C in summertime for the Rhone River at the level of Saint-Alban Power Plant); and a maximum threshold for water withdrawals (e.g., water consumption/evaporation is prohibited at the Chooz Power Plant if the flow of the River Meuse is under 20 m^3/s on average over 12 days).[11]

Periods of extreme heat and drought (which increase the risk of low waters) therefore heighten the risk of: 1) having insufficient water to cool power plants; and 2) reaching the regulatory limits, which threatens the activity of the power plants and the safety of infrastructure if they cannot be cooled down. In May 2022, particularly early compared to previous years, EDF was forced to slow down the activity of the Blayais Nuclear Power Plant located on the edge of the Gironde Estuary: the temperature of the river was too high and EDF could no longer discharge the water used for cooling, mainly to protect biodiversity.[12] RTE also insists on the location of nuclear power stations as a means for adaptation,[13] requiring not just a source of cold water nearby, but a location that limits the risk of submersion and tidal waves. Faced with these risks, Hervé Cordier, group leader of the engineering and new nuclear projects department at EDF, explains that, "*additional heat exchangers and air conditioning units have been installed at the plants [since 2003]*" adding that, "*work is underway at Gravelines Power Plant to raise the embankment and take account of sea levels*".[14]

BOX 1 • **EXPERIENCE FEEDBACK**

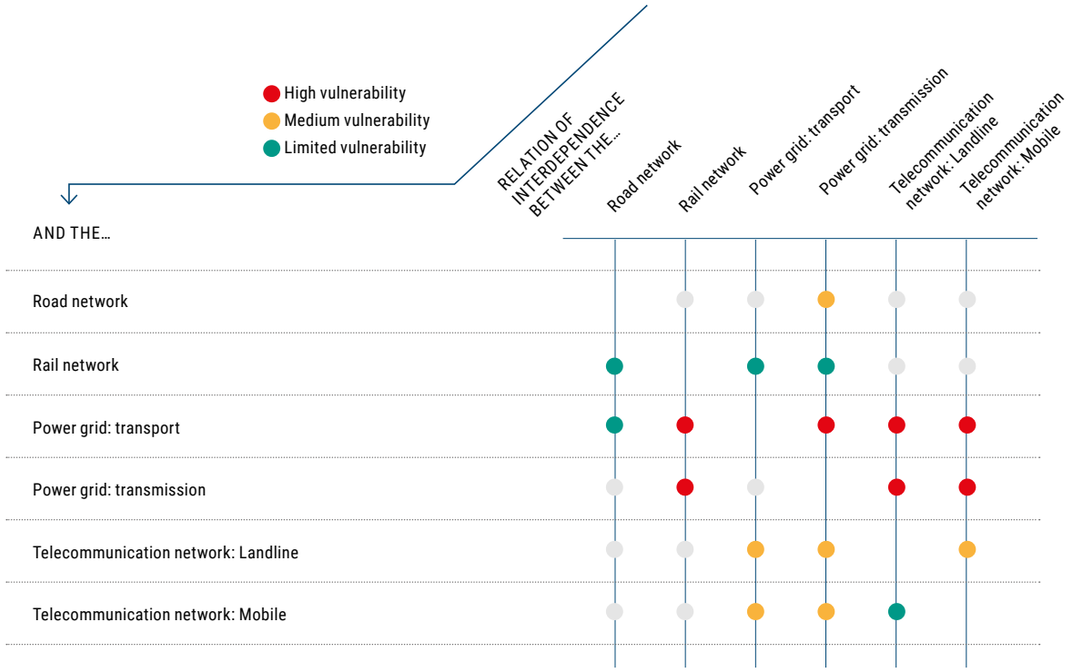
CHARACTERIZING THE IMPACTS OF CLIMATE CHANGE ON ENERGY INFRASTRUCTURE AND IDENTIFYING RESILIENCE OPTIONS: THE CASE OF CANADIAN INFRASTRUCTURE

The conclusions of a report by the International Institute on Sustainable Development (IISD) on the resilience of Canadian infrastructure recommend "*an integrated, whole-of- society approach to making infrastructure across Canada resilient to a changing climate" in order to combat "cascading failures*". Experts go on to suggest three categories of resilience: using assessment and monitoring tools; building in redundancy (emergency backup) systems; and structural modifications (**Tab. 2**), all of which should be informed by scientific knowledge on climate change observed and anticipated in the future.[15]

FIGURE 1

QUALITATIVE OVERVIEW OF INTERDEPENDENCIES BETWEEN NETWORKS

Source: France Stratégie, 2022



BOX 2 • **EXPERIENCE FEEDBACK**

ELECTRICITY SUPPLY MANAGED BY ENEDIS

The company ENEDIS, which manages the electricity supply grid in France is currently looking at the resilience of its infrastructure in the face of climate change impacts, such as "*severe climate events, storms, floods and heatwaves*", and also "*at transition events, like progressively rising temperatures and sea levels,*" (Nicolas Perrin, Director of CSR at Enedis).16 Adaptation avenues have emerged since the "wake-up call" triggered by the massive storm in December 1999 and the excessive heat of August 2003. The work in identifying major risks (storms, heatwaves, fires, rainfall, sticky snow) has led to the formulation of responses, like burying lines in wooded areas that are particularly sensitive to storms and wildfires; installing watertight apparatus in electricity stations; and installing pumps in flood risk areas. However, these responses still need to be improved because, for example, "*during heatwaves, the ground cools down less and therefore the heat loss from equipment underground is less effective.*"

Energy "sufficiency" is the new watchword for mitigation and adaptation policies

Energy sufficiency, although still not fully defined, involves controlling and reducing consumption and ranking uses and needs.[17] The concept undeniably calls for "*changing individual behaviour, economic frameworks and business models, with the aim of decoupling the creation of societal value and the consumption of resources/energy*".[18] In the face of threats weighing on the grid and on the production and operating capacities of energy infrastructure, taking up energy sufficiency or conservation practices constitutes a strategic approach, in particular in these times of geopolitical tension.

Numerous countries have recently unrolled their "energy conservation plans" in order respect the European target to reduce electricity consumption by 10% by March 2023 and by 5% during peak demand. European states, which remain free to choose which measures to adopt, have established solutions like incentives to reduce heating in households (-1 °C in Italy) and a drop in the maximum temperature threshold (19 °C in public buildings in Italy, France and Spain; maintaining buildings at 16 °C or 17 °C during the weekend in Lithuania); postponing the start of the heating season (two weeks later in France, not before November in Italy); reducing temperatures at sports facilities (gymnasiums, municipal swimming pools), and the use of hot water in offices; turning off lights during the night for some monuments and shops after closing time (Portugal, France), and from 10 pm in Spain; restrictions for Christmas lights; the extension of teleworking; and regrouping of public services in adapted premises to limit the heated surface area, etc.

Beyond Europe, other countries are also encouraging energy conservation. In June 2022, the Japanese government – struggling with rising summer temperatures and a plummeting yen that had contributed to increasing the cost of energy imports – called on inhabitants and companies to act more ecologically (turning off lights in unoccupied areas, reducing the use of televisions by an hour a day, turning off heating of toilet seats, etc.) in order to reduce energy consumption and avoid cuts.[19,20] These rapid conversions subject to constrained

circumstances akin to "state energy conservation" fit into a defined, limited timeframe and are very different from integrating energy sufficiency into long-term transition scenarios. The CACTUS project,[21] driven by the French association négaWatt and the German research institute Fraunofher ISI, is one initiative that encourages such integration into transition scenarios, such as by training energy and climate policy actors in Hungary and Lithuania between 2020 and 2022.

Heatwaves and pressure on the grids

Increasingly frequent heatwaves are encouraging inhabitants of numerous regions in the world to change their behaviour and install air-conditioning. Yet the rising use of air conditioning causes a local increase in night-time temperatures that has negative impacts on the comfort and health of inhabitants and could create a negative feedback loop, with increased temperatures pushing for the use of even more air conditioning, and vice versa.

According to the International Energy Agency, about 2.27 billion air conditioning units were in operation in the world in 2021, which represents about 16% of global electricity consumption.[22] Forecasts show that "*the global stock of air conditioners [is likely to rise] by over 50% during the next decade*": the threshold of four billion appliances in service in the world will probably be reached in 2040. While currently China and the United States make up most of demand, the biggest-growing markets will probably be India and Indonesia, "*where the number of units in service is expected to be multiplied by respectively fifteen and eight from 2020 to 2040*". In France in 2020, the number of air conditioning units sold "*exceeded 800,000 units compared to only 350,000*" in 2019. Twenty-five percent of households were equipped with air conditioning in 2021, compared to only 14% of households in 2017.[23,24]

As a direct consequence of the increase in electricity needs during excessively hot periods, some States are obliged to make emergency changes to their energy mix, to the detriment of GHG emissions reduction targets. For example, in spring 2022, India and Pakistan were confronted with an unprecedented heatwave with temperatures reaching 43.5 °C in New Delhi in the end of April and up to 48 °C in parts of the rural area of Sindh, which is +8 °C higher than the seasonal average. On 26 April, India reported record national electricity consumption levels (204.65 GW),[25] following a 12% increase in energy demand that month. To cope with this increased demand, the country relaunched coal production (the country's main energy source) and set up rationing (cuts in some factories, reduction in industrial activity, etc.).

In China, in particular in the Sichuan province, temperatures exceeded 40 °C several times during the month of August 2022. Faced with the almost-systematic use of air conditioning by the province's 84 million inhabitants and with dried-up rivers (Sichuan depends on hydropower for 80% of its electricity), the government imposed electricity rationing on professionals, and the China Internet Network Information Center[c] reported that, "*the quantity of coal used to operate electricity power plants increased by 15% in the first half of August, compared to the same period*" in 2021.[26]

Influence of climate change on national energy choices

Wind power production depends on a number of factors, such as speed, intensity, direction, windshear and wind direction, the amount of cloud cover, and the transmission capacity of the atmosphere. Slower wind speeds[27,28,29] have been observed in several places around the globe, with greater changes than average at local level, such as in the north of China ("*in Inner Mongolia and in the Gansu, the two best-equipped provinces, the wind potential has dropped by about 15% since 1979*")[30] and in the United Kingdom (the wind power sector only supplied 7% of electricity in September 2021, compared to 24% usually in the same period, which led the country to restart a coal power plant).[31] French start-up Callendar, which specializes in evaluating climate risks, also confirms this trend in France, where wind speeds were abnormally low in September 2021. At the scale of the Hauts-de-France region, the average wind speed was 58% lower than normal speeds from 1991-2020 for the month of September, bearing in mind that a quarter of the country's wind farms are located in this region.

For solar power, forecasts clearly show an increase in the degree of solar radiation, but it appears that solar panels produce smaller yields in periods of high temperatures.[32,33]

Water stress: a major challenge for hydropower facilities all over the world

The potential for hydropower is directly related to the availability of water. A changing climate will therefore affect the production capacity of hydropower plants (modification of natural inputs feeding into the reservoir lake upstream in terms of both time and quantity, higher air temperatures, early snow melts, reduction of precipitation in the form of snow) and energy demand (modification of demand peaks according to temperature variations). For multi-usage reservoirs, other activities that require water can be impacted and enter into greater competition with hydropower.

The heatwaves of the summers of 2021 and 2022 caused numerous rivers around the world to dry up. In South America, the Parana River (second largest river on the continent) lost six metres in two months, reducing hydropower production. Due to insufficient supplies, Brazil turned to the United States to import gas, the price of which rocketed around the world. In China, a heatwave hit the southwest of the country (up to 43.3 °C in Chengdu). The level of the Yangtze River was 40% below normal over the summer. During the summer of 2022, like 2021, the authorities were forced to cut electricity supplies to some industrial sites (Toyota, Foxconn, Contemporary Amperex Technology Co., Limited – CATL), as well as steelworks and other metal foundries, which had to interrupt their activities, some of which are strategic for the ecological transition, such as the manufacture of solar panels. In Italy, the River Po reached a historically low level during the

c Official State-run web portal.

summer of 2022 and hydropower reserves were 40% below the historical average for the same period **(FIG. 2, UPPER PANEL)**. Hydropower represents about 35% of the total production of green energy, and usually meets over 15% of Italian energy demand. The same trend can be observed in Spain, where hydropower production was over 30% lower during summer 2022 compared to its average of the last seven years **(FIG. 2, LOWER PANEL)**.[34]

This pressure on water resources due to low levels of precipitation and higher temperatures can generate situations of conflicts of use when a river supplies different activities in the same geographic area. For example, the hydropower system on the Durance River is one of the most engineered in France, and provides 3.5 million inhabitants with drinking water (in the Bouches-du-Rhône and Var areas); it also provides water to farms and manufacturers in the region. Overall, the Durance and its tributary the Verdon produce 50% of regional electricity and 10% of national hydropower. In 2022, EDF had to reduce its production starting from the month of February, and by up to 60%, to maintain enough water for other uses judged to be a priority.[35]

Nevertheless, the development of renewable energy remains a key driver of the energy transition, and of national energy independence vis-à-vis the exterior, and local resilience. In Benin, the United Nations Development Program supported a project to bolster the resilience of the energy sector against the impacts of climate change in order to reduce the vulnerability of urban and rural communities, at every stage of the energy grid (production, transport and energy supply). The project led to the installation of mini solar power stations, solar lampposts, and the rehabilitation of an electricity station with the acquisition of a smart electric transformer.[36]

BOX 3 • **EXPERIENCE FEEDBACK**

THE AMERICAN GRID UNDER PRESSURE

In the United States, a combination of several factors (relating to climate, in particular the sharp rise in heatwaves; the economy, marked by a big shortfall in investment in infrastructure; behaviour, with an increase in electricity demand; and structure, with aging infrastructure that are therefore more vulnerable to the impacts of climate change) has led the country into a complex situation involving increased pressure on an aging grid of energy infrastructure.

It is known that "*climate hazards are the main cause of blackouts in the United States. In total, 679 system-wide outages occurred from 2003 to 2012 due to climate conditions*". Thus, American infrastructure and in particular power transformers need renewal. For example, Superstorm Sandy (2012) "*provoked the explosion of a power transformer operated by the company ConEd, contributing to a blackout that deprived over 8.1 million households and companies in and around New York of electricity, 800,000 of them for 10 days*".[37]

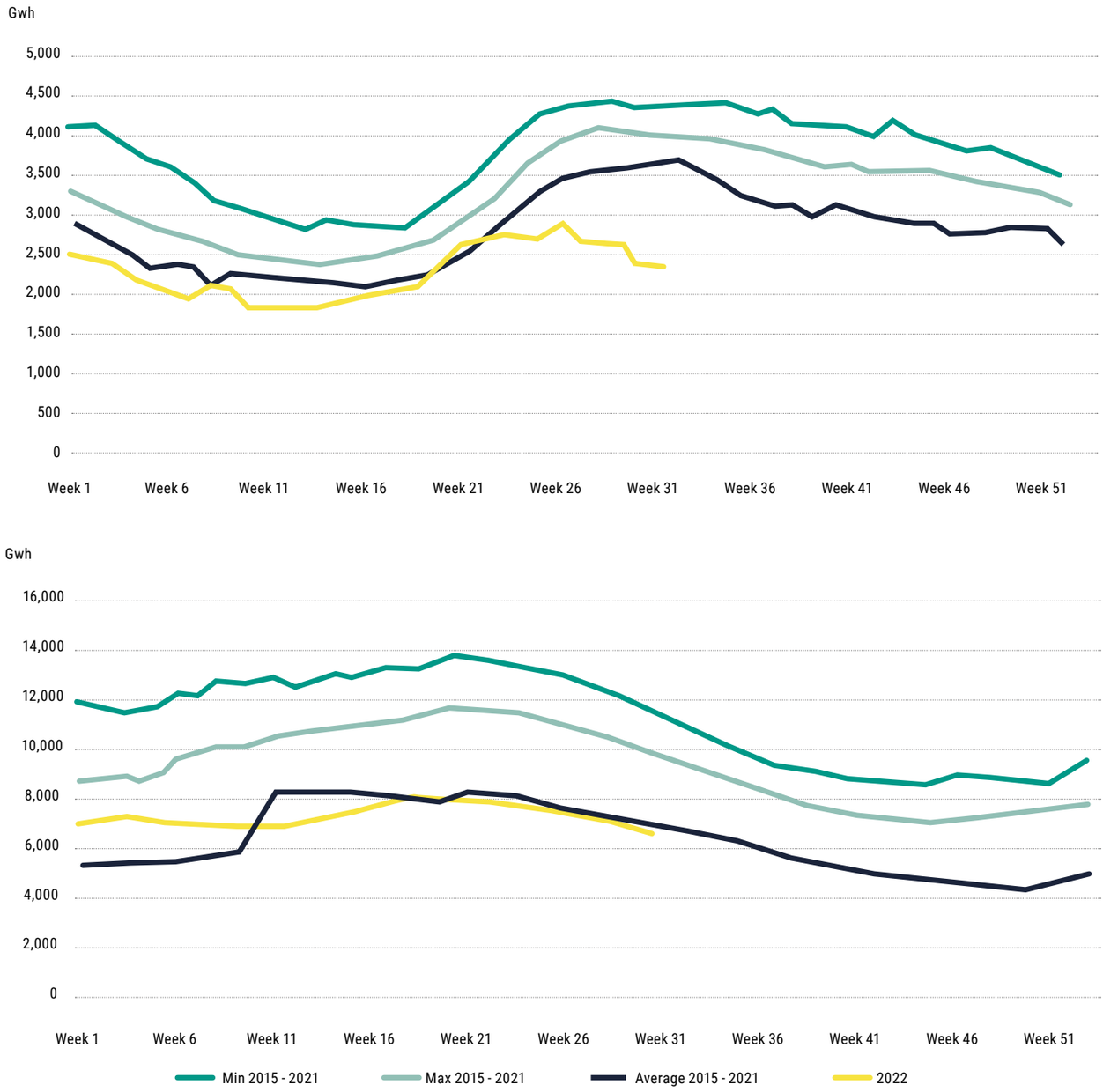
During the last two years, the United States has been confronted with increasingly frequent heatwaves; the population reacts by increasingly turning to air conditioning: the surge in electricity demand could result in higher energy costs[38] and significant risks of electricity cuts.[39] California appears to be particularly vulnerable to these risks, as was the case in early September 2022.[40,41] The Californian government launched the FlexAlert measure (created by the non-profit operator California ISO) and disseminated energy-saving tips to avoid saturating the grid, like avoiding setting air conditioning lower than 25 °C, limiting the use of electric devices, and turning off unneeded lights.

In early summer 2021, an unprecedentedly hot heatwave (up to 51 °C) affected the electricity grid and infrastructure in the city of Portland, Oregon (some cables melted, trams stopped running, the grid was saturated by increased use of air conditioning, etc.).

FIGURE 4

UPPER PANEL: HYDROPOWER RESERVES IN ITALY; LOWER PANEL: HYDROPOWER RESERVES IN SPAIN

Source: Schroders, 2022



KEY TAKEAWAYS

The energy market crisis has highlighted how exposed energy grids and infrastructure are to intensifying climate change. Although attention tends to focus on the war in Ukraine that began in February 2022 as a driver of inflation, the direct and indirect consequences of drought, flooding and heatwaves indicate that the conflict could hide more structural challenges arising from climate change. With a combination of demand peaks caused by air conditioning, the drying-up of hydropower production capacities, and water shortages for cooling down power plants, repeated heatwaves have accentuated several points of tension affecting the electricity grid. Aging infrastructure, concentrated production capacities, and insufficient anticipation of adaptation requirements are among the causes of grid vulnerability on infrastructural and organizational levels. The observation of global phenomena, like the slowing down of windspeeds (stilling), also involves new risks for renewable production that have been little studied to date. When it pushes up the demand for energy, "maladaptation" itself becomes a factor in destabilizing the grid.

Two main response models emerged in 2021 and 2022. Firstly, the emergency use of fossil fuels, which are more flexible, to take over from renewable production capacities affected by climate variables, underlines the fact that ill-prepared adaptation can clash with mitigation strategies. In addition, the war in Ukraine brings a reminder of the geostrategic cost of such a dependence on fossil energy. As a result, accelerating the transition of the energy mix towards low-carbon energy sources is clearly a keystone in the strategy to adapt production networks in order to guarantee supply and strategic autonomy for States and non-state actors.

Next, the sudden propulsion of "energy sufficiency" to the top of the political agenda, in the form of emergency plans driven by States, opens up new horizons for directing demand in transition scenarios. The long-term consequences of energy conservation will be apparent in the years to come: will it become a key feature of mitigation policies, reducing the pressure generated by climate change on energy infrastructure, or will its emergency adoption without prior planning have a rebound effect on energy demand?

In any case, the adaption of energy actors and infrastructure requires adopting a holistic, ecosystem approach to energy issues in order to better control the domino effect (on a network or between different networks) and conflicts of use in the case of diminishing resources. On the other side, integrating data and long-term climate forecasting into the planning, sizing and operation of energy infrastructure is clearly crucial in order to anticipate the impacts of climate change on energy infrastructure and grids as soon as possible.

REFERENCES

RETURN TO PREVIOUS PAGE

1 WMO (2022) State of the Global Climate 2021. *World Meteorological Organization*

2 Copernicus Climate Change Service (08/09/2022). « Copernicus: l'été 2022 est le plus chaud jamais enregistré en Europe ». *Copernicus*

3 Météo France (30/08/2022). Changement climatique : l'été 2022 et ses extrêmes météorologiques pourraient être la norme après 2050. *Météo France*

4 MacCarthy, J., Tyukavin, S., Weisse, M., Harris, N. (17/08/2022). New Data Confirms: Forest Fires Are Getting Worse. *World Resources Institute*

5 European Forest Fire Information System (06/09/2022). Répartition de la surface brulée en Europe depuis le 1er janvier 2022. *public. flourish.studio*

6 France Stratégie (2022). « Risques climatiques, réseaux et interdépendances : le temps d'agir »

7 Braun, M., Fournier, E. (2016), Études de cas d'adaptation dans le secteur de l'énergie – Surmonter les obstacles à l'adaptation. Rapport présenté à la Division des impacts et de l'adaptation liés aux changements climatiques, *Ressources naturelles Canada*, 114 p

8 https://www.adaptaville.fr/alea-climatique/tensions-sur-les-ressources-energetiques

9 Connaissance des énergies (5/07/2021), « Les centrales nucléaires face aux risques liés au changement climatique »

10 Dorfman, P. (28/06/2021). Nuclear energy isn't a safe bet in a warming world – here's why. *UCL Energy Institute, University College London*

11 RTE, GT1 Climat, Réunion n°4 : effets du climat sur la production électrique d'origine nucléaire et thermique, 10 mars 2021

12 Lonchampt, J., Raymond, A., Fleury, N., Wursthorn, P., Laurentin, R. (11/05/2022). Sécheresse: la production nucléaire ralentie. *France Info*

13 Guarato, J. (08/12/2021). Nucléaire: face au changement climatique, le casse-tête du refroidissement. *NaturaSciences*

14 Fleitour, G. (05/07/2022). Comment EDF compte éviter le coup de chaud à ses centrales nucléaires cet été. *Ouest-France*

15 IISD (2021). « Renforcer la résilience climatique des infrastructures canadiennes : une revue de la littérature pour éclairer la voie à suivre ». *International Institute on Sustainable Development*

16 Enedis (2022). La distribution électrique face au dérèglement climatique. *Pour la science*, n°535

17 Cézard, F., Mourad, M. (2019). Panorama sur la notion de sobriété – définitions, mises en œuvre, enjeux. *Ademe*

18 Laurent, D. (2020). La sobriété dans les scénarios de transition. *La Revue de l'Energie*, n°648

19 Bloomberg (28/06/2022). Tokyo power crunch eases as Japan renews call to save energy. *The Japan Times*

20 Oda, S. (07/06/2022). Japan Wants People to Use Less Energy to Prevent Blackouts. *Bloomberg*

21 https://cactus-energy-sufficiency.eu/

22 IEA (2022). Space Cooling. *International Energy Agency*

23 Ademe (2021). La climatisation: vers une utilisation raisonnée pour limiter l'impact sur l'environnement.

24 Binet, G., Grignon-Massé, L. (2020). La climatisation des logements résidentiels: laisser faire ou encadrer intelligemment ?. *Équilibre des énergies*

25 PTI (29/04/2022). India's peak power supply touches record level of 204GW on Thu. *Energyworld*

26 Les Echos (16/08/2022). Une vague de chaleur contraint la Chine à rationner l'électricité. *Les Echos*

27 Robbins, J. (13/09/2022). Global 'Stilling': Is Climate Change Slowing Down the Wind ? *YaleEnvironment360*

28 Dodgshun, J. (05/10/2017). The stilling: global wind speeds slowing since 1960. *Horizon, the EU Research and Innovation Magazine*

29 van Halm, I. (22/11/2021). Weekly data: Changes in wind speed caused by climate change may affect future wind power output. *Energy Monitor*

30 Laconde, T. (12/11/2021). « Résilience climatique : l'éolien aussi doit faire ses preuves. *Le Monde de l'énergie*

31 Alvarez, C., Fricot, P. (21/10/2021). Partout dans le monde, le changement climatique exacerbe la crise énergétique. *Novethic*

32 Jerez, S., Tobin, I., Vautard, R. et al. (2015). The impact of climate change on photovoltaic power generation in Europe. *Nature Communication*, vol. 6 (10014)

33 Müller, J., Folini, D., Wild, M., & Pfenninger, S. (2019). CMIP-5 models project photovoltaics are a no-regrets investment in Europe irrespective of climate change. *Energy*, vol. 171, pp. 135-148.

34 Lauro, I. (16/09/2022). L'impact des sécheresses sur le mix énergétique. *Schroders*

35 Isnard-Dupuy, P. (12/07/2022). Durance, la fin d'un modèle de résilience. *Politis*

36 UNDP (n.d.). Projet de renforcement de la résilience du secteur de l'énergie aux impacts des changements climatiques au Bénin. *undp.org*

37 Aboukrat, M., Lepousez, V. (2021). Les réseaux électriques, un enjeu majeur de la résilience climatique. *Carbone 4*

38 Oleniacz, L. (05/01/2022). Climate Chance could lead to blackouts, higher power costs on West coast. *NC State University*

39 Cool Coalition (10/05/2021). A growing summertime risk for cities: power failures during waves.

40 Halper, E., Werner, E. (07/09/2022). California scrambles to avoid blackouts as it pursues a green energy future. *The Washington Post*

41 Hubler, S., Borwning, K., Penn, I., Cowan, J. (06/09/2022). California Narrowly Averts an Electricity Crisis Amid Scorching Heat. *The New York Times*

SIGNALS

A ROUND-UP OF THE INITIATIVES, REGULATION CHANGES, AND MARKET TRANSFORMATIONS OF TODAY THAT SIGNAL THE CLIMATE ACTION TRENDS OF TOMORROW

Jobs • "Green jobs" are all the rage, to the detriment of carbon-based activities

In the United States, although the production of fossil energies increased in 2021, the number of jobs in the sector diminished, unlike in the renewable energy sector. These new jobs are mainly found in the hybrid vehicle sector (+20%), the electric vehicle sector (+26%) and in solar energy. Furthermore, fossil companies have not rehired as many staff as they lost during the pandemic, in spite of their record profits in 2021. At the global level, renewable energies created 700,000 jobs in 2021, for a total of almost 13 million jobs. Two-thirds of these job opportunities can be found in Asia, and China accounts for 42% of the global total, followed by the European Union, Brazil, the United States, and India. The social co-benefits and the opportunities associated with "green jobs" explain their success. In France, young engineers are leaving companies such as TotalEnergies because of its climate image.

Grist, 30/06/2022

Cities • Paris and New York join legal action against TotalEnergies

On 21 September 2022, the Paris Court added the cities of Paris, New York, and Poitiers, alongside Amnesty France NGO, to an international coalition of associations and local authorities suing TotalEnergies. The legal action began in January 2020, based on the French law of 21 February 2017 on the duty of care. This law requires that major French companies draw up plans to avoid environmental damage, risks to humans, and corruption. The coalition wants the court to force the oil giant to reduce its GHG emissions to be aligned with the Paris Agreement. A similar case was ruled on by the Dutch court regarding Shell in May 2021.

Reuters, 21/09/2022

Agrivoltaics • Solar photovoltaics grow on European farmlands

Agrivoltaics refers to the simultaneous use of a site for agricultural production and electricity generation from solar PV panels, thus making it possible to achieve renewable energy targets while also limiting land-use. As of mid-2022, agrivoltaics accounted for 14 GW of global capacity. France has recently developed a definition for agrivoltaics and a classification of projects, in order to encourage the installation of more facilities. In another boost to agrivoltaics, the government eased the environmental evaluation criteria for solar installations smaller than 300 kWp. A recent regional court ruling in Apulia, in Italy, has also spurred on agrivoltaics, by guaranteeing that regional authorities must consider electricity generation alongside crop cultivation and livestock rearing when sanctioning permits for solar projects on agricultural lands. While the German government has also been trying to develop agrivoltaics, it has been met with resistance from the German Farmers Association. Still in its infancy in the United States, there have nevertheless been developments in certain states.

Universities • University investments struggle to divest from fossil fuels

In April 2021, after multiple campaigns, the student body presidents of the eight prestigious Ivy League institutions signed a resolution calling for their universities to withdraw from all fossil energy funding arrangements, which they say are "financing climate change". In the following months, Brown, Columbia, Cornell, Harvard and Dartmouth terminated their financing agreements. The students' arguments highlight the inconsistency of their universities in training climate researchers while financing fossil industries and accepting their funding. Recently, student activists have put additional pressure on Yale, Princeton, Stanford, MIT and Vanderbilt, saying that their investments are no longer simply immoral but illegal. Stanford's announcement in May to accept donations from the fossil fuel industries further inflamed the situation. The university community has specifically asked the new college dedicated to climate research to refuse such donations.

The Daily Pennsylvanian 10/10/2021

Civil society • The repertoire of contention of activists grows ever more radical

In recent years, radical forms of environmental activism have become increasingly open to the destruction or sabotage of material goods. In the United States in 2018, various citizens that were members of a group known as "The Valve Turners" were convicted for simultaneously stopping the flow of five pipelines carrying oil from Canada. In Canada, in the north of British Columbia, the indigenous Wet'suwet'en people are leading the opposition against the construction of the Coastal GasLink pipeline on their traditional territory. In February 2022, the pipeline was the target of an attack by masked militants, resulting in millions of dollars of material damages. In the context of a larger action against the opening of new methane terminals in August 2022, members of the Ende Gelände movement covered pipes under construction with bitumen to make them unusable. In London, Bristol, and Brighton, the "Tyre Extinguishers" deflate SUV tyres, while in France, in the Deux-Sèvres, la Vienne, and Vendée, activists demanding a greater say have damaged "mega-basins", which are controversial because they monopolize water resources in a context of drought.

Reporterre, 25/08/2022

Oil • The French business world against the TotalEnergies pipeline project in East Africa

$10 billion was earmarked in February 2022 for the construction of a 1,443 km pipeline by TotalEnergies. It will transport Ugandan crude oil to a Tanzanian port and is being presented as environmentally responsible. According to various experts, however, the East African Crude Oil Pipeline (EACOP), the TotalEnergies Tilenga, and Lake Albert CNOOC projects all endanger biodiversity in both countries. They create significant risks to the endangered species present in the 16 protected areas they cross, and risk contaminating a catchment area on which 40 million people depend. According to some estimates, the oil production phase could generate 35 $MtCO_2$/year. Friends of the Earth and other NGOs have filed a complaint in a French court for failure of "duty of care". The Stop EACOP campaign led by these NGOs prompted some twenty banks and eight insurers to pledge not to finance the project. 600 players in the entrepreneurial world then called on TotalEnergies and its partner Station F to stop EACOP, calling it a "carbon bomb".

Financial Times, 12/04/2022

Peru • German judges examine RWE's responsibility in the melting of the ice caps

For the first time in the history of climate litigation, German judges have travelled abroad, to Peru, to assess the responsibility of a company in a climate phenomenon. In fifty years, the volume of the Palcacocha glacial lake has increased by a factor of 34. Located in the Cordillera Blanca massif, the lake is threatening to overflow into the surrounding towns as a result of melting ice. In 2017, Saúl Luciano Lliuya, a mountain guide, decided to file a complaint against RWE to obtain an compensation commensurate with the historical accountability of the German electrical supply firm in climate change. With 89 $MtCO_2e$ of Scope 1 emissions, a study by Greenpeace estimated that RWE was the largest emitter in Europe in 2021, and is responsible for 0.47% of post-industrial revolution emissions. The plaintiff thus claims $20,000 to cover part of the costs to prevent damages which could be caused by flooding. The German court has already declared that RWE will be held accountable if it can be demonstrated that the glacier poses a flooding risk, and that climate change is the cause of that.

The Guardian, 27/05/2022

Solar Energy • Record yields for perovskite solar cells

The yield of photovoltaic panels – which varies between 6% and 20% – depends on both the external climate and the materials of which it is made. While solar panels are often made from silicon, some of them incorporate cells based on perovskites instead. Research into the use of this mineral in photovoltaics has been making very rapid progress, particularly in its application on flexible mounts. As part of the European Apolo project, the CEA (the French Atomic Energy and Alternative Energies Commission) at INES announced the development of new solar perovskite cells with a yield of 18.95% – a world record for sizes exceeding 10 cm^2 and for flexible surfaces; the absolute record stands at 25.7% for a single perovskite cell. This type of cell makes it easier to adapt and integrate solar panels into buildings. The increase in the yield of these cells has occurred more rapidly than for silicon cells. The best global performances observed on flexible surfaces were not compatible with low-cost surfaces, unlike the CEA project.

L'Echo du Solaire, 28/06/2022

CASE STUDIES

COUNTRY	POPULATION	MITIGATION GOALS	NATIONAL EMISSIONS IN 2020
GEORGIA	3,714,000	-15% BY 2030 (BASELINE: 2021)	11.74 $MTCO_2E$ (12.02 IN 2019; 11.33 IN 2018)

Georgia • Gender-sensitive energy cooperatives in Georgian rural areas

82% of the energy used by Georgia's rural population (i.e., 41% of the national population) stems from unsustainably harvested firewood which causes emissions, deforestation and indoor air pollution. Georgia also has a precarious energy situation because of the lack of sufficient infrastructure, significant fuel costs, and extreme weather conditions. In 2016, the NGO Women Engage for a Common Future (WECF), created four gender-sensitive energy cooperatives, in partnership with Clean Power Europe and other Georgian NGOs. These cooperatives are driven by goals of both climate change mitigation and the empowerment of rural women.

Giving access to clean and affordable energy for all

The role of the cooperatives is to set up, manufacture, and promote the use of locally produced energy-efficient equipment. The project relies on two pillars to directly reduce carbon emissions: replacing firewood with solar energy and promoting efficient stoves to conserve wood fuel. 1,000 solar water heating systems and 300 energy-efficient stoves are currently in use – versus 650 and 100 respectively at the beginning – leading to an emissions reduction of 1 to 2.55 tCO_2 and the saving of around 3 m^3 of wood per year for each household.

Deforestation caused by using firewood is a major issue for the sustainable management of Georgia's forests, which cover almost half of the country. Despite its abundance, firewood (30% of the energy mix) is overexploited with 600,000 m^3 of trees being legally cut down per year and 1,800,000 illegally logged, whereas the forests are able to sustain 200,000 m^3. Georgia's 2030 Climate Change Strategy (June 2021) mentioned the goal of reducing firewood consumption by 245,000 m^3 which could save 1,000 ha of forest per year. Objective 3.4 of the Strategy supports the use of solar water heating systems and energy-efficient stoves to reduce both poverty and carbon emissions.

WECF, and the German company Solar Partner Süd, have been collaborating on an ambitious programme since 2009, which trains rural populations on the manufacturing of solar equipment and how to create and manage energy cooperatives. 183 "solar ambassadors" were also trained to promote the equipment in the region, making a revenue based on their sales. Since 2015, WECF has focused on training women since they usually lack access to technical, management and decision-making jobs. At the national level, Heliotech is the umbrella cooperative coordinating centralised activities such as purchasing, marketing and finances. In remote rural areas, this model of energy communities, based on citizen's participation, provide access to clean, sustainable and affordable energy. Start-up costs of energy communities are usually paid off in three to six years.

A local and replicable project in quest of a sustainable economic model

The four cooperatives to date are owned by 128 constituting members, who have bought shares for a price between €30 to €60 each. Democratic governance is ensured by the rule that each member has one vote, regardless of their number of shares. Each cooperative has created between one and six local jobs. 40% of the 31 employees are women, since gender equality is a core element of the cooperatives.

Nonetheless, even though four cooperatives were launched thanks to grants fundraised by WECF, the main obstacle in the future is access to finance. In view of the low purchasing capacity of the population, subsidies and loans are needed. Three cooperatives had to temporarily stop their activities due to the pandemic and the armed conflict in Ukraine.

While Heliotech had negotiated one-year loans at 0% interest for people interested in buying the equipment, the customers were unable to reimburse them in one year. Furthermore, the country has been marked for many decades by a Soviet-style planning policy, which makes it difficult to establish a market approach and trust in financial institutions.

The project was integrated in Georgia's NDC and three Nationally Appropriate Mitigation Action (NAMA) applications have been made since 2015 in cooperation with the government, in order to obtain the necessary subsidies, but they have been rejected despite having a high rating. The Covid-19 crisis put a strain on the internal resources generated by the cooperatives. Guesthouses constitute a part of the energy demand and were therefore affected by the decline in tourism during the pandemic. The project is now working to obtain carbon credit, using the Gold Standard's methodology, to cover subsidies and private investors setting up a market of scale.

COUNTRY CASE STUDY

COUNTRY	POPULATION	NATIONAL EMISSIONS IN 2020	MITIGATION GOALS
MALI	20,250,834	5,99 MTCO$_2$e	-31% OF ENERGY-RELATED EMISSIONS BETWEEN 2025 AND 2030

Mali • Access to "clean" energy thanks to decentralised solar mini-grids

In Africa, close to 600 million people have no access to electricity. In Mali, 83% of the population is faced with this problem, while the energy potential of the country is enormous. To remedy this, the Malian government has implemented a rural electrification strategy based on decentralised mini-grids. Thanks to this strategy, which was broken down into multiple projects such as those funded by the IRENA/ADFD Project Facility, the solar energy production capacity in Mali increased from 16 MW in 2013 to 100 MW in 2022. This project to install solar mini-grids is expected to benefit 123,000 people.

Easy access to drinking water and "clean" energy

In Africa, rural populations have difficulty accessing water and electricity. In Mali, water sources can be far from villages, which hampers daily life and the development of economic activities.

For the deployment of a decentralised solar mini-grid system with a capacity of 4 MW, the government of Mali has received a loan of nine million dollars via the IRENA/ADFD Project Facility scheme. Supported since 2013 by the International Renewable Energy Agency (IRENA) and the Abu Dhabi Fund for Development (ADFD), this scheme aims to finance renewable energy projects in developing countries via low-interest loans (with interest rates ranging from 1% to 2% over a period of 15 to 20 years).

A decentralised solar mini-grid is a small-scale electrical grid that is separate from the national grid, is powered by solar energy using photovoltaic panels, and meets local needs. In Mali, mini-grids produce electricity, which is then stored in batteries by the population. In particular, the electricity powers water pumps that help people to meet their daily water needs. The project, supported by IRENA/ADFD, converts the diesel mini-grids planned by the Malian Rural Electrification Strategy into hybrid solar systems, making it possible to avoid the emission of 5,000 tCO$_2$/year, while ensuring better access to energy for 123,000 people and providing access to water and electricity for the rural populations of 32 villages in six regions of Mali.

A lever for local development and the achievement of six Sustainable Development Goals (SDGs)

The solar mini-grids are also at the heart of the socio-economic development of these regions. Using electricity from the solar mini-grid, a pharmacist from Bancoumana, for example, can now sell medicines that require cold storage. Previously, the range of products sold in his pharmacy was limited, thus preventing some of his clients from meeting their medical needs. By powering water pumps, farm processing machinery, and other industrial equipment, this system provides households and companies with opportunities for economic growth and decent work, as set out in SDG 8. The project generated more than 2,000 direct or indirect job opportunities.

In addition, solar-powered water pumps reduce the time women in rural Mali spend fetching water. Thanks to better access to water requiring far less manual labour, those who make a living from farming and gardening increase the yield of their crops and generate better income. This makes it possible for people to improve their quality of life and to reduce inequalities (SDG 10) while fighting poverty (SDG 1). Finally, through access to drinking water and clean energy, SDGs 6 and 7 are addressed.

SDGs COVERED BY THE PROJECT

Source: IRENA ADFD, 2020

COUNTRY	POPULATION	NATIONAL EMISSIONS IN 2020	MITIGATION GOALS
CAMBODIA	17,000,000 (2022)	125,2 MTCO2e	-42% BY 2030 (COMPARED TO BAU)

Cambodia • A sustainable wood fuel value chain to combat deforestation

Cambodia remains highly dependent on wood and charcoal for its thermal needs (domestic cooking, catering, industrial heating, etc.). Half of the carbon consumed in Phnom Penh comes from the Cardamom Mountain region, one of the last flora and fauna sanctuaries in the Mekong countries. Traditional wood char production is often done by migrants living along the illegal deforestation line. However, the degradation of the Cardamom Mountain region aggravates climate risks and land-related or land use conflicts. Geres, which has been working in Cambodia since 1994, with the support of the UNDP, has developed a new commercial model for wood fuel in the provinces of Pursat and Kampong Chhang: the KjuonGo, a sustainable, legal and traceable value chain.

A sustainable, legal and profitable value chain

From 2019 to 2022, the KjuonGo project was part of the CEMAATERR climate programme with support from *l'Agence Française de Développement* (the French Development Agency), the Nordic Development Fund, and the Maisons du Monde foundation.[a] The charcoal makers buy sustainably harvested wood from community forests (CF), within the limits of the quotas issued by the forest administration (FA). KjuonGo is built around two elements: a sustainable community charcoal value chain and community plantations. Regarding the first element, Geres is assisting forestry and charcoal communities in technical and organisational matters, and helping the local FA through legal charcoal production procedures. The commercial activities are carried out by the social enterprise KGC: placing orders for wood from CFs, sales of sustainable charcoal, quality monitoring up to the final consumers and communication with the national FA regarding administrative legalisation procedures.

The second element of the project focuses on community plantations by supporting reforestation initiatives in communities using native species and by testing three alternative models: acacia trees planted on communal land, fruit trees planted on private land, and commercial acacia plantations for firewood and products with a higher added value.

Socio-economic and environmental impacts

Twelve CFs and several charcoal makers were involved over the three years of the project. The legal charcoal quotas were fully respected (100%), 12 more efficient charcoal kilns were built or renovated. Seventeen hectares have been reforested, 13,000 seedlings produced in nurseries, nearly 9,000 trees planted, and 7,400 ha of forests managed sustainably or protected by communities. 7.5% of the revenues generated by the CFs were reinvested, mainly to fund patrols. Participatory maps (plantations, degraded areas, etc.) and action plans were drawn up by the communities for the protection and restoration of their forests.

The new charcoal production process has prevented the direct emission of 588 tCO_2e and avoided 4,800 tCO_2 of deforestation emissions. The commercial community plantation project created 163 jobs, most of them part-time, of which 54 are for women, and a viable business for KGC. With a license and legal status, charcoal makers now have access to a legal, secure, profitable and socially recognised activity. However, the slow action on the part of the forest administration in legalising these activities, and the drop in demand associated with the Covid-19 health restrictions have had a strong impact on the amount of charcoal produced in three years: 74 tonnes of KjuonGo charcoal sold, against an expected 300 tonnes.

The challenges of upscaling

The Geres project, completed in 2022, initiated a collaboration between KGC and the local communities. Sustainable charcoal purchase agreements have already been concluded between KGC and 4 charcoal producers. In addition, 50 textile factories have undertaken an energy diagnosis that includes biomass (the Switch Garment project with Geres). The increasingly stringent requirements of international brands regarding the fuels used by their suppliers provides opportunities for wood that is produced sustainably and legally.

a This article is based notably on the assessment report produced by ACK International for AFD and Geres: *CEMAATERR Programme - "Climate - Energy: Adaptation and Mitigation Measures in Rural Areas" - Final Assessment of Phase II - Project Component NoteCountry: Cambodia - 2022*

“AS DEMAND FOR MOBILITY EXPLODES AGAIN, TRANSPORT EMISSIONS ARE FALLING IN EUROPE WHERE ELECTRIFICATION IS PROGRESSING.”

The transport sector is one of the sectors with the largest rebound in activity in 2021-2022, accompanied by a rebound in domestic emissions of 7.4% in 2021 (still 4% below 2019) **[INDICATORS]**. In Europe, it is the only sector whose emissions have shown an increasing trend since 1990 (+20%).

Nevertheless, as demand for mobility explodes again, transport emissions are falling in Europe where electrification is progressing, for example in Norway (-14.5% since 2014; 86.2% share of electric vehicles sold in 2021) or Sweden (-28% since 2000). The electrification of the road sector is progressing at an ever-faster pace (10% of global new vehicle sales), but not without raising fears about the new geopolitical dependencies it could create if it is not accompanied by a reduction in car use and the development of public transport networks **[TRENDS]**. Above all, while the sale of electric vehicles is growing faster than others, particularly in Europe and China, it is sharing the race with SUVs, which account for almost half of global sales, and are holding back the sector's decline in emissions.

At the same time, municipalities are putting in place various measures, adapted to local priorities, to get personal cars off the roads within the city **[TRENDS]**. Buenos Aires, one of the first 25 cities in the world to commit to achieving carbon neutrality by 2050, has placed great emphasis on the development of "intelligent mobility", with the aim of promoting multimodal transport **[CASE STUDIES]**. In addition to cities, companies are also involved in implementing solutions. In Zimbabwe, the micro-mobility system of the local start-up Mobility for Africa addresses the combined challenges of development, access to mobility and social equity **[CASE STUDIES]**.

Mobility policies have significant potential to help cities adapt to the various social, political and environmental challenges they face. By reorganising urban space through its "superblocks" project, the city of Barcelona shows that the transition in mobility does not rely solely on motorisation. In addition to reducing GHG emissions, it also promotes soft mobility and the quality of the atmosphere in the city centre. **[CASE STUDIES]**.

In terms of adaptation strictly speaking, the rail sector is the one most exposed to the intensification of climate change, but adaptation actions to deal with it are still relatively underdeveloped **[TRENDS]**. However, it is one of the preferred means of transport for connecting cities and encouraging modal shift, as shown by the European initiatives of summer 2022 with the introduction of "climate tickets" **[SIGNALS]**. Conversely, the use of aeroplanes, and in particular jets, has been under the spotlight since the intensification of "jet tracking" practices over the last two years **[SIGNALS]**.

The recovery in trade and economic activity has led to an increase of around 7% in domestic emissions from the rail, maritime and road sectors and 13.2% for aviation. Although accounting for a small proportion (1%) of global freight, air cargo has seen an increase in its competitiveness with maritime cargo between May 2020 and March 2022. Commercial flights have also picked up, following predictions of increased demand and leaving the CORSIA offset system on the tarmac **[TRENDS]**. In another sector that is difficult to decarbonise, international maritime freight, the long-term hopes placed on alternative propulsion systems are still not convincing; in this context, the shortening of logistics chains is emerging as a shorter-term intermediate path. The penetration of the major global charterers in the management of the last few kilometres of land transport illustrates the trend towards the vertical integration of the market **[TRENDS]**.

IN THE RACE TO DECARBONISE TRANSPORT, EMISSIONS ARE FASTER

2021: emissions back on track

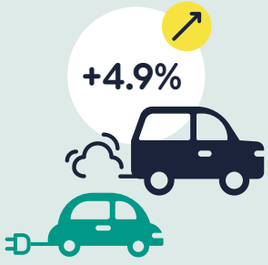
EMISSIONS FROM DOMESTIC TRANSPORT PICK UP, BUT DON'T TOUCH THEIR 2019 LEVELS

+7.6% CO_2

Enerdata, 2022

+7.3% +7.6% +7.3% +13.2%

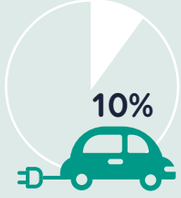
The electrification of vehicles gains momentum...



SALE OF NEW VEHICLES IN 2021

After declining since 2018, new vehicle sales are on the rise again after a historic drop of 13.7% between 2020 and 2019, although they have not yet returned to their 2019 level (82 million versus 91 million).

OICA, 2022



SHARE OF ELECTRIC VEHICLE SALES IN 2021

Electric vehicle sales account for 10% of new vehicle sales in 2021 (up to 20% in Europe) after a sales growth of 57.3%. China is once again the world's largest market, and BYD the largest manufacturer, ahead of Tesla.

IEA, 2022 ; IEA, 2022

+264%

GLOBAL MARKET FOR ELECTRIC BATTERY TRAINS BETWEEN 2019 AND 2021

The rail sector is also relying on batteries to reduce emissions, growing from a global market valued at $132 million in 2019 to $483 million in 2021. The Asia-Pacific region is driving these increases.

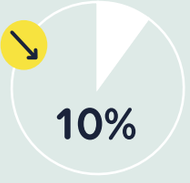
Allied Market Research, 2022

... driven by efficient investments...

$273 bn +77%

INVESTMENT IN ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE IN 2021

REN21, 2022

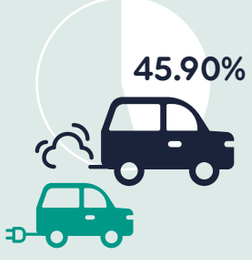


SHARE OF PUBLIC INVESTMENTS IN THE TOTAL SPENDING ON ELECTRIC VEHICLES IN 2021

Government spending on electric cars doubled between 2020 and 2021; but its percentage share was 20% in 2017, reflecting the leveraging effect of government investment on household spending. In other words, government spending leverages more than proportional private investment.

IEA, 2022

... but remains overwhelmed by the success of SUVs



SHARE OF SUVs IN NEW VEHICLES

The electric market is not immune to the SUV trend: in 2021, 55% of electric models on the market were SUVs (45% in 2019). SUVs are the second largest contributor to emissions growth, after carbon-based electricity generation.

IEA, 2021

The urban mobility transition takes different forms depending on the region

+39 cities

ADDITIONAL CITIES WITH LOW EMISSION ZONES IN 2021

At the end of 2021, 270 cities has put in place low emission zones, up from 231 in 2020.

REN21, 2022

+7.5%

SALE OF BICYCLES AND ELECTRIC BICYCLES IN EUROPE IN 2021

The sales of bicycles and e-bikes reached 19.7 billion euros in Europe, 7.5% more than in 2020, particularly driven by the e-bike market accounting for over 5 million units sold out of a total 22 million.

Conebi, 2022

+27%

SALE OF ELECTRIC BUSES IN LATIN AMERICA

+45% of electric buses/year on average in Latin America since 2018. From January to September 2022, growth is already at 49%. Electric buses are being deployed mainly in large cities, driven by Chinese manufacturers, notably BYD.

E-Bus Radar, 2022

+132%

SALE OF ELECTRIC TWO-WHEELERS IN INDIA

The 'electric revolution' in two-wheelers in India continues in the first quarter of 2022 with a five-fold increase in sales.

EtAuto, 2022

Air traffic soars again, riding the wings of demand

377.6 $MtCO_2$

CO_2 EMISSIONS FROM INTERNATIONAL FLIGHTS IN 2021

Emissions from international flights have increased by "only" 10%, partly due to the reopening of the borders in 2021, but the 2019 level is expected to be reached again as early as 2023, and not 2024 as predicted last year.

Enerdata, 2022

+150%

INCREASE IN INTERNATIONAL AIR TRAFFIC BETWEEN JULY 2021 AND JULY 2022

This figure is at 67.9% of the 2019 level.

IATA, 2022

CO_2

661.9 $MtCO_2$

CO_2 EMISSIONS FROM INTERNATIONAL MARITIME FREIGHT IN 2021

The pick up in maritime freight in 2021 has pushed emissions back up to 661.9 $MtCO_2$ (612.5 $MtCO_2$ in 2020), still below their level in 2019 (682.9 $MtCO_2$). Fossil energy accounts for almost all of the emissions from maritime freight, with biofuels representing less than 0.5% of its energy in 2021.

Enerdata, 2022

-49%

EVOLUTION OF THE FREIGHT RATE

Maritime freight rates fell by 49% between September 2021 and August 2022 after growing exponentially from July 2020 to August 2021. In August 2022, they are still 170% higher than in September 2020.

Freightos Data Index, 2022

The maritime sector struggles to start its shift towards decarbonisation

86

ZERO-EMISSION VESSELS

NEW "ZERO-EMISSION" VESSEL PILOT PROJECTS LAUNCHED BETWEEN 2021 AND Q1 OF 2022

Of the more than 200 projects studied by the Getting to Zero coalition, 45 are based on hydrogen technologies, 40 on ammonia and 30 on electric batteries.

Global Maritime Forum, 2022

TRENDS
ROAD TRANSPORT

Metals, the precious fuel for the automotive market in the race to electrification

ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance

The upsurge in new vehicle sales observed in 2021 features an acceleration in purchases of electric models. The high concentration of strategic mineral resources and battery production sites means that car market players are in stiff competition, both to secure their supplies and to take up position on the new low-carbon services that accompany the development of electric vehicles. Whether it concerns opening lithium mines, recycling batteries, or building gigafactories, industrial competition is taking on a whole new dimension. Nevertheless, the success of electric vehicles has had no impact on another strong market trend: the rocketing rise in SUV sales.

DATA OVERVIEW

Electric car sales still outpaced by the growth of SUVs

After a historic 9% drop from 2019 to 2020 due to the pandemic, global greenhouse gas (GHG) emissions from the road transport sector shot up by 7.1% in 2021, although still below pre-Covid levels (5.5 $GtCO_2$ compared to 6.1 $GtCO_2$).[1] This recovery can be attributed to the gradual pickup in activities for both passenger and goods transportation by road, which concern 75% of global emissions related to transport.[2]

The growth in global sales of new vehicles in 2021 brought to an end three years of successive decreases, accelerated by the pandemic. 82,684,788 new vehicles were sold, which is 4.9% more than in 2020, but still far below the pre-crisis figure (-9%), according to data from the International Organization of Motor Vehicle Manufacturers (OICA). The European market has remained relatively stable (+1%), while the American (+6%) and Asian (+6%) markets have risen sharply. Africa, where the new vehicle market is smaller, has seen a very high growth rate (+24%). The Chinese automobile market has been relatively unaffected by the crisis, and in 2021 was already 2% higher than 2019. Countries like Chile (+61%), Ukraine (+23%), Saudi Arabia (+23%) and Pakistan (+91%) have also clocked up bigger sales volumes than in 2019, while major car-making countries like Germany (-9%), Japan (-3%) and South Korea (-9%) have continued their decline.[3] The downward trends of these countries can be explained by supply chain difficulties following product bottlenecks due to lockdown inactivity, the dispersion of maritime freight capacities **(SEE "MARITIME TRANSPORT" TREND)**, the rocketing demand for electric vehicles, and especially, the hike in oil prices which has brought down sales of internal combustion enging (ICE) vehicles.

In this highly contrasting picture, the market is still pursuing the same two-way trend involving contradictory emissions impacts: the electrification of vehicles on one side, and the shift towards SUVs and heavy vehicles on the other. Global sales of electric vehicles

(EVs)[a] have doubled in the space of a year, reaching 6.6 million units and 10% of the global market. In the first quarter of 2022, sales were already 2 million units, which is 75% more than during the first quarter of 2021.[4] China (3.3 million sales) has overtaken Europe (2.3 million, +65%) as the leading global market, far ahead of the USA (630,000 units). EVs have also benefited from the slump in the conventional market caused by the oil crisis to take a bigger share of the market: one car in five sold in China and Europe[5] is now rechargeable electric (BEVs and PHEVs). In India, two-wheelers, the dominant mode of transport, are undergoing their own "electric revolution": sales of electric two-wheelers shot up by 132% in 2021,[6] and multiplied by five in the first quarter of 2022, to reach 3.6% of the market.[7] However, two- and three-wheelers with ICEs still represent 84% of vehicle sales in the country.[8] The shift to electric for heavy vehicles, like trucks and buses **(SEE "URBAN TRANSPORT" TREND)**, is growing fast but remains marginal and is mainly concentrated on the Chinese market. Nevertheless, the International Energy Agency (IEA) points out that electric vehicles currently represent only 1% of the world's automobile fleet. And traditional hybrid (non-rechargeable) vehicles are no exception, since their market share amounted to 22.6% in the EU in the first quarter of 2022.

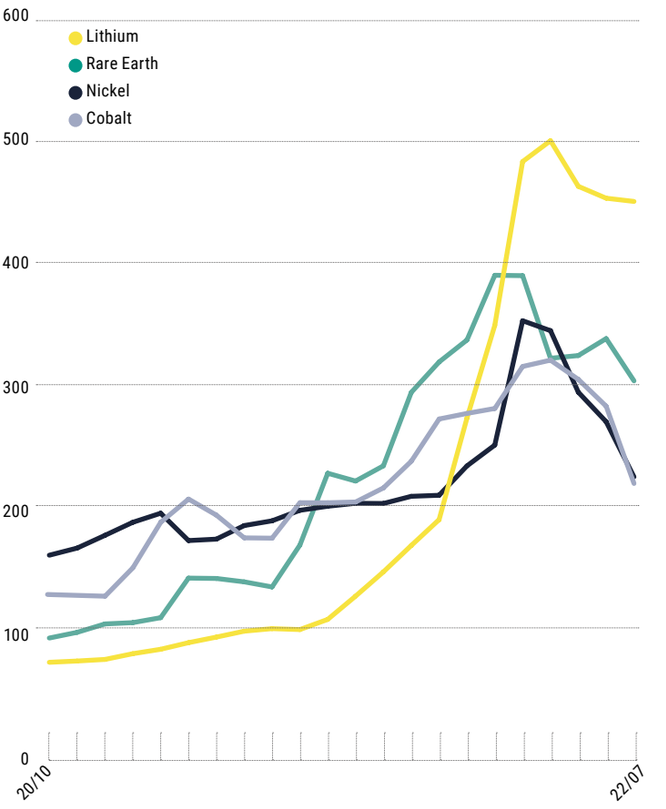
The emission gains achieved thanks to the electrification of vehicles are offset by sales of Sport Utility Vehicles (SUVs). These vehicles, which are much heavier and consume more fuel than average, now represent 45.9% of global vehicle sales.[9] According to the IEA, SUVs, were the second largest cause of the increase in GHG emissions from 2010 to 2021, behind electricity production and ahead of heavy industry, while emissions from traditional vehicles are decreasing. The more than 35 million SUVs that entered the market in 2021 will generate 120 $MtCO_2$ of emissions a year. As the Observatory pointed out in 2020, the enthusiasm of carmakers and consumers for SUVs also concerns the electric vehicle market. Although they do not yet make up the majority of sales, 55% of electric vehicle models on the market in 2021 were SUVs according to the IEA. While the electrification of SUVs is now following the same pace as the rest of the market, 98% of the 320 million SUVs in circulation in the world are still ICE vehicles.[10]

With its continued move towards heavier vehicles with higher material footprints, the automobile market is vulnerable to price swings in mineral raw materials and fossil fuels. The average weight of an EV on the market is 1,940 kg: one third are heavier than 2,000 kg, and more than half are between 1,500 and 2,000 kg.[11] That figure is much greater than the average weight of new vehicles in France (1,240 kg),[12] and even the United States (1,857 kg),[13] while the energy efficiency of an electric car tends to decrease as its weight increases.[14] Electric cars also require six times more rare metals than their conventional alternatives,[15] and the price of most cobalt, lithium and nickel, the main three metals contained in batteries, has been subject to very high inflation since the second half of 2020 **(FIG. 1)**.

FIGURE 1

EVOLUTION OF A SELECTION OF METALS PRICES INDEX FROM OCTOBER 2020 TO JULY 2022

Source: IMF Energy Transition Metal Index, 2022



The move towards heavier vehicles featuring more raw materials exposes carmakers, states, and consumers to structural risks caused by the unprecedented rise in global demand for strategic metals. As a result, a major trend in the automobile market this year is massive investments in the regionalization of battery production, metal supply security, and the vertical integration of the value chain.

THE OBSERVATORY'S LENS

The automobile market's mad scramble for electric batteries

Policies favouring electric vehicles

One of the main drivers of the market according to the IEA is the doubling of public subsidies and incentives for EVs in 2021 ($30 billion), such as purchase bonuses. At the same time, consumer expenditure is close to $280 billion. Combined with the drop in the cost of batteries **(SEE BELOW)**, the lever effect of

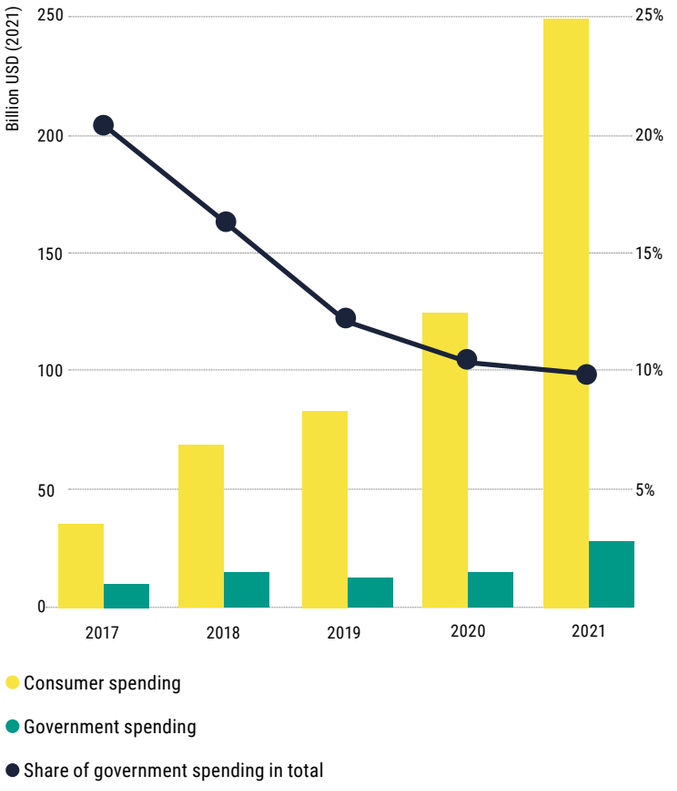
a EVs comprise vehicles with "100% electric batteries" (Battery Electric Vehicle – BEV) and those with rechargeable batteries (Plug-in Hybrid Electric Vehicle – PHEV). PHEVs are not the same as traditional hybrids (Hybrid Electric Vehicles – HEV).

public expenditure is therefore obvious, since the share of government expenditure in total investments in electric vehicles constantly dropped, from 21% in 2017 to 10% in 2021 **(FIG. 2)**.[16]

FIGURE 2

CONSUMER AND GOVERNMENT SPENDING ON ELECTRIC CARS, 2016-2021

Source: IEA, 2022



The gradual global shift away from ICE vehicles is also gaining ground. Thirty-nine countries, sixty local and regional governments, and thirteen automobile manufacturers signed the COP26 Declaration on accelerating the transition towards "100% zero emission" cars and vans by 2040.[b, 17] Since then, the State of California has voted to phase out sales of thermal vehicles by 2035, along with a 35% sales target for "zero emission" passenger vehicles (BEV and hydrogen) by 2026.[18] This initiative should have an automatic knock-on effect in the States of Washington and Massachusetts, which have linked their regulations to California's. Oregon and the State of New York are also expected to follow suit.[19] Canada has presented an emissions reduction plan for 2030, aiming at sales of 100% electric passenger vehicles by 2035.[20] In its national strategy for electric mobility published in October 2021, Chile is aiming at 100% sales of electric light- and medium-duty vehicles and urban public transport (buses, taxis, etc.).[21]

The European Parliament's vote to prohibit the sale of ICE cars by 2035 is a major milestone in the electrification of the market.[22] This new goal supplements the European regulation aimed at reducing CO_2 emissions from new vehicles that came into force on 1 January 2020 (regulation EU 2019/631)[23], in place for the third consecutive year. However, this is the first time that performances are being measured in line with the new WLTP standards.[c]

BOX 1 • **KEYS TO UNDERSTANDING**

EU REGULATION ON EMISSION STANDARDS FOR NEW VEHICLES

The EU regulation 2019/631 does not establish sale targets for electric vehicles, but rather sets emission limits that must not be exceeded by individual carmakers. The limit of 95 gCO_2/km set for all new vehicles sold in 2020 was not extended when the WLTP system was adopted. Instead, specific targets have been set for each car manufacturer, based on the average weight of their vehicles measured in 2020 and 2021, and the WLTP/NEDC emissions ratio measured in 2020. The principle is the same: it is still possible to produce and sell units above this limit if those sales are compensated by sales of less-emitting vehicles.

There are several ways of getting around the rules. Carmakers can gather into manufacturer pools, such as Fiat-Chrysler, which got together with Tesla to bring down its average level, in return for a $1.8 million payment over three years, before merging with Peugeot in the Stellantis group. Moreover, the emissions limit takes cars' weight into account, so that the CO_2 target set by carmakers that sell heavier than average cars can be brought down, which gives no incentive to reduce the weight. A bonus system is also applied to electric cars, which are counted more than once in the average emissions calculation, making the emissions limit more flexible (1 EV counted for 2 vehicles in 2020, then 1.67 in 2021). Lastly, automobile manufacturers can obtain eco-innovation CO_2 bonuses by equipping their vehicles with innovative technology.[24] However, in 2021, the provision that allowed carmakers to only present 95% of their fleet for evaluation was withdrawn. Following these various adjustments, the emissions limit allocated to each carmaker by the EU can be significantly different: ranging from 100 gCO_2/km for Kia, Hyundai and Renault-Nissan-Mitsubishi group, and up to 133 gCO_2/km for Volvo in 2022.[25]

In 2021, average emissions by car manufacturers amounted to 115 g/km in Europe, compared to 131 g/km in 2020 (12%). After applying the flexibility mechanisms, exemptions and bonuses allowed by the European standard **(SEE BOX 1)**, the

b Leading carmakers (Toyota, Renault-Nissan, Volkswagen, BMW, etc.) and major economies (France, Germany, China, USA, etc.), which nevertheless have individual targets to transition towards electric vehicles and/or phase out thermal vehicles, did not sign the agreement.

c The global vehicle standard *Worldwide Harmonized Light Vehicles Test Procedure* (WLTP) replaced the *New European Driving Cycle* (NEDC) in 2021, whose shortfalls came to light during the Dieselgate crisis. Consequently, WLTP values are higher than NEDC values. In the 2021 Global Synthesis Report on Climate Action by Sector, the figures given are still based on the NEDC standard; the level of the results presented here is therefore different, but the trend from one year to the next remains downward.

average drops to 113 g/km. All carmaker groups reached and exceeded their targets with variable margins: from a margin of 1 gCO_2/km for Renault-Nissan-Mitsubishi (109 g/km, for a target of 110) to 96 gCO_2/km for Tesla-Honda-Jaguar Land Rover, which attained 33 gCO_2/km for a target of 129.[26] Honda and Jaguar Land Rover benefit from the results of Tesla, which only sells BEVs, just as Fiat-Chrysler, which is now part of the Stellantis pool, did last year. The transaction cost paid to enter this group has not been disclosed. Overall, these positive results demonstrate the further penetration of electric vehicles in the fleets of vehicle manufacturers.

BYD outstripped Tesla to become the leading producer of electric cars in the first six months of 2022. The Chinese carmaker sold a reported 641,000 vehicles, which is an increase of 300% in one year, compared to 564,000 for Tesla. Tesla appears to have particularly suffered from the lockdown in Shanghai, where BYD does not have a factory.[27] However, most BYD vehicles are PHEVs, which always partly use a thermal engine. Even more remarkable, BYD has overtaken LG as the world's number two producer of batteries, behind a Chinese company called Contemporary Amperex Technology (CATL). BYD and Shell have signed a strategic cooperation agreement in Europe and China. In Europe, the two companies will form a pan-European Mobility Service Provider (MSP) to provide BYD's private and commercial clients with subscriber access to a network of Shell electric charging stations. In China, a joint venture is due to be launched to equip the city of Shenzhen with over 10,000 electric charging stations.[28]

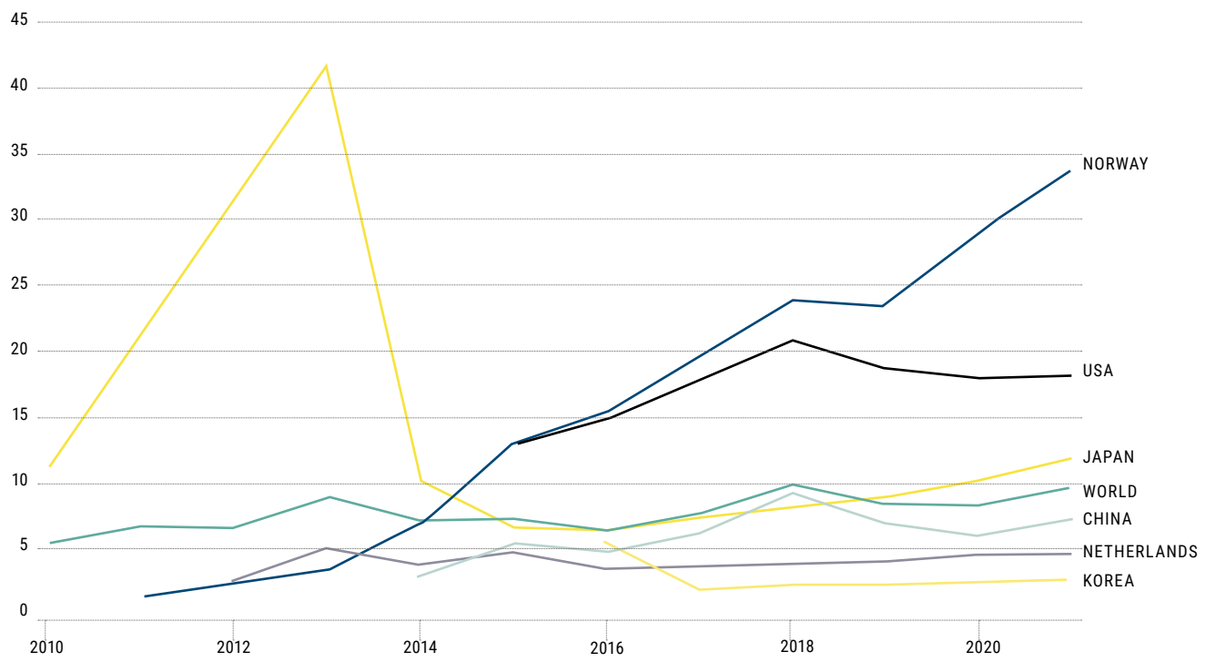
Electric vehicles are increasingly popular as company cars. The Corporate Electric Vehicle Alliance is an initiative run by Ceres and gathers companies committed to accelerating the electrification of their corporate fleets. In early 2022, Ceres presented major carmakers with the results of a survey of its members: companies like Amazon, Best Buy, DHL, Hertz, Schindler Elevator and T-Mobile confirmed that they were ready to order 330,000 EVs in the next five years in the United States.[29] In 2021, 31 new companies joined EV100, an initiative launched by the Climate Group to make company fleets electric. The initiative now covers 98 markets in the world, with a total commitment to 5.5 million electric vehicles. In 2021, EV deployment in corporate fleets grew by 42%; 53,361 EVs had been integrated, taking the number of operating electric company cars to 209,654. EDF has the biggest EV fleet (6,331 units) among EV100 members, and recorded the highest growth in 2021, followed by E.ON and BT Group.[30]

The ride-hailing sector is shifting more slowly towards electric vehicles. Yet market leaders Uber, Lyft and Didi Chuwing, as well as some local governments like California, have made formal commitments to ensuring 100% electric fleets by 2030. In Brazil, the e-hailing app 99, Uber's main competitor in the country, has moved into a partnership with BYD to test the deployment of EVs in Sao Paulo.[31] However, the electrification of ride-hailing fleets in Europe, the United States, and Canada is slower than the rest of the market, according to a study by the World Resource Institute (WRI).[32] The authors identify three major obstacles to ride-hailing electrification: the high cost

FIGURE 3

ELECTRIC LIGHT-DUTY VEHICLE PER CHARGING POINT IN SELECTED COUNTRIES, 2010-2021

Source: IEA, 2022



of purchasing an EV for drivers; the lack of rapid charging solutions that are inexpensive and easily accessible at night; and insufficient information and awareness of drivers about electric vehicles. Although Uber pays its drivers an extra $1 per hour for driving an EV, last year Bloomberg identified reports of late payments. The partnership signed by Hertz in October 2021,[33] which aims at making it easier for drivers to rent Tesla vehicles, is also out of reach for a large number of drivers.[34] Some cities stand out as exceptions. In Amsterdam, where over 6.5% of Uber vehicles are electric, the installation of charging stations corresponding to user requests has made it easier to equip different areas of the city to meet drivers' requirements. In London, where Uber works closely with the municipality, the Californian firm claims that nearly 90% of new drivers use 100% electric cars.[35] To meet its target of 100% electric activities in the British capital by 2025, Uber recently extended its "Uber Green" service from Zone 1 to cover the entire city of London.[36] In India, Delhi has become the first territory in the country to make electric cars obligatory for some new taxis (in particular two- and three-wheelers), and numerous start-ups are taking part in this burgeoning market: with 1,000 electric four-wheelers, BluSmart is the biggest 100% electric ride-hailing company in the country.[37]

The number of electric charging stations accessible to the public went up by 40% in 2021, which is 500,000 new stations installed in the world.[38] 85% of these charging stations are located in China. On a global scale, the International Energy Agency observes that the EV/public charging station ratio tends to drop as the proportion of BEVs in the automobile fleet rises (**FIG. 3**). In China, Korea, and the Netherlands, this ratio has remained relatively stable since 2015, indicating that the charging network is developing at a similar pace as the EV market. In Norway and the United States, where the number of individual houses with garages is very high, the ratio is greater than average and on an upward trend due to the predominance of home charging stations. The European Union, which in 2014 established in its AFID (Alternative Fuel Infrastructure Directive) an objective of one charging station for ten electric vehicles by 2020, has not reached its goal (1/14 in 2021).[39] The revised EU Energy Performance of Buildings Directive could make it obligatory to install charging stations in carparks in new buildings. At COP26, then prime minister Boris Johnson announced a plan to make the installation of electric charging plugs obligatory in all new housing featuring private parking starting from 2022.[40]

In the United States, cities are starting to restrict and even prohibit the construction of new gas stations. Petaluma, a city with 60,000 inhabitants in California, was the first town in the world to change its building code to ban not only the construction of new gas stations, but also the extension of existing ones. In contrast, state senators in Raleigh, North Carolina, introduced a bill to remove free electric charging stations unless gasoline and diesel are also offered at no fee. The Infrastructure Investment and Jobs Act passed by Joe Biden in November 2021 establishes an investment of $7.5 billion to support the installation of electric charging stations with the aim of reaching 50% sales of electric vehicles in 2030, compared to 2% currently.[41] The Inflation Reduction Act, which was finally voted by the House of Representatives in August 2022, establishes a new tax credit of $ 7,500 for the purchase of an electric vehicle. The aim is not just to accelerate sales and the transition of the automobile fleet, but to initiate a shift towards national supply chains: only vehicles assembled in the United States qualify for the tax credit.[42]

In fact, following the trend of 2021, electrification of transport is not just motivated by climate and energy targets; states and non-state actors are also keen to establish strategic autonomy, involving domestic battery production and a secure supply of critical resources.

Europe and the United States move towards local battery production

Global battery production grew by 83.4% in the space of a year, to reach 122.9 GWh between January and April 2022. China alone was responsible for 77% of the lithium-ion batteries produced in the world in 2020.[43] Asian producers largely dominate the market: the Chinese company CATL (33.7% market share) is ahead of the Korean LG Energy Solution (12.8%) and Chinese carmaker BYD (12.1%). Despite the pandemic and temporary factory closures, like the Tesla Gigafactory in Shanghai, each of these companies has doubled, sometimes tripled, its annual battery production.[44] The average price of a battery continues to drop, reaching $132/kWh at the end of 2021, compared to $140/kWh in 2020 and $1,200/kWh in 2010.[45]

However, the ten-year downward trend of the cost of electric batteries took a remarkable U-turn during the second half of 2022 due to the combined effect of increased demand and the inflation of raw materials that has put a strain on supply chains. The cost of Li-ion[d] batteries went from $105/kWh in 2021 to $160/kWh in April 2022.[46] On average, the prices of batteries produced in the United States and Europe are 40% and 60% higher than in China, according to BloombergNEF, which monitors annual trends. Yet the price of the battery represents 40% to 60% of the cost of an electric vehicle.[47] With the high growth of the global electric vehicle market, this sudden inflation is spurring manufacturers and states to find ways of bringing battery production closer to automobile manufacturing sites.

In order to get away from this double exposure to the domination of Asian actors and the pressure of inflation in a high-demand situation, Europe and the United States have launched into a veritable race to produce electric batteries. These projects are the result of joint investments involving automobile manufacturers, electronics companies, and public support. As part of the Infrastructure Investment and Jobs Act voted in November 2021 by the US Congress, $7 billion were earmarked to help companies develop projects to produce and recycle electric batteries in the country.[48] Since 2017, the European Battery Alliance (EBA) has allocated public funds and

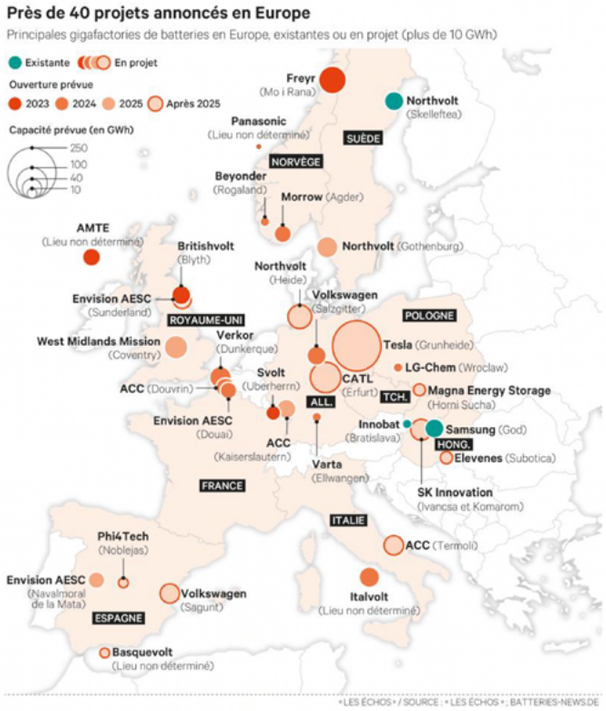
d Lithium-ion batteries are generally produced for electromobility, unlike lead batteries. This family includes Nickel-Manganese-Cobalt (NMC) batteries, which are the most common because they have the best energy density, and Lithium-Fer-Phosphate (LFP) batteries, which are more stable and have higher storage capacities.

authorized state aid for the development of battery-related projects; in a press release in February 2022, the EBA listed 111 projects developed around Europe amounting to a total investment of €127 billion throughout the entire value chain.[49]

Close to 1,400 GWh of "Gigafactories" are planned in Europe **(FIG. 4)**, which is enough to equip about 17.5 million vehicles a year in 2030.[50] Overall, close to forty Gigafactories have been announced. To date, only three factories manufacturing batteries for electric vehicles are operational in Europe: a small pilot and R&D factory opened by InoBat in early 2022 in Slovenia; a factory operated by Samsung since 2017 in Göd, Hungary (40 GWh); and in particular Northvolt Ett, in Sweden. In December 2021, this Gigafactory with a capacity of 60 GWh announced the very first lithium-ion battery cell to be designed, developed and assembled by a European company.[51] Northvolt has already secured supply contracts worth the equivalent of $50 billion with carmakers like BMW, Scania, Volkswagen, and Volvo, and made its first commercial deliveries in June 2022.[52] In 2022, Northovolt announced the opening of two new sites in the next few years, in a former paper mill close to Gothenburg in northern Germany.

FIGURE 4

EXISTING OR PLANNED BATTERY GIGAFACTORIES IN EUROPE (OVER 10 GWH) - *Source: Les Échos, 10/07/2022*



The latest projects include one by Volkswagen, which holds 20% shares in the Northvolt Ett factory. The carmaker announced the creation of a new company, "PowerCo", which will develop five Gigafactories in Europe, the first of which is planned in Salzgitter, Germany. In total, the automobile group plans investing €20 billion and creating almost 20,000 jobs.[53] Also in Germany, Tesla opened the biggest Gigafactory in Europe in spring 2022, in Grünheide, near Berlin. With a capacity of 100 GWh, the factory is due to start manufacturing in the second half of 2022 – initially 30,000 units for the first six months, and eventually up to 500,000 cars per year.[54] In the United States, the Energy Department has reported thirteen Gigafactory projects due to start operating in 2025.[55] Recently, Stellantis and Samsung announced their intention to invest €2.3 billion to construct and operate a new Gigafactory in Indiana,[56] while Honda has teamed up with LG Energy Solution to invest $4.4 billion in a new 40 GWh factory.[57]

BOX 2 • **KEYS TO UNDERSTANDING**

THE CRITICALITY OF METALS IS ALL RELATIVE

The "criticality" of metals depends on two factors: the risks related to its supply (geological availability, concentration of extraction and production, political stability of producing countries, etc.), and how important it is for economies. Different appreciations of these factors result in different evaluations of how critical metals are, depending on the economic area, context, and period: the latest list produced by the European Union in 2020 qualifies 30 materials as "critical", compared to only 14 in 2011, while the United States list 35, Japan 34, and China 24. These lists feature metals that are rare from a geological point of view along with abundant metals subject to high pressure from anticipated demand (copper, bauxite, and even "rare earths") or the political and environmental contexts involved in their extraction when they are very geographically concentrated (e.g., cobalt in the Democratic Republic of the Congo – DRC).

Sources: BRGM, 2018; Commission européenne, 2020; Interior Department of the United States, 2019; Andersson, P., 2020

The relocation of strategic minerals comes up against local opposition

Apart from battery production, another significant imbalance affects the top of the value chain: the concentration of capacities to produce, refine and process critical metals **(SEE BOX 2)**. The Democratic Republic of Congo for example extracts 70.9% of the world's cobalt, China 59% of rare earths[e] and 67.1% of graphite, and Australia 52.3 % of lithium. The DRC also features 51.4% of global cobalt reserves, while China, Brazil and Russia have 68.4% of the world's rare earths, and the sub-soil

e "Rare earths" are a group of 17 metals that are not rare in the true sense of the term, but whose concentrations in the Earth's crust are very low, which makes them costly to extract in terms of energy. They have remarkable catalytic, magnetic, electric, chemical, optical and heat-resistant properties, making them indispensable for numerous technologies such as smartphones, LCD screens, low-energy bulbs, lasers, permanent magnets in wind turbines, particularly offshore, and weapons.

of Chile and Australia harbours almost three-quarters of the lithium available in the world.[58] The distribution is even more impressive further down the value chain, with China alone concentrating the vast majority of capacities to refine and process all of these metals,[f] and a very high proportion of global production capacities.

In an ultimate symbol of the convergence between the issues of environmental transition and geostrategic independence, in early March 2022 President Joe Biden invoked the Defense Production Act dating from the Korean War era to free up additional credits to accelerate the production of strategic metals for the country's energy transition.[59] The United States currently only has one rare earth mine (Mountain Pass in California), but numerous other projects are under development.

The production of strategic minerals kindles economic nationalism, including in emerging countries that want to take advantage of their raw materials to integrate value chains and improve added value. In Mexico, President Andres Manuel Lopez Obrador announced in April 2022 the creation of a state company, Litio para México, to explore and exploit lithium and control the value chain.[60] One year earlier in April 2021, the Korean LG Energy Solutions (LGES), which dominates the rechargeable battery market, signed a memorandum of agreement with four Indonesian state companies to form the Indonesian Battery Corporation.[61] The prohibition of nickel exports decided in January 2020 by the government has reportedly already boosted domestic investments.[62] Once refined, nickel sulphate is an essential element used to make cathodes in domestic batteries and li-ion batteries used in electric vehicles. The ambition of the Indonesian president Joko Widodo is to develop an integrated national economic industry, from mining to battery production, rather than only export raw materials. In the Democratic Republic of the Congo, in February 2022, a court withdrew the control of one of the biggest cobalt mines in the world from China Molybdenum, suspected of tax fraud.[63] The Congolese government intends to take back control of cobalt production through its state company Gécamines, bolstered by an anticorruption campaign and a rapprochement between President Tshisekedi and his American counterpart Joe Biden, concerned by Chinese control of the supply chain.[64] With a view to strengthening its dominating position, China has authorized a merger between China Minmetals Rare Earth Co, Chinalco Rare Earth and Metals Co, and Ganzhou Rare Earth Group, to form a single group under the authority of central government, the China Rare Earth Group, which will control 70% of the national production of rare earths.[65]

But this ambition to open new mines is coming up against opposition from a civil society that sometimes turned the page of its mining history years ago. In January 2022, the Serbian government ended up revoking the operating license of the Anglo-Australian group Rio Tinto to open one of the biggest lithium mines in the world in the Jadar Valley. The mining giant, which had planned to invest $2.4 billion, came up against strong opposition from local inhabitants and politicians.[66] In Portugal, the project to open a lithium mine by Savannah Resources in the Barroso region, which is a world agricultural heritage site located 150 kilometres northeast of Porto, has also stirred up protests.[67] The mine could have the capacity to provide lithium for 500,000 EVs over almost ten years. In France, in the Finistère area, 600 people carried out a "preventive" demonstration against any plans to extract lithium in a Natura 2000 area, after the *Bureau des Ressources Géologiques et Minières* published a map showing the region's potential.[68] In Indonesia, increasing numbers of activists have been arrested since the 2020 revision of the mining law: in 2021, 53 people faced criminal charges for opposing mining projects.[69] A last example is in the United States, were native American peoples are joining forces to combat the Thacker Pass project, destined to become the biggest lithium mine in the country, and constructed by the Lithium Nevada Corporation. During the project's 41-year lifespan, the mine is expected to produce 80,000 tonnes of lithium carbonate a year, which is the equivalent of a fifth of global production in 2020.[70]

Manufacturers and suppliers join forces in their quest for supply security

Throughout the entire market, manufacturers are tending to move closer to suppliers by signing contracts to supply strategic metals. The Stellantis group (PSA/ Fiat-Chrysler) signed a lithium supply contract with Vulcan Energy for its European factories. This young Australian company is developing a project called "Zero Carbon Lithium" in Germany, aimed at employing geothermal energy to produce lithium hydroxide from brine. It has agreed to supply Stellantis with a minimum of 81,000 tonnes of lithium hydroxide for five years starting in 2026. The project is similar to and in competition with an initiative developed by Eramet in the Alsace region of France **(SEE ASLACE CASE STUDY)**. Renault and battery manufacturer LG have also signed supply contracts with the Australian firm.[71] On the US market, Stellantis has secured an agreement with Controlled Thermal Resources (CTR) to supply it with lithium hydroxide produced in California. CTR will therefore provide 25,000 tonnes a year to the carmaker during the next ten years, in order to manufacture batteries in North America.[72] On its side, Ford has announced that it has secured supplies to produce 600,000 EVs starting from 2023; for example, via a recent joint venture with Ioneer Ltd, a lithium producer soon to open up a base in Nevada.[73] Taking advantage of a diplomatic trip by German Chancellor Olaf Scholz to Canada in August 2022, Volkswagen and Mercedes-Benz signed agreements with the Canadian federal government to secure their supplies of lithium, nickel, cobalt and graphite, which are abundant in Ontario.[74]

Another way for manufacturers to guarantee their resources is to acquire a stake in companies located upstream in the value chain. For example, Stellantis, in addition to its supply contract, has also become the second shareholder of Vulcan Energy.[75] These strategies are not exclusive to large carmakers,

f From 35% for nickel to 50-70 % for lithium and cobalt, and up to 90% for rare earths, according to IEA figures. Source: IEA, 2021

and other midsize actors are asserting their strategic position in the value chain. Plastic Omnium, for example, global leader in the manufacture of bumpers and tank systems, is set to acquire Actia Power, a branch of the Toulouse-based group Actia, which specializes in the design and manufacture of embedded batteries, power electronics and electrification systems for the electric mobility of trucks, buses, coaches, trains and construction machines.[76]

Battery recycling, a value chain shortcut that is still a long way off

The new frontier of electric mobility is battery recycling, which introduces another geostrategic challenge into the international competitive context surrounding metal supplies.[g] According to IEA, global capacities for battery recycling in 2021 amounted to 180,000 t/year, half of it in China.[77] Japan, France and Germany offer most of the current and planned recycling capacities. Whatever the case, the global capacity for recycling is still far below what is put on the market, and remains the poor relation of industries' regionalization strategies. In the best-case scenario, the IEA deems that recycling could for example meet up to 12% of global cobalt demand and 5% of lithium in 2040. In the European Union, only 12% of aluminium, 22% of cobalt, 8% of manganese, 16% of nickel and almost no lithium is currently recycled.[78]

BOX 3 • **KEYS TO UNDERSTANDING**

HOW LI-ION BATTERIES ARE RECYCLED

The recycling process for li-ion batteries is broken down into four stages. The first stage is stabilization to discharge the battery pack, followed by pre-treatment, which involves dismantling the battery pack to isolate the modules. At the end of this stage, the modules are either dismantled or crushed before being separated into different materials. A "black mass" is then obtained containing hydrophobic carbon and hydrophilic metal oxides.

Two processes are used at this point to recycle lithium-ion batteries: hydrometallurgy and pyrometallurgy. Pyrometallurgy is the most common, and basically involves heating the battery to a high temperature to recover a metal alloy. This is a standard technique for recycling metals that has been adapted for electric vehicle batteries. Nevertheless, the operation has a limited yield, insofar as it is difficult to remove metals with high added value, such as cobalt, lithium, nickel and manganese, from the alloy. Hydrometallurgy is an emerging technique that involves dissolving the "black mass" in solvents (leaching), so that the different metals can be isolated. Hopes are pinned on employing this technique to put the strategic minerals found in batteries back into circulation.

Source: Culture Sciences Chimie, 2021

Quebec plays a pioneering role on the international scene for recycling li-ion batteries.[h] Thanks to an electric mix dominated by 95% hydropower, Quebec is well-suited to the electrification of uses, in particular transport, which represents 43% of the province's emissions. With its strategy to develop the battery industry, Quebec aims to position itself among global leaders at every stage of the industry, from mineral extraction from its rich subsoils to battery manufacturing, and including assembly and the manufacture of anodes and cathodes. The young Montreal-based company Recyclage Lithion receives support from the provincial government, which is one of its shareholders. A demonstration factory with a 200-tonne capacity was opened in 2020 in Anjou, a district of Montreal. The next step is a li-ion crushing site, due to open in 2023, with a capacity of 7,500 tonnes of batteries per year, or 25,000 EVs. Recyclage Lithion recently raised an additional CAN$125 million to feed into its investment plan of CAN$350 million over five years.[79] Li-Cycle, another Canadian company based in Toronto with a strong presence in North America, plans to open two battery recycling factories in Germany and Norway in early 2023, and to reach a recycling capacity of 65,000t/year by the end of 2023.[80]

Demand for recycled matter in Europe is growing with the opening up of new Gigafactories. Northvolt for example has committed to employing 50% recycled raw materials in 2030. French mining company Eramet and urban services giant Suez are planning a battery recycling factory project in France due in 2024,[81] at the same time as BASF in Germany.[82]

KEY TAKEAWAYS

The sharp rise in automobile sales in 2021 after the slump caused by Covid-19 continues the two-way trend from the last few years. While sales of new electric vehicles are picking up speed in Europe and China with: one vehicle in five sold in the world is now rechargeable electric (BEV and PHEV); SUVs are increasing their market share, pushing up the average size, weight and consumption of vehicles. One vehicle in two sold in the major economies is an SUV, and electric vehicles are no exception. The material result of this trend is an increased need for critical metals. Requirements for minerals indispensable for the production of electric batteries (lithium, nickel, cobalt) are intensifying international competition. Carmakers, battery manufacturers, mining companies, states and local governments are part of a mad race to secure their supply of raw materials, in a situation where value chains are highly concentrated between a few countries. In the United States and Europe, the regionalization and relocation of battery and critical mineral production is confronted with local opposition, which underlines the contradictions between creating low-carbon industries and preserving the environment. The same is true in emerging countries, where the vertical integration of value chains capitalising on mineral resources is being challenged. Finally, the concentration of value chains around a handful of dominant players upstream and downstream of the automotive sector is confirmed.

g For a detailed analysis of battery recycling capacities, see: "Recycling Lithium-ion Batteries, the New Frontier in the Electrification of Mobility", page 162 in Observatory of Non-State Climate Action (2021). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

h Idem.

REFERENCES

RETURN TO PREVIOUS PAGE

1 Enerdata, Global Energy & CO_2 Database

2 IEA (2021). Tracking Transport 2021. *International Energy Agency*

3 OICA (2022). Global Sales Statistics 2019-2021. *International Organization of Motor Vehicle Manufacturers*

4 IEA (2022). Global EV Outlook 2022. *International Energy Agency*

5 ACEA (20/07/2022). New car registrations by fuel type, European Union. *European Automobile Manufacturers Association*

6 Banerji, S. (06/01/2022). Electric two wheelers register a staggering 132% growth in 2021 but 2022 promises to be event better. *Economic Times*

7 Dalvi, A. (13/07/2022). EVs account for 3.6 percent of two-wheeler sales in first half of 2022. *Autocar India*

8 Kamboj, P., Malyan, A., Kaur, H. et al. (2022). India Transport Energy Outlook. *Council on Energy, Environment and Water*

9 Cozzi, L., Petropoulos, A. (21/12/2021). Global SUV sales set another record in 2021, setting back efforts to reduce emissions. *International Energy Agency*

10 *Ibid.*

11 Kane, M. (21/08/2021). Electric cars from heaviest to lightest. *InsideEVs*

12 Ademe (2021). Évolution de la masse moyenne – Véhicules particuliers neuf vendus en France.

13 Walton, E. (29/04/2021). How much does a car weigh? *Autolist*

14 Weiss, M., Cloos, K. C., Helmers, E. (2020). Energy efficiency trade-offs in small to large electric vehicles. *Environmental Sciences Europe*, vol. 32 (46)

15 IEA (2021). The Role of Critical Minerals in Clean Energy Transitions. *International Energy Agency*

16 *IEA (2022). Global EV Outlook 2022, op. cit.*

17 Department for Business, Energy & Industrial Strategy, Department for Transport (up. 28/06/2022). COP26 declaration on accelerating the transition to 100% zero emission cars and vans. *Government of United Kingdom*

18 Karlamangla, S. (29/08/2022). What to Know About California's Ban on New Gasoline-Powered Cars. *The New York Times*

19 Melillo, G. (30/08/2022). Several states will follow California's lead in banning gas-powered car sales by 2035. *The Hill*

20 Dow, J. (01/04/2022). Canada's new 2035 gas car ban may not actually ban gas cars. *Electrek*

21 Ministerio de Energia, Gobierno de Chile (15/10/2021). Lanzamiento Estrategia Nacional de Electromovilidad: Gobierno anuncia que al 2035 se venderán solo vehículos eléctricos en Chile. *energia.gob.cl*

22 Abnett, K. (08/06/2022). EU lawmakers back ban on new fossil-fuel cars from 2035. *Reuters*

23 REGULATION (EU) 2019/631 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 April 2019 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011

24 European Commission (n.d.). CO_2 emission performance standards for cars and vans. *ec.europa. eu*

25 Mock, P., Tietge, E., Wappelhorst, S., Bieker, G., Dornoff, J., Bernard, M.R. (01/09/2021). Market monitor: European passenger car and light-commercial vehicle registrations, January–July 2021. *The International Council on Clean Transportation*

26 Tietge, U., Dornoff, J., Mock, P., Diaz, S. (2022). CO_2 emissions from new passenger cars in Europe: Car manufacturers' performance in 2021. *The International Council on Clean Transportation*

27 White, E., Li, G., Jung-a, S. (05/07/2022). Warren Buffett-backed Chinese group BYD overtakes Tesla in global electric vehicle sales. *Financial Times*

28 BYD (24/03/2022). BYD and Shell partner on EV charging across China and Europe. *BYD*

29 Corporate Electric Vehicle Alliance (20/01/2022). Major companies with large fleets release new electric vehicle 'blueprint' for car and truck... *Ceres*

30 EV100 (2022). EV100 Progress and Insights Report 2022. *Climate Group*

31 Reuters (12/07/2022). Brazilian ride-hailing app 99 to test electric car with China's BYD. *Reuters*

32 Lazer, L., Wachche, S., Sclar, R., Cassius, S. (2021). Electrifying Ride-Hailing in the United States, Europe, and Canada: How to Enable Ride-Hailing Drivers to Switch to Electric Vehicles. *World Resources Institute*

33 Bellon, T. (27/10/2021). Uber partners with Hertz to offer 50,000 Tesla rentals to U.S. ride-hail drivers. *Reuters*

34 Marshall, A. (22/03/2022). California's Plan to Electrify Uber and Lyft Doesn't Add Up. *Wired*

35 Trudell, C. (05/05/2022). Uber's Push to Electrify London Turns Former Foes Into Partners. *Bloomberg*

36 Hampel, C. (04/04/2022). Uber expands EV options to the whole of London. *Electriv*

37 Roy, S. (14/03/2022). Delhi: How ride-hailing startups with electric vehicle-only. *The Times of India*

38 *IEA (2022). Global EV Outlook 2022, op. cit.*

39 *Ibid.*

40 Reuters (22/11/2021). UK to require charge points for electric vehicles in new buildings. *Reuters*

41 Williams, A. (24/07/2022). US states divided over petrol stations as LA considers ban on new pumps. *Financial Times*

42 Rezvani, A. (19/08/2022). What the Inflation Reduction Act means for electric car buyers and auto companies. *NPR*

43 Yu, A., Sumangil, M. (16/02/2021). Top electric vehicle markets dominate lithium-ion battery capacity growth. *S&P Global Market Intelligence*

44 Choo, C. (03/06/2022). Global EV battery makers raise output by 83% on year in January-April: SNE Research. *S&P Global*

45 BNEF (30/11/2021). Battery Pack Prices Fall to an Average of $132/kWh, But Rising Commodity Prices Start to Bite. *BloombergNEF*

46 Lienert, P., Carey, N. (20/04/2022). Analysis: Soaring battery costs fail to cool electric vehicle sales. *Reuters*

47 IEA (2021). The Role of Critical Minerals in Clean Energy Transitions. Agence internationale de l'énergie

48 Plautz, J. (15/02/2022). DOE makes $3.1B available for battery manufacturing incentives. *Utility Dive*

49 Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (23/02/2022). European Battery Alliance moves ahead: new European Battery Academy launched to boost skills for fast-growing battery ecosystem in Europe. *European Commission*

50 Feitz, A. (10/07/2022). En Europe, la course aux gigafactories. *Les Échos*

51 Northvolt (29/12/2021). Northvolt assembles first lithium-ion battery cell at Swedish Gigafactory. *Northvolt*

52 Northvolt (22/06/2022). Europe's first homegrown gigafactory delivers. *Northvolt*

53 Feitz, A. (10/07/2022). Volkswagen : coup d'envoi d'une offensive massive dans les batteries. *Les Échos*

54 Graupner, H. (22/03/2022). Tesla's first European Gigafactory opens near Berlin. *Deutsche Welle*

55 DoE (20/12/2021). FOTW #1217, December 20, 2021: Thirteen New Electric Vehicle Battery Plants Are Planned in the U.S. Within the Next Five Years. *Department of Energy*

56 Kane, M. (24/05/2022). Stellantis And Samsung SDI To Build Battery Gigafactory In Indiana. *InsideEVs*

57 Reuters (20/08/2022). Honda Motor, LG Energy to build $4.4 bln U.S. EV battery plant. *Reuters*

58 BP (2021). Statistical Review of World Energy. *British Petroleum*

59 Williams, A. (10/05/2022). Powering electric cars: the race to mine lithium in America's backyard. *Financial Times*

60 Reyes, C. (23/08/2022). Nace la empresa Litio Para México; Diario Oficial publica el decreto. *El Universal*

61 Ekonid Insight (01/04/2021). Indonesia launches Indonesia Battery Corporation. Perkumpulan Ekonomi Indonesia-Jerman

62 Gupta, K. (30/03/2022). Indonesia's claim that banning nickel exports spurs downstreaming is questionable. *The Conversation*

63 Lipton, E., Searcey, D. (28/02/2022). Chinese Company Removed as Operator of Cobalt Mine in Congo. *The New York Times*

64 Searcey, D., Forsythe, M., Lipton, E. (20/11/2021). A Power Struggle Over Cobalt Rattles the Clean Energy Revolution. *The New York Times*

65 Yu, S., Mitchell, T. (23/12/2021). China merges 3 rare earths miners to strengthen dominance of sector. *Financial Times*

66 Dunai, M., Hume, N. (20/01/2022). Serbia pulls plug on planned Rio Tinto lithium mine. *Financial Times*

67 Morel, S. (04/02/2022). La fièvre du lithium gagne le Portugal. *Le Monde*

68 Collet, V. (26/02/2022). Finistère: 600 personnes contre une exploitation de lithium à Tréguennec. *Le Figaro*

69 Jong, H. N. (09/02/2022). In Indonesia, a 'devious' policy silences opposition to mining, activists say. *Mongabay*

70 Stone, M. (28/10/2021). Native opposition to Nevada lithium mine grows. *Grist*

71 Thoin-Bousquié, J. (29/11/2021). Stellantis va se fournir en lithium made in Allemagne auprès de Vulcan Energy pour ses batteries. *L'Usine Nouvelle*

72 Randall, C. (03/06/2022). Stellantis is buying lithium from California. *Electrive*

73 Boudette, N. E. (21/07/2022). Ford increases its battery supply to meet its electric-vehicle goals. *The New York Times*

74 CBC News (23/08/2022). Agreement with German automakers 'unprecedented' for Canada, says auto industry insider. *CBC*

75 Stellantis (24/06/2022). Stellantis Expands Relationship with Vulcan Energy Becoming Shareholder in Decarbonized Lithium Company. *Stellantis*

76 AFP (27/06/2022). Plastic Omnium va acquérir une branche d'Actia, dédiée notamment à la fabrication de batteries électriques. *Connaissance des Énergies*

77 Hund, K., La Porta, D., Fabregas, T. P., et al. (2020). Minerals for Climate Action : The Mineral Intensity of the Clean Energy Transition. Banque mondiale

78 European Parliament (2021). Briefing. New EU regulatory framework for batteries. Setting sustainability requirements. *europarl.europa.eu*

79 Tomesco, F. (24/01/2022). Lithion Recycling raises $125 million, moves closer to recycled battery production. *Montreal Gazette*

80 Lazzaro, N. (14/06/2022). Li-Cycle to reach 65,000 mt battery recycling capacity by end-2023. *S&P Global*

81 Reuters (16/03/2022). Eramet, Suez eye EV battery recycling in France by 2024. *Reuters*

82 Lewis, M. (20/06/2022). BASF is going to build a commercial battery-recycling, black-mass plant. *Electrek*

TREND
AVIATION

Air traffic takes off again, leaving the climate transition on the tarmac

OPHÉLIE CUVILLARD • Research Assistant, Global Observatory of Climate Action, Climate Chance
ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance

Following an unprecedented paralysis of the aviation sector caused by the pandemic, airlines and airports are almost back to their "normal". Despite some regional and inter-sectoral differences, air traffic is on track to return to 2019 levels and exceed them in 2023. While the sector prepares for exponential growth in demand, the current energy crisis underlines the unsustainability of a fuel based on fossil energy. To reconcile geopolitical and ecological priorities, the chosen strategy appears to be the decarbonization of fuel and aviation activities, rather than modal shifts in transport demand.

DATA OVERVIEW

Despite turbulence, air traffic successfully takes off again

Since the 2000s, commercial flights have grown by 5% per year on average, leading to a 2% annual increase in CO_2 emissions.[1] Emissions from the sector amounted to 905 megatonnes of CO_2 in 2019, double the level of 2000. They make up 2.8% of global annual emissions – but contribute over 3% of radiative forcing[a] – and constitute 10.9% of emissions from the transport sector, ranking the aviation sub-sector second after road transport.[2] Although aviation went took a nosedive in 2020 with the Covid-19 crisis, it has picked up speed since restrictions began to relax in mid-2021. In 2022, the sector's recovery is confirmed, with a return to 2019 levels expected in 2023,[3] while only a year ago, this recovery was not expected until 2024.[4] *"Aviation is resilient and on the rise,"*[5] headlines a new report by the International Air Transport Association (IATA). Total traffic in July 2022 reached 74.6%[6] of its July 2019 level. Emissions have also started to increase once more: following a drop from 905 $MtCO_2$ in 2019 to 495 Mt in 2020, they rose again to reach 577 Mt in 2021 and are expected to total 809 Mt in 2022.[7] Losses for the industry went down from $137.7 billion in 2020 to $42.1 billion in 2021 and are not likely to exceed $9.7 billion in 2022. While all regions have seen their financial performance improve, only North America chalked up a positive margin in 2022.[8]

The recovery of traffic has been driven by domestic travel (domestic flights in July 2022 were at 86.9% of their July 2019 level) but international flights are catching up (in July 2022, they amounted to 67.9% of their July 2019 level). In any case, the impact of the pandemic on domestic flights was not so great as for international travel: international passenger flights dropped 74% over the whole of 2020 (and up to 98% in April), while domestic flights only decreased by 49%. In 2022,[9] the regional distribution of aviation activity saw some notable changes compared to 2019.[10] Asia-Pacific shrank from 34.7% to 27.5 % of the market, Europe from 26.8% to 25%, the Middle East from 9% to 6.5%, and Africa from 2.1% to 1.9 %. Two regions saw their share increase: Latin America moved from 5.1% to 6.6%, and North America from 22.3% to 32.6%. These changes can partly be put down to the slower recovery of the Asia-Pacific region **(FIG. 1)**, due to continued health restrictions in China.

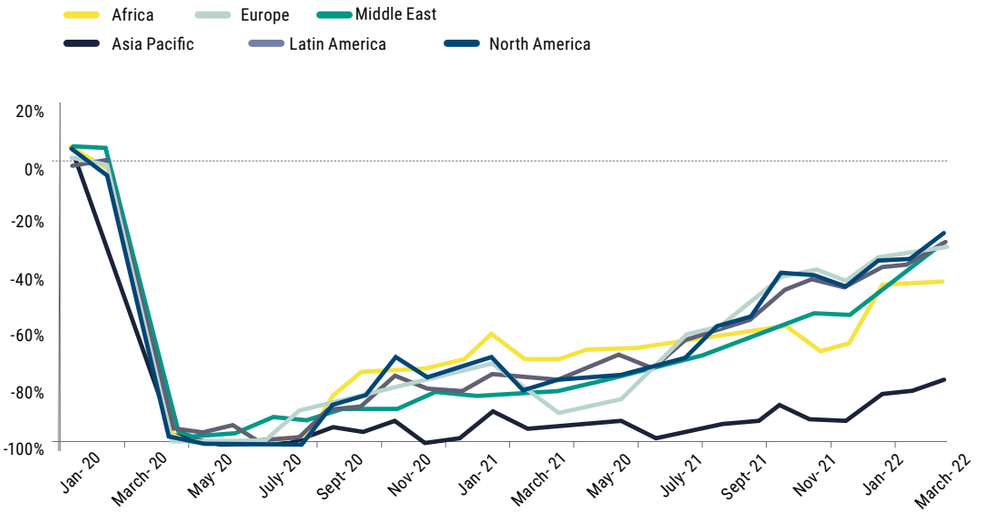
Away from the spotlight, the pandemic provided an opportunity for new airlines to enter the market. An academic study shows that following the most serious crises affecting the sector over the last twenty years, i.e., the aftermath of 9/11, the 2007 financial crisis, and the 2010 debt crisis in Europe, the aviation sector has emerged stronger each time.[11] According to the same study, the pandemic – or future pandemics – could be a boon for start-ups in the aviation sector, mostly because they are more flexible in the face of demand. The pandemic also perturbed the distribution of operating staff – pilots, flight attendants, etc. – prepared to accept new posts. Bearing in mind that start-ups generally manage to establish themselves in closed markets thanks to new technologies, the pandemic gave them greater margins for manoeuvre in terms of investment compared to companies in debt. Other reasons related to market perturbation are highlighted in the study. Of the 46 airline start-ups during the pandemic analysed, most are located in Europe, low cost, and designed to carry out regional or domestic flights. These young companies also tend to find their position on the market, not thanks to new green technologies, but because they offer additional, cheaper flights. Despite some first success stories dating from June 2021, their future is still uncertain.

a Radiative forcing describes the balance in the atmosphere caused by the energy received by and reflected back by the earth, which determines the temperature on the planet. The concentration of greenhouse gases affects this balance, causing global warming.

FIGURE 1

YEAR-ON-YEAR CHANGE IN INTERNATIONAL REVENUE PASSENGER KILOMETRES (RPKs)

Source: IATA, 2022



Air freight is following a different upward trend, since by May 2021 it had already exceeded its May 2019 level, driven by a 9.4% increase in global demand[12] (measured in cargo tonne kilometres – CTKs), 4.6% of it involving US cargo planes.[13] Commercial flight activity in fact made up over two-thirds of the sector's revenues, generating $155 billion, which is twice as much as in 2020.[14] Nevertheless, in 2022 freight flights went down by 10.2% compared to their level in July 2021, and 3.5% compared to 2019,[15] due to a drop in exports (which started picking up in China in June 2022) and the war in Ukraine. Europe is the most affected region, with a decreased freight capacity of over 11%[16] in March 2022 compared to March 2021. Yet the future of air freight looks bright: Boeing is planning on increasing its cargo fleet by 70% in 2040, compared to 2019, partly to meet the surge in online trade. In addition, although it represents only a small proportion (1%[17] of global freight), air freight became much more competitive vis-à-vis maritime[18] from May 2020 to March 2022 **(SEE "MARITIME TRANSPORT" TREND).**[b]

Order books are filling up again, but manufacturers are having to deal with a disrupted supply chain. Airbus and Boeing, with respectively 771 and 909 orders in 2021, are returning to their average sales during the decade preceding the pandemic. At the end of August 2022, the two major airplane manufacturers had already clocked up 843 (Airbus)[19] and 446 (Boeing) new orders, pursuing the trend of 2021. While the industry saw the cost of fuel decrease dramatically in July 2020, prices have since surged, reaching over $155 a barrel for kerosene[c] in April 2022, a level not seen since the 2008 financial crisis. Not all airlines are impacted equally by these price hikes due to different financial hedges, which have in particular protected US airlines.[20] In addition to rocketing operational costs for airlines due to the rise in the price of fuel, supply of new aircraft has been saturated by the pressure of demand and by numerous disruptions in the supply chain. Inflation in raw materials affecting the construction of airplanes (aluminium, nickel, cobalt, magnesium) constitute an additional cost, and the difficulties encountered in supply chains of electronic components have hit airplane manufacturers hard.[21] Deliveries are thus delayed, accentuated by labour shortages in the sector.[22] The armed conflict in Ukraine has done little to relieve pressure on supplies, since the Russian Federation is the world's third producer of aluminium and nickel, and the second for cobalt and magnesium. Flight prohibitions over Russian territory also mean that planes have to make large detours that require more fuel.[23]

The Covid-19 pandemic and the energy crisis in Europe have upset the linear growth pursued by air traffic since the 2000s, but they are also the catalysts for its future transition. Airlines, subject to frequent criticism from civil society, are banking on breakthrough technologies to come up with "zero-emission" planes. But the race for biofuels raises ecological questions, involves shifting strategic dependencies, and requires waiting until 2035-2040 for them to be operational. Until then, flight emissions are supposed to be offset, but CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation, has come up against obstacles before even starting. The obvious solution of reducing traffic is controversial, since it goes against the economic objectives of stakeholders in the sector: airlines, airports and manufacturers.

b A year-on-year change compares a value at two dates, usually one year apart – or one quarter (variation from one quarter to the next) – it is therefore different from an annual variation, which analyzes the variation over the same year. (Insee)

c The price of kerosene is slightly higher that of a barrel of crude oil.

THE OBSERVATORY'S LENS

Traffic picks up fast while attempts to reduce carbon intensity lag behind

CORSIA kick-off delayed, carbon offsetting on the back burner

The 2015 Paris Agreement established specific national measures for emissions generated by domestic flights as part of the application of the United Nations Framework Convention on Climate Change (UNFCCC). However, as of 2021, only 6%[24] of nationally determined contributions (NDCs) that explicitly designate modes of transport identified aviation as a sector for mitigating carbon emissions (compared to 5%[25] in 2016). To compensate for the absence of international flights in the Paris Agreement, since they represent about 65% of the sector's CO_2 emissions, in 2016 the International Civil Aviation Organization (ICAO) launched CORSIA. This programme established the possibility for airlines to purchase carbon credits to offset their annual emissions when they exceed their average emissions in 2019 and 2020. However, following the Covid-19 crisis and the drop in emissions in 2020, the ICAO Council decided in June 2020 to activate a safeguard clause contained in the CORSIA agreement that allows the reference threshold of the offsetting programme to be modified, thus taking 2019 as the sole reference year for the pilot phase. CORSIA had already come under fire, but the establishment of this measure rendered meaningless the pilot phase running from 2021 to 2023, during which time emissions were not supposed to exceed 2019 levels.[26] In June 2022, the ICAO Council decided that the baseline applied to the first (2024-2026) and second phases (2027-2035)[d] would be the equivalent of 85% of emissions during 2019.[27] Other criticisms of CORSIA include: the voluntary nature of the pilot phase and the first phase that only allows carbon offsetting between participating countries;[e] the risk of an excess supply of carbon credits compared to demand, which reduces their price and effectiveness; and the risk of "double counting" global emissions reductions.[28] In addition, the effectiveness of the carbon offsetting measures put in place has been called in to question.

As part of the new Fit for 55 EU roadmap, a revision by the European Parliament intends to integrate CORSIA into the EU ETS.[29] Since 2012, before CORSIA started, the European Emissions Trading System (EU ETS) has included domestic aviation activities. EU Member States have mostly been reticent about the CORSIA international programme, considering that it is likely to be less effective than the EU ETS since CORSIA does not apply sanctions, whereas the EU ETS imposes financial penalties if end-of-year quotas are not respected. The EU ETS, launched in 2005, operates on the basis of emission quota exchanges between actors in the industry, whereas CORSIA involves an emission threshold above which companies must offset additional emissions. The EU ETS therefore removed offsetting from its scope of action in 2020. CORSIA's aim is to offset emissions from international flights, which make up most of the emissions in the sector (60%[30] in 2019) and are not covered by the emissions trading system, which only deals with flights arriving in or leaving the European Economic Area (EEA). CORSIA therefore applies to all flights arriving in the EEA or outside it, for countries participating in the programme. As CORSIA concerns international flights, its scope of application overlaps that of international flights between EEA countries. Airlines in this area are therefore subject to two legislations as soon as their emissions reach 2019 levels, which triggers the application of CORSIA.

A study has evaluated that from 2010 to 2016 the EU ETS only led to a reduction in emissions growth from aviation of 3 $MtCO_2$ per year and did not result in an absolute reduction in emissions.[31] The effectiveness of the EU system is slightly better when only taking into account short and low-cost flights, going from an overall reduction of 4.7% to 10-11%. The study compared this annual reduction in emissions growth with the reduction of annual flights over the same period (-4.9 %), "*indicating the main channel through which carbon pricing operates in the sector is via output reduction, as opposed to aircraft improved efficiency*". The limited effectiveness of the EU ETS over this period should also be considered in terms of the low price of a tonne of carbon, which was about €5 per tonne compared to a current average of about €80. While the ambition of CORSIA, in particular since the reference year was changed, was called into question by the European Union in a study published in September 2020,[32] the High Council for the Climate in France underlined in 2020 that aviation was the only sector subject to the EU ETS for which emissions continued on an upward trend (5% in 2019).[33] Both systems are therefore subject to criticisms, either between each other or coming from the outside. Airlines are reticent about the fact that the two systems overlap because they do not want to be subject to different legislations. Despite conflicting interests, climate change organisations are also not in favour of both systems in situ in view of the fact that emission reduction results are far below the increase in traffic. However, a study by Carbon Market Watch has illustrated that emissions would be more effectively reduced if the EU system covered all flights leaving and arriving in the EEA rather than relying on CORSIA for flights outside the EEA.[34] The two systems remain intrinsically different and, as a carbon offsetting system, CORSIA also offers a possibility to contribute to projects with environmental co-benefits.

In response to these limitations, some countries, airports and airlines have set up parallel initiatives to offset their carbon emissions. However, a study dating from October 2022 carried out by the Okö Institute and commissioned by Carbon Market Watch deplores the environmental quality and offsetting

d Starting from this phase the system becomes mandatory.

e On 1 January 2022, 107 countries out of the 193 ICAO members were voluntary participants, and eight others volunteered during 2022, taking the total to 115 for 2023. Russia, China, India and Brazil are still absent from the list.

effectiveness of carbon credits purchased by airlines.[35] "Carbon pricing" is a complementary tool employed by carbon offsetting markets which are applied after emissions are made. Voluntary compensation is based on credits granted by local or international labels. Airlines can give passengers an opportunity to pay a "carbon charge" in addition to the cost of their flight. Nevertheless, participation varies widely depending on the company, and among those that offer this option, only 1%[36] of passengers take it up. Voluntary carbon offsets are criticized because they put the onus of emissions on consumers, but are also put forward as an efficient complementary tool to regulate future demand. The Okö Institute study of eight major European companies reveals a lack of transparency and ambition concerning the voluntary compensation actions they claim to make. Of the eight airlines, only three provided results on the emissions avoided thanks to carbon pricing and only easyJet effectively offset all of its emissions. The cost of the price of a tonne of offset carbon also varied from €9 to €30 depending on the company, and the price paid by passengers for an offset tonne was up to four times higher than that paid by the airline as a company.

International carbon offsetting is necessary for airlines to achieve their carbon neutrality targets without compromising the expected tripling of traffic by 2050. The British company easyJet has nevertheless announced its decision to drop this lever and simply focus on reducing its carbon intensity.[37] The airline's new roadmap includes stopping its carbon offsetting system from 31 December 2022, with exceptions up to September 2023. The programme has allowed easyJet to offset over 8 $MtCO_2$ since its launch in 2019, but incurs costs for the company, which has announced that it prefers to devote these amounts to reduction efforts. The airline therefore aims to target using biofuels, renewing its fleet, integrating flight optimization systems, and participating in future projects such as hydrogen engines and direct air capture (DAC). While the objectives of this new roadmap are more ambitious than before, this focus on emissions intensity only allows for a relative drop in emissions (by turnover or passenger kilometre), while the airline's total emissions will likely continue to rise.

To meet demand, airlines are setting their sights on carbon neutrality and technological innovation

The ICAO's triennial assembly agreed to set an objective of carbon neutrality for the sector for 2050, following a meeting held from 27 September to 7 October 2022.[38] The opening speech mentioned the sector's focus on new technologies and biofuels to reach these objectives. Also included on the agenda was a consideration of the sustainability of the measures defended, and a reflection on optimizing air traffic routes. Carbon neutrality may be the buzzword of the moment, but results do not always follow suit. A study published in May 2022 by the NGO Possible concluded, for example, that only one of the 50 British airlines had achieved the climate targets they set since 2000.[39]

Policies aimed at fostering the growth of biofuel production are niche measures: in late 2021, only three countries (Finland, Indonesia and Sweden) had set targets specifically concerning biofuels in the aviation sector.[40] In parallel, since 2020, numerous European states have modified their legislation with the aim of accelerating the transition to biofuels for the aviation sector. To align with the European roadmap featuring in the Fit for 55 regulations, since 1 January 2022 France has required that airplanes refuelling in the country must use at least 1% sustainable aviation fuels (SAF) (this requirement climbs to 2% in 2025, 5% in 2030, and 50% in 2050).[41] ReFuelEu[42] also stipulates avoiding overloading airplanes and only filling them with enough fuel for the flight, while encouraging European airports to adapt their facilities for alternative fuels. According to the IATA, airlines purchased the entire stock of SAF available in 2021 and have signed future purchasing contracts worth $17 billion.[43]

Europe launched its Destination 2050 programme in 2021, aimed at reducing the carbon intensity of the sector, at the same time as a 1.4% annual increase in traffic.[44] The joint Clean Aviation initiative also joined the Alliance for Zero-Emission Aviation (AZEA) in 2022. Following on from Clean Sky 1 and 2, Clean Aviation is a public-private partnership involving the European Commission and the European aerospace industry with a target of reducing the carbon intensity of the aviation sector. The first call for projects was launched by Clean Aviation in 2022. The initiators of the programme say that it also aims to adapt airport facilities since, for example, hydrogen takes up three times more volume[45] than kerosene for the same energy capacity. AZEA includes 74 stakeholders from the entire aviation sector and has a goal to develop research and set up model airplanes running on hydrogen and electricity.[46]

The Association of Asia Pacific Airlines (AAPA) announced in September 2021 that it was committed to reaching carbon neutrality by 2050. Some of the fifteen airlines had already committed to the same target, but the AAPA was keen to make the goal a shared one. These strategies are massively based on substituting fossil fuels with either biofuels (bearing in mind that the Asia-Pacific region is likely to constitute 40% of global biofuel demand)[47] or more marginal solutions like electrofuels[f] and hybrid ad electric engines. The AAPA nevertheless immediately pointed out that hydrogen and electricity solutions were not suitable for the Asian market, where flights are generally longer than 1,500 km, outstripping the capacities of existing electric and hydrogen engines.

The ICAO published a second edition of the definition of "sustainability criteria"[48] for biofuels in November 2021. Airlines that use fuels respecting these criteria "*can claim associated reductions in their CORSIA* CO_2 *offsetting requirements*".[49] These criteria are based on the quality of SAF *vis-à-vis* numerous objectives. They will be applicable from 1 January 2024, which is the end of the pilot phase during which only the first edition is in force. The second edition is more detailed than

f Electrofuels comprise recycled CO_2 and green hydrogen (green hydrogen, unlike blue or grey hydrogen, is produced using a renewable energy source and is formed by electrolysis).

the first one, integrating twelve different themes compared to only two: greenhouse gases (GHG) and carbon sinks. The fuels eligible for the CORSIA programme must, for example, generate fewer emissions over their lifecycle to respect the GHG criterion and, to respect the carbon sink criterion, must not have been produced from biomass coming from land with a high carbon sequestration potential. From 2024 onwards, they will therefore also need to respect criteria relating to: water, soil health, air quality, conservation of biodiversity, promotion of waste management, human rights, land use rights, water access rights, local and social development, and food security. These new themes integrate more fully the impacts of biofuels and the Sustainable Development Goals (SDGs), in response to increasing criticisms concerning their negative externalities on the environment.[50] In competing with agriculture, the increased demand for biofuels could trigger higher prices for essential foodstuffs.[51] The respect of these criteria will be certified by the Sustainability Certification Scheme, developed by the ICAO. American Airlines received the first CORSIA certificate for biofuels in July 2022[52] after using biofuels produced by the Finnish company Neste at San Francisco airport. Neste, one of the key SAF producers, is in parallel attempting to attain German international sustainability and carbon certification (ISCC). The company claims that its biofuels reduce usual GHG emissions by 80%.

Since 2011 and the first flight operated by KLM, 443,512 commercial flights[53] have employed SAF (342,256 flights in June 2021) although no plane is 100% SAF-reliant. Sustainable aviation fuels are used instead of kerosene for up to 50% of an airplane's fuel, combined with fossil-derived kerosene. The latter is a pure source of hydrocarbons, whereas biofuels are derived from biomass, organic waste, and other plant matter, and cannot yet be used autonomously.[54] At a cost three or four times higher than conventional fuels, their expense is also dissuasive. Some organizations are attempting to improve SAF so that they can be used on their own, involving local production. Japan Airlines (JAL) successfully carried out its first commercial flight using SAF produced in Japan in February 2021[55] combined with kerosene. TotalEnergies has launched its own production in France and has started supplying French airports with alternative fuels following a first successful commercial flight in June 2021.[56] In particular, the company supplies fuel to the collaborative French programme *Vol Avec Carburants Alternatifs Nouveaux* (VOLCAN) – which includes Airbus, Safran and Dassault – launched in late 2021. The programme is funded by the sector's recovery plan in the wake of the pandemic, which has a budget of €1.5 billion over three years for research on low-carbon airplanes. The project saw its first 100% SAF Airbus flight take off in October 2021, but will continue testing into 2023.[57] To evaluate the impact of these first "unmixed" flights, the Airbus will be followed by a "sniffer plane" to measure its emissions.[58]

Despite numerous "carbon-neutral" initiatives put forward by private companies, jet planes have a major responsibility for emissions in the sector. Private jets are five to fourteen times more polluting than commercial (passenger) flights, and the CO_2 emissions from flights in private jets rose 31% from 2005 to 2019, according to the NGO Transport & Environment (T&E) in a study[59] published in 2021. T&E also conclude that jet planes are twice as likely to be used for flights of under 500 km within Europe, to the detriment of commercial flights, or other means of transport. This negative impact is highlighted by civil society with the practice of "jet tracking",[60] which intensified in 2022. Jet tracking consists in following the journeys of jets by well-known personalities on social networks, indicating the distance and emissions associated with each journey **(SEE SIGNALS)**. Jets emit on average 50% more than trains, and in Europe, 70% to 80% of private jet flights have a high-speed train alternative.[61] Private jets are also exceptions in the EU ETS, and kerosene is not taxed, bearing in mind that the average private jet owner is worth €1.3 billion. In France, these inconsistencies motivated the left-wing political party LFI to present a bill in September 2022[62] to ban private jet planes from the territory due to their excessive ecological cost compared to the proportion of the population that uses them.

To save face, some jet companies are branching out. In September 2021, the Canadian jet builder, Bombardier, announced the launch of a new prototype that took off in 2022, running partly on alternative fuels in order to be carbon-neutral.[63] The Brazilian company Embraer made a commitment in August 2021[64] to make its activities carbon-neutral by 2040 thanks to alternative fuels, coupled with electrification and hybrid engines. The company has, for example, tested out a plane running on 100% SAF, which it says reduces emissions by 85%.[65]

Lastly, while electric vehicles are booming in the road transport sector, and even in the rail sector, electric batteries and hydrogen apparatus are harder to put in place in airplanes[66] and maritime freight. Research on e-kerosene, produced from green hydrogen and renewable energy, has made progress since 2018, but its capacities remain limited. If demand continues to follow its current growth path, the European aviation sector could consume up to 24% of the renewable electricity produced in Europe by 2050.[67] In addition, airplanes running on electric or hybrid engines, or on hydrogen, are not expected before the 2030 decade and are likely to mainly concern short flights. For long-haul flights, the challenges are much greater: hydrogen planes require bigger fuel tanks, which increases the weight of the aircraft and therefore the energy required for the flight. While e-fuels have the advantage of not competing with agriculture, they are in competition with critical materials required to produce electric batteries.

Measures aimed at carbon neutrality do not deal with all of the pollution generated by aviation. Two-thirds[68] of the particles generated by flights that participate in radiative forcing are not CO_2. While the sector is focused on carbon neutrality, an academic article published in 2022[69] makes the case for thinking in terms of climate neutrality rather than carbon neutrality in order to consider the other impacts of aviation. Nevertheless, carbon dioxide particles remain in the atmosphere for years, unlike other particles, which means that each tonne of CO_2 avoided has a direct effect.[70] The interest in CO_2 emissions is partly due to the fact that they are easy to evaluate, unlike other particles, which have different effects depending on climate conditions. For example, the particles emitted during night flights tend to contribute more to global

temperatures than flights during the day.[71] However, the data available is not precise enough to produce sufficiently targeted trajectories, in particular since night flights are strategic for the aviation industry. Air traffic adaptation features among the European objectives announced in the Destination 2050 roadmap, which anticipates that it could contribute 6% to CO_2 emissions reduction targets.

Calls to reduce traffic receive relatively less attention

While the aviation sector's strategies for reaching carbon neutrality are mainly based on innovation and technology so as not to compromise the increase in traffic – and even to boost it – the degrowth of the sector[72] could be a complementary lever for action. The French environment and energy management agency, Ademe, defends capping air traffic as a means to reduce the sector's carbon intensity, which could be 75% in 2050 "*only if all levers are activated: energy efficiency of planes, decarbonization of fuels, and reduction of traffic.*"[73] A few days before the Ademe study was published, the president of the Aéroports de Paris (ADP) group invited consumers to "be reasonable"[74] while awaiting the decarbonization of aircraft and their fuels, which is unlikely in the next 20 years. Traffic has already been capped by numerous airports to limit sound pollution at night.[75] On 24 June, following complaints about the sound level of traffic at Amsterdam-Schiphol Airport, the Dutch government presented a project to restrict traffic to 440,000 flights per year – compared to 500,000 before the pandemic – starting from end 2023, a decision that it justified as being ecologically coherent.[76] This government measure was hailed as pioneering by numerous climate change action organizations.

France illustrates the conflict of interest between companies encouraging a rise in traffic, and civil society calling for a reduction. In 2021, the *Convention Citoyenne pour le Climat* (the citizens' climate convention) attempted to pass laws to complement limitations of short flights, aimed at airport extension projects. Nevertheless, dozens of projects[77] are going ahead or underway: those that began before 1 January 2022 are not concerned by the laws ultimately voted. As pointed out by Sarah Fayolle, transport campaign officer for Greenpeace, in an article in Reporterre, the prohibition only concerns projects, "*that need new land for their extension, which involves expropriating other owners […]. But in the vast majority of cases, airports have land reserves, which means they have enough room to extend on their own land without needing to expropriate anyone, and therefore they don't need a declaration of public utility* [recognition that the proposed project has public benefits] *to carry out the work*."[78] The extension of terminal 2 at Nice Airport was the subject of an appeal by environmental associations that was rejected on 19 September 2022.[79]

Caught between calls from civil society and experts, and the need to respond to a growing demand from airlines, governments are focusing on limiting domestic flights. In the European Union, Austria and France have started to put this type of restriction in place. Austria has prohibited flights when an alternative by train is possible in under three hours (France has done the same for journeys with a direct alternative under two and a half hours that operates several times a day) and has established a tax of €30 per passenger since 1 September 2020 on flights shorter than 350 km, except for transfer flights.[80] This tax applies to both domestic and international flights. Belgium has set up a tax in force since 1 April 2022, mostly on international flights given the size of the country, amounting to €10 for flights under 500 km, €2 on flights within the EEA, the United Kingdom and Switzerland, and €4 for other flights, excluding transfers. Bills have been presented in the Netherlands but have not gone through due to a lack of political or government agreement. The definition of a "short-haul flight" is unclear, with some basing it on flight distance and others on the duration of rail alternatives.

The capacity of the modal shift of consumers towards other means of transport depends on political volition. The creation of a "climate ticket" in Austria and a €9-ticket in Germany in summer 2022 showed the positive response of demand when trains are easier to access. They also showed the importance of adapting infrastructures to respond to an increased use of the network. Another study[81] by the NGO Possible, whose aim is to encourage climate action, calls for a shift in British policy to support rail infrastructures instead of subsidizing airlines. The NGO's conclusions are based on a study of a representative sample of the British population who said they would respond positively to such a measure. The frequent passenger tax,[82] which makes plane travel more expensive, is one example put forward by the NGO. This tax would target frequent flyers – according to Possible, 70% of British flights are used by 15% of passengers – and revenues would be employed to support less carbon-intensive alternative means of transport. This measure came second (with 89% positive responses) in a British survey in 2021[83] designed to evaluate which measures the population supported to ensure that the country reaches is emissions reduction targets by 2030. In another example, in 2019 Sweden recorded a drop in traffic compared to 2018, put down to the rise of "flight shame" (*flygskam*) among Swedish people, who opt to make some of their journeys by train instead.[84]

KEY TAKEAWAYS

After going through a very turbulent zone in 2020 and 2021, air traffic has taken off again. But initiatives to direct the sector towards decarbonization are lagging behind the recovery of traffic growth, which is already catching up to pre-pandemic levels. Alternative to fossil fuels, either based on biofuels or electricity, are unlikely to be sufficiently developed before 2040, although some successful tests were observed in 2021 and 2022. While awaiting 2040, the effectiveness of the CORSIA system, designed to offset the sector's emissions, has been weakened and delayed by the drop in traffic in 2020. As a result of these realities, the ultimate option – a decrease in traffic – is increasingly being called for, especially in Europe, although it goes against the economic *raison d'être* of airlines. Recent studies and civil society therefore insist on the role of states, local governments, and airports to reach national emissions reduction targets.

REFERENCES

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1 IEA (2020). Tracking Aviation 2020. *International Energy Agency*

2 UIC & AIE (2017). Railway Handbook 2017. *International Union of Railways & International Energy Agency*

3 IATA (2022). Annual Review 2022. *International Air Transport Association*

4 IATA (2020). Annual Review 2020. *International Air Transport Association*

5 IATA (2022). Annual Review 2022, *op.cit.*

6 IATA (07/09/2022). July Passenger Demand Remains Strong. *International Air Transport Association*

7 IATA (June 2022). Industry Statistics. *International Air Transport Association*

8 Thomsen, M. O. (2022). Economic Outlook: Air Transport in Times of Turbulence. *International Air Transport Association*

9 IATA (07/09/2022). July Passenger Demand Remains Strong. *International Air Transport Association*

10 IATA (06/02/2020). Slower but Steady Growth in 2019. *International Air Transport Association*

11 Sun, X. et al. (March 2022). Startups: Founding airlines during COVID-19 - A hopeless endeavor or an ample opportunity for a better aviation system? *Transport Policy*, Vol. 118

12 Raven, P. (n.d.). May Air Cargo 9.4% Above Pre-COVID Levels. *Cargonow*

13 *Ibid.*

14 IATA (2022). Annual Review 2022. *International Air Transport Association*

15 IATA (07/09/2022). Air Cargo Tracks Near Pre-COVID Levels. *International Air Transport Association*

16 IATA (03/05/2022). War in Ukraine and Omicron Weighs on Air Cargo. *International Air Transport Association*

17 *UIC & AIE (2017). Railway Handbook 2017, op. cit.*

18 Thomsen, M. O. (June 2022). Economic Outlook: Air Transport in Times of Turbulence. *International Air Transport Association*

19 AIRBUS (August 2022). Orders and deliveries. *AIRBUS website*

20 IATA (March 2022). IATA Factsheet. The impact of the war in Ukraine on the aviation industry. *International Air Transport Association*

21 McLeod Hunt, C. (13/01/2022). Volatile supply chain tightens grip on aviation industry. Manufacturers combating parts shortages, manufacturing delays, sharp increases in cost. *AOPA*

22 Morrison, M & Hemmerdinger, J. (19/08/2022). Is recovery at risk from a broken supply chain? *Flight Global*

23 Swanson, A. (01/03/202). Ukrainian Invasion Adds to Chaos for Global Supply Chains. *The New York Times*

24 UNFCCC Secretariat (Sept 2021). Nationally determined contributions under the Paris Agreement. Synthesis report by the secretariat. *United Nations Framework Convention on Climate Change*

25 Gota, S., Huizenga, C. Peet, K., Kaar, G. (2016). Nationally-Determined Contributions (NDCs) Offer Opportunities for Ambitious Action on Transport and Climate Change. *Paris Process on Mobility and Climate Climate, SLoCaT*

26 ICAO (2021). Executive Summary – Committee on Aviation Environmental Protection (CAEP) analyses in support of the 2022 CORSIA periodic review. *International Civil Aviation Organization*

27 ICAO (30/06/2022). Analyses in Support of the 2022 CORSIA Periodic Review: Assessment of Additional CORSIA Baseline Options. *International Civil Aviation Organization*

28 Observatory on non-state action (2021). Global Synthesis Report on climate action by sector. *Climate Chance*

29 European Parliament (13/07/2022). Aviation's contribution to European Union climate action: Revision of EU ETS as regards aviation. *European Parliament*

30 IEA (2022). Aviation – Tracking report. *International Energy Agency*

31 Fageda, X & Teixido, J, J. (2022). Pricing carbon in the aviation sector: Evidence from the European emissions trading system. *Journal of Environmental Economics and Management*, Vol. 111

32 European Commission (2020). Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost pass-through pursuant to Article 3d of the EU ETS Directive. *European Commission*

33 HCC (2020). Climat, santé : mieux prévenir, mieux guérir. *Haut Conseil pour le Climat*

34 Van Velzen, A. (2022). Environmental and economic impacts of EU ETS and CORSIA policy scenarios for European aviation. *Carbon Market Watch*

35 Okö Institute (2022). Flights of fancy – Preventing European airlines from making far-fetched climate claims. *Carbon Market Watch*

36 Becken, S. & Pant, P. (2021). Airline initiatives to reduce climate impact. *Amadeus, University of Surrey, Griffith University*

37 Trévidic, B. (26/09/2022). EasyJet bouscule sa stratégie CO_2. *Les Echos*

38 ICAO (07/10/2022). States adopt net-zero 2050 global aspirational goal for international flight operations. *International Civil Aviation Organization*

39 Gayle, D. (10/05/2022). Just one of 50 aviation industry climate targets met, study finds. *The Guardian*

40 REN21 (2022). Renewables 2022 Global Status Report. *REN21*

41 Ministère de la transition écologique et des territoires, Ministère de la transition énergétique (05/10/2022). Biocarburants. *Ecologie.gouv.fr*

42 Conseil Européen (14/07/2022). Infographie - «Ajustement à l'objectif 55» : accroître l'utilisation de carburants plus écologiques dans les secteurs aérien et maritime. *Conseil Européen*

43 IATA (2022). Annual Review 2022. *International Air Transport Association*

44 Destination 2050 (2021). A route to net zero european aviation. *Destination 2050*

45 Krein, A. (21/09/2021). Investment into clean aviation technologies has a significant socio-economic impact. *Euractiv*

46 European Commission (26/09/2022). Green Aircraft: Players from the aeronautics industry and beyond sign up to the Alliance for Zero-Emission Aviation. *European Commission*

47 Curran, A. (13/09/2021). New Net Carbon Zero Goal For Asia-Pacific Airlines. *Simple Flying*

48 ICAO (2021). CORSIA Sustainability Criteria for CORSIA Eligible Fuels. *International Civil Aviation Organization*

49 ICAO (12/11/2021). ICAO Council approves CORSIA Sustainability Criteria for sustainable aviation fuels. *International Civil Aviation Organization*

50 Piris-Cabezas, P. (17/11/2021). UN aviation agency sets a new standard for sustainable flight by adopting critical fuels criteria. *Environmental Defense Fund*

51 Fickling, D. (10/06/2022). It's Time to Get Biofuels Out of Your Gas Tank. *Bloomberg*

52 American Airlines (12/07/2022). American Airlines Receives Aviation Industry's First-ever CORSIA-certified Sustainable Aviation Fuel From Neste. *American Airlines*

53 Aviation Benefits Beyond Borders (2022). Sustainable aviation fuel. *Aviation Benefits Beyond Borders* (page consultée le 6 octobre 2022)

54 El Dahan, A. (22/06/2021). The Road To A Cleaner Sky: Can Planes Fly on 100% Sustainable Jet Fuel? *Eways Aviation*

55 Aviation Benefits (05/02/2021). JAL Successfully Operates a Commercial Flight Using Sustainable Aviation Fuel Produced in Japan. *Aviation Benefits Beyond Borders*

56 AirFranceKLM Group (18/05/2021). Air France-KLM, Total, Groupe ADP et Airbus ont joint leurs efforts pour réaliser le premier vol long-courrier avec du carburant aérien durable. *AirFranceKLM Group*

57 Capital (29/10/2021). Airbus lance ses premiers essais de vols sans kérosène. *Capital*

58 AFP (10/06/2021). Un Airbus A320 d'essai effectuera un vol utilisant 100% de carburant d'aviation durable d'ici à la fin de l'année. *Connaissance des Energies*

59 Transport & Environment (2021). Private jets : can the super-rich supercharge zero-emission aviation? *Transport & Environment*

60 Clairouin, O. (18/08/2022). Jets privés des célébrités : derrière la dénonciation de la pollution, le succès grandissant du « flight tracking ». *Le Monde*

61 *Transport & Environment (2021). Private Jets (...), op. cit.*

62 Nelken, S. (12/09/2022). LFI dépose une proposition de loi pour interdire les jets privés sur le territoire français. *Libération*

63 Bombardier (2022). Nouveau Jet d'affaires de Bombardier : Challenger 3500. *Bombardier website*

64 Aviation Benefits (13/08/2021). Embraer commits to carbon neutral operations by 2040. *Aviation Benefits Beyond Borders*

65 Siddiqui, H. (01/07/2022). Towards carbon neutral ops: E195-E2 Aircraft from Embraer to use 100% on GTF-powered engines. *Financial Express*

66 Barber, G. (01/02/2022). What It'll Take to Get Electric Planes off the Ground. *Wired*

67 Transport & Environment (08/03/2022). Why "flying less" offers the best path to sustainable aviation. *Transport & Environment*

68 Lee, D.S. et al. (2021). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric Environment*

69 Brazzola, N et al. (2022). Definitions and implications of climate-neutral aviation. *Nature Climate Change*

70 Barber, G. (11/08/2022). Carbon offsets alone won't make flying climate-friendly. *Grist*

71 Davies, A. (02/03/2020). Plane Contrails Have a Surprising Effect on Global Warming. *Wired*

72 Köves, A. & Bajmócy, Z. (2022). The end of business-as-usual? – A critical review of the air transport industry's climate strategy for 2050 from the perspectives of Degrowth. *Sustainable production and consumption*, Vol. 29, pp. 228-238

73 Roussel, F. (28/09/2022). La décarbonation du secteur aérien devra intégrer un plafonnement du trafic, selon l'Ademe. *Environnement*

74 Reporterre (20/09/2022). Prenez moins l'avion : le surprenant conseil du PDG d'Aéroports de Paris. *Reporterre*

75 ICAO (2013). Night Flight Restrictions – Worldwide Air Transport Conference. *International Civil Aviation Organization*

76 Gerretsen, I. (27/06/2022). Dutch government issues world-first cap on flights from European hub. *Climate Home News*

77 Lavocat, L. (03/12/2021). Nantes, Lille, Montpellier... La folie des grandeurs des aéroports français. *Reporterre*

78 *Ibid.*

79 Reporterre (03/10/2022). Aéroport de Nice : la justice valide l'agrandissement. *Reporterre*

80 Dobruszkes, F. et al. (2022). Banning super short-haul flights: Environmental evidence or political turbulence?. *Journal of Transport Geography*, Vol. 104

81 Possible & Survation (2021). Fare competition. A route to climate-friendly travel choices. *Possible*

82 McDonagh, S. (05/05/2021). A frequent flyer tax could be the aviation industry's only solution. *Euronews Green*

83 Coffey, H. (13/10/2021). Higher flying costs and frequent flyer levy backed by 89% of Brits to tackle climate crisis. *Independent*

84 Faux, F. (01/04/2019). En Suède, la honte de prendre l'avion face à la fierté de voyager en train. *FranceInter*

TRENDS
MARITIME TRANSPORT

The energy transition in international shipping remains at the dock

ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance
YANN BRIAND • Senior Researcher, Climate & Transport, IDDRI

After years of low profits, the maritime transport sector has benefitted greatly from the upswing in trade that followed the lifting of lockdowns. A commitment to reducing sulphur and greenhouse gas emissions has seen the sector increasingly turn to scrubbers and liquid natural gas (LNG) – a trend confirmed in 2021. But international shipping is still struggling to make these transformations on a large scale, and needs to resolve the negative externalities of some of its technological choices.

DATA OVERVIEW

Major shipowners reap benefits from the pick-up in international maritime transport

The pick-up in freight following the progressive end of lockdown polices saw greenhouse gas emissions from international shipping shoot up by 8%, to reach 661.9 $MtCO_2$ in 2021, compared to 612.5 $MtCO_2$ in 2020, according to Enerdata figures.[a] That level is however lower than the 2019 figure (682.9 $MtCO_2$). Domestic maritime traffic (river transport, ferries, coastal navigation, etc.) went up by 7.3% over 2021 (177.83 $MtCO_2$), following a 3% drop in 2020. In this area too, emissions were below pre-crisis levels.[1] According to the fourth study by the International Maritime Organization (IMO) on greenhouse gas (GHG) emissions, 98% of GHGs emitted were carbon dioxide (CO_2). However, for the period 2012-2018, the study observes a particularly sharp increase (150%) of methane (CH_4) emissions, which have a global warming potential (GWP) 86 times higher than CO_2 over 20 years.[2]

According to the latest report by the Intergovernmental Panel on Climate Change (IPCC) on climate change mitigation, international maritime transport emissions are the second highest source of emissions from the transport sector after road transport of passengers and goods, and represent about 9% of the transport sector's total emissions.[3] Emissions related to international transport of freight grew faster than emissions related to the transport of passengers, mainly due to increased trade and an organization of logistics chains that involves very long distances.[4] In 2023, the IMO is set to revise its GHG reduction strategy, while numerous voices are calling to step up ambition and action and consider all possible options for the sector **(SEE BOX 1)**.

The UNCTAD Review of Maritime Transport published in November 2021 announced a 4.3% upswing in the volume of trade by ship, with different regional profiles. This return to growth in activities follows a 3.8% decrease in trade in 2020[5] provoked by the Covid-19 pandemic, and before that, two consecutive years of a slow-down in the growth of transported volumes: 2.7% in 2018, then 0.5% in 2019. These figures are below the average rate recorded from 1970 to 2017 (+3%/year).

The global traffic of container ships, which is a key indicator of the state of international trade, followed a similar trend: -1.2% activity in 2020, after a drop in growth from 6.7% in 2017 to 2% in 2019.[6] Container traffic in Asia, which concentrates 54% of global maritime trade, only went down slightly in 2020 (-0.4%), and not at all in Africa (0%), with a much bigger decline in Europe (-4.2%), North America (-1.9%) and Latin America and the Caribbean (-1.8%).[7] This decreased activity did not therefore outweigh the long-term growth in maritime traffic for developing countries, which now receive 69.5% of shipped goods in the world. Another indication of the sector's healthy economic state is the rate of shipbuilding capacity in shipyards, which dropped by 14% from 2015 to 2020, then shot up again by 13% from 2020 to 2021, although without returning to 2019 levels.[8]

The general drop in activity in 2020 had a variable impact on shipping companies depending on the activity sector. Oil tankers were initially hit hard by the drop in fuel demand and

a Other sources provide different figures, but with similar orders of magnitude in proportion to other transport sub-sectors. The IPCC, in its report "Climate Change 2022: Mitigation of Climate Change", published in April 2022, announced a figure of 0.8 $GtCO_2e$ emitted by the sector in 2019; the fourth IMO report published in 2020 estimates that the sector's emissions reached 1.076 $GtCO_2e$ in 2018.

the reduced production organized by OPEC, but then returned to profitability following Russia's invasion of Ukraine.[9]

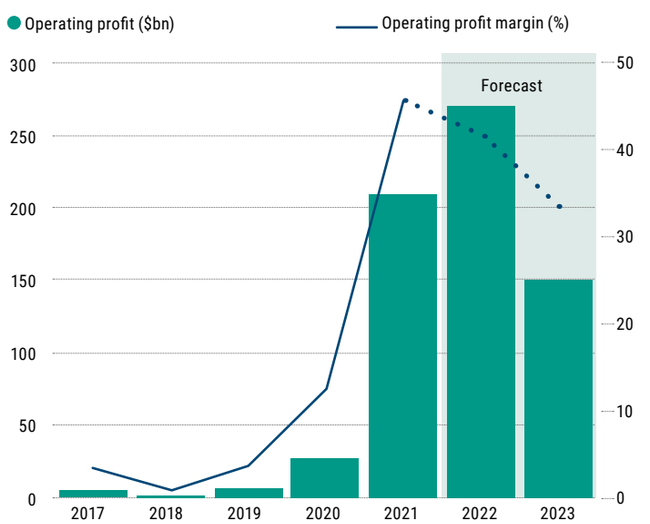
But the biggest winners of the crisis are undeniably container ship operators (Maersk, CMA-CGM, MSC, COSCO, etc.). This is because the tariffs fixed by shipowners for transporting goods, known as "freight rates", are inversely proportional to demand: the greater the transport capacities, the lower the tariffs. For several years, this situation limited transporters' financial margins. Yet the generally disorganized distribution of container ships available between the main commercial zones, coupled with the high demand for manufactured goods during and after lockdowns, sent freight rates soaring. In February 2022, one-year contracts, which make up three-quarters of the annual revenues of shipping operators, were being negotiated at between $7,000 and $8,000 for a forty-foot-equivalent-unit container between China and the West Coast of the USA, compared to an already record average cost of $5,500 in 2021.[10] As a result, the industry made record-breaking earnings before interest and taxes (EBIT) of $210 billion in 2021, compared to only $7 billion in 2019 and $26 billion in 2020. Even more spectacular results are expected for 2022, with Drewry, a consultancy firm specializing in maritime, predicting profits of $270 billion for the industry.[11]

This advantageous situation for the sector's finances could therefore make it easier for shipping companies to make investments to reach the long-term emissions and pollution reduction objectives set by the IMO. Yet when actors in the sector start deploying strategies to implement them, these commitments sometimes reveal contradictions.

FIGURE 1

EARNING BEFORE INTERESTS AND TAXES FROM THE INDUSTRY BETWEEN 2017 AND 2023 (FORECASTS)

Source: Financial Times, 08/09/2022, based on Drewry Maritime Research



BOX 1 • **KEYS TO UNDERSTANDING**

MARITIME TRANSPORT: A SECTOR THAT ORGANIZES ITS OWN CARBON-REDUCTION ACTION

Since the Kyoto Protocol in 1997, the question of reducing emissions generated by international maritime transport has been handled by the International Maritime Organization (IMO). This organization has historically specialized in shipping security issues and today has nearly 140 member countries. Spurred by the agenda of the Paris Agreement in 2016, the IMO has defined a two-step global strategy, with an initial strategy for 2018 and a revised strategy for 2023. In April 2018, over one hundred States gathered at the IMO headquarters in London, where they adopted an initial strategy to reduce emissions by transport unit (in gCO_2/tkm) by at least 50% in 2050 compared to 2008. More precisely, the agreement establishes the reduction of emissions for all international transport activities by at least 40% by 2030, and up to 70% by 2050 compared to 2008.[12] In spring 2023, a revised strategy is due for publication, following an appeal by several state and non-state actors at COP26 to scale up the sector's ambition to reach "zero emissions by 2050"; these actors included the main G7 countries (Declaration on Zero Emission Shipping by 2050) and over 200 companies and organizations from the sector through the global maritime forum (Call to Action for Shipping Decarbonization).

For years, maritime shipping has claimed to have made major advances in energy efficiency and carbon intensity thanks to a range of measures with exponential impacts, such as reducing the cruising speed of ships[b]. Indeed, the average carbon intensity of the entire sector, whether in terms of vessels or journeys, is 21-30% lower today than in 2008, according to the IMO's energy efficiency operational indicator (EEOI). As a result, the sector has maintained relatively stable emissions compared to 2010 levels, despite rising international demand. Nevertheless, most of these efficiency gains were made before 2012, and the carbon intensity of activities has not gone down more than 1 to 2% a year since 2015, which is insufficient to reduce absolute emissions compared to their 2008 level.

Today, commitments and investments to decarbonize the sector are concentrated on developing zero-emission fuels; however, they depend on the capacity to produce enough zero-emission energy to meet needs, and on the speed of rolling out "green corridors" equipped with charging stations. More than 20 countries have partnered with private actors to develop at least six corridors by 2025 (Clydebank Declaration). Lastly, notably none of these strategies considers the reorganization of logistics chains towards shorter, more regional chains, as a lever to develop and to reduce the sector's emissions, despite the fact that this option could help alleviate pressure on the demand for zero-emission energy and facilitate the penetration of alternative forms of motorization.

b There is a cubic relation between the reduction of a ship's speed and fuel consumption: reducing the speed by 10% decreases the engine power required by 27%. Therefore, for an equal distance covered more slowly, the energy necessary for the journey diminishes by 19% (Faber et al., 2017). Slowing the speed therefore allows companies to lower their emissions and save on fuel consumption.

THE OBSERVATORY'S LENS

LNG increasingly popular for long-distance transport

To reduce sulphur emissions, scrubbers are overtaking VLSFO

Since 2018, the IMO has been calling on shipping companies to reduce their GHG emissions by at least 50% by 2050 compared to 2008. And since January 2020, the IMO 2020 regulation has reduced the limit of sulphur content in heavy fuel oil (HFO) used in ships from 3.5% m/m (mass by mass) to 0.5% m/m for all ships outside Emissions Control Areas (ECAs). To succeed in meeting this double requirement for decarbonization and depollution, the IMO plans four other types of mid-term measures: the development of low-carbon (or even "zero-carbon") fuels, operational measures for the energy efficiency of ships, technical cooperation and capacity-building activities, and feedback mechanisms to share good practices.[13]

To reduce sulphur emissions, two options are possible: replacing HFO with a fuel that has a lower sulphur content but is much more expensive or requires technical adaptations, such as VLSFO (Very Low Sulphur Fuel Oil), MGO (Marine Gas oil) or LNG **(SEE BELOW)**; or equipping ships with systems that clean sulphur particles from exhaust gases, i.e., "scrubbers", and continuing to use HFO. Following a trend that began in 2020, scrubbers have overtaken VLSFO as the preferred market option; the price spread between VLSFO and HFO reached record levels in 2022, thus favouring the option of maintaining traditional fuels and fitting smokestack scrubbers.[14] In late 2020, over 4,000 ships around the world were equipped with these systems, which is double the number at the start of the year, according to BIMCO, a network of maritime sector actors that represents 60% of the global freight fleet.[15]

However, the most popular version on the market, which is cheap and easy to install, is the "open-loop" scrubber, which directly discharges wash water from the smokestack into the sea. This discharge, which is loaded with polycyclic aromatic hydrocarbons, nitrates, nitrites and heavy metals, makes the ocean water more acidic and threatens marine life. Eighty percent of this wash water is discharged into exclusive economic zones (200 nautical miles), within which states have the exclusive right to exploit resources, according to an ICCT study.[16] A recent Swedish study estimates that open-loop scrubbers are responsible for 9% of certain pollutants in the Baltic Sea.[17] To date, about forty States and port authorities in the world have prohibited or restricted discharges of wash water from scrubbers.[18]

The track record is not much better for VLSFO, with a recent study presented to the IMO revealing that VLSFO combustion produces from 10% to 85% more black carbon emissions than HFO combustion.[19] Black carbon not only has significant negative impacts on human health, it is also a greenhouse gas (GHG) with a short lifespan but a strong radiative forcing effect. Resulting from the incomplete combustion of fuel, its global warming potential (GWP) is between 460 and 1,500 times higher than that of CO_2 during the four to twelve years it stays in the atmosphere.[20]

LNG is the choice fuel for long-distance transport

In terms of decarbonization, investments and research and innovation mostly focus on developing alternative means of motorization to the high-carbon fuels used by the majority of ships. At the moment, according to figures from the insurance and risk management company DNV,[21] 99.8% of ships operating in the world and 78.9% of those on order run on conventional fuels. Among the alternative options, LNG largely dominates order books for long-distance vessels (90% of tonnage on order and 98% of tonnage in operation), while the other options (batteries, hybrid, methanol, liquified petroleum gas) are aimed at short-distance vessels.

Currently, 923 LNG-fuelled vessels are in operation in the world, and 534 are on order, according to DNV figures.[22] This increase is substantial compared to the figures reported in the 2021 edition of the Global Synthesis Report on Climate Action by Sector.[c] LNG is not just an alternative to conventional heavy fuels to help the sector reach its decarbonization targets, it is also one of the fastest-growing products in international trade, and therefore one of the main drivers of the growth of international maritime transport. In 2021, imports of LNG, which had not gone down despite the pandemic, increased 4.5% compared to 2020, while LNG transport capacities increased by 9%.[23] In 2022, the market is likely to profit from the increased demand for LNG as an alternative to Russian gas.

Nevertheless, while LNG effectively emits 25% less CO_2 than traditional ship fuel, and contains practically no sulphur, it is still a gas, and its combustion contributes to the increased CH_4 emissions observed by the IMO in recent years.[24] These emissions are generated by low-pressure injection dual fuel (LPDF) engines, the most common technology for operating LNG vessels, which release significant levels of CH_4, in particular from ships carrying light loads.[25] According to a life cycle assessment carried out by ICCT, the use of LNG with this technology produces 70% to 82% more GHG emissions than the other gas-based fuel option: marine gas oil (MGO). An investigation by Transport & Environment using infrared cameras reported methane leaks on ships moored in the port of Rotterdam;[26] these leaks could represent from 0.2% to 3% of the combustion process, according to the IMO.[27] In 100 years' time, provided a more efficient technology is adopted, gains in emissions thanks to LNG could reach 15% compared to MGO; in 20 years, closer to the urgent deadline for climate action, the use of LNG would generate 4% more emissions.[28]

c These figures are cited by secondary sources. In the 2021 edition of the Global Synthesis Report on Climate Action by Sector, the figures quoted date from April 2021 and report 563 ships running on LNG, either in operation or on order. See Observatory of Non-State Climate Action (2021). Global Synthesis Report on Climate Action by Sector. Climate Chance

FIGURE 2

HYDROGEN DEMAND IN INDUSTRY, 2020

Source: International Energy Agency, 2022

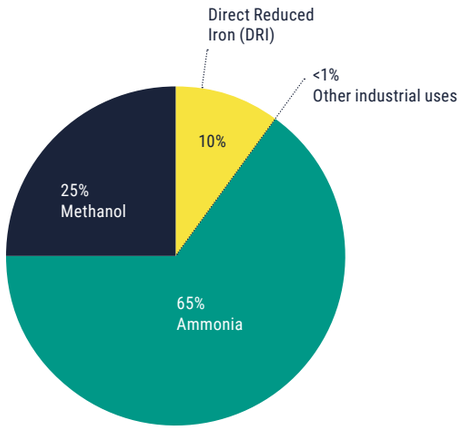
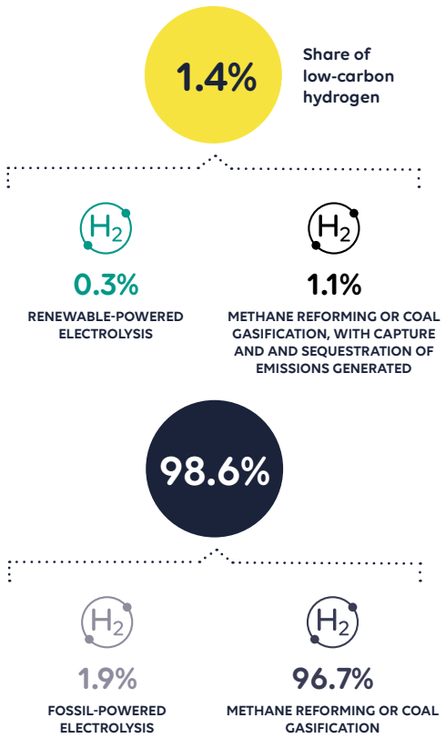


FIGURE 3

SHARE OF DIFFERENT HYDROGEN PRODUCTION METHODS

Source: Climate Chance, based on Global CCS Institute, 2021



Ammonia and methanol: two fledgling bets on the future

In an analysis of 24 transition scenarios for the maritime sector, DNV excluded electric propulsion from the shipping decarbonization options. Hydrogen was also ruled out for long-distance transportation, due to the technical difficulties of storage **(SEE BOX 2)**: hydrogen derivatives like ammonia and methanol are more viable for long distances, while hydrogen could be employed for shorter distances if mixed with other fuels.[29] Ammonia (NH_3) is one of the main outputs of hydrogen, known for its application as a fertilizer in the farming sector: in 2020, according to the IEA, ammonia production[d] already concerned 65% of the demand for hydrogen **(FIG. 2)**, of which 70% was used to produce fertilizer. According to the International Chamber of Shipping, because the energy density of ammonia is lower than that of oil, converting the entire international maritime fleet would mean tripling ammonia production to reach 440 million tonnes, which would require no less than 750 GW of renewable electricity.[30] Yet today, only 0.3% of the hydrogen produced in the world comes from renewable energy **(FIG. 3)**. In February 2022, the Greek shipowner Avin International launched *Kriti Future*, a "Suezmax" tanker presented as the first ship in the world ready to run on ammonia; to date, the vessel still operates on conventional fuel, but is equipped with the technology required for its conversion.[31]

The use of methanol as a fuel remains extremely marginal, but is entering into the strategies of the big shipping companies to diversify their energy sources. Methanol is an alcohol naturally produced by the metabolism of anaerobic organisms; while scarce in its natural state, it is produced synthetically using various chemical reaction processes mainly based on the use of gas (65%) and coal (35%). As a result, almost all of the 98 million tonnes of methanol produced annually come from fossil energies. Only 0.2 million tonnes of "renewable" methanol are produced each year, mostly biomethanol from biomass. But other forms of "e-methanol", obtained from blue or green hydrogen, open up perspectives for developing a low-carbon alternative – largely depending on the market capacity to develop a sufficient supply of low-carbon hydrogen to satisfy all of its potential uses.

Methanol, which has a high octane rating, can be used as a fuel in internal combustion engines. Today, 31% of methanol is used to produce biodiesel, and 14% employed directly as a fuel.[32] Although it is widely used in urban transportation in some countries (like China), methanol is still rarely employed in maritime transport: only 11 ships are currently in circulation, and 35 are on order.[33]

Actors have nevertheless become more interested in this option over recent years. AP. Moller – Maersk, which has committed to only order ships able to operate on low-carbon fuels, for example, placed an order for six vessels running on methanol in October 2022, with delivery expected in 2025.[34] With the aim of ensuring supplies of around 730,000 tonnes/year of methanol starting from late 2025, the Danish shipowner has

d 1 tonne of ammonia requires 180 kg of hydrogen

formed a series of strategic partnerships with industrial companies (including Orsted, Proman and European Energy) in order to develop bio- and e-methanol production.[35] CMA-CGM also ordered six ships operating on methanol in June 2022.[36]

BOX 2 • **KEYS TO UNDERSTANDING**

AMMONIA SEEN AS "ANOTHER" FORM OF HYDROGEN FOR THE ENERGY TRANSITION

Ammonia takes the form of a gas at room temperature and can be stored in liquid form once compressed (at -33 °C, against -253 °C for hydrogen). It is also cheaper than hydrogen to store in the long term ($0.5/kg-$H_2$ against $15/kg-$H_2$ for hydrogen), one to two times cheaper to transport by pipeline, and up to three times less expensive by boat. Therefore, more and more actors are thinking about using ammonia, in a similar way to hydrogen, as an alternative fuel for transportation or to supply gas or coal plants for example. The benefit of ammonia is that its combustion only generates water and nitrogen, and emits no carbonated molecules or soot particles. Japan in particular is banking on this molecule to reduce the carbon intensity of its maritime industry, transport hydrogen, and store energy. In November 2020, the Japanese Ministry of Economy, Trade and Industry (METI) announced the formation of a council to work on developing ammonia as an energy product. By 2030, Japan intends to import 3 million tonnes of "clean" ammonia, and to this end, is accelerating its international cooperation efforts (especially with the Middle East, Australia and New Zealand).

Electrification targets short-distance transportation and ships moored at the quay

Only very few large ships running on electricity or hydrogen have entered into service or even into the test phase. DNV currently lists 396 vessels in operation running on electric batteries or hybrid systems. The *Yara Birkeland*, announced in 2017 as the first autonomous container ship propelled by an electric battery, was named this year in Norway and has started a two-year test phase to attain certification.[37] To support its strategy of carbon neutrality by 2050, the port of Antwerp ordered a hydrogen-powered tugboat in 2019. Called *Hydrotug*, it is not due to enter into service for several years.[38] The Swedish company Stena Line, which already operates hybrid ferries (diesel-electric), announced in September that it would be launching a 100% electric ferry, the *Stena Elektra*, for journeys between Gothenburg and Frederikshavn (Denmark) – but not until 2030.[39] In addition to the obstacles related to the supply of strategic metals indispensable for manufacturing batteries, the negative environmental externalities of extraction, and the pressure on demand for electricity **(SEE "ROAD TRANSPORT" TREND)**, the electrification of ships requires creating a political, economic and infrastructural ecosystem shared by the ports of different countries. In fact, guaranteed access to charging stations and their compatibility with the different vessels are indispensable for the roll-out of electric ships. In the absence of an international agreement, port authorities and cities have set up bilateral and multilateral initiatives that aim to coordinate their efforts to reduce the carbon intensity of maritime transport.

BOX 3 • **EXPERIENCE FEEDBACK**

GREEN SHIPPING CORRIDORS

Green shipping corridors involve developing low-carbon commercial shipping routes between major ports, by promoting the deployment of low-emitting vessels, the installation of shore power facilities, and an incentivizing legal environment. One year after the Clydebank Declaration, a report by the Global Maritime Forum provides the very first overview of these fledgling initiatives: 21 green shipping corridor initiatives have been listed, twelve of them short distance and seven in the high seas. Nineteen of them are run by non-state actors: ports (9), industries (4), and public-private partnerships (9), and the remainder by states (3). At the moment, the targets fixed by these projects run from 2027 to 2030. For example, in January 2022, the ports of Los Angeles and Shanghai, joined by the port of Long Beach in June, in partnership with the global city network C40Cities, A.P.Moller–Maersk, CMA-CGM and other industrial and research actors, announced the kick-off of a project to create the first transpacific green shipping corridor between China and the United States;[40] the implementation plan of the corridor is expected in late 2022. At COP27 in Sharm el Sheikh, the Norwegian prime minister Jonas Gahr Støre and the US special presidential envoy for climate, John Kerry, officially launched the Green Shipping Challenge, an initiative aimed to encourage all actors in the maritime transport value chain to make concrete commitments to decarbonize the sector. About forty announcements were made during the conference to promote innovation for ships, the expansion of low-carbon fuels, and policies encouraging the adoption of new-generation vessels.[41]

Shoreside electricity for ships also reduces pollution in the ports. The activities associated with the highest-emitting port in Europe, Rotterdam, for example total almost 14 MtCO_2e, which is as much as the Weisweiler coal-fired plant in Germany, the fifth most emitting industrial site in Europe according to an assessment by the NGO Transport & Environment.[42] Of these emissions, 640,000 tCO_2e are produced by activities at the port site, i.e., loading, unloading and fuelling. The Alternative Fuels Infrastructure Regulation (AFIR) proposed by the European Commission as part of the Fit for 55 plan and voted by the European Parliament in October 2022 anticipates establishing minimum targets for shoreside electricity supply in sea ports.[43] The ports of Southampton (United Kingdom),[44] Sydney (Australia)[45] and the French Haropa Port complex (Le Havre, Rouen, Paris)[46] have for example launched works to install power supply facilities for ships at the quayside. Maersk has announced a plan to set up offshore charging stations to supply ships with electricity through underwater pipelines to avoid the combustion of fossil fuels when ships moor close to ports. The Danish group is planning to install ten buoys in 100 ports by 2028, to reduce emissions by 5 MtCO/year as well as air and sound pollution.[47]

BOX 4 • **EXPERIENCE FEEDBACK**

INNOVATIVE USE OF WIND POWER FOR BIG SHIPS

As part of the Fit for 55 plan, the European Commission has proposed the FuelEU Maritime directive, with the aim of driving the sector towards low-carbon fuel. In its position on the text adopted in October 2022, the European Parliament suggested a more ambitious reduction of the intensity of GHG emissions: 2% starting from 2025, 20% in 2035, and 80% in 2050. To achieve this, the Parliament rapporteur defends a "technologically neutral" approach, which gives shipowners the possibility of using methanol, hydrogen, advanced biofuels and… wind propulsion. In moving away from an approach centred on fuels and extending the scope of the text to "energies", the Parliament satisfies the demands of industrial and political actors that advocate the development of widescale wind-assisted propulsion, like the International Windship Association. In France, several projects are based on wind-assisted propulsion to transport goods. On a small scale, the Grain de Sail company makes transatlantic crossings using a 23-metre sailboat with a 350-tonne loading capacity to import chocolate and coffee from North America to Europe, which it then processes in Brittany in its own factories. This approach leads to a 97% reduction in the journey's carbon footprint.[48] A second ship is due to be launched in 2023. The French region of Brittany, with over 150 companies in the sector, announced that it was launching a new maritime transport activity by sailboat in November 2021.[49] The cooperative Windcoop will begin building a first ship with a load capacity of 1,400 tonnes in 2023 and inaugurate its activities in 2025 between France and Madagascar.[50] The TOWT (TransOceanic Wind Transport) project, backed by the European Union and French public donors, is pursuing similar objectives to increase transport of organic goods by sailboat from the port of Le Havre.[51]

Reorganizing logistics chains: the elephant in the room

Demand for transport of goods in tonne-kilometres is set to triple by 2050 if no action is taken.[52] This demand is the result of an intensification of international trade (tonnes), coupled with a logistics chain organization that involves very long distances (km). The latest IPCC report in fact explains that emissions from goods transportation grew faster over recent years than the total emissions from transportation of people, mostly due to a sharp increase in distances and trade. The report also highlights the need to integrate more mitigation options, and in particular to consider organizational and systemic changes, in addition to technological changes, if we want to reach carbon neutrality half way through the century.[53] Whereas technological avenues for deep decarbonization of long-distance ships and the production of low-carbon fuels are still far from mature, the reorganization of international value chains helps to reduce distances and the associated energy consumption, therefore decreasing the need for alternative zero-emission fuels and facilitating the penetration of alternative forms of motorization at regional level. This reorganization involves the transition from a production-consumption system towards more circularity, proximity and resilience to simplify and shorten value chains.[54] A recent study by UNCTAD for example characterized four main development trends in logistics chains (reshoring, diversification, regionalization and replication); three of them tend towards shorter, sometimes less fragmented chains.[55] Other reports observe a regionalization of trade and the shortening of current logistics chains, in particular in Asia.[56] At present, numerous non-coordinated public actions already underway are transforming international production and logistics chains, such as the development of new economic and industrial policies (e.g., reinforcement of regional and bilateral commerce, change in commercial and geopolitical alliances, reinforcement of national production strategies) or the development of new environmental policies (e.g. carbon emissions trading, carbon taxation at borders, zero-deforestation product regulations). Nevertheless, none of the strategies to reduce maritime transport emissions (not even the official IMO strategy) considers a real change in logistics chains.

KEY TAKEAWAYS

While the sector struggles to reduce its emissions in absolute value, the IMO is planning to revise the emissions reduction strategy for the shipping sector in 2023 by setting an even more ambitious target. Over recent years, international maritime transport actors have already made initial short-term technological choices: scrubbers to reduce sulphur emissions, LNG to reduce long-distance transport emissions, and electrification for short distances. However, these options will not be sufficient in the long term to considerably reduce the sector's emissions. The course is set, but alternative routes are emerging to reduce the climate impact of the sector. First, the reorganization of logistics chains around regional hubs can reduce the distance of international exchanges and the associated energy consumption. Second, still rather exceptional local initiatives are attempting to organize value chains based on transporting goods by sailboat. Alternative fuels based on hydrogen, such as methanol and ammonia, although still marginal on the market, are the object of increasingly large investments and feature in shipowners' decarbonization strategies. But the very low current production of low-carbon hydrogen (green and blue) and competition with other usages (decarbonization of industry, for example) raise the question of whether these alternative fuels are really capable of shifting the sector in the next few years.

REFERENCES

RETURN TO PREVIOUS PAGE

1 Enerdata, Global Energy & CO_2 Data

2 IMO (2020). Reduction of GHG emissions from ships. Fourth IMO GHG Study 2020 – Final report. *International Maritime Organisation*. MEPC 75/7/15

3 IPCC (2022). Climate Change 2022: Mitigation of Climate Change. AR6 Chapitre Transport. *Intergovernmental Panel on Climate Change*

4 *Ibid.*

5 UNCTAD (2021). Review of Maritime Transport 2021. *United Nations Conference on Trade and Development*

6 UNCTAD (2019). Review of Maritime Transport 2019. *United Nations Conference on Trade and Development*

7 UNCTAD (2021). *Review (...), op. cit.*

8 Daniel, L., Adashi, T., Lee, S. (2022). Shipbuilding market developments, first semester 2022. *OECD*

9 Gyasi, K., Longley, A. (08/08/2022). Oil Tankers See Strongest Market in Decades on Thirst for Fuels. *Bloomberg*

10 Paris, C. (25/02/2022). Next Threat to Prices: A Surge in Costs to Ship Products. *The Wall Street Journal*

11 Milne, R. (08/09/2022). Hard landing threat hangs over booming container shipping industry. *Financial Times*

12 IMO (2018). Adoption of the initial IMO strategy on reduction of GHG emissions from ships and existing IMO activity related to reducing GHG emissions in the shipping sector. *International Maritime Organisation*

13 IMO (2018). Adoption of the initial IMO strategy (...), *op. cit.*

14 Chamber, S. (13/06/2022). VLSFO to HSFO price differential stands at record $538 per ton in Singapore. *Splash*

15 Ovcina, J. (03/05/2021). BIMCO: Steady rise in scrubber-fitted ships backs demand for HSFO. *Offshore Energy*

16 Osipova, L., Georgeff, E., Comer, B. (2021). Global scrubber washwater discharges under IMO's 2020 fuel sulfur limit. *The International Council on Clean Transportation*

17 The Maritime Executive (20/10/2022). Study: Open-Loop Scrubbers Contribute to PAH Pollution in the Baltic. *The Maritime Executive*

18 North (09/09/2021). No Scrubs: Countries and Ports where Restrictions on EGCS Discharges Apply. *North*

19 The Editorial Team (21/01/2020). New marine fuels blends emit more black carbon than HFO, study says. *Safety4Sea*

20 Climate & Clean Air Coalition (n.d.). Black carbon

21 Mandra Ovcina, J. (12/09/2022). DNV: Hydrogen likely to have limited uptake in deep-sea shipping. *Offshore Energy*

22 *Ibid.*

23 GIIGNL (2022). GIIGNL Annual Report 2022. *International Group of Liquefied Natural Gas Importers*

24 IMO (2020). Reduction of GHG emissions from ships, *op. cit.*

25 Ushakov, S., Stenersen, D., Einang, P. M. (2019). Methane slip from gas fuelled ships: a comprehensive summary based on measurement data. *Journal of Marine Science and Technology*, vol. 24, pp. 1308-1325

26 T&E (13/04/2022). Methane escaping from 'green' gas-powered ships fuelling climate crisis – Investigation. *Transport & Environment*

27 IMO (2020). Reduction of GHG emissions from ships, *op. cit.*

28 Pavlenko, N., Comer, B., Zhou, Y., Clark, N., Rutherford, D. (2020). The climate implications of using LNG as a marine fuel. *The International Council on Clean Transportation*

29 La rédaction (18/09/2022). Maritime : l'hydrogène exclu du transport longue distance. *H2 Mobile*

30 ICS (2020). Catalysing the fourth propulsion revolution. *International Chamber of Shipping*

31 Hakiveric Prevljak, N. (04/02/2022). World's first ammonia-ready vessel delivered. *Offshore Energy*

32 IRENA, Methanol Institute (2021). Innovation Outlook: Renewable Methanol. *International Renewable Energy Agency*

33 Mandra Ovcina, J. (12/09/2022). DNV: Hydrogen likely to have limited uptake in deep-sea shipping, *op. cit.*

34 Reuters (05/10/2022). Maersk orders six more vessels fuelled by carbon neutral methanol. *Reuters*

35 Maersk (10/03/2022). A.P. Moller - Maersk engages in strategic partnerships across the globe to scale green methanol production by 2025. *Maersk*

36 Hakirevic Prevljak, N. (06/06/2022). CMA CGM orders its first methanol-powered containerships. *Offshore Energy*

37 The Maritime Executive (29/04/2022). Yara Birkeland Begins Further Testing for Autonomous Operations. *The Maritime Executive*

38 World Maritime News (26/09/2019). Port of Antwerp Orders World's First Hydrogen-Powered Tug. *Offshore Energy*

39 Stena Line (10/05/2021). Stena Line challenges the shipping industry – by going electric. *Stena Line*

40 C40 (01/2022). Port of Los Angeles, Port of Shanghai, and C40 Cities announce partnership to create world's first transpacific green shipping corridor between ports in the United States and China. *C40*

41 Office of the spokesperson (07/11/2022). Launch of the Green Shipping Challenge at COP27. *U.S. Department of State*

42 T&E (02/02/2022). Rotterdam tops ranking of port carbon polluters. *Transport & Environment*

43 Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council

44 Hakirevic Prevlja, N. (14/04/2022). UK's Port of Southampton opens its first shore power facility. *Offshore Energy*

45 Bahtić, F. (11/011/2022). NSW Government fast-tracks shore power project in Sydney. *Offshore Energy*

46 Haropa Port (24/09/2021). HAROPA PORT s'équipe pour alimenter les navires à quai en électricité et réduire leur empreinte environnementale. *haropaport.com*

47 Gronholt-pedersen, J. (25/01/2022). Maersk to tackle air pollution at ports with ship-charging buoys. *Reuters*

48 https://graindesail.com/fr/

49 Région Bretagne (10/11/2021). Bretagne : naissance d'une nouvelle filière de transport maritime à propulsion par le vent. *bretagne.bzh*

50 Gouty, F. (13/06/2022). Propulsion vélique: la nouvelle coopérative Windcoop parie sur le premier porte-conteneur à voiles. *Actu Environnement*

51 https://www.towt.eu/en/towt-home/

52 International Transport Forum (2019). ITF Transport Outlook 2019. *OECD*

53 IPCC (2022). Climate Change 2022: Mitigation of Climate Change, *op. cit.*

54 Waisman, H., et al. (2021). Climate ambition beyond emission numbers: taking stock of progress by looking inside countries and sectors. *Deep Decarbonization Pathways (DDP) Initiative, IDDRI*

55 UNCTAD (2020). World Investment Report 2020. International production beyond the pandemic. *United Nations Conference on Trade and Development*

56 Falk, S., Ruiz Hernanz, A., Seric, A., Steglich, F., Zagato, L. (2021). The future of GVCs in a post-pandemic world. *United Nations Industrial Development Organization*

TRENDS
RAIL

Heatwaves pushing the sector off its rails

TANIA MARTHA THOMAS • Research Officer, Global Observatory of Climate Action, Climate Chance

While rail is one of the least polluting modes of transport, it is also one of the most vulnerable to climate change. 2022 and its succession of heat waves around the world put railways under stress, even though the issue has been studied for a long time. While there are ways to adapt, including nature-based solutions, their uptake to date has not been rapid, with current responses more geared to short-term crisis management than to longer-term adaptation.

DATA OVERVIEW

The electrification of railways charts it course around the world

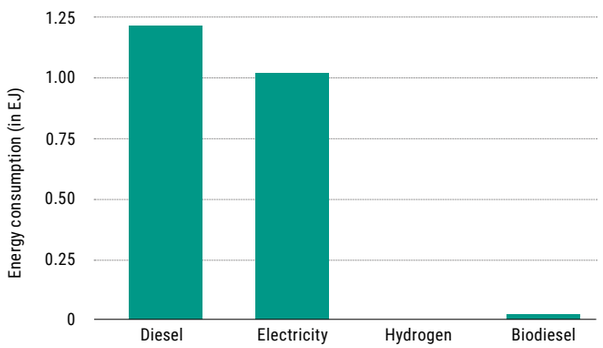
Rail transportation is among the means of passenger transport that emit the least greenhouse gases (GHG): with a carbon intensity of about 15 gCO_2e[1] per passenger-kilometre,[a] which is less than a tenth of that of large cars or aircraft.[2] It also has about the same efficiency when transporting goods. While it represents about 9% of the global transport of passengers and 7% of global freight,[3] rail transport only accounted for 2.2% of the total energy consumption of the transport sector in 2021,[4] and no more than 1.5% of the sector's direct CO_2 emissions.[5] In 2021, total direct worldwide emissions from the railway sector amounted to 96.8 $MtCO_2$, on the rise compared to 2020 (89.91 $MtCO_2$, an increase of 7%), but well below the peak reached in 2019 (104.22 $MtCO_2$).[6] With the annual increase since 2019 in diesel rail operations being less than 1%, and electric rail not directly emitting CO_2, emissions from the sector are not expected to reach 2019 levels again.[7]

In the face of limited options for increasing the efficiency of rolling stock, the decarbonisation strategies of actors in the railway sector essentially seek the electrification of rail lines, a trend that has already seen progress in recent years; the worldwide share of electrified railway tracks increased from 36.7% in 2015 to 40.2% in 2019.[8] Rail electrification percentages for passenger and freight transport differ significantly from each other: electric rail accounts for about 80% of passenger transportation, and about half of all freight traffic. As a result, the final energy consumption for rail transport in 2021 is almost equally split between electricity and diesel, with biodiesel accounting for only a tiny share, while developments in fuel cell (hydrogen) trains are not yet substantial enough[9] (**FIG. 1**).

FIGURE 1

FINAL ENERGY MIX OF RAIL TRANSPORT IN 2021

Source: IEA, 2022



Yet regional and intra-regional variations in the rates of rail electrification persist. While a substantial part of European rail networks is already electrified (more than 60% of main lines),[10] it is in Western Europe that electrification is highest. According to data from the European Commission and the German Ministry of Transport and Digital Infrastructure, compiled by the NGO Pro-Rail Alliance, Switzerland leads with an electrification percentage of 100%, ahead of Belgium with 86%. The Netherlands, Sweden, Austria, Italy, Poland, and Spain follow, while Germany is placed at 61%—having increased railway electrification by no more than 2% between 2009 and 2019,[11] and France at 58%—having increased by 0.22% since 2014 and by 4% since 2019.[12] The Deutsche Bahn, the German railway company announced its 2040 climate neutrality goals in 2021, bringing them forward by 10 years compared to its previous target. The company has also committed itself to supplying its factories, offices, and stations with 100% renewable energy by 2025. To this end, it signed renewable energy purchasing agreements with Statkraft

a The passenger-kilometre, which corresponds to transporting a passenger over a distance of 1 kilometre, is the unit of reference for measuring the volume of passenger transport. In the same way, the tonne-kilometre corresponds to the transportation of a tonne of goods over a distance of 1 kilometre. These units therefore depend on the carbon footprint of the means of transport used as well as on their capacity (in goods or passengers).

and RWE[13] in 2021. To free low-traffic smaller regional lines (*"petites lignes"*) from diesel, the SNCF in France has targeted a strategy known as "frugal electrification", which is based on the development of battery-powered trains, particularly for sections of railway that would be difficult to electrify – as seen in the pilot project using battery-powered trains on the Aix-Marseille line. This strategy also involves taking into consideration the specific needs of each line, whether mostly used by passengers or freight, and choosing electrification options accordingly—catenary or other.[14]

Throughout Europe, efforts are underway to electrify more lines or develop greener alternatives to diesel trains. In Lithuania, ABB won a contract for the electrification of the Vilnius-Klaipėda line within the framework of a larger programme aiming to electrify 39% of the country's railway lines (currently, only 8% are electrified), and to ensure better interoperability with the European network.[15] Alstom and Avax will work on the modernisation of the Thessaloniki-Idomeni line in northern Greece. This line is part of the pan-European X corridor which connects Thessaloniki to Budapest, passing through North Macedonia, Serbia and Hungary—one of the main freight corridors in Central and Eastern Europe.[16] Hungary is targeting hybrid trains in order make its network greener,[17] and recently strengthened its collaboration with Alstom, with the signing of a cooperation agreement to develop both the national rail sector and the manufacture of rolling stock at Alstom production sites in the country.[18]

Alongside electrification processes, the European energy crisis led to the issue of overall energy saving being added as a rail sector priority. Major operators have been taking steps to reduce their energy consumption: the SNCF is working to reduce the energy consumption of its trains by regulating their speed using more efficient traction technology, switching off the motor during stops, and reducing the energy consumption of its buildings and its heating.[19] Deutsche Bahn proposed an energy consumption reduction incentive to employees,[20] while the Swiss Federal Railways is reducing the speed of its trains, the temperature inside the trains, and the lighting in stations.[21]

In the United States, where the rail network is used more for freight than for passengers, the electrification percentage is below 1%.[22] Its future growth and profitability remain uncertain.[23] The Association of American Railroads states that electrification of the network using overhead lines is "unfeasible", while touting investments in battery-powered electric trains.[24] On the other side of the world, in Asia, electrification is in full swing. By March 2022, India had electrified almost 80% of its network,[25] while Pakistan and Bangladesh were also modernising their networks.[26] Southeast Asia has made progress in both electrification and the construction of high-speed lines, as evidenced by the development of the Jakarta-Bandung line in Indonesia (expected opening in 2023) or the construction works for the Bangkok-Nong Khai line in Thailand.[27]

As electrification progresses, the source of the electricity used to power the trains has without doubt an effect on the ultimate carbon footprint of rail transport—a concern that is being taken into account on the African continent,[28] as new rail projects are emerging in Senegal, Nigeria, Kenya, Guinea, and elsewhere. While rail electrification on the continent is currently at 15%, new projects are being developed, in particular those financed by the Chinese Belt and Road initiative,[b] or by way of competing European investments through the Global Gateway initiative.[29]

THE OBSERVATORY'S LENS

Adapting rail transport to global warming in order to stay on track

While rail transport has been identified as the least vulnerable to liability and transition risks[c] due to its relatively low share of emissions, they are relatively more exposed to physical risks. The modal share of rail transport for passengers and freight could be affected by an increase in traffic in years to come as current incentives materialise (such as those which are part of the EU's Sustainable and Smart Mobility Strategy, or the Green Deal, for example, or even national and local policies).[30, 31] In this context, rail operators should be better prepared to manage this additional traffic, given that they are exposed to physical risks associated with the impacts of climate change.

Little flexibility and high vulnerability

The greatest challenge for railways in the face of climate change comes from the low flexibility of their infrastructure and operations. These are very vulnerable to extremes of temperature and intense weather events. Failure of a single component may entail high replacement costs and long service interruptions.[32, 33] Extremes in temperature and amounts of rainfall, as well as storms, can all have an effect on various components of rail infrastructure, including the tracks themselves, railway signalling systems, overhead power lines, track-carrying infrastructure (such as bridges, tunnels, viaducts, etc.) and trackside structures (embankments, drainage, and vegetation) (**FIG. 2**).

High temperatures can, for example, directly affect the tracks, with thermal expansion and buckling of the rails, or electrical equipment, with sagging overhead cables. In most countries, rails are designed to operate within a range of 45 °C, depending on local conditions. In Great Britain, for example, rails are resistance-tested at temperatures up to 27 °C—a threshold that would undoubtedly be higher in a warmer climate—beyond which they remain vulnerable.[34] Forest fires may also affect the rails or obstruct them when vegetation alongside the tracks burns. High winds may cause overhead lines, trees, or

b See Observatory of Non-State Climate Action. (2021). Global Synthesis Report on Climate Action by Sector. *Climate Chance*.

c As proposed by Mark Carney, former Governor of the Bank of England, the risks faced by companies usually fall into 3 categories: "physical risks" resulting from the unpredictable effects of climate change on our environment; "transition risks" resulting from the effects of imposing a low-carbon economic model on economic actors; "liability risks" resulting from legal action initiated against the financial actors when they are held accountable for climate inaction.

objects to fall on tracks. Heavy and light rainfall may affect surrounding infrastructure such as slopes and embankments through landslides and flooding, or cause water damage to equipment.

The most recent examples of these effects occurred in 2022 when a heat wave severely hampered infrastructure and train routes across Europe. During last summer in France, problems with power lines and track-side fires interrupted train services in Brittany, and power cuts as a result of the heatwave led to a suspension of train traffic in Hauts-de-France. After calculating the temperature of the rails, the SNCF, and the RATP in Paris, imposed much lower speed limits on the trains and metros they operate, owing to the risk of rail deformation due to heat.[35] Similarly, in the UK, train speed was restricted as part of the red extreme heat warning,[36] two main line closures occurred, damage was caused to overhead power lines, and fires also spread to the tracks.[37]

UK operator Network Rail also reported the need to rebuild embankment infrastructure following landslides, and increasing pressure on drainage systems.[38] This problem is particularly acute in Europe and North America, where a lot of railway infrastructure is in places up to a century and a half old, and are therefore even less resilient to climate change.[39, 40] In 2018, a landslide caused a derailment in Catalonia, Spain, leading to one death and several injuries.[41] In 2020, heavy rainfall caused a derailment in Scotland, the first fatal railway accident in the UK in over 10 years. The 2021 floods in Belgium and Germany caused €1.3 billion in damage to railways, with damage to level crossings, bridges and signalling and electricity masts.[42]

The financial costs of these incidents increase each year, shifting their status from "*inconveniences*" to "*serious threats affecting every aspect of a rail operator's cost structure*".[43] In 2021, the Lava and Dixie fires in the United States caused serious damage to the infrastructure of freight giant Union Pacific, costing 100 million dollars. This was compounded by the chaos rampant throughout the network because trains needed to be rerouted, taking detours which quadrupled the duration of the journeys, and the need for additional manpower and resources.[44]

Around the world, rail operators must also adapt their operations to climate effects, whether by rerouting or rescheduling trains, or reassessing transport priorities. In the north of India, the 2022 summer heat wave forced Indian Railways to cancel more than 1,100 passenger and mail trains in order to make way for trains transporting coal to the country's power stations.[45] While timetables are being altered due to delays, operators are also asking passengers to limit their train travel,[46] or to prepare for higher temperatures.[47]

"Grey" and "green" solutions to adapting infrastructure

"Grey" or "hard" solutions in the context of adaptation (mainly coastal adaptation until now) refer to engineered solutions that involve artificial constructions. In contrast, "green" or "soft" solutions refer to using nature through smaller-scale initiatives, and may even complement "grey" solutions.[48, 49] In the context of railways, the majority of adapted solutions so far have been grey solutions, while the use of green solutions has been very limited, with very few studies on them.[50]

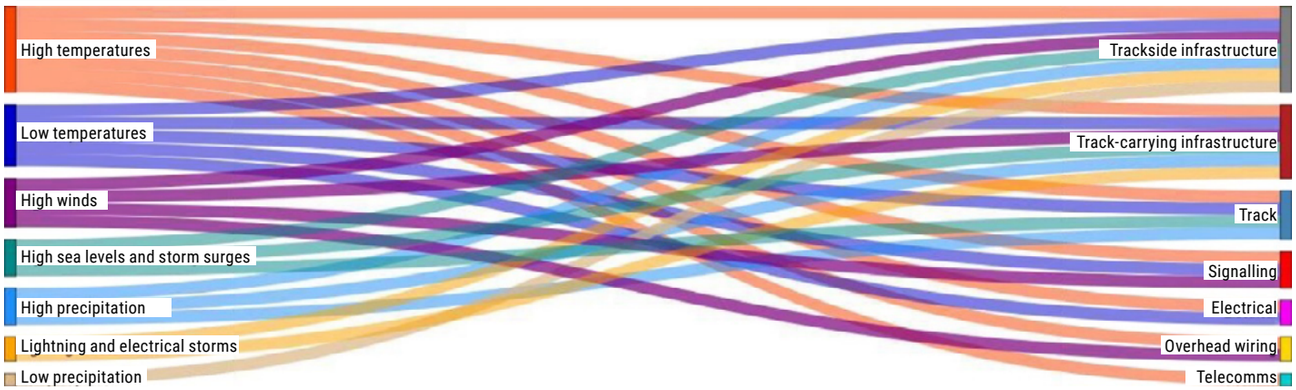
In the event of high temperatures directly affecting rails, an example of a commonly adopted solution is to paint the rails white in areas where they are directly exposed to the sun and therefore at risk of expansion—this has already been done in Germany, Italy,[51] Switzerland[52] and the UK,[53] among others. At the same time, the effectiveness of this method has been questioned, with calls for better anticipation and preparation for rail expansion and buckling by using composite materials or rail expansion joints that leave enough space.[54, 55] Network Rail has also resorted to using concrete to lay tracks rather than the traditional sleepers or gravel, since concrete can withstand greater forces.[56]

Overhead electrical cables can be adapted to higher temperatures by installing them with weights or springs to compen-

FIGURE 2

HYDRO-METEOROLOGICAL RISKS AFFECTING RAIL INFRASTRUCTURE

Source: Blackwood, Renaud & Gillespie, 2022



sate for sagging or, in the case of older cables, by adjusting their height and tension.[57] While slowing down trains is also an option, it carries the risk of traffic disruption and of potential losses for the operator. Generally, with infrastructure like bridges or overpasses, the most common protection against overheating is the use of automatic water sprinklers, or replacing existing infrastructure with heat-resistant infrastructure.[58]

In response to flooding and rising sea levels, grey options include raising the level of stations, installing dikes and pumps, and stabilising hillsides and slopes. Although all of these options have been put in practice at varying scales, a common problem often encountered by older railway networks is related to land use restrictions, since land surrounding the tracks is often not owned by the operators, which leads to extremely steep slopes along railway lines, for example. This remains a limiting factor that prevents many operators from taking action, as does the overall age of the rail network.[59, 60]

This is one of the advantages that green solutions could have, being relatively cost effective and requiring less extensive work. In addition, whereas grey infrastructure degrades over time, vegetation grows stronger as trees and plants take root.[61] Green corridors and vegetation for shade have been identified as ways to reduce direct sun exposure, although careful selection of specific species and vegetation management is crucial to ensure that the trees and plants do not become a hindrance or block the rails. Windbreaks, biotechnical stabilisation and bioengineering[d] of embankments and slopes are potential solutions to turning grey infrastructure green.[62]

Although limited, there are examples of the use of such solutions, such as the net positive biodiversity policy of the Thameslink upgrade and extension programme, which involved the construction of embankments on either side of the railway in London by planting wild native flower species to reduce runoff.[63] The Adelaide-Seaford line in Australia completed a project to green the corridor by planting trees along the line, but these were eventually uprooted in order to carry out the electrification of the line, thereby highlighting the potential conflicts between the mitigation and adaptation strategies in the sector. Although other projects have been proposed and vegetation planting initiatives have been carried out, there is insufficient information on the relevant benefits of these initiatives.[64]

Adaptation specific to the region in question is also to be considered, because railways face different challenges in different geographic areas.[65] In Egypt, for example, sandstorms cause problems on railway lines, with sand accumulating and settling on the tracks. Since 1999, Egyptian National Railways has studied wind patterns and topology to make aerodynamic modifications to the slopes of embankments in order to protect the Abou Tartour – Qena freight line.[66]

In various projects in emerging countries, adaptation is integrated into new rail projects from the outset. Incorporating adaptation as a criterion at the design phase is also less costly.[67] In India, the Dedicated Freight Corridor development project takes proactive adaptation measures against fog (advanced communication between track signals and the train cabin), temperature variations (definition of thresholds, development of early warning systems and sensors on the rails), and floods (definition of thresholds and integration of climatic provisions in construction standards).[68] In China, the Railway Design Corporation is developing measures to keep high-speed lines running under conditions of extreme cold, such as "freeze-thaw" embankments, antifreeze materials for bridges and other civil engineering structures, switches to melt ice and snow, etc. In 2017, 2,659 km of tracks were built using these technologies and an additional 2,572 km were under construction during this period.[69] In 2021, the country successfully tested the Fuxing high-speed train, which is capable of withstanding blizzards and temperatures down to -40 °C.[70]

Adaptation at the institutional level: a matter of taking ownership of issues

At the transnational level, especially in Europe, various initiatives have been launched to study the impact of extreme meteorological conditions and climate change on rail transport and related infrastructure. In 2009, the International Union of Railways (UIC) launched the Adaptation of Railway Infrastructure to Climate Change (ARISCC)[71] project, with the aim of establishing cooperation between professional sectors and fields, meteorologists and climatologists working with railway experts to improve preparedness.[72] The findings and case studies resulting from the programme were then made available on the dedicated website. The UIC also has a framework document—RAIL ADAPT—to help rail companies adapt to climate change and support national climate commitments.[73]

Various initiatives have also been launched at the European level, such as those financed by the European Commission, with programmes that include FP7 EWENT, FP7 WEATHER, FP7 SMART RAIL, MOWE-IT, or the Horizon2020 Destination RAIL project, all of which have produced results and recommendations on topics such as the impacts, consequences, and costs of extreme weather on rail networks, risk modelling, and the best practices for the effective management and maintenance of such infrastructure.[74] There are also research initiatives at the national level, often led by governments in partnership with rail operators and relevant stakeholders—such as the TRaCCA (Tomorrow's Railway and Climate Change Adaptation)[75] project in the UK. In Spain, a government initiative[76] working with all major transport stakeholders (including Renfe, the national railway company) studied the vulnerability of infrastructure to climate change in order to understand requirements in terms of adaptation.

d Bioengineering and biotechnical stabilisation involves the use of vegetation to maintain stability and reduce the risk of erosion and runoff—instead of using gabions or soil nails, for example.

Building on this knowledge and working within national institutional adaptation frameworks, rail operators have adopted various adaptation strategies, taking ownership of adaptation actions to varying degrees. In the United States, several operators are working under Federal Railway Administration programmes to bolster the resilience of the sector.[77] The SNCF carries out annual inspections in order to assess adaptation measures each summer, and is currently working on its adaptation roadmap as part of the national adaptation plan.[78] In Canada, as part of the development of the first National Adaptation Strategy, the Rail Climate Change Adaptation Program will contribute up to 2.2 million dollars of funding to Canadian railways to share the costs of research on improving their resilience.[79] Network Rail is working on its network based on findings from TRaCCA and its own Weather Resilience and Climate Change Adaptation plans (WRCCA).[80, 81] In response to the 2022 heat wave, Network Rail also launched its resilience task force made up of independent experts.[82]

Therefore, while most railway operators, nationalised or not, have set up a strategy for adapting to climate change, the manifestation of these strategies varies, ranging from dispersed actions or a wider adoption of national strategies, to detailed and documented operator strategies. Among the factors influencing the effectiveness of adaptation strategies are the organisational values of operators, knowledge of the vulnerabilities to climate change and the integration of this knowledge into daily operational practice, and the simultaneous consideration of adaptation and mitigation actions.[83]

KEY TAKEAWAYS

Rail is currently among the relatively green modes of transport for both freight and passengers, and is on the way to becoming more so as rail electrification progresses—although rates vary according to region, and the benefits of this process must be assessed while taking the electricity mix into account. However, with the effects of climate change becoming apparent, the rail sector is left vulnerable to costly disruption and damage to infrastructure. While short-term "grey" solutions are adopted in immediate response to crises, railway operators are already considering longer-term options, such as using more natural "green" solutions. The incorporation of adaptation criteria in the design of projects prior to their launch is emerging in developing countries. While knowledge of rail transport adaptation issues is growing, the implementation of the relevant recommendations is hindered by a number of factors, such as land ownership and the lack of ownership of adaptation issues within national institutional frameworks.

REFERENCES

RETURN TO PREVIOUS PAGE

1 IEA, UIC (2017). Railway Handbook 2017. *Agence Internationale de l'Energie, Union Internationale des Chemins de fer*

2 SLOCAT (2021). Tracking Trends in a Time of Change: The Need for Radical Action Towards Sustainable Transport Decarbonisation, Transport and Climate Change Global Status Report – 2nd edition. *SLOCAT.*

3 IEA (2019). The Future of Rail. *International Energy Agency.*

4 Enerdata (2021). Global Energy & CO_2 Database. *Enerdata.*

5 *Ibid.*

6 *Ibid.*

7 IEA (2022). Rail. *International Energy Agency.*

8 SLOCAT (2021). Tracking Trends in a Time of Change..., *op. cit.*

9 IEA (2022). Rail, *op. cit.*

10 Commission européenne (2017). Electrification of the Transport System: Studies and Reports. *Commission européenne.*

11 Allianz pro Schiene (25/10/2021). Deutschlad fällt bei E-Mobilität auf Gleisen zurück. *Allianz pro Schiene.*

12 DataLab (2021). Chiffres clés du transport – Edition 2021. *Ministère de la Transition Ecologique.*

13 Meza, E. (17/06/2021). German railway accelerates transformation towards climate neutrality. *Clean Energy Wire.*

14 SNCF (02/06/2022). L'électrification frugale pour décarboner les petites lignes. *SNCF.*

15 Artymiuk, S. (21/10/2022). Vilnius-Klaipeda electrification contract signed. *International Rail Journal.*

16 Papatolios, N. (17/03/2022). Alstom undertakes railway infrastructure upgrades in Greece. *RailFreight.com*

17 Zasiadko, M. (15/05/2020). Hungarian Railways focuses on hybrid trains. *RailTech.com*

18 Robinson, E. (18/10/2022). Alstom sign Strategic Cooperation Agreement with the Government of Hungary. *Global Railway Review.*

19 SNCF (30/09/2022). Notre engagement au service de la sobriété énergétique. *SNCF.*

20 DW (08/02/2022). Deutsche Bahn offers staff bonus to save energy. *Deutsche Welle.*

21 Augusteijn, N. & Steffers, K. (21/10/2022). SBB taps the brakes in bid to save energy. *RailTech.com*

22 Nunno, R. (30/05/2018). Electrification of U.S. Railways: Pie in the Sky, or Realistic Goal? *Environmental and Energy Study Institute.*

23 Hoecker, J. et al (2022). Rail Electrification in North America: Benefits and Barriers. *Rail Electrification Council.*

24 AAR (2021). Freight Railroads and Climate Change. *Association of American Railroads.*

25 Central Organization for Railway Electrification (2022). Home. *Indian Railways.*

26 Raina, A. et al (2022). Railways in Developing Countries: A Global Review. Mobility and Transport Connectivity Series, Transport Global Practice. *World Bank.*

27 Clark, J. (18/10/2022). Southeast Asia Railways Report – 2022 edition. *Future Southeast Asia.*

28 Filou, E. (06/07/2022) How can Africa's under-developed railway network become one of the most modern in the world? *Electric & Hybrid Rail Technology.*

29 Van Gaal, W. (14/04/2022). Scepticism in Africa about the EU's green connectivity plan. *EUObserver.*

30 Chapuis, R., Delporte, T., & Lotz, C. (2022). Boosting passenger preference for rail. *McKinsey.*

31 Chapuis, R. et al. (2022). Bold moves to boost European rail freight. *McKinsey.*

32 Palin, E. J., Oslakovic, I. S., Gavin, K., Quinn, A. (2021). Implications of climate change for railway infrastructure. *WIREs Climate Change*, vol. 12 (5).

33 Blackwood, L., Renaud, F. G., Gillespie, S. (2022). Nature-based solutions as climate change adaptation measures for rail infrastructure. *Nature-Based Solutions*, vol. 2

34 Topham, G. (19/07/2022). Why do Britain's roads melt and its rails buckle in heat? *The Guardian.*

35 Slavicek, M. (23/07/2022). Comment la canicule malmène les infrastructures ferroviaires et oblige les trains à rouler au ralenti. *Le Monde.*

36 Austin, K. & Race, M. (18/07/2022). Train speeds limited over track buckling heatwave fears. *BBC.*

37 Topham, G. (20/07/2022). Britain's rail services severely disrupted as heatwave damage is repaired. *The Guardian.*

38 Network Rail (28/01/2022). Climate change and resilience report outlines future rail challenges. *Network Rail.*

39 Palin, E.J., et al (2021). Implications of climate change.; *op. cit.*

40 Campbell, L. (08/04/2022). Climate Change Poses a Huge Threat to Railroads. Environmental Engineers Have Ideas for How to Combat That. *Inside Climate News.*

41 MOMIT (18/12/2019). December 19, 2018. *Multi-scale Observation and Monitoring of Railway Infrastructure Threats.*

42 Georgiadis, P. & Plimmer, G. (27/12/2021). Climate change's challenge to UK's ageing railways. *Financial Times.*

43 Chavez, S. (16/09/2021). Wildfires and 'violent' weather leave railroad giant facing $100m bill. *Financial Times.*

44 *Ibid.*

45 Sharma, M. (05/05/2022). Power crisis: Train cancellations continue to facilitate movement of coal rakes. *India Today.*

46 Topham, G. (15/07/2022). Rail passengers urged to avoid train travel in extreme UK heatwave. *The Guardian.*

47 Fleitour, G. (14/06/2022). Face aux fortes chaleurs et risque de canicule, que prévoit la SNCF pour vos trajets en train ? *Ouest France.*

48 Hausmann, H. (18/08/2019). Soft vs Hard Engineering for Coastal Defense Adaptation. *Climate Institute.*

49 Blackwood, L. et al. (2022). Nature-based solutions as climate change..., *op. cit.*

50 *Ibid.*

51 Railway Technology (04/12/2019). Cool runnings: is white paint the perfect solution to overheated tracks? *Railway Technology.*

52 SWI (18/07/2018). Swiss railway field tests white paint to keep tracks from buckling. *Swissinfo.ch*

53 Network Rail (n.d.). Hot weather and the railway. *Network Rail.*

54 Le Figaro, AFP (22/09/2022). Cadence lente, peinture blanche... Comment le train d'adapte au réchauffement climatique. *Le Figaro.*

55 Howe, B. (2017). Railway equipment – Adapting to climate change [slides]. *UIC.*

56 Network Rail (n.d.). Hot weather and the railway, *op. cit.*

57 *Ibid.*

58 Blackwood, L. et al. (2022). Nature-based solutions as climate change..., *op. cit.*

59 Campbell, L. (08/04/2022). Climate Change Poses..., *op. cit.*

60 Palin, E.J., et al (2021). Implications of climate change.; *op. cit.*

61 Campbell, L. (08/04/2022). Climate Change Poses..., *op. cit.*

62 Blackwood, L. et al. (2022). Nature-based solutions as climate change..., *op. cit.*

63 Oppla (2021). Thameslink Programme: Bermondsey Dive Under. *Oppla.*

64 Campbell, L. (08/04/2022). Climate Change Poses..., *op. cit.*

65 Wang, T. et al. (2020). Impact analysis of climate change on rail systems for adaptation planning: A UK case study. *Transportation Research part D: Transport and Environment*, vol 83.

66 UIC (2017). Rail Adapt: Adapting the railway for the future. *Union Internationale de chemins de fer.*

67 Dépoues, V. (24/07/2022). Pourra-t-on faire rouler les trains à la prochaine canicule ? *Libération.*

68 Goetsch, H., Harinath, A.S. & Lawrence, M. (23/07/2019). How do you build future-proof railways in a changing climate? *World Bank Blogs.*

69 UIC (2017). Rail Adapt: Adapting..., *op. cit.*

70 SCIO (17/08/2021). Cold-capable Fuxing bullet train tests new line. *State Council Information Office, People's Republic of China.*

71 Climate ADAPT (n.d.). Adaptation of Railway Infrastructure to Climate Change. Climate ADAPT.

72 ARISCC (n.d.). Home. Adaptation of Railway Infrastructure to Climate Change.

73 UIC (2017). Rail Adapt: Adapting..., *op. cit.*

74 Palin, E.J., et al (2021). Implications of climate change*; op. cit*

75 ARUP (n.d.). Increasing knowledge of the impacts of climate change.

76 CEDEX (2013). Working group for the analysis of the climate change adaptation needs of the core network of transport infrastructure in Spain. Final report. *CEDEX.*

77 FRA (03/10/2022). Rail Climate Considerations. *Federal Railroad Administration.*

78 L'Express (07/08/2022). Comment la SNCF s'adapte-t-elle aux vagues de chaleur et à la canicule ? *L'Express.*

79 Transport Canada (05/07/2022). Minister of Transport announces new measures to address extreme weather and climate change impacts on rail infrastructure. *Government of Canada.*

80 Dépoues, V. (2017). Organizational uptake of scientific information about climate change by infrastructure managers: the case of adaptation of the French railway company. *Climatic Change*, Springer Verlag.

81 Network Rail (n.d.). Climate change adaptation. *Network Rail.*

82 Network Rail (20/07/2022). Network Rail launches resilience taskforce in wake of record-breaking heatwave. *Network Rail.*

83 Palin, E.J., et al (2021). Implications of climate change*; op. cit*

TRENDS
URBAN TRANSPORT

Beyond the mobility transition, cities are reorganizing the urban space for low-carbon mobility

SAMUEL LAVAL • Policy officer for transport decarbonization at the Ministry of Ecological Transition, former member of the Climate Chance Observatory

2022 does not (yet) mark the end of cars in cities. Nevertheless, municipalities are not only making their public transport fleets greener thanks to electric and hybrid buses, they are also striving to reduce the number of cars on the road. The car's place in urban mobility is shrinking, sometimes even disappearing from certain neighbourhoods, at certain times of day, depending on certain driving conditions. Active mobility is also gaining ground, with cycling and walking leading the way.

DATA OVERVIEW

From one continent to the next, different paths lead to the same goal: To make public transport greener

Relying on 97% fossil fuels, the transport sector is currently responsible for around a quarter of greenhouse gas (GHG) emissions related to energy.[1] From 2000 to 2019, emissions from transport around the world went up 17.2 %. Forty percent of these emissions come from urban mobility.[2]

Local authorities, primarily cities, are therefore in a key position to implement policies to reduce emissions from urban mobility. Many have set ambitious targets to get there. Copenhagen is aiming at carbon neutrality for 2025, while Greater Manchester wants half of all journeys to be made by public transport, walking or cycling by 2040,[3] and Buenos Aires is promoting "healthy" mobility by encouraging pedestrians and cyclists **(SEE BUENOS AIRES CASE STUDY)**. Bogota has set up a climate plan that mostly relies on urban mobility to reach carbon neutrality by 2050, reducing the number of kilometres covered by vehicles by 10% in 2050.[4] These actions fit in with a general trend in cities that are adopting carbon neutrality objectives – for example, 1,143 towns have joined the initiative Cities Race to Zero, with a commitment to reach "net zero emissions" by 2040 or earlier.[5]

In 2020 and 2021, the Covid-19 pandemic and the restrictions imposed on journeys had a considerable impact on urban transport: transport is in fact the only major sector for which 2021 emissions remained well below 2019 levels (about 600 Mt less), more as a result of reduced activity than efforts to decarbonize.[6]

Nevertheless, initiatives are blossoming. One particular lever is being employed by towns that want to reduce their urban pollution and transport emissions, on all continents: the electrification of public transport vehicles. In fact, global sales of electric buses have shot up by 40%, bringing their number to about 4% of the total rolling stock.[7] This increase is due to different factors depending on the continent: regulation in the European Union, subsidies in Asia, and funding programmes responding to high demand in South American cites.

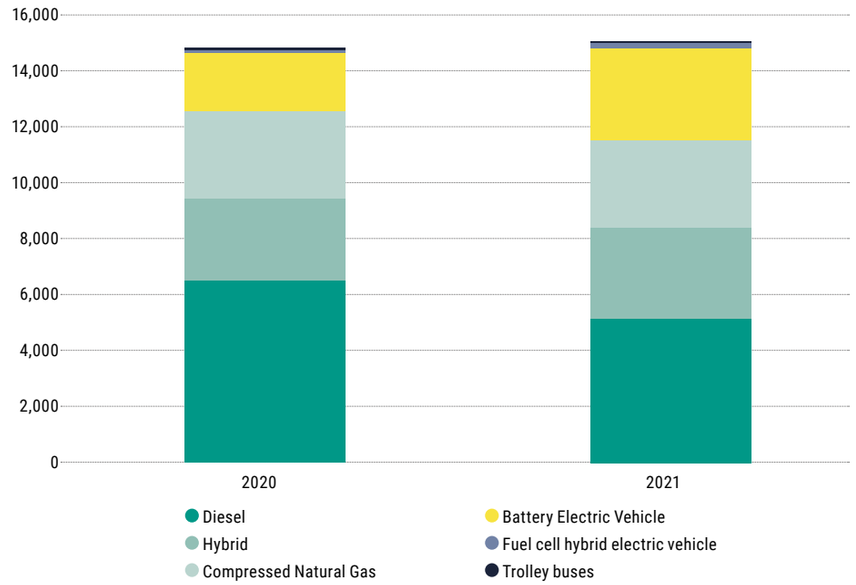
In Europe, in addition to greater availability of electric buses and a total cost of ownership (TCO) comparable to that of a diesel bus thanks to relatively low electricity prices, the recent boom in sales has mainly been driven by regulations. The revision of the EU Clean Vehicles Directive, adopted in 2019 and in force since August 2021, has established minimum proportions of "clean vehicles"[a] and zero-emission heavy duty vehicles (electric or hydrogen) when renewing public fleets. These rates vary from one country to the next and one type of vehicle to another (cars, utility vehicles, buses, etc.). For example, from August 2021 to December 2025, thirteen Member States must incorporate 45% of clean buses in their public orders, half of which must be "zero emission", while for Romania the target is 24%, and 27% for Croatia. As a result, the share of electric buses in new registrations in the EU has risen sharply, from 12% in 2019 and 15% in 2020 to reach 22% in 2021[8] **(FIG. 1)**. For the first time, in 2021 three countries bought more than 500 electric buses, which together make up almost half of the 3,282 electric buses purchased in Europe: Germany

a The directive includes in this category vehicles running on gas, biofuels, electric batteries, hydrogen, and hybrid vehicles.

FIGURE 1

REGISTRATIONS OF BUSES IN 2020 AND 2021 ACCORDING TO PROPULSION TYPE

Source: UITP, based on data from Chatrou Solutions (data for the EU + UK + Iceland + Switzerland + Norway)



(555), United Kingdom (540), and France (512). The total fleet of electric buses in circulation on the continent comprised over 9,000 buses in late 2021, which is more than six times the 2017 figure. Some cities are way ahead, totalling 70% (Amstelland-Meerlanden, Netherlands), 65% (Osnabruck, Germany) and 62% (Jaworzno, Poland) electric vehicles in their fleet. The Clean Bus Europe Platform (CBEP)[9] was created online to monitor the application of the directive and help cities, transport authorities, transport operators, manufacturers and finance organizations to exchange their expertise and good practices with the aim of accelerating the roll-out of "clean buses".[10]

Nevertheless, the leading means of alternative propulsion for European buses is gas, because the necessary equipment is cheaper to buy and it can be easily substituted with biogas, which has a smaller carbon footprint. Compressed natural gas (CNG) for vehicles represents about two-thirds of the alternative fuel bus fleet listed by the European Alternative Fuels Observatory (EAFO),[11] although the trend slowed down slightly last year: in 2021 the EAFO recorded the lowest number of registered gas-fuelled buses since at least 2008. French cities are particularly keen on this source of energy: in 2021, 54% of the more than 3,000 new registrations around the world were recorded in France, where Iveco is the leading European manufacturer.[12]

In China and India, public subsidies act to stimulate local supply. In China, electric buses benefit from the government's proactive policy aimed at electric mobility.[13] The 378,000 electric buses in the country are manufactured by the two giants BYD and Yutong and represent 98% of the global fleet currently in service,[14] and 17% of the domestic bus fleet. In India, government subsidies (FAME – Faster Adoption and Manufacturing of Electric Vehicles) enabled 6,265 electric buses to be purchased in 2021.[15] Other local subsidy programmes have also provided similar impetus, such as in the state of Kerala (50 electric buses) and the city of Pune (350 electric buses).[16]

In Latin America, international finance programmes give shape to the ambitious targets put forward by states and cities to purchase only "zero emission" buses (Chile and Colombia in 2035, Uruguay in 2040). Financed by the International Council on Clean Transportation (ICCT) and the C40 city network, the project ZEBRA (Zero Emission Bus Rapid deployment Accelerator) gathers cities, manufacturers and operators to accelerate the conversion of bus fleets in major cities on the continent (Mexico City, Medellin, Sao Paulo, Santiago de Chile, etc.). Bogota, the Latin American city with the biggest electric bus fleet totalling over 1,000 buses in 2021, officialized an order of over 400 new unites from the French group Transdev in April 2022.[17] In total, 2,564 electric battery buses were on the roads in Latin America in February 2022.[18] This figure is set to rise in 2023 – for example, the Grand Santiago region in Chile will be doubling its current fleet of 800 buses with the acquisition of new electric buses that should be in operation for the start of the year.[19]

In parallel, the TUMI project, led by ICLEI, C40, SLOCAT, WRI and UN Habitat, supports electric mobility in cities in the Global South. As part of the TUMI E-bus Mission, launched in September 2019, Bogota, Mexico City, Kampala, Jakarta, Mumbai and four other Indian cities are part of the 20 "Deep Dive Cities" selected to receive support to develop and implement individual roadmaps for electric buses. More than 100 beneficiary cities should be ready for intensified deployment of electric buses by the end of 2022. The mission's aim is to roll out 100,000 buses in 500 cities by 2025 and save up to 15 million tons of CO_2.[20, 21]

All of these efforts, coupled with the boom in electric lightweight vehicles (**SEE "ROAD TRANSPORT" TREND**) are having the effect of "greening" public fleets, but do nothing to alter the dominant trend: the car is still king of the road. In 2020, the observation made by the European Court of Auditors in its special report on urban mobility is striking: *"Although cities have put in place a range of initiatives to expand the quality and quantity of public transport, overall, there has been no significant reduction in private car usage. Although some air quality indicators have slightly improved, there are still many cities exceeding EU minimum air quality standards. Greenhouse gas emissions due to road transport have been steadily increasing."*[22] The irruption of Covid-19 did little to improve things. In France, for example, the increase in teleworking and fear of contamination led to a rise in the share of car transportation in 2021 for the first time in years.[23]

To compound matters, the huge rise in e-commerce during Covid, which seems to have become an established feature, has undoubtedly increased urban traffic. The sector has in fact expanded considerably: 80% of people who answered a survey in Hanoi said that they now shopped online more than they did before Covid.[24] This type of shopping has also opened up to include new customers (e.g., an older demographic) and new products (groceries).[25]

Therefore, faced with the difficulty of triggering a massive modal shift and reducing the place of the car in cities, working on the modes of propulsion of vehicles is necessary, but far from sufficient. Municipalities are therefore also trying to reorganize themselves spatially and geographically with the aim of giving more space to types of transport other than cars, creating quiet areas, and even reducing the mobility needs of their inhabitants.

THE OBSERVATORY'S LENS

Spatial organization as the new key to alleviate urban traffic

The way that urban space is allocated creates competition between different uses in a city: habitat, journeys, leisure, shopping, services, etc. In the 20th century the clear winner was the car, which gradually ate up the town, ultimately taking up over half of the public space in numerous cities. In the 21st century, the match is bound to be closer: cities are attempting to give space to other modes of transport, sometimes by restricting, even banning access for cars. Cities "*are redistributing public space*",[26] both for environmental and social reasons,[27] by allocating more space to bicycle and pedestrian infrastructures. This trend, which was already in place but gained ground during the Covid-19 pandemic, has seen several cities, such as Paris,[28] Amsterdam,[29] and even Melbourne,[30] begin to eliminate parking spaces for cars and replace them with bike lanes, sidewalks, and sometimes green areas.

Cycling infrastructure: emergency measures now set to stay

The biking boom observed during the first lockdowns in numerous cities, encouraged by the rapid installation of new cycle lanes to avoid crowding and Covid-19 contamination in public transport, seems to be here for the long term.

Numerous cities have decided or plan to make permanent these initially temporary bike lines: Bogota (which is currently setting up a self-service bike system), Paris, Sydney,[31] Mexico City,[32] Toronto,[33] etc. For some, these installations decided in a hurry have triggered planning policies for active mobility. After closing over 160 km of roads to cars during lockdowns (for the use of pedestrians, bicycles, and bar and restaurant terraces), the city of New York has set an objective of converting 25% of car traffic areas into spaces for pedestrians, cycling, green areas, or special bus lanes as part of its NYC 25x25 plan.[34] Also in the USA, Los Angeles wants to make permanent its "Slow Streets" programme set up during the pandemic.[35] The city of Minneapolis has also been applying itself to maintaining and improving cycling infrastructures, dating from even before the pandemic. Over 400 km of cycle lanes already exist in the city, and another 220 km are planned by 2050.[36] According to the country's biggest advocacy organization for the bicycle, the League of American Bicyclists, Boston, Chicago, Austin, Oakland and Missoula have all seen an exceptional rise in journeys by bike over the last decade due to better planning and the development of safer cycling infrastructures.[37]

Given the now acknowledged importance of strong political support to accelerate uptake of the bicycle in numerous cities,[38] many subsidies and financial packages to support bike riding have been put in place to accompany and strengthen these new practices. The European Cyclists' Federation (ECF) lists about 300 tax incentives or purchasing aids in Europe set up by national, regional and local authorities, a figure that has "increased significantly" since 2019.[39] The market is growing fast on the continent: 13.5 million bikes were manufactured in the EU in 2021, which is 10% more than in 2020, and 11% more than in 2019,[40] and 22 million bikes were sold in Europe in 2021, the highest sales figure ever recorded.[41, 42]

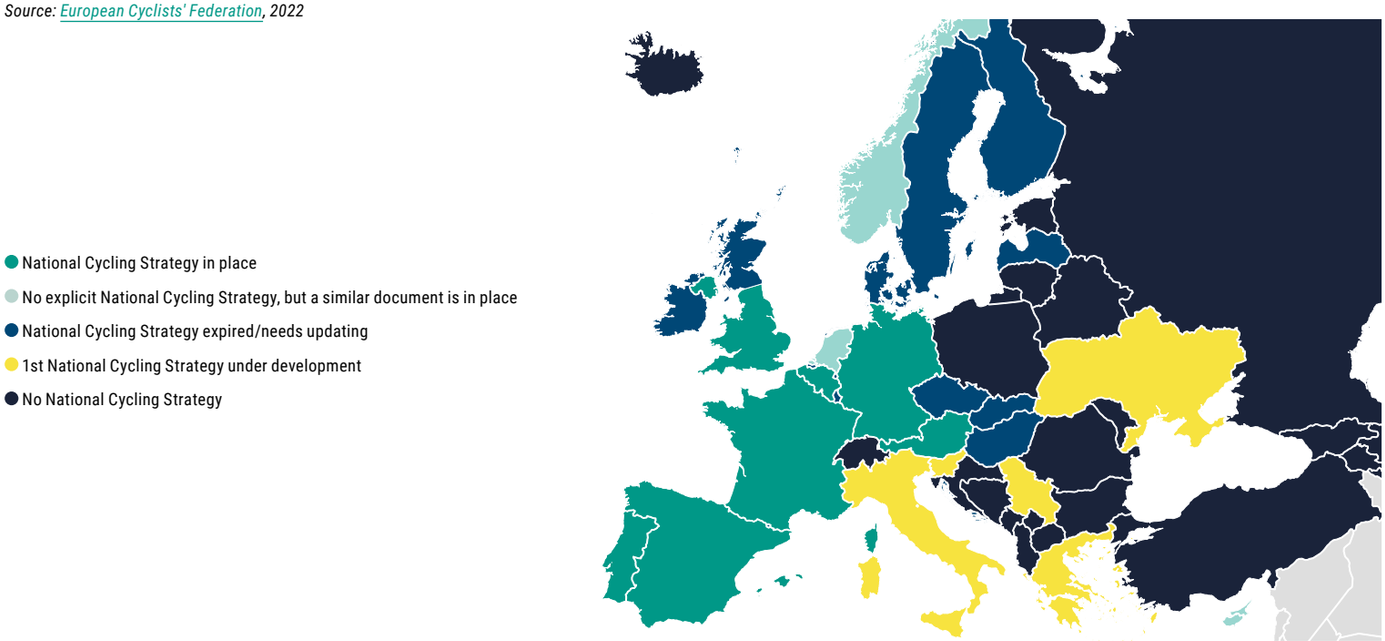
Despite this boom, the objective of doubling bicycle use adopted by around fifty European countries at the WHO pan-European conference in Vienna in 2021 may not be reached. In its report on national strategies to promote cycling,[43] the ECF observes that, since the pioneering adoption of a cycling strategy by the Netherlands in 1990, despite an increased number of countries with such strategies, more than half of European countries are still without one **(FIG. 2)**. The vice president of the European Commission, Frans Timmermans, announced his plan to unveil a joint initiative between the European executive and European MPs in fall 2022 to strongly develop the bike in Europe, in terms of both usage and manufacturing.[44]

Of the 23 strategies that have been adopted, most of them (12) are at their early stages at national level. Apart from Northern Ireland, which is planning its cycling policy over 25 years (2015-2040), all have a timespan of less than ten years.

FIGURE 2

STATE OF NATIONAL CYCLING STRATEGIES IN EUROPE

Source: European Cyclists' Federation, 2022



Almost all aim to promote the combined use of bikes and other means of transport, change road traffic rules to make cycling safer, extend the cycling infrastructure network, finance pilot projects to develop cycling, and facilitate the exchange of good practices between different stakeholders.[45] Eleven national strategies have also established concrete targets to increase the share of cycling in transportation, like Austria, which is aiming for at least 13% by 2025.[46]

In China too, the demand for bicycles has shot up, both as an alternative to public transportation when Covid-19 was rife (the use of self-service bikes had more than doubled in Beijing by the end of the first lockdown)[47] and as a new sport for the middle classes, with over 20 million people cycling at national level according to the Chinese cyclists' association. This situation is also the result of Covid-19 lockdowns, when the authorities closed gyms. In 2021, the Chinese market was worth between 12 and 15 billion dollars.[48]

The combination of other forms of transport with bikes, evoked in European strategies, also plays a key role to ensure the connectivity of the last mile in public transport, like in Singapore, or Jakarta, where the bike lanes that link the Harmoni BRT mean that five times more people can get to the centre in 15 minutes, than by walking.[49,50]

Low-emission zones gaining ground over the use of internal combustion engines

As well as installing infrastructures to encourage the adoption of active mobility, towns are increasingly resorting to regulations to limit the circulation of the most polluting cars. In late 2021, REN21 listed 270 cities that had set up Low Emission Zones (LEZs):[51] urban areas to which access is restricted and sometimes prohibited for vehicles that do not respect specific emissions standards **(FIG. 3)**. This is 21 more cities than last year. Most LEZs are located in Europe, led by Italy with 172. In the European Union, the United Kingdom, and Norway, the total number of LEZs rose 40% between 2019 and 2022, from 228 to 320, and is likely to increase by another 58% by 2025 (507 LEZs in total) thanks to laws voted in Spain, France and Poland.[52]

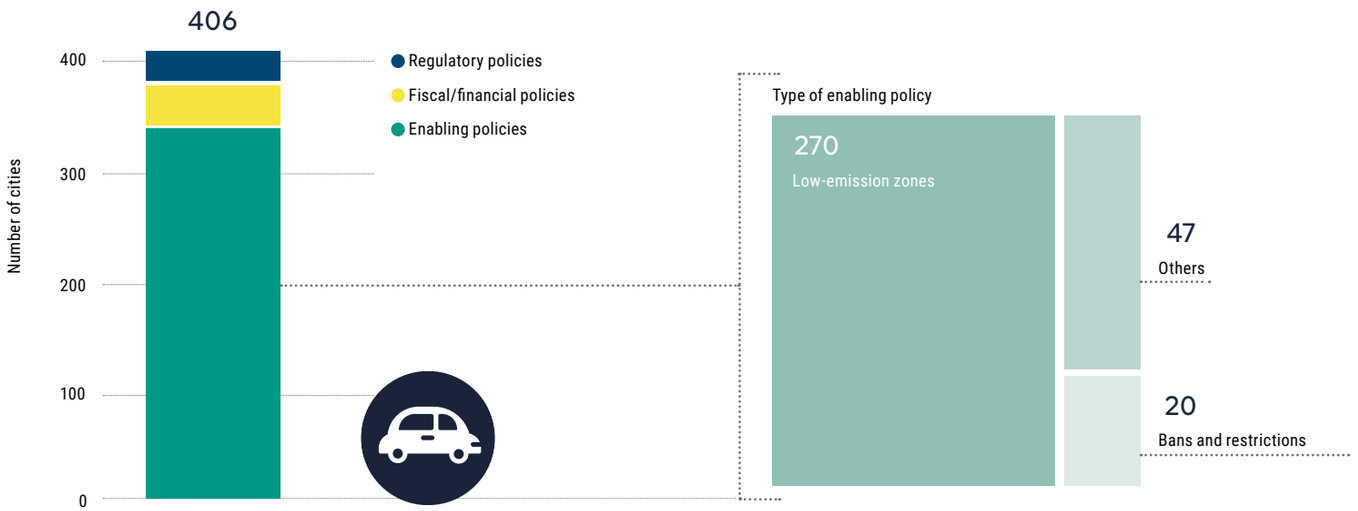
The impact of an LEZ is strongly dependent on the system decided by the municipality. Even when a national government establishes an obligation to create LEZs, cities can decide which vehicles are concerned, fix the thresholds, determine the area, and set up specific traffic controls, all of which influence the impact of the initiative.

The creation of these zones can generate tensions with those living and working in the area. Criticisms include a lack of clarity surrounding restrictions, such as in Italy, where numerous laws at different decision-making levels apply to these measures in the absence of a clear national framework.[53] LEZs can also bring a risk of widening inequalities in an area, both because the poorest people find themselves unable to access certain zones, and because they tend to live far from the city centres in which LEZs are located, and do not therefore benefit from the resulting better air quality.[54] In New York, an urban toll that could charge drivers 23 dollars to enter the heart of Manhattan in order to reduce traffic and finance public transport has proved controversial.[55] London is the first city to have created an Ultra Low Emission Zone (ULEZ), with stricter emissions thresholds, that covers a quarter of the city. The UK capital has also created Low Traffic Neighbourhoods to encourage active mobility. Yet the creation of these neighbourhoods has generated considerable protests and public demonstrations gathering thousands, reflecting the opposition of numerous residents angry about having to deal with longer journey times and more complicated deliveries.[56]

FIGURE 3

NUMBER OF CITIES HAVING ONE OR MORE TRANSPORT-SPECIFIC POLICIES IN PLACE

Source: REN21, 2022



LEZs are therefore generally tools to improve air quality rather than designed to limit greenhouse gas emissions, but they nevertheless generate numerous joint benefits: studies evaluating the impact of these zones generally indicate decreased CO_2 emissions along with lower concentrations of atmospheric pollution.[57]

Some cities are even going as far as to experiment the creation of "zero emission" zones (ZEZs) that prohibit the circulation of combustion-powered vehicles. After several pioneering examples, such as in the United Kingdom, Europe could still take the lead: 35 ZEZs are planned for 2030, mostly for urban logistics, such as in the Netherlands, where this type of zone could be commonplace for urban freight in most cities by 2025[58]. Similar measures have been adopted or are planned for urban freight in Shenzhen, Foshan and Luoyang in China.[59]

Areas reserved for soft mobility

Lastly, as well as creating infrastructures for soft and active types of transport that often take up space previously dominated by cars, and restricting the circulation of the most polluting vehicles in certain areas, numerous cities now prohibit the circulation of cars in some of their neighbourhoods in order to make way for other ways of getting around, especially walking.

Pedestrian neighbourhoods are now a familiar feature of many cities around the world, and European towns were the frontrunners in creating pedestrian areas.[60] In France, since the first pedestrian street was created in Rouen in 1971, walkers have been steadily gaining ground. Most recently, Nantes, Toulouse, and Strasbourg have blocked off streets to traffic during the summer, or only in the evenings to limit the impact on drivers.[61] Paris also features a number of pedestrian streets, which are however accused of fostering gentrification because they push up rental prices in the surrounding areas and attract more tourists.[62] Cities like Ghent and Nuremberg have also been pioneers in developing pedestrian areas, and Nuremberg still possesses the biggest zone for pedestrians in Europe.[63]

In Brussels, the "Good Move" plan, which is the 2020-2030 mobility strategy for the Brussels-Capital region, was designed based on a "specialization" approach to the public space: each street has been attributed with a different role depending on its area and context. Some will soon only be open to cyclists, or public transportation, or cars. Since 2016, the city of Oslo has been implementing its "Car-free Livability" programme, which effectively makes the city centre free from cars, while progressively improving pedestrian facilities. During the life of the programme, the number of pedestrians in these zones has increased by 14%, and the number of people spending time in the different urban areas has shot up by 43%. The share of bicycles and public transport used has also increased.[64]

In Barcelona, the municipality has taken advantage of the configuration of its Cerda plan to establish "superblocks" of buildings and green belts of streets connecting squares, therefore creating exclusive zones for soft mobility **(SEE BARCELONA CASE STUDY).**

The movement is gathering speed, in particular on the American continent. In Buenos Aires, the local government has improved the pedestrian infrastructure and created several

transitory pedestrian areas in the city, which are closed to traffic on weekends and public holidays **(SEE BUENOS AIRES CASE STUDY)**. In the United States, where the car reigns supreme, highly populated cities like New York and Philadelphia have made their streets pedestrian, especially since the pandemic.[65]

KEY TAKEAWAYS

A strong move to decarbonize urban modes of transport is underway with the energy transition of motorized vehicles. Along with light-duty vehicles (SEE "ROAD TRANSPORT" TREND), buses are making a clear shift towards electrification, driven by different approaches depending on the continent: regulation in the European Union, state subsidies in India and China, strong municipal ambitions and international funding programmes in South America. Nevertheless, the volumes involved are still too small to compete with combustion engines; additionally, the accumulation of vehicles does not help the decarbonisation of the sector.

At the same time, other levers, i.e., the modal shift and sufficiency, continue to take a back seat in the process. To stimulate these levers of transformation, many cities are making efforts to rethink the urban space to give more room to infrastructures for active mobility, and restrict or even prohibit the use of cars. Bicycles, which became extremely popular during the pandemic, continue to gain ground: once-temporary measures are now established features in towns. Cities are also rethinking the way that they organize the public space with the creation of different zones – low-emission (or zero-emission) zones, pedestrian areas, and similar measures. These actions are motivated by both environmental reasons, such as reducing emissions and improving air quality, and social issues, to allow the mobility of every citizen without having to depend on individual internal combustion vehicles and fossil fuels.

REFERENCES

RETURN TO PREVIOUS PAGE

1 SLOCAT (2021). Tracking Trends in a Time of Change : The Need for Radical Action Towards Sustainable Transport Decarbonisation, Transport and Climate Change Global Status Report – 2nd edition. *SLOCAT Partner*

2 International Transport Forum (2021). ITF Transport Outlook 2021. OECD

3 UITP (2022). Urban Mobility Innovation Index 2021. *Union Internationale des Transports Publics*

4 Observatoire mondial de l'action climat non-étatique (2021). Mobilité douce et électrique : la mue du système de transport de Bogota. *Climate Chance.*

5 Cities Race to Zero (2022). Who's in Cities Race to Zero? *C40 Knowledge Hub.*

6 IEA (2022). Global Energy Review. *International Energy Agency*

7 REN21 (2022). Renewables 2022. Global Status Report. *REN21*

8 UITP (2022). Clean Bus Report. An overview of clean buses in Europe. *Union Internationale des Transports Publics*

9 Clean Bus Europe Platform

10 UITP. (2022). Clean Bus Report..., *op. cit.*

11 European Alternative Fuels Observatory, consulté le 19/07/2022

12 UITP (2022). Clean Bus Report. An overview of clean buses in Europe, *op. cit.s*

13 Verdevoye, A.-G. (20/07/2018). Bus électrique : comment les Chinois envahissent l'Europe. *Challenges*

14 Sustainable Bus (12/07/2022). Electric bus, main fleets and projects around the world. *Sustainable Bus*

15 IISD (27/12/2021). Two and three-wheelers drive sale of EVs. *International Institute for Sustainable Development*

16 UITP (2022). Clean Bus Report. An overview of clean buses in Europe, *op. cit.*

17 Caisse des Dépôts (08/04/2022). Transdev déploie 406 nouveaux bus électriques à Bogota (Colombie). *Caisse des Dépôts*

18 UITP (2022). Clean Bus Report. An overview of clean buses in Europe, *op. cit.*

19 Ministero de Energia (29/08/2022). Comienzan a llegar los buses eléctricos que duplicarán la flota en 2023. *Gobierno de Chile.*

20 Observatoire mondial de l'action climat non-étatique (2022). Bilan mondial de l'action climat des territoires. *Climate Chance*

21 NRDC (23/03/2021). St. Louis Initiates Electric Transition. *CleanTechnica*

22 Cour des comptes européenne (2020). Sustainable Urban Mobility in the EU: No substantial improvement is possible without Member States' commitment.

23 Guérin, J.-Y. (30/11/2021). Covid : la revanche de la voiture. *Le Figaro*

24 Nguyen, M. H., Armoogum, J., Thi, B. N. (2021). Factors Affecting the Growth of E-Shopping over the COVID-19 Era in Hanoi, Vietnam. *Sustainability*, vol 13 (16)

25 Shen, H., Namdarpour, F., Lin, J. (2022). Investigation of online grocery shopping and delivery preference before, during, and after COVID-19. *Transportation Research Interdisciplinary Perspectives*, vol. 14.

26 Kay, M. (2022). The Economics of a Mobilist Future. *Autonomy*

27 Grabar, H. (15/09/2021). The Liberation of Paris From Cars is Working. *Slate*

28 Park4SUMP (n.d.). Why Paris is eliminating 72% of its on-street parking spaces. *Park4SUMP*

29 O'Sullivan, F. (29/03/2019). A Modest Proposal to Eliminate 11,000 Urban Parking Spots. *Bloomberg*

30 Hall, B. (14/06/2020). Hundreds of car parking spaces to go as city embraces cycling. *The Age*

31 UITP (2022). Urban Mobility Innovation Index 2021. *Union Internationale des Transports Publics*

32 ITDP (07/2021). Cycling and Mexico City: Better than Before. *Institute for Transportation & Development Policy*

33 City of Tortonto (16/12/2021). City Council makes seven ActiveTO cycling network routes permanent, endorses a plan for 100 kilometres of new cycling routes. *City of Toronto*

34 Toll, M. (12/05/2022). NYC wants to take 25% of tis street space away from cars in favor of a walkable/bikable city. *Electrek*

35 *UITP (2022). Urban Mobility Innovation Index 2021, op. cit.*

36 Pearson, S. (16/09/2021). Minneapolis is a big wheel in the urban cycling movement. *National Geographic.*

37 Bliss, L. (26/01/2022). 5 U.S. Cities Where Bike Commuting Is Booming. *Bloomberg.*

38 Chen, W. (18/08/2022). Historical patterns and sustainability implications of worldwide bicycle ownership and use. *Nature*

39 European Cyclists' Federation, accessed on 21/07/2022

40 Eurostat (12/09/2022). EU produced 13.5 million bicycles in 2021. *European Commission*

41 Razemon, O. (16/07/2022). Le marché du vélo dopé par la mobilité urbaine. *Le Monde*

42 Bike Europe. (07/07/2022). European bicycle and e-bike sales hike to 22 million units, a record. *Bike Europe*

43 ECF (2022). The state of national cycling strategies in Europe (2021). *European Cyclists' Federation*

44 Cazenave, F. (30/06/022). Vers un grand plan vélo pour relocaliser la production de la bicyclette «made in Europe». *Ouest France*

45 ECF (2022). The state of national cycling strategies in Europe (2021), *op. cit.*

46 Küster, F. (15/06/2022). National cycling strategies: How to boost cycling across Europe towards 2030. *Autonomy*

47 Liu, D. (30/04/2020). 3 Ways China's Transport Sector Is Working to Recover from COVID-19 Lockdowns. *TheCityFix*

48 The Associated Press (09/08/2022). Pandemic Fuels Sports Biking Boom in Cycling Nation China. *Bloomberg*

49 ITDP (2022). 2022: The Year of the Bicycle. *Institute for Transportation and Development Policy*

50 Chong, J. (03/01/2022). Singapore: Will the Cycling Fad Outlive the Pandemic? *Reporting Asean*

51 REN21 (2022). Renewables 2022. Global Status Report, *op. cit.*

52 Clean Cities (2022). The development trends of low- and zero-emission zones in Europe

53 *Ibid.*

54 Secours Catholique (2022). Pour des métropoles et des agglomérations à faibles émissions et à forte accessibilité. *Secours Catholique*

55 Le Billon, V. (01/09/2022). New York s'écharpe sur le pojet de péage urbain. *Les Echos*

56 Lewis, T. (01/11/2020). Car-free neighbourhoods: the unlikely new frontline in the culture wars. *The Guardian*

57 Urban Access Regulations in Europe (n.d.). Impact of Low Emission Zones

58 Clean Cities (2022). The development trends of low- and zero-emission zones in Europe

59 Cui, H. (2021). A global overview of zero-emission zones in cities and their development progress. *International Council on Clean Transportation*

60 Kiss, B. (2022). Will Europe lead the new mobility revolution? *Autonomy*

61 Razemon, O. (16/09/2022). Comment les piétons investissent les villes. *Le Monde*

62 Kirmizi, M. (2021). The Mobility of Paris Residents and Retailers: Their Viewpoints on the Effects of the City's Pedestrianization. *HAL*

63 Pelke, N. (10/05/2022). Nürnbergs Fußgängerzone soll Europas Spitzenreiter bleiben: „Leute suchen das Erlebnis in der Innenstadt". *Merkur.de*

64 Figg, H. (05/02/2021). Oslo – Promoting Active Transport Modes. *Eltis*

65 Hirschfeld, A. (05/05/2021). Urban Walkability Gains a Foothold in the U.S. *Yes! Magazine*

IDEAS

A ROUND-UP OF THE INITIATIVES, REGULATION CHANGES, AND MARKET TRANSFORMATIONS OF TODAY THAT SIGNAL THE CLIMATE ACTION TRENDS OF TOMORROW

Train • Europe gets back on the rails with climate tickets

In October, Austria launched the *Klimaticket* ("climate ticket") which gives access to the entire public transport network for €1,095 per year, i.e., €3 per day. Following of the mobility plan adopted by the conservative-Green coalition, the ticket aims to reduce transport-related emissions in the country. Other cities have opted for free public transport, but the costs are high and may generate rebound effects. Switzerland also set up universal ticketing giving access to the entire national transportation network, but the tickets are expensive. The innovative aspect of the project is therefore to ensure national coverage at limited costs. This summer, Germany followed suit with the introduction of a single €9 ticket. Despite the limitations due to infrastructure capacities, the scheme avoided the emission of 1.8 $MtCO_2$ thereby reducing the level of pollution in the country by 6%.

Vert Eco, 10/01/2022

Three-wheels • In Sudan, the electric tuk-tuk against inflation

In a country where inflation has reached 250% under the dual impact of a military coup and rising petrol prices, electric tuk-tuks and tricycles are gaining popularity. Although the government has increased electricity prices to compensate for the loss of international aid, which contributed to 40% of the state budget, users can still make substantial gains: 200 to 350 Sudanese pounds for the 8 hours needed to fully charge the battery, compared to 700 pounds (€1.25) for a single litre of petrol. The roofs of some tuk-tuks are even fitted with photovoltaic cells to power the engine with solar energy. In recent years, the explosion in the number of imports of three-wheeled combustion engine vehicles, often old and inefficient, has contributed to the increase in air pollution in the country.

Franceinfo Afrique, AFP, 30/05/2020

Argentina • Bike repair workshops in prisons

The city of Buenos Aires recorded a 27% increase in individual mobility (motorised and non-motorised), with individual bicycle journeys increasing from 320,000 in 2019 to 405,000 in 2020. To meet the high demand for bicycle maintenance, the NGO Voy en Bici Argentina launched a programme that collaborates with prison services, NGOs, provincial states, the judicial system, families of the detainees and the detainees themselves, in order to employ the latter to repair donated bicycles. The repaired bicycles are then made available in bicycle banks around the city for community use.

Autonomy, 02/06/2022.

Freight • Switzerland gives a green light to the *Cargo sous terrain* mega-project

Announced in 2013 by La Mobilière, CFF, La Poste, Swisscom, Coop, and Migros, the *Cargo sous terrain* (CST) or Underground Cargo project aims to clear the roads by moving cargo freight through a nationwide network of underground tunnels. These 450 km-long underground logistics systems will connect all cities in the country. Automated wheeled vehicles will be driven by induction rails at 30 km/h on 3 tracks throughout the network. Powered by renewable energy sources, the project is expected to reduce freight emissions by 80% compared to road transport, and to reduce road and rail traffic by 30%. In December 2021, the Swiss Parliament adopted a federal law on the underground transport of freight, thus providing the project its legal status. The law came into force in August 2022, following government approval. At the end of 2022, the cantons of Aargau, Solothurn, and Zurich will start drawing up their master plans. The project is not expected to be completed before 2045, but a first 70 km section is due to open in 2031 between the distribution centre of the municipality of Härkingen-Niederbipp in the canton of Solothurn, and the Zurich metropolis.

Transitions & énergies, 13/07/2022

Name and shame • "Jet tracking" condemns the use of private jets

Social networks have created a new purpose for public platforms that transmit flight data: civil society tracking of private jets. Bots act as intermediaries here: on Instagram, laviondebernard (tracking the LVMH group's private jet) has more than 85,000 subscribers; and on Twitter, 480,000 members are following ElonJet (Elon Musk's private jet). Flights taken by celebrities and politicians are also targeted. Target of the campaigns: the carbon footprint of flights. Jets emit 40 times more than commercial aircrafts, in relation to the number of passengers carried. In France, MPs proposed a measure to regulate such flights, due to their disproportionate contribution to GHG emissions compared to their number: 4,600 jets in the world today emit approximately 7,500 tCO_2 per year, equivalent to the annual emissions of Mozambique or Latvia.

Le Monde, 18/08/2022

Energy • A niche of French maritime freight picks up wind

90% of manufactured goods are carried by sea. Maritime transport accounts for about 2 to 3% of global greenhouse gas emissions. Yet, the decarbonisation of the maritime sector is lagging behind other sectors. In France, the concept of cargo sailboats has sparked the interest of several shipbuilders (Grain de Sail, Airseas, Windcoop), in the wake of other initiatives in the world. Wind energy can make fuel consumption savings of between 20 to 40%. Some projects even aim to achieve savings of 90%, such as Wincoop, a cooperative funded by various players (individuals, companies, authorities) whose container ship will begin construction in 2023. The Wind Ship association, created in 2019, brings together various project developers and has published a collaborative white paper on the current state of affairs and the outlook for this new industry. In spite of the technological challenges and the costs involved, there are many advantages to using wind power for maritime transport.

The Guardian, 14/07/2022

Business • French driving schools move to full electric

The ECF driving school franchise presented a plan aiming to exclude diesel vehicles from its fleet from 2022 onwards, and then to replace the entire fleet with electric vehicles between 2022 and 2026, in partnership with Renault. Today, electric vehicles constitute no more than 4% of its cars. The switch to electric will reduce fuel costs while allowing the driving schools to continue giving lessons in the low emission zones (LEZs) set up in thirteen French cities following a decree adopted in 2020. By requiring a number of driving hours using a manual gearbox, which entails keeping the combustion vehicles, a European directive on obtaining a driving licence stands in the way of this transformation. In the UK, the electric motorcycle manufacturer Sunra UK is also trying to increase the use of electric motorcycles by entering into partnerships with driving schools.

Egypt • Cairo launches its first bikeshare service

Cairo is a typical large African city, with 22 million inhabitants and rampant urbanisation. It is one of the most congested in the world, and the traffic is generally impossible and dangerous for non-motorised two-wheelers. The Cairo bike project, set up with support from UN Habitat and funding from the Swiss Drosos foundation, aims to lay the first milestones for shared soft mobility organised by the city. Since July 2022, 250 bicycles have been made available at 26 stations. 250 additional bicycles were then added in mid-September, for a total of 45 stations powered by solar panels. Covering an area of 6.4 km^2, the bicycle stations have been placed near metro stations to optimise intermodal transport. A million metro users are likely to access the service. In order to promote bicycle use among women, the city plans to reduce subscription rates, organise promotional cycling events, and include women in decision-making.

ITDP, 03/03/2022

CASE STUDIES

COUNTRY	CITY	POPULATION	MITIGATION GOAL	EMISSIONS IN 2018
ARGENTINA	BUENOS AIRES	3,068,043 INHABITANTS (2018)	-53% BY 2030, -84% BY 2050	11.74 $MTCO_2e$ (-15% FROM 2013)

Buenos Aires • Leveraging environmental and climate data to promote soft mobility

Within the framework of its "Open Government and Climate Change" policy, the BA Climate Action platform, which was selected to be a part of the UCLG Local4Action Hub, allows the collection and visualization of climate data, as well as of the efforts of the municipal government, non-state actors and citizens to reduce the city's emissions. The platform provides open data on Buenos Aires' goals and initiatives, and seeks to merge open government tools with climate action to promote accountability, collaboration, and transparency regarding the municipal policies. Specifically in the area of urban mobility, the platform gathers data on public transport services, public bicycles, bicycle lanes, vehicle flows and, the existing automotive fleet, in order to inform and guide action.

An open platform resulting from co-creation

In 2017, Buenos Aires became one of the first 25 cities in the world to make a commitment to achieving carbon neutrality by 2050. Through the BA Climate Action platform, co-created with more than 600 citizens, experts and representatives from the civil society, the municipality draws on the collective action of citizens, civil society organizations, academia and the private sector to find impactful and effective solutions.

As part of its open government agenda, Buenos Aires has opened up and graphically designed more than 30 datasets that can be downloaded and reused. BA Climate Action gives access to the city's emission reduction goals and information on clean energy generation, existing infrastructures to promote sustainable mobility and comprehensive waste management. In addition, it displays interactive graphics on greenhouse gas inventories, the evolution of temperature and precipitation, and air quality.

The platform also contains the latest news on the city's leading climate initiatives, as well as proposals for the different city stakeholders to contribute themselves to climate action. Any actor can download the data and adapt it to the characteristics of their project or administration to build their own climate change site.

Sparking changes in urban mobility

As part of its action on sustainable mobility, the city has identified four axes of action: prioritising public transport, promoting healthy mobility, improving traffic regulation and road safety, and the development of intelligent mobility.

Under public transport, the city buses and metros are under the local government, which created the Metrobus Network, with eight corridors of exclusive bus lanes, which has reduced travel time by 40% and fuel use by 20%. The municipality also developed 'transfer stations' to facilitate multimodal transport for over 1.6 million users.

As part of 'healthy' mobility, the city promoted bicycling and pedestrian infrastructure. The city bikeshare system recorded 600,000 users and more than 3,500,000 trips in 2019, which was furthered expanded during the pandemic. Currently, 287 km of bike lanes exist in the city. The city also created five blocks of pedestrian-centred areas, with wider sidewalks, larger green spaces, and restrictions on vehicular traffic; and 20 transitory pedestrian areas that are operational on weekends and holidays.

Tying together the various initiatives and facilities available to the citizens is the data from the BA Climate Platform, which also serves towards the city's objective of intelligent mobility, where trips can be better planned and predictable, and thus more efficient. The municipal authorities worked with applications like Waze, Moovit, Google, Ualabee and developed the Unified Transportation API, allowing for real time traffic and mobility information across the various modes of transportation.

A replicable model for city networks

As this initiative is part of UCLG's Local4Action HUB, it is intended to amplify the platform and its local impact at a global level, through city networks. Furthermore, the co-creation process of the site has been thoroughly documented so that it can be replicated by other local governments, and thus contribute to more spaces for collaboration, collective intelligence and action in the fight against climate change.

COUNTRY	CITY	POPULATION	MITIGATION GOAL	EMISSIONS IN 2017
SPAIN	BARCELONA	1,664,182	-45% BY 2030 (2005 BASELINE)	3.41 $MTCO_2e$

Barcelona • Sant Antoni, the green street inspiring the city

Since 2016, the city of Barcelona has been supporting the establishment of "superblocks" (*superillas*) – micro-neighbourhoods consisting of blocks of 3x3 buildings. In these urban spaces, priority is given to pedestrians, slow traffic, and a greater presence of vegetation. This strategy is one of the 103 measures in the climate emergency plan decreed in March 2020 by Ada Colau, the mayor of Barcelona, to reduce GHG emissions by 2 million tonnes by 2030. The Cerdà Grid model, using which the city has been organised intro quadrangular blocks since the 19th century, is particularly conducive to the creation of these superblocks.

The Sant Antoni superblock

In 2017, the Barcelona municipality launched a public consultation to create a "green axis" connected to a square – a new, second-generation conception of "superblocks" – in the central Sant Antoni neighbourhood. Work was completed in 2019. Traffic within the superblock is now limited to 10 km/h for all vehicles. The Barcelona City Council spent €7 million on the project, notably on the street fixtures. The street is divided in two parts, one with more classic permanent street fixtures, the other with provisional fixtures that are innovative and inclusive, and can be easily dismantled and reused to create new ones. Floor markings bring colour and outline games for children, with the aim of bringing out new ways of "living" the street.

A success by and for the residents

For this "green axis" project, Barcelona relied on strong citizen involvement. During the public consultation, a group of 40 representatives of associations and shopkeepers of the street reassessed the outlines of the project together with the city council, before presenting it to the residents. This process was particularly influential in decisions such as not changing the direction of street traffic because *"people would not understand these traffic changes"*, said Ariadna Miquel, Director of Urban Strategy at the Office of the Chief Architect of the City Council of Barcelona. *"We lowered the ambition of our project, but it became feasible."* The city thus intends to learn from the discontent encountered in the Poblenou district when a *Superilla* was created there. The neighbourhood residents, who were interviewed about a year after the end of the street works, spoke of the benefits experienced: more street life at different times, fewer cars hence more visibility, etc. In addition, the pedestrian area has expanded by almost 135% to reach a total of 43,209 m², i.e., 100%, of the neighbourhood's public space. As a direct result, the presence of pedestrians has increased by up to +44% in certain areas.

Changes to expect

On Sant Antoni Street, the combination of the different modes of mobility regularly causes conflicts between cars and pedestrians *"owing to the disregard of traffic rules by some vehicles but also because of a lack of signage and information"*, according to Julia Goula Mejón, associate architect in the firm Equal Saree. Greater efforts in terms of signage are therefore planned for the future green streets of Barcelona. To slow down the pace of traffic on the street, it was necessary to work on traffic planning at the level of the street, but also of the entire district and city. However, being located in the touristic heart of Barcelona, the green street of Sant Antoni is often accused of gentrifying the neighbourhood. Thus arises the need for a social housing policy in support of the project: any establishment of new businesses has been prohibited in the street usage plan, to prevent it from concentrating the centres of attraction to the detriment of neighbouring districts.

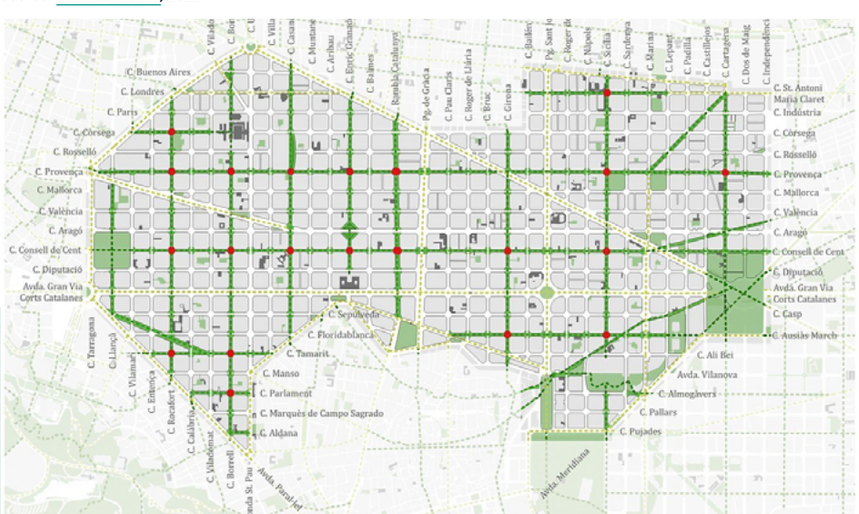
What next for the superblocks?

Superblocks are a flexible tool that can be adapted to various urban fabrics and so they can be easily exported, according to Ariadna Miquel. For her, it is essential to study the locality, build a consensus with the residents and stakeholders, and be able to count on committed citizens to bring the project to life. At the end of 2020, the Barcelona City Council announced 21 new squares and 21 new green streets to come in the Eixample district, in the same vein as Sant Antoni **(FIG.)**. Work on these superblocks began in the summer of 2022.

FIGURE

THE 21 GREEN STREETS UNDER CONSTRUCTION IN THE EIXAMPLE DISTRICT

Source: Construction21, 2022



PROJECT CASE STUDY

COUNTRY	DISTRICT	POPULATION	MITIGATION GOAL	EMISSIONS IN 2017
ZIMBABWE	WEDZA	70,700	-40% BY 2030 (COMPARED TO BAU)	35.84 $MTCO_2e$

Mobility for Africa • Promoting access to sustainable electric mobility in rural areas to empower women

In Africa, approximately 450 million people (more than 70% of its rural population) lack access to mobility options due to a lack of infrastructure and transport systems. In Zimbabwe, the lack of transport infrastructure has a significant impact on the agricultural sector, which provides livelihoods for about 70% of the population and 15-20% of the country's GDP. It provides employment, contributes to economic growth, poverty reduction, and food and nutrition security. An estimated 18,000 new farmers are working in contract and outgrower schemes in Zimbabwe. These small-scale farmers travel long distances on foot or by motorcycle to reach their farms. To address this, local startup Mobility for Africa has been developing an integrated, safe, and replicable electric micro-mobility system for rural populations in Wedza, Domboshawa, and Chipinge since 2019 to sustainably improve their mobility and working conditions and help reduce pollution.

Improving the quality of life of rural populations thanks to the "Hambas"

In a context of transformation of mobility and emergence of new modes of transport in Africa, Mobility for Africa, has been providing since 2019 a shared electric mobility service based on "Hambas", geolocatable tricycles powered by a standardized solar energy battery swap system. Unlike a battery recharging system that can take a few hours, the swap system allows to change the discharged battery for a charged one in a few minutes.

Mobility for Africa rents the tricycles to groups of women (of a maximum of five) for $15 per month. These women can then transport and sell their agricultural products to more distant markets. In addition to meeting SDGs 1, 5, 7, 10, and 17, this integrated service opens up growth opportunities for beneficiaries in the rural communities of Chipinge, Domboshawa, and Wedza by significantly increasing their income.

According to 60 Decibels, an independent impact measurement company, the transport and logistics service, these Hambas allow 92% of beneficiaries to improve safety during their travels. They also make it easier to transport people to health facilities, including pregnant women. 87% said that they experienced a net reduction in travel time and 99% saw an increase in their self-confidence.

Electric tricycles for "cleaner" mobility

Adopting a mode of community micro-mobility such as the electric tricycle is one way to achieve "cleaner", safer and more accessible mobility, independent of fossil fuels, responsible for 33% of the country's greenhouse gas emissions. The solution implemented by Mobility for Africa integrates the training of beneficiaries and employees to drive and operate the technological device around the tricycle and batteries.

A Research and Development (R&D) programme has also been deployed within the community to ensure continuous monitoring and testing of the tricycle's adaptability and safety, as well as the battery management system, GPS system, fleet management and new data collection.

A nationwide initiative

In 2020, in partnership with PManifold, an energy, e-mobility and environmental research and consulting firm, Mobility for Africa supported the Zimbabwean government in developing its framework law and roadmap for electric mobility adoption. The process was initiated by the Ministry of Environment, Tourism and the Ministry of Energy and Power with funding from the Climate Technology Center and Network (CTCN) and the United Nations Environment Programme (UNEP) Digital Transformation Section. In Zimbabwe, as in many countries in the region, vehicle classification is outdated and managed by a multitude of entities, which hinders the transition to electric mobility. The bill and targets are due to be passed in 2022 and can accelerate the action and investment needed to make this transition a reality.

“THE BUILDING SECTOR IS FINDING ITSELF AT A CROSSROADS: THE NEED TO ADAPT TO AN INCREASINGLY WARMING WORLD WHILE ALSO REDUCING ITS ENERGY CONSUMPTION AND RELATED EMISSIONS.”

Accounting for about 37% of global greenhouse gas (GHG) emissions, the building sector is finding itself at a crossroads: the need to adapt to an increasingly warming world while also reducing its energy consumption and related emissions. Following an exceptionally slow year during the pandemic, economic activity in the sector picked up in full swing, bringing the total emissions from the sector up by 15.25% from 2020, to 13.6 $GtCO_2$ in 2021 **[INDICATORS]**. The largest share of these emissions come from the operation, or the use of buildings: indirect emissions from the electricity used for cooling, and appliances, and direct emissions from fossil-fired heating.

Heading into a winter marked by the energy crisis, actors on the frontline in the Global North are mobilising efforts to revamp their heating systems, counting on the shift to heat pumps and district heat – as in the example of Vienna **[CASE STUDIES]** – to decarbonise the building sector, while also ensuring energy security. Improving the energy efficiency of the existing building stock is also a priority, be it through scalable projects of renovation like EnergieSprong **[CASE STUDIES]**, or through measures aiming at sufficiency in order to actively reduce energy consumption.

The trend of conserving energy and increasing energy efficiency has spread across all categories of actors in the building sector, applying to both residential and non-residential buildings. With the growing recognition of the potential to reduce energy consumption in non-residential buildings, commercial actors are exploring energy efficiency improvement, even turning to energy conservation, while also turning to renewable sourcing and on-site generation to reduce their climate impact **[TRENDS]**.

While the increasing climate footprint of space cooling remaining a point of concern, particularly in the Global South where the lack of access to cooling poses a threat to lives and livelihoods, actors across sectors are deploying solutions, right from more efficient large-scale industrial and commercial equipment to smaller scale off-grid cooling technologies **[SIGNALS]**, or even reflective rooftops that bring down inside temperatures **[CASE STUDIES]**.

The growing attention to the impacts of global warming, manifesting themselves through extreme weather and more frequent catastrophic events, has also forced actors in the buildings and construction sector to re-examine their vulnerability and resilience, insuring existing structures against potential damage and conceiving newer ones to be more resilient **[TRENDS]**. This concern is showing itself right from changes in materials being used (as with the use of more locally-adapted earthen bricks or Typha in Africa), and in the conception of structures and their uses (as with participative housing in France). **[SIGNALS]**

UNDER CONSTRUCTION, LOW CARBON BUILDINGS STAND ON A FOUNDATION OF FOSSILS

The sector's emissions continue their growth...

EVOLUTION OF THE BUILDING SECTOR'S EMISSIONS FROM 2020 TO 2021

13.6 $GtCO_2$

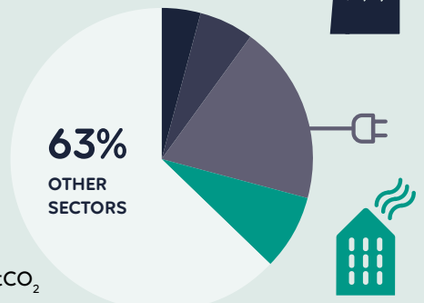
CO_2

+15.25%
COMPARED TO 2020

These emissions increased from 11.8 $GtCO_2$ in 2020 to 13.6 $GtCO_2$ in 2021, exceeding their their 2019 level. *GlobalABC, 2022*

SHARE OF BUILDINGS AND CONSTRUCTION IN GLOBAL EMISSIONS

GlobalABC, 2022



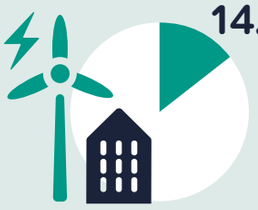
4% EMISSIONS FROM THE PRODUCTION OF ALUMINIUM, GLASS, BRICKS, ETC.

6% EMISSIONS FROM THE PRODUCTION OF CONCRETE AND STEEL

19% INDIRECT EMISSIONS (MAINLY ELECTRICITY)

8% DIRECT EMISSIONS (MAINLY FROM HEATING)

...faster than the renewable-powered electrification of buildings



14.7%

SHARE OF RENEWABLES IN FINAL ENERGY DEMAND FROM BUILDINGS IN 2019

This includes the use of renewable electricity, modern bio-heat and solar and geothermal heat. This share was 10.7% in 2009.
REN21, 2022

BUILDING ENERGY CODES

51/196 COUNTRIES HAVE ADOPTED A BUILDING ENERGY CODE COVERING BOTH RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS.

79/196 COUNTRIES HAVE ADOPTED A BUILDING ENERGY CODE. THIS FIGURE STOOD AT 62 IN 2015. IN 2021, GEORGIA WAS THE ONLY NEW COUNTRY TO ADOPT A CODE.

GlobalABC, 2022

BUILT AREA CERTIFIED BY MEMBERS OF THE WORLD GREEN BUILDING COUNCIL

4.2 bn m^2

+18%
2020-2021

This total includes benchmark programmes for energy efficiency in buildings, such as LEED certification, created by the US Green Building Council, or the French HQE certification. *WorldGBC, 2021*

Renovation and low-carbon constructions attract investments

INVESTMENTS IN ENERGY EFFICIENCY OF BUILDINGS IN 2021

These investments increased by $33 bn, from about $204 bn in 2020 to $237 bn in 2021— the largest increase since 2014.
IEA, 2022

AN EXPLOSION OF GREEN BONDS FOR THE CONSTRUCTION SECTOR

The total value of green bonds for the construction sector went from about $80 bn in 2020 to more than $140 bn in 2021, after having stagnated in 2019.
IEA, 2022

Space heating and cooling, a burning issue

10%

+3% IN ONE YEAR

GLOBAL HEATING NEEDS IN BUILDINGS MET BY HEAT PUMPS

This share was 7% in 2020. In 2021, the sale of heat pumps increased by 13% globally, and by 35% in the European Union.

IEA, 2022

11%

GLOBAL HEATING NEEDS IN BUILDINGS MET BY DISTRICT HEAT NETWORKS

District heat, however, remains largely fossil-fed, especially in China and Russia.

IEA, 2022

+4% PER YEAR

ANNUAL EVOLUTION OF THE DEMAND FOR SPACE COOLING SINCE 2000

Cooling is the fastest growing end-use of energy in buildings, and one of the main drivers of the growth in electricity demand, accounting for 16% of electricity use in buildings.

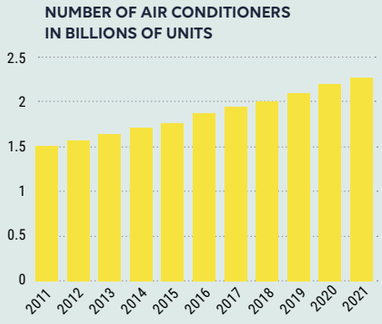
IEA, 2022

SHARE OF FUELS IN BUILDING HEATING

Fossil fuels currently account for the largest share of heating in buildings, natural gas being the most used.

IEA, 2022

NUMBER OF AIR CONDITIONERS IN THE WORLD IN 2021



2.27 billion

China, the US and Japan are the largest markets for AC sales, with India and Indonesia showing the highest growth.

IEA, 2022

1.1 million m²

SURFACE AREA OF "COOL ROOFS" INSTALLED ACROSS THE WORLD

As part of the Million Cool Roofs challenge, an initiative of the Clean Cooling Alliance, Clean Cooling Collaborative, Global Cool Cities Alliance, SEforALL et Nesta Challenges, awarding $125,000 to 10 teams from around the world for testing various cool roof technologies.

SEforAll, 2022

Adaptation and energy independence converge to drive out fossils in the buildings and infrastructure of cities

586 CITIES

HAVE REPORTED MITIGATION ACTIONS

This includes actions like renovation and energy efficiency improvements, but also the implementation of buildlings codes or on-site energy generation. *CDP, 2022*

461 CITIES

HAVE REPORTED ADAPTATION ACTIONS

The largest number of these actions were related to floods and sea-level rise, followed by those related to extreme precipitation and extreme heat. *CDP, 2022*

59 CITIES

HAVE BANNED FOSSILS IN BUILDINGS

These bans are already in place or in the process of being so, mainly in American and European cities.

REN21, 2022

TRENDS
ADAPTATION

Real estate players are re-examining their foundations to adapt to climate change

OPHÉLIE CUVILLARD • Research assistant, Global Observatory of Climate Action, Climate Chance
ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance

Between calls for energy sufficiency, geopolitical pressure on the energy supply, and increasingly intense weather events, the building sector needs to adapt. Exposure to extreme climate episodes is bringing down the value of real estate. The layout, design and composition of new buildings therefore need to be revised to stand up to anticipated weather events. Both the renovation of existing buildings and the construction of future property will need to combine energy efficiency with resistance to climate impacts. To meet this challenge, the focus is on integrating adaptation into building codes, improving architecture, and updating the insurance sector.

DATA OVERVIEW

Human & financial costs and emissions are escalating due to the impact of climate change on infrastructure

The exceptionally high temperatures and torrential rain of the last few years[1] confirm the observations of the Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), which signals increasingly intense climate episodes and more frequent extreme weather. Climate events like higher precipitation, melting of the permafrost, and more frequent, intense wildfires and storms are destroying increasing numbers of infrastructures and homes, involving considerable reconstruction and renovation costs.

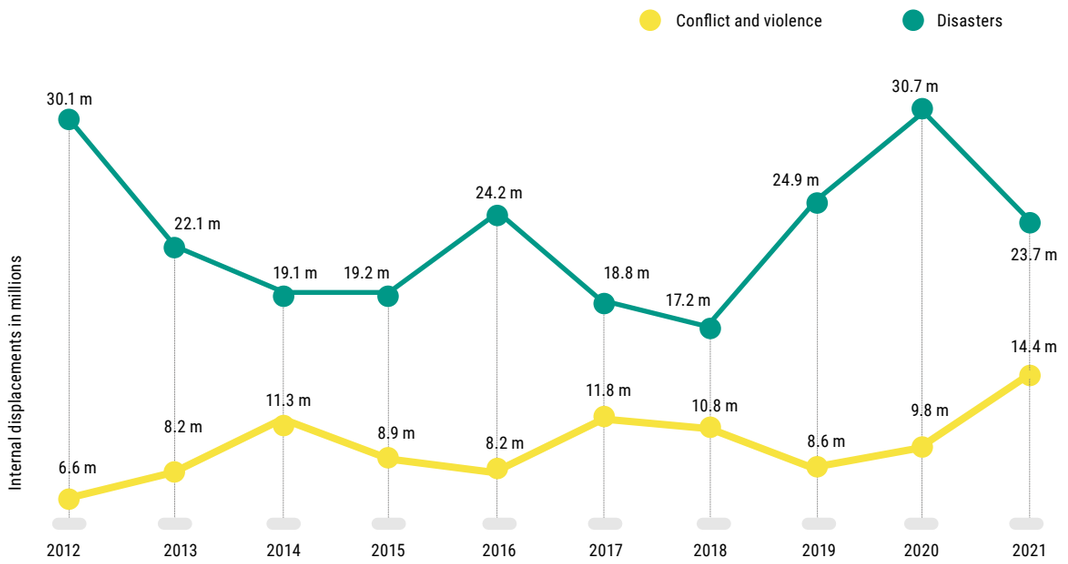
According to the IPPC scenario of a 1.5 °C temperature increase,[2] Africa and Asia are at the biggest risk of experiencing frequent, intense precipitation, followed by North America and Europe. Droughts are likely to become more prevalent on all continents compared to the period from 1850 to 1900, with the exception of Asia. From a 2 °C temperature rise, heavy rainfall and flooding will increase, in particular in the Pacific islands and some regions of North America and Europe.

These climate events impact the infrastructure of global property stock. Four Twenty Seven (427), a Californian company created in 2012 to analyze climate change risks, and the company GeoPhy, concluded in a report that 35% of the 73,500 properties owned by 321 listed Real Estate Investment Trusts, around the world, were exposed to climate hazards, of which 17% to flooding, 12% to hurricanes and typhoons, and 6% to rising sea levels and coastal floods.[3] US real estate also appears to be under particular threat. The cities of New York, San Francisco, Miami, Fort Lauderdale, and Boston face a high risk of rising water levels. On a global scale, the real estate most exposed to rising sea levels is located in Hong Kong and Singapore. The infrastructures most at risk from typhoons are in Japan, while flooding threatens cities in southeast Australia and parts of Europe (eastern France, Belgium, Germany, the Netherlands, the United Kingdom, Denmark and Sweden). The heatwave that hit the United Kingdom last summer revealed how ill-adapted British buildings

FIGURE 1

DOMESTIC DISPLACEMENTS TRIGGERED BY CONFLICT, VIOLENCE AND NATURAL CATASTROPHES FROM 2012 TO 2021

Source: IDMC, 2022



are to deal with the heat: some old hospitals in London have no air conditioning and their windows cannot be opened.[4]

Infrastructures in developing countries are particularly vulnerable to climate change, which mostly threatens countries in Asia,[5] including Bangladesh, India, Myanmar, Nepal, Pakistan, the Philippines, Thailand and Vietnam.[6] During the summer of 2022, Pakistan was subject to its wettest month in 30 years, and by early September flooding had led to the death of 1,100 people, destroyed 287,000 houses, flooded 2 million hectares of farmland, and killed 735,000 heads of livestock.[7] Asia could feature almost half of all new buildings by 2040. Yet in 2020, fewer than 50% of countries in the region had obligatory or voluntary building codes or certification programs in place.[8] Islands are also particularly vulnerable to rising water levels and are already feeling the impacts. The Alliance of Small Island States (AOSIS) is one of the most influential voices calling for funding to adapt particularly exposed and vulnerable countries to climate change.[9]

The building sector is responsible for 37% of global greenhouse gas emissions and 36% of the world's energy consumption (including construction).[10] Targets aimed at developing "net zero emission buildings" mainly focus on energy efficiency for mitigation. But in recent years, the target of "resilience" has increasingly featured in public debates, referring in this case to the capacity of buildings to withstand the impacts of climate change.

Among other things, climate change generates higher financial costs and impacts the value of real estate. In any given country, property exposed to rising sea levels has already lost 7% of its value compared to similar property not exposed to this risk.[11] The damage caused by natural disasters amounts to considerable losses. Hurricanes Harvey, Irma and Maria in 2017 caused $220 billion in damages and, in 2018, Hurricane Florence generated a loss of $10 million.[12] In the United States, the damage bill amounted to $56.92 million in 2021.[13] These figures mostly cover the cost of reconstruction, renovation and financial aid, with the risk that the new buildings might be destroyed again a few years later. In the long term, some urban areas will have to be abandoned and homes relocated.[14] For example, almost 33 million people were displaced in Pakistan during the flooding that hit the country in the monsoon of 2022;[15] in other words, almost as many people were displaced in that single country in 2022 as were displaced on the entire planet in 2021 (38 million; **FIG. 1**).[16] In terms of the carbon involved in the construction phase in a building's life cycle – about 10% of global CO_2 emissions are emitted when manufacturing building materials[17] – these reconstructions and renovations generate significant emissions.

In order to limit the sector's greenhouse gas (GHG) emissions and the financial, social, human and cultural costs of climate events, adaptation is slowly making its way into building-sector strategies. The sector is well placed for adaptation actions because it allows the topic to be approached in different ways: in addition to creating a physical rampart against climate change, buildings can make energy savings in response to the increased risk of supply shortages and the geopolitical context.

THE OBSERVATORY'S LENS

The fast-changing climate shakes the foundations of the building sector

Integration of climate data in building codes and urban planning

Building-sector strategies are based on more precise mapping of risks and local climate features, and on new construction methods to make buildings more resilient to climate phenomena. One study[18] undertaken by the National Institute of Building Sciences (NIBS) shows that the adoption of the latest building codes[a] in the United States could avoid having to build about 15,000 new homes, saving the equivalent of 1.5 million tonnes of CO_2 per year.[19] The study also indicates that if disasters were given greater consideration in building codes, thus minimizing the risk of having to rebuild, emissions would reduce accordingly.

The Global Resiliency Dialogue (GRD) was launched in 2019 and involves a working group of authorities and researchers based in Canada, the United States, Australia, and New Zealand to exchange and share experiences on integrating new climate risks into building codes. Coalition members all recognize that their building codes, traditionally based on observing historical meteorological events, are unsuitable for anticipating future climate episodes. Based on two reports published in January and November 2021, the GRD is preparing to publish its *International Resilience Guidelines*[20] in the second half of 2022. The results of the first survey show that an average ten-year wait is necessary between each new publication of historic meteorological data in building codes. For each of these countries, it is therefore vital to include climate modelling when designing their building codes to deal with the resilience of buildings **(SEE BOX 1).**

The second report[21] published by the Global Resiliency Dialogue takes the example of New York to illustrate the integration of climate forecasts in building codes and standards. The city is particularly exposed to rising sea levels – along with Calcutta, Bombay, Dhaka, Miami, Alexandria and Lagos[22] – with a projected average rise of 2.25 metres every five years.[23] To include climate forecasts in its public investment plans, the municipality has devised a set of guidelines called the *NYC Climate Resiliency Design Guidelines*.[24] The guide provides engineers, architects and urban planners with a method that integrates historical data, new data, and scientific progress. The method acts as a relay between climate data and potential action to respond to it. It tackles three climate risks that the city is exposed to: flooding; increased, more intense rainfall; and heat waves. To reduce urban heat for example, the report encourages thinking about the materials used on the external facades of buildings: materials that reflect the sun create urban heat islands and increase the use of air conditioning, which in turn feeds into the effect. Several solutions are proposed for each problem raised: for urban heat, the guide suggests covering 50% of the site's surface with a green roof project, shading and/or highly reflecting surfaces (light-coloured paving). These solutions therefore respond to a target of reducing urban heat while ensuring a stable temperature inside buildings: jointly integrating the different methods avoids putting contradictory measures in place. This is one of the messages communicated by the latest Global Resiliency Dialogue survey: "*Planning regulations should be developed in parallel with building codes, to harmonize the approach to resilience taken in both*".[25]

BOX 1 • **KEYS TO UNDERSTANDING**

CLIMATE RESILIENCE

The Center for Climate and Energy Solutions defines climate resilience as "*the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to the climate*" and in particular mentions acute events, like heat waves, heavy downpours, hurricanes and wildfires, along with long-term changes like rising sea levels, worsening air quality and population migration. Municipal resilience plans are taking shape, especially concerning buildings – such as the heat action plan in place in Phoenix, which encourages natural air-cooling methods.[26] The International Code Council (ICC), in partnership with the Alliance for National & Community Resilience (ANCR), defined how building codes contribute to the resilience capacities of communities in its 2018 report *Building Community Resilience through Modern Model Building Codes*.[27] The report lists the four aspects covered by resilience in the building sector: efficient disaster mitigation and recovery; ensuring the mental and physical health and well-being of occupants; improving building life cycles; and creating a "sustainable" community. A building that has to be demolished after an event is not considered to be "sustainable". Lastly, the resilience of the building stock is recognized by the ANCR as one of the three pillars that ensure community resilience, along with social measures and governance.[28]

Integrating different weather events into urban planning also turns out to be strategic when the risks are high. To deal with flooding, China is developing "sponge cities",[b] involving better water control thanks to soil infiltration and water evacuation management. They also include Low Impact Development (LID) plans developed in 1987 to manage storm water, which is particularly urgent in the face of intensifying storms due to climate change.[29] The LID concept has generated numerous studies on storm water management in Europe, North America, and Australia, contributing to the establishment of sponge cities in the State of Georgia and in Chicago, for example.[30] This concept also applies to some infrastructures like green

a Building codes are political instruments for national and local governments to improve the energy performance of buildings, either at their time of their construction or when renovated.

b In these cities, in addition to wetlands that readily absorb water, underground reservoirs can store water during flooding for evacuation later. The urbanization pursued to date prevents water infiltration, which worsens the impact of flooding.

roofs, permeable pavements, and infiltration trenches, whose effectiveness has been demonstrated in simulations in southern Italian cities[31] and the Polish city of Gorzow Wielkopolski.[32] Thirty cities in China have been selected as pilot sponge cities and other towns have the appropriate characteristics **(FIG. 2)**. These cities are mostly located in the south and east of China due to climate and geographic features.

Setting up this type of urban planning has numerous joint benefits: as well as increasing protection from flooding for people and buildings, it helps improve soil and water quality, fosters richer biodiversity, and contributes to the well-being of the city by creating more green spaces. Although reaching these different objectives depends on geographic and climate characteristics, the different Chinese cities in the study have so far all reported "satisfactory" impacts in terms of controlling surplus water flows.[33]

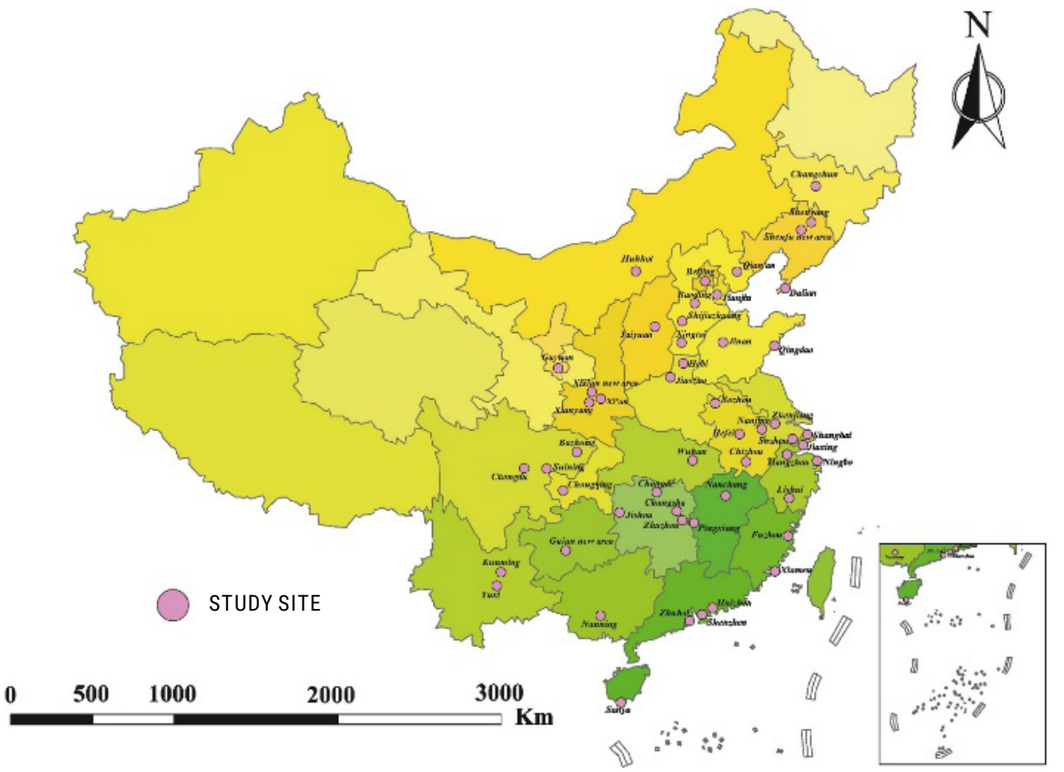
The energy performance of buildings also plays a role in their adaptation to climate hazards. Along with installing equipment that optimizes energy consumption, the energy performance of a building can be improved by insulation, ventilation and planting. In anticipation of future heat waves, the city of Basel in Switzerland initiated a green roof program with the result that today it is the city with the largest surface area of green roofs per inhabitant. The program was financed by a fund created by the city in the 1990s, thanks to a law that established that 5% of electricity bills should contribute to the Energy Saving Fund. The project developed further following an obligation in 2010 to convert all flat roofs being constructed or renovated into green roofs. The initiative has been praised for its energy-saving benefits and its adaptation qualities: green roofs can reduce indoor temperatures by up to 5 °C[34] and provide an alternative when it is impossible to create green spaces around a building. They are also an effective tool to deal with storm water runoff, which, according to a draft British study,[35] could be reduced by 17% to 20% if all suitable roofs in the United Kingdom were planted.

At European level, in a situation that calls for more autonomy and energy sufficiency,[36] optimizing energy consumption can be a strategic adaptation tool in a world subject to geopolitical tensions. It reduces the need for buying in mostly fossil-based energy **(FIG. 3)** and means that a given quantity of energy can be used for longer.

FIGURE 2

CHINESE CITIES THAT HAVE BUILT LID CONSTRUCTIONS

Source: Science of The Total Environment, 2022



During the last few months, many nations have announced that they are establishing efficiency measures to reduce energy consumption in buildings. In Italy, for example, public buildings cannot set air-conditioning below 25 °C from 1 May, 2022 to 31 March, 2023 or heating higher than 19 °C in winter,[37] and Austria has brought forward the date for prohibiting the sale of new gas boilers to 2023, initially planned for 2025.[38] Fossil-fuel-fired boilers have also been identified as generating indoor pollution, which is the subject of a petition by 25 NGOs in the US sent to the Environment Protection Agency (EPA) and calling for greater consideration of this source of pollution.[39] In Ukraine, the dilapidated state of its buildings, high energy losses in the sector, and the impact of the war led the country to announce that it will reconstruct "greener" buildings after the war,[40] based on improved energy efficiency, at a meeting between Ukrainian authorities and European partners – including the European Commission, the European Investment Bank, and the World Bank – in Lugano, Switzerland on 4 and 5 July, 2022.

The establishment of buildings codes is nevertheless one of the main obstacles to efficiency, in particular in countries where infrastructures are the most vulnerable. The GlobalABC roadmap for Asia observes that, "*Compliance with, and enforcement of, building codes is crucial yet challenging, as it is often up to subnational governments to enforce, despite variations in human and financial resources.*"[41] There is limited application of building codes in Sub-Saharan African, Central America and South America.[42] Insufficient application of building codes has been identified as one of the main factors behind the vulnerability and destruction of buildings and infrastructures due to geographic and climate hazards.[43] The capacity of countries to closely comply with building codes is linked to their level of wealth. Some studies have highlighted factors like countries' dependence on importing building materials, or the fact that major stakeholders in the national building sector do not comply with the latest building codes.[44] The level of wealth is nevertheless not the only factor at play in countries that are highly vulnerable to future changes, such as New Zealand, where one person in seven lives in an area at risk of flooding, representing $100 billion in residential value.[45,46] The National Climate Change Risk Assessment published in 2020 underlined the importance of planned implementation in New Zealand, which served as the basis of the first National Adaptation Plan, published in 2022. Chapter 7 of the Plan is devoted to the building sector and includes building codes that are "resilient" to rising water levels. The country's resilience strategy anticipates avoiding new constructions in coastal areas and reinforcing legislation concerning the transparency of banks on buildings' exposure to climate risk. In 2021, New Zealand was the first country to draft a law that will make it obligatory for financial institutions to evaluate the companies they are lending money to, in terms of their environmental impact.[47]

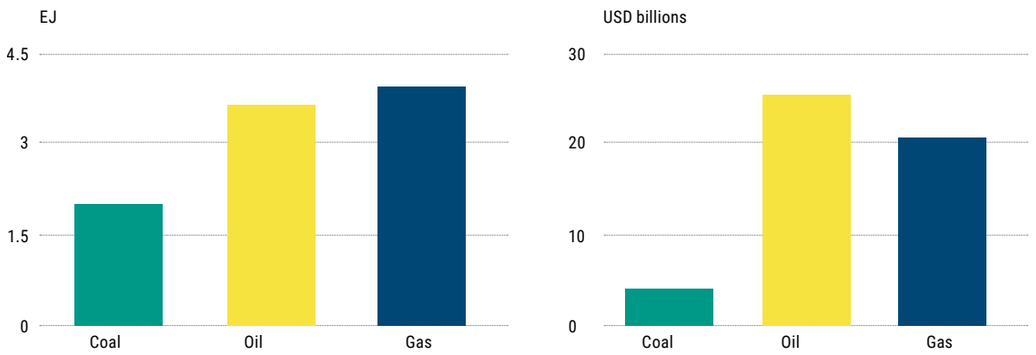
Building resilience established right from the design phase

A study by ESCAP & Asian Institute of Technology[48] demonstrates that building resilience is established at the point of architecture, while mitigation targets are dealt with during the later phases. When the construction steps are designed with climate adaption and mitigation objectives in mind, buildings are all the more resilient.

FIGURE 3

REDUCTION IN FOSSIL ENERGY IMPORTS IN IEA COUNTRIES AND OTHER MAJOR EMERGING ECONOMIES[c] FROM EFFICIENCY IMPROVEMENTS SINCE 2000 (IN DOLLARS AND FUEL)

Source: International Energy Agency, 2019

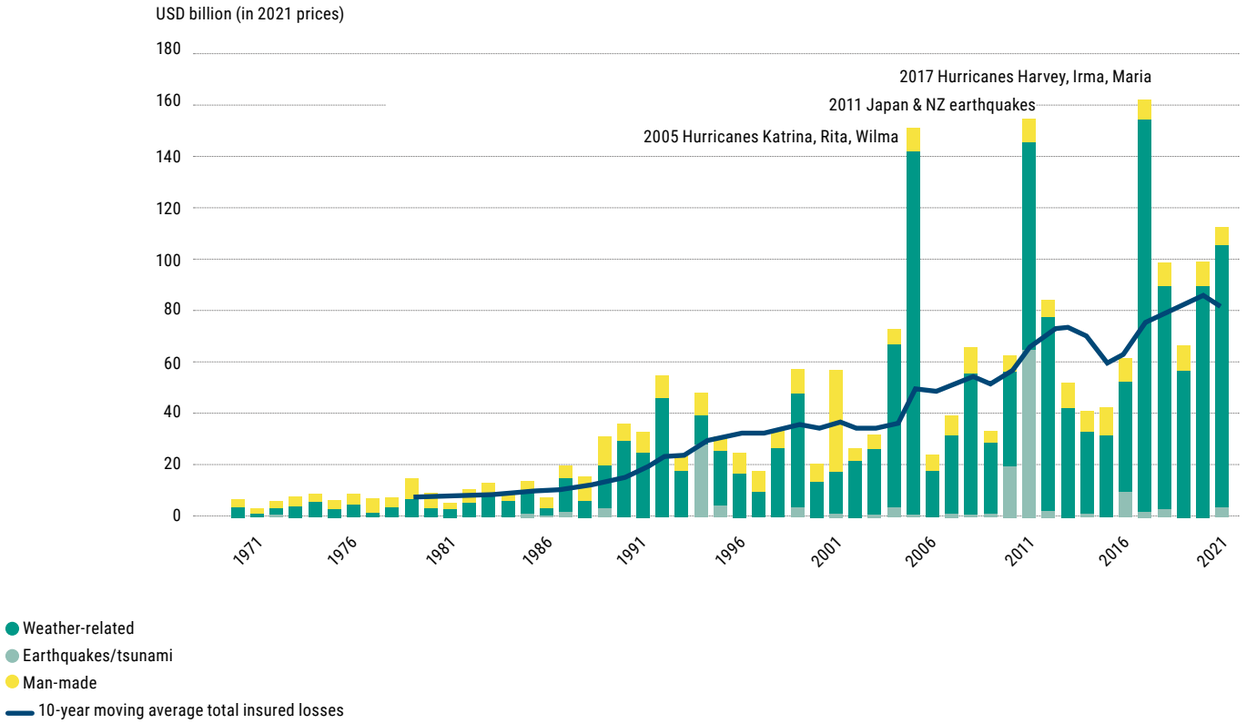


c The countries considered are the members of the International Energy Agency, and China, India, Brazil, Indonesia, the Russian Federation, South Africa and Argentina.

FIGURE 4

CAUSES OF INSURED LOSSES SINCE 1970

Source: Swiss Re Institute, 2021



Japan announced in 2022 that new buildings, both residential and non-residential, must comply with energy efficiency standards.[49] To date, only non-residential buildings over 300 m² have had to do so. Architects will have to explain the impacts of introducing renewable energy to property owners. These measures extend the contribution of the design phase in reaching mitigation targets, in addition to resilience objectives, at which Japanese architects excel. In 2018, the country was recognized by the World Bank as "*among the safest and most disaster-resilient in the world*".[50] Japanese architecture is particularly effective in standing up to the frequent earthquakes and typhoons that hit the archipelago. It was one of the leaders of the Sendai Framework for Disaster Risk Reduction, adopted by the United Nations and signed in 2015, setting out a strategy up to 2030. One of the lessons that Japan put forward was the importance of private-sector participation to share technologies and expertise.[51] Numerous initiatives have been established in Asia at different scales: further south, the city of Dapitan in the Philippines has, for example, built basalt rock houses whose dome shape makes them resistant to typhoons and wind.[52]

Architects can also improve buildings' resilience to outside temperatures at the point of design. Spain is one of the European countries most exposed to heat waves, increasingly intense droughts, and water scarcity. Located 18 km from Madrid, in Móstoles, the entire building that houses the IMDEA Materials Institute of the Madrid Institutes for Advanced Studies, constructed in 2012, was designed to resist climate hazards. The building's "bioclimatic"[d] architecture ensures resilience to very high external temperatures without using more energy for air conditioning. Insulation is provided by the building's ventilated facades and numerous other solutions have been put in place to limit direct exposure to the sun, or its radiation, and take advantage of the shade. The roof is made from a white material that reflects sunlight. The design of the building and efforts to maximize the energy efficiency of its equipment result in an A-rated energy performance certificate and a primary energy requirement of 168.90 kWhpe/m² compared to 491.70 kWhpe/m² for a standard building.[53] Water efficiency has also been integrated into the building's design: rainwater is collected on the roof and used to irrigate the planted areas. The carpark has a permeable surface to reduce the risk of flooding in anticipation of more intense rainfall. The toilets and sinks use 40% less water than those in a regular building.

The building surface area in Africa is set to double from 2017 to 2050, 90% of it for residential buildings.[54] The integration of climate risks in new constructions can bring numerous joint benefits, such as avoiding additional emissions thanks to energy efficiency measures, or creating access to better living conditions. ICLEI Africa, a regional network of local authori-

d Bioclimatic architecture makes use of renewable energy and natural ventilation, and optimizes the means employed in construction. In this case, it ensures low indoor temperatures when external temperatures are high and minimizes the energy needed for cooling and lighting.

ties committed to climate action, lists over 50 projects[55] for resilience in Africa that have been set up at municipal level. The two towns of Nacala (Mozambique) and Moroni (Comoros) have been recognized for their leadership and for being the first to align with the guide of the Global Covenant of Mayors. The Coastal City Adaptation Project (CCAP) ran in Mozambique from November 2013 to November 2018, and focused on adapting the country's numerous coastal cities, including Nacala, to climate change. Different groups and actors contributed to construction projects to ensure that the "*construction materials and techniques were appropriate and culturally acceptable*".[56] Twenty-two "model" houses were developed from this project, which gathered architects, local decision-makers, women's groups and local craftspeople. The models feature for example roofs that collect rainwater for use in the home and are built to resist high winds. The roofs are made from water-resistant materials and angles are no greater than 12.5 degrees to reduce their exposure to wind. The CCAP participated in drawing up the government's building codes. The project initiators justify the cost of adapting the buildings by the long-term savings, because more resilient designs avoid future expenditure on reconstruction.

African architects are also calling for the use of traditional methods to ensure buildings' resilience. GlobalABC[57] promotes the use of passive cooling when designing new buildings as an important way to limit the increased demand for artificial air-cooling systems. The winner of the 2022 Pritzker Architecture Prize, Diébédo Francis Kéré, employed this technique in a school in Gando, Burkina Faso, by combining traditional methods and local materials to adapt the building to its environment. The school is cooled entirely thanks to passive methods, employing natural ventilation and a structure that reduces heat absorption. As a result of integrating this feature in its architecture, the building consumes no energy for cooling.

Traditional methods inspire bioclimatic architecture when designed locally to stand up to particular climate events,[58] like cyclones and flooding in rural areas. Traditional construction techniques used on homes in the Salomon Islands[59] have inspired bioclimatic designs, such as for natural ventilation (for hot, humid areas). These designs employ local materials adapted to the climate, include multiple ventilation areas, and raise houses on stilts to protect them from flooding during monsoons. In addition, traditional materials[60] like wood, stone and earth, emit fewer greenhouse gases than concrete and steel and preserve architectural culture.

Faced with climate change, the insurance sector goes back to the drawing board

The insurance sector is highly exposed to the "physical risks" generated by climate change. According to an assessment by Swiss Re, natural catastrophes generated $112 billion insured losses in 2021, which is the fourth highest annual figure ever recorded **(FIG. 4)**.[61] An evaluation by the European Insurance and Occupational Pensions Authority (EIOPA), which is a European Union financial regulatory institution, reported that "*all property-related lines of business are expected to be impacted by physical climate change risk*".[62] In 2020, about 80% of commercial losses due to storms and flooding in Europe concerned damage to buildings. The increased number of "compound events"[e] calls for a change in the way that risk is managed.

Risk assessment reports in the sector integrate an increasing number of data and analyses,[63] the sharing of which constitutes a major lever of action for insurers and for adaptation, despite the fact that exposure to physical risks is particularly difficult to quantify.[64] In the United States, a new report by the NGO Natural Resources Defense Council (NRDC) shows that people who buy homes with a history of flooding can expect to pay tens of thousands more dollars[65] in flood damages over the course of their mortgage compared to the average homeowner. The transparency of historical data is therefore a crucial issue. However, 21 US states do not require the seller to share this information.[66] A house that collapsed into the ocean in North Carolina in May 2022[67] triggered strong reactions on social media, with calls to make it obligatory to disclose the risks of properties and the land they are built on. Yet the price of insurance contracts varies and is not always based on the same features. Since a recent change in the calculation methods employed by the Federal Emergency Management Agency (FEMA), the cost of insurance payments for houses located close to water sources or at risk from hurricanes, such as in Florida, is set to increase drastically. Some homeowners have already had to make additional insurance payments,[68] despite having adopted measures to make their homes less vulnerable.

The revision of the FEMA's calculation method is an example of adaptation measures in a sector faced with changes in the frequency and distribution of risks. While the insurance sector can constitute an adaptation tool to deal with extreme climate events, it must also adapt itself to the new situation to manage its own "transition risks". The insurance market in Louisiana saw a series of insurance companies go bust following the passage of Hurricane Ida last year.[69] These bankruptcies came at "the worst time of year", subject to numerous wildfires and flooding, leaving thousands of people without insurance. The vulnerability of part of Australia also points to an "insurance crisis", with one home in 25 highly likely to no longer be insurable by 2030.[70] This phenomenon could also increase inequalities because it makes houses at risk more affordable, attracting lower-income buyers. Another consequence is the increased value of assets, which makes insurance less affordable. Yet the number of contracting parties is central to the effectiveness and security – even resilience – of the economic model of insurance companies, which is based on sharing the cost of risks.

e "Compound events" are mentioned in the latest IPCC report as one of the main manifestations of climate change. They are defined by the combination of several drivers at once (e.g. heavy rainfall and heatwaves, or several climate conditions likely to trigger wildfires, such as dry, warm winds).

KEY TAKEAWAYS

To date, few building and renovation codes integrate adaptation, despite the increased impacts of climate change causing more numerous material damages and loss of human lives. Countries like Japan and the United States were early to undertake research to anticipate the natural disasters that have historically impacted them. Nevertheless, due to climate change, such episodes are likely to intensify in these countries and become more common in other countries. This calls for greater integration of mitigation and adaptation measures, which have not been considered in technologies that only focus on building resilience. Some pioneer initiatives attempt to implement projects aimed at both reducing energy consumption and making buildings more resilient in the long term. Integrating adaptation measures also involves including traditional techniques in building projects because of their highly local nature, making them harder to replicate than measures aimed at reducing GHG emissions. Insurance can be an important lever to tackle impacts that have already occurred, although with the increased number of events, the sector is faced with the need to adapt. This is because adaptation is related to the level of risks and therefore to the insurance sector's capacity to operate on a model that considers the increase in risks and then better distributes them.

REFERENCES

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1 World Meteorological Organization (2021). State of Climate in 2021: Extreme events and major impacts. *World Meteorological Organization*

2 Masson-Delmotte, V. et al. (2021). Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. *Intergovernmental Panel on Climate Change*, pp. 3–32. Point C.2.2

3 Starkman, K. (2018). Climate Risk, Real Estate, and the Bottom Line. *Four Twenty-Seven & GéoPhy*

4 McCann, J. (16/07/2022). UK heatwave 'will be a nightmare' for under-pressure NHS as Covid cases soar, doctor warns. *Inews*

5 GlobalABC, IEA & UNEP (2020). GlobalABC Regional Roadmap for Buildings and Construction in Asia: Towards A Zero-Emission, Efficient and Resilient Buildings and Construction Sector. *Global Alliance for Buildings and Construction*

6 Eckstein, D., Hutfils, L-M. & Winges, M. (2019). The Global Climate Risk Index 2019. *Germanwatch*

7 UNHCR (02/09/2022). Pakistan's disastrous floods uproot refugees and citizens. *United Nations High Commissioner for Refugees*

8 GlobalABC, IEA & UNEP. (2020). GlobalABC Regional Roadmap for Buildings and Construction in Asia: Towards A Zero-Emission, Efficient and Resilient Buildings and Construction Sector,*op. cit.*

9 Ourbak, T. & Magnan, A. K. (2018). The Paris Agreement and climate change negotiations: Small Islands, big players. *Regional Environmental Change*

10 GlobalABC (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zeroemission, Efficient and Resilient Buildings and Construction Sector. *Global Alliance for Buildings and Construction*

11 Bernstein, A., Gustafson, M. & Lewis, R. (2018). Disaster on the Horizon: The Price Effect of Sea Level Rise. *Journal of Financial Economics*

12 Starkman, K. (2018). Climate Risk, Real Estate, and the Bottom Line. *Four Twenty-Seven & GéoPhy*

13 CoreLogic. (2022). 2021 Climate Change - Catastrophe Report. *CoreLogic*

14 Becketti, S. (2021). Special Report - The Impact of Climate Change on Housing and Housing Finance. *Research Institute for Housing America & Mortgage Bankers Association*

15 *UNHCR (02/09/2022). Pakistan's disastrous floods (...), op.cit.*

16 IDMC (2022). Global Report on Internal Displacement. *International Displacement Monitoring Centre*

17 United Nations Environment Programme. (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zeroemission, Efficient and Resilient Buildings and Construction Sector. *Global Alliance for Buildings and Construction*

18 Santos, J. et al. (2019). Natural Hazard Mitigation Saves: 2019 Report. National Institute of Building Sciences. *National Institute of Building Sciences*

19 Porter, K. (2021). Do Disaster-Resistant Buildings Deliver Climate Benefits?. *SPA Risk LLC*

20 Global Resiliency Dialogue. (2021). Delivering Climate Responsive Resilient Building Codes and Standards. *Global Resiliency Dialogue*

21 International Code Council (2021). Global Resiliency Dialogue Second Survey of Building Code Stakeholders – USA. *International Code Council*

22 Doig, A. & Ware, J. (2016). Act now or pay later: protecting a billion people in climate-threatened coastal cities. *Christian Aid*

23 Alvarez, C. (2017). New York inondée tous les cinq ans à cause du changement climatique. *Novethic*

24 NYC Mayor's Office of Resiliency (2020). Climate Resiliency Design Guidelines. *NYC Mayor's Office of Resiliency*

25 Global Resiliency Dialogue. (2021). Delivering Climate Responsive Resilient Building Codes and Standards. *Global Resiliency Dialogue*

26 Guardaro, M. et al. (2018). Nature's Cooling Systems: Neighborhood-Built Community Heat Action Planning. *American Geophysical Union*

27 International Code Council (2018). Building Community Resilience through Modern Model Building Codes. *International Code Council*

28 *ibid.*

29 Berndtsson, R., et al. (2019). Drivers of changing urban flood risk: A framework for action. *Journal of Environmental Management*, 240, pp. 47-56

30 Yingwei, Y. et al. (2022). Evaluation of comprehensive benefits of sponge cities using meta-analysis in different geographical environments in China. *Science of The Total Environment*, Vol. 836

31 Palermo, S. A. et al. (2020). On the LID systems effectiveness for urban stormwater management: case study in Southern Italy. *IOP Conference Series: Earth and Environmental Science,* Vol 410

32 Nowogoński, I. (2020). Low impact development modeling to manage urban stormwater runoff: case study of Gorzów Wielkopolski. *Journal of Environmental Engineering and Landscape Management*

33 Yingwei, Y. et al. (2022). Evaluation of comprehensive benefits of sponge cities using meta-analysis in different geographical environments in China. *Science of The Total Environment*, Vol. 836

34 Brenneisen, S. & Baumann, N. (2021). Case studies: Green roofs in Basel, Switzerland: combining mitigation and adaptation measures. *ClimateAdapt*

35 Speak, A. F. et al. (2013). Rainwater runoff retention on an aged intensive green roof. *Science of the Total Environment*

36 Ghantous, N. (2022). Energy efficiency equals energy security. *EnergyMonitor*

37 Giuffrida, A. (21/04/2022). Italy puts 25C limit on air conditioning as Ukraine crisis forces energy rationing. *The Guardian*

38 Kurmayer, N. J. (14/06/2022). Austria to ban gas boilers in new buildings as of 2023. *Euractiv*

39 Pontecorvo, E. (23/08/2022). Will the EPA crack down on pollution from buildings?. *Grist*

40 Gumbau, A. (24/08/2022). Ukraine sets plans for ambitious 'green' reconstruction. *EnergyMonitor*

41 GlobalABC, IEA & UNEP. (2020). GlobalABC Regional Roadmap for Buildings and Construction in Asia: Towards A Zero-Emission, Efficient and Resilient Buildings and Construction Sector. *Global Aliance for Buildings and Construction*

42 GlobalABC (2021). 2021 Global Status Report for Buildings and Construction: Towards a Zeroemission, Efficient and Resilient Buildings and Construction Sector,*op. cit.*

43 Burby, R. and May, P. (2000). Issues for regulatory enforcement and compliance with building codes: American perspectives. *12th World Conference on Earthquake Engineering*

44 Nnadozie Nwadike, A., Wilkinson, S. & Charles Clifton, G. (2019). Improving disaster resilience through effective building code compliance. *Conference: i-Rec 2019 Disrupting the status quo: Reconstruction, recovery and resisting disaster risk creation*

45 Ministry for the Environment of New Zealand (2022). Adapt and thrive: Building a climate-resilient New Zealand – New Zealand's first national adaptation plan. *Ministry for the Environment of New Zealand*

46 McClure, T. (27/04/2022). New Zealand unveils plan to tackle climate crisis by adapting cities to survive rising seas. *The Guardian*

47 BBC (14/04/2021). NZ to launch world-first climate change rules. *BBC News*

48 H. Aliani, A. (2012). Integrating Environmental Sustainability and Disaster Resilience in Building Codes. *ESCAP & Asian Institute of Technology*

49 Rethink Tokyo (2022). Energy conservation architecture to be mandatory for Japan real estate from 2025. *Rethink Tokyo*

50 Moullier, T & Sakoda, K. (2018). Building regulation for resilience. Converting disaster experience into a safer built environment – the case of Japan. *The World Bank*

51 Gouvernement du Japon (n.d.). Building resilience against climate change: Japan's impact on the world. *The Economist*

52 Laput, G. (2015). Super typhoon-proof dome houses to rise in Dapitan. *Rappler*

53 Arkitools Estudio de arquitectura. (2013). Madrid Institute for Advanced Studies (IMDEA). *Construction 21*

54 GlobalABC, IEA & UNEP. (2020). GlobalABC Regional Roadmap for Buildings and Construction in Africa 2020-2050. *Global Allliance for Buildings and Construction*

55 ICLEI Africa (2022). ICLEI at the forefront of climate adaptation planning with African cities. *ICLEI Africa*

56 USAID (2018). Mozambique Coastal City Adaptation Project – Final Report. *United States Agency for International Development*

57 GlobalABC, IEA & UNEP (2020). GlobalABC Regional Roadmap for Buildings and Construction in Africa 2020-2050., *op. cit.*

58 Chalmers, P. (2014). Climate Change: Implications for Buildings. *BPIE*

59 Architecture Bulletin. (Nov/Dec. 2010). Emerging architecture in the Solomon Islands. *Architecture Bulletin*, p. 20-21

60 Dejeant, F. et al. (2021). Matériaux locaux, matériaux d'avenir: Ressources locales pour des villes et territoires durables en Afrique. *CRAterre*

61 Swiss Re (14/12/2021). Global insured catastrophe losses rise to USD 112 billion in 2021, the fourth highest on record, Swiss Re Institute estimates.

62 EIOPA (2022). Discussion paper on physical climate change risks. *European Insurance and Occupational Pensions Authority*

63 Swiss Re (06/09/2021). In a world of growing risk the insurance industry has a crucial role to play. *Swiss Re Institute*

64 McKinsey (06/01/2021). How insurance can help combat climate change. *McKinsey & Company*

65 Teirstein, Z. (04/08/2022). New report quantifies the costs of buying a home that has previously flooded. *Grist*

66 NRDC (n.d.). How states stack up on flood disclosure. *NRDC*

67 that Teirstein. Z. (05/2022). North Carolina house that collapsed into the sea is a warning for millions of Americans. *Grist*

68 Younes, L. (19/08/2022). After FEMA overhaul, hundreds of thousands of Americans are forgoing federal flood insurance. *Grist*

69 Bittle, J. (24/06/2022). Louisiana's insurance market is collapsing, just in time for hurricane season. *Grist*

70 Khalil, S & Turnbull, T. (19/05/2022). T. Australia election: How climate is making Australia more unliveable. *BBC news*

TRENDS
COMMERCIAL BUILDINGS

From efficiency to renewable energy generation: Commercial spaces in search of renewal favouring the low-carbon transition

TANIA MARTHA THOMAS • Research Officer, Global Observatory of Climate Action, Climate Chance

The operation of buildings accounts for over a quarter of global GHG emissions, with non-residential buildings in turn accounting for a significant share of this. Due to the large surface areas they occupy, and their relatively larger energy demand, commercial buildings hold great potential to reduce energy demand, increase energy efficiency, and also increase the share of renewables – either through sourcing or through on-site generation. The commercial sector can also influence trends like e-mobility, by hosting Electric Vehicle (EV) charging stations, while also being home to green spaces on built areas.

DATA OVERVIEW

Hot N' Cold: The increasing share of thermal energy use in building operations

In 2021, pushed by the reopening of the global economy, the operation of buildings accounted for about 30% of global final energy demand, increasing by 6% from 2020, and surpassing the peak achieved in 2019. The use of energy for heating, cooling, cooking, lighting and equipment use accounted for 27% of global energy-related CO_2 emissions, of 10 $GtCO_2$.[1] These emissions rose steadily at a pace of 1% between 2009 and 2019, followed by a dip in 2020 and early-2021 due to a decline in activities linked to the COVID-19 pandemic, which pushed the population from public and commercial buildings to the less energy-intensive residential ones.[2] The resumption of economic activities in 2021 has led to a rebound in building energy use, breaking the trend of 2020.[3]

The main energy end-uses in buildings can be divided into two: thermal (referring to the use of energy for space heating and cooling, water heating, and cooking), and electrical (covering the use of major appliances, lighting, and other minor demand). Out of the total, thermal energy accounted for more than three quarters (77%) of global building energy consumption.[4] This consumption is still largely dependent on fossil fuels, which makes it responsible for almost 45% of greenhouse gas (GHG) emissions from buildings, or almost 12% of global emissions.[5] The share of renewables (excluding traditional biomass) in heating and cooling of buildings rose slowly, touching 10.7% in 2019, up from 7.9% in 2009.[6] This increase is mainly driven by the electrification of heating systems[a], coupled with the rise of renewables in the global electricity mix **(SEE ENERGY SECTOR)**. In 2020, the sale of heat pumps and other renewable equipment like solar water heating systems accounted for 20% of overall installations; with nearly 190 million heat pumps in use in 2021.[7, 8] In 2021, the global heat pump market grew a further 15%.[9] At the same time, district heating and cooling networks are also growing in popularity, while evolving to include more renewable sources, and serve larger areas.[b] Up to 2020, there has been a steady decline in the use of coal, oil and natural gas in heating **(FIG. 1).**

At the same time, space cooling remains the largest growing end-use of energy in buildings, rising at an average 4% per year since 2000. This demand continued to grow in 2020, driven also by the lockdowns, which further pushed residential cooling demand.[10] Unlike heating, cooling in buildings is largely powered by electricity (with cooling accounting for 1885 TWh, or 16%, of final electricity consumption of buildings)[11], and thus depends greatly on the electricity mix of the region. The change in climate then entails not only ensuring more energy-efficient cooling, but also expanding access to cooling in the face of increasing global temperatures – in 2022, 1.2 billion urban and rural poor were identified as being at risk due to a lack of access to cooling **(SEE INDONESIA CASE STUDY).**[12]

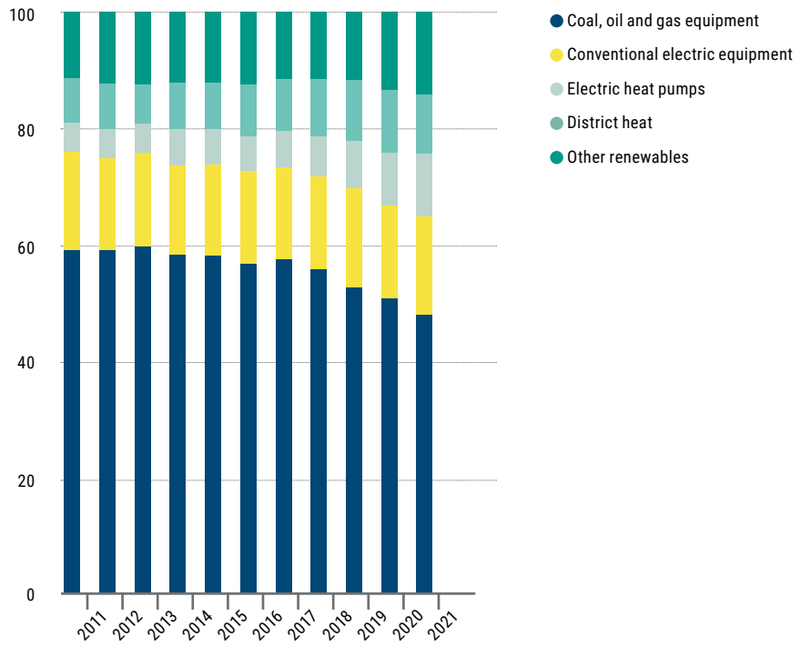
a See Observatory of Non-State Climate Action (2021). Global Synthesis Report on Climate Action by Sector. Climate Chance.

b *Idem*

FIGURE 1

SHARE OF HEATING TECHNOLOGY SOLD BETWEEN 2010 AND 2020 FOR RESIDENTIAL AND SERVICE BUILDINGS

Source: IEA, 2021



A regional overview based on 2019 data points to Asia as having the largest energy demand from buildings, followed by the Americas, and Europe, with Africa coming in last. As the move to "electrify everything" continues to spread, Europe showed the highest level of electrification at 48%, while Asia and the Americas stood at 33% and 27% respectively, while Africa touched only 8.4%.[13] Local governments have been particularly active in pushing for renewables in buildings, often using fiscal and financial incentives to encourage renewable energy uses in existing buildings, or putting in place restrictions on the use of fossils for space and water heating and cooking (59 cities had such measures in place, as of 2021).[14]

An important factor affecting the energy use, and in turn, the regulations and restrictions to which a building is subject is the purpose for which a building is used. Based on its usage or function, buildings are classified as being residential or non-residential.[c] In 2020, residential buildings accounted for 22% of global energy use and 17% of global energy-related emissions, while the non-residential sector accounted for 8% and 10% of these, respectively **(FIG. 2)**.[15]

While non-residential, particularly commercial buildings, have a relatively smaller share in energy-use and emissions compared to residential ones – a pattern that was furthered by the outbreak of the Covid-19 pandemic and following lockdowns – they hold a lot of capacity to improve energy efficiency, integrate renewables (or even generate them), and ultimately, reduce emissions from the building sector. Additionally, the reopening of economies in 2021 has also led to a visible rebound in the operation of non-residential buildings and associated emissions.[16]

THE OBSERVATORY'S LENS

Commercial buildings: A cornerstone in the decarbonisation of the building sector

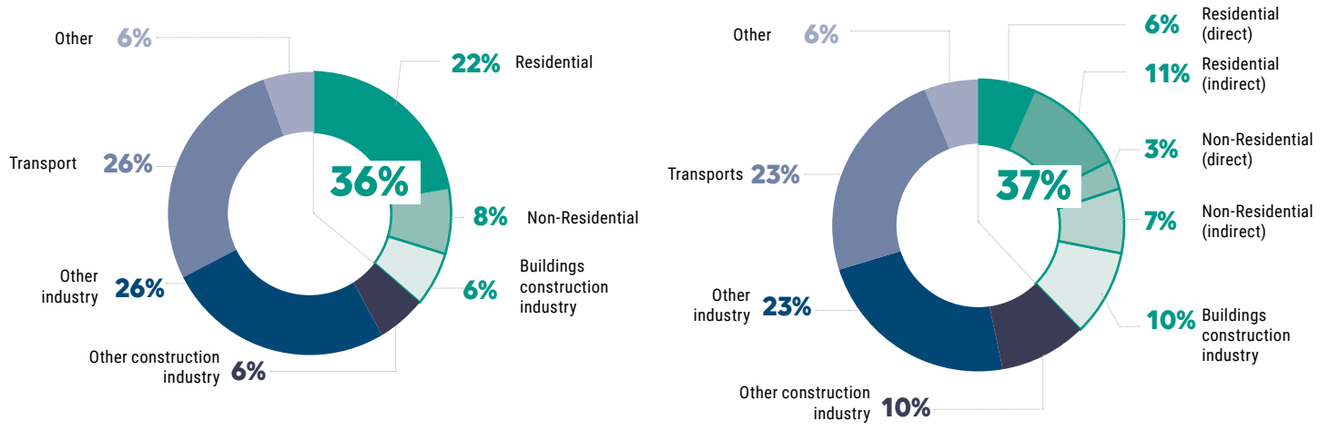
Commercial buildings often make up larger built areas depending on their purposes, and their typical operations also differ from residential ones in their scale, and duration in the day. They are also subject to different regulations under the local and national governments, while they use appliances or equipment that are subject to different performance standards. Reducing the climate impact of the commercial building sector, then, can be done through regulations that will apply to commercial buildings and their energy use. It can also be acheived through self-motivated action of private actors to reduce their energy demand and improve efficiency, generate and source their energy from renewables, and promote the

c In general, in order to enforce codes, buildings are classified based on their use and occupancy. Residential buildings are ones that provide accommodation for individuals, including apartments and houses. Non-residential buildings are an umbrella term covering all other types of built structures. Based on their uses, for the purpose of analysing buildings' energy use, the IEA for instance classifies activities related to "*trade, finance, real estate, public administration, health, food and lodging, education, and other commercial services*" as non-residential. The varying use-based classifications of non-residential buildings across regions or countries makes it harder to have data on them.

FIGURE 2

SHARE OF RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS IN GLOBAL FINAL ENERGY USE AND ENERGY-RELATED EMISSIONS

Source: GlobalABC, based on IEA data (2021)



use of such energy for sustainable practices like e-mobility. The most prominent actions in commercial buildings have been observed in Europe and in North America, with a few emerging initiatives in developing countries.

Regulatory frameworks for energy consumption in buildings

The European Union's proposed recast of the Energy Performance of Buildings Directive[17] as part of the Fit-for-55 package provides a relatively shorter timeline for non-residential buildings, including public-owned and commercial ones, to meet the minimum energy performance standards after renovation. Member states are required to ensure that non-residential buildings are at least class F by 2027, and class E by 2030.[d] Additionally, large non-residential buildings are required to have "Smart Readiness Indicators", a rating of the building's capacity to adapt to occupant behaviour, allowing owners and occupants to benefit from data about automation and electrification of technical services. The proposed directive also encourages the installation of infrastructure for charging Electric Vehicles (EVs) in car parks, and parking spaces for bicycles to encourage soft mobility. The EU Solar Energy Strategy,[18] as part of the REPowerEU plan to reduce dependence on Russian energy, also calls for the widescale deployment of solar PV, wherein large commercial centres and their parking spaces hold immense potential for rooftop installations. The European Commission has proposed a rooftop PV mandate for public and commercial buildings starting from 2027.[19]

The Energy Efficiency Directive[20] also recognises the role of energy efficient heating and cooling, and provides for the identification of heating and cooling technologies in use in non-residential buildings, including ones generating waste heat or cold, and their upgrading, and the energy renovation of non-residential buildings. The Renovation Wave Strategy lays down key principles to drive renovation in residential and non-residential buildings towards 2030 and 2050 objectives, including putting energy efficiency first, decarbonisation and the integration of renewables, and life cycle thinking and circularity, among others.[21]

Some member states have set targets that go further, such as the Netherlands, which requires all office buildings to be class C by 2023 and class A by 2030. In France, as part of its long-term renovation strategy, a progressive set of measures was adopted target poor energy-performance buildings (*passoires énergétiques*), starting with a rent increase on such buildings in 2021, a ban on renting them from 2023, and obligation to renovate them from 2028.[22] The French Climate and Resilience Act, passed in 2021 following the Citizen Convention, also promotes "efficient renovation" (*rénovation performante*), through the construction and housing code. Following the Covid-19 crisis, the government's recovery package also contained large amounts of financing for the building sector, including 4 billion euros for the renovation of public buildings and 200 million euros for the renovation of tertiary buildings of very small businesses and small and medium-sized enterprises.[23]

Germany's Building Energy Act of 2020 set the standards for energy performance of buildings, of energy performance certificates, and the use of renewables in buildings.[24] Though final energy consumption[e] reduced by 17% between 2008 and 2018, it fell short of the federal target of a 20% decrease.[25] In 2022, with the Russian invasion of Ukraine, in order to reduce

d The EU's Energy Performance of Buildings Directive requires member states to have a system of Energy Performance Certificates (EPCs), which rates the energy performance of a buildings compared to minimum performance requirements, on a scale of A to G, with A being the best performing and G the worst.

e In the case of non-residential building, the "final energy consumption" is calculated as the total use of energy for heating, cooling, the heating of water, and lighting.

its dependence on Russian gas, the State announced several energy-related measures – including updating the Building Energy act, to apply the "Efficiency Standard 55" for all new buildings from 2023, to promote at least 65% renewables in heating, to promote the use of heat pumps.[26] Reacting to the situation in Ukraine, Austria too announced measures related to building heating, banning gas boilers in all new buildings from 2023.[27]

In the United States, while commercial building codes vary from state to state, the Federal Department of Energy conducts research and works with businesses to improve the energy efficiency and reduce the cost of operating buildings, for instance, through the Better Buildings Initiative – having a repository of over 3,000 solutions from various partners, which can be replicated, while also helping businesses find financing to implement these.[28] The Environment Protection Agency (EPA)'s ENERGY STAR programme also helps businesses work on improving their energy efficiency, with buildings that have a superior energy performance earning the ENERGY STAR certification.[f] The recent Inflation Reduction Act of 2022, dubbed the Climate Act, also provides tax incentives for green buildings, and also contains measures to promote the electrification of buildings and the use of renewable-sourced electricity – including commercial and public buildings.[29] Some states in the US have been more proactive in promoting electrification, be it through EV readiness codes coupled with renewable energy obligations, or in the movement to electrify heating and move away from gas, which lead to a tug of war between the federal, and state and city governments.[g]

A trend of municipal action has also been observed in the buildings sector, with more and more cities leveraging building codes and other requirements to increase the share of renewables in their territory. More than 920 cities in 73 countries have set targets in renewable energy in at least one sector – including power (793), and heating and cooling (170). The momentum to decarbonise heating and cooling is also growing. The city of London, for example, has set a target of having 2.2 million heat pumps in operation by 2030. Municipalities have also tried to encourage private action by setting examples, acting on their own building stock, notably through on-site renewable generation – either on building facades or through rooftop PV, or alongside the buildings (George municipality, in South Africa, for instance, installed a 300-kW solar plant to cover the electricity use of its principal building).[30]

Actions of the commercial towards demand reduction and renewable generation

There are several initiatives that group together various private actors, committing to improve the sustainability of their operation. The Retail Forum for Sustainability[31], for instance, is a platform that brings together major retailers in Europe under the impetus of the European Commission, launched in 2009. Under the Retailers' Environmental Action Programme (REAP), the initiative lists the actions taken by the major retailers under three categories: *What we sell*, *How we sell*, and *Communication*. The *How we sell* category includes measures that affect the physical locations of the retailers and their building operations, and lists measures adopted such as reducing CO_2 emissions from coolant production, emissions generated from stores, increasing the share of renewables in energy consumption, a rollout of sustainable cooling, reducing lighting energy consumption, increasing energy efficiency of stores, increasing the eco-labelling of buildings, and installing independent renewable generation. Out of the 201 listed actions that are being put in place, over 45 are fall in the *How we sell* category, and under the domain of "Emissions and (alternative) energy".[32]

Both the products sold and how they are sold affect the carbon footprint of retailers, by affecting emissions both upstream and downstream of their value chains – for retailers with a physical presence, the emissions from their stores and warehouses (*i.e.,* their buildings) have a large impact on this, along with transport. **(SEE BOX 1)**

BOX 1 • **KEYS TO UNDERSTANDING**

RETAILERS' CARBON FOOTPRINTS: BUILDINGS AS AN AREA OF ACTION

Though the retail sector was relatively late in beginning to set targets to decarbonise their value-chains, the number of large retailers setting such targets has increased over fivefold between 2019 and 2021. Analyses of the strategies to decarbonise their operations has shed light on the potential for reduction of retailers' emissions across Scopes 1, 2 and 3. For most retailers, Scopes 1 and 2 represent about 20% of their total carbon footprint, and fall under their direct control, while Scope 3 emissions accounted for the rest, and depend on suppliers and consumers. Emissions from the extraction and production of goods sold, and their transportation to the distribution centres and stores were the largest sources of upstream Scope 3 emissions, while the transportation used by consumers and the use of the sold products were the largest sources of downstream Scope 3 emissions.

As for Scopes 1 and 2, these include direct emissions from the retailers' properties, and their purchased electricity, steam, heating, and cooling. A traditional retailer counts 18% of its emissions from its properties – its stores, warehouses, and offices. For an e-commerce retailer, this figure stands at 15%. While this represents a relatively smaller share, it has been identified as "low hanging fruit", as retailers can directly act to reduce these emissions – by improving energy efficiency of lighting, of heating and cooling, and by incorporating more renewables in their energy use.

Sources: Bhargava, A. Hoffman, S., & Jakic, N. (2022); MIT Real Estate Innovation Lab, 2021.

Initiatives of private actors to reduce their carbon footprint also exist at the national level – in France, the Féderation

f The ENERGY STAR certification, given on an annual basis, indicates that a building has scored better than at least 75% of similar buildings nationwide. It is based on a score of 1 to 100, calculated based on energy use.

g See Observatory of Non-State Climate Action (2021). Global Synthesis Report on Climate Action by Sector. Climate Chance.

Perifem is an interlocutor of public authorities with all the actors of the retail sector working to create a sustainable commercial sector.[33] In the face of predicted energy shortages for the winter of 2022, the federation has defined certain "common and concrete" measures to be adopted by 15 October, such as turning off the lighted signboards as soon as the store closes, systematic reduction in the intensity of lighting by reducing by reducing the lighting of sales areas by 50% before the public arrives, and by 30% after periods of critical consumption. Other measures announced also include reducing air circulation at night, and shifting the production of ice.[34] These measures have been put in place by major retailers like E.Leclerc, Carrefour, Système U, Les Mousquetaires Intermarché, Auchan, Casino, Franprix, Monoprix, Lidl and Picard.[35] SPAR Austria is also adopting a similar measure, reducing the hours of storefront advertising across all its outlets, with the intention of reducing annual energy consumption by 1 million kilowatt hours. Belgian retailers like Colruyt and Ahold have no short-term measures planned, but are relatively insulated from incoming energy shocks due to existing measures such as avoiding illuminated signs, closed freezers and such.[36]

At the same time, in Germany, France, Italy, Spain, Switzerland, Denmark, Sweden, Finland, the Netherlands, Austria, and Greece have all seen the adoption of measures reducing heating and cooling requirements, notably in public and office spaces, by increasing the range of temperature in which there is no heating or cooling activated. In Spain, while heating is mandated to be set at 19 °C throughout winter, hotel rooms, restaurant kitchens, hair salons, gyms, schools and hospitals stand to be exempted. With Greece set to offer financial incentives to organisations that monitor and curb energy consumption, actors are resorting to temperature control and systematised reduction in the use of lights and computers.[37]

According to the US Energy Information Administration, the country counts about five million commercial buildings, of which retail buildings have the largest energy cost. The ENERGY STAR database lists 39,153 commercial buildings (excluding industrial plants and data centres) that have the ENERGY STAR certification.[38] Retail giant Walmart was the first retailer, in 2016, to take up an emissions reduction plan, setting an objective of -18% emissions from their own operation by 2025.[39] In 2020, the chain counted a 17.5% reduction in Scope 1 and 2 emissions from the 2015 baseline, through the adoption of efficient design measures in terms of lighting, heating, ventilation and air conditioning (HVAC), refrigeration, etc. in new stores, and upgrades and retrofits of equipment in existing stores.[40] In another example, the ENERGY STAR administration cites clothing and home retailer JCPenney being the first to earn an ENERGY STAR in 2007, and continuing to improve on energy efficiency – realising a gain of 5.6% in energy intensity in 2019, and increasing focus on efficiency of HVAC systems.[41]

At a municipal level, the NYC Carbon Challenge brings together the New York mayor's Office of Environmental and Climate Justice and stakeholders representing universities, hospital organizations, commercial owners, commercial offices, residential property management firms, and hotels. The initiative covers around 10% of built surface area in the city, and has led to the annual reduction over 600,000 tCO_2 to date, through measuring and reducing energy use, and controlling plug loads, lighting, refrigeration, and HVAC use, and improving building envelopes.[42,43]

As far as the sourcing of renewable energy by the commercial sector goes, the trend is the strongest in Europe and North America, with Power Purchase Agreements (PPAs) and unbundled Energy Attribute Certificates (EACs) being the most preferred instruments.[44] In the United States, the EPA states that the green power use of the top retailers part of the Green Power Partnership[h] as of July 2022 amounts to 8,300 GWh[i], with Walmart, Target and Starbucks coming in the highest.[45] In 2021, Europe saw 11.2 GW contracted through PPAs, come online across more 140 deals – with the retail sector being led by Amazon, sourcing renewables for its data centres in the continent,[46]

On-site generation of renewables, while accounting for a lower share compared to other instruments of sourcing, is particularly relevant for commercial buildings with larger surface areas. The EPA lists Green Power Partners using on-site generation in the US, totalling 1,900 GWh, and including retailers like Target, Ikea, Aldi, and Kohl's among the top 30.[47] Ikea has also contributed to the on-site generation trend in Europe, a large number of its outlets and warehouses producing their electricity on-site. All of its operations (stores, warehouses, factories and offices) are 100% renewable in about 20 European countries, either through sourcing or through on-site generation. The Ingka group, the largest IKEA franchisee installed over 935,000 solar panels on the rooftops of stores and warehouses.[48] Decathlon has committed to sourcing 100% of its electricity from renewables by 2026, and had achieved a level of 82.6% at the end of 2021, with a large share of this coming generation through on-site PPAs in Spain, Portugal, Italy and France, where a third-party owns and operates the on-site renewable energy installation.[49,50] In Belgium, for instance, 27% of the electricity consumed by Decathlon stores was generated on-site.[51]

In South Africa, the country's largest retailer, the Shoprite Group has been deploying solar across its outlets, also using on-site PPAs as its instrument of choice, currently having an installed capacity of 26.6 MW from the on-site plants.[52]

Aside from retail, other service sector buildings also hold great potential to make the sector less energy-consuming, through energy efficiency and renewable generation measures. RE100, the global corporate renewable energy initiative that brings

h The Green Power Partnership is a voluntary programme under the US EPA that promotes the procurement of 'green power', defined as a subset of renewable energy providing the highest level of environmental benefit, and including solar, wind, geothermal, biogas, biomass, and low-impact small hydroelectric.

i This is the equivalent of the annual electricity consumption of 770,000 average U.S. homes.

together businesses working towards to 100% renewable energy, notes that over 60% of its members worldwide produce renewable electricity for their own consumption, with solar accounting for a large majority of these on-site installations. In an example from India, Mindspace REIT, which owns and operates one of the country's largest real estate portfolios, uses rooftop solar arrays in two of its business parks, making use of the large surface area available.[53]

Commercial buildings promoting e-mobility, and other sustainable practices

Alongside the measures taken to reduce their own footprint, actors in the commercial sector have also been active in promoting sustainable practices among their staff and consumers, making use of the large built areas under their management. The most notable of these is the provision of EV charging stations in the parking lots of commercial buildings, with publicly available EV charging points having gone up by 40% in 2021.[54] A large number of commercial establishments offering EV charging stations often power them using renewables, most commonly solar PV.[55]

For instance, following a commitment made in 2018, Walmart and Electrify America installed over 120 ultra-fast charging stations across Walmart stores in the US in 2019, with further collaboration between the two companies expected to make Walmart one of the largest retail hosts to EV charging stations.[56] Joining enterprises like Walmart and Starbucks, French retailer Carrefour also announced the installation of over 700 charging stations and 5,000 charging points across its hypermarkets by 2025. [57] In Europe, countries like Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden, Poland and the UK have incentives for commercial entities that install charging stations for EVs, in the form of various tax rebates or grants.[58]

While the rollout of EV charging infrastructure worldwide has been accelerating, it hasn't always been welcome – in the US, while cities like Los Angeles are considering banning the construction of new petrol pumps in order to encourage the transition to electric mobility, the states themselves remain divided. Petaluma, a Californian city, became the first to enact such a ban, with its initial reasoning being to stop large supermarkets and retail centres from using mega petrol pumps to lure in customers.[59]

In addition to on-site generation and EV charging facilities, another weakly emerging trend is the use of surfaces occupied by large commercial buildings and attached spaces for greening and promoting local biodiversity. Green roof requirements for commercial and service sector buildings have resulted in the uptake of rooftop gardens, often sites for pollinator habitats and small-scale urban farming. American energy bar company Clif Bar, in its site in Idaho, has a two-hectare, on-site solar array, that is also a pollinator habitat populated with native flowering plants.[60] In another example, an Ikea outlet in Vienna was designed as a park to allow area residents to access the park, even without entering the store.[61] Malls in Malaysia and Singapore have seen the introduction of urban farms on their rooftops, with produce being used for food or even beauty products.[62,63]

KEY TAKEAWAYS

While non-residential buildings account for a significant share of energy consumption and emissions, there is a lot of potential for action, which is beginning to take place. Under the threat of a looming energy crisis in Europe, retailers are resorting to demand-side measures to reduce their energy consumption, by reducing lighting use or controlling artificially maintained temperatures, while also investing in more energy efficient equipment. The same applies in the United States, where the trend however is that of continuing business as usual, while resorting to energy efficiency measures and expanding renewables-sourcing and on-site generation. The most popular option for on-site renewable generation is rooftop solar, owing to the availability of larger surface areas. The functions of the large commercial surfaces also extend to low-carbon services, by providing access to EV charging stations. The footprint of these sites on land artificialisation remains significant and poorly studied: attention given to biodiversity is still marginal.

REFERENCES

RETURN TO PREVIOUS PAGE

1 GlobalABC (2022). Global Status Report for Buildings and Construction. *Global Alliance for Buildings and Construction*

2 REN21 (2022). Renewables 2022 Global Status Report. *REN21*

3 IEA (12/2021). Tracking Buildings 2021. *International Energy Agency*

4 REN21 (2022). Renewables 2022, *op. cit.*

5 Abergel, T., Delmastro, C. (13/12/2020). Is cooling the future of heating? *International Energy Agency*

6 REN21 (2022). Renewables 2022, *op. cit.*

7 IEA (2021). Heating. *International Energy Agency*

8 IEA (2022). Heating . *International Energy Agency*

9 IEA (2022). World Energy Investment 2022. *International Energy Agency*

10 IEA (2021). Cooling. *International Energy Agency*

11 IEA (2021). Heating, *op. cit.*

12 SEforAll (17/05/2022). Chilling Prospects: Tracking Sustainable Cooling for All 2022. *SEforAll*

13 REN21 (2022). Renewables 2022, *op. cit.*

14 *Ibid.*

15 GlobalABC(2021). Global Status Report for Buildings and Construction. *Global Alliance for Buildings and Construction.*

16 GlobalABC (2022). Global Status Report for Buildings and Construction, *op. cit.*

17 European Commission (15/12/2021). Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast). *eur-lex.europa.ec*

18 European Commission (18/05/2022). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: EU Solar Energy Strategy. *eur-lex.europa.ec*

19 Santos, B. (18/05/2022). EU wants rooftop PV mandate for public, commercial buildings by 2027, residential by 2029. *PV Magazine.*

20 DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

21 European Commission (14/10/2020). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. *eur-lex.europa.ec*

22 European Commission (2020). Energy Efficiency Directive, *op. cit.*

23 La rédaction (19/10/2021). La rénovation énergétique pour répondre aux enjeux climatiques, économiques et sociaux. *Vie publique*

24 BMI (n.d.). The new Buildings Energy Act. *Federal Ministry of the Interior and Community*

25 Umwelt Budesamt (24/04/2020). Indicator: Energy consumption for buildings. *Umwelt Budesamt*

26 BMWK (24/03/2022) .Maßnahmenpaket des Bundes zum Umgang mit den hohen Energiekosten: Ergebnis des Koalitionsausschusses vom 23. März 2022. *Federal Ministry for Economic Affairs and Climate Action*

27 Kurmayer, N. J. (14/06/2022). Austria to ban gas boilers in new buildings as of 2023. *Euractiv*

28 Office of Energy Efficiency and Renewable Energy (n.d.) Better Buildings. *Department of Energy*

29 Office of Policy (08/2022). The Inflation Reduction Act Drives Significant Emissions Reductions and Positions America to Reach Our Climate Goals. *Department of Energy*

30 REN21 (2022). Renewables 2022, *op. cit.*

31 European Commission (n.d.) Retail Forum. *European Commission*

32 European Commission (n.d.) REAP: All Commitments. *European Commission*

33 Perifem (n.d.). Féderons un commerce plus responsable !. *Perifem*

34 Le Monde, AFP (18/07/2022). Eclairages, température: les supermarchés s'accordent pour réduire leur consommation d'énergie. *Le Monde*

35 Challenges.fr (18/07/2022). Les supermarchés s'accordent sur un plan de «sobriété énergétique». *Challenges*

36 Naidu, R. (10/08/2022). European retailers turn off lights, cut opening hours to save energy. *Reuters*

37 Bloomberg News (26/08/2022). Goodbye Hot Showers and Street Lights. Here's How Europe Is Slashing Energy Use. *Bloomberg*

38 ENERGY STAR (n.d.) Registry of ENERGY STAR Certified Buildings and Plants. *ENERGY STAR*

39 Walmart (2017). 2017 Global Responsibility Report. *Wal-mart Stores, Inc.*

40 Walmart (06/042022). Climate Change. *Wal-mart Stores, Inc.*

41 ENERGY STAR (n.d.) J. C. Penney Company, Inc. *ENERGY STAR*

42 Mayor's Office of Environmental and Climate Justice (n.d.) Retail Energy Efficiency Guide. *City of New York*

43 Mayor's Office of Environmental and Climate Justice (2022). NYC Carbon Challenge. *City of New York*

44 IRENA (2018). Corporate Sourcing of Renewables: Market and Industry Trends. *International Renewable Energy Agency.*

45 EPA (2022). Green Power Partnership Top 30 Retail. *Environmental Protection Agency*

46 Pexapark (2022). European PPA Market: 2021/22 Outlook. *Pexapark.*

47 EPA (2022). Green Power Partnership Top 30 On-site Generation. *Environmental Protection Agency.*

48 IKEA (2021). Becoming climate positive: IKEA Climate Report 2021. *IKEA.*

49 Decathlon (n.d.). Engagés pour 2026. *Decathlon.*

50 RE-Source (2020).On-site renewable electricity and storage for corporates: business models and policy framework. *RE-Source.*

51 Yip, C. (2021). Decathlon Belgique s'implique dans la production et de la consommation d'énergie au sein de la communauté locale. *Decathlon Vision.*

52 Kuhudzai, R. J. (25/08/2022). The Shoprite Group, South Africa's Largest Retailer, Accelerates Solar Rollout At Its Sites. *Clean Technica.*

53 RE100 (24/08/2021). Onsite renewable electricity: why it's a key part of a business' climate strategy?. *RE100*

54 IEA (05/2022). Global EV Outlook 2022. *International Energy Agency*

55 REN21 (2022). Renewables 2022, *op. cit.*

56 Walmart (06/06/2019). Electrify America, Walmart Announce Completion of Over 120 Charging Stations at Walmart Stores Nationwide with Plans for Further Expansion. *Wal-mart Stores, Inc.*

57 Reuters (30/03/2022). Carrefour plans EV charging stations at French hypermarkets, supermarkets. *Reuters*

58 Noyens, K. (22/04/2022). EV charging infrastructure incentives in Europe 2022. *EVBOX*

59 Williams, A. (24/07/2022). US states divided over petrol stations as LA considers ban on new pumps. *Financial Times*

60 RE100 (2021). Onsite renewable electricity, *op. cit.*

61 McQuaid, S. (05/05/2021). Green buildings for biodiversity – who are the industry leaders? *Connecting Nature*

62 Temasek (01/12/2022). The Shopping Mall With An Edible Rooftop. *Medium*

63 Lim, J. (21/05/2022). Malls take to indoor farming. *The Star*

SIGNALS

A ROUND-UP OF THE INITIATIVES, REGULATION CHANGES, AND MARKET TRANSFORMATIONS OF TODAY THAT SIGNAL THE CLIMATE ACTION TRENDS OF TOMORROW

Artificial Intelligence • A new tool to calculate photovoltaic potential

Spacemaker is a collaborative software program to model corporate real estate projects. It takes numerous parameters — technical, contextual, geographic — into account to optimise the configuration of buildings in the interest of well-being. In 2022, it designed a new analysis parameter which can calculate the energy production potential of photovoltaic panels. This tool facilitates and therefore encourages the consideration of environmental issues, starting from the design phase of buildings, and during subsequent renovation phases. According to its calculations, covering 60% of the European Parliament roofs, with an assumed efficiency of 15%, would make it possible to power about 160 apartments measuring 50 m² each. European renewable energy production is a strategic stake in Europe.

Batirama, 06/09/2022

Cooling • Deploying solar refrigeration in Africa

A Paris-based startup, Koolboks, raised 2.5 million dollars in seed funding to deploy solar energy refrigerators in 18 African countries, where the lack of access to electricity and frequent power outages are endangering health and food safety. The product, initially designed for campers in Europe,uses solar energy for refrigeration, freezing, and even lighting for up to 4 days without electricity. The company offers a consumption-based payment model, allowing individuals and small businesses to use the product and pay between 10 and 20 dollars per month.

TechCrunch, 18/08/2022

Real Estate • The "Tiny House" movement is gaining ground in large emerging countries

Born in the early 2000s as a movement promoting smaller homes for simpler living, the Tiny House Movement, as it is called today, gained momentum during the 2008-2009 financial crisis and has not stopped growing in popularity, even spawning a reality television series, Tiny House Nation. Tiny Houses — self-sufficient micro homes usually no larger than about 37 m² (400 square feet), and independent of local energy and sanitation networks — have now become symbols of eco-responsible and socially supportive living. The median cost to build such a house is 52,000 euros in France. While the greatest number of Tiny Houses can be found in North America, Europe, Australia and New Zealand, the movement is now taking root in major emerging countries such as South Africa, India and Brazil.

Architecture • Diébédo Francis Kéré, the first African to win the "Nobel Prize" for Architecture

The $100,000 Pritzker Prize was awarded to the Burkinabé Diébédo Francis Kéré for his work combining innovation and sufficiency. Kéré combines ancestral and modern knowledge with a view to constructing buildings adapted to the local climate that are also resilient to ensure minimum material wastage. His first project in Burkina Faso, the Gando School, was based on the idea of using energy derived from the main local resource, namely sunlight, while ensuring the buildings stay cool. The school was mainly built of brick since some experts have emphasized the unsuitability of concrete blocks in the tropical climate, given that they conduct heat quickly. Natural ventilation schemes were also devised to avoid having to install air conditioning. He has also managed projects in Europe and USA.

Afrik21, 18/03/2022

Bio-sourced materials • Typha, an ecological alternative to thermal insulation

In Africa, 75% of energy consumption and GHG emissions are related to buildings. This sector uses techniques and materials, such as cement, that are poorly adapted to tropical and Sahelian climates. To remedy this, African architects such as Francis Kéré are turning to traditional techniques and materials such as Typha, an invasive plant which threatens water supplies, the biodiversity of the Senegal river delta, and economic activities. In Senegal, the TyCCAO project or *Typha Combustible Construction Afrique de l'Ouest* (West Africa Typha Combustible Construction) promotes construction techniques using Typha as key material. It can be used in thatched roofing for example, as a low-cost ecological solution. Unlike sheet metal roofing, which needs renewing every 5 years, Typha roofs have a lifespan of at least 40 years and provide suitable thermal insulation. Shredded Typha can be used as insulation due to its thermal properties, and also to make plant-based concrete: blocks, coatings, prefabricated bricks and solutions developed on the basis of laterite. This traditional procedure reduces material costs and optimises the thermal performance of buildings.

Tyccao, 2021

Housing • Participatory housing as an alternative to single-use dwellings in France

Although "participatory housing" has existed for a long time, more and more projects are being submitted in France, with an average annual growth of 18% between 2019 and 2021. There are several factors behind this movement: the Alur Act of 2014 which created the legal conditions for it; successive lockdowns that highlighted the need for sociability and collective projects, and the inadequacy of the private housing development in the face of climate challenges. In addition to the substantial energy savings made possible by the sharing of household appliances and energy consumption, the participants are above all committed to rethinking their way of "living". A prime example is the families who renovated, and now live in, a former convent in Auch. Cities can also optimise the use of space by opening public buildings when these are unused.

Cement • Indonesian citizens sue Holcim over its climate responsibility

The companies Holcim and Lafarge, which merged in 2015, have emitted 7 $GtCO_2$ since 1950, and are thus responsible for 0.42% of global historical emissions. The cement industry generates between 4 and 8% of yearly GHG emissions and the company was ranked the 47th largest emitter in the world in 2021. Four inhabitants of the small island of Pari in Indonesia, with support from the Ngo Entraide Protestante Suisse, have filed a complaint against the company. Indonesia is one of the territories that is most affected by rising sea levels. This threatens its very existence in the upcoming decades, despite the country having almost no responsibility for GHG emissions. The plaintiffs are claiming about €3,500 each — equivalent to 0.42% of the expected costs to repair the locations and adapt the island to rising sea levels — and demanding new reduction targets adapted to the shorter term. This would be a groundbreaking legal judgment, as establishing a causal link between corporate activities and the impacts of climate change.

The Guardian, 20/07/2022

Adaptation • In the Netherlands, floating houses on a rising sea

In the Netherlands, faced with a dense population and a dearth of available land, communities have resorted to floating homes — homes built on steel foundation pillars which slide up and down as the waters rise and fall. Authorities in the country are working to make zoning laws more favourable for these dwellings, while the Amsterdam municipal council is also seeking to develop floating settlements. Rotterdam is already home to the largest floating office in the world and a floating dairy farm, projects which are at the heart of its official adaptation strategy. Dutch companies are working to set up such projects in other regions, such as a series of floating islands in the Baltic Sea that can accommodate up to 50,000 people, or the development of accommodations in Malé, Maldives, with artificial coral hulls to promote marine life, and air conditioning using water pumped from the depths.

YaleEnvironment360, 07/12/2021

CASE STUDIES

COUNTRY	POPULATION	EMISSIONS IN 2019	MITIGATION TARGET	TOTAL FINAL ENERGY CONSUMPTION
AUSTRIA	1,935,000	7.5 $MTCO_2e$	NET ZERO BY 2040 (-55% BY 2030)	37,005,GWH/YEAR

Vienna • Phasing out fossil fuels in heating to decarbonise buildings

The largest city in Austria, and fifth largest in the European Union, Vienna is working to be climate-neutrality from 2040 on, making use of its low per capita energy consumption compared to other provinces in Austria, and despite a growing population. A Green New Deal for the City is being put together, looking at system integration for a global decarbonisation of Vienna and aiming at redirecting 2 to 3% of its GDP to this objective. Phasing-out natural gas in buildings and district heating is the cornerstone of the city's strategy to decarbonise the built environment. Development of geothermal energy and heat pumps will reduce the dependency on Russian gas from 80% to 0%, and local green energy production is the way to achieve security of supply.

"Green" gases are not the way for buildings' decarbonisation

The buildings sector accounts for nearly a third of Vienna's GHG emissions, 90% of which is stemming from the use of gas for heating. The total heat consumption of the city is around 18,243 GWh per year. There are currently 600,000 households using natural gas for heating and cooking, and experiencing the brunt of the soaring gas prices.

The city does not, however, consider "green" gases, such as green hydrogen, biogas and synthetic gas to replace natural gas for heating houses. Two main reasons underpin this strategy: firstly, a limited amount of green gases is expected to be available in the future; additionally, these high-value energy carriers and sources are preferable for use in sectors in which they are the only option, such as industries requiring high temperatures, or serving as feedstock, used in heavy transport, and/or balancing the energy system.

Political will and integrated planning are key to phase-out natural gas

Since 2020 the city and Urban Innovation Vienna, its energy agency, have been leading the EU-funded project Decarb City Pipes 2050. In this framework, cities of Bilbao, Dublin, Munich, Rotterdam, Vienna and Winterthur design heat strategies which include spatially-disaggregated heating and cooling plans per district and implementation roadmaps.

This process was boosted in Vienna by the new political agreement signed end of 2020 to achieve climate neutrality by 2040. The city has associated all relevant stakeholders: different city departments, the utility Wien Energie and the grid operator Wiener Netze, to address technical, legal and financial issues of the strategy.

Relying on different local green heat sources to ensure security of supply

Vienna's strategy relies on the renovation of buildings, the development and decarbonisation of the district heating and deployment of individual heat pumps. Despite the predicted population growth, the renovation rate should lead to a decrease of heat demand by 18% between 2019 and 2040, with a total phase out of gas by 2040.

Secondly, district heating is an essential backbone of Vienna's future heat supply. Currently, it already supplies more than 1/3 of Viennese households with heat (this equals roughly 430,000 apartments and 7,700 business customers). District heating will be the preferred option in densely built areas of the city – especially in the inner city – preferably with a connection rate close to 100%.

With these objectives in mind, the city launched work on the 'Heating and Cooling Vienna 2040' programme, bringing together working groups to facilitate the heating transition. Two main levers have been identified for its implementation: the first is the creation of a framework to phase out fossil heating, with the first actions being disconnecting buildings near existing district heating pipelines from the gas grid and densifying the district heating network. In less-dense areas, individual heat pumps, especially geothermal-grounded heat pumps, are the most cost-effective solution. The second is the reduction of energy consumption and the promotion of renewables, including 'thermal rehabilitation' of housing to reduce heat consumption.

COUNTRY CASE STUDY

COUNTRY	POPULATION	NATIONAL EMISSIONS IN 2021	NATIONAL MITIGATION GOAL
INDONESIA	276.4 MILLION (2021)	597.38 $MTCO_2e$	-29% CO_2 EMISSIONS IN 2030 (BAU BASELINE)

Indonesia • Betting on reflective roofs to avoid air conditioning

In March 2022, an Indonesian team won the first prize in the Million Cool Roofs Challenge – an initiative launched by the Clean Cooling Collaborative (formerly K-CEP), SEforAll, the Global Cool Cities Alliance, and the Nesta foundation – for its reflective white roofs. The Cool Roofs Indonesia project helped to install white roofs on 70 buildings in 15 Indonesian cities. The various programme initiatives concluded that the installation of reflective roofing structures made it possible to reduce the ground temperature by at least 2 to 3 °C and up to 10 °C in the case of some pilot projects in Indonesia. Access to cooling is a challenge across the domains of development, mitigation and adaptation, for both rural and urban populations.

Access to cooling: a development challenge

Ten projects in the programme received $125,000 in grants between August 2019 and August 2021 to reap results from various cooling and solar-reflective roofing approaches. The pilot projects were located in countries affected by heat stress (a condition where the body can no longer regulate its temperature, thus increasing the heart rate) and with poor access to cooling systems. On average, between 1.8 and 4.1 billion people are at risk of heat stress, particularly in India, South East Asia, and sub-Saharan Africa.

The Cool Roofs Challenge initiatives have established reflective roofs as development solutions because of the multiple co-benefits they bring. Cooling is critical for the food industry (in distribution and storage), the healthcare sector, and for quality of life in general. As such, the project also involved raising awareness about natural and "clean" cooling solutions, by creating about 100 jobs for low-skilled workers and promoting this solution in rural areas. The awareness-raising approach emphasised in particular the energy savings made possible by the reflective roofs, thereby highlighting the financial benefits for low-income households in precarious situations.

Developing countries are experiencing the highest growth in urbanisation. At the same time, cities concentrate the heat given off by buildings. Reflective roofs have demonstrated a net effect on reducing local temperatures when installed at a neighbourhood or community level.

Energy savings as an adaptation measure

In South East Asia, only 15% of homes have an air conditioning system and the majority of newly purchased air conditioners are two to three times less efficient than the best models available on the market. Among the Southeast Asian countries, Indonesia alone will account for half of the growth in the demand for air conditioners between 2020 and 2040. Of these countries, Indonesia and Cambodia had developed National Cooling Action Plans, leading up to and ending in 2022. The objective of these plans was to identify actions that make it possible to reduce emissions from the energy consumption of air conditioning systems, and to expand access to cooling.

With the help of a producer and the municipality of Tangerang, the Cool Roofs project team from the *Universitas Pendidikan Indonesia (UPI)* developed rooftops that meet the CRRC standard in Indonesia. The goal was to offer roofing materials for a fraction of the price of other existing options. The pilot involved buildings from the residential, government and private sectors, as well as schools and religious buildings. This diversity enhanced the richness of the results. About 10,250 people now benefit from these roofs.

The Indonesian project was one of the initiatives with the best reduction results of the programme: the temperature inside an industrial site dropped from 40 °C to 29.7 °C, and a school enjoyed a drop of 3 °C. Reflecting the sun during the day reduces the temperature differences of the building between day and night and between the dry and rainy seasons, which is critical for tropical climates. Coastal towns also have a greater chance of having inside temperatures exceeding 30 °C during the day. Improving thermal comfort thus helps to adapt to increasing climatic disruption.

COUNTRY	POPULATION	EMISSIONS IN 2014	MITIGATION GOAL
FRANCE	242,000 HABITANTS	1.91 $MTCO_2E$	-75% IN 2050 (1990 BASELINE)

Angers • EnergieSprong, an industrialized zero-energy renovation project, a lever for mass uptake

To contribute to carbon neutrality in 2050, French construction actors will have to transform the majority of the housing stock to achieve an average Energy Performance Certificate (EPC) level of "B". Compensating for buildings that cannot achieve this, and to raise the overall ambition, ultra-efficient renovations make it possible to reach energy consumption levels close to zero (EPC "A") wherever possible. The EnergieSprong approach, initiated in the Netherlands in 2012, assists the development of projects allowing for mass uptake of renovations that target an "E=0" performance goal: a house producing as much energy as it consumes after renovation. These projects use prefabricated solutions to make rapid renovations possible.

Collaboration of a large number of local actors

In recent years, the Pays de la Loire region has developed an ecosystem committed to developing ultra-efficient renovations. Among the various projects, the social landlord Podéliha has initiated the renovation of 32 homes in the city of Angers to showcase the possibilities offered by the EnergieSprong approach. A team of architects, engineering offices, local associations, and building and public works companies has been assembled specially for the project. Their collaboration makes for a project with a new ambition, which aims to continue integrating new businesses and local associations into the group to improve their domains of expertise, to enhance their local presence, and to promote the development of the local economy. One of the key factors in the success of this project has been the support it received from local authorities and centres of expertise (Novabuild, Atlansun et Fibois Atlantique) as well as EnergieSprong France.

High requirements to target energy excellence

Podéliha has drawn up rigorous specifications for itself, with results-based targets. It is divided into 4 areas of activity: (1) achieving "zero energy" levels in housing, guaranteed for 30 years after renovation, thanks to a high level of energy efficiency and the local production of renewable energy; (2) funding the additional costs through energy savings, avoiding future investments and selling renewable energy over 30 years thanks to the long term performance guarantee; (3) quickly completing work on occupied sites, thus limiting the nuisance for the occupants thanks to off-site prefabrication; (4) paying particular attention to comfort, aesthetics, and architectural quality.

Results that go beyond energy efficiency

The positive actions for energy and the environment have been achieved through multi-actor collaboration, consultation with residents, and allowing companies the freedom to choose the means they deploy. The prefabricated facades incorporate bio-sourced elements, in particular wood and cellulose wadding. These materials, while being easily adaptable and industrially producible, also ensure architectural diversity, and have durable and resilient properties.

By involving residents throughout the project, this renovation opens up new practices that maximise the benefits of the undertaking: implementation by an association of collective workshops, involvement of residents in decision-making, and provision of individual support to manage consumption.

EnergieSprong, a forward-looking approach in Pays de la Loire

The technical, social, and environmental achievements of this project to renovate 32 detached houses have sparked enthusiasm among all players in the region. Political leaders, local authorities, local businesses and social landlords have carefully observed this full-scale test in order to learn the lessons necessary for the rapid upscaling of renovation projects. Thus, seven social landlords united to form a regional centre for pooling purchases (MASH, *Mutualisation des Achats au Service de l'Habitat*), and joined forces to deploy the EnergieSprong approach at a larger scale. They have committed to set more than to 1,500 homes on the path to zero-energy renovation. This strong signal sent to local players, but also to other national and European regions, represents progress towards meeting the building sector's climate commitments.

“EVERYWHERE, LANDFILLS AND DUMPING DOMINATE WASTE TREATMENT. THE CIRCULARITY RATE OF THE GLOBAL ECONOMY IS STAGNATING, BUT LOCAL PROGRESS SHOWS OTHER WAYS FORWARD.”

In 2018, the World Bank estimated that the management of the more than 2 billion tonnes of waste produced worldwide in 2016 generates 1.6 $GtCO_2e$. Very little of this waste is recycled and composted: barely 19% worldwide, and up to 48% in Europe. This rate has been revised downwards to 29% for the year 2018 with the new method of calculating recycling rates adopted by the European Union, as per a report by the European Commission in 2018. Everywhere, landfills and dumping dominate waste treatment. The circularity rate of the global economy is stagnating, but local progress shows other ways forward **[INDICATORS]**.

EU regulations coming into force in 2021 aim to further reduce plastic waste exports to non-OECD countries, which have already fallen by 50% compared to 2016. The "plastic crisis" began with China's 2018 National Sword Policy banning imports of plastic waste, and the categorisation of plastic waste as hazardous under the Basel Convention, forcing exporting countries to find new outlets, as they do not have the capacity to handle it. First, by redirecting their exports to Southeast Asian countries, before they in turn ban them, then to Latin America for the United States or Eastern Europe for the EU. More informally, the illegal waste trade continues, turning to increasingly precarious outlets **[TRENDS]**.

Recycling practices, as shown in the Greenpeace USA 2022 report for plastics, have significant limitations, both because of their social and human consequences and because of the inherent difficulties involved in recycling. As a complement or replacement, local actors are therefore developing zero waste and reuse initiatives. This is the case of the city of Kamikatsu in Japan, which has achieved 80% recycling or reuse of its waste, by organising the life of the municipality around this objective **[CASE STUDIES]**. Thanks to cooperation between a multitude of actors, the city of Sao Paulo's strategy for the treatment of organic waste, which was initially directed towards landfills, has evolved towards decentralised composting yards, reducing GHG emissions by 87% compared to landfills **[CASE STUDIES]**. Ahead of the treatment of organic waste, the FeedBackEU Foundation highlighted the importance of rethinking the production that generates this waste, in a report published in September 2022, which stated that the European Union wastes more food than it imports. The same is true of the textile sector, where reuse initiatives and second-hand platforms are making headway **[TRENDS]**, to overcome the limit of the multiplication of methods of treating waste without curbing their production.

The energy crisis aggravated by the conflict in Ukraine, which began in February 2022, has also reminded us of the limited quantity of strategic resources, both for fuels and for the transition resources that will replace them (rare metals and minerals). The EuGeLi project developed by Eramet in Alsace in 2021, for example **[CASE STUDY]** is part of this movement to relocate and vertically integrate the value chains of these strategic materials while aiming to save the resources used. Businesses have a lot of room for manoeuvre to implement circularity strategies within their scope of activity, hence the increase in the introduction of extended producer responsibilities (EPR) in various sectors **[SIGNALS]**.

THE REORGANISATION OF WASTE AND RESOURCE FLOWS STRUGGLES TO TAKE A CIRCULAR PATH

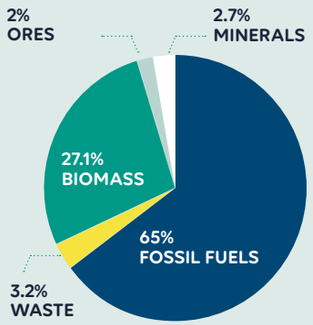
The generation of waste does not slow down, and neither do its emissions

1.6 $GtCO_2e$

GREENHOUSE GAS EMISSIONS FROM THE WASTE SECTOR

2.01 billion tonnes of solid municipal waste was generated globally in 2016, emitting 1.6 $GtCO_2e$, notably methane from the decomposition of this waste.

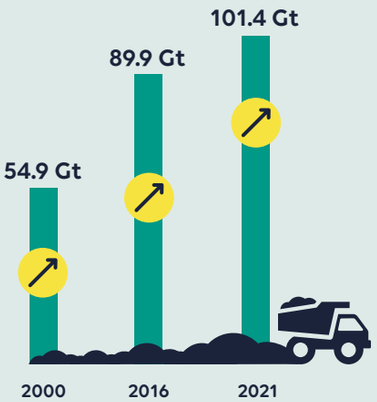
World Bank, 2018



DISTRIBUTION OF EMBODIED EMISSIONS BY RESOURCE TYPE

Embodied emissions (the emissions covering the entire life cycle of the resource) accounted for 59.1 billion tonnes of GHG emissions in 2019, of which 1.9 $GtCO_2$ stemmed from waste.

Circularity Gap Report, 2022



INCREASE IN THE EXTRACTION OF VIRGIN MATERIALS

Between 2015 and 2021, 70% more virgin materials were extracted than what the Earth can naturally replenish.

Circularity Gap Report, 2022

Europe makes tentative progress in recycling

113 Mt/YEAR

STAGNATION IN THE QUANTITY OF MUNICIPAL RESIDUAL WASTE IN EUROPE (2015-2020)

Residual waste is that which is not recycled or reused. Despite the increase in recycling rates in Europe (from 45% in 2015 to 48% in 2020), generation has also increased, preventing a decrease in residual waste.

European Environment Agency, 2022

46%

+9.5%
COMPARED TO 2018

AVERAGE RATE OF RECYCLING OF PLASTIC PACKAGING IN EUROPE IN 2020

According to the new European calculation methodology adopted in 2018 (Directive 2018/852), the rate of recycling is 32%.

Plastics Europe, 2022

EVOLUTION OF THE TREATMENT OF POST-CONSUMER PLASTIC WASTE IN EUROPE BETWEEN 2018 AND 2020

The total mass of plastic waste collected to be treated in Europe has increased from 24.5 Mt (2006) to 29 Mt (2018) and to 29.5 Mt (2020). Although stagnating from 2018 to 2020, plastics processing through energy recovery has increased by 4.2% between 2006 and 2020.

Plastics Europe, 2022

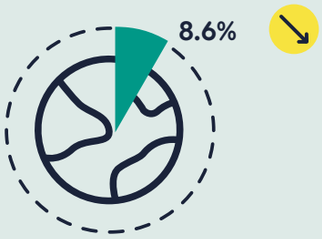
From 7.2% in 2018 to 8.5% in 2020

RATE OF INCORPORATION OF RECYCLED PLASTIC IN NEW PRODUCTS IN EUROPE

The sectors and industries where the share of recycled plastics incorporated into new products has increased the most are packaging (+43%), buildings and construction (+15%) and agriculture (+3%).

Plastics Europe, 2022

Circularity is eclipsed by the linear economy



GLOBAL "CIRCULARITY" INDICATOR

Of the 100 billion tonnes of material entering the economy in 2020, 8.6 were from circular processes. Two years earlier, this figure stood at 9.1%.

Circle Economy, 2021

INTERNATIONAL WASTE TRADE IN 2019

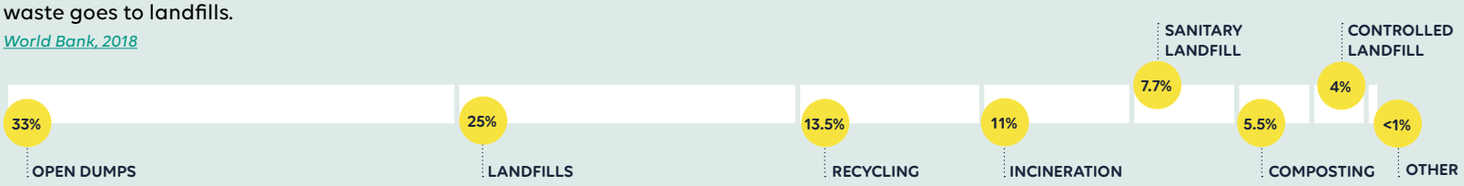
The international trade of waste generated 315 billion dollars.

UNCTAD, 2021

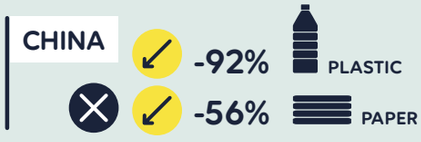
WASTE MANAGEMENT PRACTICES AT THE GLOBAL LEVEL

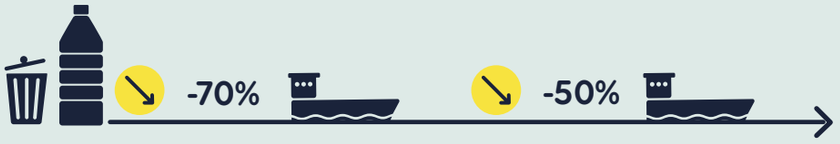
More than half of the world's waste is landfilled or sent to open dumps. Only 13.5% is recycled. In South Asia, up to 75% of waste goes to open dumps, while in Latin America, around of 68% waste goes to landfills.

World Bank, 2018



The recycling processes of the Western world are shifting as Asian countries curb their imports of plastic waste...





CHINA CLOSES ITS BORDERS TO WASTE IMPORTS (2017-2019)

The decrease in waste imports was accompanied by an increase in the unit value of waste (+27% for plastic waste, +13% for paper).

Sustainability, 2021

DECLINE IN U.S. PLASTIC WASTE EXPORTS SINCE 2017

The US initially turned to countries such as Malaysia and Vietnam following the bans by China, but these countries have also restricted imports since 2019. In 2020-21, exports increased to Canada, Mexico, India, Indonesia and El Salvador.

World Economic Forum, 2022

THE EU-27 AND THE UK COMPELLED TO REDUCE THEIR PLASTIC WASTE EXPORTS

In addition to bans in Asia, the rules of the European Commissions that came into force in January 2021 restricted plastic waste exports to non-OECD countries.

Plastics Europe, 2022

... followed by the reorganisation of the illegal trafficking of waste

$1.5-1.8 bn

REVENUE FROM THE ILLEGAL TRAFFICKING OF HAZARDOUS WASTE IN EUROPE IN 2020

Illegal trafficking networks are turning to Africa for exports of plastics and household and municipal waste, following restrictions in Asia.

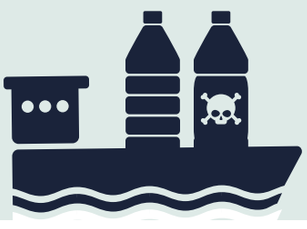
Europol, 2022

$10-12 bn

REVENUE FROM THE ILLEGAL TRAFFICKING OF WASTE AROUND THE WORLD

In terms of waste trafficking, countries highlight the particularly organised nature of trafficking in hazardous waste.

FATF, 2021



TREND
INTERNATIONAL TRADE

From illegal flows to local recycling, waste treatment is being reorganized

OPHÉLIE CUVILLARD • Research Assistant, Global Observatory of Climate Action, Climate Chance
ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance

The bans on plastic waste imports to Asia, that started with China in 2018, have had the effect of shifting geopolitical lines, but their impact has not spurred more effective waste treatment in exporting countries. Considered as a resource in developing countries but viewed as waste in developed countries, plastic waste is a source of trade from which the gains are asymmetrical. Yet the urgent need to treat this type of waste has raised a new awareness, which can be observed in major transnational agreements and in local initiatives.

DATA OVERVIEW

Bans in Asia divert waste flows towards new destinations

Plastic fibres have multiple uses, in packaging, the transport and building sectors, in textiles, industrial machines, and electronic and electric products.[1] Over the period from 1950-2015, only 9% of plastic was recycled annually in the world,[2] while 79% was accumulated in landfills or dumped in nature, ending up in the oceans, and the remaining 12% was incinerated. A 2018 study by the OECD re-evaluated the rate of global recycling as between 14% and 18%, the incineration rate as 24%, and landfill or dumping at between 58% and 62%.[3]

72% of the global waste produced from 1992 to 2016 was exported to Hong Kong and China, most of it through illegal channels.[4] Parts of Asia began to introduce restrictive policies at the start of the 2000s, culminating in the National Sword Policy (NSP) that came into force in China on 1 January, 2018. This policy prohibits the import of 24 types of recyclable solid waste:[5] non-industrial plastic, mixed papers, textiles, and vanadium slag, a rare metal used in steel metallurgy. As a result, imports of plastic waste shrank by 99%, and by more than a third for paper from 2017 to 2018.[6] The main consequence of these prohibitions in Asia was the transfer of the plastic waste to different importers, given that the exporting countries did not have the means and industrial capacities in place to take over from China.

From 2016 to 2018, Southeast Asia saw a 171% surge in imports of plastic waste, according to a study by the NGO Greenpeace Southeast Asia,[7] from 836,529 to 2,231,127 tonnes. In other words, in 2018, the region represented 27% of global plastic waste imports, compared to only 11% in 2017 and 5.38% in 2016[8]. In fact, the impossibility of exporting to China that faced Western countries (mainly Europe and the United States) led them to turn towards Southeast Asian countries, such as Malaysia, the Philippines, Vietnam, and Thailand, until these countries also put restrictions in place. Since these nations have not ratified the Basel Convention (**SEE BOX 1**), controlling the entry of hazardous waste is more difficult. Accepting to treat with the plastic waste of countries in the North was seen as an opportunity for non-OECD countries that could then sell it after processing. Nevertheless, due to the limited

recycling equipment and infrastructure, toxic and contaminated waste[a] often ends up being thrown away or burned.

BOX 1 • **KEYS TO UNDERSTANDING**

THE BASEL CONVENTION

In terms of international jurisdiction, the Basel Convention, in force since 1992, governs transboundary movements of waste in reaction to abuses observed in the 1980s, in order to prevent developed countries from dumping the management of their hazardous waste onto developing countries. Negotiations for the first amendment were at a standstill until 2011 before finally entering into force in December 2019. The convention defines the list of hazardous wastes, updated in May 2019 with the Plastics Amendment. This amendment categorizes plastics as hazardous, meaning that importing countries can require information on waste entering their territory, and refuse it. The amendment prohibits exports and imports of hazardous waste to and from States that are not party to the convention[b] and, when appropriate, requires the agreement of the importing country. Since 1 January, 2021, the procedure for prior agreement established for hazardous plastic waste (Annex VIII) has been extended to household plastics requiring special consideration (Annex II). Hong Kong has transposed the amendment into its national legislation, and so has the European Commission in a new regulation stipulating that only non-hazardous plastic waste that is easy to recycle can be exported to countries outside the OECD. The new rule has been transposed and standardized in the OECD control system for waste recovery; as a result, even the United States, which is not party to the Basel Convention, is now subject to this rule. Lastly, the convention establishes cases for reimporting hazardous waste, in particular when illegal trafficking is concerned.

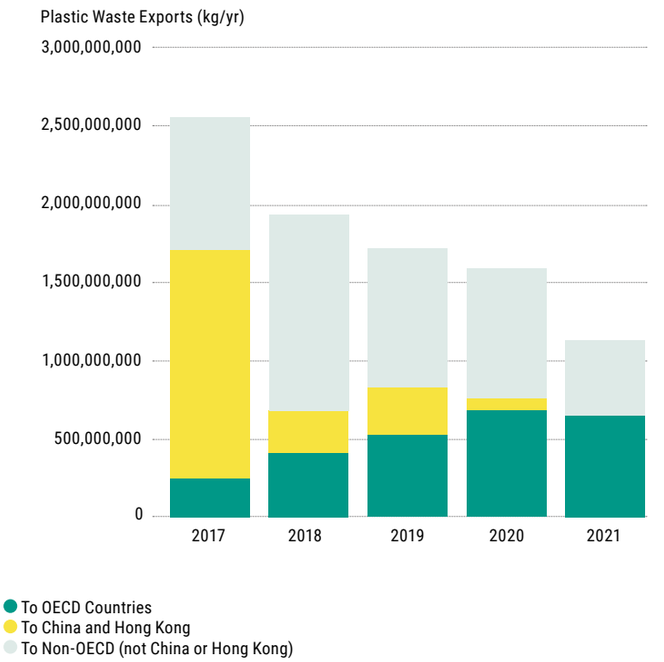
Exports of plastic waste from European countries dropped from 1,583 million kilogrammes (Mkg) in 2020 to 1,135 Mkg in 2021 (2,500 Mkg in 2017) and exports directed to non-OECD countries decreased by 45% from 2020 (887 Mkg) to 2021 (486 Mkg).[9] The bans by Asian countries therefore triggered a drop in exports to countries outside the OECD and a drop in exports in general (**FIG. 1**).[c] Apart from cargoes sent to Vietnam, which have increased, exports of waste from the EU to Southeast Asian countries went down in 2021, as did exports to Turkey, which had become the main destination for plastic waste exported by EU countries.[10]

In general, total exports of plastic waste diminished annually from 2017 to 2021 from the major exporting countries (from 6.75 Mt to 3.75 Mt).[11] The main waste exporters towards non-OECD countries in 2021 were Japan, the United States, the Netherlands, Germany, Australia, Belgium and the United Kingdom, while the biggest importers were Turkey, Malaysia, Vietnam, Indonesia, India, and Thailand.[12] India transformed the "prohibition" on imports of plastic waste decided in 2019 into "restrictions" in 2022. As a consequence of the closure of Asian borders, exports from the United States to Latin America (Ecuador, Mexico, Salvador, Guatemala and Honduras) almost doubled from 2019 to 2021. Exports of plastic waste from Europe and North America to Africa also rose, following the same trade flows in place for waste from electrical and electronic equipment (WEEE).

FIGURE 1

PLASTICS WASTE EXPORTS DESTINATIONS OF EUROPEAN COUNTRIES FROM 2017 TO 2021

Source: UN Comtrade, 2022



Despite the drastic drop in imports of plastic waste by China, the demand for recycled plastic particles has increased as major global chains step up their commitments to reduce the use of primary plastics. Stricter international trade rules, Asian import bans, and the lucrative market it represents (predicted to reach $50.36 billion in 2022)[13] have served to boost illegal activities. In parallel, recycling and circular economy activities have inevitably developed in waste-producing countries.

a Contamination designates the mixing of recyclable and non-recyclable waste. Due to relatively ineffective standards regarding the quality of the waste accepted, recyclable and non-recyclable waste often end up being mixed.

b There are 190 parties to the Basel Convention, which was signed by an initial 51 countries, not including the United States.

c "Plastic waste" refers to the UNcomtrade database classification HS3915 (named "Waste, parings and scrap, of plastics"). From 2017 to 2019, the EU includes the UK.

THE OBSERVATORY'S LENS

Faced with deficient recycling systems and illegal transfers, circularity hinges on reusing plastic waste

Recognized as hazardous waste, plastics fuel illegal trafficking

Illegal waste transactions involve different activities: waste transportation on the black market, contamination, false declarations about hazardous waste, or declarations stating reusable products rather than waste. In the latter case, the products are then not subject to international regulations on waste trade and thus can be exchanged with developing countries.[14] While these countries depend on reusable products like certain types of electronic waste and cars, most of these imported products no longer function and can hide other types of waste. According to the World Customs Organization (WCO), this type of action complicates the distinction between illegal and legal waste, creating a vast grey area in which international rules are difficult to apply.[15]

As waste accumulates, illegal transactions increase in an underground economy of trade in recycled plastic. A study has evaluated the extent of this economy by observing differences in announcements by two parties involved in the same exchange. On average, waste exporters declare a value 18.47% higher than importers do (the opposite of what is observed in other types of economic exchange).[16] According to the WCO, illegal flows are particularly high for waste trade. The WCO launched the Demeter IV operation to combat illegal flows of waste in 2018: in the 199 seizures carried out, the most common type of waste comprised plastics and electronics.[17] Illegal waste flows are transported from Western Europe, in particular the Adriatic Sea, to Turkey and Bulgaria.[18] In December 2021, the boat *Cosco Pride,* transporting 37 containers of plastic waste travelling from Germany to Turkey before being exported again to Vietnam,[19] was stopped en route to Asia, brought back by the Greek authorities following a warning from the Basel Action Network.[d] In fact, flows rarely move straight from A to B, in particular when importing countries receive illegal deliveries and then move them on to other neighbouring countries **(FIG. 2)**.

In a report published in August 2020, Interpol analysed the emerging criminal trends on the global plastic waste market since the implementation of the Chinese policy in January 2018. Drawing from data and information from 40 countries, Interpol identified a multiplication of unlawful practices: transfers of illegal waste cargoes to other destinations, unauthorized dumping, illegal incinerations, and administrative frauds have all proliferated in the absence of domestic recycling capacities in countries hitherto dependent on China.[20] In 2020, port and air freight control units intercepted 630 tonnes of waste.[21] Thirteen of the 24 countries affected by illegal exports were located in Asia. Interpol's analysis observes that illegal waste routes follow legal ones and therefore also follow their changing destinations resulting from more restrictive laws. Nevertheless, following the complaints and prohibitions established in some Southeast Asian countries, these illegal transfers tend to shift towards non-importing countries, thus rerouting toxic waste to the most vulnerable countries equipped with fewer waste treatment facilities. While this trend has already been observed in Southeast Asian countries, it will be some years before statistics are available on Africa and Latin America, which, according to Interpol, is where transfers seem to be directed. In particular, the routes used to transfer WEEE to Africa may be employed to transfer plastic waste.

WEEE headed for Africa is partly exported under false names.[22] The new report by the French council on sustainable development (CGEDD), concludes that France only knows the fate of 20% of its exported waste,[23] due to gaps in existing data. In particular, it points out that a large part of WEEE is exported under the label "second-hand products" rather than "waste", or that the same code covers products and waste, making precise data analysis impossible. Until October 2021,[24] electronic and electrical waste did not feature in the European Union's Combined Nomenclature. According to a two-year investigation (2015-2016) by the UN published in 2018, 77% of WEEE imports cams in the EU, with Germany and the United Kingdom each representing 20%.[25] Imports were mostly directed towards West Africa. The investigation concluded that the Basel Convention was largely deficient concerning controls on the nature of waste, leading to hazardous and therefore illegal waste being sent without transparency and prior agreement. Out of the 30,000 tonnes of WEEE that arrived in Nigeria in 2018, at least 25% did not function and could not be repaired, and about 70% had arrived concealed in second-hand cars.[26] In a podcast by French-language radio RFI,[27] following a report in Cotonou, Benin, journalist Samuel Turpin observes that countries can refuse waste at the point of reception according to the Convention, but that controls require resources and political volition that are mostly lacking. In May 2021, the city of Dakar (Senegal) refused to receive 25 containers of plastic waste weighing 581 tonnes from the German transporter Hapag-Lloyd, which then had to reexport the cargo to Spain and pay a fine of 2 billion CFA francs (€3 M).[28] Senegal has in fact prohibited imports of a number of single-use plastic waste products since April 2020.[29]

Tougher international legislation on waste flows

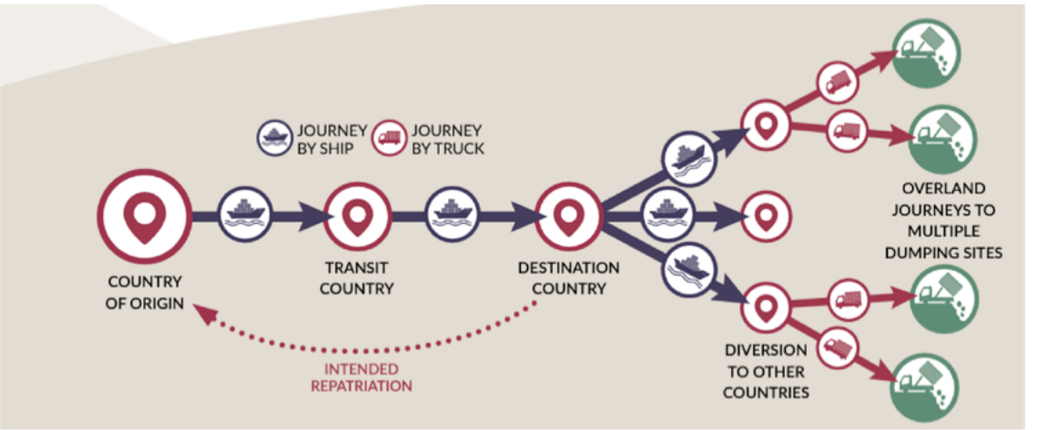
Plastic pollution restrictions target informal networks. In June 2022,[30] the Indian Ministry of Environment, Forest and Climate Change announced a ban on the production, import, stocking, distribution, and sale of single-use plastic products with a low utility and high littering potential. Anyone not respecting this new measure faces up to five years in prison

d The Basel Action Network is an NGO created following the Basel Convention to ensure its implementation and sanction its non-respect. It deals with three types of toxic waste covered by the convention: WEEE, old ships, and plastic pollution.

FIGURE 2

TRANSNATIONAL FLOWS OF PLASTIC WASTE

Source: Global Initiative against transnational organized crime, 2021



and a fine of 100,000 rupees (€1,220). On 31 December 2022, the measure is due to extend to more products.[31] In New Delhi, about 150,000 ragpickers[32] and informal waste gatherers (about 5 M in India) depend on the trash mountains present in the city. They are not officially recognized as workers but about one-fifth of municipal waste is recycled thanks to their efforts, involving exposure to potentially dangerous chemical products and methane present in the waste. These informal ragpickers are the first victims of the danger of plastic products and dependency. The announcement by the Indian government marks a positive move to reduce plastic waste, but threatens the livelihoods of the waste pickers. After three months, studies point out disproportionate consequences for the most vulnerable compared to negligeable impacts on multinationals.[33]

Other Indian local and state governments had previously attempted to ban plastic bags but failed due to numerous obstacles. The state of Maharashtra tried to reinforce and extend its policy restricting plastic bags in 2018,[34] leading to the closure of 300 plastic bag manufacturers during the first few weeks and confusion among inhabitants regarding their usage. Faced with the general confusion and pressure from major groups, the government ended up relaxing the measure. The government went on to develop other complementary measures, for example demanding a payment of 0.25 rupees by large industries for each "tetrapak"[e] to feed into a waste collection and recycling fund.[35]

Turkey, which became the leading destination for European exports following the Chinese bans, imported 50% of the EU's plastic waste in 2020-2021. Nevertheless, a report[36] by Human Rights Watch (HRW) published in September 2022, points out the negative local consequences of recycling plastic in Turkey. The lack of standards and controls has significant impacts on health and the environment. Due to the toxins released, the plastic waste recycling process endangers health (and drastically reduces life expectancy) if workers are not correctly equipped. Employees questioned[f] in the HRW study are on particularly low incomes and cannot risk losing their jobs. In a report on the illegal trade of plastic waste, Global Initiative[g] observes that on average two suspicious incinerations take place every week in Turkish recycling plants.[37]

On 17 November, 2021,[38] the European Commission adopted new rules on the subject of waste transfers outside the European Union. The objective of the proposed European measures is to only authorize exports if the importing countries "*are able to manage them sustainably*" and to oblige EU companies to subject the facilities that manage their waste abroad to environmental audits.[39] NGOs have nevertheless called for a stricter ban on waste exports, underlining the derogations granted and the insufficient distinction made between recycling and other less ambitious forms of treatment, such as incineration.[40] According to the NGOs, the revision of the text could temporarily make it possible to transfer waste to OECD countries, but would not make waste exports more difficult. In September 2021, a report[41] by the Environmental Investigation Agency[h] called on the European Union to amend the Waste Shipment Regulation due to the environmental and social consequences of these flows.

e The term tetrapak refers to food packaging. Tetra Pak is a Franco-Swedish company that is the leading global designer of food packaging and processing solutions.

f The HRW study is based on the testimonials of 64 people.

g Global Initiative is an independent NGO comprising members working for the respect of international laws. It acts to combat international crime networks.

h The Environmental Investigation Agency is a British association whose objective is to investigate environmental crimes and then use these investigations to campaign against environmental crime and abuse.

Initiatives at the local, regional and national level nevertheless shine some light on the future of waste treatment

175 countries agreed to negotiate a legally binding UN treaty on plastic[42] in March 2022. The treaty could represent a major step forward in action against plastic pollution and has even been championed as a way to impede the plan B of oil companies waging on petrochemical production to ensure their future **(SEE SIGNALS)**. On an international level, at the One Ocean Summit in February 2022,[43] CMA-CMG drew attention to the strong influence of transporters and stakeholders in the sector when it announced that it would stop transporting plastic waste on its boats from 1 June, 2022. While companies like Hapag-Lloyd, Maersk, Hamburg Sud and MSC had already stopped shipping plastic waste in Chinese waters – plus Hong Kong for the latter three – CMA-CGM has extended its ban to cover the entire globe.[44]

In the European Green Deal, in order to reach climate neutrality by 2050 the European Union has established a circular economy action plan[45] aiming to reduce waste production. In the EU strategy for plastics adopted in 2018, the measures concerning plastic waste and its production have led to a recycling rate of 41.5%[46] (as against less than 10% in the United States,[47] and 14% to 18% in the world).[48] Although primary plastic production has dropped in Europe since 2017 (from 64 Mt to 55 Mt in 2019), the average consumption of plastic products continues to rise.

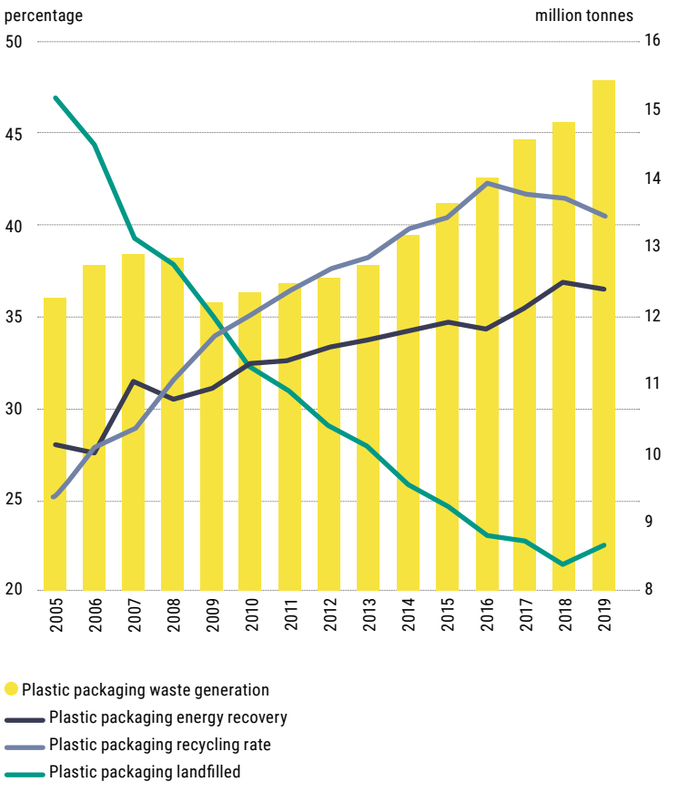
From 2009 to 2019, the quantity of plastic packaging waste increased, as did the quantity of recycling but not its relative value (**FIG. 3**). Processing of plastic packaging through incineration with energy recovery has increased from 34.4% in2016 to 36.5% in 2019.[49] Using waste to produce energy emerged as a solution to foster local energy independence during the 2022 energy crisis. For example, the Fnade, the federation of companies in the waste sector in France, has proposed to double the production of heat generated from waste;[50] however, the combustion of waste required for this energy conversion emits greenhouse gases. The revision of the EU's Waste Framework Directive is planned during the first half of 2023[51] and the planned revision of the Packaging and Packaging Waste Directive aims to better cover waste prevention and not just recycling.[52] Ten plastic products have been withdrawn from the European market since 3 July, 2021 following an EU directive in 2019, but some NGOs underline the relatively low impact of the measure since it only concerns 1% of Europe's plastic production.[53]

The circular economy is defined as an alternative to the linear "produce-consume-throw away" model of economic organisation. One of the levers it employs to manage and reuse waste is extended producer responsibility (EPR).[54] This policy shifts the responsibility for plastic waste onto producers in order to reconnect the different life cycle phases of a product. These programmes are devised to ensure that producers participate in the collection, sorting, pre-treatment, rehabilitation (recycling or energy recovery) or incineration of waste. In a report,[55] the German development bank GIZ looked at the results of five programmes of this type set up in coastal areas: in Australia, Canada (British Colombia), the European Union, South Korea, and Tunisia. The GIZ study concludes that EPR programmes are effective in avoiding marine pollution, provided that they are carefully designed, properly implemented, and constantly monitored and developed. In the United States, programmes are starting to be set up, since the first one in Maine that came into force in 2021 **(SEE SIGNALS)**. In France, a building EPR will come into force on 1 January, 2023[56] **(SEE SIGNALS)**.

FIGURE 3

EVOLUTION OF PLASTIC PACKAGING WASTE GENERATION (MT) AND TREATMENT IN THE EU-27

Source: Eurostat data in IFRI, 2022



In 2021, the EU definitively adopted a tax on non-recycled plastic waste (making it a new source of revenue for the EU). Every kilo of non-recycled plastic packaging waste costs the country involved 80 cents of a euro, or €800 per metric tonne. States can pay the tax directly via their national budget or finance it through taxes on the private sector. For the moment, France, Germany, Ireland, Luxembourg and Slovakia have opted for the first alterative, although in the long term they intend to shift the cost to companies to encourage recycling.[57] In 2021, France paid the EU €1.2 billion.[58] Spain and Italy have chosen to set up a new tax (€0.45 per kilo) on single-use plastic packaging collected and not recycled, due to enter into force on 1 January, 2023.[59] The tax established by the United Kingdom on 1 April, 2022 is different and applies to plastic packaging that contains less than 30% recycled plastic and to imported plastic packaging.[60] Belgium intends to integrate the cost of the tax into the extended producer responsibility mechanism.

In the United States, according to a report[61] by the American branch of Greenpeace, the recycling rate of polyethylene terephthalate (PET) bottles and pots is only 21%, and 10% for high-density polyethylene (HDPE).[62] However, only bottles and pots made from PET and HDPE and bearing the numbers 1 and 2 respect the government's recyclable characteristics in the United States. Most recycling plants refuse plastics numbered 3 to 7, which are harder to process or contain too many toxic substances. The report therefore observes the limits of recycling plastic products and underlines the low rate of recycling of products that can be recycled. The difficulty of recycling plastic waste due to the toxic substances it contains and the high probability of being mixed with toxic waste makes recycling more expensive than purchasing new plastics. The NGO therefore calls on companies to reduce their plastic packaging by 50% in 2030 rather than double their recycling rate. Yet action to combat plastic production comes up against significant obstacles in the United States: in July 2022 the General Services Administration submitted a bill to ban single-use plastics,[63] which triggered massive campaigns against the proposal driven by the plastics industry giants.[64]

In the Balkans,[65] planned policies mostly focus on setting up infrastructures to use waste combustion to produce energy:[i] an incineration plant is due to start operating for this purpose in late 2022 in Serbia. In this region, the little that is recycled is thanks to informal ragpickers who sell the waste on to recycling companies on site or for export. More than recycling, political concerns focus on stopping illegal dumping. Investments in other types of treatment plants have nevertheless begun in several countries. In Kosovo, a pilot project to treat organic waste was launched in the city of Pristina in 2020[66] as part of a municipal action plan[67] to direct investments towards recycling and composting plants.

In Asia, programmes are in place for managing and recycling waste, in particular marine plastic pollution in the sea. Plastic waste makes up almost 80% of the debris present in the oceans, and Southeast Asia is responsible for almost 70% of it. Countries in the region, which are the first victims of this pollution, have set up regional plans to avoid and treat the problem. Two years after the 2019 Bangkok Declaration on Combating Marine Debris, a regional action plan was launched featuring fourteen priority policies to be implemented by ASEAN member states, financed by a $20 M loan from the World Bank.[68] Moreover, since last year, the Indian Ocean Commission has implemented a programme called EXPLOI (Indian Ocean Plastic Expedition). With a budget of €6.5 M, the programme has an objective to analyse this pollution over five years and produce recommendations.[69]

In developing countries, citizens and local entrepreneurs are developing their own initiatives to reuse or recycle plastic waste, such as for infrastructures and buildings. In Nairobi, a female entrepreneur launched an company to transform plastic waste into bricks to replace concrete in building projects: "*The bricks, which are made from a combination of plastic and sand, have a melting point of over 350 °C and are more durable than their concrete alternative.*"[70] The company Gjenge Makers has therefore recycled over 20 tonnes of discarded plastics, producing from 1,000 to 1,500 bricks a day, and created 150 local jobs. Several projects to build roads from plastic waste have seen the day in India, where 60,000 miles of "plastic roads" have been built since 2018. For example, a 703 km-long highway[71] was constructed in New Delhi using this type of waste in 2021. Other countries in Africa and the West have followed this trend since 2018.[72]

KEY TAKEAWAYS

The bans on imports of plastic waste established by China in 2018, followed by some of its neighbours, have underlined the insufficient local capacities for recycling in industrialized countries that export their waste. The urgent relocation of recycling for millions of tonnes of plastic has also illustrated the precarious conditions of their recycling practices. In parallel with this process, and as part of the Basel Convention, the labelling and control of waste represents a key issue to avoid the bypassing of international rules and bilateral agreements. In fact, illegal trafficking of waste is managed by highly organized environmental crime networks and, while exports of plastic waste to Southeast Asia have officially decreased, illegal transfers have sometimes replaced formerly legal trade, leading to non-official, more dangerous recycling practices. Europe has made some progress in recycling polymers but has come up against the limits of this type of treatment to truly reduce the sector's emissions and make the move to a circular economy, which primarily involves preventing the production of plastics and the reuse and recovery of these resources.

i According to the ranking of waste treatment methods by the NGO Zero Waste, energy recovery only comes fourth out of the five solutions proposed: the environment code rates waste prevention as the priority to avoid production, followed by re-use, which considers waste as a resource. The last three solutions should only be employed when the first two are impossible: recycling, energy recovery, and elimination.

REFERENCES

RETURN TO PREVIOUS PAGE

1 OECD (2018). Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade. *Organisation for Economic Co-operation and Development.*

2 Geyer, R. et al. (19/07/2017). Production, use, and fate of all plastics ever made. *Science Advances*

3 OECD (2018). Improving Plastics Management..., *op. cit.*

4 Brooks A., Wang Shunli et Jeena R. Jambeck. (2018). The Chinese import ban and its impact on global plastic waste trade. *Sciences Advances*, Vol. 4, NO. 6

5 Staub, C. (19/07/2017). China says it will ban certain recovered material imports. *Resource Recycling*

6 Staub, C. (29/01/2019). China: Plastic imports down 99 percent, paper down a third. *Resource Recycling*

7 Greenpeace (June 2019). Southeast Asia's struggle against the plastic waste trade. *Greenpeace Southeast Asia*

8 *Ibid.*

9 BAN (2021). European Union Export Data. 2021 Annual Summary. *Basel Action Network*

10 *Ibid.*

11 BAN (2021). Global Export Data. 2021 Annual Summary. *Basel Action Network*

12 *Ibid.*

13 Interpol (2020). Interpol strategic analysis report: Emerging criminal trends in the global plastic waste market since January 2018. Interpol

14 WCO Secretariat (n.d.) Illegal waste trafficking: more data is key to getting a better grip on this trade. *World Customs Organization*

15 *Ibid.*

16 Pacini, H, et al. (July 2021). Network analysis of international trade in plastic scrap. *Sustainable Production and Consumption,* Vol. 27, pp. 203-216

17 WCO (28/11/2018). Illegal trade in waste: overview of Operation Demeter IV. *World Customs Organization*

18 Scaturro, R. & Kemp, W. (26/07/2022). Portholes. Exploring the maritime Balkan routes. *Global Initiative against transnational organized crime*

19 BAN (02/12/2021). Environmental groups move quickly and block the export of German plastic waste to Vietnam. *Basel Action Network*

20 Interpol (2020). Interpol strategic analysis report(...), *op. cit.*

21 WCO (12/07/2021). L'OMD et l'ONUDC lancent un nouveau projet pour renforcer la capacité de détection des transferts illégaux de plastique et de déchets dangereux. *World Customs Organization*

22 Collet, P. (29/03/2022). Déchets : la France connaît bien mal ses exportations. *ActuEnvironnement*

23 Baccaïni, B. et al. (2022). Le devenir des déchets exportés à l'étranger par la France. *Conseil Général de l'Environnement et du Développement Durable*

24 European Commission (12/10/2021). Modification de l'annexe I du règlement (CEE) n°2658/87 du Conseil relatif à la nomenclature tarifaire et statistique et au tarif douanier commun. *Official Journal of the European Union.*

25 Roussel, F. (16/04/2018). Les déchets électroniques se cachent pour voyager. *ActuEnvironnement*

26 United Nations University (2018). Thousands of Tonnes of E-Waste is Shipped Illegally to Nigeria Inside Used Vehicles. *United Nations University*

27 RFI (2022). Les déchets d'équipements électriques et électroniques : une plaie pour l'Afrique. *RFI*

28 RFI (25/05/2021). Sénégal: le bateau de Hapag-Lloyd chargé de déchets plastiques part en catimini. *RFI*

29 AFP (20/04/2020). Senegal bans most single-use plastics. *Phys.Org*

30 Ministry of Environment, Forest and Climate Change of India (June 2022). Ban on identified Single Use Plastic Items from 1st July 2022. *Ministry of Environment, Forest and Climate Change of India*

31 Packaging Europe (30/06/2022). India to introduce ban on some single-use plastics from July 2022. *Packaging Europe*

32 Ara, I. (30/06/2022). This Is What a Radical Plastic Ban Looks Like. *Time*

33 Deshpande, T. (02/10/2022). Three Months On, India's Single-Use Plastic Ban A Dud. *IndiaSpend*

34 Chandrashekhar, V. (28/08/2018). In India's Largest City, A Ban on Plastics Faces Big Obstacles. *Yale Environment 360*

35 *Ibid.*

36 HRW (21/09/2022).Turquie: Le recyclage du plastique nuit à la santé et à l'environnement. *Human Rights Watch*

37 Global Initiative (November 2021). Plastic for profit. *Global Initiative against transnational organized crime*

38 Loonela, V. & Stoycheva, D. (21/10/2022). European Green Deal: Commission adopts new proposals to stop deforestation, innovate sustainable waste management and make soils healthy for people, nature and climate. *European Commission*

39 Euractiv (18/11/2021). L'UE veut durcir les règles sur ses exportations de déchets. *Euractiv*

40 Arbinolo, R. (17/11/2021). EU Waste Shipment Regulation falls short of fixing Europe's waste export crisis. *European Environmental Bureau*

41 EIA (September 2021). The truth behind trash. *Environmental Investigation Agency*

42 Evans, J., Hodgson, C. (02/03/2022). World leaders agree to draw up 'historic' treaty on plastic pollution. *Financial Times*

43 CMA CGM (14/02/2022). One Ocean Summit: le Groupe CMA CGM prend la décision de ne plus transporter de déchets plastiques sur ses navires. CMA CGM

44 Shiphub (n.d). Transporting plastic waste. *Shiphub*

45 European Commission (2020). Circular Economy Action Plan. *European Commission*

46 Eurostat (13/01/2021). More than 40% of EU plastic packaging waste recycled. *Eurostat*

47 US EPA (08/03/2022). Containers and Packaging: Product-Specific Data. *US Environmental Protection Agency*

48 OECD (2018). Improving Plastics Management. *op. cit.*

49 IFRI (04/07/2022). Five Years after China's Plastic Import Ban: Have Europeans Taken Responsibility? *IFRI*

50 Combe, M. (19/10/2022). La Fnade propose de doubler la production de chaleur issue des déchets. *Techniques de l'Ingénieur*

51 Collet, P. (01/02/2022). Directive-cadre Déchets : la Commission ouvre un appel à contributions. *ActuEnvironnement*

52 Dumas, A. (20/09/2021). L'UE souhaite réduire les emballages grâce à une nouvelle législation. *Euractiv*

53 Hockens, P. (08/06/2021). Europe's Drive to Slash Plastic Waste Moves Into High Gear. *Yale Environment 360*

54 Ellen Macarthur Foundation (2021). Extended Producer Responsibility – a necessary part of the solution to packaging waste and pollution. *Ellen Macarthur Foundation*

55 GIZ (2022). Assessing the role and impact of EPR in the prevention of marine plastic packaging litter. *Deutsche Gesellschaft für Internationale Zusammenarbeit*

56 Batirama (18/10/2022). L'entrée en vigueur de la REP bâtiment approche à grand pas. *Batirama*

57 Anthesis (17/03/2022). How is the Plastic Packaging Levy Expected to Improve Recycling and Reduce Waste? *Anthesis*

58 Jacque, M. (21/03/2022). La France a payé 1,2 milliard d'euros de « taxe plastique » à Bruxelles en 2021. *LesEchos*

59 EY (13/04/2022). Spain introduces new indirect tax on non-reusable plastic packaging as of 1 January 2023. *EY Building a better working world*

60 EY (2021). Plastics and packaging taxes in Europe. *EY Building a better working world*

61 Winters, J. (24/10/2022). 380 million tons of plastic are made every year. None of it is truly recyclable. *Grist*

62 Greenpeace USA (24/10/2024). Circular Claims Fall Flat Again. *Greenpeace USA*

63 GSA (07/07/2022). Proposed Rule. General Services Administration Acquisition Regulation (GSAR); Single-Use Plastics and Packaging. *Federal Register. The Daily Journal of the USA*

64 Winters, J. (20/10/2022). The selective accounting behind the plastic industry's climate-friendly claims. *Grist*

65 EEA (27/06/2022). Municipal waste management in the Western Balkan countries. *European Environment Agency*

66 Fondation Jeshil (19/12/2019). Pristina will have a composting scheme. *Fondation Jeshil*

67 Mott MacDonald Ltd (2021). City of Pristina Green City Action Plan. *Prishtina City*

68 Van Trotsenburg, A. & Jock Hoi, L. (22/07/2022). Turning the tide on plastic pollution through regional collaboration in Southeast Asia. *East Asia & Pacific on the Rise*

69 Minas, B. (19/10/2022). Environnement : L'Océan Indien est pollué par les déchets plastiques. *FranceInfo*

70 Renault, C. (17/10/2022). Une entrepreneuse de Nairobi recycle les déchets plastiques en briques plus durables que le béton. *Ouest France & Sain et Naturel*

71 Times of India (30/07/2021). India constructed 703 km of highways using plastic waste. *Times of India*

72 Parson, A. (11/02/2021). How Paving With Plastic Could Make a Dent in the Global Waste Problem. *Yale Environment 360*

WASTE TEXTILES

In Europe, the circular economy in textiles is being reinvented

NICOLÁS E. OBANDO • Consultant

To reduce textile waste production and improve its management, laws and measures that specifically regulate the textile sector's circular economy model are being put in place, especially in Europe and China. Recent years have seen textile and clothing manufacturers in Europe increasingly accept their responsibility in the production and end-of-life treatment of their products. The EU Green Deal attempts to regulate, standardize and improve these initiatives.

DATA OVERVIEW

The textile industry is booming, accompanied by a trail of waste

Following the Covid-19 pandemic, the textile fibre market picked up again in 2021, when global production reached 113 million tonnes (**FIG. 1**), following 111 Mt in 2019, and 109 Mt in 2020.[1] Global fibre consumption per capita shot up from 8 kg in 2008 to 14 kg in 2021.

Recycled matter makes up 8.5% of the world market for textile fibres, a slight increase since 2016: 6.89% in 2016, 8.13% in 2020 **(FIG. 2)**. According to Textile Exchange — an organization whose goal is a 45% reduction in greenhouse gas (GHG) emissions from the textile industry by 2030 – these indicators show that the sector's growth is based on the production of virgin raw materials, shifting the industry away from its circular economy targets, and therefore from GHG reduction.[2] The value chain of an item of clothing comprises several stages that can take place in different geographical areas. Clothing starts out as fibre, which is transformed into yarn, then woven into fabric, and finally sewn. During the period from 2019-2020, the drop in turnover experienced by the textile (-9.2%) and clothing (-18.1%) industries in Europe due to the Covid-19 crisis underlined tensions in the supply of raw materials and the location of processing activities.[3]

In 2020, China was the leading exporter of textiles (43.5% of the market, for a total of $296 billion), followed by the European Union (18.1%) and India (4.2%). The EU was the largest importing market (24.3%), ahead of the United States (12.6%) and Vietnam (4.4%).

FIGURE 1

GLOBAL PRODUCTION OF TEXTILE FIBRE IN 2021 (MT)

Source: Textile Exchange, 2022

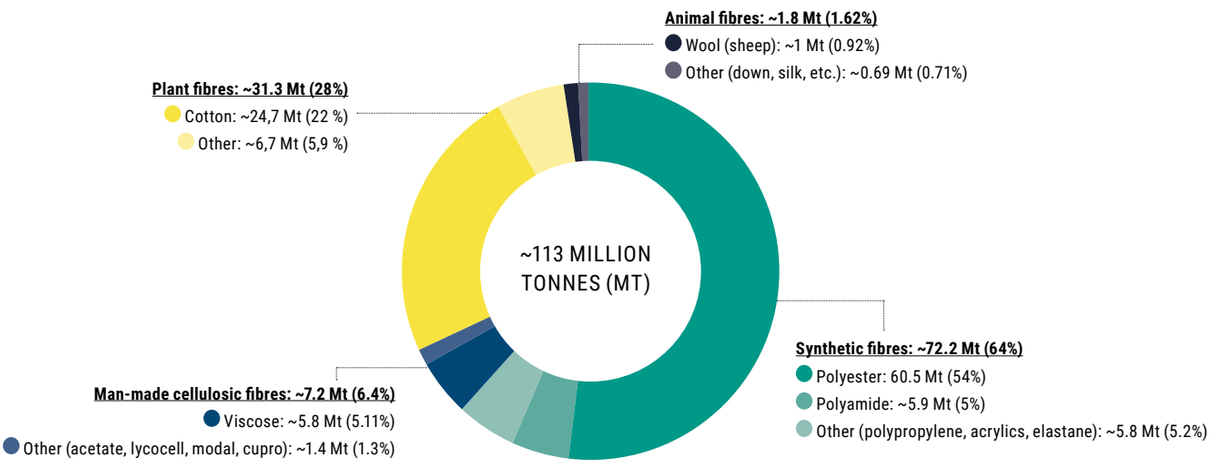
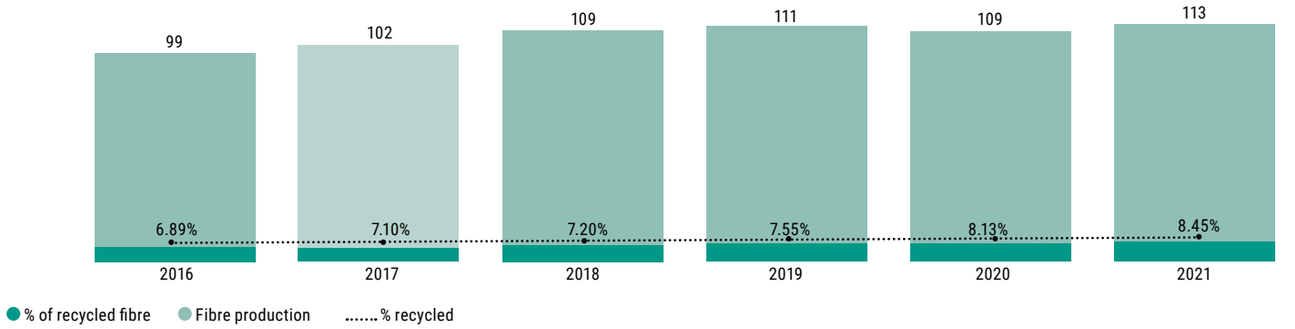


FIGURE 2

GLOBAL TEXTILE FIBRE PRODUCTION (MILLION TONNES), AND % SHARE OF FIBRES SOURCED FROM RECYCLED MATERIALS, 2016 - 2021

Source: Textile Exchange, 2022



More specifically, the main importers of clothing were the EU (34.1%), followed by the USA (16.8%) and Japan (5.3%), for a total value of $415 billion. In this area, China is the biggest exporter (31.6%), ahead of the EU (27.9%) and Vietnam (6.4%),[4] for a total market of $386 billion.

China and the European Union, the two main textile and clothes markets, presented new strategies in 2020 to improve the sector's circularity. As part of its plan to reduce emissions to reach carbon neutrality by 2060, in April 2022 China published its objectives for the textile sector: a recycling rate of 25% by 2025, then 30% by 2030, and a target to increase its production of recycled textiles by 2 Mt in 2025. The government also indicates in the plan that it intends to promote recycling, apply eco-design standards, and establish labels to improve sorting and encourage socially responsible management systems.

As to the European Commission, in March 2022, it presented its strategy[5] for sustainable, circular textiles as part of the European Green Deal to define its approach to life cycle, eco-design and extended producer responsibility (EPR).[6] In 2018, the EU Joint Research Centre (JRC) published an analysis[7] of textile flows with the aim of preparing for mandatory collection of used textiles by 2025. According to the analysis, the textile and clothing industry features over 160,000 companies and about 1.5 million employees, with a turnover of more than $162 billion.

In 2018, the annual consumption of textile products per capita in the EU was 12.3 kg, 81% of which was clothing and the rest household textile goods. The textile market comprises fibres, yarn and fabric, for which the EU's volume of imports and domestic production in 2018 respectively amounted to: 3.4 million tonnes, 30% of it imported; 2.7 million tonnes, 44% of it imported; and 3.2 million tonnes, 40% of it imported (**FIG. 3**). The textile market in 2018 represented 6.1 million tonnes of finished stored products, of which 85% were imported. Of these finished products (clothes and household textile items), 88% were consumed in the EU. The JRC study estimates that under 38% of these finished products were collected for recovery (sold on the second-hand market) or for recycling.[8]

Europe generated 7 million tonnes of these textile flows in 2020, or 15 kg/cap./year. 85% of this waste is made up of clothes and domestic textile items. However, only 38% is collected for sorting, reuse and recycling (about 10%).[9] Given that the fibre and textile industry is steadily growing, and even seems set for a post-Covid boom,[10] it is vital to come up with an economic model capable of reducing the generation of waste.

THE OBSERVATORY'S LENS

In Europe, used textiles in search of a second life

The EU's new strategy for a circular economy in textiles

The 2030 target of the European Green Deal is to increase the lifespan of textile products, their recycling rate, and the proportion of recycled matter in new items, and to reinforce standards on toxic substances in order to comply with social rights in force. The EU strategy also defines the role of manufacturers and underlines their responsibility towards the entire product value chain, comprising design, sale, usage and reusage.[11] The key points of the strategy are:

- The eco-design of products: improving their quality in order to make them last longer, easier to repair and recycle, as well as integrating more recycled materials
- The introduction of Digital Product Passports: clearer information for consumers on the composition, care and end-of-life of the product
- Tackling greenwashing and ensuring the eco-design of products through known labels and public authorities
- Reversing overproduction and overconsumption, and discouraging the destruction of unsold or returned textiles
- Extended Producer Responsibility (EPR) as a driver for an economy of recovery, separation, reuse and treatment of used textiles
- Reducing the quantity of microplastics from synthetic textiles that could end up in aquatic ecosystems

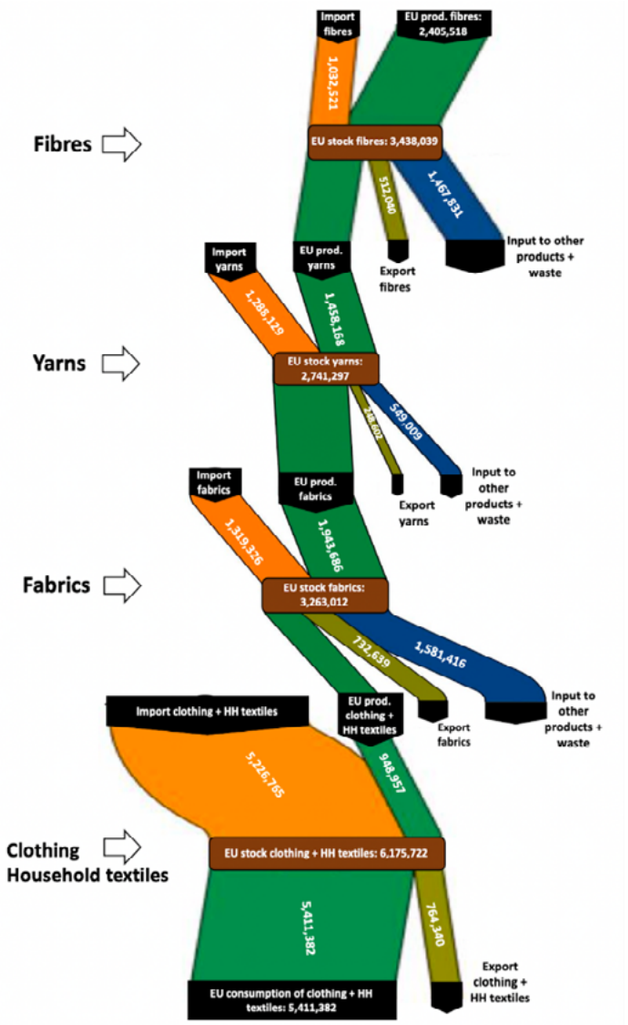
- Restricting the export of textile waste: the export of textile waste to non-OECD countries will only be authorised towards those aligned with the EU's goals and technologies for the treatment of this waste
- Encouraging the creation of businesses specialised in the reuse and repair of products
- Coordinating the implementation of the strategy with companies and Member States.[12]

80% of the environmental impacts of a product take place at the point of design: eco-design requirements would therefore avoid most environmental impacts and a large part of the volume of waste produced during this phase. In fact, designing clothing with a focus on its sustainable, repairable, reusable and recyclable aspects is an indispensable condition to diminish its environmental impact throughout its life cycle.[13]

FIGURE 3

FLOWS OF TEXTILE IN THE EU IN 2018 (IN TONNES)

Source: European Commission, 2021



In the EU, 62% of textiles collected are not recovered or recycled, due to inadequate sorting services and technologies for recycling used textile products. The separate collection systems in place in Europe are all voluntary and highly selective in order to only retrieve clothes that can be reused or recovered.[14] Most clothes are made of cotton, polyester or elastane mixes, and polyester and elastane are polluting substances that make recycling and recovery almost impossible, in particular due to their complex chemical compositions.[15]

EPR is the cornerstone of the EU textile industry

Extended producer responsibility (EPR) programmes follow the polluter pays principle. They play a crucial role in the EU's strategy on sustainable, circular textiles by facilitating the development of circular circuits for collecting, recovering, recycling and depositing used textiles at their end of life. The revision of the EU Waste Framework Directive scheduled for 2023 requires Member States to establish a single, unified EPR system for textiles by 2025.[16] This measure consists in involving producers of textile products and ready-made clothes in the management of their end of life. EPRs can be of two types: with "financial" EPRs, the companies that put products on the market pay a fee to an eco-organization in the private sector responsible for waste prevention and management. These financial contributions are based on eco-modulation, meaning that they are calculated according to the materials used in a product and circular economy principles (sustainability, repairability, reuse and recyclability).[17] In "operational" EPRs, agencies use the funds to directly manage waste, outsourcing its collection, transport, sorting and treatment.

The EPR programmes currently in place in the EU consists mainly of mandatory targets for collecting used textiles by 2025. Most of the programmes are developed in countries like the Netherlands, Sweden and Denmark. They have already set up systems for the collection, sorting, recovery, recycling and final destruction of used textiles and are ready to implement laws to align existing EPRs with European Commission guidelines. France is the only country to have established a law regulating EPRs in the textile sector, dating from 2007. In 2019, the collection rate of textile waste was 38% in France, 45% in the Netherlands, 19% in Sweden, and 43% in Denmark.

Although the collection rate in France is not the highest, the French system is recognized for being particularly successful in federating textile market actors, by improving and standardizing collection, sorting, recovery and recycling flows. The implementation of the programme has enabled the French system to overcome some of the problems facing other countries. These challenges include, for example, the collection of low-quality fabric, which can be impossible to recover and reuse. It is also sometimes difficult to ensure that collected matter is homogenous, which makes it easier to sort and thus recycle. This means that some fabrics that could have been recycled are eliminated by incineration because they are mixed with other materials. The French system has created a model featuring collection points close to consumers, which improves collection rates and flows, and channels investments towards circular economy solutions concerning used textiles, so that the industry can innovate **(SEE BELOW)**.[18]

BOX 1 • **KEYS TO UNDERSTANDING**

TYPES OF RECYCLING IN THE TEXTILE SECTOR

Once used, textile materials can be recycled to manufacture new textiles ("closed loop") or in the case of materials such as plastic, used to manufacture other non-woven products or to produce energy ("open loop"). Another distinction concerns the way that the waste is ultimately used: upcycling (recovering used products by giving them a new, higher-quality life without destroying the raw material)[19] or downcycling (recycling in such a way that the recycled product has a lower value than the initial product).[20]

Depending on the technical process employed, textile recycling methods can be split into three categories:[21]

- Chemical: textile fibres, comprised of natural polymers (linen, latex, cotton, etc.) or synthetic fibres (PET, acrylic, etc.) are dissolved to separate the monomers[a] in the fibre. A new recycled polymer can then be created with the same properties as a virgin polymer.
- Mechanical: the first step involves dismantling the used textiles (removing buttons, zips, etc.), which are then shredded, carded (transformed into long fibres by passing them through a Garnett machine), cut into pieces or split into fibres. After this stage, the fibres are mixed with other materials to make a new product.
- Physical: the physical separation of poly-fibres uses the different density of each material to separate them. This method is employed, for example, for cotton-PET and cotton-elastane mixes.

Since each of these processes comprises several steps, their environmental impacts are different. While most scientific publications underline the potential environmental advantages of recycling textiles, they also agree that reuse is preferable to recycling. Some exceptions exist: in the case of reuse, longer transportation distances reduce the environmental advantages. For recycling, if the process involved operates on fossil fuels or is less energy-efficient, the impact on the climate is greater.[22]

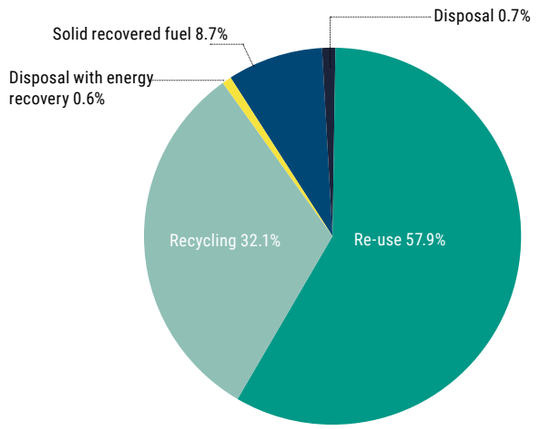
France puts the emphasis on EPR and input from civil society

In 2007, the French law establishing EPR for textiles – clothing, household textile articles and shoes – aimed to resolve the problem of used textiles, which amounted to 600,000 tonnes a year, or 10 kg per person. The law led to an increase in the amount of waste collected, from 100,000 tonnes in 2009 to 239,000 tonnes in 2018. The objective for the end of 2022 is to collect about 300,000 tonnes of waste annually. Once sorted, the collected textile waste is mainly reused (57.9%) or recycled (32.1%) **(FIG. 4)**.

FIGURE 4

END OF LIFE OF TEXTILE WASTE AFTER SORTING IN FRANCE, ANNUALLY

Source: ReFashion, 2021



Collection, sorting and recovery are central to the EPR system for textiles in France. This programme is run by the eco-organization ReFashion, a private company that organizes handling the end-of-life of equipment put on the market by companies. Since its creation, ReFashion has set up 44,829 voluntary drop-off containers where citizens can deposit their textile waste. Over 50% of these drop-off points are containers in public areas, and under 10% are in private areas. In 2021, 244,448 tonnes of waste (3.6 kg/cap./year)[23] were collected at drop-off points. The waste is then taken to sorting centres.

In 2021, the ReFashion EPR system featured 66 accredited sorting centres, 51 of them in France and 15 elsewhere in Europe. In 2021, following the Covid-19 pandemic, sorting of textile products grew by 22% (190,000 t). In sorting centres, operators separate reusable textiles and shoes for recovery and non-reusable items for other activities like recycling, solid recovered fuel (SRF), and elimination.

Reuse represents about 57% of the treatment of textile waste collected in France according to a ReFashion report **(FIG. 4)**. The EPR programme has observed a reduction in the percentage of reusable textile waste compared to 2014 (64%), due to the low quality and sustainability of products on the market, which makes resale and recovery more complicated. Reuse and recovery here refer to diverting used textiles to second-hand clothing markets in France and abroad (37% of reusable products are exported to Africa under the customs code "used clothing").[24]

With the idea of providing information on recycling market actors, ReFashion has launched Recycle, an internet platform that connects European recycling companies and producers. To date, 245 actors feature on the platform, of which 75% are French and 25% European.[25] They come from diverse industries (textile, buildings, plastics processing, automobile, etc.),

a Monomer: composed of simple molecules, capable of combining to form polymers.

thus extending the outlets for recyclable or recycled matter. Among the companies listed on the ReFashion website, 40% are suppliers of textiles and shoes, and 60% are processors offering semi-finished products to other industries.[26]

In order to encourage short, local circuits for the recycled fibre market, the FIREX project was launched in July 2022 with a budget of €14 M. Its goal is to recover occupational clothing and the waste from its production (20,000 t/year) in order to recycle it mechanically. The idea is that the products resulting from the project will meet the demand for recycled raw materials in the textile industry. The initiators of the project are Synergies TLC, Tissages de Charlieu (LTC), TDV Industries, Mapea and the European Centre for Innovative Textiles (CETI). The partners should ensure that systems are in place for collecting, dismantling clothes to remove buttons, rivets, etc., automated sorting, carding and spinning activities, and sewing of fabrics, clothing and accessories.[27]

In 2017, the Emmaüs Association[b] warned of the difficulties of recycling collected clothing following an increase in the quantity to process after ReFashion set up drop-off points. Due to the difficulties encountered in recovering waste, the Ouatéco project emerged to finance a recycling process for old textiles that have not been reused. In 2021, Ouatéco set up an industrial dismantling and carding line for used textiles in order to manufacture thermal insulation. The project should lead to the recovery of around 1,000 tonnes of waste per year in the first phase.[28]

The CE-PET project, launched by the Carbios company, kicked off in 2018, aimed at the chemical recycling of textile and PET waste using an enzyme that facilitates processing. For the moment, when the enzyme employed releases the PET monomers it does not distinguish between colours, sources, textiles and mixed matter. The objective of the project is to offer manufacturers products made from recycled PET that can be endlessly recycled, although there are some limitations, such as the quality of plastic fibres, which sometimes prevents recycling. The actors targeted by the project are upstream waste collectors, manufacturers, and companies that put PET products on the market.[29]

Concerning reuse, sales in the second-hand clothing market grew by 140% in 2021 compared to 2019. Big brands like Vepee, Zalando, Aigle and Kiabi have their own second-hand websites and some online platforms specialize in the field, like Vinted, Leboncoin and Vestiaire Collective. Vinted, which has 16 million French users,[30] is the second most visited e-commerce website in France. Some big retailers like Printemps and Galeries Lafayette have set up second-hand sales and repair stations in their shops.[31] Independent players have launched applications listing second-hand shops in France, like Unique, which indicates the location of local thrift stores.[32] Upcycling is also becoming a feature of fashion markets, with two specialized marketplaces: Revibe and Reiner Upcycling, where creators put their designs online.[33,34]

KEY TAKEAWAYS

Driven by the urgent global need to deal with used textile items, legislation is making progress and initiatives are being set up to make the textile chain more circular and sustainable, in countries like China, and especially in Europe. The European Union has made a significant step in unveiling its circular economy strategy for the textile and clothing industry for 2030, aimed at producing better, recycling better, and discarding fewer textile products. This strategy encourages a quest to identify new recycling strategies. In parallel, sales and purchases of second-hand clothing have made huge progress with users, involving both more availability and alternatives, and a change in practices. Nevertheless, selling second-hand clothing is not enough to resolve the problem of used clothing and textiles. As a result, research and innovation in the mechanical and chemical textile recycling sector are focused on boosting the performance of these activities.

b Emmaüs is a French NGO created to carry out socially responsible action including helping to recuperate and upscale donated and discarded objects.

REFERENCES

RETURN TO PREVIOUS PAGE

1 Preferred Fiber & Materials Market Report 2021 *Textile Exchange*

2 Textile Exchange (2022). Preferred Fiber & Materials Market Report Foreword *Textile Exchange*

3 European Commission (2022). EU Strategy for Sustainable and Circular Textiles *European Commission*

4 Fashion United (2022). Global Fashion Industry Statistics *Fashion United*

5 European Commission (n.d.). A European Green Deal. *European Commission*

6 Development and reform commission, Ministry of Commerce & Ministry of industry and information technology (31/03/2022). Implementation Opinions on Accelerating the Recycling of Used Textiles *State Council Policy Document Library*

7 Köhler, A., Watson, D., Trzepacz, S., Löw, C., Liu, R., & Danneck, J. (2021). Circular economy perspectives in the EU Textile sector Final report *European Commission*

8 *Ibid.*

9 Scaling textile recycling in Europe-turning waste into value *McKinsey & Company*

10 Duthoit, A. (22/07/2020). Bruised but not beaten, Europe's textile industry us a perfect candidate for a greener and digital recovery. *Allianz Trade*

11 European Commission (2022). EU Strategy for Sustainable and Circular Textiles, *op. cit.*

12 European Commission (2022). Sustainable and Circular Textiles by 2030 *European Commission*

13 European Commission (2022). EU Strategy for Sustainable and Circular Textiles, op. cit.

14 Boiten, V. (2022). Ellen MacArthur Foundation perspective on EPR for textiles | Shared by Fashion. *Ellen MacArthur Foundation*

15 Ecos (2021). How ecodesign can make our textiles circular. *Ecos*

16 European Commission (2022). EU Strategy for Sustainable and Circular Textiles, *op. cit.*

17 Boiten, V. (2022). Ellen MacArthur Foundation perspective on EPR for textiles | Shared by Fashion. *op. cit.*

18 Christiansen, A. et al. (2021). Extended producer responsibility in the Danish textile sector. *TekstileRevolutionen*

19 CCI (n.d.). L'upcycling, c'est quoi ? *Chambre de Commerce et d'Industrie*

20 Merriam-Webster (n.d.). Downcycle Definition & Meaning. *meriam-webster.com*

21 Techniques de l'ingénieur (n.d.). Recyclage dans le secteur textile. *Techniques de l'ingénieur*

22 Sandin, G., Peters, G. M. (2018). Environmental impact of textile reuse and recycling – A review. *Journal of Cleaner Production,*

23 ReFashion (2021). Ré_ générer les matières *ReFashion*

24 *Ibid.*

25 https://recycle.refashion.fr/

26 *Ibid.*

27 Ademe (2022). Mise en place d'une filière complète de valorisation des déchets textiles en fin de vie. *Ademe*

28 Ademe (2021). Projet Ouateco. *Ademe*

29 Ademe (1991). Recycler à l'infini tous les matériaux PET. *Ademe*

30 Dumonteil, P., & BFM TV (20/10/2021). Les Français achètent toujours plus de vêtements d'occasion. *BFM TV*

31 Printemps (n.d.). Rendez-vous au 7ème ciel !. *Printemps* (site accessed on 2 november 2022)

32 DMB (n.d). Unique Appli : le nouveau guide friperie. Digital Marketing and Business (site accessed on 2 November 2022)

33 Reiner Upcycling (n.d.). Regenerated fashion marketplace. Reiner Upcycling. (site accessed on 2 November 2022)

34 Revibe (n.d.). The upcycling marketplace. Revibe (site accessed on 2 November 2022)

SIGNALS

A ROUND-UP OF THE INITIATIVES, REGULATION CHANGES, AND MARKET TRANSFORMATIONS OF TODAY THAT SIGNAL THE CLIMATE ACTION TRENDS OF TOMORROW

United States • California adopts an EPR for plastics

EPR (Extended Producer Responsibility) programmes, aimed at shifting the responsibility for plastic pollution from consumers to producers, are slowly making headway in the US. Maine became the first US state to pass a bill on the subject in July 2021, followed by other States such as Oregon, New York, and California. The latter requires that by 2032, certain packaging should be recyclable or compostable, plastic packaging should be reduced by 25%, and 65% of single-use packaging should be recycled. The bill requires producers to contribute to a common fund to cover waste management and recycling costs. While the vote for the programme has been lauded as a success, the community of environmental associations is divided on the issue. Some fear that it contains ambiguities that give extra undesired leeway to companies, such as allowing the use of controversial chemical substances for recycling, or exempting certain plastics.

Inside Climate News, 12/10/2022

Luxury • $535,000 in fines for the Ritz-Carlton

Six Californian counties have sued the Ritz-Carlton luxury hotel chain for poor management of its hazardous waste since at least 2018. The city of Los Angeles has joined the complaint, accusing the chain of badly disposing of electronic waste, cleaning products, and other toxic and flammable waste. The court argued in their favour, ordering the hotel chain to pay a fine of $400,000 in civil penalties, $100,000 to fund environmental projects in California, and $35,000 in cost reimbursements. The hazardous waste would have been dumped directly into local landfills instead of being sorted as required by hazardous waste laws. While the investigations did not conclude that the offense was wilful, the court representative stated that *"the improper management of hazardous waste is criminal, regardless of the intentions"*.

Grist, 19/08/2022

Sorting • Cameroon-Rwanda: selective sorting and smart bins met by unanimous success

"Intelligent waste bins" were installed in November 2021 as part of a $100,000 pilot project in Kigali, Rwanda. It was launched after a 2018 report showed that only 36% of inhabitants benefited from a waste collection service. Solar-powered sensors are installed on the bins to monitor how full they are, and waste collectors receive a notification when they need emptying. The bins can be green (biodegradable waste), blue (recyclable materials such as plastic and paper) or grey (electronic waste). The project was initiated by the Smart Africa Alliance and the Rwandan Ministry of ICT and Innovation. It aims to expand to more cities in sub-Saharan Africa, to improve waste management systems. Cameroon has already started studying the results.

Afrik21, 26/08/2022

Petrochemicals • The UN treaty against plastic pollution thwarts oil companies' plan B

The United Nations Environment Assembly (UNEA) in Kenya agreed in March 2022 on a resolution to move towards a legally binding treaty on plastics which is meant to discourage their production and to promote their recycling and anti-waste measures. The actions resulting from this treaty would therefore constitute an alternative to the production of plastic, which the oil industries are betting on. Indeed, these companies are anticipating an increase in the demand for plastic, and are currently multiplying investments in petrochemical production to ensure future prospects. Plastic production has in fact increased from 2 Mt in 1950 to 380 Mt in 2015 (1.7 $GtCO_2e$) and the trend is for an increase in the use of oil for the petrochemical industry rather than for fuel production. The investments are mainly located in Africa, where contrary trends are also at work, such as the fact that 34 countries out of 54 have already put in place legislation to curb single-use plastics.

Climate Home News, 14/03/2022

Buildings • Eiffage develops a circular economy strategy for metals within the building sector

The buildings and public works group, Eiffage, created a subsidiary for the dismantling and recycling of materials in 2021, in order to set up a shorter supply chain and optimise the recycling of construction rubble. To boost this initiative, the group wants to enhance the waste treatment value chain by determining *"the nature of construction debris and planning for its reuse"*. In 2022, the group developed the new Carasol system for this purpose, in partnership with the Atomic Energy Commission. This consists of a mobile laboratory that can be deployed as needed on construction sites. It can analyse the nature of the debris in 90 minutes, compared to current initial analysis procedures that can paralyse the construction site for several days. It was born out of a need to address the problems posed by the 45 million tonnes of debris generated by the Grand Paris Express worksite. Guillaume Sauvé, Chairman of Eiffage Génie Civil, states that the sector is able to recycle 95% of materials during deconstruction.

Newsly, 15/07/2022

Toxic substances • Further delays to improving REACH

The update of the European REACH regulation on chemical substances, which is at the heart of the European Green Deal zero pollution strategy, has been postponed to 2023. In 2018, the Commission proposed overhauling the legislation ten years after the initial vote, following the publication of a report showing mixed results. Although the report did observe progress on transparency, it acknowledges the warning of several specialised associations concerning the persistence of these substances in everyday products (toys are among the most dangerous). The new framework would therefore aim to facilitate its implementation. In parallel with the European Citizens' Initiative (ECI), named "Save Bees and Farmers", which collected a million signatures in Europe, the postponement of the report is especially prone to criticism. ECI is calling for *"a gradual elimination of 80% of the use of synthetic pesticides by 2030 and 100% by 2035"*.

Novethic, 20/10/2022

South Korea • Launching research into the recycling of solar panels

A South Korean research team has developed a process for creating high-performance solar cells from end-of-life solar panels. Solar panels have a lifespan of 20 years, and recycling them constitutes a major challenge in Asia where the solar panel market is growing fastest and solar technology waste is starting to accumulate. The new process makes it possible to recycle damaged and intact panels. 100% of the glass components and 80% of the other materials can be recycled into solar cells with an energy production efficiency of about 20.52% (compared to an average of 15% elsewhere). Recycling a tonne of photovoltaic panels would reduce GHG emissions by 1.2 tonnes. The recycling of panels poses significant challenges, which can be reduced if the issue is taken into account when designing them and choosing the materials.

Energy Asia, 24/08/2021

Plastic • The Plastic Odyssey ship embarks on a world tour against plastic pollution

Departing from Marseille on 1 October, 2022, the Plastic Odyssey ship began a three-year expedition against plastic pollution in three continents — Africa, South America, and Asia-Pacific. The aim is to train close to 300 plastic recycling entrepreneurs in 30 cities that are *"most burdened by this waste"* due to a lack of infrastructures and resources. To do this, the Plastic Odyssey company has developed machines, which it will demonstrate during stopovers, designed to be easy to reproduce and with freely available blueprints. They shred plastic and treat it to make it suitable for manufacturing other products such as furniture, construction bricks, etc. The waste gathered during the stopovers will be used to showcase the machines in operation. Some waste will be converted into fuel for the ship: *"A dedicated engine connected to a generator serves as a test bed using pyrolysis fuel."* The approach also relies on discussions and "solution villages".

Techniques Ingénieur, 05/10/2022

CASE STUDIES

PROJECT CASE STUDY

COUNTRY	REGION	YEARS	BUDGET	EU GOAL 2021-2023
FRANCE	ALSACE	2019-2021	€3.9 M	40 GWH LITHIUM BATTERY PRODUCTION CAPACITY (3 GWH IN 2020)

Alsace • Towards a Made-in-Europe production of low-carbon lithium with the EuGeLi project

Since 2020, lithium has been included in the list of "critical metals" drawn up by the European Union. While the geological risk for lithium is low, it is susceptible to economic, geopolitical, and industrial risks. The EuGeLi (European Geothermal Lithium Brine) project offers a local lithium supply model in Europe that is inexpensive in energy terms. Eramet Ideas and IFP Énergies Nouvelles (IFPEN) have developed a method of extracting lithium directly from geothermal brine waters in Soultz-sous-Forêt, in Alsace. The pilot project was launched in January 2019 and achieved its first success in May 2021 by creating the first kilogramme of battery-quality lithium carbonate from geothermal energy in Europe.

A project at the heart of Europe

EuGeLi is the result of a partnership between Eramet and Électricité de Strasbourg accompanied by a consortium of numerous industrial and research actors: IFPEN, Chimie Paris Tech, BASF (The Chemical Company), Eifer (European Institute for Energy Research), VITO (Vision on Technology) and Vrije Universiteit Brussel (VUB). 85% of its 3.9 million euro budget was financed by EIT Raw Materials (an EU body) following a call for projects launched in 2019.

The Rhine Trench, on the border between France and Germany, has significant geothermal resources over a stretch of more than 300 km, with an energy potential of around 350 GW per year. The lithium present in this area comes from frictions between the rocks which are rich in it, and the underground water in which it is found dissolved.

This type of lithium resource has been little exploited until now because the quantities present in the Alsatian subsoils remain well below those of the main reserves such as the "Lithium Triangle" in Latin America. Geothermal brines represent only 1% of lithium resources, but the development of these local unconventional deposits can address a strategic challenge. Dozens of battery production plant projects developed in the region are dependent on lithium imports from Latin America, Australia, or China.

The demand for electric batteries, of which lithium is a principal component, is set to grow, both because their opportunity cost increases thanks to increasingly competitive usage costs, and because of European measures such as emissions standards, voted in 2019, or the ban on the sale of internal combustion engines from 2035 onwards, voted in June 2022.

Extracting lithium from water without evaporating it

The extraction of lithium involves either mining, with its severe environmental impact, or the evaporation of geothermal waters. The latter constitutes an indirect loss of energy because the particular conditions of these waters allow geothermal power stations to convert the water's thermal energy into electrical energy. The goal of this project is to extract lithium dissolved in subterranean water without resorting to evaporation, and thus allow water to be reinjected into the underground layers and the geothermal power plant.

To achieve this, IFPEN and Eramet have developed a solid crystalline material in the form of granules which selectively extract lithium like a sponge. The geothermal water flows through a tube holding this absorbent material and exits the tube free of the ore. It the absorbent material is then rinsed with fresh water to recover the lithium and form a solution which will be filtered and evaporated to yield the lithium carbonate used by battery assemblers.

This process has already been tested in Argentina, extracting lithium from a salt flat. The challenge here was to adapt this process to the temperature and pressure of Alsatian geothermal brines, respectively 80 °C and 20 bars. The success of this EuGeLi pilot project was thus to be able to use this process under the conditions to which geothermal water is subjected, and recover 90% of the lithium; the evaporation method, by contrast, recovers 40 to 50%.

The extraction procedure does not release CO_2 and the lithium treatment operations do not consume much energy. Together with the losses, the energy used to pump the water amounts to about a quarter of the total electrical energy produced by the power station. The lithium extraction process optimises the use of this energy.

CITY CASE STUDY

COUNTRY	CITY	POPULATION	RATE OF RECYCLING AND REUSE	NATIONAL WASTE PRODUCTION
JAPAN	KAMIKATSU	1,457 (2020)	80% (20% AT THE NATIONAL LEVEL)	41,670,000 T (2020; -2.5% COMPARED TO 2019)

Kamikatsu • A social project beyond the zero waste objective

Per capita waste generation in Japan is among the lowest in the OECD, but the recycling rate (20% in 2020) is below average. In this regard, the municipality of Kamikatsu, which recycles or reuses 80% of its waste, serves as a model. This is the outcome of a pioneering declaration made in 2003, when the city pledged to achieve "zero waste" by 2020, concentrating initially on improvements in recycling before insisting more recently on prevention in order to reduce waste production upstream. The success of its sorting centre is hinged on community involvement in the project. Its reputation as a "Zero Waste Town" also makes it more attractive for younger populations.

A municipal project part of a wider national approach

Because of the nature of its borders, Japan was quickly confronted with limitations in its landfill capacity. The "Basic Act for establishing a sound material-cycle society" of 2001 is based on the principle of the 3Rs: Reduce, Reuse, Recycle. It aimed, among other things, to reduce household waste by 25% and corporate waste by 35% by 2020.

Kamikatsu closed its two incinerators in 2000, following new control measures, and with the help of the NGO Zero Waste Academy, it is counting on recycling and, ultimately, achieving zero waste. The initiative taken by the town in 2003 was facilitated by the decentralisation of waste management in 1997. In 2004, the town established a fund for the project and in 2014, it appointed "zero waste advocates" to enhance the prevention component.

In addition to sorting, the project also encourages waste prevention, in a context where the generation of waste is unfortunately still increasing: from 283 tonnes in 2018 to 302 tonnes in 2019. The prevention component echoes the objective of the 2001 law to establish a Sound Material-Cycle Society (SMCS). The sorting centre building also hosts an awareness and learning centre, a shared laboratory, and the WHY hotel. Residents of the town and surrounding areas must sort their waste according to 45 categories – the rest is still sent to an incinerator. While the constraints associated with recycling – transport to the sorting centre, cleaning of waste upstream, the relatively large number of sorting categories – have led to some complaints, they have contributed to the adoption of new habits; the less waste a resident produces, the less they will have to go to the sorting centre.

At the same time, Zero Waste Academy has encouraged industries and manufacturers to recycle, and made them aware of the issue of illegal landfills. As an incentive, it also accredits certain businesses that meet the objectives of the "Zero Waste Map".

Considering waste as a resource

Kamikatsu's results are also reliant on a circular economy, complementing recycling actions. Globally, only 9% of plastics and 13.5% of solid waste are recycled. Various activities have been undertaken to limit the amount of waste to treat. The town has established the Chiritsumo point system, where points can be won by sorting waste which can be exchanged for "essential ecological" products.

This municipal initiative is spreading to local businesses. The Kuru-Kuru shop and workshop were founded in 2006 and 2007 to promote a second life for some objects which are donated by the inhabitants and redistributed for free. The Rise & Wine Company, for its part, reuses misshaped grains to brew two types of beer, and since 2021 it has been converting unused grains into liquid fertilizer for farmers, who use it to grow the barley used for the beer.

The WHY hotel promotes an "anti-waste" policy, particularly at its restaurant, and the Polestar Cafe offers only a single choice of meal to avoid waste. The hotel and store are built from recycled and salvaged materials. The tendency to overpack goods, however, is still proving difficult to eradicate.

CITY CASE STUDY

COUNTRY	CITY	POPULATION	MITIGATION GOAL	EMISSIONS IN 2017
BRAZIL	SÃO PAULO	22,429,800	-50 % IN 2050 (2017 BASELINE)	15.42 $MTCO_2E$ (SCOPES 1 & 2)

São Paulo • A circular food system to reduce organic waste

As the most populated city in Brazil, São Paulo produces about 100,000 tonnes of organic waste every year from its hundreds of street markets, and almost 100,000 tonnes from the pruning of trees and plants, in addition to organic household waste. The waste sector accounted for 8% of the city's emissions in 2017. To address this problem, the city has adopted various strategies to divert this organic waste from landfills, notably towards decentralised composting yards and to integrate it into the city's award-winning circular agriculture programme "Connect the dots".

São Paulo's strategy for handling organic waste began with the idea of diverting it from landfills, where almost all of it was being sent (before the launch of the composting activities), causing methane emissions and the infiltration of contaminating liquid toxins into adjacent areas.

The diversion strategy has 4 main elements: separate collection and transportation of organic waste, treatment and recycling of this waste, communication regarding organic waste, and the deployment of economic incentives to encourage the diversion and treatment of organic waste, such as landfill fees. This strategy was drawn up in collaboration with the Climate and Clean Air Coalition and the International Solid Waste Association.

The sustainable markets and gardens policy

The sustainable markets and gardens policy was launched in 2015 to tackle this problem, by composting organic waste including produce waste from street markets and pruning waste: in particular tree trunks, branches, leaves and grass. These two types of waste can be easily separated and traced to their source. Shopkeepers, restaurants and businesses have agreements in place with the local government which make it easy to collect the waste from them. Additionally, waste from markets and pruning also have the advantage of complementing each other: fruit and vegetable waste is high in nitrogen, while gardening waste is drier and higher in carbon.

The decentralised composting yards

Work began in 2015 on five decentralised and semi-local composting yards, intended to receive organic waste from the whole city, thereby reducing the use of landfills, as well as the distance between the source of the waste and its treatment location.

By 2016, a composting pilot site was already receiving waste produced by 26 street markets and all pruning waste from the sub-prefecture of Lapa; a total of 170 tonnes were composted per year on this site. In 2020 on various sites, 10,000 tonnes of waste were composted, bringing the total since 2015 to 20,000 tonnes. Compared to sending this waste to landfills (which would emit about 819.1 kg of CO_2e per tonne of waste), composting it reduces GHG emissions by 87% (thereby emitting 110.3 kg of CO_2e per tonne).

These composting facilities use natural aeration and the "thermophilic compost method" – composting by heat-loving bacteria. The method creates piles of alternating layers of organic waste and straw/green waste from pruning, which are transformed into compost after 120 days.

Feeding back into the food system

The compost produced in these yards now serves two major purposes. First, it is used for landscaping and the environmental recovery of degraded areas, and in the city's urban gardens. Second, and primarily as part of the "Connect the dots" programme, the compost produced in the city is used for organic agriculture in the rural areas surrounding the city.

This programme provides technical assistance to help smallholder farmers employ agroecological practices that promote soil health, and works to improve their access to markets. Using compost from municipal waste as an agricultural input also makes it possible to reduce farmers' production costs.

“COLLABRATIVE APPROACHES ARE EMERGING AS PART OF A NEW PARADIGM WHERE BIODIVERSITY PROTECTION AND CLIMATE ARE INTRINSICALLY LINKED.”

2021

The year 2021 saw an overall slowdown in deforestation. In 2021, 25.3 million hectares of forest cover, all biomes combined (rainforests, boreal, etc.), were lost, including 11.1 million hectares of tropical forest. This represents a decrease of 2% compared to the year 2020. Emissions from land use have also decreased by at least 3% compared to 2020. Nevertheless, on a global scale, the carbon absorption capacity of forests is slightly decreasing. In 2020, the net balance was 7.35 $GtCO_2e$/year, in 2021 it is estimated to be 7.17 $GtCO_2e$/year **[INDICATORS]**.

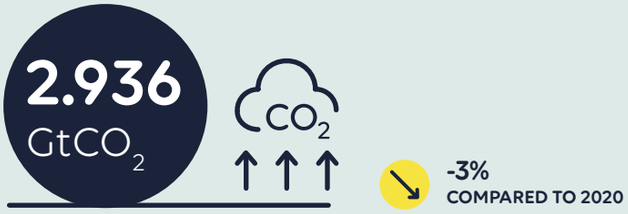
A growing number of initiatives based on collaborative approaches are being implemented in several regions of the world to reduce the depletion of the carbon sink that forests represent, while benefiting biodiversity. Some of these initiatives are launched and led by indigenous peoples, whose knowledge and support are essential to the protection of forests. These initiatives are also part of a new paradigm where biodiversity protection and climate are intrinsically linked. This is the case in Tanzania, in the Yaeda Valley, where the protection of land and wildlife by local populations is finding new sources of financing via the voluntary carbon market, where nature-based solution credits are particularly sought after **[CASE STUDY]**.

In the same vein of complementarity between the protection of biodiversity and the fight against global warming, biodiversity corridors are being set up all over the world to connect conservation areas. They are an illustration of the usefulness of collaborative approaches to climate change adaptation **[TRENDS]**. This is also the case in certain agricultural sectors such as coffee, whose cultivation is undergoing profound changes in land suitability due to climate change. Here too, the collaborative approach of producers' cooperatives which are organizing themselves for the socio-ecological resilience of the sector, is proving effective, alongside initiatives aimed at developing agroecology, hybridization or even the diversification of species **[TRENDS]**. The creation of a community seed bank in Nepal, aimed at preserving local species of crops, is part of this effort to conserve biodiversity and natural heritage in order to better adapt communities to climate change **[SIGNALS]**.

The law is also mobilized as a shield to protect biodiversity. New legal levers such as "rights of nature" are being developed and spread around the world. Used by a heterogeneous group of actors (NGOs, local populations, citizens, communities), the rights of nature have become a means of protecting rivers, mountains and forests. However, the first rights granted to natural entities in Colombia, New Zealand, Tanzania and Ohio have yet to prove their effectiveness **[TRENDS]**.

THE SLOWDOWN IN TREE COVER LOSS DOES NOT HALT THE LOSS OF CARBON SINKS

Emissions from land use decrease, but carbon sinks continue to shrink



NET EMISSIONS FROM THE LAND USE SECTOR IN 2021

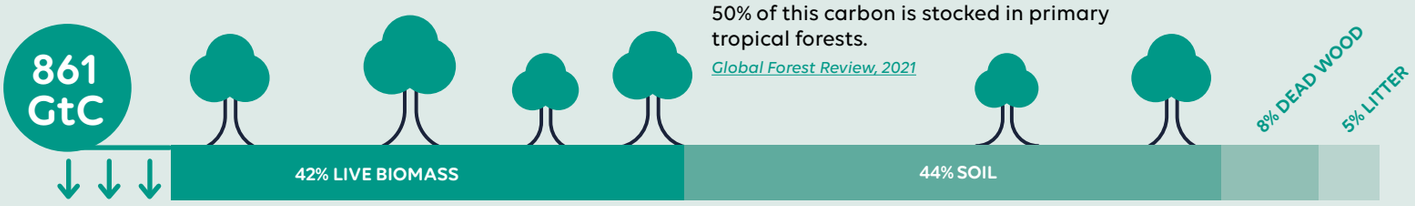
These emissions were 3.03±2.6 $GtCO_2$ in 2020, and have decreased by about 3%, due to continued wet conditions in Indonesia and a below average fire season in South America.

Friedlingstein et al., Global Carbon Budget, 2021

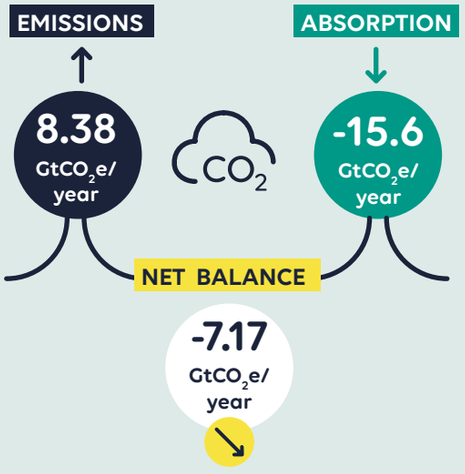
TOTAL STOCK OF CARBON IN FORESTS

50% of this carbon is stocked in primary tropical forests.

Global Forest Review, 2021



AVERAGE ANNUAL EMISSIONS AND ABSORPTION BY FORESTS BETWEEN 2001 AND 2021



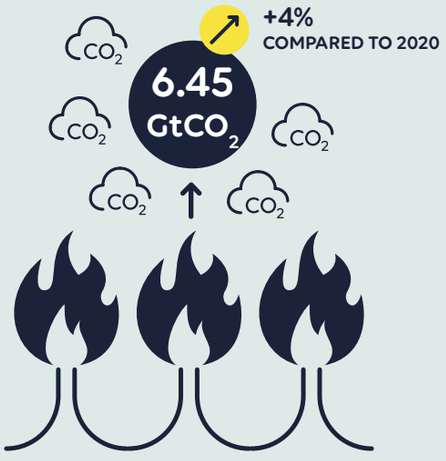
This means a net balance of -7.17 $GtCO_2e$/year, compared to -7.35 $GtCO_2e$/year in 2020. This means that on a global scale, forests remain a net sink for CO_2, but less efficient.

Global Forest Watch, 2022

CO_2 EMISSIONS INTO THE ATMOSPHERE FROM FOREST FIRES IN 2021

In August 2021, monthly emissions were the highest ever, at 378 $MtCO_2$. Large areas within Siberia, North America, the Eastern and Central Mediterranean, and North Africa experienced the highest fire-related emissions since data collection began.

Copernicus, 2021

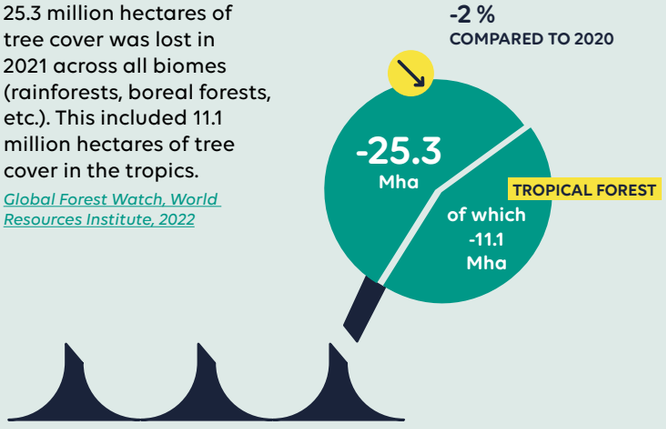


Despite more destructive fires, global deforestation slowed down

TREE COVER LOSS

25.3 million hectares of tree cover was lost in 2021 across all biomes (rainforests, boreal forests, etc.). This included 11.1 million hectares of tree cover in the tropics.

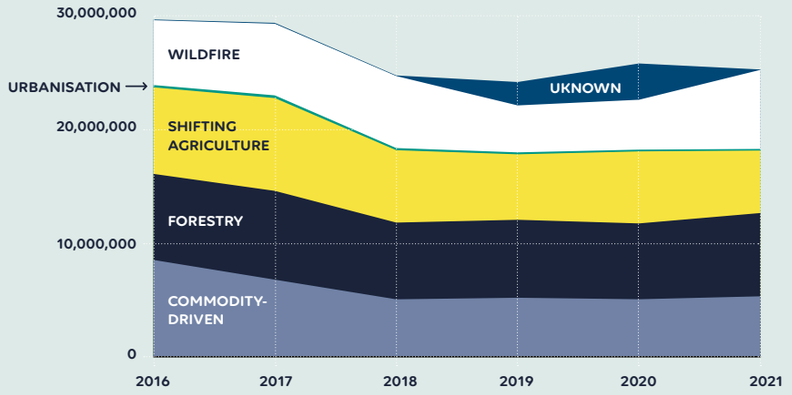
Global Forest Watch, World Resources Institute, 2022



SHARE OF THE MAIN DRIVERS OF TREE COVER LOSS, BETWEEN 2016 AND 2021

Between 2020 and 2021, the loss of tree cover due to forest fires increased, as well as loss due to forestry.

Climate Chance, based on data from Global Forest Watch, 2022



Progressing slowly, the commitment of companies vary across sectors

RATES OF COMMITMENT AGAINST DEFORESTATION BY COMPANIES IN HIGH FOREST RISK SECTORS

	2021		2020
LEATHER	28%	↗	25%
PALM OIL	72 %	↗	71%
TIMBER	67%	↗	48%
SOY	40%	↗	31%
CATTLE	30%	↗	28%
PAPER	49%	↘	66%

58% of the 500 companies and financial institutions in forest-risk supply chains have made commitments on deforestation, up from 57% in 2020 and 52% in 2019

Forest 500, 2022

CONSERVATION

Trailing behind international targets, conservation seeks to deliver results

AICHI BIODIVERSITY TARGETS

TARGETS REACHED IN 2020

The United Nations Convention on Biological Diversity set 17 targets for the decade of 2011-2020, of which none were fulfilled.

Secretariat of the Convention on Biological Diversity

ENDANGERED SPECIES

28%

of the 147,517 animal, plant and fungal species species assessed by the IUCN are classified as endangered.

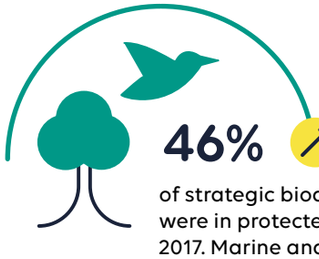
68%

There has been a 68% decline in vertebrate populations between 1970 and 2016.

UICN Red List, 2022

WWF, 2020

INCREASE IN THE PROTECTION OF STRATEGIC BIODIVERSITY SITES



46% ↗ **+1/3** SINCE 2000

of strategic biodiversity sites were in protected areas in 2017. Marine and mountain areas follow the same trend.

Protected Planet, 2021

TRENDS
BIODIVERSITY

Biodiversity Corridors: Strengthening ecological connectivity to adapt ecosystems to climate change

OPHÉLIE CUVILLARD • Research Assistant, Global Observatory of Climate Action, Climate Chance
ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance

The American Conservation Movement in the 19th century gave birth to the first great national parks with the idea that the best way to protect nature was to isolate certain spaces from human activity. Faced with the alarming observation of biodiversity decline in recent years, conservation is undergoing a paradigm shift, both in its definition and in the governance of protected areas where the role of indigenous peoples and local communities in managing them is being increasingly defended. This new vision of conservation underscores the significance of the degree of connectivity between ecosystems, for which ecological corridors are an important instrument.

DATA OVERVIEW

The convergence of climate, biodiversity and desertification issues, which intensified following the Covid-19 pandemic, highlights the challenge of reconnecting environments

The zoonotic nature of the SARS-CoV-2 virus, originating from the collapse of natural boundaries between animal and human species, has highlighted the interconnections between different ecosystems as well as between climate, biodiversity, and soil management. Among the emergent infectious diseases, 75%[1] appear to be zoonoses, which circulate from animals to humans or vice versa, and which have been on the rise since the 1980s. The reasons for this rise are the trade in and consumption of wild animals, the degradation of ecosystems constituting their natural habitat, and global warming, which shrinks their geographical range.[2] This is what was first advanced by a community of experts and researchers with the "One Health"[3] concept before it was put on the political agenda during the Covid-19 crisis. This concept promotes a future course of action that would take human as well as animal and environmental health into account.[4] Politically, it is reflected in the reconciliation between the conventions signed at the Earth Summit in Rio in 1992 and it encourages the linking of their objectives. This vision takes climate action out of a "carbon-centric" view, highlighting the co-benefits to be promoted along with the Sustainable Development Goals (SDGs).[5,6]

The practical application of this holistic vision can be found in the increasing integration of biodiversity into the funding mechanisms for climate action. Funding that is favourable to biodiversity doubled between 2012 and 2020, from 52 billion dollars[7] annually to approximately $130bn,[8] of which 80 to 85% comes from public funds. This evolution parallels the

growing attention paid by actors to "nature-based solutions". Having been dominated by renewable energy projects for a long time, the voluntary carbon market is now switching towards projects dedicated to forests and land use (45% of credits issued in 2021).[9] Labels certifying the contribution of carbon credits to the preservation or restoration of biodiversity are also appearing in major certifying bodies. Thus, the Climate, Community & Biodiversity Standards of the American Verra standard (VCS) listed in July 2022 contains 49 validated and 71 verified projects, and more than 291,690,000 credits issued with the label (accounting for about 30% of all credits issued by Verra).[a] These credits, which also certify co-benefits, trade at a higher value on the market.[10]

This trend towards the incorporation of co-benefits for biodiversity can be seen within the REDD+ mechanism,[b] the initial purpose of which was to preserve forests for their role as natural carbon sinks. REDD+ in fact aims to assign a financial value to carbon stored in forests to encourage their preservation. In recent years, REDD+ deeds have focused increasingly on forests located in protected areas to reinforce their positive externalities to the benefit of ecologically strategic areas. The preservation of forests has a direct positive impact on biodiversity because forests are home to a very large part of Earth's biodiversity – 75% of birds, 80% of amphibians and 68% of mammals.[11] The volume of REDD+ credits aimed at avoiding unplanned deforestation increased by 166% between 2020 and 2021, and by 972% in the case of planned deforestation. Other incentivising mechanisms promote actions aimed at preserving or restoring biodiversity, such as Payments for Ecosystem Services (PES).

At the political level, inclusion of biodiversity in the agenda was notably marked by the COP10 of the Convention on Biological Diversity (CBD), when the signatory states meeting in Nagoya adopted a strategic plan for biodiversity for the period 2011-2020, including the twenty Aichi targets. Objective C.11 set the ambition for the surface area of protected land to reach 17% in 2020, and the new goals for the 2020-2030 decade are expected to be set this at 30%. However, according to the ProtConn[c] index, the surface area of protected areas was only 14.7% in 2020. Only a third[12] of the countries have managed to achieve the Aichi C.11 target as of 2017, mostly in Europe and Micronesia. But although the surface of protected areas doubled between 1990 and 2018,[13] biodiversity continues to decline: the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) still listed a million species headed for extinction in 2019.[14] The conservation of protected areas is itself threatened not only by the impacts of climate change, but also by invasive species, increased tourist numbers, poaching, wildfires, and water pollution. In a report assessing the conservation of natural World Heritage sites published in November 2020, the International Union for Conservation of Nature (IUCN) believes that since 2017, the situation has further deteriorated.[15]

Although they are essential for the preservation of ecosystems and species, protected areas and national parks are also the cause of loss of genetic diversity. Protected areas and parks are in fact delimited,[16] which hinders the migration of species and therefore the congregation of different groups of the same species. However, biodiversity, as defined by IPBES,[d] is assessed in part according to the rate of genetic variation within a given habitat. Protected areas in the form of islets are not suitable for large-ranging species, called "umbrella species". For instance, it hinders the natural migration of jaguars,[17] and the limited size of the areas does not allow species like elephants[18] to meet all their needs.

The United Nations stressed in 2020 that SDG 15 on the conservation of biodiversity cannot be achieved with the current state of protected areas[19] and with the increase in fragmentation of natural habitats. This observation comes along with a paradigm shift regarding the conservation of biodiversity which highlights the concept of an "ecological conservation network". An ecological network includes protected areas, intact natural areas, and Other Effective area-based Conservation Measures (OECM), which constitute its "core conservation units". The connections between these critical habitats are achieved with "ecological corridors", and the whole of these parts constitutes an ecological network. The network is "*established, restored as necessary, and maintained to conserve biological diversity in fragmented environments*".[20] Connectivity between these areas could be damaged by climatic events or anthropogenic activities such as land use and farming, construction of infrastructure such as buildings, roads, railways, dams, electricity networks, etc. Connectivity thus materialises through the ability of ecosystems to be physically connected and not separated by physical barriers. This connectivity can be through land, sea, air, or a mix of these.[e]

Today, according to the ProtConn index, only half of protected areas are connected. Some countries already show a relatively high degree of connectivity between their protected areas: Brazil, Venezuela, Peru, Morocco, Guinea, Benin, the Republic of Congo, Namibia, Botswana, Zimbabwe, Tanzania, Armenia, Tajikistan, Sri Lanka and Bhutan. Conversely, India, Indonesia, Malaysia, Papua New Guinea, China, Australia and the United States, which account for approximately 60%[21] of biodiversity loss, all exhibit a low degree of connectivity between their protected areas **(FIG. 1)**. Other countries are also particularly under threat, such as Kenya, Nigeria and Pakistan,[22] where

a See the Verra Registry

b The REDD+ (Reducing Emissions from Deforestation and Forest Degradation) mechanisms were developed by the parties to the United Nations Framework Convention on Climate Change (UNFCCC), i.e., one of the three conventions signed in Rio in 1992.

c The ProtConn index, which was set up in 2016 by the Digital Observatory for Protected Areas within the framework of the joint research centre of the European Commission, aims to assess the degree of connection within a given region or country, particularly between protected areas.

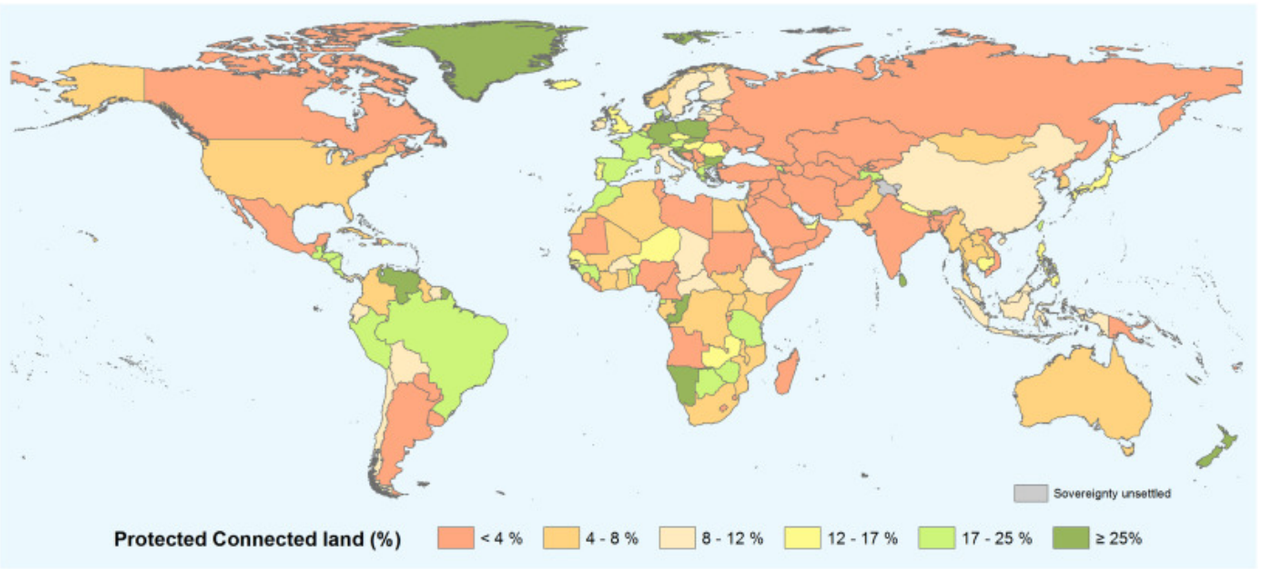
d See the IPBES glossary

e The term "connectivity" can also be used in an urban area to describe projects that aim to improve the coexistence, in an urban environment, of human activities with the presence of biodiversity – the development of green infrastructure, for example.

FIGURE 1

PORTION OF CONNECTED PROTECTED LAND BY COUNTRY

Source: Biological conservation, March 2018



farming, which is very important for the economy, is based on fragile ecosystems. At the global level, more than 30%[23] of ecosystems in one-fifth of countries are at risk of collapse, according to the index of the Swiss Re Institute Biodiversity and Ecosystem Services.

The connectivity between critical habitats in conservation networks are provided through what are known as "corridors" – "*a clearly defined geographic area that is governed and managed over the long term with the aim of maintaining or restoring an effective ecological connectivity*".[24] Corridor boundaries can nevertheless evolve over time in relation to the transformations of the territory, climatic events, or the construction of new infrastructures. They can take various forms: hedges, agricultural paths, streams, etc. but are not always continuous and can constitute "stepping stones".[f] Corridors are often large projects which require several years studying species and land mapping, as well as management requiring close collaboration between actors. They are generally set up around strategic areas – such as forests or bodies of water – which often come into conflict with the human activities that also exploit these areas. In Sri Lanka, the elephant corridor, for example, was blocked in May 2021 by local farmers who needed space for their farming activities.[25] But the goals of biodiversity conservation rely on the protection of 50 key eco-regions in just 20 countries, which in many cases overlap with areas populated by indigenous communities.[26]

THE OBSERVATORY'S LENS

Biodiversity corridor projects highlight the contribution of collaborative approaches and are used for adapting to climate change

The 25 corridor examples studied in the IUCN[g] report show that certain projects implemented in the 2000s and yielding results today are those which managed to be designated as "corridors" or which have been established in areas officially recognised as protected areas. This official and legal recognition helps establish "conservation frameworks" which facilitate the set up and management of these corridors. In particular, the integration of corridor projects into public planning seems to be a *sine qua non* for the success of such projects, so that the space of the corridors is known, and does not come into conflict with other land use projects carried out by a neighbouring country or by other actors within the country.

As strategic spaces for resources, both for animal species and human populations, transnational borders are often the subject of corridor projects. These cross-border projects have been made possible thanks to inter-state agreements via a

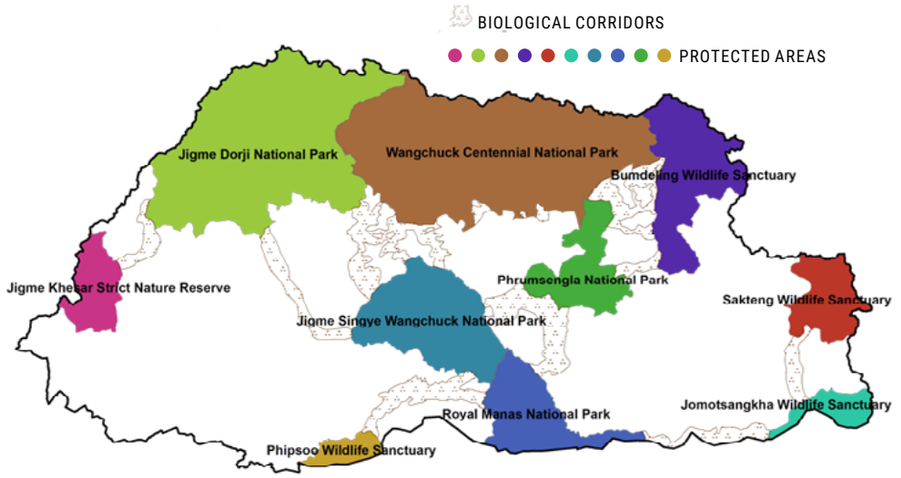
f "Stepping stones" is a term used specifically to define strategic areas on long migration routes (for species such as marine mammals, sea turtles, and birds) whose aim is to ensure access to food as well as to provide tranquillity and security, and thus make the migration feasible.

g Unless otherwise stated, the examples referred to in this Trend are cited in the report *Guidelines for conserving connectivity through ecological networks and corridors* (see References)

FIGURE 2

PROTECTED AREAS AND BIOLOGICAL CORRIDORS OF BHUTAN

Source: Bhutan Biodiversity, n.d.



shared integration of the corridors into the various national plans. This is, for example, the case of the Kavango-Zambezi cross-border conservation zone (ZCT) at the intersection of the borders of five countries (Angola, Botswana, Namibia, Zambia, and Zimbabwe) and the Albertine Rift region concerning five countries (Burundi, the DRC, Rwanda, Uganda, and Tanzania). In the first case, a "cross-border ecological network" was recognised: the five countries produced a development plan (which was integrated into the national plans) to clearly describe the connection that each of the plans has with the others. In the second case, the MacArthur Foundation provided the funds for a "collaborative planning" approach with the aim of drawing up a conservation framework plan as well as detailed conservation plans. Once the plans were issued, Memorandums of Understanding (MOUs) were established.

Integrating corridor projects into national and local planning can act as a lever to limit land conflicts over the use of the territory. The protected areas are often surrounded by land in use, particularly for farming or by private parties, and the management of corridors in these territories often involves dealing with land use conflicts. This is the case of the restoration project of the Kilombero Valley Ramsar site in Tanzania in 2000, which used to be a natural refuge for migration of species during the dry season until the transformation of the landscape in the 1990s (increased agriculture, grazing, livestock and deforestation, due to the increase in population of the region). Recovery projects for certain corridors in the area have been relatively successful: although they are indeed used by many species, the corridors have had to face major land disputes with local owners, farmers, etc. This is why an integrated management plan was launched in 2016 by the Ministry of Natural Resources and Tourism, the main aims of which were improved coordination (which was practically non-existent) of the use of land in the territory between villagers, private owners, local communities, and farmers, in favour of the harmonisation of land protection and control of practices.

Home to 5% of the world's biodiversity, Costa Rica has been one of the pioneer countries in biodiversity conservation policies since the 1990s. Its policies were mainly based on one programme for protected areas, one for biodiversity corridors, and municipal land management plans. The integration of the project at the level of national policies, and following that, into the municipal plans, has allowed Costa Rica to showcase one of the most advanced policies on conservation in the world. Thus, *"Biological Corridors are not State conservation areas, but rather a separate conservation strategy implemented by the National System of Conservation Areas within the framework of the national biological corridors programme"*.[27] Since the 1990s, 40 corridors representing 38% of the territory have been set up[28] and land management plans make it possible to control activities in the territory. However, a recent assessment has shown that the corridors did not always fulfil the goal of reducing fragmentation of the territory in certain locations. In the view of the authors,[29] the results of the corridor projects in terms of connectivity could be improved if they were prioritised in government policies.

Ranked among the poorest countries on earth in GDP per capita, Bhutan has succeeded in setting up biodiversity corridors since 1999 at the initiative of the Queen Mother, thereby ensuring the conservation of 51% of its territory. Bhutan's corridors extend over 2,966.53 km², one of the largest corridor areas recorded in the Protected Planet database. The royal authorities and the government have based their country's biodiversity conservation strategy on the corridors, being pioneers in this vision of conservation. Bhutan is also one of the only countries in the world that enacted laws specifically aimed at ecological corridors via constitutional decrees.[30] Since 2008, Bhutan's constitution has set a target of protecting and conserving 60% of its territory.

The management of ecological corridors is more effective when in collaboration with local populations

Once established, corridors require detailed observation and careful management. The absence of data regarding the management and protection (via ex-post evaluations) of protected areas and corridors is one of the key points of the 2020 report from Protected Planet[31] for the 2020-2030 decade. In addition to ensuring compliance with the corridor objectives, these observations serve to limit the risks. Corridors can faster propagation of certain diseases, of invasive species, or even the spread of forest fires. This is why collaboration with local populations and their complete inclusion in corridor projects will help the monitoring and long-term existence of the corridors.

The projects with good results so far are those that involved a very detailed collaboration between all actors at a national and local level. This collaboration is usually enabled and facilitated by third-party actors, such as international foundations or NGOs that play an intermediary role between national and local governments and local populations. These intermediaries first raise awareness of the project and establish contact between the various communities before ensuring the redistribution of the benefits to the local populations. They also play a supporting role in financing, as in the case of lawyers responsible for defending the perspective of local communities regarding the corridor projects. This is what the African Wildlife Foundation (AWF) did to launch the corridor projects for the Kilimanjaro landscape, by funding a Maasai lawyer on behalf of the community, which was then able to discuss the lease before it was signed without the presence of AWF (the community thereby feeling free to provide additional input).[32]

Since it affects the human activities that surround the protected areas, achieving corridor project objectives is partly the result of successful co-management between landowners, biodiversity conservation NGOs, and communal ground managers. This coordination is difficult to establish in view of the many actors with their different interests, and the legitimacy conflicts that may arise.[33] The projects highlight the need for the decentralisation of the management of areas and corridors; the following can be read in the IUCN report on the establishment of corridors within the Ramsar site of the Kilombero valley in Tanzania: "*A long-term vision anchored in the conservation agencies could in principle underpin a long-term adaptive management process, but a shared vision, financial resources and institutional capacities are not yet available for the implementation of the plan.*"[34] It also emphasises the benefits of a transition from centralised management to "mosaic" management of smaller areas which are located on farmland, for example. This horizontal collaboration involving areas that constitute the corridors is also highlighted by the national corridor programme managed by the national government along with the local communities. For example, they are responsible for creating specific regulations on the use of land that concerns them.

The association of local communities also resurrects historical knowledge on the territory and movements of species. In the case of the Kavango-Zambezi ZCTs, it was the local communities who pointed out that a certain area in the project "*used to be a haven for animals and mobile species such as elephant and buffalo*".[35] In the case of the Albertine rift in Central Africa, the local communities helped in the study of the territory for the implementation of the corridor project to the benefit of the conservation of their ancestral territory.

Namibia, Nepal and Bhutan constitute three strategic eco-regions for biodiversity which have achieved a level of conservation and protection covering at least 50% of their territory.[36] To ensure the connectivity between the protected areas, the first two have established communal management of the connecting territories and Bhutan implemented biodiversity corridors **(FIG. 2)**.

Other types of financing are also common for biodiversity conservation. For example, the financing of corridor projects in northern and southern Kenya is based on three major instruments: REDD+ action programmes, payments for ecosystem services, and "community conservancies".[37] More than 60 conservation communities have been established in northern and southern Kenya, in territorial continuity with northern Tanzania. They promote community governance of the territory, numerous social benefits, and ensure reliable contact with donors and investors. Nevertheless, the Oakland Institute's *Stealth Game* report,[38] published in November 2021, presents a critical view of these community conservancies. Based on testimonials and complaints from recent years, the report states that the establishment of conservation communities would be carried out at the cost of an overwhelming presence of the *Northern Rangeland Trust* on the lands of pastoralists, who no longer have any power over the management of their land and who do not benefit from tourist activity revenues in these territories.

Conservation and corridor projects also generate new sources of income for local populations, based on the value placed on the biodiversity that these populations help to protect and conserve. In particular, the financial benefits generated by conservation tourism facilitate funding the management of protected areas and the corridors connecting them. The establishment of the corridors itself can also generate new jobs, such as scouts, in the case of the Kilimanjaro project, or local patrollers, in the ZCTs of Kavango-Zambezi, for example. In this region, new activities have emerged, such as "conservation agriculture".[h] Finally, projects may depend to a greater or lesser extent on donors.

h According to the definition given by the FAO, conservation agriculture "*is a farming system that prevents the loss of arable land while regenerating degraded land. It promotes maintaining a permanent soil cover, minimal disturbance of the soil, and diversification of vegetable species. [...] It opens up increased possibilities for the integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes*".

However, as the Peoples Forests Partnership pointed out at COP26 in November 2021, indigenous peoples receive only 1% of international climate finance assistance, while helping to conserve almost one fifth of the carbon sinks in tropical and semi-tropical forests.[39] In central Africa, 85% of protected areas is managed by a public authority, 14% is managed through shared governance, and 1% through community or private management.[40] At the global level, however, the management by indigenous peoples proves effective and yields results that are better than or equivalent to those of public managers in protected areas.[41] The very management of protected areas is therefore increasingly turning towards the promotion of community management. The creation of protected areas and national parks has often been done to the detriment of local communities who have lost the management and use of these lands. This is the purpose of the "LandBack" movement, born in the United States in October 2020 by leaders of indigenous peoples,[42] which aims to recall the transgenerational knowledge of their people about the history of their land and the skills for its management. The defence of this added value endorsed by the movement is based in particular on a criticism of the conservation of nature, such as it had been advocated by the first American naturalists in the 19th century, and which led to transformation of their lands into national parks – contrary to the traditional usage of the territory,[43] and without taking into account the millennia of land management by indigenous peoples.

Corridors allow species to adapt to climate change

By facilitating their migration, the corridors allow wild species to adapt to seasonal changes and ecological disturbances aggravated by climatic changes, such as wildfires or water scarcity. The delimitation of protected areas can in fact impede the ability of species to avoid these disturbances, because the biological richness of an ecosystem also promotes its stability and its ability to adapt to climate change. In fact, "*at local scales, it is likely that ecosystems with greater biodiversity are more productive and more stable through time*"[44] In this sense, the connectivity networks boost the resilience[i] of biodiversity in the face of climate change and enable the migration of species in order that they may better adapt to climate change. Numerous measures have been identified in academic research to address this problem: "*increasing the number and size of protected areas and OECMs; managing habitats to increase their resilience; establishing or widening connectivity areas; locating reserves in areas of high heterogeneity*".[45, 46, 47] To boost this resilience, researchers focus on reinforcing the conservation of existing natural habitats rather than increasing the size of protected areas.[48] To allow adaptation to temperature variations, it is necessary to ensure connectivity between different geographical areas: from a high-altitude area to a low-lying area, from a continental area to a coastal area, etc. This is the case of the Albertine Rift in Central Africa, where the aim was to strengthen existing corridors and take into account the different reliefs and altitudes. One of the drawbacks of re-establishing connectivity between two areas would be the appearance of invasive species in areas they did not previously occupy, but this phenomenon is observed mostly in marine networks.[49] The main advantage of corridors is that they benefit most species, unlike stepping stones.

The expression "climate-wise connectivity" (the use of which was popularised in 2018) describes the role of connected ecological networks in adapting to climate change. This approach goes hand in hand with the paradigm shift associated with nature conservation, taking into account the consequences of climate change. The establishment of corridors to support adaptation to climate change therefore requires, initially, a careful study of the territories and the consequences of climate change for them in order to identify the locations where these corridors will be most effective.

Several studies on the implementation of this concept have focused on the mountainous coasts of northern California. This area provides an example of climate-adapted connectivity that has yielded many results. The first assessment of climate change in California dates back to 2006, and the fourth gave rise to a report dealing with connectivity reinforcement strategies.[50] This report presented thirteen approaches to implementing climate-adapted connectivity based on the species involved, the geography of the landscape, etc. The field study identified areas that were particularly resilient to climate change, "*areas where today's climate will persist into the future and places with low climate velocity*".[51] The report also points out the difficulty of converting official planning into concrete projects and notes the low number of climate-adapted corridors put in place so far, thereby emphasising the importance of the results of the corridors already established in California. The establishment of biodiversity corridors depends on the objectives of the project: corridors that have climate change adaptation as their main objective will therefore not require the exact same corridor modelling methodology. This does not prevent it from contributing to other objectives, such as the migration of species, genetic diversity, etc.

i Ecological resilience is the ability of a system to withstand disturbances – fires, climate change, human disturbances – and to reorganise and regenerate itself in a manner that always preserves the same functions and characteristics.

KEY TAKEAWAYS

Having come to the forefront in recent years, the connections between climate and biodiversity issues make it possible to understand the cascading effects of global warming on the decline of biodiversity, and *vice versa*. Nevertheless, the conservation of biodiversity, as it has been conceived up to now, has not really made it possible to limit its decline, nor to adapt it to climate changes. The recent assessment of the corridors established at the end of the 1990s underscores the fact that they could be a tool for the strengthening of biodiversity connectivity and for the adaptation of species, if they are conceived as such. The latest results have shown that having once passed the field study and seed funding stages, corridor projects were often threatened by a complex management among the miscellaneous stakeholders and by being disregarded in national planning.

REFERENCES

RETURN TO PREVIOUS PAGE

1 Taylor, L. H. (2001). Risk factors for human disease emergence. *The Royal Society*

2 Brondízio, E. S. (2019). Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. *IPBES*

3 Observatory of Non-State Climate Action. (2020). 2020 Global Synthesis Report on Climate Action by Sector. *Climate Chance*. P.232

4 Kelly, T. R. et al. (2017). One Health proof of concept: Bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface. *Preventive Veterinary Medicine*. Vol. 137, Part B, 112-118

5 Fuso Nerini, F., et al. (2019). Connecting climate action with other Sustainable Development Goals. *Nature Sustainability*, 2, 674-680

6 Gonzalez-Zuñiga, S., et al. (2018). SCAN (SDG & Climate Action Nexus) tool: Linking Climate Action and the Sustainable Development Goals. *New Climate Institute*

7 Parker, C., et al. (2012). The Little Biodiversity Finance Book. *Global Canopy*

8 Deutz, A., et al. (2020). Financing Nature: Closing the global biodiversity financing gap. *The Paulson Institute, The Nature Conservancy & The Cornell Atkinson Center for Sustainability*

9 Forest Trends' Ecosystem Marketplace. (2021). 'Market in Motion', State of Voluntary Carbon Markets 2021, Installment 1. *Forest Trends Association*

10 *Ibid.*

11 FAO & UNEP. (2020). The State of the World's Forests (SOFO). *FAO & UNEP*

12 Santiago, S. et al. (2018). Protected area connectivity: Shortfalls in global targets and country-level priorities. *Biological Conservation*, Vol. 219, 53-67

13 Environment and Climate Change Canada. (2021). Global trends in conserved areas. *Environment and Climate Change Canada*, p.15

14 Brondízio, E. S. Global assessment report *op. cit.*

15 Osipova, E. et al. (2020). IUCN World Heritage Outlook 3 – a conservation assessment of all natural World Heritage sites. *IUCN*

16 Watson, J.E.M. et al. (2018). "Protect the last of the wild". *Nature*, 27-30

17 Hilty, J. et al. (2020). Guidelines for conserving connectivity through ecological networks and corridors. *IUCN. P.104*

18 Natarajan, I. (2001). Integrating Elephant Conservation with Protected Area Management in Sri Lanka. *World Heritage Centre, UNESCO*

19 United Nations. (2020). The Sustainable Development Goals Report. *United Nations Publications*

20 Hilty, J. et al. Guidelines. *op. cit.*

21 Waldron, A, et al. (25/10/2017). Reductions in global biodiversity loss predicted from conservation spending. *Nature*, 551, 364-367

22 Tobin-de la Puente, J. et Mitchell, A.W. (2021). The little book of investing in nature. *Global Canopy*

23 Swiss Re Institute. (23/09/2020). A fifth of countries worldwide at risk from ecosystem collapse as biodiversity declines, reveals pioneering Swiss Re index. *Swiss Re Institute*

24 Hilty, J. et al. Guidelines. *op. cit.*

25 Rodrigo, M. (13/04/2021). Farmers move to occupy a critical elephant corridor in Sri Lanka. *Mongabay*

26 Dinerstein, E., et al. (04/09/2020). A "Global Safety Net" to reverse biodiversity loss and stabilize Earth's climate. *Science Advances*, Vol. 6, issue 36

27 Hilty, J. et al. Guidelines. *op. cit.*

28 Morera-Beita, C. et al. (2021). Assessment of biological corridors in Costa Rica: landscape structure and connectivity-fragmentation processes. *Revista Geográfica de America Central*

29 *Ibid.*

30 Dinerstein, E. Olson, D., Joshi, A. et al. (Juin 2017). An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. *BioScience*, Vol. 67, Issue 6, 534–545

31 Bingham, H.C. et al. (2021). Protected Planet Report 2020. *Protected Planet*

32 Hilty, J. et al. Guidelines. *op. cit.*

33 Gray, M. et al. (2020). Climate-Wise Habitat Connectivity Takes Sustained Stakeholder Engagement. *Land*

34 Hilty, J. et al. Guidelines. *op. cit.*

35 Hilty, J. et al. Guidelines. *op. cit.*

36 Dinerstein, E. et al. (Juin 2017). An Ecoregion-Based Approach. *op. cit.*

37 Gordon O. Ojwang', et al. (2017). Wildlife Migratory Corridors and Dispersal Areas: Kenya Rangelands and Coastal Terrestrial Ecosystems. *Government of the Republic of Kenya*

38 The Oakland Institute. (2021). Stealth Game – "Community" Conservancies devastate land & lives in northern Kenya. *The Oakland Institute*

39 Bennett, G. (07/11/2021). New Global Partnership Opens Door for Indigenous People, Traditional Owners and Local Communities to Directly Benefit from Private Climate Finance. *Ecosystem Market Place*

40 Doumenge C., et al. (2021). State of protected areas in central Africa 2020. *OFAC-COMIFAC, Yaoundé, Cameroun & IUCN.*

41 Schuster, R. et al. (2019). Vertebrate biodiversity on indigenous-managed lands in Australia, Brazil, and Canada equals that in protected areas. *Environmental Science & Policy*, Vol.101, 1-6

42 Thompson, C. E. (25/11/2020). Returning the Land. *Grist*

43 Thompson, C. E. (13/01/2022). How the Indigenous landback movement is poised to change conservation. *Grist*

44 Stoett, P. et al. (2019). Biodiversity – Global Environment Outlook (GEO-6): Healthy Planet, Healthy People Chapter 6. *United Nations Environment Programme*

45 Heller, N.E., & Zavaleta, E.S. (2009). Biodiversity management in the face of climate change: A review of 22 years of recommendations. *Biological Conservation*, 142, 14–32

46 Anderson, M. G., Clark, M. & Sheldon, A. O. (2014). Estimating climate resilience for conservation across geophysical settings. *Conservation Biology*, 28(4), 959–970

47 Elsen, P. R., Monahan, W. B., & Merenlender, A.M. (2018). Global patterns of protection of elevational gradients in mountain ranges. *Proceedings of the National Academy of Sciences*

48 Hodgson, J. A., et al. (2012). The speed of range shifts in fragmented landscapes. *PLoS One 7*

49 Keeley, A.T.H, et al. (2018). New concepts, models, and assessments of climate-wise connectivity. *Environmental Research Letters*

50 Keeley, A. T. H. (2018). Climate-wise landscape connectivity: why, how, and what's next. Report for California's Fourth Climate Change Assessment. *California Natural Resources Agency*

51 *Ibid.*

TRENDS
DEFORESTATION

Rights of nature as a bastion against the destruction of natural ecosystems

MÉLAINE ASSÈ-WASSA SAMA • Project manager, Observatory of Climate Action in Africa, Climate Chance

Successive reports observe rising numbers of attacks on nature, and none of the recommended measures have succeeding in breaking the trend. Millions of hectares of forests are being lost, rivers polluted, biodiversity destroyed, and megatonnes of CO_2 emitted. But what if all of these natural elements had rights? Would nature be better protected if it had a legal personhood? All over the world, citizens and local associations have obtained official recognition of the rights of natural sites, with varying degrees of success.

DATA OVERVIEW

Deforestation continues unabated

Forests play a key role in mitigating climate change. They store about 861 billion tonnes of carbon (GtC), and over half of the global stock of carbon in soil is located in tropical primary forests.[1] Deforestation and the degradation of forest ecosystems mean that at least 260 GtC of that stock risks being emitted into the atmosphere. Without additional measures, 289 million hectares (Mha) of forests could disappear from 2016 to 2050, emitting 169 $GtCO_2e$.[2] According to estimations, deforestation is responsible for around 15% of global CO_2 emissions.[3] Tropical deforestation in particular is a significant source of CO_2 emissions: if it were a country, it would be the third biggest source of carbon dioxide emissions in the world, after China and the United States. In 2021, 25.3 million hecatres of tree cover was lost, of which 3.75 Mha of primary forests **(FIG. 1)**.[4] Tropical deforestation led to emissions of 2.5 GtCO2e, equivalaent to the annual fossil fuel emissions of India. In the Brazilian Amazon, deforestation shot up by 22% in 2021, reaching its highest level for 15 years.[5] In Africa, the annual net rate of forest loss from 2010 to 2020 is evaluated at 3.9 Mha (the highest in the world).[6]

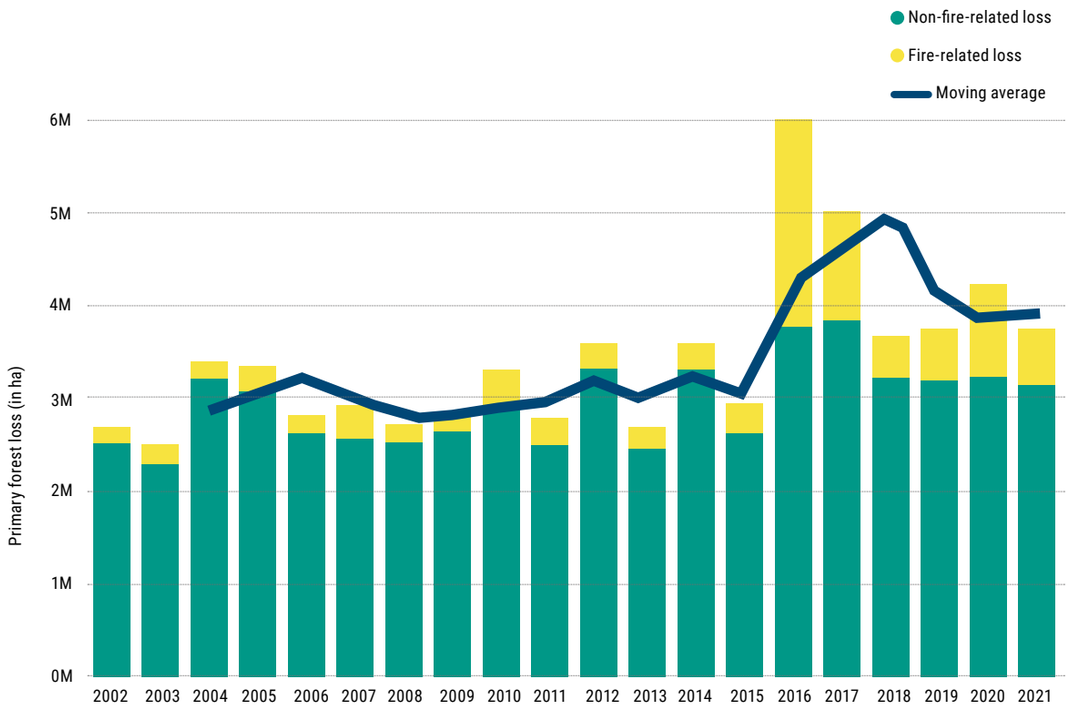
One of the causes of this disaster is agriculture, identified as responsible for 90% of global deforestation. In Africa and Asia, for example, 75% of deforestation is due to land use changes for agricultural purposes. In 2019, emissions from the farming sector represented about 7 $GtCO_2e$.[7] An estimated 4 $GtCO_2$ of emissions are due to changes to land use. Deforestation and land use changes also bring health risks. Scientists have reported a correlation between climate change, the loss of biodiversity, and deforestation,[8] while more generally, economic crises, ecological crises, and health crises are closely linked. Changes to land use are for example responsible for 30% of the new diseases identified since 1960. A recent study has also showed that, out of 250 emerging infectious diseases considered, 15% had a connection with forests.[9] Agriculture is also identified in numerous countries as the main source of water pollution. According to the FAO, about 2,250 km^3/year of wastewater is discharged into the environment, of which 1,260 km^3/year is drainage water from farmland.[10]

Among the potential solutions, the IPCC, FAO, and other monitoring organizations recommend better forest management and the implementation of innovative, inclusive measures that respect nature. The so-called rights of nature movement seems to fit in with this way of thinking. It calls for a new paradigm to protect nature, based on a legal principle, i.e., legal personality. Scattered round the world, 409 initiatives[11] in 39 countries **(FIG. 1)** including Ecuador, New Zealand, Uganda, the USA and India have had varying degrees of success in protecting rivers and forests by recognizing their rights on the same level as human rights.

FIGURE 1

ABOVE: PRIMARY FOREST LOSS BY COUNTRY IN 2021 (HECTARES)
BELOW: GLOBAL TROPICAL PRIMARY FOREST LOSS FROM 2002 TO 2021 (HECTARES)

Source: Global Forest Watch, 2022



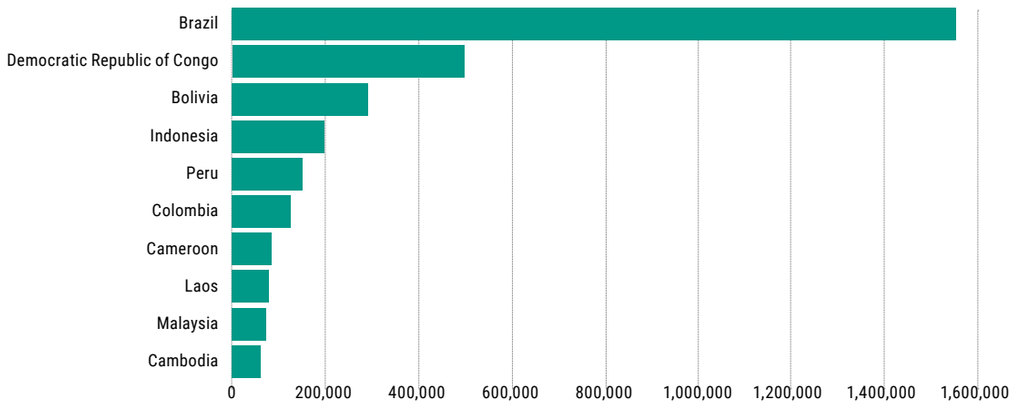
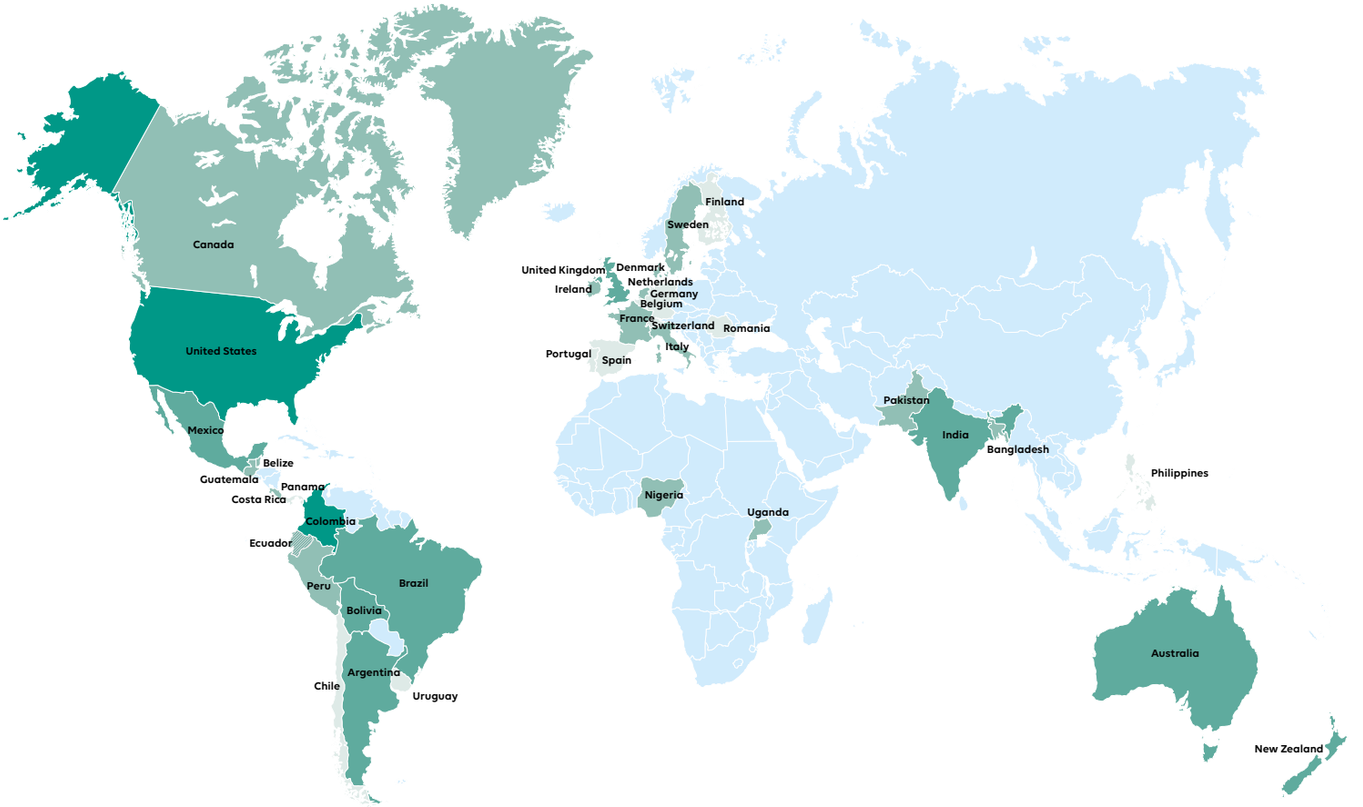


FIGURE 2

GLOBAL DISTRIBUTION OF THE RIGHTS OF NATURE

Source: Putzer, A. Lambooy, T. Jeurissen, R. & Kim, J., 2022



Distribution by country

None | Ongoing/introduced | 0-5 | 6-15 | 16 - 155

Legal types

Constitution | National Law | Court decision | Local regulation | Policy | Indigenous law | Other legal document

Debate on the constitutional rights of nature

(Ecuador is the only country to have adopted them)

Canada	
United States	
Mexico	
El Salvador	
Costa Rica	
Belize	
Guatemala	
Panama	
Colombia	
Ecuador	
Peru	
Bolivia	
Brazil	
Chile	
Argentina	
Uruguay	
Sweden	

Finland	
Romania	
Portugal	
Denmark	
Ireland	
United Kingdom	
Netherlands	
Germany	
Belgium	
France	
Switzerland	
Italy	
Spain	
Vatican	
Nigeria	
Uganda	
Pakistan	
India	
Bangladesh	
Philippines	
Australia	
New Zealand	

THE OBSERVATORY'S LENS

Recognizing the rights of nature, a new paradigm to protect natural entities

The origins of the movement: rights as a response to the relative failure of environmental law

The roots of this movement go back a long way, to the so-called animist cultures of Africa, South America and Asia, where indigenous peoples considered that natural elements, such as forests and rivers, had a soul. This meant that they were just as sacred as human life. Yet it was in the United States in 1972, in the wake of the "deep ecology" movement, that the idea of granting rights to nature clearly emerged. This school of thought appeared in the 1970s with the aim of establishing a deep relationship between humans and nature, "*beyond simply repairing and limiting ecological damage*".[12] At the time, in his article, *Should Trees Have Standing?*,[13] the lawyer Christopher Stone put forward the idea that biodiversity could have rights and plead its case when damaged by human activity.

This way of thinking was based on the following observation: the way that Western legal systems are designed makes them incapable of effectively protecting the environment. These legal systems are mostly based on the principle of *summa divisio*, which stems from Roman law and divides the legal method of analysis and organization into two categories. Western legal systems therefore make a distinction between people with rights and duties on the one hand, and things or goods likely to be appropriated on the other hand. This human-centred approach has therefore historically put human rights before natural elements, which are considered as secondary. Humans are viewed as external to nature, which is inferior, and which they dominate. Interdependence between humans and nature has no place in this system, which consecrates human domination over nature, leading to the overexploitation of natural resources, deforestation, destruction of biodiversity, pollution of lakes and rivers, and land degradation. In this system, legal and political mechanisms are established to protect forests and water courses. However, they tend to be limited by overriding economic interests and omnipresent anthropocentrism. The champions of the rights of nature movement see ecological crises like climate change and the loss of biodiversity as the consequences of legal instruments that treat nature like human property to be exploited.[14] In reaction to this relative failure of the law, the movement started by Christopher Stone, and since followed all over the world, promotes the original idea of recognizing a set of rights for natural entities like rivers and forests.

Rights for nature and its components (forests, water bodies, animals)

Unlike classic environmental law, which sees nature as an object, a thing, or a good or resource at humans' disposal, the objective of rights of nature is to recognize nature as a natural entity with inherent rights. A forest or river can therefore be considered as a legal subject. The aim is to recognize that (non-human) nature has the same rights as humans do. Society, and humans in particular, are morally bound to respect these rights of nature and protect them.[15] These include for example the right of a natural element to exist, develop, regenerate and be restored, and the right to defend itself in a court of law. The places in which this movement has had the most success are South America and Oceania.

Several countries to date have recognized the right of elements of nature to exist and develop.[16] Sometimes this involves recognizing the rights of a specific natural element like rivers or forests, and sometimes the rights of nature as a whole.

The latter option was chosen by Panama in 2022. The Central American country recently passed a law on the rights of nature that guarantees the natural world (fauna and flora) the "*right to exist, persist and regenerate its life cycles*".[17] Much earlier, Bolivia made the pioneering choice of protecting all natural elements. Through its laws of 2010 and 2012, the country recognizes the legal personality of Mother Earth, which it grants numerous rights, such the right to exist, be protected, and have its rights respected.[18] Two years earlier in 2008, Ecuador was the first country in the world to recognize the rights of nature in its Constitution. Uganda is the only African nation to date to have passed a law, in 2019, consecrating the laws of nature.[19] In the same vein, but this time through legal action, an Indian court declared that nature has a legal status comparable to that of humans, and that humans are bound to protect it.[20]

Along with these cases of recognizing the rights of nature as a whole, other initiatives have led to the recognition of the rights of specific natural entities, like rivers and streams. The most emblematic example is the recognition of the Whanganui River in New Zealand as a legal person[21] in March 2017.[22] Similarly, but this time in the Himalayan region of India, the Ganges River and its main tributary, the Yamuna, were recognized by judges as legal entities possessing their own rights.[23] In the United States, citizens decided through referendum to grant a legal personality to Lake Erie in order to protect it from a number of threats.

Rights have also been granted to forests and natural parks. In India, for example, where in their judgement on the Ganges River, judges extended these rights to all elements comprising the Himalayan ecosystem (glaciers, streams and forests). In Colombia, in a case brought to court by young children claiming that deforestation of the Amazon undermined their right to a healthy environment, the Constitutional Court recognized by extension that nature had rights just as humans do. The Court considered that citizens were part of an interdependent ecosystem that included the Amazon rainforest. As a result, it was morally conceivable that the forest had rights that should be protected in the same way as human rights.[24] In New Zealand, based on the secular beliefs of a local tribe that considered the mountain as a living being, an agreement between the government and the tribe recognized that Taranaki Mountain had a legal personality and a set of rights.[25]

These numerous examples of consecration around the world show that promoting the rights of nature has become a lever of action employed by NGOs and local communities to preserve natural ecosystems.

A means of combating deforestation, land use changes and pollution, all of which undermine natural ecosystems

This procedure can be an effective militant act used by NGOs, local inhabitants and citizens to block projects that have disastrous environmental impacts.

One example is the case of Serengeti National Park in Tanzania, the site of "*the largest remaining intact animal migration in the world, in which more than a million wildebeest and hundreds of thousands of other ungulates (gazelles, zebras) engage in an annual 1,000 km circular trek, straddling neighbouring countries Kenya and Tanzania*".[26] The Park harbors over 500 species of birds and 300 species of mammals (including 80 large mammals). Due to changes in land use, deforestation and climate change, the existence of the park is under threat.[27] Several initiatives to save the Park have been launched by local activists like Kisula Yeyeye, a member of the organization Nature's Rights, with the aim of recognizing the Serengeti National Park as a legal subject.

In Nigeria, the River Ethiope[28] is the focus of attention. The river is located in the south of the country, and crosses four areas housing over 1.7 million people. Yet the river water is highly polluted by industrial waste, along with household and farm waste, including pesticides. Lack of action by the authorities and companies concerned has seen the state of the river worsen. The Nigerian NGO RETFON, with the support of the Earth Law Center, has therefore campaigned to establish the legal rights of the Ethiope. Like other rivers in New Zealand and India, the idea is to ensure the recognition of the Ethiope's right to flow, to perform essential functions within its ecosystem, to be free from pollution, to be fed from sustainable aquifers, and its right to biodiversity and restoration.[29] In Tanzania, citizens have also employed this procedure to prevent the park from disappearing.

In the United States, a citizen ecologist called Chuck O'Neal campaigned against his home county of Orange in Florida. The aim was to change the county's charter – its mini constitution – by introducing rights of nature.[30] The county's rivers, such as the Wekiva, are subject to pollution from agricultural fertilizer, run-off from septic tanks, and badly managed rainwater. Thanks to O'Neal's efforts, an amendment recognizing the rights of nature was voted in 2020 by 89% of voters in the county. Lake Erie, located in Toledo (Ohio), has also been impacted by fertilizer and manure run-off from industrial farming, making it vulnerable to a proliferation of blue-green algae. To solve the situation and provide optimal protection for the lake, in a referendum 67% of citizens voted in favour of a project to give the lake the legal right to "*exist, flourish and naturally evolve*".[31] In Minnesota, rights of nature have been employed to block a controversial project to construct the Line 3 pipeline by Enbridge Energy, a Canadian company specializing in transporting oil. The 2.6-million-dollar installation was to bring Canadian tar sands to the Enbridge terminal on the banks of Lake Superior, the biggest freshwater lake in the world. The pipeline was planned to go through non-tribal waters where the tribes of the Indian White Earth reserve "*have the right to hunt, fish and harvest rice under treaties*".[32] In December 2018, with the "Rights of Manoomin" tribal law, the Ojibwe Indians on the White Earth reserve recognized the legal personality of wild rice, including rights like the right to exist and to flourish. Since they esteem that these rights are threatened by the oil pipeline project, the tribe has decided to take legal action.[33]

One of the most recent examples of this kind of legal action took place in France, concerning a landfill project on the banks of the Tavignano River in Corsica. The potential site is located in a Natura 2000 area,[34] and the landfill risks exposing the river to irreversible pollution, with potentially disastrous repercussions on the river's ecosystem functions. The Tavignano provides some of the coastal area with drinking water, "*irrigates surrounding crops and harbors protected species like the Raspail snail*".[35] Determined to save the river and its ecosystem, militant ecologists in the Tavignanu Vivu collective are campaigning to have the river's legal rights recognized. A first step was made with the symbolic adoption of a declaration of the river's rights in 2021. With support from local groups in the region, the collective hopes to have the legal value of this declaration recognized in order to reinforce protection of the river.

Authorities and guardians responsible for protecting recognized rights of nature

Despite the successes of this movement to recognize the rights of nature, several uncertainties remain. These mostly concern two key points: the effectiveness of the respect of these rights of nature, and how they will be defended before a judge.

In terms of their effectiveness, the movement is in its early days, and progress has been relatively recent. Nevertheless, several court cases involving the respect of recognized rights of nature have already taken place.[36] Concerning the actual protection of these rights, some original solutions have been put in place in different countries. In Ecuador and Bolivia for example, all citizens are morally bound to respect the rights of nature. Therefore, a forest can be defended by any citizen who observes that a right has not been respected. The different governments are also bound to respect these rights.

In other systems, like in New Zealand, guardians have been designated to ensure that the rights of natural entities are respected. The River Whanganui has two guardians (one named by the Maori community, or the Iwi, and another by the Crown) to defend its interests. They are therefore the river's legal representatives. Sometimes, governance committees are created to protect the rights of the natural entity concerned. This is the solution chosen for Taranaki Mountain, by which eight Maori tribes share guardianship with the government. In Bangladesh, the National River Conservation Commission has been set up to ensure the wellbeing of Bangladeshi rivers and ensure that their rights are respected.[37]

Another concern is whether this mechanism is really capable of protecting the natural entities in question. The case of the Colombian Amazon rainforest underlines this concern. In 2018, following an appeal by about twenty young people supported by the NGO *Dejusticia*, the Supreme Court of Justice of Colombia recognized that the Amazon forest had a legal personality.[38] However, in practice, the impact of this decision remains limited due to a number of factors, such as the lack of financial, logistical and human resources.[39] In addition, several people involved in protecting the Amazon rainforest have received threats, and the land continues to be occupied by private individuals. And all the while, deforestation carries on at a worrying pace.[40] Since the Farc guerrillas laid down their arms in 2016, the expansion of agricultural land and coca cultivation has accelerated the rate of forest loss: in 2021, 174,103 hectares of forest have disappeared, 1.5% more than in 2020.

KEY TAKEAWAYS

Forests, rivers and other natural elements are subject to anthropogenic violations with disastrous impacts, but at the same time a developing movement is promoting a new defence system: a legal personhood status for nature. This notion consists in recognizing the nature of fundamental rights through a jurisdiction or law. Given the relative failure of classic environmental law, rights of nature constitute a serious alternative in numerous countries around the world, such as Ecuador, Bolivia, New Zealand, India, Tanzania, and Nigeria. Indigenous communities, NGOs, and citizens have taken up this shield to tackle the threats confronting rivers, lakes and forests. Although in some countries the results have been remarkable, they need to be weighed up against the failures observed in others.

REFERENCES

RETURN TO PREVIOUS PAGE

1 World Resources Institute (2022). Global Forest Review, 2022. *WRI*.

2 FAO (2022). The State of the World's Forests 2022. Forest pathways for green recovery and building inclusive, resilient, and sustainable economies. *Rome, FAO*.

3 Burley, H., and Thomson, E., (2022). A climate wake-up: but business failing to hear the alarm on deforestation, *Global Canopy,* Oxford, UK.

4 Weisse, M., Goldman, L. (2022). Forest Loss Remained Stubbornly High in 2021. *Global Forest Watch*.

5 Burley, H., and Thomson, E., (2022). A climate wake-up…., *op. cit*.

6 FAO (2020). Global Forest Resources Assessment 2020: Main report. Rome, FAO.

7 FAO (2021). L'État des ressources en terres et en eau pour l'alimentation et l'agriculture dans le monde - Des systèmes au bord de la rupture. Rapport de synthèse 2021. Rome.

8 FAO (2022). The State of the World's Forest, *op. cit*.

9 FAO (2022). L'État des ressources en terres et en eau, *op. cit*.

10 L'état des ressources…,*op. cit*.

11 Putzer A., Lambooy T., Jeurissen R. & Kim J. (2022). Putting the rights of nature on the map. A quantitative analysis of rights of nature initiatives across the world, *Journal of Maps*.

12 Charmetant, E. (2015). Écologie profonde : une nouvelle spiritualité ?. *Revue Projet*, 347, pp. 25-33.

13 Christopher D. Stone (1972). Should Trees Have Standing? - Toward Legal Rights for Natural Objects. *Southern California Law Review*, 45, pp. 450-501.

14 Surma, K. (25/02/2022), Le Panama promulgue une loi sur les droits de la nature, garantissant le « droit d'exister, de persister et de se régénérer » du monde naturel, *Inside Climate News*.

15 Boyd, D. (2017). *The rights of nature: A legal revolution that could save the world*. ECW Press.

16 Cyrus R. Vance Center for International Justice and al. (2020), Rights of Rivers A global survey of the rapidly developing Rights of Nature jurisprudence pertaining to rivers.

17 République du Panama, Loi n° 287 du 24 juillet 2022.

18 Cyrus R. Vance Center for International Justice and al. (2020) Rights of Rivers…,*op. cit*.

19 *Ibid*. p. 49.

20 Surma, K. (04/05/2022), Indian Court Rules That Nature Has Legal Status on Par With Humans and That Humans Are Required to Protect It, *Inside Climate News*.

21 See the map of the river :https://teara.govt.nz/en/map/2174/map-of-the-whanganui-river

22 Te Awa Tupua (Whanganui River Claims Settlement) Bill, 14/03/ 2017.

23 Calmet, M. (27/12/2017), 2017, 2017, une année décisive pour les droits de la nature, *Nature Rights*.

24 Cyrus R. Vance Center for International Justice and al. (2020). Rights of Rivers…,*op. cit*.

25 Mount Taranaki Record of Settlement, 20/12/2017.

26 Observatoire International des Droits de la Nature (OIDN), (13/06/2022).The Rights of Nature : An ancient and emerging concept in Africa. *Observatoire International des Droits de la Nature*.

27 The Norwegian University of Science and Technology (NTNU) (21/05/2015). Serengeti Park disappearing. ScienceDaily.

28 Google Maps - River Ethiope

29 Blain, N. (08/05/2018). Bientôt une première rivière dotée de Droits en Afrique ?. *Droits de la nature*.

30 Surma, K. (19/09/2021). Does Nature Have Rights? A Burgeoning Legal Movement Says Rivers, Forests and Wildlife Have Standing, too. *Inside Climate News*.

31 Bouvier, P. (28/02/2022). Aux Etats-Unis, le lac Erié a désormais le droit légal « d'exister et de prospérer naturellement ». *Le Monde*.

32 Cabanes, V., Toussaint, M. (17/07/2019). Le riz sauvage reconnu sujet de droit. *Politis n° 1562*.

33 CDER. Rights of Manoomin (Wild Rice): White Earth Law and Enforcement Case. CDER.

34 http://www.natura2000.fr/natura-2000/qu-est-ce-que-natura-2000

35 Faure V. (11/07/2022). En Corse, le combat du fleuve qui parle. *Le Monde*.

36 Cyrus R. Vance Center for International Justice and al. (2020). Rights of Rivers, *Op. cit*.

37 Green Citizens. (18/02/2022). Les droits de la nature : quand l'environnement devient une entité vivante. *Unesco Green Citizens*.

38 Cour Suprême de Justice. Claudia Andrea Lozano Barragán, et al. c. Présidence de la République et al. 5 avril 2018.

39 Perruso, C. (2020). Jeunes c. Colombie (2018). *in* COURNIL, C. *Les grandes affaires climatiques, Confluence des droits*.

40 Courrier international. (01/08/2022). Incontrôlée, la déforestation continue d'empirer en Colombie.

TRENDS
AGRICULTURE

How the coffee industry is dealing with climate change

AUDE VALADE • Researcher, CIRAD

Coffee is the leading agricultural commodity on global markets in terms of value. All of the world's coffee producers are located in countries in the Global South, while nearly all of the processors and consumers are in the North, which puts the industry at the heart of the globalized economy: only 30% of the coffee volumes traded are consumed in the country they were produced in. The crop's vulnerability to climate change is therefore amplified by its likely impact on millions of small-scale farmers.

DATA OVERVIEW

Climate crisis, economic difficulties and rising demand: a hard-pressed coffee industry

Growing concentration of an expanding industry focused on export

The global production of coffee has grown 60% since the 1990s.[1] From 2000 and 2019 in particular, the production and consumption of coffee increased by an average 2% a year and forecasts based on demographic growth predict a doubling or tripling of demand by 2050,[2] depending on consumption patterns. Coffee is intensely traded on international markets: 70% of the world's production is exported, mostly from developing countries towards countries of the North. Fifty-six percent of global coffee consumption is concentrated in North America, Europe and Japan.[3] The increase in production since the 1990s is mainly driven by three countries,[4] with two different motors. In Brazil (+86%), the number one global producer, growth can be explained by the increased productivity of plantations,[5] while in Vietnam (+105%) and Ethiopia (+136%), the rise is due to an expansion of cultivated areas.[6,7] The high growth in production in these countries boosts their market share to the detriment of small producer countries. Thus, in 2018, the five biggest coffee producers took up 62% of market shares, compared to just 47% in 1995.[8]

The way that the industry is organized also generates inequalities. Coffee production is mainly the work of 25 million small producers that cover 80% of global production[9] but only marginally benefit from the profits created by actors upstream in the industry that are responsible for a large part of the value added in the chain, through coffee blends, different roasting methods, and symbolic attributes provided in bars and cafés.[10]

A series of shocks fuel already strong concerns about climate change

Despite this general upward production and consumption trend, in the short term, global economic and climate conditions and shocks create numerous variable factors in the supply and demand of coffee, reflected by a very volatile price. Following a strong downward trend since 2016, the price of coffee then doubled between 2020 and 2022, reaching 200 cents/pound after two years of successive shocks. In 2020, lockdowns all over the world saw a slump in consumption levels. Production was also perturbed by a lack of available labour and frozen international distribution channels.[11] In 2021, consumption took off again, but an exceptional drought and episodes of frost in Brazil saw global production take a dive: the price of coffee peaked. In 2022, consumption has dropped again in the wake of Russian and Ukrainian demand drops. The tension between supply and demand is easing slightly, but prices remain above 200 cents/pound.

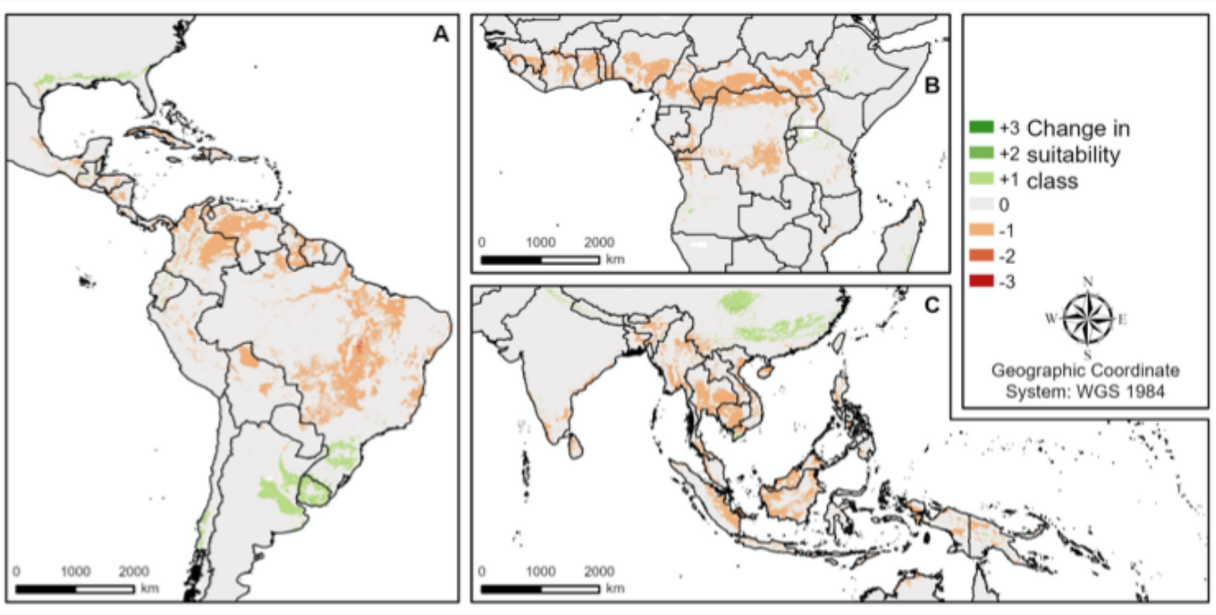
The medium-term effects of the Covid-19 crisis on coffee production are still unclear. Despite the price rise, which could encourage producers to invest, the economic difficulties facing small producers are reminiscent of the effects of the 2008 financial crisis. At that time, the drop in prices and the resources allocated to monitoring plantations led to the abandon of numerous plantations contaminated by a fungus causing coffee leaf rust, which then spread across the American continent from 2008 to 2013.[12] In 2022, the price of coffee is at its highest point but inflation is also pushing up the price of oil, and thus of fertilizers.

The industry's vulnerability to climate change is a cause for concern. Areas suitable for coffee crops could shrink by 50% by 2050 according to climate simulations.[13,14] Coffee plants only develop in specific climate zones: temperatures between 18 °C and 23 °C at altitudes between 1,000 and 2,000 m for arabica, which makes up 70% of global production; temperatures between 22 °C and 30 °C at altitudes below 800 m for robusta, although the optimal temperature was recently

FIGURE 1

CHANGE IN SUITABILITY OF LAND FOR GROWING COFFEE IN 2050 ACCORDING TO THE RCP 4.5 SCENARIO (INTERMEDIATE EMISSIONS)

Source: Grüter et al., 2021



reevaluated at around 20.5 °C.[15] Climate change brings five main risks for crops:[16,17] the shift of suitable areas to higher altitudes; an increase in water stress; temperatures too high for fruits to blossom and grow; the propagation of pests and diseases; and the increased vulnerability of small-scale producers.

Apprehensions not only concern plantations, but also the vulnerability of wild coffee plants, which are a reservoir of genetic diversity, since 60% of all wild coffee species are threatened by extinction due to climate change. In addition, deforestation and the proliferation of pathogenic attacks cause concern.[18,19]

The differing environmental footprints of coffee

The carbon footprint of coffee can be calculated using life cycle assessments (LCA), which add up the emissions at each stage of the coffee manufacturing process: manufacture of fertilizer from fossil gas, plantation, harvest, processing of coffee berries to produce green coffee, transport of coffee beans, and roasting. The scope of the analysis can be extended to include the commercialization stages with emissions related to packaging, distribution, manufacture and use of machines to prepare coffee right up to the consumer, the collecting and recycling of containers, and even emissions related to the company's operations. Despite standardized LCA methods, life cycle assessments evaluating the carbon footprint of a cup of coffee give very different results depending on the origin of the coffee, its cultivation, and transport. A global study of the carbon footprint of foodstuffs evaluated emissions related to coffee farming at 17 kgCO_2e/kg of green coffee.[20,21] But another study, focused on organic Costa Rican coffee consumed in Germany, gives a value of 5 kgCO_2e/kg of green coffee.[22] In Vietnam and Brazil, with conventional practices and exported production, the figures are reported as 16.04 and 14.61 kgCO_2/kg respectively, dropping to 3.64 and 3.37 kgCO_2/kg with sustainable practices, mostly thanks to transportation by cargo rather than air, which reduces the share of transportation in CO_2 emissions from 70% to 6% and 11% for Vietnam and Brazil respectively[23] and partly explains the variability between the different studies. When transport is left aside, as in a study on the local consumption of organic coffee in Thailand, the steps related to growing and harvesting represent up to 80% of total emissions.[24] With the cultivation stages being so important, conventional practices emit less than organic practices because they have a greater yield per surface unit.

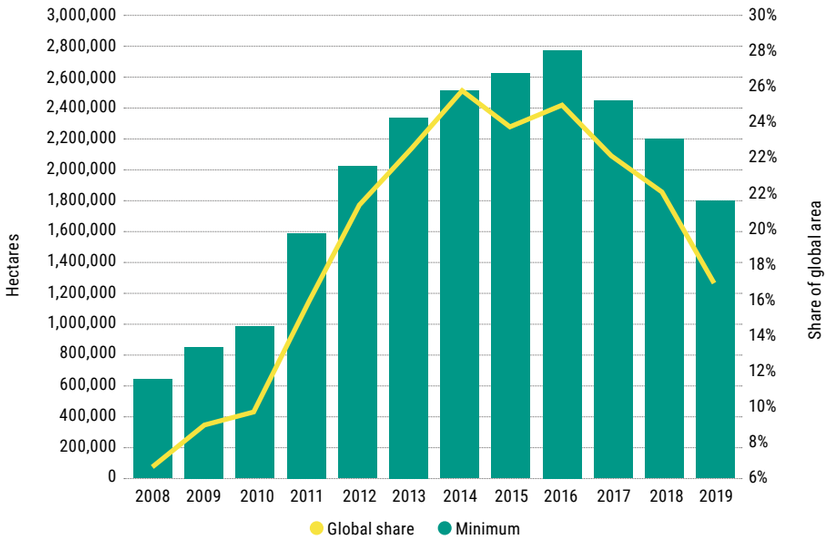
Drop in certification

Voluntary certification is one way of trying to respond to this concern. A reported 1.8 to 3.8 million hectares of cultivation are covered by one of the five voluntary standards available for coffee, which is between 16% and 34% of the global surface area of coffee crops.[25] Despite increasing demand from importing countries, and an initial rise in certifications of 78% from 2011 and 2016, coffee certification has in fact generally dropped since the mid-2010s: -31.5% between 2015 and 2019.[26,27] This contrasts with other certified raw materials following an upward trend, especially cotton and palm oil. The changing share of certified coffee is due to the investment difficulties faced by small-scale producers, at a time when production costs are rising, supply chains are disturbed, and demand is too low for these products that are sometimes sold without their label.[28] In fact, only 52% and 57% of the coffee production certified by the labels Rainforest Alliance and UTZ respectively is sold as such.

FIGURE 2

EVOLUTION OF THE SURFACE AREA OF COFFEE CROPS WITH A VOLUNTARY CERTIFICATION STANDARD

Source: ITC, 2021



THE OBSERVATORY'S LENS

The product life cycle as the primary lever of action for companies

For several years, stakeholders in the industry, from small-scale entrepreneurs to major distribution companies, have been trying to reduce the CO_2 emissions related to their activities and to coffee consumption in the Global North. Each company aims at one or more different stages of the product lifecycle.

At production level, generic tools directly target coffee growers. One example is "Cool Farm", a digital tool developed by a consortium of companies involved at all levels of the agribusiness industry. One of the objectives of Cool Farm is to put producers at the heart of action to combat climate change. In 2022, a pilot project distributed Cool Farm to organic coffee farms. Farmers use the application to input their yield, surface area, consumption of fertilizer, and energy consumption, and after several minutes receive an estimation of their carbon footprint with keys to understand the environmental implications of their practices. During this pilot project, 250 volunteer farmers will share their data and $200,000 of carbon bonuses will be distributed to those who demonstrate, using Cool Farm, the carbon sequestration in their farm.

Intercontinental distances between producers and consumers make transport a key process in CO_2 emissions linked to coffee. The Grain de Sail company, established in 2010, works to reduce the level of carbon emitted by international transportation of agricultural commodities. Four years of research and development resulted in the manufacture of an innovative cargo-carrying sailboat that complies with international expedition standards certified by independent experts (Bureau Veritas and the Marine Safety Centre). The boat can transport goods with a load capacity of 50 tonnes in a refrigerated hold using green energy. Thus, high-quality organic coffee is transported in a cargo-carrying sailboat to be roasted using high-end methods in an enterprise centred on the professional integration of people with disabilities.

Downstream in the value chain, one capsule market actor stands out for its efforts to tackle emissions relating to the final preparation of coffee by the consumer, by looking at the way that its coffee machines are made. French coffee roaster Malongo launched its ethical coffee machine, Eoh, in 2021, comprising 60% French-made parts and assembled in the Vendée region. The machine operates using pods made from unbleached paper and is guaranteed over a period of five years – compared to a legal obligation of two years.

Nespresso is a market leader in the coffee capsule segment and keeps a close watch on the entire life cycle of its coffee. According to the LCA carried out for Nespresso in 2020, 49% of emissions from a cup of coffee are generated during the coffee-growing stages, mainly as a result of fertilization (14%) and deforestation (13%).[29] In 2014, Nespresso invested €600 M in developing "The Positive Cup" plan, which aims to make its permanent "Grands Crus" range from 100% sustainable sources, increase capacities to collect aluminium capsules,

and only sell "carbon-neutral"[a] capsules from 2022 on five of its markets (USA, France, Austria, Australia, New Zealand) covering 41% of Nespresso's carbon footprint in the world.[30] The final report on the plan[31] describes the progress made. Concerning coffee-growing, 93% of the coffee purchased by Nespresso in 2021 respects the rules of its own AAA sustainable quality program, compared to 84% in 2014; 48% is certified by the Fairtrade or Rainforest Alliance labels compared to 39% in 2014. Since 2014, over five million trees have been planted, agroforestry being one of the pillars of the AAA program, which also supports the UN Sustainable Development Goals (SDGs). The recycling rate of capsules was 32% in 2020. The target of 100% "ASI" certified virgin aluminium in capsules has nevertheless been postponed and redirected towards targets to integrate recycled aluminium.

The plan implemented to reach "carbon neutrality" for capsules centres on six types of mitigation and compensation action: regeneration of parcels cultivated at each cycle to avoid deforestation, eco-design of coffee capsules and packaging using recycled and/or recyclable materials, the use of renewable energy sources for factories and stores, recycling of collected used capsules and coffee grounds, optimization of distribution logistics, and planting of trees and reforestation in and around coffee plantations. In 2021, the remaining emissions that Nespresso must compensate through the funding of certified carbon projects on voluntary markets to reach carbon neutrality in the five targeted markets amount to 506,760 tCO_2e/year. The amount of offsets required is therefore high and is likely to remain so, with an objective to reduce emissions by 20% from 2018 to 2025 established in its commitment to carbon neutrality. Nespresso's compliance with its carbon footprint and carbon neutrality objectives is assessed by a third party, the Carbon Trust Assurance, based on ISO 14067 standards (carbon footprint of products) and PAS 2060 (carbon neutrality),[b] which leave large room to carbon offsets.

Therefore, despite considerable efforts, the share of Nespresso activity covered by these commitments, in other words the production and distribution of capsules commercialized by Nespresso on five of its markets, only represents 41% of the company's overall emissions, and with a high dependence on carbon offsets.

In Costa Rica, the coffee produced by the Coopedota company has been certified as carbon neutral since 2011, also by the PAS 2060 institute. Certification was obtained after the cooperative changed its techniques, including a move to use biomass residue to produce energy, either by producing ethanol from waste to create fuel, or by burning plant waste in an electricity-producing unit, or using their own compost as fertilizer. From 2007 to 2009, Coopedota reduced its emissions from 3,889 tCO_2e to 938 tCO_2e, which is a 75% decrease.

Deforestation casts a shadow over the industry's climate footprint and worries consumers

As coffee demand continues to rise by 2% a year, climate change is threatening coffee yields. Concerns are emerging on the risk of deforestation already observed in some countries. In Vietnam, for example, production went from 19,400 tonnes a year in 1980 to 1.76 million tonnes in 2016. Although the boom can be partly explained by increased yields, currently 3.5 tonnes per hectare (compared to 0.8 tonnes in Thailand, for example), it is mostly the expansion of cultivated areas that has turned the country into the world's number two coffee producer. The production surface shot up from 50,000 hectares in 1986 to over 1.4 hectares in 2015, and continues its upward trend, with the coffee crop surface increasing by another 21% from 2010 to 2018. The Forest Trends report estimates that in 2019, deforestation to make way for coffee crops in Vietnam generated a million tonnes of CO_2 emissions.[32,33]

Action to combat deforestation in the coffee industry is organized at several levels. At institutional level, regulations are becoming stricter. In Europe, in September 2022, the European Parliament amended the proposal by the European Commission aimed at obliging private companies to ensure that agricultural products sold in the European Union, including coffee, do not come from deforested land after 31 December 2019.[34]

At company level, consortiums have been created. The "Sustainable Coffee Challenge", launched in 2015 at the initiative of Starbucks and the NGO Conservation International, now gathers 164 partners involved in the industry. Of these partners, 105 have signed 166 commitments on their actions to ensure the sustainability of the sector, including 33% roasters, 21% retailers, 19% investors, and 17% NGOs.[35] Sustainable Coffee Challenge encourages its partners to align their commitments with the UN SDGs. As a result, 50% of commitments are aligned with SDG 12 "responsible consumption and production", 39% with SDG 8 "decent work and economic growth", 31% with SDG 2 "zero hunger", 35% with SDG 13 "climate action", and 32% with SDG 15 "life on land". However, the 2021 report on partner commitments observed that only 10% of commitments made for 2020 had been met, and the 2022 report[36] esteems that only 36% of partners report on their progress after signing the commitment.

The large number of small-scale coffee farmers makes monitoring and verification of deforestation complex. Digital tools are now therefore widely used by governments, NGOs, companies and certifying bodies to evaluate the risks of deforestation. One example is GRAS (Global Risk Assessment Services).[c] Financed by the German Ministry of Food and Agriculture and developed by a multidisciplinary team comprising, among others, a consultancy firm on the use of

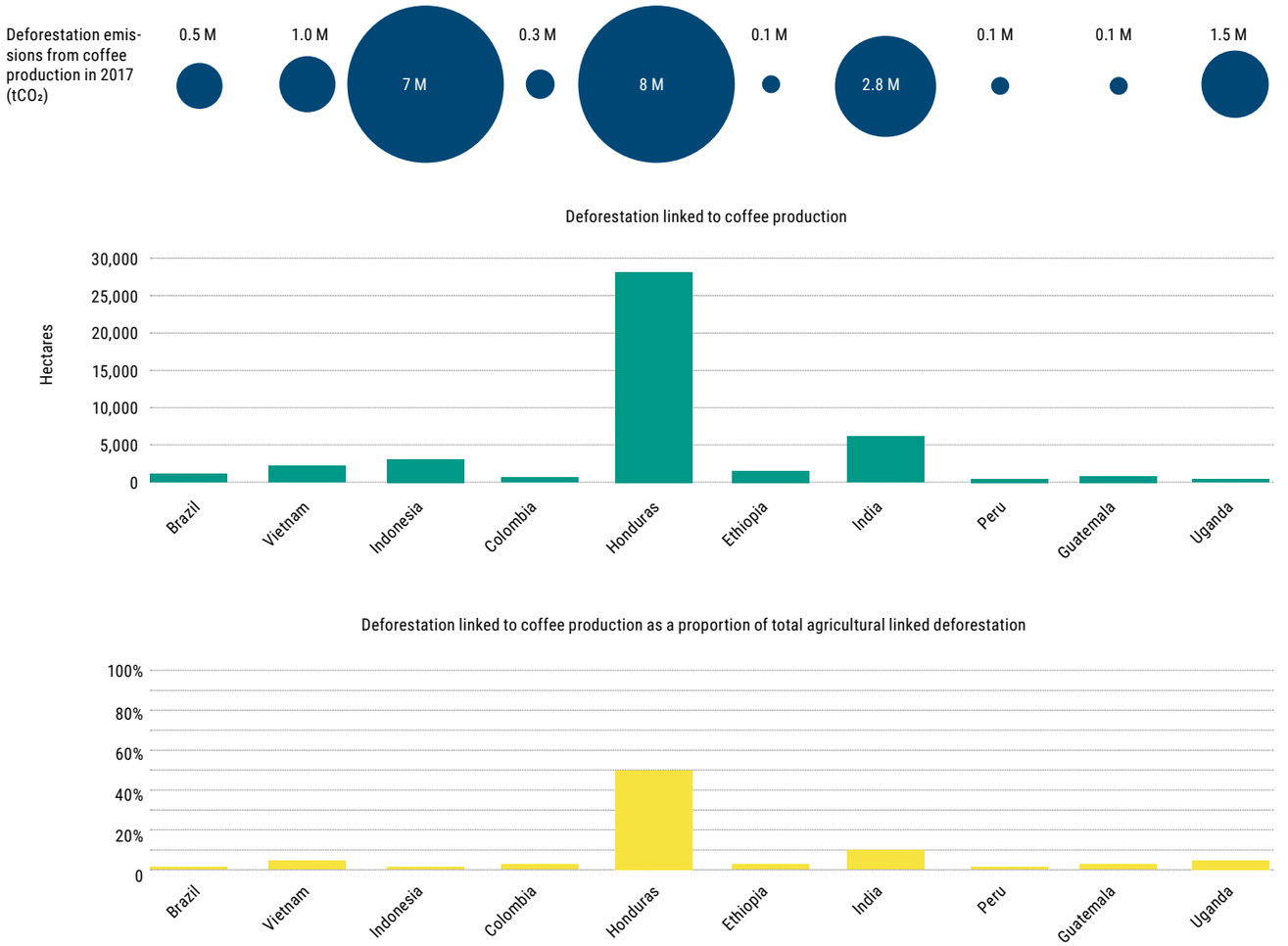
a The application of the concept of carbon neutrality at the scale of a product is controversial. To find out more, see *The Net Zero Target: The Voluntary Carbon Market Enters a New Dimension* in Global Observatory on Non-state Climate Action (2022). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

b *Idem*. For more information on PAS 2060, see *The Net Zero Target: The Voluntary Carbon Market Enters a New Dimension* in Global Observatory on Non-state Climate Action (2022). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

c https://www.gras-system.org/

FIGURE 3

LOSS OF FOREST SURFACE AND CO_2 EMISSIONS RELATED TO DEFORESTATION FOR COFFEE PRODUCTION IN THE TOP TEN PRODUCING COUNTRIES - *Source: Treanor, N.B., Saunders, J., 2021*



natural resources, a certifying body, and an aerospace research centre, GRAS employs high-resolution satellite images and data on forest areas, protected zones, and the timeline of past deforestations, to estimate the risk of deforestation for each plantation. The 4C coffee certification scheme uses this mapping tool to carry out its audits.

The fight against deforestation is also driven by consumer pressure in high-income countries, where the market for certified sustainable coffee is growing as citizens become more aware of the climate crisis. In response to this demand, roasters and retailers are undertaking different types of action. The French roaster Malongo has been committed to a sustainable approach since the 1990s. In 2022, 65% of the volume of coffee imported by Malongo is certified Max Havelaar, and 28% is certified AB (*Agriculture Biologique*). To make coffee more traceable for consumers, Malongo now includes a QR code on all of its coffee tins to inform consumers on the supplier villages, the timeline of the coffee's journey through different ports, the dates of control and roasting, and the means of preparation.[37,38] Along with roasters, some retail giants are making commitments on coffee featuring their own brands. In Europe this is the case for example for Aldi, Lidl and Sainsbury's, which only obtain their supplies from coffee certified UTZ, Fairtrade, Fairtrade USA or Rainforest Alliance. In 2022, 53% of everyday coffee sold by Aldi is certified to be sustainable, and 100% of its Simply Nature brand.[39] Retailer commitments also involve funding projects close to producers, such as the "Guatemala project" launched by Lidl in 2018. Given that women in Guatemala have less access to funding, land, and technology than men, and only 70% of women can read and write, the "Guatemala project" aims at both environmental and social issues. Its action involves supporting 92 small farms managed by women in order to help them increase their productivity and their resilience to climate change thanks to climate plans, training and technical assistance to adapt cultural practices and the introduction of new varieties, along with support to develop skills in business, management and gender issues to make women more independent.[40]

Adapting varieties and practices: intensive farming versus agroecology

Although 214 varieties of coffee plants are known today, global production turns around only two: arabica with 56% of global production, and robusta, with 43%. Arabica has a low tolerance for temperature increases and is very sensitive to coffee leaf rust, making it more vulnerable to climate change. Robusta is more resilient and resists high temperatures and leaf rust, but it has an inferior taste.

The first way of adapting coffee growing while maintaining the varieties currently cultivated involves changing practices. Coffee can in fact be grown in direct sunlight or in agroforestry, with trees planted between the coffee shrubs to give them shade. Developing crops using agroforestry currently appears to be a useful practice for adaptation and mitigation because it is a way of reducing the temperature for coffee plants by protecting them from the sun's rays while increasing carbon sequestration in land parcels.[41] The carbon stored in agroforestry parcels could be three to four times greater than in monocultures.[42,43]

A second option involves working with the genetic diversity of coffee plants to look for other varieties adapted to future climate conditions and resistant to diseases and pathogens while maintaining the quality of the coffee berries. The difficulty of this strategy is the near-extinction of wild coffee varieties. A study in 2019 estimated that 60% of coffee varieties were threatened.[44] Ethiopia and Sudan are the only two countries in which arabica grows in the wild. On the other side of the continent, in Sierra Leone, researchers working with historic specimens conserved by the Royal botanic gardens (United Kingdom) have located a planting of Coffea Stenophylla, a formerly cultivated variety that had not been observed in the wild since the 1950s.[45] The interest of this variety is that it resists temperatures 6 °C higher than arabica and 2 °C higher than robusta, and tolerates periods of drought. In addition, tasting tests carried out in a sensory analysis laboratory by a panel of experts judged that it had similar qualities to arabica.[46] Agronomic tests are being launched in Sierra Leone and on Réunion Island.[47]

Another approach is based on genetic selections from among the same variety and involves collaborations between genetic researchers, agronomists and farmers. The Breed CAFS research project, which received EU funding of €6 M, gathered researchers and farmers to select coffee varieties that are both resistant to health and climate risks and taste good in order to maintain farming revenues. Researchers have developed hybrid F1 varieties (first generation) of arabica by crossing American varieties with wild accessions originating from Ethiopia. These hybrids, which were selected for their good capacity for adapting to shade while maintaining high productivity, were tested in Vietnam, Cameroon, Nicaragua and Costa Rica. In Vietnam, for example, 40,000 seedlings were distributed to twelve farmers, planted in parallel with the Catimor arabica variety used as a control. The farmers then cultivated the hybrid plants in their farms located at different altitudes, using shading trees and sometimes interweaving annual crops in between the coffee shrubs. The Vietnam Academy of Agricultural Sciences and the Agricultural Genetics Institute then monitored the growth and health of the young plants up to the first harvest, which was then evaluated for its quantity and taste properties.[48] In the four countries where the experiment was carried out, the productivity gains ranged from 10% to 20% and the resistance to disease led to a 15% to 20% drop in the use of pesticides. The experiment has therefore been extended and a process to accredit new varieties is under way.

Cooperatives get together to boost the industry's socio-ecological resilience

Cooperatives constitute resilient organizations to tackle climate change and economic crises. Thanks to cooperatives, producers can access training on agricultural practices adapted to climate change and pool their processing and distribution services, thus increasing their profits and so boosting their investments.

Uganda features more than 1.5 million coffee producers and cultivates both varieties of coffee: robusta in the central plains, and arabica in the eastern highlands. The country also has the second youngest population in the world, with 78% of inhabitants aged under 30. Farms differ on a number of criteria – altitude, the surface area allocated to crops, the type of crops combined with coffee shrubs, the household members working outside the plantation, and the presence of livestock or not. A recent study explored the connections between the characteristics of a farm, the perception of climate risks, and the adoption of adaptation strategies.[49] The researcher showed that the adoption of adaptation practices differs depending on the level of education of the head of the family, the size of the farm, the share of dependent household members (children or old people), and the share of banana trees and coffee plants on the cultivated surface. In fact, a high level of education results in heads of family implementing more complex strategies that take into account the economic results of the farm, but that are further removed from indigenous practices. A small farm size and a high number of dependent household members weigh heavily on possibilities for investment, whereas a high share of banana and coffee trees, which are commercial crops, increases investment capacities. The gender of the head of the family also has an influence. The solutions chosen by women tend to be directed towards providing food by increasing the size of animal rearing or subsistence crops on fragile soil, while men are more likely to make structural changes, extend the surface rented, or change the varieties cultivated, with no direct relation to providing food for the household.

Faced with this diagnosis, cooperative groups make great sense and are often put forward as prerequisites to adaption action. For example, International Coffee Partners (ICP), which has an objective to support and develop the potential of small producers around the world, works with twelve cooperatives in Uganda to help each of them develop an action plan to adapt to climate change in line with their own characteristics.[50] A central component of this project is training farmers to use resourceful agricultural practices for the climate with

the aim of developing more resilient crops. Raising awareness about gender issues is also a key part of the action proposed in order to increase the number and influence of women in managing cooperatives. The current project includes 41% women on training courses and in activities organized by the projects, which concern 50,000 households.

In Rwanda, a collective of 3,000 women has gone further still by gathering female coffee farmers from six cooperatives to launch their own products under the brand *Angelique's Finest*, established in 2018 and now distributed in over 800 stores in Germany.[51] Thanks to taking charge of the entire value chain, from growing to distributing, the women have seen their profits increase by 55% compared to only selling green beans. For these women, selling their own coffee means having their own income and so financial independence. Support for this initiative from Fairtrade International is part of a goal to reduce gender inequalities in the coffee industry, where women only represent 15% of the 656 certified farmers.

KEY TAKEAWAYS

One of the most commercialized agricultural commodities in the world, coffee is facing a profound shift in its growing and consumption conditions due to climate change. Coffee production is concentrated among a handful of developing countries, and depends on very specific climate conditions. For this reason, changes in the aptitude of land to grow coffee crops is threatening the genetic diversity of species, increasing the vulnerability of plants, and exposing small farmers to revenue losses.

For producers, the industry's adaptation is taking place in two stages. One of them involves the transformation of farming practices via the development of agroecology, the selection of species, and the hybridization of varieties, all aimed at adapting coffee crops to a changing climate. The other involves the socio-economic reorganization of production units, designed to protect the farming communities that feed into and live from coffee production from the risks related to climate change. These cooperatives are a good way of pooling knowledge, disseminating practices, and boosting the resilience of producers.

In countries in the North, consumer pressure is pushing retail and producer companies to better control their impact on deforestation and its consequences for biodiversity and greenhouse gas emissions. Multilateral initiatives organize companies' implementation of their commitments to reduce emissions and deforestation. Major industry players are adopting life cycle assessment approaches to measure and trace the impact of their products throughout the industry; nevertheless, the volumes of certified coffee have been on a downward trend since the mid-2010s, due to the increase in investment costs and insufficient promotion of labelled products.

REFERENCES

RETURN TO PREVIOUS PAGE

1 ICO (2020). Coffee Development Report. The value of coffee. Sustainability, inclusiveness and resilience of the coffee global value chain. *International Coffee Organization*

2 Killeen, T.J., Harper, G. (2016). Coffee in the 21st century. Will climate change and increased demand lead to new deforestation? *Conservation International*

3 ICO *(2020). Coffee Development Report, op. cit.*

4 ICO (2022). Historical Data on the Global Coffee Trade. *International Coffee Organization*

5 Volsi, B., Santos Telles, T., Caldarelli, C. E., Gabardo da Camara, M. R. (2019). The dynamics of coffee production in Brazil. *PloS one*, vol. 14 (7)

6 Ayele, A., Worku, M., Bekele, Y. (2021). Trend, instability and decomposition analysis of coffee production in Ethiopia (1993–2019). *Heliyon*, vol. 7 (9)

7 Meyfroidt, P., Tan Phuong Vu, et Viet Anh Hoang. (2013). Trajectories of Deforestation, Coffee Expansion and Displacement of Shifting Cultivation in the Central Highlands of Vietnam. *Global Environmental Change*, vol. 23 (5), pp. 1187-98.

8 Utrilla-Catalan, R., Rodríguez-Rivero, R., Narvaez, V., Díaz-Barcos, V., Blanco, M., Galeano, J. (2022). Growing Inequality in the Coffee Global Value Chain: A Complex Network Assessment. *Sustainability*, vol. 14 (2), p. 672.

9 Treanor, N. B., Saunders, J. (2021). Tackling (Illegal) Deforestation in Coffee Supply Chains: What Impact Can Demand-Side Regulations Have? *Forest Policy Trade and Finance Initiative, Forest trends*

10 *Utrilla-Catalan, R., et al. (2022). Growing Inequality (...), op. cit.*

11 Ekita Café (21/02/2022). Pourquoi le prix du café est-il en train d'augmenter fortement ? *Ekita Café*

12 Rhiney, K., Guido, Z., Knudson, C., et al. (2021). Epidemics and the future of coffee production. *Proceedings of the National Academy of Sciences*, vol. 118 (27)

13 Grüter, R., Trachsel, T., Laube, P., Jaisli, I. (2022). Expected global suitability of coffee, cashew and avocado due to climate change. *PloS one*, vol. 17 (1)

14 *Killen, T.J., Harper, G. (2016). Coffee in the 21st century (...), op. cit.*

15 Kath, J., Byrareddy, V. M., Craparo, A. et al. (2020). Not so robust: Robusta coffee production is highly sensitive to temperature. *Global Change Biology*, vol. 26 (6), pp. 3677-88

16 *Grüter, R., et al. (2022). Expected global suitability (...), op. cit.*

17 Solymosi, K., Teche, G. (2019b). Coffee production in the face of climate change: country profiles. *IDH Sustainable Trade Initiative, Global Coffee Platform, Specialty Coffee Association, Initiative for coffee&climate implemented by Hanns R. Neumann Stiftung, Conservation International*

18 Davis, A. P.,Chadburn, H., Moat, J., et al. (2019). High extinction risk for wild coffee species and implications for coffee sector sustainability. *Science advances*, vol. 5 (1).

19 Tournebize, R., Borner, L., Manel, S., et al. (2022). Ecological and genomic vulnerability to climate change across native populations of Robusta coffee (Coffea canephora). *Global Change Biology*, vol. 28 (13), pp. 4124-4142

20 Poore, J., Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, vol. 360 (6392), pp. 987-92.

21 Pourailly, N. (2021). Some CO_2 with your coffee. *Act for coffee. The mag*

22 Killian, B., Rivera, L., Soto, M., Navichoc, D. (2013). Carbon footprint across the coffee supply chain: the case of Costa Rican coffee. *Journal of Agricultural Science and Technology. B*, vol. 3 (3B): 151.

23 Nab, C., Maslin, M. (2020). Life cycle assessment synthesis of the carbon footprint of Arabica coffee: Case study of Brazil and Vietnam conventional and sustainable coffee production and export to the United Kingdom. *Geo: Geography and Environment*, vol. 7 (2)

24 Phrommarat, B. (2019). Life cycle assessment of ground coffee and comparison of different Brewing methods: a case study of organic Arabica coffee in Northern Thailand. *Environment and Natural Resources Journal*, vol. 17 (2), pp. 96-108.

25 Meier, C., Sampson, G., Larrea, C., et al. (2020). The state of sustainable markets 2020. Statistics and emerging trends. *International Trade Centre*

26 Kath, J., et al. (2020). Not so robust.... *op. cit.*

27 Meier, C. et al. (2020). The state of sustainable(...), *op. cit.*

28 Rainforest Alliance (2021). Coffee certification data report 2020. Rainforest alliance and UTZ programs. *Rainforest Alliance*

29 Quantis (2021). Life cycle assessment (LCA) of an espresso cup of coffee made from a Nespresso professional capsule compared with other Quantis coffee systems in Switzerland, in a business environment. *Nespresso*

30 Nespresso (2021). Product carbon footprint. Qualifying explanatory statement. First period: 1st January 2020 to 31st December 2020. *Nespresso*

31 Nespresso (2020). The positive cup. Because coffee can a positive impact. 2014-2020 achievements. Creating shared value report. *Nespresso*

32 Thang, T. C., Vu Huy Phuc (2016). Vietnam's Coffee Policy Review. *FFTC Agricultural Policy Platform*

33 *Treanor, N. B., Saunders, J. (2021). Tackling (Illegal) Deforestation (...), op. cit.*

34 European Parliament (08/09/2022). New Rules for Companies to Stop EU-Driven Deforestation around the World | 12-09-2022 | News | European Parliament. *European Parliament*

35 Sustainable coffee challenge (2021). 2021 Hub report. *Sustainable Coffee Challenge, Conservation International*

36 Sustainable coffee challenge (2022). 2022 Hub report. *Sustainable Coffee Challenge, Conservation International*

37 Hoffman, F. (11/06/2021). Malongo lance un café chez Carrefour avec la technologie blockchain. *Linéaires*

38 Depinoy, S. (25/06/2021). Jean-Pierre Blanc (Malongo) : "Le consommateur veut avoir la certitude que le produit est naturel et équitable mais il veut aussi en savoir plus sur les paysans". *Franceinfo*

39 ALDI (2022). How We're Working Together to Make Sustainability Affordable. *ALDI*

40 Rainforest Alliance (06/11/2018). 'Project Guatemala': How Lidl Empowers Women And Addresses Climate Change in Coffee Farming. *Rainforest Alliance*

41 Rahn, E., Vaast, P., Läderach, P., et al. (2018). Exploring Adaptation Strategies of Coffee Production to Climate Change Using a Process-Based Model. *Ecological Modelling*, vol. 371, pp. 76-89

42 Hergoualc'h, K., Blanchart, E., Skiba, U., et al. (2012). Changes in Carbon Stock and Greenhouse Gas Balance in a Coffee (Coffea Arabica) Monoculture versus an Agroforestry System with Inga Densiflora, in Costa Rica. *Agriculture, Ecosystems & Environment*, vol.148, pp. 102-10

43 Van Rikxoort, H., Schroth, G., Läderach, P., Rodríguez-Sánchez , B. (2014). Carbon footprints and carbon stocks reveal climate-friendly coffee production. *Agronomy for Sustainable Development*, vol. 34, pp. 887-897

44 *Davis, A. P., et al. (2019). High extinction risk (...), op. cit.*

45 Royal Botanic Gardens Kew (2021). 'Forgotten' coffee species that grows at higher temperatures and boasts a superior flavour could help to futureproof the coffee industry under climate change, says new study. *Kew*

46 Davis, A. P., Mieulet, D., Moat, J., et al. (2021). Arabica-like flavour in a heat-tolerant wild coffee species. *Nature Plants*, vol. 7 (4), pp. 413-18.

47 *Royal Botanic Gardens Kew (2021). 'Forgotten' coffee species (...), op. cit.*

48 Communicaffe (2021). A Cirad/Breedcafs Project Introduces Climate-Resilient Coffee Hybrids in Vietnam. *Comunicaffe International.*

49 Mulinde, C., Majaliwa, J. G. M, Twinomuhangi, R., et al. (2019). Perceived Climate Risks and Adaptation Drivers in Diverse Coffee Landscapes of Uganda. *NJAS - Wageningen Journal of Life Sciences*, vol. 88, pp. 31-44.

50 ICP (2021). International Coffee Partners (ICP) in Uganda. *International Coffee Partnership*

51 Fairtrade international (07/03/2022). Strong Women, Strong Cooperatives, Strong Coffee. *Fairtrade International*

SIGNALS

A ROUND-UP OF THE INITIATIVES, REGULATION CHANGES, AND MARKET TRANSFORMATIONS OF TODAY THAT SIGNAL THE CLIMATE ACTION TRENDS OF TOMORROW

Urban Planning • Greening the American Rust Belt

Cities forming the "Rust Belt" (a region in the United States that has been undergoing an industrial decline in the last half century) have been sitting on resources like abandoned neighbourhoods or factories for years. A few years ago, cities like Gary, Detroit and Buffalo, started working to put these sites to alternate uses – creating urban forests, farms, stormwater management lots and other green spaces. The movement, along with reducing urban temperatures and sequestering carbon emissions (by up to 14,000 tCO_2 over 15 years, as in the case of a tree-planting project in Gary and six other Rust Belt cities), also contributed to the economic revival of the cities, beginning with an increase in property values, as observed in the case of Detroit. With the ongoing economic inflation, as bigger cities become unaffordable, the Rust Belt is seeing a rebirth, with people moving into these cities, citing access to green spaces as a motivating factor.

Finance • France's pioneer thematic investment fund for the timber industry

With the RE2020 regulation set to encourage the use of timber in construction, IDIA Capital Investissement (Crédit Agricole) and the forestry investor network Forinvest have created the *Fonds Développement Filière Bois* (FDFB), the first French investment fund in the timber sector. A thematic fund selects its assets on the basis of a societal theme (e.g., global warming mitigation, water management, mobility, ageing, etc.), which can cover several sectors of activity, categories of companies and geographies. Between 2019 and 2021, assets under management in thematic funds tripled $806 bn worldwide, mostly in Europe (55%) and the US (21%), with a focus on water, security and robotics. With a hoped-for fundraising of €40 M, the FDFB will invest €0.5-5 M in minority stakes in projects across the entire sector: primary and secondary processing, construction, wood energy, wood chemistry, etc.

Spain • A land dispute over Europe's largest PV solar power plant

Two years after its commissioning in April 2022, the High Court of Justice of the Spanish region of Extremadura has ordered Iberdrola to close down 60% of the Nuñez de Balboa solar power plant, near the Portuguese border. With a capacity of 500 MWp installed on more than 1,000 ha, it is the largest photovoltaic plant in Europe. Its annual production of 832 GWh is expected to provide electricity to 250,000 inhabitants and avoid the emission of 215 $MtCO_2$/year. The court decision ruled that 525 ha of land were illegally expropriated for the plant. Natura Manager, which had a 25-year lease on the land, did not challenge the project: but the ruling states that Iberdrola did not follow the legal procedures for expropriation. The EU's RePowerEU plan aims to ease the procedures for installing solar and wind power to speed up the continent's energy transition.

PV Magazine, 20/06/2022

Indigenous peoples • Onondaga Nation recovers ownership and management of over 1,000 hectares of its ancestral lands

1,023 hectares of land will be returned to the Onondaga Nation, according to a June 29 2022 decision by the State of New York and the Department of the Interior. The land is located in the Tully Valley, a biodiversity hotspot rich in forests, wetlands and protected species such as brook trout, bald eagles and great blue herons. The Department of the Interior and NY State had previously assessed the damage to Onondaga Lake caused by Honeywell in a 2018 decree at $26 million. The transfer of title to the valley, held by the company, is one of 18 restoration projects included in the 2018 agreement. The "Landback" movement, officially launched on October 12, 2020, has thus achieved a major victory with this previously unmatched portion of ancestral land returned to an indigenous people. *Grist, 05/07/2022*

New Zealand • A tax on emissions from burping cows and sheep

New Zealand counts more than double the number of cattle, and five times the number of sheep than of people, and has about half its total greenhouse gas emission come from the agricultural sector. As per a recent plan drafted by representatives from the government and the farm community, farmers will have to pay a price for emissions from livestock. The scheme proposes incentives to farmers to reduce emissions of methane from their belching livestock through feed additives, while also allowing for on-farm forestry as a means to offset emissions. The revenue from the scheme is to be invested in research and development, and advisory services for farmers. This proposal, if accepted, will be the biggest regulatory disruption in the agriculture sector in the country, since the removal of subsidies in the 1980's.

Reuters, 08/06/2022

Carbon markets • AgriCarbon, a carbon credit programme for the transition of South African agriculture

In South Africa, livestock farming is one of the largest sources of greenhouse gas emissions. To help decarbonise the sector, the carbon offset operator Climate Neutral Group (CNG) has launched AgriCarbon, a programme to certify emission reductions from the agricultural sector. Forty dairy farms are participating in the project, committed for example to reducing their inputs of nitrogen fertiliser, which generates nitrous oxide (N_2O). More than 18,000 ha have been audited since the programme was launched, and 230,000 tCO_2 of carbon credits will be issued on the voluntary market this year, at a price of \$15-25/tCO_2e – well above the global market average (3.37\$/t). This initiative illustrates the growing interest in nature-based solutions, and in particular "carbon farming", which aims to value mitigation actions in the agricultural sector. In France, the France Carbon Agri Association engages 302 farmers to reduce their emissions, for a potential reduction of 138,800 tCO_2, while the European Commission is seeking to develop the potential of carbon farming in the EU.

Reuters, 06/04/2022

Agriculture • Adapting to climate change through a network of community seed banks in Nepal

Community seed banks in Nepal date back to 1994, initially being established with the aim conserving local species of crops, under the pilotage of local NGOs. As the practice grew in success, attracting more funding, it has also fulfilled more functions – including community and women empowerment, food security, and most recently, climate change adaptation. As the seed banks have coalesced into a national network (with the government recognising 53 seed banks in operation), increasingly larger numbers of farmers are resorting to them. Native species of crops, including staples like rice, have proven to be more resistant to local conditions, and the increased occurrence of extreme weather. While larger seed banks exists throughout the world, their importance highlighted in light of the Russia-Ukraine crisis, the strongest community-led trends appear to be in Asia, Latin America and Africa.

Mongabay, 14/07/2022

Wood fuel • A new EU amendment aims to exclude wood fuel from the list of renewable energy resources

If the new amendment tabled by Nils Torvalds is confirmed by a vote in the European Parliament in September, governments will no longer be able to grant subsidies for producing electricity from biomass from forests from 31 December, 2026. Wood fuel is the largest source of primary renewable energy production in Europe. However, for the same mass, it generates two to three times more CO_2 than burning fossil fuels. The deforestation caused also affects the carbon sink capacity of forests. This is particularly true of primary forests, which are the guardians of a larger carbon stock than other forests and of unique biodiversity resources. This is the message of an open letter by 500 scientists published in March 2021, which states that if wood fuel were to be increased to 2% of the world's energy mix, forest harvesting would have to be doubled. However, another group of environmentalists regretted that secondary biomass (sawdust, black liquor and wood waste) was not taken into account in the amendment. As for the bioenergy lobbies, they defended its importance as a means of freeing themselves from Russian gas.

Euractiv, 20/05/2022

CASE STUDIES

REGION CASE STUDY

COUNTRY	STATE	POPULATION	REDUCTION TARGET	NATIONAL EMISSIONS IN 2018
TANZANIA	MANYARA	59,734,213	-35% GHGS IN 2030 (BASE BAU)	11.58 MT

Yaeda valley • By protecting their land and wildlife, local populations obtain income through the carbon compensation mechanism

In the United Republic of Tanzania, a forest management policy is being developed involving local communities. This is the Yaeda valley project, which involves the Hadza community and contributes to achieving 12 of the 17 Sustainable Development Goals (SDGs) through a carbon offset scheme.

NGOs at the origin of an initiative to restore land rights to the Hadza

One of the last hunter-gatherer tribes in the Yaeda valley, the Hadza people have lived in Tanzania for about 40,000 years. Their very ancient way of life depends on forests which provide them with everything they need: seeds, fruits, meat, water, and pasture for livestock. Over the last century, their land was reduced by three quarters largely due to the influx of immigrant farmers who illegally converted forests into farmland. This change in land use threatens the existence of the Hadza, their traditional way of life, and the biodiversity of the Yaeda valley. Faced with this problem, in 2011, the NGO UCRT started to help the Hadza people protect their land by acquiring titles to at least 32,000 hectares. The Yaeda-Elyazi project sprang from this initiative.

The project was first developed in 2011 by Carbon Tanzania and UCRT in partnership with Hadza hunter-gatherer communities under the REDD+ label, a scheme for reducing emissions from deforestation and forest decline.

Protecting forests from poachers and encroaching agriculture

In its initial phase, the project covered 32,000 ha of ancestral Hadza forests. As of 2019, it covers 110,500 ha of forests belonging to the Hadza and Datooga peoples. Concretely, during the first phase of the project, the land use plans were worked out as required by the Tanzanian government (as a condition for obtaining the title), by zoning farm areas, housing, pastures, merged areas, cattle pens, water catchments, hunting grounds, and the setting aside of some land for nature.

During the second phase, members of the Hadza communities were trained as scouts to patrol and collect data. They also reported any changes in land use, such as invasive and illegal farming and poaching activities. Starting from 20 scouts initially, it now employs 57 people trained as patrollers in forest protection, the monitoring of wildlife, and the use of smartphones for mapping. Today, patrols protect 37 large mammal species, including the endangered elephant, the wild dog, the lion and the leopard, and 255 species of birds, including the endangered lappet-faced vulture and two endemic bird species, according to a scientific study conducted in 2019. The project has also maintained and revived the hunting traditions of the Hadza people.

An example of successful carbon offsetting

Each year, the project prevents the felling of 171,100 trees and the emission of 177,284 tCO_2e. These avoided emissions are quantified, certified as carbon credits, and then sold on the voluntary carbon market. After expansion of the project, at least 60% of the revenue from the sale of credits was given directly to the communities. The remainder covers the project follow-up and overheads. According to estimates, the project in its current phase is expected to return $450,000 per year to the local population. At present, the compensation company MyClimate is the main buyer of project credits.

Social and economic benefits for Indigenous communities

Until recently, the Hadza were marginalised in Tanzania. Revenues from the project made it possible to provide basic services to the 61,000 members of the community: health care, children's education, food security, and straightforward, sustainable jobs as community guards. For example, the project has bolstered their legal rights to their land and natural resources. The monthly payments to the community stimulate forest monitoring and protection. The project is helping to reduce gender inequalities: the women are employed as project leaders and are encouraged to participate in community meetings and to give their opinion on the management of the revenues. These revenues are used to ensure the primary and secondary education of more than 20 children and to finance the introduction of outreach clinics once per semester in the region.

REGION CASE STUDY

COUNTRY	STATE	POPULATION	NATIONAL MITIGATION TARGET	STATE EMISSIONS IN 2013
INDIA	WEST BENGAL	101,600,000 (2022)	-33 TO -35% IN EMISSIONS INTENSITY OF GDP BY 2030 (BASELINE 2005)	171,7 $MTCO_2e$

Sundarbans • Banking on mangroves for land, life and livelihood

The Sundarbans are archipelago of islands at the mouth of the Ganges, in eastern India and Bangladesh, and the world's largest estuarine mangrove ecosystem. In the face of increasingly frequent and devastating flooding and storm surges, local communities in the state of West Bengal, in India, have taken the lead in afforesting embankments with mangroves, enabled by a local NGO, the Nature Environment and Wildlife Society (NEWS), channelling funding from the private sector and international non-profits. Along with its immense carbon sequestration potential, these mangroves are also home to the Bengal tiger, and species of rare snakes, fish, and crustaceans – all of which have benefitted from the afforestation programme.

Adaptation through afforestation

The Sundarbans delta has already experienced the impacts of global warming, having lost more than 28% of its habitat, and nearly 4% of island surface area due to rising sea levels in the last century. While higher salinity in the water has affected fish populations and local agriculture, cyclones like Aila in 2009 have also caused significant damage to villages and settlements.

In this context, local communities have taken to planting more mangroves along the embankments protecting the land, with the project headed by NEWS, launched in 2011, having planted more than 16 million mangroves. Since then, 5,200 ha of mangroves have been restored, through rigorous planting drives every monsoon season. The mangrove forest has proven to protect the embankments, and subsequently, the settlements and habitats it hosts, against storm damage by reducing the height and velocity of waves. In 2020, when the Amphan cyclone hit the region, the restored mangroves played an important role in acting as bio-shields.

Climate and biodiversity benefits

One of the most significant outcomes of the mangrove restoration is the sequestration of carbon – blue carbon ecosystems (blue carbon referring to carbon that is stored in marine or ocean environments) are some of the most effective natural carbon sinks. The NEWS project in the Sundarbans, over a span of 20 years, is set to sequester 700,000 tonnes of CO_2. The project issues carbon credits to the private institutions financing it (such as Danone, Schneider Electric, Crédit Agricole and others, through the Livelihoods Carbon Fund), a model that has helped NEWS scale up the project and replicate it across more villages in the delta. Funding is also channelled from the domestic private sector, and from national and international non-profit organisations and initiatives.

The project has also contributed to a restoration of local biodiversity. The Sundarbans are the sole habitat of the Bengal tiger, the Ganges River dolphin, the Irrawaddy dolphin, the Indian Python, the Estuarine crocodile, and over 260 species of birds. The mangrove restoration has helped fish, bird, shrimp, crabs and other species to return, and have also contributed to livelihoods, through for example, the culture and local trade of shrimp and crabs.

Improving livelihoods

The project also has economic inclusion at its heart, and a goal to empower the local community, especially women – who have been the stewards of the project, right from making hand-drawn maps of the areas covered, working in the nurseries, and planting the mangroves, to surveying and protecting them. Their participation allows them to earn about $430 a year, a valuable addition to the household budgets.

In exchange for their work, NEWS also helped the local communities by launching a brand, Badabon Harvest (*Badabon* being the Bengali word for mangrove), accelerated by the start-up GRINS, to facilitate the access to the market in Kolkata to sell organically cultivated food. This permitted improved revenues, and the implementation of more sustainable methods of livestock breeding, agriculture, pisciculture, apiculture, and so on.

CITY CASE STUDY

COUNTRY	VILLE	POPULATION	GOAL	NATIONAL UNDERNUTRITION RATE	NATIONAL OBESITY RATE
SOUTH AFRICA	DURBAN - MUNICIPALITY OF ETHEKWINI	3,442,361 (2011)	INCREASE THE AMOUNT OF FOOD PRODUCED LOCALLY BY 50% BY 2030	45.6% (2013)	35.2% (2017)

Durban • Agroecology to fight against food inequalities

Since 1975, global obesity has almost tripled: 1.9 billion adults were overweight in 2015, and of these, 650 million were obese. In the same year, 340 million children and adolescents from five to 19 years of age became overweight or obese. Yet, the "Zero Hunger" SDG 2 solely focusses on the food deficit component, and does not mention in its targets the quality of nutrition or overconsumption. Globally, there are now more deaths from excess weight and obesity than from insufficient weight: this is called the double nutritional load. In this respect, South Africa is in a paradoxical situation, with half of the country's population suffering from malnutrition while there is an increase in problems related to being overweight.

Inequalities in access to food are the primary cause of this health scourge. Young people and women are particularly affected: 70% of women are overweight and 42% are obese. Low-income households tend to turn to junk food, which is widely accessible, more affordable, and a source of instant gratification.

The Municipality of eThekwini: public action in the service of small-scale farmers

The municipality of eThekwini (Kwazulu-Natal province), one of the eight metropolitan municipalities that make up South Africa, participates in the AgriHubs project initiative. While 55% of the eThekwini territory is made up of rural areas, the majority of the population is concentrated in urban centres. The Zulu population, in particular, (77.8 % of the population of Kwazulu-Natal) is concentrated in urban ghettos, a lingering legacy of Apartheid. Aware of the links between unemployment, food insecurity among young people, and the increase in obesity, the municipality supports the introduction of new farmers to land belonging to the metropolitan municipality and is developing a cross-cutting approach to meet SDGs 10 "reduced inequality", 13 "the fight against climate change" and 15 "life on earth". In 2020, 426 new farms were created in the territory.

In order to train these farmers and facilitate their access to the market, seven AgriHubs or "agrotechnological platforms" have been set up around the city. These multifunction sites offer training in agroecology (schooling farms) as well as shared tools and logistics. New farmers can thus develop their skills in order to increase their production while reducing their costs, thanks to donations of seeds, inputs, compost, or even fences. Spread throughout the territory, the AgriHubs make it possible to gather and store the farming products, which are then purchased by the municipality in order to supply the 589 small school refectories and soup kitchens in the territory, or be directly sold on wholesale markets. Supplying the schools with fresh fruits and vegetables contributes to curbing weight problems among the youngest. 400,000 healthy meals are in this way distributed to the city's children every day. Agroecology also reduces emissions related to agriculture, the second largest emitter of GHGs in South Africa.

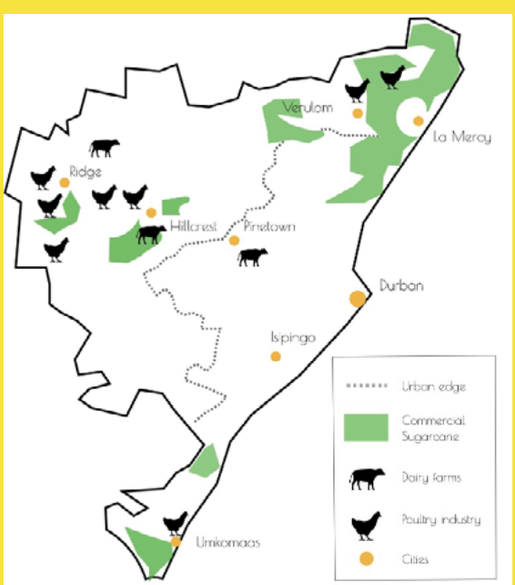
Public and private partners addressing the SDGs

The agroecology and agribusiness services of the eThekwini municipality work closely together in building a sustainable food system for the territory. The municipality is thus one of the main investors in the Fair Food Company social enterprise. The Fair Food Company supports and trains small farmers in sustainable and productive agricultural practices while offering them a variety of markets in order to increase their income. Since 2013, the company has been developing the Edamame bean industry. The beans are rich in proteins and are particularly beneficial for soil enrichment.

Fair Food Company has created many jobs in the vegetable business: it guarantees the purchase of a quantity of vegetables which will be processed and sold wholesale and to company restaurants. The company supports about 1,600 small farmers in the Kwazulu-Natal province.

IDENTIFICATION OF THE MAIN AGRICULTURAL AREAS IN THE METROPOLITAN AREA

Source: eThekwini Metropolitan Municipality, 2005, via Let's Food Cities



SPECIAL FEATURE

THE NET ZERO TARGET: THE VOLUNTARY CARBON MARKET ENTERS A NEW DIMENSION

GLOBAL SYNTHESIS REPORT ON CLIMATE ACTION BY SECTOR

2022

CLIMATE CHANCE

IN PARTNERSHIP WITH

ecoact
an atos company

SWEPT BY THE NET ZERO WAVE, THE VOLUNTARY CARBON MARKET DRIFTS TOWARDS NATURE-BASED SOLUTIONS

A barometer of climate action, carbon neutrality boosts the voluntary carbon credit market

137 States with a carbon neutrality target

Portion of global emissions covered by States' carbon neutrality commitments

zerotracker.net

NON-STATE ACTORS COMMITTED TO THE RACE TO ZERO CAMPAGNE

67 REGIONS

5,235 BUSINESSES

1,049 CITIES

441 INVESTORS

1,039 HIGHER EDUCATIONAL INSTITUTIONS

CITIES RACE TO ZERO

1,049 CITIES

SBTI GLOBAL COMPACT

1,225 BUSINESSES

$23,000 bn market capitalisation, across 53 sectors in 60 countries.

OF WHICH 64 BUSINESSES

are certified to the Net Zero Corporate Standard of the SBTi for their short-term and long-term strategy to acheive net zero.

NET ZERO ASSET MANAGERS INITIATIVE

273 ASSET MANAGERS

$61,300 bn in assets managed

NET ZERO INSURANCE ALLIANCE

20 INSURANCE COMPANIES

$7,000 bn in assets managed and 11% of the total premiums paid worldwide.

NET ZERO BANKING ALLIANCE

115 COMMERCIAL BANKS

$70,000 bn in assets managed, 38% of the global total.

RACE TO ZERO

Race to Zero is the global campaign to mobilise non-state actors towards carbon neutrality by 2050. It covers 25% of global CO_2 emissions and 50% of the global GDP.

Race to zero
C40, 2022
United Nations Global Compact & Science Based Targets initiative (SBTi)
The Net Zero Asset Managers initiative, 2022
UNEP FI, 2022
SBTi, 27/07/2022

The volume of carbon credits issued exceeds the volume of credits retired by 129% over the first 11 months of 2021. The difference is due in particular to the stocks of credits accumulated by intermediaries, and therefore does not necessarily reflect a demand deficit.

The size of the voluntary carbon market quadruples in 2021

VOLUME OF VOLUNTARY CARBON CREDITS EXCHANGED GLOBALLY IN 2021

Over 2021, traded carbon credits' value quadrupled and carbon volume increased by 143%.

Ecosystem Marketplace, 2022

CREDITS ISSUED

1,488,304,473 tCO_2e

VOLUME OF VOLUNTARY CARBON CREDITS PLACED ON THE MARKET

+129%

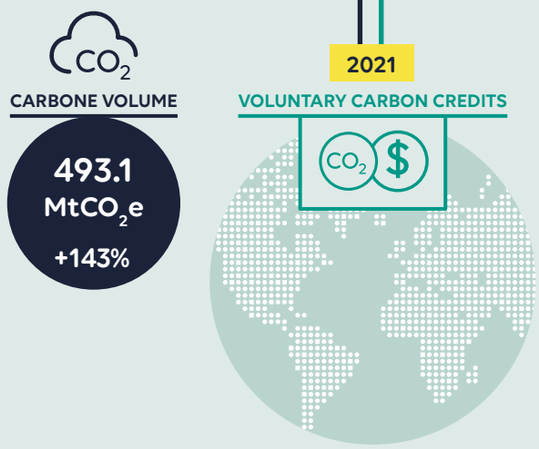
+40% BETWEEN 2020 AND NOVEMBER 2021

CREDITS RETIRED

792,746,307 tCO_2e

VOLUME OF VOLUNTARY CARBON CREDITS RETIRED FROM THE MARKET

+65% BETWEEN 2020 AND NOVEMBER 2021



For the first time, the voluntary carbon market crossed the billion-dollar mark.

$4/$tCO_2e$

AVERAGE PRICE PER TONNE TRADED

According to the work of the Carbon Pricing Leadership Council, the price of carbon should reach between $50 and $100/t in 2050 to serve the objectives of the Paris Agreement

Carbon Pricing Leadership Council, 2019

A market shifting towards Nature-based Solutions

$75 bn

APPROVALS OF REDD+ PROJECTS

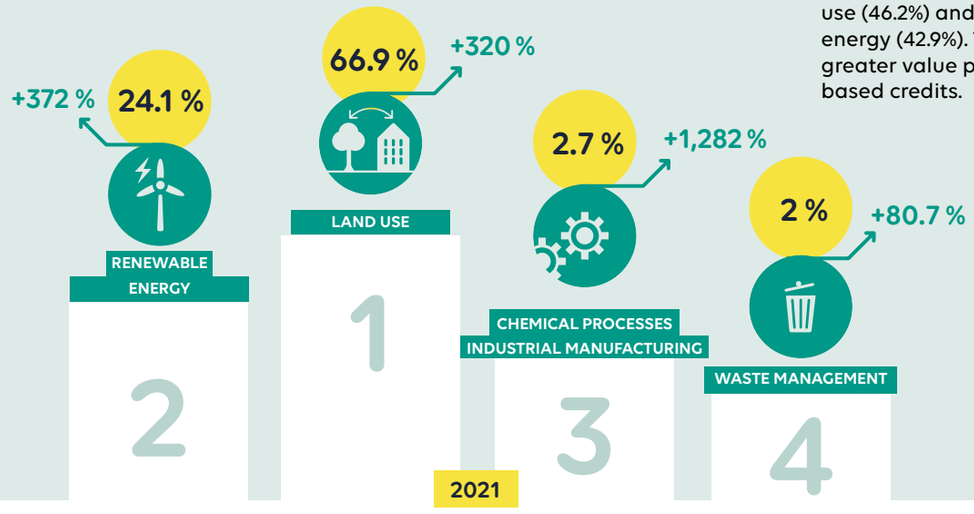
In 2021, only 75 million dollars of REDD+ conservation projects were approved, well below the annual average of 263 million dollars for the five preceeding years. Approvals have shifted however more in favour of projetcs integrating results-based payments.

Heinrich Böll Stiftung, 2022

CREDITS LINKED TO LAND USE OVERTAKE THOSE RELEATED TO RENEWABLE ENERGY PROJECTS

Ecosystem Marketplace, 2022

Nature-based carbon credits occupy more than two thirds of the market in value. In particular, credits with biodiversity co-benefits are highly valued. The last month of 2021 saw almost as many carbon credits traded as the rest of the year, by value. In contrast, carbon volumes are more balanced: 227.7 $MtCO_2e$ for land use (46.2%) and 211.4 $MtCO_2e$ for energy (42.9%). This is a sign of the greater value placed on nature-based credits.



DISTRIBUTION OF VOLUNTARY CARBON CREDITS TRADED BY SECTOR OF ACTIVITY

SPECIAL FEATURE
CARBON OFFSET

The Net Zero target: The voluntary carbon market enters a new dimension

ANTOINE GILLOD • Director, Global Observatory of Climate Action, Climate Chance[a]

Born from the 1997 Kyoto Protocol, the voluntary carbon market has taken up much space in debates of recent years on the transition pathways to "carbon neutrality". Now in full swing, the purchase and sale of carbon credits according to an emissions offsetting logic is being driven by a wave of non-state commitments towards "Net Zero". More than an arithmetic tool to balance the carbon footprint accounting of organisations, the trading of carbon credits is emerging as a channel for mobilising private capital at the service of mitigation projects. The market is progressively becoming regulated, the instruments are multiplying, and the volumes traded are increasing; but in the absence of universal regulation and standardisation of practices, financialization of the market raises concerns about the integrity of projects and the claims of "carbon neutrality" made by companies. This "special feature" of the 2022 Global Synthesis Report on Climate Action by Sector presents a panoply of recent regulatory trends, initiatives, and instruments for tracking carbon credit transactions.

1. CARBON CREDITS, AN INSTRUMENT OF ACTION TO ADDRESS THE CARBON NEUTRALITY CHALLENGE

Planet-wide carbon neutrality: A scientific and political objective

The 197 States that signed the 2015 Paris Agreement set themselves the goal of "*holding the increase in the global average temperature to well below 2 °C compared to pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels*" (Article 2). To achieve these goals, the Parties have agreed to "*reach global peaking of greenhouse gas emissions as soon as possible [...] and to undertake rapid reductions thereafter [...] so as to achieve a balance between anthropogenic emissions from sources and removals by sinks*" by 2050 (Article 4.1).

This commitment establishes the concept of carbon neutrality, defined by the Intergovernmental Panel on Climate Change (IPCC) in its special report on the consequences of global warming of 1.5 °C. The report assesses the possible pathways available for staying within the carbon budget imposed by a 1.5 °C trajectory and concludes:

"*Staying within a carbon budget of 580 GtCO_2 means that the CO_2 emissions would reach carbon neutrality in about 30 years; this period is reduced to 20 years for a residual carbon budget of 420 GtCO_2 (high level of confidence).*"

In this context, achieving carbon neutrality means reducing net CO_2 emissions to zero: "*This means that the amount of CO_2 entering the atmosphere must equal the amount removed.*" This goal is sometimes restricted to carbon dioxide, the main source of greenhouse gases in the world (about 72%),

aThe author warmly thanks Emilie Alberola, Anouk Faure et Mathieu Salel (EcoAct) for their advices and prood reading, as well as Renaud Bettin (Sweep), Gilles Dufrasnes (Carbon MarketWatch), César Dugast and Arthur Pivin (Carbone4), Harold Levrel (CIRED, AgroParis Tech), Amaury Parelle (Transitions-DD), Saverio Ragazzi and Lucas Winkelmann (Geres), for sharing analysis and informations.

or extended to other greenhouse gases with greater global warming potential (GWP), such as methane (CH_4), nitrous oxide (N_2O) or sulphur hexafluoride (SF_6). Regardless of the entry route or scope of gases included in the strategy, reduction of climate change boils down to two physical objectives which the actors can implement using three levers:

- Objective 1: Limiting the flows of greenhouse gases emitted into the atmosphere (level 1: **avoiding** emissions and level 2: **reducing** emissions);

- Objective 2: Increasing the flows captured and sequestered by natural carbon sinks (forests, oceans) or technological ones (direct air capture, capture and sequestration of carbon at factory outlets, etc.) (level 3: **removing** carbon emissions).[1]

From this perspective, offsetting emissions with carbon credits on the voluntary carbon market (VCM) is one financial instrument among others, which is available to actors, enabling use of one of these three levers. A carbon credit can be defined as a deed that certifies the reduction, avoidance, or removal of a certain quantity of emissions by a project somewhere in the world: installation of renewable energy generation capacity, improvement in energy efficiency, woodland conservation, creation of new green areas, etc. Once issued, the credit can either be placed in the assets of the project leader who wishes to have its impact on GHG emissions recognised, or be put for sale on the voluntary market (*issuance*).

For the organisation that sells carbon credits on the voluntary market, the objective is to finance its project through an influx of private capital obtained through the sale of credits. By doing so it renounces claiming for itself the emissions reduced, avoided, or removed thanks to its project.

For the organisation that purchases credits on the voluntary market, its investment is generally motivated by the prospect of being able to credit the mitigation results obtained by the project in its own carbon footprint. By doing so, it may wish to eventually claim a form of "carbon neutrality" (included in its climate strategy) to highlight its mitigation efforts, once the remaining volume of emissions following its own reduction efforts equals the compensated volume of emissions. Once included in the carbon accounting of an organisation, the credit can no longer be traded on the market; the credit is then said to be "retired" (*retirement*).

In the absence of universal regulation of the voluntary carbon market, both the quality control of certified projects and the verification of the integrity of the climate strategy of the organisation purchasing credits are the subject of numerous technical, political, and even philosophical controversies. Within these discussions, it is necessary to distinguish those that concern each of the three key elements of the voluntary carbon market:

- the "carbon credits", in other words, the rules and methodologies that govern the certification of the impact on emissions of a mitigation project;

- the "market", that is, the rules and credit trading conditions between sellers, buyers, and intermediaries;

- the "compensation", which relates to the criteria an organisation has to abide by to claim for itself the mitigation results obtained by the purchase of carbon credits, and then communicate its own "carbon neutrality" regarding the robustness of its climate strategy and its reduction efforts.

BOX 1 • **KEYS TO UNDERSTANDING**

CARBON PRICING, A SINGLE CONCEPT FOR MULTIPLE INSTRUMENTS

The World Bank defines **carbon pricing** as "an instrument that captures the external costs of greenhouse gas (GHG) emissions – the costs of emissions that the public pays, such as damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise – and ties them to their source through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted." Various mechanisms put a price on carbon:

• The **Emissions Trading System (ETS)**, where "cap and trade" are intended to bring about emissions reductions of regulated emitters. These markets operate according to the "polluter-pays" principle as applied to GHG emissions: each emitter is allocated an emission quota beyond which it is forced to change its activities to reduce its sources of emissions, or to purchase other quotas from companies that have not exceeded their own limit. The evolution of the price then depends on the level of constraint applied to the supply of credits allocated on the market compared to the demand – the objective being to reach a price high enough to encourage companies to prefer undertaking transformational measures rather than resorting to the purchase of quotas.

• The **"baseline-and-credit" markets**, such as those provided by Article 6 of the Paris Agreement **(see below)**, which entails generating carbon credits based on the reduction of emissions compared to a reference scenario (business-as-usual). There is, therefore, no limit to the number of available credits. The purchase of these credits, in a carbon offsetting approach for example, makes it possible to finance the mitigation project.

• A **carbon tax** is a fiscal instrument which, while also adhering to a "polluter-pays" logic, predetermines a certain level of levy on the emission of one tonne of CO_2.

There are other mechanisms, such as the **results-based climate finance**, which delivers funds as a function of emission goals set beforehand, or the **internal carbon pricing**, set by organisations to guide their decisions based on the opportunity costs represented by the reduction of emissions.

Source: World Bank, Carbon Pricing Dashboard

This study intends to draw up an inventory of the dynamics of the voluntary carbon market, and to analyse recent changes in the rules and standards governing the use of carbon credits and the communication surrounding carbon neutrality.

Net zero and carbon neutrality, a barometer of the voluntary strategies of the actors

The carbon neutrality concept was initially conceived on a planetary scale: since emissions have no borders, the concentration of GHG in the atmosphere is non-discriminatory and its effects are felt on the entire globe. However, since its definition in major international agreements and in the work of the IPCC, States and non-state actors have gradually appropriated the language of "neutrality", both as the ultimate goal of their emission reduction strategies, and as a narrative framework for describing their transition.

The vast majority of States have now set carbon neutrality at various deadlines aligned with their climate strategies. Since Sweden first adopted carbon neutrality in June 2017, the 137 countries which have formulated a "net zero" goal now cover 83% of global emissions, 90% of GDP and 85% of the population according to Net Zero Tracker.[2] While the IPCC talks of achieving global carbon neutrality by mid-century, the deadline set by States on their own emissions scope varies according to the country and the levels of emissions, from Costa Rica's 2021 target to India's 2070 target. Bhutan and Suriname are today the only two countries said to have a "negative" carbon balance, i.e., whose GHG emissions are lower than their absorption.[3] The quality of these commitments is assessed against the precision of the detailed plans and strategies to achieve the objective of carbon neutrality, by independent organisations such as Climate Action Tracker.

Since 2015, the UNFCCC secretariat has wanted to extend the adoption of neutrality to actors not party to the Convention. The Climate Neutral Now initiative was launched for this purpose to promote the voluntary use of carbon market mechanisms by local authorities, companies, civil society organisations, and citizens.

Today, the Race to Zero mobilisation campaign serves this purpose. Initiated by the High-Level Climate Champions Nigel Topping and Gonzalo Muñoz prior to COP26, Race to Zero listed, in February 2022, 67 regions, 1,049 cities, 5,227 companies, 1,039 educational institutions, 441 financial institutions and more than 3,000 hospitals among 52 signatory health services for carbon neutrality in 2050. All of these actors cover 25% of global CO_2 emissions and 50% of GDP. By establishing "minimum criteria" for participation in the campaign, Race to Zero aims to act as an "umbrella" initiative that encompasses many independent initiatives for actor commitment to carbon neutrality.

In October 2020, the NewClimate Institute listed **929 local governments with a net-zero commitment**, covering 880 million inhabitants and representing an emissions reduction potential of 6.5 $GtCO_2$/year.[4] The Carbon Neutral Cities Alliance network brings together 22 international cities (New York, London, Rio de Janeiro, Yokohama, etc.) committed to carbon neutrality, with a view to supporting them in reducing their emissions through the implementation of transformative climate actions in the spirit of just transition.

BOX 2 • **KEYS TO UNDERSTANDING**

CARBON NEUTRALITY TERMS

"Carbon neutrality", "Net Zero"... The Glossary of the IPCC Group III Climate Change Mitigation Report, published in April 2022,5 has updated the definition of the various terms in use:

• **Carbon neutrality** refers to the condition "*in which anthropogenic carbon dioxide (CO_2) emissions associated with a subject are balanced by anthropogenic CO_2 removals. The subject can be an entity such as a country, an organisation, a district or a commodity, or an activity such as a service and an event. Carbon is often assessed over the life cycle including indirect ("scope 3") emissions, but can also be limited to the emissions and removals, over a specified period, for which the subject has direct control*". Greenhouse gas neutrality applies more broadly to all greenhouse gases (CH_4, SF_6, N_2O, etc.), and not just to carbon dioxide, as in the definition of "carbon neutrality".

• **Net zero CO_2 emissions** refer to the condition "*in which anthropogenic carbon dioxide (CO_2) emissions are balanced by anthropogenic CO_2 removals over a specified period.*". **Net zero GHG emissions** also include all gases. The difference between "net zero" and "carbon neutrality" sometimes remains unclear and varies according to use. The IPCC holds that at the global scale, the terms "net zero" and "carbon neutrality" are equivalent. On a smaller scale, "net zero" is restricted to emissions or removals that are under the direct control or territorial responsibility of the entity, while "carbon neutrality" also applies to emissions and removals beyond this scope. In practice, net zero can refer to a trajectory aligned with the 1.5 °C goal, such as for the Science-Based Target Initiative (SBTi, see below), whereas carbon neutrality is a state of static equilibrium between emissions and absorptions not based on any trajectory.

It should be noted that following AR6, the IPCC has adopted a broad view of the neutrality concept which allows it to be used at the organisation or product level. So far, in the special report on the consequences of global warming of 1.5 °C, "net zero emissions" was only envisaged as "*when anthropogenic CO_2 emissions are globally balanced by anthropic CO_2 uptake over a period of time. Net CO_2 emissions is also referred to as carbon neutrality.*" In other words, the carbon neutrality of organisations such as cities or companies was not mentioned here. It should be remembered in this regard that the IPCC is not a normative authority, and this broad definition of neutrality continues to be debated (Box 3).

At the European Union level, the NetZeroCities consortium coordinated by EIT Climate-KIC, brings together 33 partners from thirteen countries to support thirty pilot projects between cities. These projects aim to promote rapid learning on how to achieve climate neutrality at the city level. Funded by the Horizon Europe programme, NetZeroCities addresses over a four-year period (2021-2025) a Mission proposed by the European Commission in September 2020 as part of the Green Deal, "100 Climate-neutral Cities by 2030 – by and for the Citizens". The Mission should give rise to 100 carbon neutral cities in 2030 to act as centres of innovation and experimentation with all other cities by 2050. At the national level, numerous initiatives also exist for the alignment of cities and regions with carbon neutrality, such as the UK100 Net Zero pledge in the United Kingdom, which brings together 97 signatory cities, or the RAMCC (*Red Argentina de Municipios frente al Cambio Climático*) network, with 259 member municipalities.[6]

By November 2021, **1,045 companies representing more than $23 trillion in market capitalisation, across 53 sectors in 60 countries**, had made a commitment to formulate emission reduction objectives aligned with the 1.5 °C target based on science (*1.5 °C-aligned science-based targets*), according to a press release issued by the United Nations Global Compact and Science Based Targets initiative (SBTi) during COP26.[7] Of the 2,000 largest companies in the world, 417 (one third of the total turnover) have set a net-zero target.[8]

This movement extends to companies operating in carbon-intensive business sectors, and even reaches companies reluctant to undertake climate action. In early October 2021, the International Council on Mining and Metals (ICMM), which brings together 28 of the largest mining companies in the world, published an open letter stating that all of its members have committed to reducing emissions and to aiming for "carbon neutrality" by 2050.[9] Several of its members had already adopted climate plans several months previously with "carbon neutrality" as an objective. Among the major European oil companies, BP, Shell, TotalEnergie, ENI and Equinor have integrated carbon neutrality into their growth strategies.[10] Even the American ExxonMobil, still embroiled in anti-climate lobbying cases, recently introduced the term "net zero" across its operations in the Permian Basin.[11]

As regards financial actors, the Net Zero Asset Managers Initiative, launched in December 2020, claims 220 signatory **asset managers** with $57 trillion under management, committed to supporting the goal of net zero GHG emissions by 2050; similarly, the Net Zero Asset Owner Alliance claims 74 committed **institutional investors** ($10.6 trillion in assets). The Net Zero Banking Alliance has 113 signatory **commercial banks** covering $69 trillion of assets under management, while the more recent Net Zero Insurance Alliance brings together 20 **insurers** ($7 trillion in assets under management). In April 2021, the Global Financial Alliance for Net Zero (GFANZ) was launched by the UN Special Envoy for Climate Action Mark Carney and the High-Level Champions in order to bring together all actors from the finance sector around the Race to Zero. It now claims 450 member firms representing more than $130 trillion in assets under management.

Verifying the individual carbon neutrality of organisations: Corporate standards

Within the context of the mass adoption of the language of "neutrality", the credibility of commitments (*pledges*) rests on the ability of the actors to rely on solid standards for (1) taking *inventory*, (2) setting *objectives,* (3) formulating *plans*, (4) implementing *actions*, and (5) assessing their *impact* on the reduction of emissions. For each of these steps, numerous international standards exist and are still being developed, aimed at providing both technical methodologies for verification, and a frame of reference for the interpretation and communication of the results.

Discussions about the assessment of the requirements of these standards currently revolve around several criteria for assessing their ambition:

- The degree of constraint applied by the standards on organisations to reduce their GHG emissions;
- The range of qualified carbon credits that comply with the standard for offsetting, with regard to their age (vintage) and the requirements of the project certifying body;
- The assessment method;
- Communication on the efforts made.

The PAS 2060 standard was created in 2010 by the British Standard Institution (BSI) and updated in 2014. It not only certifies organisations, but also products or events. It is now one of the most widely used standards in the world. The PAS 2060 certification process is organised according to four criteria:

- Assessing 100% of Scope 1 and 2 emissions and Scope 3 emissions that contribute more than 1% of its carbon footprint.
- Reduction of emissions according to a plan which sets out an agenda, specific reduction goals, the means to achieve them, and how to offset residual emissions.
- Offsetting surplus emissions with carbon credits that meet the additionality and permanence criteria, avoids double counting without carbon leaks.
- Documentation and verification for reporting, based on self-validation, validation by external parties, or validation by independent third parties.

PAS 2060 nevertheless suffers from a mixed reputation of its certification criteria. The weakness of the Scope 3 requirements, extensive use of compensation allowed by the standard, and the self-validation of the authorised statement weaken the credibility of the commitments. This last point means it is not possible to judge whether the efforts to reduce emissions declared by the organisation are sufficient before resorting to offsetting residual emissions. It is one of the main criticisms of PAS 2060: companies are authorised to claim being "neutral" based on 100% compensation in the first year. They

must then present a mitigation plan, but it is not subject to any minimum level of ambition.

PAS 2060 is set to serve as the basis for the future ISO 14068 standard.[12] Under preparation since February 2020, this new standard should provide a standardised definition of carbon neutrality. These terms are the object of consultations and negotiations in a workgroup (comprising representatives from almost 60 countries) which will determine its degree of ambition. In the "Preparation" phase for two years, the adoption process must undergo a long series of steps before its validation, expected in 2023. The "Greenhouse gas and climate change management and related activities" committee (ISO/TC 207/SC 7)[b] steers the process; however, the committee's site has not been updated since 2019, and little public information on the status of negotiations is available.

The **CarbonNeutral Protocol** was published for the first time in 2002. Supported by the American group Natural Capital Partners, this standard also makes it possible to certify companies, products, and activities. Like PAS 2060, the CarbonNeutral Protocol does not constrain companies regarding the degree of internal emission reduction required to obtain the CarbonNeutral® status: organisations are only "encouraged" to use the management tools to define the right balance between reduction and offsetting. Similarly, it is not required that their internal reduction efforts be "science-based", that is, aligned with the Paris Agreement objectives. The CNP only invites organisations to use the Science-Based Target initiative to align with the 2 °C or 1.5 °C objectives.

In fact, **the Science-Based Target initiative (SBTi) is now the reference standard for assessing emission reduction strategies** with regard to the Paris Agreement objectives. As of February 23, 2022, it showed 2,530 companies committed to setting a "science-based" emissions reduction target, aligned with the 1.5 °C and 2 °C Paris Agreement objectives. Among them, 1,181 were certified "science-based"; in other words, their emission reduction objectives were approved according to the SBTi methodology.[13] This methodology is internal to the initiative, developed by a Technical Advisory Group and a Scientific Advisory Group, bringing together companies, researchers, NGOs and certification standards.

In October 2021, SBTi unveiled its net zero standard for companies in partnership with CDP, Global Compact, the World Resource Institute, and the WWF. Called the **"Corporate Net-Zero Standard" (CNZS)**, it describes itself as the world's first standard aimed at providing guidelines, criteria and recommendations to help companies formulate "net zero" goals that are based on science and aligned with the 1.5 °C and 2 °C Paris Agreement objectives.[14] In summary, the SBTi defines "corporate net zero" as:

The reduction of Scope 1, 2, and 3 emissions to zero or to a residual level compatible with achieving net zero emissions at a global or sectoral level, in a course of action aligned with the 1.5 °C objective (approximately 90% reduction in emissions). 95% of emissions must be covered;

- The **neutralization** of all residual emissions *in the target year* and any GHG emissions released into the atmosphere thereafter.

For their "Net Zero emissions" commitments to be "science-based" certified, companies must meet two criteria:

- Set a short-term (5-10 year) SBT objective aligned with a 1.5 °C trajectory;
- Set a long-term (2050 or beyond) SBT objective aligned with a 1.5 °C trajectory;

Optionally under the SBTi criteria, they can also:

- Take measures to remove carbon from the atmosphere and store it permanently so as to "neutralize" residual emissions;
- Carry out actions or make investments to reduce emissions outside of its value chain.

Unlike PAS 2060, the CNZS is very robust on short- and long-term emission reduction requirements. However, the CNZS is weaker on the compensation component, and does not provide instructions nor clear criteria on the quality of the carbon credits that may be used, unlike PAS 2060. Although it ties the terms of "net zero" claims to the "target year", SBTi does not give any clear indication on the possibilities of producing this claim at an intermediate date.

So far, only 33 companies have met the first two criteria and have received the "science-based" certification for their net zero goals, the first being Holcim Ltd., CVS Health, JLL, Dentsu International, Orsted, AstraZeneca, Wipro and even Ricardo PLC. SBTi is a verification standard: it produces its assessment according to its own methodology without third-party certification. This double stance raised questions on the independence of the standard (**SEE BELOW**), to which the SBTi responded by excluding oil companies from its field of activity, and by deciding to extend the certification time frames.[15] The SBTi is also developing a similar standard intended for financial institutions.[16]

b See the site: https://committee.iso.org/home/tc207sc7

BOX 3 • **KEYS TO UNDERSTANDING**

IMPOSSIBLE NEUTRALITY? THE CONTRIBUTION PARADIGM

More than a semantic controversy, the discussion surrounding the "neutrality" terms divides the actors according to two paradigms regarding the possibility offered to organisations to claim to be "net zero", "carbon neutral", etc. On the one hand is **the "offsetting" paradigm**, which conceives that a company or an organisation can claim carbon neutrality on its territory or its scope of activity by offsetting its residual emissions via the financing of reduction, avoidance, or removal projects according to arithmetic logic. On the other hand is **the "contribution" paradigm** which only conceives carbon neutrality at a planetary level and therefore rejects the possibility of declaring "zero net emissions" at the individual actor level, preferring instead to refer to the "individual contribution to collective neutrality".

This second paradigm draws from the exclusively "planetary" definition of carbon neutrality that the IPCC used to employ. In France and abroad, the Net Zero Initiative and the companies it supports continue to advocate this approach. In June 2022, the "10 principles for an ambitious corporate climate strategy" presented by NZI adopt this restrictive conception of carbon neutrality.[17] Among the 46 signatory organisations active in supporting the climate action of companies is the Ademe, the ecological transition agency in France. This public institution had already positioned itself in this direction in two "expert opinions" on carbon neutrality (May 2021) and on its use in communications (February 2022), in which it calls on organisations to "*relinquish the purely arithmetic approach to neutrality*" and to "*communicate in a transparent, proportionate and distinct manner on the different levers for contributing to collective carbon neutrality*". However, the Ademe still grants the possibility for States to claim neutrality at a national level.

In the context of a voluntary market, companies are essentially driven by the possibility of promoting and communicating their actions. In order to preserve this investment driver, while further incorporating corporate communications, other avenues advocate regulating "carbon neutrality" claims **(see below)**.

2. VOLUNTARY CARBON MARKETS SWITCH TO NATURE-BASED SOLUTIONS

"Ecological compensation corresponds to actions in favour of certain components of nature, whose objective is to produce ecological gains deemed to be quantitatively or qualitatively equivalent, or better than, ecological losses suffered elsewhere by these same components as a result of human activities".[18] Among the ecological compensations, carbon offsetting specifically aims to address the global warming problem caused by atmospheric GHG concentrations. Carbon offsetting may be required within a regulatory framework (example: CORSIA, the voluntary offset framework for the international aviation sector), or be the subject of a voluntary approach by a committed actor. The voluntary carbon market allows the free trade of carbon credits aimed at financing projects contributing to the reduction, avoidance or removal of GHG emissions, such as energy production, energy efficiency, agriculture, or forestry. The voluntary carbon market is an important potential channel for low carbon transition projects. The voluntary carbon market differs from "polluter pays" regulations, in that it is based on the funding of field projects.

Nature-based solutions are taking root; removal projects are still at an early stage

Whether it is part of an "offsetting" or a "contribution" logic, the purchase of carbon credits in the voluntary market is booming. In its *Net Zero Stocktake 2022* report, 40% of the 702 companies listed on the stock exchange tracked by Net Zero Tracker are explicitly considering using offset credits to achieve their goals (only 2% do not, and the majority did not specify).[19]

For the first time, the market value exceeded the $1 billion mark in 2021, and quadrupled year-on-year to nearly reach $2 billion, according to Ecosystem Marketplace.[20] Thus nearly 500 $MtCO_2e$ were traded on the voluntary market in 2021, at an average price of $4/tCO_2e$. Overall, these are much lower volumes than those observed in some regulatory carbon markets,[c] but they do not reflect the same reality. The prices in "cap and trade" markets are directly influenced by the ratio-

c The market value of CO_2 emission permits traded around the world increased by 164% in 2021, to reach 760 billion euros, according to the firm Refinitiv. 90% of this increase is attributable to the European Union Emissions Trading System (EU ETS), the largest in the world. While it has capped at €5/t for the majority of the time it has existed, between 2005 and 2018, the price per tonne of carbon increased in June 2022 to 88€/t (with a peak of 97€/t in February), due in particular to the drop in the volume of free allowances and the general tightening of supply. This is a level compatible with the Paris Agreement, according to the Carbon Pricing Leadership Council, which estimated in 2019 that only a carbon price of 50 to 100$/t can have sufficient leverage to bring about the necessary changes.

ning of allocated quotas, and thus reflect the opportunity cost to the company between the purchase of additional quotas and a capital expenditure of transition. Conversely, on the voluntary market, the price of credits is mainly based on the real cost of certified projects. However, growing intermediation and increasing financing of the market, the tightening of certification standards, and the growth in demand expected in view of the net zero commitments is likely to generate a greater price variation, as observed.

Indeed, while the average prices of the voluntary market remain quite low, on the whole they increased sharply during 2021, before falling – sometimes abruptly – in the first quarter of 2022 under the effects of inflation and rising energy prices, which may have reduced demand **(FIG. 2)**. In addition, the volume of credits issued on the market exceeded retirements by 129% over the first eleven months in 2021,[21] whereas they were at equilibrium until 2017. This difference does not necessarily mean that the demand does not follow the growth in supply of credits. Rather, it reflects a dual market orientation towards standardised long-term contracts and increasing market intermediation. Indeed, the World Bank[22] notes a trend towards the standardisation of contracts, in particular through the emergence of futures contracts in organised markets, making it possible to assemble carbon credit "package" offers that share common features (vintage, type of project, co-benefits, standards, etc.). Over-the-counter (OTC) spot contracts between seller and buyer of credits is still the norm, but the massive entry of financial intermediaries (brokers, traders, investment funds, etc.) into the voluntary market in recent years complicates the landscape and exposes the market to speculation as it becomes more lucrative.

The voluntary carbon market is gradually shifting towards "nature-based solutions" (NbS). According to the Voluntary Carbon Market Dashboard facilitated by Climate Focus, a think tank, the issuance of NbS credits increased by almost 170% between 2020 and 2021. Representing 45.2% of the credits issued in 2021 (31.6% in 2020), they are now ahead of renewable energy projects (37.6% in 2021 compared to 47% in 2020) which have dominated the market for several years. Among these credits, emissions avoidance activities are dominant, amounting to 80% (174.7 $MtCO_2e$) of these new NbS credits in 2021-2022.[23] For the most part, these are forest conservation projects funded via REDD+ (*Reducing emissions from deforestation and forest degradation*), the UNFCCC programme for the protection of forests. However, methods to estimate the carbon impact of avoided deforestation suffer from uncertainty.[24] Carbon Direct, a carbon management consulting firm, is also concerned that the renewable energy projects do not meet the additionality criterion: with or without carbon credit, the projects would have taken place in view of the growth of the renewables market.

FIGURE 1

THE ECOSYSTEM OF VOLUNTARY CARBON MARKET

Source: Abatable, 2022

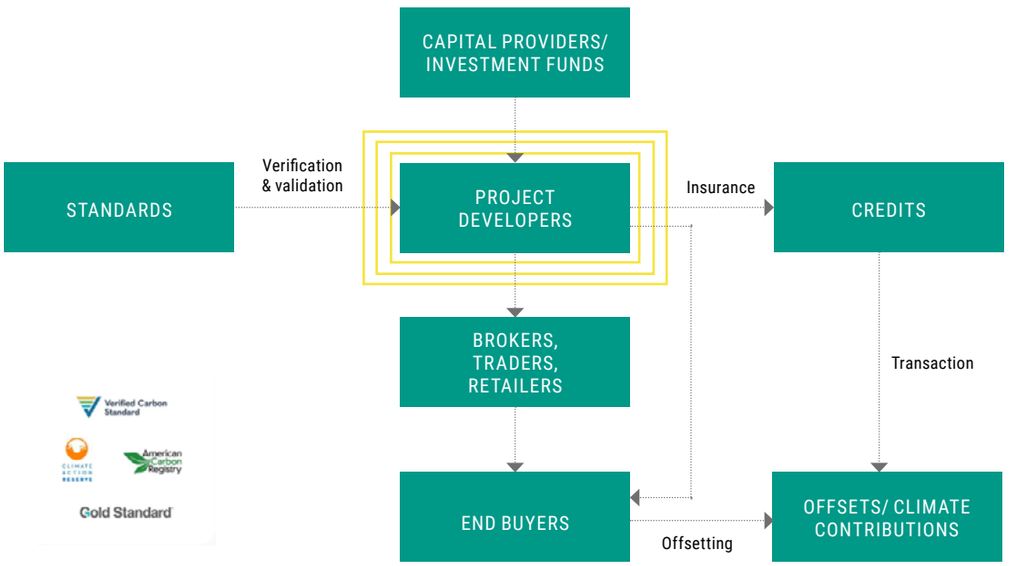
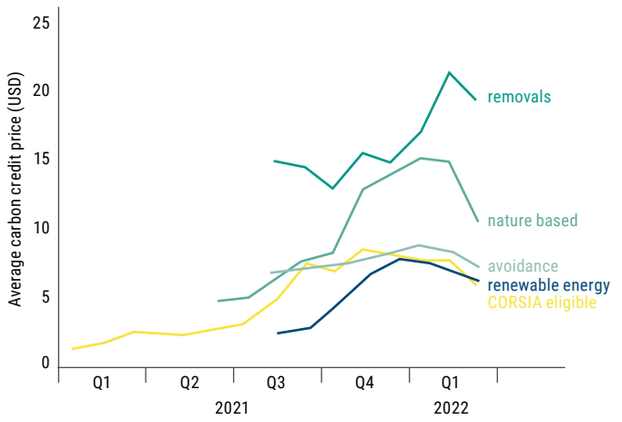


FIGURE 2

PRICES OF STANDARDISED CARBON CREDIT CONTRACTS

Source: World Bank, 2022



The volume of removal credit transactions which aim to develop natural carbon capture and storage projects (via reforestation, or afforestation), or technological ones (Direct Air Capture, CCUS), remains modest. In 2021, the traded volume of carbon reduction credits was 21 times greater than that of carbon removal credits, according to Ecosystem Marketplace. According to Carbon Direct,[d] pure removal projects represent only 3% of the credits issued in 2021, with the credits for combined removal and reduction amounting to 13%. No sustainable removal credit, making possible the removal of carbon in the very long term and ensuring a real impact on the concentration of GHGs in the atmosphere, was issued in 2021.[25]

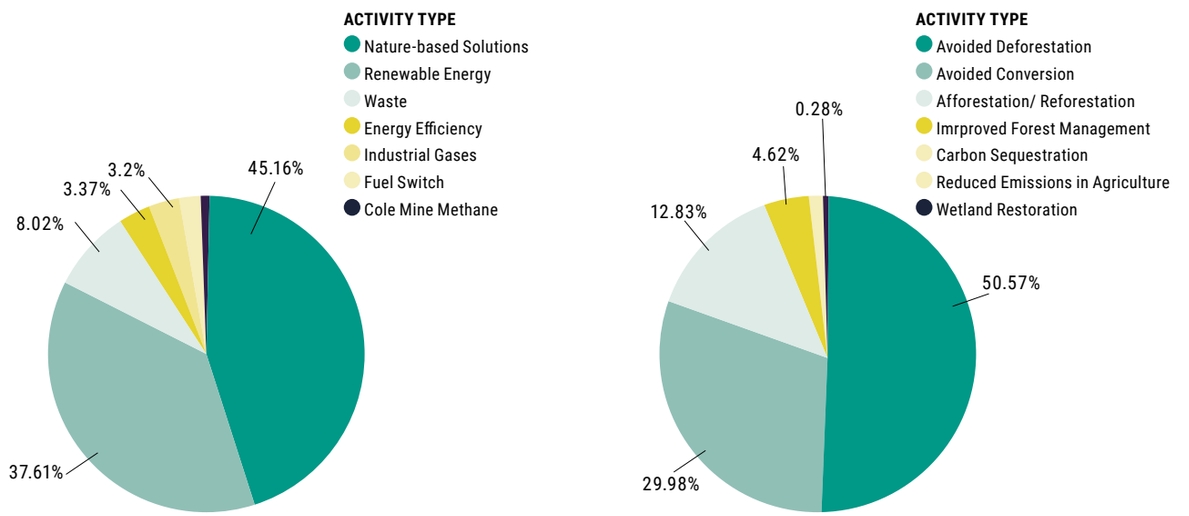
Still, the increase in demand for NbS credits is reflected in the prices observed on the market. From less than \$5/tCO_2e in June 2021, the Platts CNC index for natural avoidance and removal credits rose to \$14.55/tCO_2e. Highly sought after by customers in the face of a tight supply, these are credits tied to the removal of carbon which drove average prices up, rising to \$19/tCO_2e in March 2022.[26] Thus, there may be observed a narrowing of the spread between natural removal credits (Platts Natural Carbon Capture) and avoidance credits (Platts Nature-based Avoidance), from \$7/tCO_2e in August to 0.95/tCO_2 at the end of 2021.

The market shift towards nature-based credits is part of the trend of recent years. Indeed, according to Ecosystem Marketplace, it is also the credits linked to afforestation and reforestation projects that were traded at the highest price in a sustainable way between 2019 and 2021 (\$8.1/t in 2021). By comparison, the trading of credits for household appliance installation projects (especially improved cookstoves) fell by 40% but their price continues to increase and remains above average, from \$3.84/t in 2019 to \$5.75/t in 2021. The price index for renewable energy credits also increased at the end of the year, to a level close to CORSIA credits.[27] Conversely, the switch from credits linked to the agricultural sector, which is booming (+876% in one year), to low-cost pasture management credits precipitated the price drop from \$11.8/t in 2019 to \$1.36/t in August 2021 (**BOX 4**).

FIGURE 3

TYPOLOGY OF CARBON CREDITS (LEFT) AND NATURE-BASED CREDITS (RIGHT) PLACED ON THE MARKET IN 2021

Source: Climate Focus, 2022



d Carbon Direct's analysis is based on data from Berkeley's Voluntary Registry Offsets Database (VROD), which aggregates all carbon management projects from the four largest voluntary compensation registries: American Carbon Registry (ACR), Climate Action Reserve (CAR), Gold Standard (GS) and Verra (VCS) – is more than 1.5 GtCO_2 from more than 5,000 projects.

BOX 4 • **EXPERIENCE FEEDBACK**

CARBON FARMING, A NEW DEVELOPMENT IN NATURE-BASED SOLUTIONS

On a global scale, carbon credits linked to agricultural activities, although maintained at a marginal portion of the market, are flourishing. The mitigation potential of agricultural soils prompted the European Commission to adopt a Communication on sustainable carbon cycles in December 2021, as part of its Farm to Fork Strategy. The Commission wishes to promote "carbon farming" in this context, based on existing funding programmes (Common Agricultural Policy, LIFE program, Interreg, etc.) to encourage farming practices favourable to the sequestration and reduction of emissions (agroforestry, soil protection, restoration, etc.). In particular, the EU plans to strengthen the standardisation of methodologies for monitoring, reporting and verification of carbon farming. Such a framework has existed in France since 2019. The Low Carbon Label is a national certification framework for local projects to reduce and sequester greenhouse gas emissions. Operational since 2019, it was designed by the Ministry of Ecological Transition and technical partners, such as the think tank Institute for Climate Economics (I4CE). 233 projects now benefit from the Low Carbon Label, having met the criteria set by one of the sectoral methods established by the Ministry to assess reduced or removed emissions compared to a reference scenario. These methods now mainly cover the forestry and agricultural sectors, but also construction and transport. The Carbon Agri method gave birth to France Carbon Agri Association, which groups 302 farmers committed to reducing their emissions, for a potential reduction of 138,800 tCO_2. In South Africa, in 2021, the AgriCarbon programme run by the local operator Climate Neutral Group conducted the certification of 40 milk farms committed to the reduction of their carbon and environmental footprint, and the issuance of 230,000 tCO_2 of credits, sold at between $15 and $25/t. [28]

Sources: *Ecologie.gouv, n.d.; France Carbon Agri Association, 12/02/2021; Climate Neutral Group, n.d.*

Beyond carbon: the co-benefits of compensation projects increase the value of the credits

The growing success of NbS credits is based on their potential as natural carbon sinks. The extent of the mitigation potential resulting from the planting of trees has been the subject of global modelling exercises that have led to academic controversies. In 2019, a study conducted by researchers at the Swiss Federal Institute of Technology in Zurich (ETH Zurich) estimated that ecosystems could support 0.9 billion hectares of additional continuous forest, i.e., a 25% increase in forest area. At maturity, this would represent a carbon sink of more than 200 Gt, and the capacity to store 25% of atmospheric carbon.[29] This study raised many debates and elicited many responses, both on the method of modelling on such a scale and on the "simplistic" conclusions to which the study could lead regarding the value of trees as a solution to environmental problems.[30] This "carbon-centred" view of the NbS also questions their co-benefits for biodiversity, the economy, and local communities. All academic literature generally tends to show that the impacts of nature-based solutions are complex and vary according to local contexts, with synergies or compromises with the Sustainable Development Goals (SDGs).

Co-benefits refer to all the additional environmental, social and other benefits derived from a carbon project. In its "Special Report: Global Warming of 1.5 °C", the IPCC emphasises this point: "*Mitigation options consistent with a 1.5 °C pathway are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs).*"[31] Thus, the co-benefits of an emission reduction, avoidance or removal project can be assessed according to whether it facilitates the access to energy (SDG 7), reduces gender inequalities(SDG 5) and/or economic inequalities(SDG 10), creates economic value or employment (SDG 8), or protects land (SDG 15) and marine (SDG 14) biodiversity.

Forest conservation projects, which represent the majority of nature-based projects, can in particular generate important co-benefits for biodiversity in addition to carbon sequestration. In this respect, the countries participating in the REDD+ programme for the conservation of forests increasingly tend to integrate non-forest biodiversity indicators into their national forest inventories, but the methodologies are still very disparate, according to one study.[32]

However, researchers believe that tree planting is more often motivated by its utilitarian and commercial benefits than by its value for biodiversity and as a carbon sink. The number of organisations, especially for-profit ones, supporting and developing tree planting projects (afforestation or reforestation) in tropical and subtropical areas has almost quadrupled in the last 30 years. For the most part, they implement agroforestry systems, planting campaigns of mixed or single species, or carry out assisted natural regeneration. The species most often reported are cocoa, teak, moringa, mango and coffee, which primarily meet the economic needs of local populations.[33]

A recent example of this utilitarian and commercial approach is that of Gabon, whose forests still occupy 88% of the territory. Environment Minister Lee White recently announced the issue of 187 million carbon credits under REDD+, with the aim of selling half of them on the voluntary market before COP27. It would be the largest carbon credit issuance ever. The minister of Gabon thus hopes to generate revenue, estimated at $291 million, in order to preserve national forests, but also to ensure the sustainable exploitation of resources.[34] A few days earlier, TotalEnergies announced the acquisition of 49% of the shares of Compagnie des Bois du Gabon, which manages 600,000 ha of FSC-certified forests in the country, in order to generate carbon credits and offset its emissions.[35]

In general, social and environmental co-benefits increase the value of carbon credits on the voluntary market: accor-

ding to Ecosystem Marketplace, credits certifying projects with co-benefits reach a weighted average price of $5.95/t, against $2.77/t for other projects. A recent study of 2,259 projects certified under the Kyoto Protocol's Clean Development Mechanism (CDM) reckons that the projects with the highest guarantee of co-benefits received a 30.4% higher price compared to projects with lower co-benefits, with an additional premium for CDM projects certified with the Gold Standard.[36]

In fact, the evaluation of the co-benefits of carbon credits has for a long time been included in the evaluation criteria of the main certification standards. Since its birth in 2003, the Gold Standard has prescribed the assessment of the impact of carbon projects on neighbouring communities and populations. In 2017, the "Gold Standard for Global Goals" (GS4GG) became its new reference standard, intended to meet the objectives of the Paris Agreement as well as the SDGs. More recently, the Gold Standard has mandated the use of the SDG Impact Tool, an instrument introduced in December 2021 to help project leaders assess the impact of their carbon project on the SDGs. In 2019, Verra presented the Sustainable Development Verified Impact Standard (SD VISta), a set of rules and assessment criteria that allow an independent assessor to certify a project's contribution to the SDGs.[37] Under its Climate, Community & Biodiversity (CCB) Standards programme, Verra labels certified projects (VCS) that generate positive benefits for local communities and biodiversity. So far, 51 projects have been validated, 75 verified, and more than 310,000,000 credits have been issued with the label (about 30% of all issued VCS credits).[e]

The growth of interest in NbS also calls for regulation of practices to ensure the credibility of projects and credits issued. In July 2021, the Natural Climate Solution Alliance (NCSA), a multi-actor coalition led by the World Business Council for Sustainable Development (WBCSD) and the World Economic Forum, published a guide on the use of nature-based credits. The document, entitled "Natural Climate Solutions for Corporates", provides guidelines for actors in the supply and demand of credits, on the credible and integrated use of credits certifying nature-based projects.[38] In May 2022, NCSA sanctioned six nature-based trailblazer projects, all of which were Verra certified. Other initiatives such as Nature4Climate, launched in 2017 made up of 19 specialist organisations, are campaigning to develop investments in this sector.

3. INTERNATIONAL REGULATORY FRAMEWORKS FOR CARBON MARKETS ARE BEING STRENGTHENED

Rules for the application of Article 6 of the Paris Agreement adopted at COP26

After several years of negotiations, the rules for the application of Article 6 (*Article 6 rulebook*) were finally adopted on November 13, 2021. They include a number of significant advances which settle controversial debates that were under discussion since the signing of the Paris Agreement. In particular, the accounting rules to avoid double counting have raised a lot of concerns. Certain conclusions remain open to interpretation, and many implementation methods will be the subject of a work programme in the coming years.[39] The provisions of Article 6 will have direct consequences on the functioning of the voluntary market.

Article 6 of the Paris Agreement aims to define the rules for voluntary cooperation between Parties to implement their Nationally Determined Contributions (NDCs). Two market mechanisms are provided:

- **Article 6.2** provides for the possibility for States to carry out bilateral international trading of mitigation outcomes (internationally transferred mitigation outcomes – ITMOs) among themselves within the framework of "cooperative approaches".

- **Article 6.4** establishes a new multilateral, centralised market with its own office, in the manner of the Kyoto Protocol's Clean Development Mechanism.

The Glasgow decisions allow ITMOs that are eligible under Article 6.2 to be traded with a view to not only help Parties achieve their own NDCs, but also for other "international mitigation purposes" or even "other purposes" as determined by the Parties. The "international mitigation purposes" are not specified, but are understood to refer implicitly to the emissions reduction programmes of the ICAO for aviation and IMO for maritime transport. The reference to "other purposes" suggests that States are free to decide whether their ITMOs can be used in the voluntary carbon market. If they are not authorised by the Parties to be traded under Article 6.2 (then referred to as "unauthorised credits"), the mitigation outcomes can then be credited to the NDC, or be used for domestic purposes, results-based financing, or in a voluntary

e See the Verra Registry: www.registry.verra.org/#/ccb

carbon market.

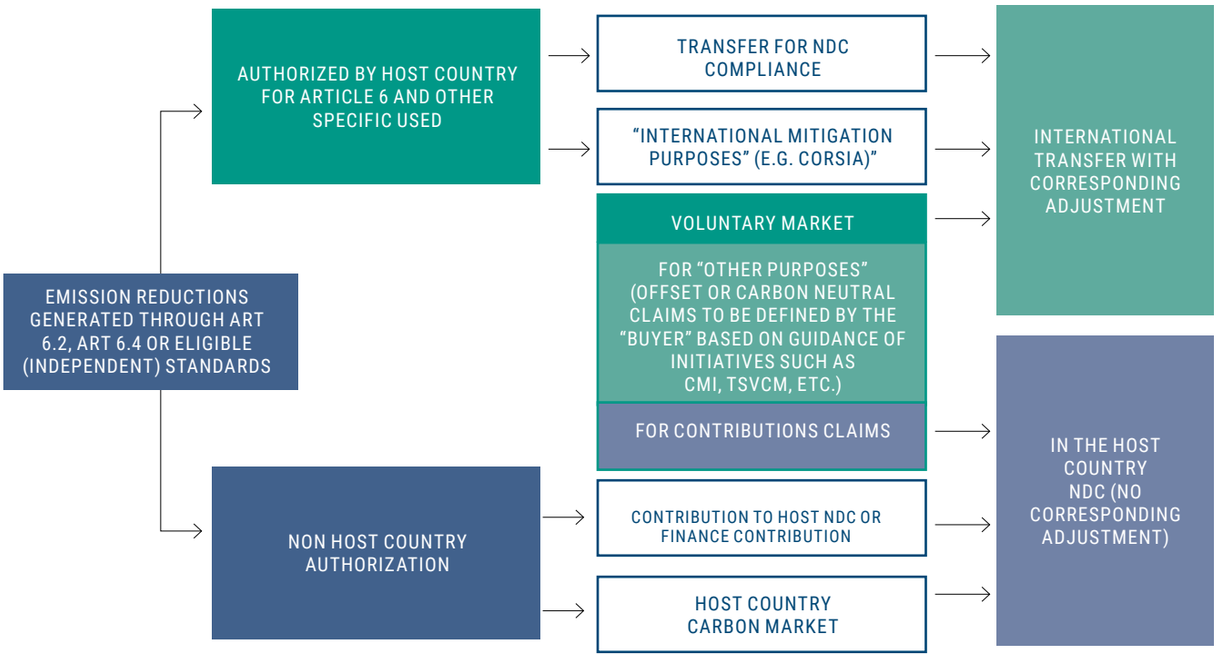
All ITMO trades must lead to a "corresponding adjustment" in order to avoid double counting when a Party credits its NDC with the mitigation outcome transferred from another Party. As a result, two parties cannot claim the same mitigation outcome on their balance sheet. In contrast, the Glasgow decisions leave it to the discretion of the Parties whether or not to make a corresponding adjustment to "unauthorised credits" for Article 6.2 that are used in the voluntary market, and to certifiers and credit programmes whether to discriminate these credits or not. In other words, the question is whether a country like the United States can claim in its carbon accounting a mitigation outcome obtained by a domesticallybased company, such as Amazon, via the purchase of carbon credits on the voluntary market, at the risk of weakening its proactive reduction policies.

By the rules established by the Voluntary Carbon Markets Integrity Initiative (VCMI) in its provisional Code of Practice in June 2022 (**SEE BELOW**), corresponding adjustments will not be mandatory. Verra,[40] then Gold Standard – which had, however, announced the opposite at the start[41] – have aligned themselves with this position. Four States among the 32 signatories of the "San José Principles" for the integrity of international carbon markets have already declared that they will not use or transfer a mitigation outcome without a corresponding adjustment.

FIGURE 4

THE CORRESPONDING ADJUSTMENTS SYSTEM AND ELIGIBILITY OF CARBON CREDITS UNDER ARTICLE 6.2

Source: World Bank, 2022



Article 6.4 seals the end of the Clean Development Mechanism

Article 6.4 establishes the creation of a new mechanism to replace the Clean Development Mechanism (CDM) of the Kyoto Protocol. Under the CDM, developed countries with an emission reduction target (known as "Annex B" countries) could purchase "Emission Reduction Certificates" (ERCs) generated by projects implemented in developing countries. To be delivered an ERC, a CDM project had to achieve an "additional" emissions reduction that would not otherwise have occurred. But CDM credits have acquired a bad reputation owing to the weakness of the standards governing their certification. The negotiation of this article proved to be particularly delicate, owing to the opposition of Brazil, China, India, and South Korea to the rules preventing double counting. The Glasgow decisions prompted the evolution of the Article 6.4 mechanism to address several criticisms of the CDM:

- Corresponding adjustments when transferring emission reductions (called "A6.4ER" in the jargon) between the Parties or to CORSIA or Emission Trading Systems (ETS).
- To boost the ambition of the mechanism compared to the CDM, a "global emissions reduction goal" has been set. This means that 2% of the A6.4ER credits will be cancelled at the time of their issuance, and therefore cannot be credited to any Party for the purpose of pure compensation.
- An obligatory share of 5% of transactions will be deducted to feed the Adaptation Fund.
- One item remains controversial regarding the use of old CDM credits in the Parties' NDCs. The ERCs issued between 2013 and 2020, i.e., about 100 $MtCO_2$, have finally been admitted for use by the Parties to meet the objectives of their first NDC cycle.

Under pressure from the pandemic, CORSIA fails to take off

In order to "*achieve carbon neutral growth from 2020 and reduce its carbon emissions by 50% compared to 2005 levels*",[f] since 2016, the international civil aviation sector has been organised around the Carbon Offsetting Scheme for International Aviation (CORSIA), an emission compensation programme set up by the International Civil Aviation Organisation (ICAO). The programme is planned in three main implementation phases: the pilot phase (2021-2023) and the first phase (2024-2026) are voluntary; the programme only becomes compulsory from the second phase onwards (2027). The pilot phase of the programme was launched on the 1st of January, 2021. During this phase the participating companies will only have to compensate the flights between the countries which will have volunteered to test the programme. There are now 107 countries ready to participate, among the 193 members of ICAO, representing 76% of international activity. From 2027 onwards, the offsetting obligations will become mandatory for all international flights.

Since its creation, the CORSIA program has struggled to answer questions about its real ability to drive the sector's transition. The ICAO council has gradually strengthened its rules of application, restricting qualified credits for the programme to eight certification registries[g] and prohibiting the use of credits linked to projects that started before the 1st of January 2016.

But the SARS-Cov2 pandemic halted the programme before it even started. In June 2020, the ICAO council decided to activate a safeguard clause contained in the CORSIA agreement to lower the programme's reference threshold to 2019 emissions level instead of the sector's average emissions in 2019-2020, as initially planned.[42] This decision actually delays the entry into the programme by three years, since with emissions still lower than those of 2019 due to the drop in traffic induced by the pandemic, the volunteer companies will, in theory, have no additional emissions to compensate during the entire pilot phase.[43] In 2021, the weighted average price of credits traded in five of the compensation programmes eligible for CORSIA was only $3.08/t, compared to $4.89/t in 2020. This is lower than the average market price (4$/t), with a spread between $0.5/t and more than $45/t.[44] This drop in price is normally attributable to the renewable energy credits (**SEE ABOVE**).

In addition, the voluntary phase, which will end in 2026, will only impose compensation on flights between two voluntary countries, reducing its scope to around 44% of total international aviation emissions.[45] Sixteen new countries have joined the voluntary programme as of 2022, but China, Russia, Brazil and India are still among the notable abstentions.[46] Finally, there is a significant risk of double-counting emission reductions if countries transferring credits to airlines do not make a "corresponding adjustment".

To inform carbon credit purchase decisions, at the end of 2020, the International Air Transport Association (IATA) launched the *Aviation Carbon Exchange*, an electronic platform thanks to which airline companies can identify, select, and exchange voluntary emission units eligible under CORSIA.[47] JetBlue, a low-cost U.S. airline, inaugurated the programme by purchasing credits for the development of the *Larimar* wind farm in the Dominican Republic. When completed, the project will credit the company with 200,000 tCO_2 avoided per year.[48]

f As stated by ICAO in the resolution adopted at its 39th Session in October 2016, thereby creating the CORSIA programme.

g These eight registries are: American Carbon Registry, China GHG Voluntary Emission Reduction Program, Clean Development Mechanism, Climate Action Reserve, The Gold Standard, Verified Carbon Standard, Global Carbon Council and Architecture for REDD+ Transactions.

To this system, major companies around the world have added voluntary compensation programmes, several of which began in 2020. However, in May 2021, an investigation published by Unearthed[h] and The Guardian newspaper, showed how, out of a selection of projects aimed at reducing deforestation (funded by British airline companies and certified by Verra, the largest carbon credits purveyor in the world), the methodologies used did not make it possible to draw conclusions on the real reductions in CO_2 emissions.[49] In particular, the notion of "avoided deforestation", measured arbitrarily by the certifying body without any oversight from an independent central authority, was questioned.

4. GOVERNANCE OF THE VOLUNTARY CARBON MARKET IS TAKING SHAPE

New standards to regulate "claims"

As it allows for the financing of a mitigation project outside the scope of its activity, the prospect of being able to claim being "carbon neutral" is the main incentive for an organisation to finance a project through the purchase of carbon credits on the voluntary market. But in the absence of universal standards and a central regulating authority, the net zero commitments of companies lack a certain credibility.
In a report published in February 2022 entitled "*Corporate Climate Responsibility Monitor 2022*" (CCRM) Carbon Market Watch and the NewClimate Institute have pinned down the carbon neutrality commitments formulated by 25 of the world's largest companies. While their cumulative emissions reported in their inventories amount to 2.7 $GtCO_2e$, i.e., 5% of global annual emissions,[50] the objectives formulated by these companies only commit them to an aggregate reduction in their emissions of 40% on average at the due date they have set for themselves. Only 13 companies out of these have matched their commitments with their reduction targets, and only eight take into account the entire value chain (Scope 3).

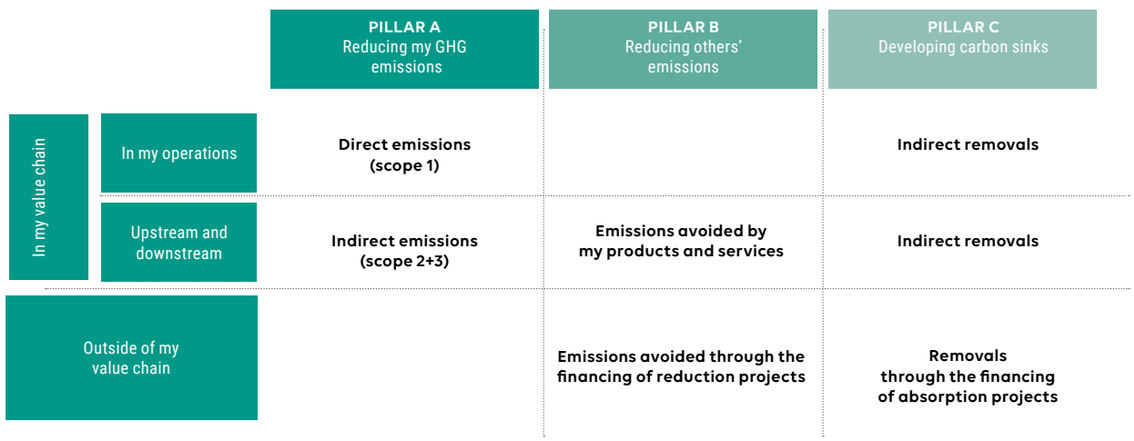
This analysis runs counter to the assessments made by the main standards and assessors of corporate climate strategies. The authors of the study reckon that for the majority of the 18 companies in the sample, the endorsement by SBTi of their carbon neutrality objective according to the "Net Zero" standard is in reality "contentious or inaccurate". In particular, the CCRM notes reference years that are too high, and inconsistencies between SBTi assessments and the companies' own monitoring and progress reports. The authors point in the end to a "potential conflict of interest" for the SBTi, which produces fee-based assessment of companies against its own standards, and raise the question of whether it is "realistic and acceptable to conduct mass assessments for companies without sufficient resources to probe further."[51]

In France, the consulting firm Carbone 4 presented the Net Zero Initiative (NZI) standard in April 2020.[52] This standard for companies offers a normative definition of "corporate neutrality" in order to reconnect it with the objective of planetary neutrality. Concretely, NZI supports and provides a framework for companies to implement their carbon neutrality climate strategies.

FIGURE 5

THE THREE PILLARS OF THE NET ZERO INITIATIVE BENCHMARKS FOR "CORPORATE NEUTRALITY"

Source: Carbone4, 2020



h Unearthed is a Greenpeace news initiative.

NZI is based on a restrictive but ambitious view of carbon neutrality, which it only conceives on a collective scale – planetary or national. In the NZI, unlike the CNZS, an individual organisation cannot therefore claim to be "carbon neutral", but can instead communicate around its "contribution" to planetary or national neutrality. To maximise the contribution of companies, the NZI standard, like CNZS, distinguishes between a company's own emissions reduction actions (which it calls "Pillar A"), the reduction of others' emissions ("Pillar B") and removals through development of carbon sinks ("Pillar C").

Within the framework of the NZI standard, the purchase of carbon credits therefore constitutes only one instrument among others that can be mobilised by the organisation within the framework of its Pillar B or C. Within the framework of Pillar B, the carbon credit certifies the financing of a project leading to the avoidance of emissions (compared to a reference scenario) outside the company's value chain. Within the framework of Pillar C, the carbon credit certifies the funding of a project leading to the sequestration of carbon. In both cases, the company cannot claim "possession" of the reduction, but only its funding, within the spirit of a "contribution" to collective neutrality.

To address the need for credibility and integrity of companies that claim to be "carbon neutral", **the Voluntary Carbon Markets Integrity Initiative (VCMI) unveiled a "Claim Code of Practice" in June 2022**. In particular, the Code provides that a claim must first be based on a "net zero" objective (pledge) based on science, recommending certification of the SBTi Net Zero Standard for this **(SEE BELOW)**; it also requires the purchase of carbon credits allowing mitigation outside of the organisation's value chain, and the use of high quality credits.

Subject to consultation until August, the code has already raised some concerns. The NGO Reclaim Finance describes it as a "greenwashing manual", considering in particular that it does not sufficiently compel companies to reduce their emissions before resorting to offset credits and to be able to claim a "net zero" claim, and that it lacks precision in all of its expectations.[53]

In the end, some States have taken up the subject and have undertaken to regulate the carbon neutrality claims of companies. This is the case for France, which in the Climate and Resilience Law voted in August 2021, prohibits an advertiser from claiming "carbon neutrality" for its product or service without presenting an easily publicly accessible and yearly updated GHG balance sheet for its entire life cycle.[54] The European Union is also considering an initiative to regulate "green claims" more generally.

Standards for building a common approach to offsetting aligned with the Paris Agreement

As with organisations' commitments and claims to carbon neutrality, there is no regulatory authority for the voluntary carbon market. Since 2008, the International Carbon Reduction and Offset Alliance (ICROA) has been accrediting organisations, active in the emissions reduction and compensation value chain and which comply with its own "Code of Good Practices", with a view to enhancing the integrity, quality, and impact of carbon credits. In 2011, it joined the International Emission Trading Association (IETA), created in 1999 following the signing of the Kyoto Protocol. In recent years, several standards have been developed to promote adherence to common principles of integrity and robustness in the area of compensation.

Published in September 2020, **the Oxford Principles seek to define common principles in order that all Net Zero commitments may converge to the same propositions and requirements regarding the use of carbon credits**. These principles aim to provide credit buyers with a consistent understanding of the role of compensation as part of an overall mitigation strategy.[55] The Oxford Principles have been integrated into the Race to Zero campaign mobilising coalitions of businesses, investors, universities, cities, states and regions committed to carbon neutrality.[56] The principles of the *Race to Zero* campaign include:

- **Principle 1.** Prioritise reducing your own emissions first, ensure the environmental integrity of any offsets used, and disclose how offsets are used;
- **Principle 2.** Shift offsetting towards carbon removal, where offsets directly remove carbon from the atmosphere;
- **Principle 3.** Shift offsetting towards long-lived storage, which removes carbon from the atmosphere permanently or almost permanently;
- **Principle 4.** Support for the development of a market for net zero aligned offsets.

The principles proposed by the study are intended to be applicable to all non-state actors who, on the demand side, wish to use offsetting in the carbon neutrality plans. By encouraging carbon capture and storage (CCS), the Oxford Principles prioritise a resolutely technological approach to offsetting over a "nature-based" approach, arguing for greater permanence of storage made possible by CCS.[i] A position shared by Carbon Direct in its analyses **(SEE ABOVE)**, which pleads for the multiplication of long-term sequestration credits.

i Regarding the status of carbon capture and storage technologies, read "CCUS is entering a pivotal period", by Guillaume Marchand, page 141 in: Global Observatory of Non-State Climate Action (2021). Global assessment of non-state climate action by sector. *Climate Chance*

At the same time, in September 2020, the **Taskforce on Scaling Voluntary Carbon Markets (TSVCM)** was born, an international multi-actor initiative aimed at driving the growth of the voluntary carbon market. Initiated by Mark Carney, United Nations Special Envoy for Climate Action and financial adviser to Boris Johnson for COP26, the TSVCM has brought together more than 250 representatives of private companies (Nestlé, Shell, Maersk, Tata Steel, Etihad, etc.), carbon offsetting operators (EcoAct, South Pole, etc.), certifying agencies (Gold Standard, Verra, ACR, etc.), financiers (BNP, UBS, Goldman Sachs, etc.), and even researchers (LSE, etc.). The work of the taskforce has resulted in the publication of several reports and the formation of a new governance body in October 2021, called the **Integrity Council for Voluntary Carbon Markets (IC-VCM)**.

The IC-VCM is now responsible for developing the *Core Carbon Principles (CCPs)*, a "meta standard" that should serve as a common denominator for certification methodologies to promote high-quality and transparent carbon credits. The first step in IC-VCM's work was to appoint three members from indigenous peoples and local communities to its governing board to represent people living in the regions of the world most affected by carbon projects.[57]

KEY TAKEAWAYS

2021 was a banner year for the voluntary carbon market, driven by the upsurge of corporate commitments to achieve "net zero emissions". By exceeding a billion dollars for the first time and multiplying fourfold year-on-year between 2020 and 2021, the value of credits traded globally shows the growing interest of companies in this instrument within the framework of their transition plans. In particular, credits certifying nature-based solution projects (afforestation, reforestation, conservation, etc.) are enjoying a thriving success and occupy the leading position in the market. The co-benefits for biodiversity and the socio-economic development of local communities are also highly sought after. However, emission removal credits allowing the capture and additional sequestration of CO_2 in the long term, remain very underdeveloped.

While it is dynamic, the size of the voluntary carbon market nonetheless remains modest and still far from carbon pricing levels considered compatible with a trajectory that limits global warming to 2 or 1.5 °C. While it allows channelling of private financial resources towards projects beneficial to the mitigation of greenhouse gas emissions, the possibility offered to companies and other organisations to claim "carbon neutrality" in the absence of universal standards incites controversy. Therefore, alongside this development, new governance frameworks and standards are being created, that structure and regulate the use of carbon credits and strategies based on carbon neutrality. Though the adoption of Article 6 of the Paris Agreement may not result in a change on the fundamentals of the market for the time being, it will allow better integration of the voluntary market with that of the signatory States.

REFERENCES

RETURN TO PREVIOUS PAGE

1 IPCC (2018). Special Report: Global Warming of 1.5ºC. Summary for Policymakers. *Intergovernmental Panel on Climate Change*

2 Net Zero Tracker. *Energy & Climate Intelligence Unit, Data Driven EnviroLab, NewClimate Institute, Net Zero Climate*

3 Goering, L. (03/11/2021). Forget net-zero: meet the small-nation, carbon-negative club. *Reuters*

4 Day, T., Mooldijk, S., Kuramochi, T. (2020). Navigating the Nuances of Net-Zero Targets. *NewClimate Institute, Data-Driven EnviroLab*

5 IPCC (2022). Climate Change 2022: Mitigation of Climate Change. *Intergovernmental Panel on Climate Change*

6 Ryan, D. (2021). Accelerating climate action: the role of in-country local leadership networks in delivering Net Zero. *UK100*

7 SBTi (10/11/2021). More than 1,000 companies commit to science-based emissions reductions in line with 1.5ºC climate ambition. *Science Based Targets iniative*

8 Black, R., Cullen, K., Fay, B., Hale, T., Lang, J., Mahmood, S., Smith, S.M. (2021). Taking Stock : A global assessment of net zero targets. *Energy & Climate Intelligence Unit, Oxford Net Zero*

9 Reuters (05/10/2021). World's largest miners pledge net zero carbon emissions by 2050. Reuters

10 Climate Chance Observatory (2021). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

11 ExxonMobil (18/01/2022). ExxonMobil announces ambition for net zero greenhouse gas emissions by 2050. *ExxonMobil*

12 NQA (28/03/2022). ISO 14068 – GREENHOUSE GAS MANAGEMENT AND RELATED ACTIVITIES. *NQA*

13 See on website: https://sciencebasedtargets.org/companies-taking-action

14 SBTi (2021). SBTI CORPORATE NET-ZERO STANDARD. Version 1.0. *Science Based Target initiative*

15 Lo, J. (18/05/2022). Science Based Targets initiative kicks out oil companies, delays validation criteria. *Climate Home News*

16 See on website: https://sciencebasedtargets.org/sectors/financial-institutions

17 Net Zero Initiative (29/06/2022). 10 principes pour une stratégie climat d'entreprise ambitieuse. *Carbone 4*

18 Levrel, H. (2020). Les compensations écologiques. Paris: *La Découverte*, Repères Écologie

19 Net Zero Tracker (2022). Net Zero Stocktake 2022. *Energy & Climate Intelligence Unit, Data-driven EnviroLab, NewClimate Institution, Oxford Net Zero*

20 Donofrio, S., Maguire, P., Daley, C. et al. (2022). The Art of Integrity. State of the Voluntary Carbon Markets 2022 Q3. *Ecosystem Marketplace*

21 Donofrio, S., Maguire, P., Myers, K., Daley, C., Lin, K. (2021). Ecosystem Marketplace Insights Report. Markets in Motion: State of Voluntary Carbon Markets 2021 Installment 1. *Ecosystem Marketplace*

22 Shifflett, S. (22/07/2022). Booming Carbon-Credits Market Took Hit as Stocks Sold Off. *Wall Street Journal*

23 Climate Focus (up. 06/06/2022). Voluntary Carbon Market Dashboard. *Climate Focus*

24 Brimont, L. (28/09/2016). La performance des projets REDD+ : prédire le pire et promettre le meilleur ? *IDDRI*

25 Carbon Direct (06/05/2022). Assessing the State of the Voluntary Carbon Market in 2022. *Carbon Direct*

26 Banque mondiale (2022). State and Trends of Carbon Pricing 2022. *Banque mondiale*

27 Sebastian, V. (06/01/2022). Voluntary carbon market rally set to stretch into 2022 on demand optimism. *S&P Global Platts*

28 Roelf, W. (06/04/2022). South African dairy farmers eye carbon credits while curbing emissions. *Reuters*

29 Bastin, J-F., Finegold, Y., Crowther, T. W., et al. (2019). The global tree restoration potential. *Science*, vol. 365 (6448), pp. 76-79

30 Holl, K. D., Brancalion, P. H. S. (2020). Tree planting is not a simple solution. *Science*, vol. 368 (6491), pp. 580-581

31 *IPCC (2018). Réchauffement planétaire de 1,5ºC, op. cit.*

32 Gillerot, L., Grussu, G., Condor-Golec, R., et al. (2021). Progress on incorporating biodiversity monitoring in REDD+ through national forest inventories. *Global Ecology and Conservation*, vol. 32

33 Martin, M. P., Woodbury, D. J., Doroski, D. A., et al. (2021). People plant trees for utility more often than for biodiversity or carbon. *Biological Conservation*, vol. 261

34 Rizk, Y. (04/07/2022). Gabon to sell $2bn worth of carbon credits before COP27. *The Africa Report*

35 AFP (15/06/2022). Crédits carbone: TotalEnergies investit dans la forêt gabonaise, avec l'acquisition de parts dans la Compagnie des Bois du Gabon. *Connaissance des Énergies*

36 Lou, J., Hultman, N., Patwardhan, A., Qiu, Y. L. (2022). Integrating sustainability into climate finance by quantifying the co-benefits and market impact of carbon projects. *Communications Earth & Environment*, vol. 3 (137)

37 Verra (23/01/2019). Verra Launches Sustainable Development Verified Impact Standard. *Verra*

38 WBCSD, WEF (15/07/2021). Natural Climate Solutions for Corporates. *World Business Council on Sustainable Development, World Economic Forum*

39 Marcu, A. (2021). Article 6 rule book. A post COP26 assessment. *European Roundtable on Climate Change and Sustainable Transition*

40 Verra (2021). The Future of the Voluntary Carbon Market. *Verra*

41 Gold Standard (2021). Aligning Gold Standard projects with the Paris Agreement Summary of consultation feedback and next steps. *Gold Standard*

42 ICAO (30/06/2020). ICAO Council agrees to the safeguard adjustment for CORSIA in light of COVID-19 pandemic. *International Civil Aviation Organisation*

43 European Commission (2020). Feedback from: Environmental Defense Fund (Accessed 9 July, 2022)

44 ICAO (Nov. 2021). CORSIA Newsletter

45 Dufrasne, G. (2020). What will airlines buy to offset their pollution? Today's supply of carbon credits and tomorrow's demand from CORSIA. *Carbon Market Watch*

46 ICAO (06/07/2021). Over 100 States now participate in ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). *International Civil Aviation Organisation*

47 IATA (2021). Aviation Carbon Exchange (page consultée le 8 juillet 2021)

48 Drab, E. (16/11/2020). L'IATA lance un programme de compensation carbone. *Le Journal de l'Aviation*

49 Clarke, J. S., Barratt, L. (04/05/2021). Top airlines' promises to offset flights rely on 'phantom credits'. *Unearthed*

50 Day, T., Mooldijk, S., Smit, S., et al. (2022). Corporate Climate Responsibility Monitor 2022. *NewClimate Institute, Carbon Market Watch*

51 Clark, P. (05/05/2022). New SBTi boss takes over as criticisms mount. *Financial Times*

52 Dugast, C. (2020). Net Zero Initiative. A framework for collective carbon neutrality. *Carbone 4, Net Zero Initiative*

53 Reclaim Finance (23/06/2022). VCMI: Carbon or Greenwashing Market? *Reclaim Finance*

54 Ministère de la Transition écologique et de la Cohésion des territoires, Ministère de la Transition énergétique (03/05/2022). Mise en œuvre de la loi Climat et Résilience : entrée en vigueur de 3 dispositifs pour une publicité plus responsible. *Ecologie.gouv.fr*

55 University of Oxford (29/09/2020). Oxford launches new principles for credible carbon offsetting. *University of Oxford*

56 Race to Zero (2020). Defining the "Starting Line". Minimum criteria required for participation in the Race to Zero campaign. *United Nations Framework Convention on Climate Change*

57 ICVCM (19/04/2022). Integrity Council for the Voluntary Carbon Market appoints new IPLC leadership. *The Integrity Council for the Voluntary Carbon Market*

ASSOCIATION CLIMATE CHANCE

association@climate-chance.org
www.climate-chance.org