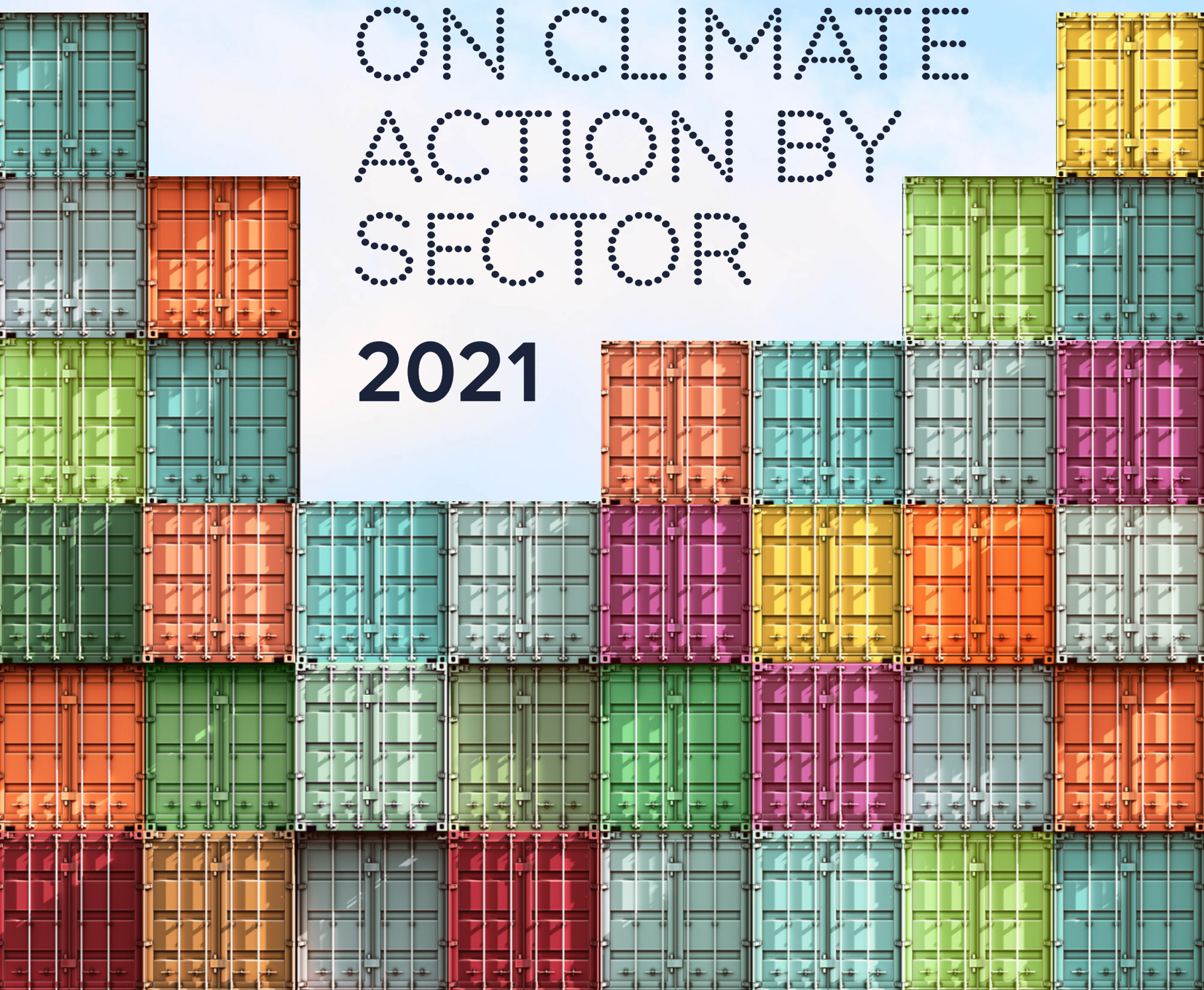
CLIMATE CHANCE

GLOBAL SYNTHESIS REPORT ON CLIMATE ACTION BY SECTOR

2021



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CLIMATE CHANCE

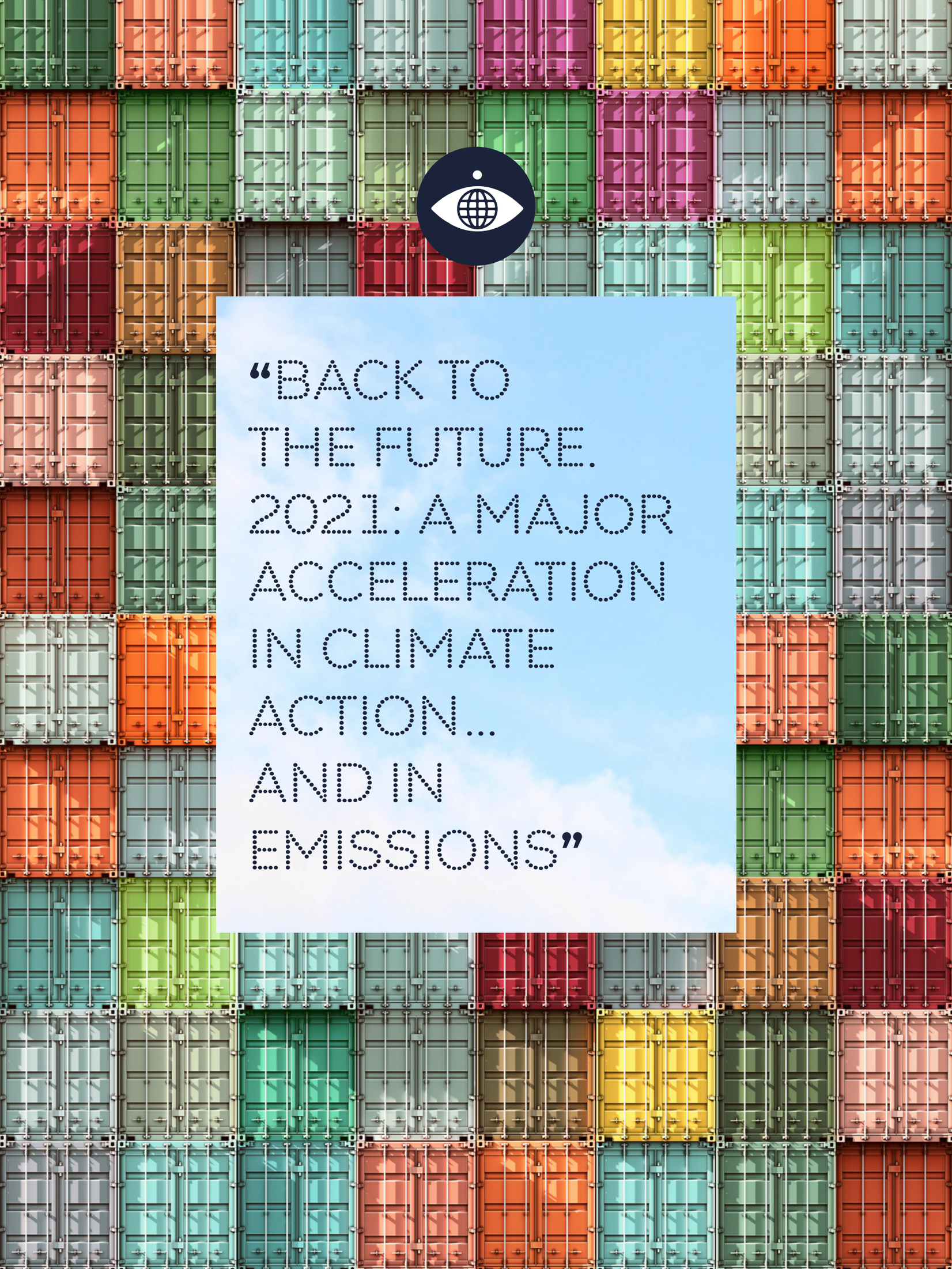
Since 2015, Climate Chance has been working to create a favourable environment to strengthen climate action and contribute to the attainment of the goals of the Paris Agreement. It is the only international organisation that aims to bring together all the non-state actors recognized by the United Nations 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


“BACK TO
THE FUTURE.
2021: A MAJOR
ACCELERATION
IN CLIMATE
ACTION...
AND IN
EMISSIONS”

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THE ACCELERATION OF THE RISE IN GREENHOUSE GAS EMISSIONS

In its latest report published on 9 August 2021, the Intergovernmental Panel on Climate Change (IPCC) has made it clear: "unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach". Global temperatures have already gone up by 1.1°C compared to preindustrial levels, and the link between human activity and the increase of greenhouse gases is now indisputable. Nevertheless, 2020 saw a historical drop in the rising emissions trend, mostly offset by the increase in 2021.

Historic decline in emissions almost eclipsed by the 2021 economic recovery

In 2020, the Covid-19 pandemic led numerous governments to announce measures restricting movements and economic activities. These measures led to the biggest ever annual drop in global greenhouse gas (GHG) emissions related to energy: -5% compared to 2019[a].

Starting from the second half of 2020 in China, and early 2021 in most OECD countries, economic activities returned to pre-Covid levels. The GDP of G20 countries is set to exceed its 2019 value in 2021 (+2.9%), as it is for the OECD as a whole (+0.1%), according to the International Energy Agency (IEA).

This recovery is generating an upswing in energy-related emissions: in total, they are predicted to increase by 4.4% in 2021 compared to 2020 in the G20, reaching close to the 2019 level (without equaling it). A similar trend is taking place globally: the IEA forecasts that the world's emissions will rise sharply to a level slightly below the 2019 peak (-1.2%), which would be the second highest emissions increase in history (IEA, 2021).

These global figures nevertheless mask wide regional variations.

In Europe and America, a slow structural decline in emissions accelerated by the pandemic

In Western countries (Europe, North America) and Latin America, where domestic energy-related emissions had been declining since 2015 (-4.2% in Europe from 2015 to 2019, -1.8% in North America and -7% in Latin America), the pandemic triggered a very sharp drop in emissions of over 10% in all three regions. The biggest decreases in national emissions in 2020 were in these regions, for example Mexico (-17%), Brazil (-7%), Argentina (-10%) and the United States (-11%) in the Americas, and France (-13%), Germany (-9%), Italy (-13%) and the United Kingdom (-12%) in Europe. For the United States and the European Union, the rebound expected in 2021 (respectively +5% and +3%) will probably not offset the decreases observed in 2020.

A similar trend can be observed in Japan, were the expected 2% rise in 2021 will not offset the 6% drop in 2020, in the same proportions as South Korea, after several years of structural decline for both countries (-6% and -8 % from 2015 to 2019 respectively).

The evolutions are slightly less obvious regarding the carbon footprints of these countries, which, taking import-related emissions into account, are higher than their domestic emissions. The downward trend of these last few years is yet to be confirmed. From 1990 to 2017, the European Union's carbon footprint decreased more slowly than its domestic emissions (15% vs. 21%; French Ministry of the Transition, 2021). The French carbon footprint, which is 40% higher than its domestic emissions, has followed a downward trend since 2011, but recent estimates indicate a stagnation from 2017 to 2019 (High Council on Climate, 2021). Similarly, the reduction of the United Kingdom's carbon footprint since 2004 gave way to a 1% rise from 2017 to 2018 (Department of Environment Food & Rural Affairs, 2021). Emissions related to imports have stagnated in the United States since 2010 (Our World in Data, 2020) ; (**see tab.1**).

a Unless otherwise indicated, the statistics relating to economic activities and emissions reported in this part come from Enerdata's *Global Energy* & CO_2 *Data* database.

Faster rebound in emissions from high-emitting Asian countries

This trend contrasts with high-emitting Asian countries, where per capita emissions rose sharply from 2015 to 2019 (China: +5%, India: +14 %, Indonesia: +27%), similar to Russia (+8%) and Turkey (+12%). In these countries, the pandemic generated a smaller drop in CO_2 emissions of around 5% from 2019 to 2020 (Russia: -5%, Turkey: -5%, India: -5.5%, Indonesia: -6%). In the Pacific area, Australia followed a similar trend: after a rise of over 2% from 2015 to 2019, the country's emissions went down by 4% in 2020. In 2021, India's emissions are predicted to increase by 5.7%, overshooting 2019 levels. Despite a first half of 2020 strongly impacted by the pandemic, China, the world's biggest greenhouse gas emitter, ended the year with a 1.6% emissions increase, set to go up by another 5% in 2021 (**see tab.2**).

When considering their carbon footprints, these countries appear as net GHG exporters, unlike European and American countries. For example, China and India export the equivalent of 10% of their domestic emissions, but the United Kingdom imports 40% more emissions than its domestic emissions (Our World in Data). Taking into account emissions related to imports and exports and expressed per capita, the differences between these countries are less marked. In fact, after reaching EU levels in 2017 (about 7 tCO_2/person/year) (French Ministry of the Ecological Transition, 2021), per capita emissions in China are now even higher depending on the method used (7 tCO_2/person/year vs. 6 tCO_2/person/year). However, in 2017, the carbon footprint per capita was still 20% lower in China than in the EU-28, and more than 40% lower than the OECD average (6 tCO_2/person/year in China, vs. 8 tCO_2/person/year in the EU and 11 tCO_2/person/year on average in the OECD) (Ministry of the Ecological Transition, 2021). But studies show that shifts in consumptions patterns and the expansion of middle- and rich-classes generate exponential growth of carbon footprint and emissions from Chinese households (Wiedenhofer et al., 2016 ; Wei, L., et al., 2020), as well as widening gaps with an important share of low-income rural populations.

Rampant emissions growth in Africa and the Middle East brought to a halt by the pandemic

In Africa and the Middle East, emissions had been rising sharply since 2015 (+6.6% in Africa from 2015 to 2019, +3.5% in the Middle East), but were diminishing when expressed per capita (-3.7% in Africa from 2015 to 2019, -3.4% in the Middle East). Economies in these countries were strongly impacted by the pandemic, which led to significant drops in emissions (-6.9% in Africa from 2019 to 2020, -3.6% in the Middle East).

In Africa, emissions decreased by 9% in Algeria and Egypt, following a respective 9% and 14% rise from 2015 to 2019. Emissions from South Africa, the continent's biggest emitter, only declined by 6% in 2020 following a long period of stagnation at around 440 MtCO2e. An exception is Nigeria, one of the rare countries were emissions went up in 2020 (+0.4%).

Similarly, in the Middle East, Iraq saw a 10% decrease in its emissions following a 27% rise from 2015 to 2019, along with a 6% decrease in Qatar following a 9% increase since 2015, and a 6% decrease in the United Arab Emirates after a 3% rise from 2015 to 2019. On the other hand, the Middle East's biggest emitters buck the trend: the pandemic brought Iran's structural increase in emissions to a halt, although with only a slight decrease compared to 2019 (-0.1%), following a similar pattern to the other Asian emitting countries. Saudi Arabia saw a drop in emissions of around 3% in 2020, accelerating the trend in place since 2015 (-8% from 2015 to 2019), similar to Western countries (**see tab.3**).

GREENHOUSE GAS EMISSIONS (WITHOUT LAND USE), IN $MTCO_2E$

TABLE 1

	2015	2016	2017	2018	2019	2020	Evolution 2015-2019 (%)	Evolution 2019-2020 (%)
Canada	622.26	611.99	623.06	633.99	631.26	555.66	**1.45**	**-11.98**
France	346.64	346.86	351.80	346.28	336.73	294.00	**-2.86**	**-12.69**
Germany	794.56	801.17	786.53	765.44	714.86	650.47	**-10.03**	**-9.01**
Italy	355.07	351.30	347.51	341.94	334.99	291.07	**-5.66**	**-13.11**
United Kingdom	422.96	397.77	385.68	377.53	364.23	319.71	**-13.89**	**-12.22**
United States	5 244.79	5 137.85	5 083.75	5 255.45	5 127.39	4 578.62	**-2.24**	**-10.70**
Brazil	524.28	485.18	492.21	463.67	465.86	434.69	**-11.14**	**-6.69**
Argentina	191.79	189.37	185.19	181.59	177.85	160.90	**-7.27**	**-9.53**
Japan	1 234.28	1 222.96	1 204.31	1 156.80	1 132.75	1 062.25	**-8.23**	**-6.22**
South Korea	690.48	707.52	717.11	719.30	655.76	614.10	**-5.03**	**-6.35**

TABLE 2

	2015	2016	2017	2018	2019	2020	Evolution 2015-2019 (%)	Evolution 2019-2020 (%)
China	11,033.45	11,050.31	11,156.08	11,350.49	11,612.95	11,801.05	**5.25**	**1.62**
India	2,257.15	2,302.49	2,425.83	2,546.61	2,578.45	2,436.34	**14.23**	**-5.51**
Indonesia	521.72	524.56	563.40	620.29	663.98	622.49	**27.27**	**-6.25**
Russia	1,773.04	1,752.23	1,802.12	1,868.73	1,918.97	1,807.14	**8.23**	**-5.83**
Turkey	374.83	398.43	437.68	434.05	423.08	400.83	**12.87**	**-5.26**
Australia	406.30	417.48	422.53	421.04	415.88	399.19	**2.36**	**-4.01**

TABLE 3

	2015	2016	2017	2018	2019	2020	Evolution 2015-2019 (%)	Evolution 2019-2020 (%)
Iran	649.63	655.29	678.18	689.82	695.34	694.30	**7.04**	**-0.15**
Iraq	160.55	170.87	172.88	189.94	203.97	184.01	**27.05**	**-9.78**
Kuwait	91.67	93.59	93.34	93.08	96.14	94.90	**4.87**	**-1.28**
Qatar	98.08	99.30	102.10	105.30	106.80	100.03	**8.90**	**-6.34**
Saudi Arabia	576.26	573.31	559.66	534.07	530.78	513.54	**-7.89**	**-3.25**
United Arab Emirates	200.26	206.70	216.12	207.43	205.58	193.50	**2.66**	**-5.88**
Algeria	151.91	150.29	149.81	159.50	165.02	150.23	**8.63**	**-8.96**
Egypt	234.29	245.14	252.05	260.20	266.29	241.31	**13.66**	**-9.38**
Nigeria	110.57	110.76	115.05	139.24	116.20	116.65	**5.10**	**0.39**
South Africa	442.54	444.14	451.60	448.63	436.56	409.94	**-1.35**	**-6.10**

Source : www.enerdata.net

THE ACCELERATION IN INTERNATIONAL COMMITMENTS

Since the signing of the Paris Agreement, the international community has had a universal framework for action to coordinate the efforts of all countries to reduce emissions and adapt to the changes already underway. COP26 in Glasgow marks an important milestone in the process of mobilising the States party to the United Nations Framework Convention on Climate Change (UNFCCC), with the renewal of the Nationally Determined Contributions (NDCs) of the States signatory to the Paris Agreement. Originally scheduled for the end of 2020, it was postponed to November 2021 due to the Covid-19 pandemic.

At the time of the opening of the COP, many NDC updates were still missing, including those from India, Turkey and Saudi Arabia, and many new NDCs were not more ambitious than the previous ones (UNEP, 2021). On the second day of the COP, India's announced goal of "carbon neutrality" by 2070 pushed State commitments over a symbolic hurdle: for the first time, full compliance with all these commitments could lead to global warming of less than 2°C (+1.9°C) (The Guardian, 03/11/2021). By the end of the COP, however, India had still not incorporated this target into a new NDC, and Climate Action Tracker estimated that the package of actions announced by all of the new NDCs for 2030 would lead to a warming of 2.4°C (Climate Action Tracker, 2021).

A true barometer of commitments since the Paris Agreement, the objective of "carbon neutrality" is now included in many NDCs. The share of the global economy covered by national commitments to carbon neutrality went from 16% in 2019 to 68% in 2021, totalling 61% of emissions(ECIU & Oxford Net Zero, 2021). After the first week of COP26, nearly 90% of global greenhouse gas emissions were covered by carbon neutrality commitments of States (Bloomberg, 02/11/2021). These targets also incorporate the recovery and growth strategies of large companies. Of the 2,000 largest companies, 417, accounting for one third of the total turnover, have a "carbon neutrality" target (ECIU & Oxford Net Zero, 2021). No sector has escaped this wave, not even those whose core business is based on the production or consumption of carbon-intensive energy, such as the European oil majors (BP, Shell, TotalEnergies, Eni, etc.), mining companies (BHP, Rio Tinto, etc.) or the major steel groups (ArcelorMittal, Baowu Group, etc.).

In addition, the COP was the occasion for many other international commitments. On 2 November, 105 countries signed a Global Methane Pledge, initiated by the European Union and the United States, committing to reduce their emissions of this powerful greenhouse gas by 30% by 2030. Russia, India and China are not among the signatories. On the same day, 100 countries covering 85% of the world's forests, including Brazil, the Democratic Republic of Congo and Indonesia, pledged to halt deforestation and land degradation by 2030, in a text similar to earlier unfulfilled agreements like the New York Declaration (**see the 2020 Sector-based Report**). The prevarication of Indonesia, through its forestry minister, just a few days after the signing of the pact, is already weakening the scope of the commitment (Mongabay, 05/11/2021). Two days later, some twenty countries pledged to stop financing fossil fuel projects abroad from the end of 2022 (notable absentees: China, Japan, South Korea, and Spain), and some forty countries pledged to end coal-fired power generation by 2030 or 2040 (Canada, Poland, Vietnam… but not the United States, China, India or Australia). In the Glasgow Declaration on Zero Emission Cars and Vans, a group of governments, carmakers, mobility operators and investors have pledged to accelerate low-carbon mobility, towards 100% zero-emission sales by 2040. While manufacturers such as Volvo, Ford and General Motors have joined the pact, the world's two largest car companies, Volkswagen and Toyota, have not; neither have major industrial countries such as the United States, China, Germany and France.

"Nearly 90% of global greenhouse gas emissions are now covered by carbon neutrality commitments."

Nevertheless, it is to be ensured that 30-year commitment do not delay short-term action, as rapid action forms the basis of all scenarios stabilizing warming under 2°C. In this respect, the recovery plans of Western countries after the initial lockdowns of 2020 paint an ambiguous picture. According to Energy Policy Tracker, since the start of the pandemic, G20 members have committed to investing over 700 billion dollars in their economies, about 40% of it for emitting sectors and 37% for low-carbon sectors. It is currently difficult to evaluate the impact: some of these plans are aimed at accelerating the deployment of low-carbon sectors (hydrogen, electric mobility, etc.), but rescue plans for some high-emitting sectors as part of national recovery plans (aviation, automobile) and involving no environmental compensation could slow down the decrease in emissions.

To accelerate the decarbonisation of their economies, more and more countries are implementing carbon pricing mechanisms. These mechanisms have taken on particular importance this year and have reached significant milestones.

THE ACCELERATION OF THE INCREASE IN THE PRICE OF CARBON

According to I4CE, all 47 jurisdictions that have a carbon pricing mechanism (tax or market) account for 60% of global GDP, and also 60% of global greenhouse gas emissions (I4CE, 2021). However, this does not guarantee that 60% of emissions are "effectively" covered by such a mechanism, as some sectors or populations may be exempt. More than 21% of global greenhouse gas emissions are covered by carbon pricing today, compared to 15% in 2020 according to the World Bank (World Bank, 2021).

Of these emissions covered, less than half are covered by a price of less than $10 per tonne (I4CE, 2021). The average price is no more than $3/tonne, while the Stern-Stiglitz Commission on Carbon Pricing concluded in 2019 that "*the explicit carbon price level consistent with meeting the temperature targets of the Paris Agreement is at least $40-80 per tonne of CO2 in 2020.*" (CPLC, 2019).

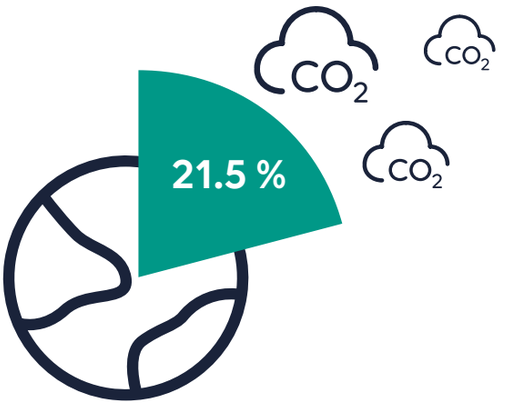
In Europe, the price of a tonne of carbon has continued its upward trend since 2019 and passed the symbolic €50 mark in May 2021, peaking at €62/tonne at the beginning of October, whereas it had been capped at less than €5/tonne since the opening of the emissions trading scheme (ETS) in 2005 (Ember, 2021). By inaugurating its ETS on power generation in early 2021, China has opened the world's largest carbon market, with a price of around $4-$5/tCO2e. The US and the EU are increasingly considering taxing carbon products at their borders.

In total, these taxes and allowance markets have generated revenues of $56.8 billion in 2020, compared to $48 billion in 2019, which were allocated either to projects related to the ecological transition or to the general budgets of the jurisdictions (I4CE, 2021).

Thus, faced with the limits of these incentive mechanisms, and with the discrepancies observed between the long-term commitments of States and their immediate actions, civil society no longer hesitates to resort to legal strategies to force the actors to align their actions and ambitions with the texts and commitments they have signed.

jurisdictions have a carbon pricing initiative implemented (tax or market)

11.65 $GtCO_2e$ are covered by these initiatives in 2021, i.e., 21.5% of global GHG emissions



THE ACCELERATION OF THE JUDICIALIZATION OF CLIMATE ACTION

UNEP's Global Climate Litigation Report listed 1,500 lawsuits on climate underway in July 2020, of which 1,200 were in the United States, 90 in Australia, 58 in the United Kingdom, and 55 in the European Union, compared to 884 in 2017 (UNEP, 2021).

This judicialization of climate action is accompanied by the growing prescriptive force of court decisions on mitigation. Although it has little immediate legal effect, a judgment delivered in late 2019 by the Dutch Supreme Court ruled in favour of a case filed by the Urgenda Foundation to oblige the state to reduce its emissions by 25% from 1990 to 2020. The decision put timely pressure on the government just as it was presenting its integrated national energy and climate plan 2021-2030 to the European Commission (Urgenda, 2019). Since then, the government has also met with resistance from RWE and Uniper, who are demanding compensation for the announced closure of coal-fired power stations before 2030 (Ember, 2021). But one prosecution leads to another, and successful court cases abound, like Greenpeace contesting the low level of climate compensation for Dutch state support for KLM after Covid-19 struck, or the recent condemnation of Shell by the Hague Tribunal.

Condemned in October 2020 for climate inaction at the initiative of the town of Grande-Synthe, the French government failed to prove to the Council of State that the 40% emissions reduction trajectory between 1990 and 2030 could be met without additional measures; the highest civil court therefore recognised the inadequacy of its action, and gave the government until March 2022 to take the necessary measures (Conseil d'État, 2021). In contrast, the British Supreme Court revoked the decision of the tribunal that had judged illegal the construction of terminal three at Heathrow Airport based on the non-respect of the Paris Agreement, arguing that the ratification of the Agreement did not constraint the government in this case (White & Case, 2021).

In parallel to these decisions judging the compliance of mitigation efforts with the commitments of States or companies, other court cases aim to attribute responsibility for past climate change and its consequences, such as sea level rise or extreme weather events. In France, a few months after the case filed by the mayor of Grande-Synthe, prompted by the rise in sea level that directly threatens the municipality, the Administrative Tribunal ruled in favour of the "Affaire du Siècle" movement when it sentenced the State to "repair the ecological prejudice" caused by exceeding the carbon budget set by France from 2015 to 2018 (Tribunal administratif, 2021).

In the United States, owners of land flooded by Hurricane Harvey in 2017 attacked the federal government, accusing it of not having anticipated this risk, even though climate change is known to be responsible for the increase in the intensity and frequency of hurricanes. The State defended itself by arguing that climate change is causing new and difficult-to-predict extreme weather events. In the end, the court asked the State to compensate the plaintiffs, but did not rule on the predictability of the storm (UNEP, 2021).

In California, the main electricity utility PG&E had been challenged and sued for triggering the Camp Fire of November 2018. This gigantic fire, which killed 85 people and wiped out the town of Paradise, was triggered by a falling power line tower, causing sparks that ignited the surrounding vegetation, which had dried out due to the unusually warm weather (New-York Times, 18/06/2020). *PG&E's failures to maintain its power lines and clear nearby land led to the historic utility being found guilty of manslaughter and ordered to pay tens of thousands of dollars in damages to victims. PG&E subsequently filed for bankruptcy, described by the Wall Street Journal as "the first climate-change bankruptcy, and probably not the last"* (Wall Street Journal, 18/01/2019).

AN OBSERVATORY FOR UNDERSTANDING THE CONTRADICTIONS AND COMPLEXITIES IN THE RECOVERY

Thus, while the need for climate action is now established and almost universally recognised, its nature, forms and modalities remain subject to uncertainties and disputes.

Since 2015, Climate Chance has endeavoured to create a favourable environment to strengthen the climate action of local governments, businesses and civil society, and contribute to the attainment of the goals of the Paris Agreement. Within this framework, the Observatory of Non-State Climate Action observes and analyses what is actually being done to reduce global greenhouse gas emissions, presenting the same in its Reports.

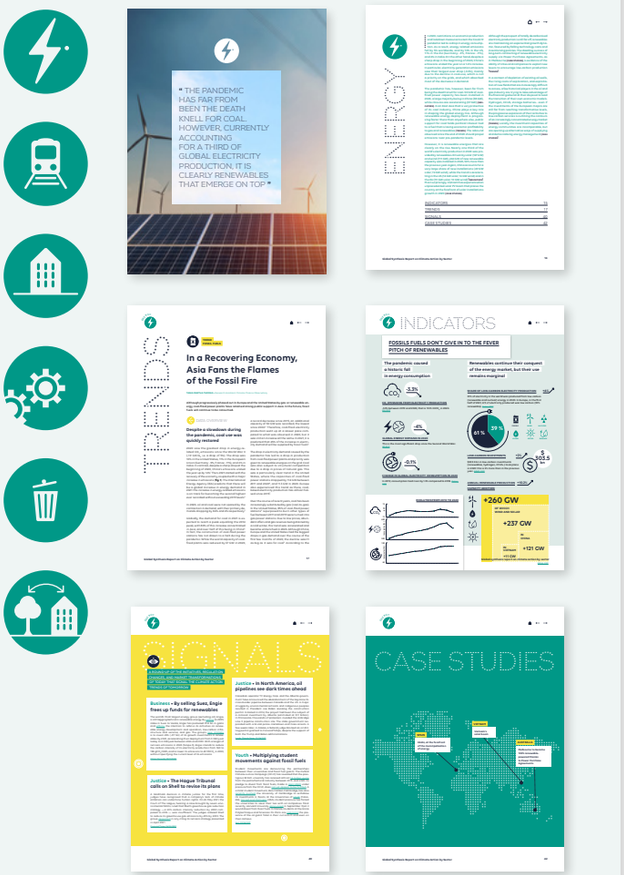
Therefore, to the question of "*What is to be done*?", the Observatory responds by showcasing what has already been done. In main emitting sectors at the global level (energy, transport, buildings, industry, waste, and land-use), it shows what non-state actors around the world are currently doing to reduce their emissions, and what they are not. It thus becomes easier for policymakers to identify the levers they can use, and they difficulties they might encounter.

"The Observatory shows climate action for what it is, and not what it should be."

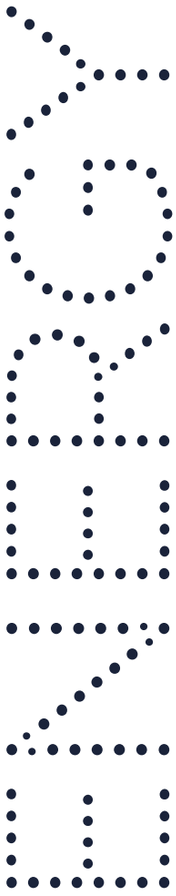
The Observatory thus recounts the story of climate action behind the figures of evolving emissions that permeate the news. Its approach aims to give meaning to the events that structure international climate action at the level of private actors and local governments, by weaving together all the publications, initiatives and events produced by the constellation of non-state actors in the climate domain.

4TH EDITION

This year, in its fourth edition, the Global Climate Action Report has been redesigned and its analysis of the emissions sectors has been organised under four new sections, which offer different approaches to understanding the driving forces behind the climate action of non-state actors and the evolution of emissions. Starting with objective data on emissions and actions taken **[INDICATORS]**, the Observatory analyses recent trends in the actions of companies, local authorities and civil society organisations as a whole, which help to explain the evolution of emissions **[TRENDS]**. It highlights remarkable initiatives **[CASE STUDIES]** 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. The Observatory only believes what it has seen: it is therefore only interested in what has actually been achieved in the recent past and, as far as possible, can demonstrate quantitative results. The Observatory shows climate action as it is, and not as it should be.




“ THE PANDEMIC HAS FAR FROM BEEN THE DEATH KNELL FOR COAL. HOWEVER, CURRENTLY ACCOUNTING FOR A THIRD OF GLOBAL ELECTRICITY PRODUCTION, IT IS CLEARLY RENEWABLES THAT EMERGE ON TOP ”



In 2020, restrictions on economic production and lockdown measures to stem the Covid-19 pandemic led to a drop in energy consumption. As a result, energy related emissions fell by 5% worldwide, and by 10% in the US, 11% in the EU (Germany: -9%, France: -11%), and 6% in India. On the other hand, despite a sharp drop in the beginning of 2020, China's emissions ended the year on a 1.6% increase. In particular, electricity generation emissions saw their largest ever drop (-3.3%), mainly due to the decline in coal-use, which is not a priority on the grids, and which absorbed most of the decrease in demand.

The pandemic has, however, been far from being the death knell for coal. 50 GW of coal-fired power capacity has been installed in 2020, a large majority being in China (38 GW), while closures are accelerating (37 GW) **[INDICATORS]**. In an East Asia that is very protective of its coal industry, China plays a key role in shaping the global energy mix. Although renewable energy deployment is progressing faster there than anywhere else, public support for coal holds political interest tied to a fuel that is losing economic profitability to gas and renewables **[TRENDS]**. The rebound observed since the end of 2020 should propel emissions near pre-pandemic levels.

However, it is renewable energies that are clearly on the rise. Nearly one third of the world's electricity production in 2020 was provided by renewables. Driven by solar (127 GW) and wind (111 GW), 260 GW of new renewable capacity was installed in 2020, 50% more than the previous year. Again, China accounts for a very large share of new installations (49 GW solar; 72 GW wind), while the trend is accelerating in the US (14 GW solar; 14 GW wind) and in the EU (19 GW solar; 10 GW wind) **[INDICATORS]**. Most surprisingly, Vietnam has experienced an unprecedented solar PV boom that places the country at the forefront of solar installations growth in 2020 **[CASE STUDIES]**.

Although the prospect of totally decarbonised electricity production is still far off, renewables are maintaining an exponential growth dynamic, favoured by falling technology costs and incentivising policies. The dazzling success of long-term contracting of renewable electricity supply via Power Purchase Agreements, as in Melbourne **[CASE STUDIES]**, is evidence of the ability of cities and companies to exploit new levers to encourage low-carbon production **[TRENDS]**.

In a context of depletion of existing oil wells, the rising costs of exploration, and exploitation of new fields that are increasingly difficult to access, a few historical players in the oil and gas industry are trying to take advantage of the financial godsend at their disposal to lead the transition of their own economic models. Hydrogen, CCUS, storage batteries… even if the investments of the European majors are still far from reaching transformative levels, the progressive expansion of their activities to low-carbon services is outlining the contours of an increasingly concentrated energy market **[TRENDS]**. Locally, the investment capacities of energy communities are incomparable, but are opening up alternative ways of supplying and democratising energy management **[CASE STUDIES]**.

FOSSILS FUELS DON'T GIVE IN TO THE FEVER PITCH OF RENEWABLES

The pandemic caused a historic fall in energy consumption

-3.3%

CO_2 EMISSIONS FROM ELECTRICITY PRODUCTION

-3.3% between 2019 and 2020, that is 13.15 $GtCO_2$ in 2020. *IEA, 2021*

-4%

GLOBAL ENERGY DEMAND IN 2020

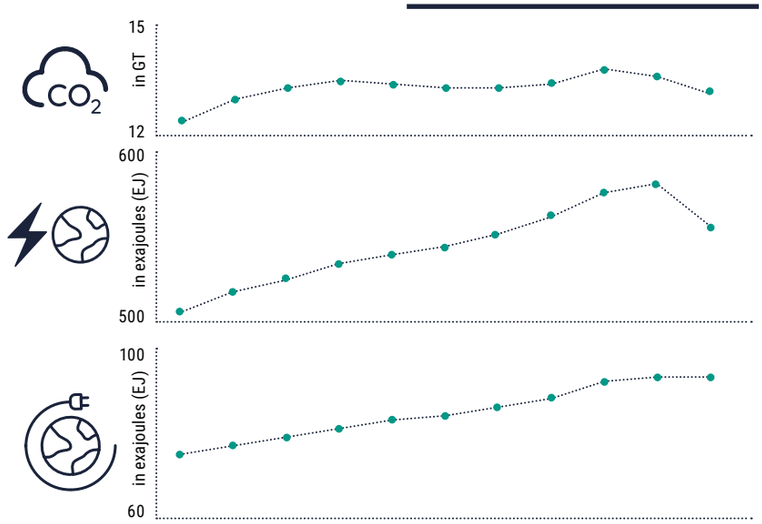
This is the most significant drop since the Second World War. *BP, 2021*

-0.1%

CHANGE IN GLOBAL ELECTRICITY CONSUMPTION IN 2020

In 2019, consumption had risen by 1.3% compared to 2018. *Ember, 2021*

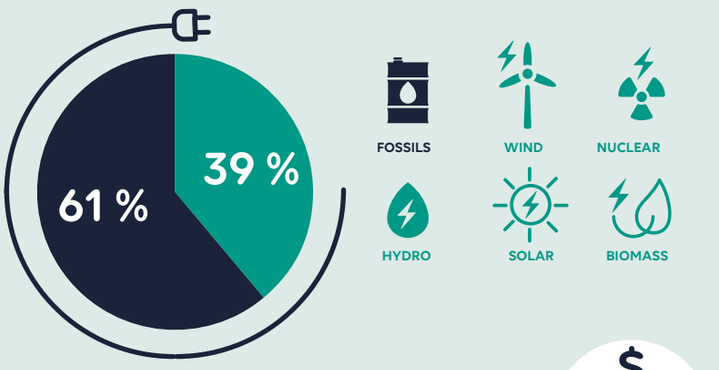
EVOLUTION FROM 2010 TO 2020



Renewables continue their conquest of the energy market, but their use remains marginal

SHARE OF LOW-CARBON ELECTRICITY PRODUCTION +6%

39% of electricity in the world was produced from low-carbon (renewable and nuclear) energy in 2020. In Europe, in the first half of 2021, 2/3 of electricity produced was low carbon (39% renewable). *Ember, 2021*



LOW-CARBON INVESTMENTS +2%

$303.5 bn in low-carbon investments (renewables, hydrogen, CCUS...) took place in 2020: this is 2% more than in the previous year. *REN21, 2021*

$303.5 bn

ANNUAL RENEWABLE PRODUCTION CAPACITY ADDITION +10.2%

+260 GW

OF WHICH WIND AND SOLAR

+237 GW

IN CHINA

+121 GW

IN VIETNAM

+11 GW

Global synthesis report on climate action by sector

IRENA, 2021

Cities and businesses are diversifying their procurement tools

NUMBER OF CITIES HAVING ADOPTED AN OBJECTIVE IN TERMS OF RENEWABLES IN AT LEAST ONE SECTOR

1 BILLION INHABITANTS

834 cities
had, as of 2020, adopted an objective in terms of renewables in at least one sector.

617 cities
set objectives of 100% renewables for their energy procurement

REN21, 2021

PPAs SIGNED BY BUSINESSES IN 2020 +18%

This is 18% more than in the previous year. These direct electricity purchase agreements are sourced from nearly 10% of the renewable capacity addition in 2020.

BloombergNEF, 2021

FINANCIAL RESULTS OF ENERGY SUPPLIERS

Out of 170 energy suppliers, those that draw the majority of their revenue from oil and gas saw losses averging 23%, while businesses focused on solar photovoltaic and wind saw profits of 17%

Rystad, 2021

THE G20'S POST-PANDEMIC RECOVERY PLANS

$295.16 bn
FOSSIL FUELS

$230.66 bn
CLEAN ENERGY

Energy Policy Tracker, 2021

The recovery of the world's leading economies hinges greatly on fossils... China increases its coal-use

ANNUAL COAL-FIRED CAPACITY ADDITION

FOSSILS
+60 GW

OF WHICH COAL
+50 GW

New capacity addition in coal-fired electricity generation at its lowest since 2006: around 50 GW were added in 2020

OF WHICH CHINA
+38.4 GW

China added 38.4 GW of capacity in coal-fired electricity generation in 2020, which is nearly 80% of the global total.

IN THE UNITED STATES
-11.3 GW

The United States saw a reduction in capacity of coal-fired plants of 11.3 GW in 2020. *Global Energy Monitor, 2021*

TREND
FOSSIL FUELS

In a Recovering Economy, Asia Fans the Flames of the Fossil Fire

TANIA MARTHA THOMAS • Research Assistant, Climate Chance Observatory

Although progressively phased out in Europe and the United States by gas or renewable energy, coal-fired power plants have retained strong public support in Asia. In the future, fossil fuels will continue to be consumed.

DATA OVERVIEW

Despite a slowdown during the pandemic, coal use was quickly restored

2020 saw the greatest drop in energy-related CO_2 emissions since the World War II (-1.9 $GtCO_2$, i.e. a drop of 5%). The drop was 10% in the United States, 11% in the European Union (Germany: -9%, France: -11%), and 6% in India. In contrast, despite a sharp drop at the beginning of 2020, China's emissions ended the year up by 1.6%.[1] Then, 2021 started with the recovery of the economy, coupled with a major increase in emissions (**fig. 1**). The International Energy Agency (IEA) predicts that there will be a global increase in energy demand in 2021: this increase in energy-related emissions is on track for becoming the second highest ever recorded without exceeding 2019 levels.[2]

In 2020, oil and coal were not spared by the contraction in demand, with their primary demands dropping by 8.6% and 4% respectively.[3]

Globally, the demand for coal in 2021 is expected to reach a peak equalling the 2014 peak, with 80% of this increase concentrated in Asia, and over half of this being in China[2]. In fact, the construction of coal-fired power stations has not drawn to a halt during the pandemic. While the world capacity of coal-fired plants was reduced by 37 GW in 2020, a record decrease since 2015, an additional capacity of 50 GW was recorded, the lowest since 2006[4]. Therefore, coal-fired electricity production went up at a slower pace compared to what was observed in 2020, but it was still an increase all the same. In 2021, it is predicted that 45% of the increase in electricity demand will be supplied by fossil fuels[5].

The drop in electricity demand caused by the pandemic has led to a drop in production from coal-fired power plants and priority was given to renewable energies on the grid. Coal was also subject to structural competition due to a drop in prices of natural gas. This was a particularly clear trend in the United States, where the capacities of coal-fired power stations dropped by 114 GW between 2011 and 2020[6], and 11.3 GW in 2020. Europe also experienced this trend as there, coal-based electricity production has almost halved since 2015[7].

Over the course of recent years, coal has been increasingly substituted by gas (coal-to-gas). In the United States, 85% of coal-fired power stations[8] repurposed to burn other types of fuel between 2011 and 2019 were turned into gas power stations. Due to low prices, abundant offers and gas reserves being drained by a cold winter, this trend was accelerated and became entrenched in 2020. Although China, Europe and the United States had the biggest drops in gas demand over the course of the first few months of 2020, the decline wasn't as big as it was for coal[9]. According to the

FIGURE 1

THE EVOLUTION OF CO_2 EMISSIONS BY TYPE OF FUEL 1990-2021 (PROJECTION FOR 2021)

Source: IEA, 2021

Energy Information Administration (EIA), gas represents 36% of CO_2 emissions linked to energy in the USA. Nevertheless, the agency expects this percentage to be lower in 2021 with an increase in gas prices.[10] In Europe, natural gas consumption dropped in fifteen of the EU's member States, whereas it remained constant and even sometimes increased in the twelve other States.[11]

Like with coal, the Asia-Pacific region expected the highest rebound in gas demand. In fact, as the region's emerging and developed economies are gradually recovering from the crisis, a high demand in liquefied natural gas (LNG) is to be expected.

THE OBSERVATORY'S LENS

In competition with gas and renewables, coal remains a key part of Asia's energy mix

The dying embers in Europe and the United States

The popularity of the use of coal to produce electricity presents a contrasting picture on the global scale, with notable declines recorded in the United States and Europe. The combined consumption of coal in these two regions currently represents around 10% of the world total.[12] This decline in coal isn't necessarily due to voluntary policies, but rather due to market trends and notably, a loss in profitability of coal-fired power generation.

At the start of 2020, coal-fired plants representing 268 GW of capacity had already shut down across the United States and Europe since 2010, resulting in a net loss of 138 GW in capacity over the period.[13] In the United Stated, natural gas, which is extremely abundant and accessible, is used as a substitute for coal due to coal's loss of profitability. This was combined with a 30% drop in gas prices in 2019 in the United States,[13] and a reduction in electricity demand during the pandemic, which promoted a drop in the use of coal. In Europe, half of all coal-fired power stations have already been closed down, or there has been a commitment to shut them down between now and 2030.[14] This is the combined product of the market forces, the EU's environmental regulations and the pandemic. While the price of carbon on the European Union Emissions Trading Scheme (EU ETS) has long been capped at around €5/tonne since the creation of the scheme in 2005, it has soared since the end of 2020 to over €50/tonne from May 2021.[15] This was because of the anticipation of a quota restriction issued by the EU, which precipitated purchases and drove prices up.

There was also an additional incentive for the emissive industries to decarbonise[a] but in the context of increasing oil prices and tensions surrounding the Nord Stream 2 gas pipeline project, the gas and electricity prices paid by the consumer could also increase. In total, fourteen of the EU's member States have already stopped using coal, or will between now and 2030, but some have fixed objectives for a later date, such as Romania for 2032 or Germany for 2038.[16]

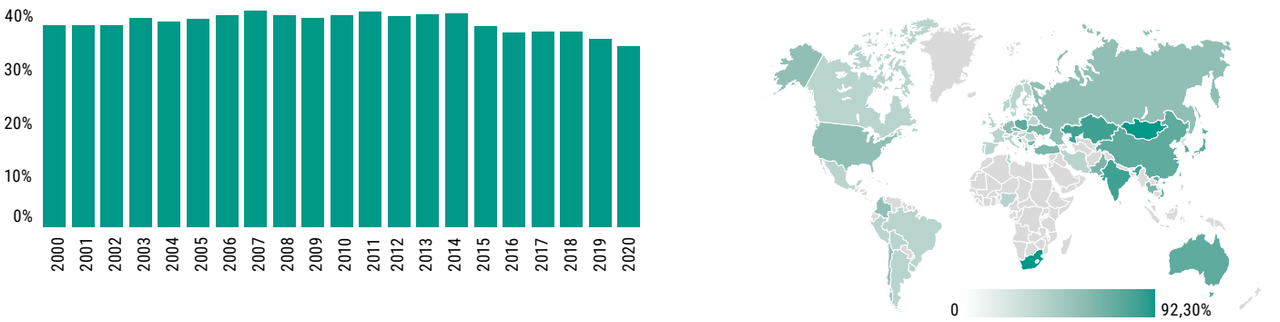
Germany is one of the three top consumers of coal in Europe – forming the "lignite triangle"[17] with Poland and the Czech Republic. This dependence generates criticism and concerns, under the pressure of climate objectives and the increase in

a In September 2019, the report from the High Commission on Coal Prices, directed by economists Joseph Stiglitz and Nicholas Stern, concluded that *"the unequivocal level of carbon prices compatible with achieving the temperature targets set by the Paris Agreement is at least 40 to 80 dollars per tonne of CO_2 for 2020 and 50 to 100 dollars per tonne for 2030, provided that the supporting favourable policies are implemented."*

FIGURE 2

SHARE OF COAL IN GLOBAL ELECTRICITY GENERATION, 2000 TO 2020; AND SHARE IN NATIONAL ELECTRICITY GENERATION, 2020

Climate Chance, based on data from Ember



coal prices. At the same time, the German private sector is working to gradually eliminate coal. The energy giant RWE, for example, has signed a public-law contract with the government to gradually stop using lignite. A coal-fired electricity plant has already been removed from the network and three others will be removed over the course of the year. RWE aims to have "carbon neutrality" by 2040.[18] The energy supplier Eins Energie also plans to cease all electricity and heat production generated by coal between now and 2023.[19]Germany and the Czech Republic have both progressed more rapidly than Poland, which has set the objective of closing its last coal mine between now and 2049. The government will nationalize non-profitable power plants, thus opposing market forces to ensure a "gradual and long-term" transformation of the electricity sector.[20]

In Spain, the evolution of coal is an example of the combined effects of the market's forces and regulations. In the past, coal was Spain's predominant energy source, but its decline began in the 1980s with competition from other sources of electricity production. There has been an accelerated transition in the past few years due to a drop in energy demand. This was exacerbated by the 2008 economic crisis, as well as the application of the EU's environmental standards.[21] More recently, the Spanish electricity company Endesa announced it would bring forward the closure of all of its coal-fired stations to 2021. Seven of the country's fifteen coal-fired power stations belonging to Naturgy, Endesa, Viesgo and Iberdrola, already closed in June 2020 and four others will soon follow suit. These closures have been precipitated by the low electricity demand during the pandemic,[22] with no coal exit plan ever formulated by the Spanish government.

Like the Czech Republic and Germany, Spain has set up an institute and its own strategy to ensure a Just Transition, to negotiate and ensure a coal exit which is fair for the workers who work in the regions where the power plants are closing. In order to achieve that and insofar as closing mines and power plants in regions that are dependent on coal, it is the unions that lead negotiations with the government. An agreement was signed in 2018 between the government and the Workers' Commissions (CCOO), the Unión General de los Trabajadores (UGT: the General Union of Workers), the Unión Sindical Obrera (USO: the Workers' Labour Union) and the Federación Nacional de Empresarios de Minas de Carbón (Carbounión, the National Federation of Coal Mine Entrepreneurs). This agreement plans to put 250 million euros of investments into the mining regions.[23] A second agreement, signed in 2020 by the government, the unions and EDP, now covers all the Spanish thermal power plants. It is presented as a "unique pact in the world" by the government and it notably plans to set up "fair transition conventions" on a cantonal level, which include employment transition plans and the maintenance of economic activity.[24]

Other European countries have accelerated their coal exit strategies. Since the closure of the Sines power plant (1,296 MW) by EDP in January 2021, Portugal no longer has a single thermal power plant running on coal.[25] Consequently, their exit from coal has been moved forwards from 2023 to late 2021, despite it generating a quarter of the country's electricity from 2017[26] Earlier, Austria shut down its last power plant in April 2020.[27]Although a slight resurgence in coal usage is predicted on a global scale in 2021, the viability of this fuel in the long-term seems fragile in Europe, whereas renewable energies are increasingly more readily available (**see PPA Trend**).

Asia fans the flames

The global demand for coal is mainly driven by China, India, and certain countries in South-East Asia. China produced over half of the world's electricity generated from coal in 2020, whereas renewable energies covered around half of its increase in electricity consumption. 38.4 GW of new coal capacities have been set up in China in 2020, accounting for almost 80% of the 50 GW of new global capacity created, despite promises to cut down on the use of coal and the Chinese State's commitment to aim for carbon neutrality by 2060[28]. In addition, China remains the main driving force behind international coal demand, even though this demand should stabilise between 2021 and 2025: the 14th five-year plan of the Chinese government promises to "*rationally control the scale and development pace of electricity produced from coal*"[13]. The recent introduction of an emissions trading scheme for electricity generation is expected to boost this momentum. As can be seen in **figure 2**, Asia, although not an isolated case, represents a strong concentration of States which have a high

share of coal in their electricity generation. While individual countries or regions have been progressively reducing the percentage of coal in their energy mix, the global percentage shows a more gradual decline over the years.

Other Southern and South-East Asian countries (notably India) are also set to increase their coal electricity production capacities in 2021. While the pandemic has slightly cooled down these projections, the prospects for coal in 2025 are now lower than those predicted in 2019.[13] In India, no new coal-fired electricity power plant was opened in 2020, and electricity production generated from coal dropped by 5%, bearing the entire weight of the lockdowns.[29] The government encouraged an increase in the extraction and production of coal, with potential additions to its coal production capacity in the near future, sending out contradictory messages relating to its energy transition objectives.[30]

The Indian government is looking to increase the efficiency and competitiveness of the coal sector, by introducing commercial mining. In November 2020, 50 million tonnes of annual coal extraction capacity were auctioned to the private sector, even if that only represented a small fraction of the country's production level, which is around 800 million tonnes a year[13]. In June 2021, a second phase of putting the capacity up for auction was announced: at a much more significant level with 36 billion tonnes of resources up for grabs[31]. Both points of view have been defended: on the one hand, this commercialisation would lock India into coal, and it would make coal cheaper and more readily available for electricity companies. On the other hand, it was also argued that this commercialisation would only reduce the country's coal imports, whilst responding to internal demand, and thus not contribute to an increase in emissions.[32] The Institute for Energy Economics and Financial Analysis (IEEFA) estimates that most of the 33 GW capacity coal-fired power plants being built and 29 GW capacity coal-fired power plants in the pre-construction stage in India, could end up being stranded as the price of coal struggles to keep up with the constantly declining prices of renewables.[33] The price increase observed from the start of 2021 relating to Australian thermal coal (+86%) and South African thermal coal (+44%), two major exporters of coal to Asia, seems to confirm this trend.[34]

Indonesia, a major producer and exporter of coal, protects its coal industry with subsidies for upstream investment in coal, with an argument to promote domestic enterprises. The country is now driving 75% of the planned coal-fired power projects in South-East Asia. In addition, the government has modified a legislation, allowing the coal industry greater control over mining permits.[35] By converting its coal-fired power stations to a combustion combined with biomass, the public electricity company PLN has attempted to begin the transition, but the feasibility and economic viability of this shift in Indonesia have been doubted, given the high prices of biomass with a high calorific value.[36]

More recently, PLN announced the full closure of all its coal-fired power plants between now and 2055. This sent out mixed signals, as the business also announced that no less than 117 power plants in construction would be operational over the course of the next few years. Although the announced

FIGURE 3

COAL INVESTMENT FLOWS IN SOUTHEAST ASIA

Source: Climate Analytics, 2021

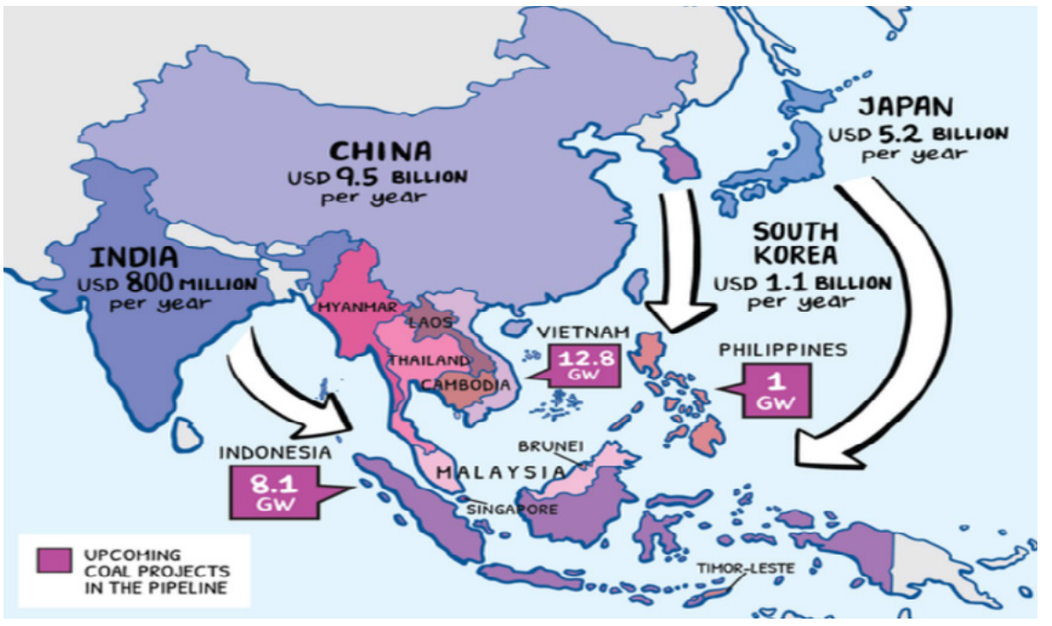
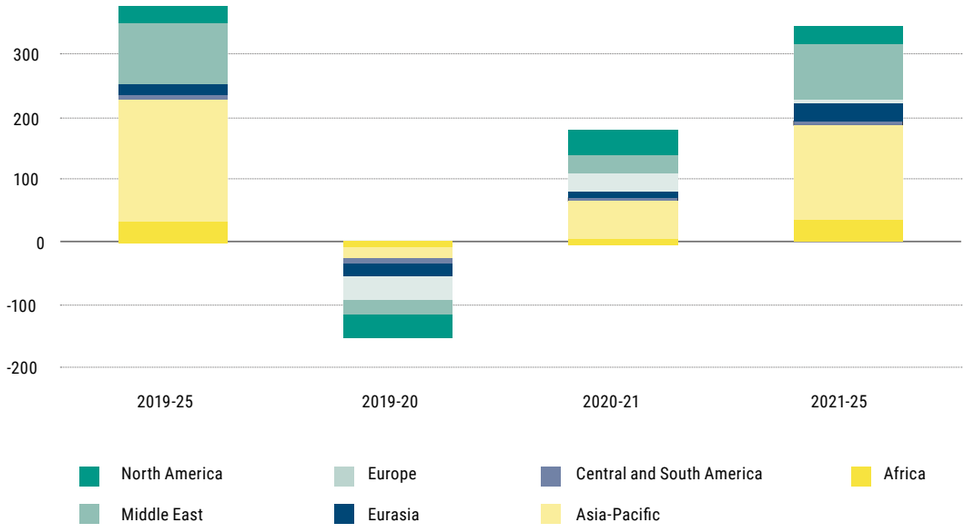


FIGURE 4

REGIONAL BREAKDOWN OF GAS DEMAND GROWTH, 2019-2025

Source: IEA, 2020.



closures were supported by activists, they were called into question by government officials and the industry.[37]

Adding to this are the concerns over projects financed by external funds, with Japanese, Chinese and Korean businesses investing in the region while their national markets have turned towards renewable energies.[38] The broader patterns from Southeast Asia, where state policies, industry control and external investments (**fig. 3**) are all helping coal survive as a fuel, have been identified as perpetuating the "myth of cheap coal" – contrary to market trends from around the world. The pursuit of public investments in coal infrastructures makes alternatives relatively more costly, which in turn delays the gradual elimination of coal.[39] At the same time, countries like Japan and Korea are committed to reducing the use of coal in the years to come. With the recent abandonment of their latest project for a coal-fired power plant, Japan is no longer planning to go ahead with any new constructions[40]. Although the State has the objective of closing 100 power stations deemed ineffective between now and the end of the decade, it is also planning to replace some of them with more efficient power plants with better performance[41]. Japan, along with the US, remain the two G7 countries stopping a full exit from coal for the group, with the former depending on coal to ensure energy security, and the latter caught in a conflict of political interests as the Democrats try to maintain their margin of majority in the Senate.[42,43]

Japan also announced that it would stop exporting coal-fired power stations and that it would only authorise the export of "high efficiency coal technologies", by supporting other countries with their "ultra super-critical power stations" to reduce the emissions of coal-fired power stations, to improve efficiency, to enable coal gasification, CCUS and coal recycling.[44] Two major Japanese banks, Sumitomo Mitsui Financial Group and Mizuho, are committed to decarbonising their investments and to no longer financing coal. However, several NGOs are worried that the loopholes in these commitments will allow banks to keep financing coal by indirect means[45]. The Malaysian bank CIMB has committed to stop asset level and general corporate financing for coal by 2040. CIMB has also declared that it expected electricity production businesses to put in place diversified strategies to reduce dependence on coal, an uncommon position with regards to the financing of coal in South-East Asia.[46]

South Korea has committed to cease the financing of coal abroad[47]. This commitment was added to the announcement made by G7 to cease the financing of electricity generation projects using coal by late 2021[48]. Moreover, whilst other countries like Vietnam and Bangladesh have committed to reducing coal development, the Philippines announced a moratorium on this fuel. The case of Vietnam is also exceptional in terms of its boom in solar PV (**see Vietnam case study**).

Natural gas: The final frontier

Whilst the governments and banks are trying to turn their backs on coal, gas is sometimes presented as the bridge fuel which must be used to make the transition go more smoothly. The G7 countries, with the exception of Japan, provided negligible funding for coal over the past few years. However, they are now relying a lot more on gas, which received 16 billion dollars of public financing between 2017 and 2019.[49]

In particular, the global trade of liquefied natural gas (LNG)[b] experienced an increase of 1.4 Mt in 2020, reaching 356.1 Mt. However, this increase was greatly hindered by the pandemic[50]. Japan, China, South Korea, and India are the biggest importers of LNG in the world, while Qatar and Australia dominate production. The pandemic has pulled back gas prices even more, which has benefitted Asian importers with their short-term purchases and their regasification capacities, particularly in China, India, Myanmar, and Bangladesh. On the contrary, the European markets have become tense under the effects of extended lockdowns, a slowdown of activity, and the increasing share of renewables in the energy mix[51].

The Asia-Pacific region will be the driving force behind the increase in demand and represent over half the increase in global gas consumption in the years to come[51] (**fig. 4**). The biggest rebound, especially expected by the hard-hit US LNG industry, is to be driven by China, though with stiff price resistance[52].

Contrary to coal, the demand for gas is set continue increasing well into the century, and reach its peak in 2037, thus becoming the fossil fuel with the longest growing demand. The demand for LNG, which is the main driving force behind the international gas trade, is set to grow even up until 2050[53]. This situation has attracted the attention of activists, who have now refocused their efforts on fighting against the gas industry. For example, the South-Korean SK *chaebol* (conglomerate) has recently faced a spirited reaction from activist groups for a major LNG contract in Australia, despite its promise to put an end to oil and gas investments abroad[54].

The financing of LNG projects in the electricity sector is often justified by its role as a bridge fuel. According to a study by the International Institute for Sustainable Development[55], gas projects in countries with low or middle income, receive four times the amount of financing received by solar power or wind projects. For example, Japan recently announced a public financing of 10 billion dollars for the ASEAN countries within the framework of the Asia Energy Transition Initiative (AETI), which also covers LNG projects in the transition process[56].

At the same time, Wood Mackenzie observed a push for "greener" LNG purchasing contracts in Asia, coupled with compensation credit for buyers. For example, in the agreements between Shell and several Asian buyers, offsets are carried for emissions right from upstream processes to end-use. In another example of an agreement between the Japanese utility JERA and an Indian buyer, only the downstream combustion was offset[57].

As international finance for coal declines, and Asian countries go through with their energy transitions, the demand for gas in these countries is set to increase – for industrial processes, and transport, as well as power generation. The simultaneous shift in Europe towards renewables and away from fossils, would thus render the Asian markets all-powerful in setting the global prices for gas.[58]

KEY TAKEAWAYS

The first months of the pandemic were marked by an unprecedented drop in energy demand and related emissions all over the world, with economic activity slowing down and lockdown measures imposed in several countries. Over the course of that period, coal, gas and oil experienced the greatest drops in demand, while renewable energies emerged as the star performers. As the world adapts to the pandemic and economies recover, the observed trend is not only one of continual expansion in terms of renewable energy, but also a resurgence in terms of coal and fossil fuel use. This resurgence, which is largely concentrated in Asia, is in juxtaposition with the current climate where increasing commitments are being made in favour of reducing emissions and implementing an energy transition strategy, as the unprofitability of coal increases.

Gas continues to experience a strong growth in demand, driven by Liquefied Natural Gas. At the same time, there is also increasing activism against its use, while renewable substitutes become increasingly accessible.

b Liquefied Natural Gas (LNG) is a gas which has been transformed into a liquid state, making it easier to store and transport, notably via ships, limiting the need to resort to pipelines. It can then be gasified or used again, or be directly used as a fuel for transport.

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TRENDS
RENEWABLE ENERGY

With PPAs, Businesses and Cities Are Making the Production and Supply of Low-Carbon Electricity Safer

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A major trend that the pandemic had little impact on in 2020 was the increasing number of businesses that are contractualising their long-term renewable electricity supply through Power Purchase Agreements (PPAs). These contracts also contribute to the installation of new renewable production capacities, by ensuring that producers have a stable revenue. This movement has already spread to large Australian and American municipalities, as well as to the city of London in 2020.

DATA OVERVIEW

Pro-renewable energy commitments are multiplying, and their implementation is becoming more organized

The pandemic has not put a stop to the exponential increase of the renewable energy sector, which has been going on for a few years now. On the contrary: the installed renewable energy capacities reached 2,800 GW in 2020[1], a record increase of 260 GW from 2019, which is almost 50% higher than the previous year (**fig. 1**). Globally, fossil capacities remain much higher (around 4,460 GW in late 2020[2]), but their increase slowed down (60 GW added in 2020, the lowest increase since 2000, **cf. trend "Fossil Fuels"**). As a result, even though fossil fuels continue to dominate the installed capacities, renewable energies represent most of the increase.

Solar (127 GW) and wind power (111 GW) are responsible for 91% of this increase. The vast majority of their new installations are located in China (49 GW solar, the second record year after 2017, 72 GW wind power), and to a lesser extent in the United States (14 GW solar, 14 GW wind power) and in the European Union (19 GW solar, 10 GW wind power). Vietnam experienced an unprecedented boom in solar energy, tripling its installed capacities in a year to reach 16 GW, notably thanks to the establishment of feed-in tariffs which came to a close in 2021 (**cf. case study Vietnam**). Extremely reliant on coal, South Korea, India and Japan have each installed 4 GW of solar capacities.

Regarding electricity consumption, the drop in demand following the pandemic and the priority given to renewable energy on electricity grids led to a two percent increase of the share of renewables in the global *electricity* mix between 2019 and 2020, from 27% to 29%, the highest ever recorded[3]. Once again, the strong dynamics of solar and wind power, for which electricity production has increased by 20% and 12% respectively between 2019 and 2020, have greatly contributed to this increase[4]. However, the share of renewable energy in the global *energy* mix has only slightly increased between 2009 (9%) and 2019 (11%)[5].

In total during 2020, around 260 cities set new objectives or adopted new policies relating to renewable energy, bringing the number of inhabitants living in a city with such objectives to around 1 billion (from around 1,300 cities). Amongst them, 617 have the objective of achieving "100% renewable". Furthermore, 799 municipalities have adopted policies to promote renewable energy in different sectors. The majority are related to electricity, but heating and transport were also featured[6].

The global dynamic is similar amongst the private players. The RE100 initiative, which groups together businesses committed to solely using renewable energies for their activities, had over 300 members in April 2021, totalling an electricity consumption of over 278 TWh/year (more than Australia). Amongst them, 77 of the members were already powered by 90% renewable energy. Overall, around 40% of the total electricity used by the members is generated from renewable energy[7].

However, the technical and physical structure of an electrical grid makes it impossible to follow and trace where an electron originates, thus whether is from renewable energy or fossil fuels. Therefore, what are levers for non-state actors to stick to their commitments? Several tools guarantee renewable

energy is supplied besides auto-consumption, such as the now-essential Energy Attribute Certificates. One tool stands out due to the strong dynamic it has benefitted from over the past few years on all continents for all of the actors: Power Purchase Agreements (PPAs).

THE OBSERVATORY'S LENS

With PPAs, cities and businesses are diversifying their methods for the supply of renewable energy

Energy Attribute Certificates are essential cogs in the machine, but they have a limited impact

Since the end of the 2000s, the markets for energy certificates have progressively been established in the United States, in Europe and other areas of the world. These electronic documents are sent out by renewable energy producers and are certified by the authorities of the obligatory or voluntary market they are in. They are then bought by suppliers wishing to certify the origin of their electricity, sometimes to meet minimum consumption quotas, such as in certain American states. They can also be bought by companies wishing to declare that their electricity has been produced by a renewable source. By offering a source of complementary revenue to certified producers, the sale of certificates helps to support renewable energy production. These markets are booming: in Europe, the number of "guarantees of origin" (European label) has almost doubled between 2014 and 2018[8]. This was notably brought about by hydroelectricity which accounts for two thirds. In 2020, over 737 TWh of guarantees were bought, 41.7% more than in 2018[9]. This has encouraged a multitude of alternative suppliers to emerge, hoping to stand out on the European electricity market, which has been open to competition since the late 1990s[10].

However, the absence of geographical restrictions between the certificates and the actual origins of the electricity showed there were certain limitations to this system[5]. For example, Iceland is a major exporter of guarantees of origin thanks to its several geothermal and hydroelectric power stations. However, its electrical grid is not physically linked up to the European continent. There is therefore the risk that the avoided emissions will be double counted, both in the countries producing the renewable energies and in the countries importing the guarantees of origin[11]. Furthermore, this tool does not allow to secure the demands of consumers, as the certificates relate to electricity which has already been produced by existing installations. Therefore, they in no way guarantee the availability of future renewable energy or the construction of new local capacities.

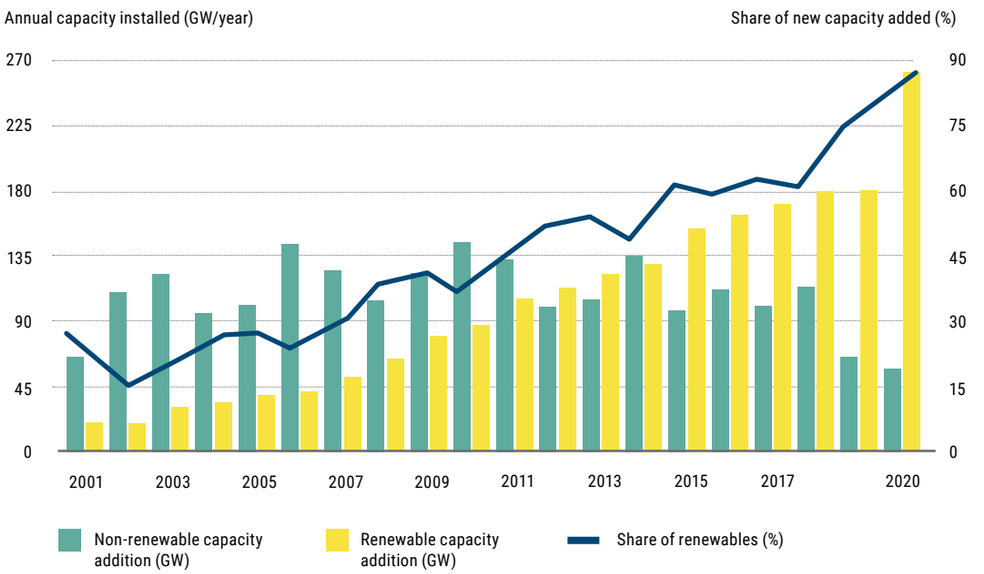
Furthermore, with the offer being twice as high as the demand in the EU in 2018, the low prices of guarantees of origin (in the range of 1€/MWh in May 2020[8], similar to those of American Renewable Energy Certificates (REC)), are not currently lucrative enough to encourage producers to invest in new projects[11].

However, the French Agency for ecological transition (Ademe) estimates that the increasing popularity of 'local' guarantees of origin (certifying a production geographically close to the consumer) could accelerate the emergence of local tensions between the offer and demand and thus increase the prices

FIGURE 1

RENEWABLE AND NON-RENEWABLE CAPACITY ADDITION BETWEEN 2001 AND 2020.

Source: IRENA, 2021



in several areas over the next few years. According to the international RECS organisation, the global demand for guarantees of origin could meet the level of supply prior to 2023[8].

With an exponential increase amongst businesses, PPAs are now being extended to cities

Alongside renewable energy certificates, public and private consumers are increasingly turning towards other renewable energy supply mechanisms allowing them to play a more active role in the development of these energies[6] and to secure the supply. The key tool, which has been booming for a few years now, are the Power Purchase Agreements (PPAs).

Generally, PPAs (**see Keys to Understanding**) are long-term contracts, at a fixed or variable price, negotiated directly between the producers and consumers (buyers) of renewable electricity, without going via an intermediary supplier. Relatively marginal up until 2016, they experienced a big increase with the development of renewable energies and the drop in their prices: PPAs were at the origin of almost 10% of renewable capacities installed globally in 2019[12]. In 2020, the pandemic had little impact on this dynamic: 23.7 GW of renewable energy was contractualised with PPAs by private actors in 2020, 18% more than in 2019 and almost four times more than in 2017[13]. Although the first semester of 2020 saw a clear drop in the contractualisation of PPAs in America (AMER) due to the pandemic, the volume of new contracts almost tripled between 2019 and 2020 in Europe, the Middle East and Africa (EMEA), as well as in Asia and the Pacific (APAC) (**fig. 2**). The last trimester of 2020 even established a new record, with 7.2 GW contractualised in the world[13], and the volume of PPAs rose by 86% in the first semester of 2021 compared to the same period from the previous year[14]. PPAs are mostly relating to solar and wind energy.

The market is largely dominated by digital companies: Amazon is the leader, with 35 PPAs announced in 2020, representing 5.1 GW, bringing the total contractualised by the company since 2010 at 7.5 GW. Google and Facebook follow on from this with 6.6 GW and 5.9 GW respectively contractualised since 2010. Heavy industries also have an interest in them, such as the Norwegian aluminium producing group Norsk Hydro (1.8 GW contractualised in 2020)[15]. A quarter of the renewable electricity used by companies that are members of the RE100 initiative originate from PPAs, compared to 3% five years ago[16].

In November, over 4 GW have been contractualised since the beginning of the year in Europe[15]. For example, Air Liquide signed a 15-year PPA with Vattenfall to supply 15% of its electricity consumption to the Netherlands with renewable energies, thanks to the production of a 25 MW wind farm which will begin operating in 2023[17]. This electricity will power industrial gas generation installations, as well as a new hydrogen generation plant in the port of Moerdijk. A few weeks later, EDF Renewables and the rail group SNCF (which aims to have 40 to 50% renewable energy for its trains between now and 2025), signed a PPA to supply SNCF with the production of a 20 MW solar power station for 20 years from when it is brought into operation in 2023[18].

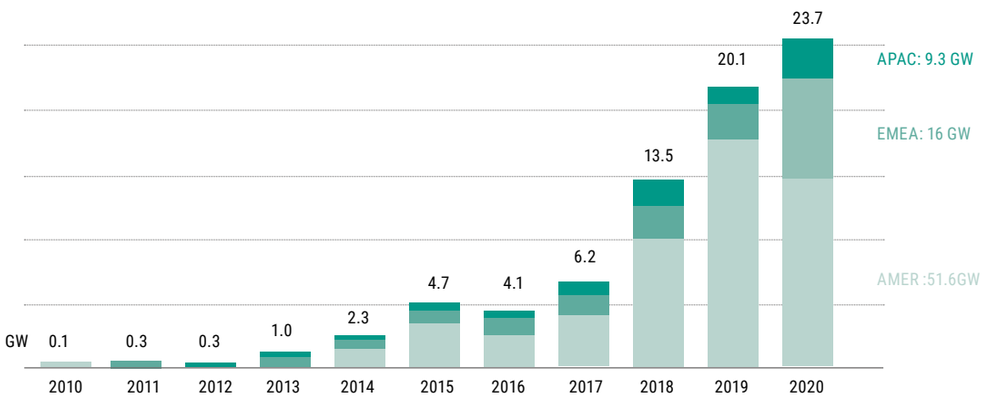
PPAs also attract more and more public actors, even if the volumes are still rather weak compared to those from the private sector. In total, between 2015 and 2020, the volume of PPAs contractualised by American cities more than tripled, going from 1,062 MW (2015) to 3,306 MW (2020)[20]. During this period, almost 90% of the renewable energy bought by these cities was the subject of an off-site PPA[21].

In the United States, PPAs are sometimes contractualised by Community Choice Aggregations (CCA), entities which unite the demand of several actors from a territory, often grouped around a municipality, which wouldn't be big enough to contractualise a PPA individually. California has 23 CCAs which group together 182 cities and counties, and are accessible to over 30% of the population. Fourteen of them buy 100% renewable electricity and almost all impose a minimum

FIGURE 2

VOLUMES OF PPAs BOUGHT BY COMPANIES FROM 2010 TO 2020 AROUND THE WORLD.

Source: BloombergNEF, 2021



KEYS TO UNDERSTANDING

THE DIFFERENT TYPES OF PPAs

The term PPA indicates an electricity purchasing mode which, in reality, covers several different types of 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 simply the property of the business or the municipality. In these cases they can be recovered by auto-consumption. PPAs can also be cross-border, meaning that the actors need not belong to the same electricity markets. In that case, an agreement can be established between the grid operator for the transportation of electricity, but most of the time, cross-border PPAs are "virtual". The producer sells electricity on the market it belongs to, the consumer continues to buy its electricity from the supplier on the market it is developing, and it compensates for any potential fluctuations in prices on the producer's market via the PPA. In such a situation, the two markets are not necessarily physically connected[19].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. That is referring to a *sleeved PPA*. Whatever the type of PPA, if it is concerns renewable energy (which is often the case these days), the buyer almost systematically couples their contract with the purchase of any corresponding Energy Attribute 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 purchased electricity.

threshold for renewable energy.[22] As a result, 6,000 MW of renewable energy contractualised by Californian CCAs, including 2,600 MW in 2020, were the subject of a PPA. Most of them concern solar energy (3,800 MW), followed by wind energy (1,030 MW).[23]

In the rest of the world, the public actors resorting to PPAs are, first and foremost, large cities. For example, London signed a 15-year PPA with the French renewable energy producer Voltalia. The city has committed to buying all the electricity from a solar farm with 95,000 solar panels being built in the county of Dorset (south of England). In Australia, since 2019, the municipality of Melbourne has covered 100% of the energy consumption of its infrastructure with renewables. In June 2020, the city facilitated the signing of a second grouped PPA with seven local actors including universities and enterprises, which will prevent the equivalent of 1 $MtCO_2$ being produced over the decade of the project's span (**see case study Melbourne**).[24]

The dynamics of PPAs are particularly strong in Australia, in both the public and private sectors. Between 2017 and 2020, 79 PPAs covering 3 GW (of which over a third were in 2020 despite the pandemic) were contractualised by businesses or local governments based in Australia, including over half concerning new solar and wind farms.[25] The Australian supermarket chain Coles, for example, has signed two PPAs with the French groups Engie and Neoen to source its electricity from on-site solar power stations.[26]

In most cases, the capacities concerned by the PPA have not yet been installed. The contract helps the business to finance the project, whereas the buyer saves money in supply costs (around 3 million pounds in the case of London)[27]. PPAs therefore emerged as a means of securing both the investments from producers of renewable energy, which were often victims of the volatility of the market's prices, and the supply of consumers who wish to turn towards renewables.

To a lesser degree, PPAs also emerged in Africa (notably in Kenya, Tanzania and South Africa), as well as Asia, sometimes under different forms so they could be adapted to smaller scale projects in terms of capacity and of contract duration.[28] During COP22, when Morocco had just opened the Noor solar power station (580 MW) near Ouarzazate, the country signed a Sustainable Electricity Trade (SET) Roadmap with four European countries (Spain, Portugal, France and Germany) to trade electricity from renewable sources thanks to cross-border PPAs. Within the framework of this agreement, the European businesses, which are now driven towards renewable energy by the Green Deal, will be in a position to virtually contractualise their supply from Moroccan producers. In fact, the country is running an ambitious solar policy, that allowed to reach a 37% share of renewable energy in its capacity until now.[29] However, the SET is late in making this a reality as it came across regulatory, infrastructural and markets barrriers,[30] and Morocco recorded major financial losses for these projects.[31]

On the face of it, this global dynamic isn't set to wind down. The International Energy Agency (IEA) estimates that the PPAs will be the first point of leverage for the deployment of wind power in North America between 2020 and 2025.[32]

The civil society and municipalities are exploring alternative models of renewable energy production

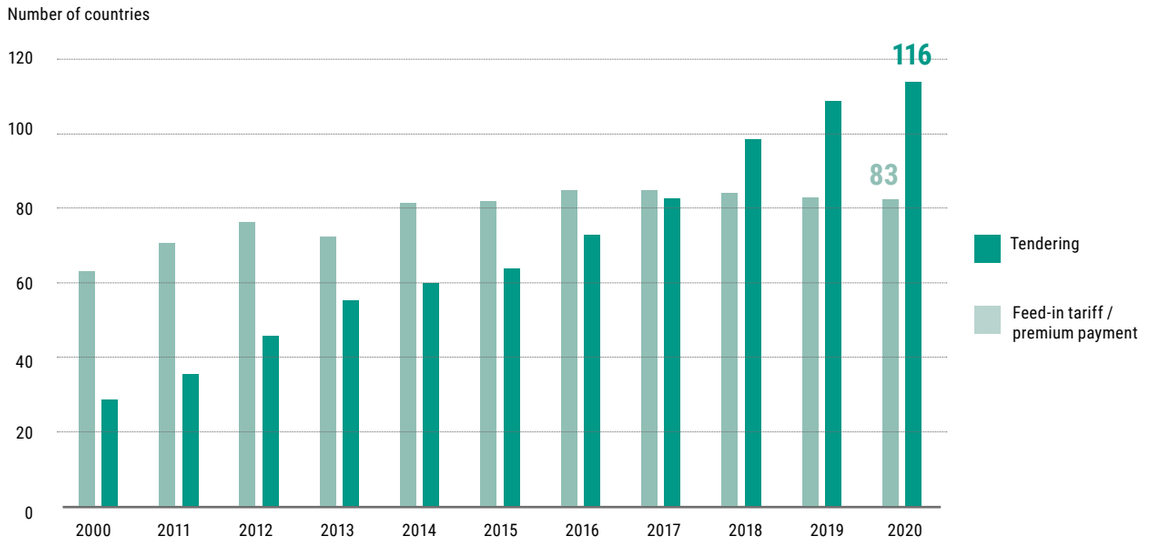
PPAs mainly concern big actors who, on the one hand are setting up giant wind and solar farms, and on the other hand, are buying electricity for high-energy industrial sites or large settlements.

In general, populations do not have access to this type of contract (except through a CCA). To be supplied with renewable energy, a household has several tools at its disposal, among which self-consumption, feeding renewables energy into the grid leading to a reduction in bills, the choice of an supplier who supplies on the renewable energy market (and therefore also in the Energy Attribute Certificate market) and even the direct purchase of Energy Attribute Certificates. In order to have a greater impact in directing the market towards renewable energy, several "energy communities" have grouped together individuals (generally) to work on

FIGURE 3

NUMBER OF COUNTRIES APPLYING FEED-IN TARIFF AND TENDERS MECHANISMS FROM 2010 TO 2020.

Source: REN21, 2021



a specific electricity production project. These communities have particularly emerged in Europe, often assisted by public powers (via subsidies or feed-in tariffs).

Energy communities have been formally recognised in the 2018 renewable energy Directive of the EU. In 2019, there were over 3,600 of them, compared to 2,400 four years earlier, a really high figure compared to the few hundred others spread across the other continents[6]. This total certainly increased in 2020. For example, in Croatia, the European Institute of Innovation and Technology (EIT) and Climate KIC financed the construction of a thousand solar parks in the form of cooperatives in ten cities[6]. The vast majority is focused on electricity production, but more and more communities have been set up to manage heating networks, to organise electric mobility or to lead energy efficiency projects.[33]

However, a few years of acceleration, this dynamic showed some weaknesses. In Germany, for example, the system of feed-in tariffs for citizen energy cooperatives, which had been in place for 20 years, ended on 1 January 2021. The 883 cooperatives[a] from the country are now in competition with major energy players who have emerged on the market in recent years and are better equipped to take on the major investments required by public markets (for example off-shore installations). Observers fear this redevelopment of a capitalistic concentration will impact the popularity of the development of renewable energy and how it is accepted.[34] The dynamic of the cooperatives losing impetus in this country is clearly visible. Only 14 new projects were set up in 2019, compared with a record of 167 in 2011.[6]

To have a greater influence in the markets where calls for tender and bids are increasingly important (**fig. 3**), and to promote a democratic and citizen view of energy production, these cooperatives are grouped together in networks and federations. Joined by 400 new members in 2020, the REScoop networks now unite 1,900 European cooperatives, representing 1.25 million citizens.

The cities also play a role in diversifying renewable electricity generation models, by municipalising all or certain parts of the production activities and the supply of electricity. They can then direct these activities towards renewable energy. In 2019 in the United States, around 1,800 organisations, controlled entirely or partially by cities, supplied 15 million clients. However, they are not always committed to low carbon energy transition. The NGO Massachusetts Climate Action Network (MCAN) observed that local energy companies were not restricted, like private businesses, to access renewable energy within their public lighting system to reach the State's objectives.[35]

Europe has 1,500 local electricity companies which supply 85 million clients. For example, Stadtwerke München (SWM) recently set out to buy twelve photovoltaic parks to supply the city of Munich with electricity.[36] In Spain, the municipality of Cádiz owns 55% of the electricity supply and distribution company Eléctrica de Cádiz (EdC), which allowed for the supply of 100% certified renewable energy (thanks to guarantees of origin) and the implementation of assistance for disadvantaged households, financed in equal parts by the municipality and EdC (**see Cadiz case study**).

a There are 883 "energy cooperatives" or members of the DGRV (the federal office of energy cooperatives) out of the 1,750 "energy communities" in Germany, according to the European Union's Joint Research Centre. The energy cooperatives indicate a category of "energy communities" which is more close-knit, marked by a governance of rules which are specific to cooperatives. For further information see: Caramizaru, A., Uihlein, A. (2020). Energy communities: an overview of energy and social innovation. *Joint Research Centre of the European Commission*

However, a few municipalisation projects had to be abandoned in 2020. In the Netherlands, the 44 municipalities which owned the renewable energy production company Eneco, got rid of all of their shares in March 2020 and sold them to a Japanese consortium made up of Mitsubishi (80%) and Chubu (20%). Reduced to the role of electricity supplier by the opening of the market to competition, Eneco's mission was no longer considered by its shareholder municipalities as a public service. In August 2020, Nottingham had to sell Robin Hood Energy, the first municipal energy company set up by a local British council over 75 years ago due to losses of up to around 34 million pounds.[37] A few months earlier, the city of Bristol had also to split from Bristol Energy, which was in debt by over 30 million pounds.[38]

As a result, the opening of competition on the electricity market in Europe created an increase in new actors, desiring to offer democratic and local alternatives. However, this liberalisation also constitutes a threat for these fragile models. Public assistance is gradually being reduced for them and they are ending up in competition with big actors which have considerable investment capacities at the heart of a market whose capitalistic concentration is constantly growing (**see Renewable Energy trend**).

KEY TAKEAWAYS

Since the creation of Energy Attribute Certificates, the standard for claiming a supply of renewable energy, meant to stimulate the market and assist producers, it is evident that overall the assessment was mixed: the demand does not meet the supply, the prices are low, and their credibility has been called into question. As an alternative, the Power Purchase Agreements, sales contracts for electricity from renewable origins, directly drawn up between a producer and a consumer, have experienced a thriving success by securing a stable revenue over the long term for producers, who are able to install large capacities, and also by guaranteeing the supply of renewable energy to high-energy consumers (often businesses, but also a few cities more recently).

In parallel: whilst energy communities were becoming increasingly important with their sights set on citizen re-appropriation of electricity production, they are now being left to the side in "wholesale market" and find themselves at threat, even in the countries where they were established. Some cities, however, are still managing to give a voice to their inhabitants through local companies who generate or supply electricity. But the question remains: for how much longer? The recent bankruptcy of several of them has planted a seed of doubt with regards to their resilience.

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TRENDS
RENEWABLE ENERGY

From Big Oil to Big Power? At the Heart of the Renewable Energy Boom, Oil Producers Are Dreaming-of a Low-Carbon Future

ANTOINE GILLOD • Coordinator, Climate Chance Observatory

Cornered by pressure from their shareholders and civil society, some of the major oil producers are envisaging a future in low - carbon services, and producing renewable energy. However, their declarations of hope in the climatic situation are hardly convincing, and their emergence on the wind and solar energy markets is challenging the sector's pioneers.

DATA OVERVIEW

Covid-19 is rearranging the energy market landscape

In 2020, the investments in renewables rose to $303.5 billion, an increase of 1.7% compared to the previous year.[1] The sector continues to benefit from the low prices of solar photovoltaic energy, (**fig. 1**) which ended up being $20 per Megawatt hour (MWh), the *"cheapest energy in history"* according to the International Energy Agency (IEA).[2] Attracting $148.6 billion, or almost half of the world total, it is the only renewable energy to have experienced an increase in investments (+12%). At the same time, the capital expenditure in relation to offshore wind farms exceeded offshore oil and gas investments for the first time[1]. All of the other renewable energies, such as biomass, biofuels and small hydro recorded a drop in investments compared to 2019, continuing the decadal downward trend.

During the pandemic, public aid has been a great support for industries: 31 States directly allocated $51.3 billion for renewable energies between January 2020 and April 2021. This allowed investments to bounce back in the latter half of the period, after an initial six months marked by the interruption of production chains. REN21 explains this sum is six times lower than the public funding allocated as a form of support for fossil fuels, drawing figures from the Energy Policy Tracker.[1] Contrary to several European countries, China has substantially reduced its public aid for solar and wind energy. Likewise, in India, Latin America and Sub-Saharan Africa, there has been a drop in investments in new renewable capacities.

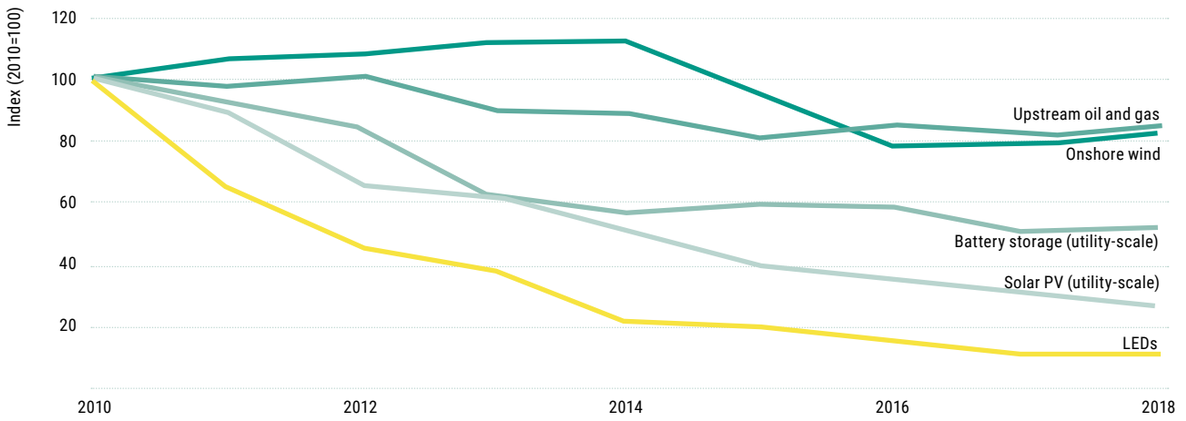
As for businesses, this year the gap has increased between the dynamics across the booming renewable sector and the oil and gas sector, which greatly suffered from the health crisis. According to Rystad's analyses, out of the 170 energy suppliers, those who drew the majority of their revenue from oil and gas were subject to financial losses averaging at 23% in 2020, whereas the businesses that focused on PV and wind power recorded gains of 17%.[3] In the United States, 107 exploration companies and parapetroleum services became bankrupt in 2020, compared to 63 in 2019.[4] In Europe and North America, oil and gas businesses depreciated their shares by a record sum of $145 billion during the three first quarters of 2020.[5] The projections for capital global expenditure (capex) relating to renewable energy projects in 2021 ($243 billion) got increasingly closer to the level of those anticipated for oil & gas ($311 billion). To compensate for the depletion of the fields being exploited, the exploration and drilling of new deposits became increasingly costlier and energy-consuming. The success levels of conventional oil and gas drilling dropped from 60% in 2016 to 10.6% in 2020.[6] The ultimate sign of this shift was when Florida-based renewable energy producer NextEra's stock market value exceeded that of ExxonMobil at the point, which was once one of the most listed business in the world on the stock market.[7]

In this context, a few of the Oil Majors seem to want to get the energy transition train in motion. On the horizon: the uninviting prospect of reigning over a future empire of stranded assets. The International Energy Agency, which was set up overnight after the first oil shock to ensure the safety of energy supplies, advises putting an end to any investments in new fossil energy extraction projects and to reach carbon neutrality by 2050, to which over 100 countries are committed to this day.[8]

FIGURE 1

EVOLUTION OF CAPITAL COSTS FOR SELECTED SECTORS AND ENERGY TECHNOLOGIES

Source: IEA, 2020



THE OBSERVATORY'S LENS

The Oil & Gas sector tries join the energy transition club

Climate change, an 'existential problem' for the oil & gas sector

While in 2020 the sector experienced the most abrupt drop in demand in its history (-8.8%)[9], forcing the OPEC+[a] to reach an agreement on a coordinated drop in production all throughout the year, 2021 started with uncertainty. Oil prices, briefly negotiated to below zero in April 2020, have once again reached profitable levels for most mining projects. It was up to around $70/barrel in May 2021[b]. In principle, this constitutes a situation which is conducive to capital investment and relaunching production. The OPEC+ gradually relaxed the restrictions it had imposed on itself.

Nevertheless, there was no more optimism for several of the private companies, if the declarations of several of the leaders in the industry were to be believed. They estimated that the oil demand would not return to its pre-crisis levels. From Matt Gallagher, the CEO of the Texan shale oil producer Parsley Energy,[10] to Bernard Looney, who runs BP,[11] the analyses predicting a higher peak in demand were multiplied at the height of the crisis. This was until the annual figures of the extremely popular *Energy Outlook,* which is edited by BP, corroborated the premonition – even in a business-as-usual (BAU) scenario, oil demand had never exceeded its record level from 2019[12] (100 million barrels, that is 192 exajoules a day)[c]. Russia, the third largest global producer whose exporting revenues of oil and gas represent a third of the State's budget, estimated it had already reached its peak offer in 2019.[13]

The economic situation questions the sector's ability to be able to endure a forced transition and reinvent new activities besides oil. In that respect, the Oil Majors must now face a contradicting double injunction. On the one hand, the shareholders are demanding their businesses to maintain the levels of high dividends, rather than keep investing in drilling and explorations, which are increasingly expensive and hard to access.[d] In 2020, the five biggest oil companies[e] spent more on dividends than what they had generated from cash flow, producing a deficit of $29.4 billion.[14] Concurrently, the capital expenditures of those same companies were cut by $22.8 billion (-25.7% between December 2019 and December 2020),[15] and layoff plans were put in place.

Also adding pressure are the regulators, investors, and NGOs who, worried about the 'existential problem'[f] of climate change and how it could affect business, are pushing the industry to reduce its emissions and to become a major player in the energy transition. 26 May 2021 was the climax, when the activist hedge-fund Engine No. 1 achieved its goal, with the

a The OPEC+ refers to a group of 23 oil producing countries, including the 13 OPEC members. This cartel was founded in 1961 and the 10 producing non-member countries of the cartel include Russia, which is the third largest oil producer in the world.

b https://oilprice.com/oil-price-charts/

c Since then, the International Energy Agency has formulated projections which will see the oil demand exceed its pre-Covid level once more.

d 10 billion barrels were found in 'wildcats' (exploration drilling areas where production hasn't yet started) in 2020, and very few had a capacity that was greater than 250 million barrels. Out of them, 66% were located in deep to ultra-deep water, which made them harder and more expensive to exploit. Source: Rystad (05/03/2021). Wildcat safari running dry: Onshore success rate dips to lowest on record, falls for fourth year in a row. *Rystad*

e Referred to as "super majors" by the IEEFA, this category includes Shell, Total, Chevron, BP and ExxonMobil.

f Engine No. 1 also formulated this in its shareholder appeal during ExxonMobil's general assembly in May 2021.

support of major financial players,[g] of electing three directors at ExxonMobil's administrative council,[16] whereas Shell was sentenced by a Dutch tribunal to reassess the ambition of its climate goals, following a complaint filed by seven NGOs supported by 17,000 signatures.[17] On that same day, 61% of Chevron's shareholders voted in favour of a resolution forcing the business to reduce its emissions.[18] The contradiction resides in the fact that as of today, only the yields from oil-sourcing activities would allow them to achieve the levels of financial profitability demanded from their shareholders.

However, earlier in April, the IEA, in its Net Zero By 2050 roadmap, recommended to put an end to investments in any new fossil fuel extraction projects.[8] As for the UNEP, it estimates that to reach the Paris Agreement's objectives, oil and gas production must be reduced by 4% and 3% a year respectively from now until 2030 (11% for coal, 6% in total for fossil fuels).[19] Overall, the oil & gas sector would be directly or indirectly at the root of 42% of the world's greenhouse gas emissions, according to McKinsey.[20]

Fragile commitments to carbon neutrality

In December 2019, Repsol was the first of a long list of major European oil companies to commit to achieving carbon neutrality by 2050.[21] Total, BP, Shell and ENI adopted also this objective identified by the IPCC to limit global warming to 1.5°C.[22] This was soon supported by various plans of action which detailed, with varying levels of precision and ambition, how each one could go about it. However, there were a few rare exceptions, such as Occidental Petroleum,[23] their American sister company, which chose to go down the business-as-usual route – a strategy which is starting to prove risky in the eyes of their shareholders, as proven by the misfortunes of Chevron and ExxonMobil.

It is mainly the Oil Majors and independent companies who have undertaken such commitments. Equinor, 70% of whose capital is held by the Norwegian State, is the only INOC (**see Keys to Understanding**) to also be committed to it, in keeping with the strategic shift which took place from 2018 onwards to diversify its activities outside of oil. Malaysian enterprise Petronas,[24] and PetroChina[25] are the only national companies (NOC) to follow this movement. A few majorly symbolic moves added to these strategies, like when Total left the American Petroleum Institute (API), one of the biggest lobbies in the sector in early 2021.[26] Last year, BP had also left three American oil associations which were not respecting the Paris Agreement. Since then, the API has shown signs of supporting the idea of a coal tax in the United States,[27] a market tool which for them would be a lesser evil, compared to the normative standards Biden's cabinet could impose.[h]

The ambition and the impact of these new strategies has been greatly analysed. In May 2021, the Carbon Tracker Initiative**,** published its report *Absolute Impact* for the second consecutive year. In it, it proposes a ranking of the low-carbon strategies from the largest oil companies (**tab. 1**). These strategies may fall in line with the Paris Agreement if the following three criteria have been fulfilled:

- The fixed objectives cover Scopes 1, 2 and 3;
- The objectives are expressed in absolute terms, with intermediate deadlines;
- The objectives cover all of the products sold by the business on a worldwide scale.[28]

g CalSTRS, CalPERS and New York State Common, the three biggest American pension funds, as well as BlackRock, Vanguard and State Street, the three biggest asset managers in the world, all voted in favour of candidates proposed by Engine No. 1 to attend Exxon's administrative council.

h From the very first few days of his mandate, Joe Biden signed a moratorium suspending the concessions for federal land and water to be used for oil and gas exploration. Thirteen American states filed complaints in March, before a judge in Louisiana issued a favourable decision on their behalf in May, estimating that the federal administration does not have that power. Source: Puko, T., Ferek, K. S. (15/06/2021). Federal Judge Stops Biden Administration From Blocking New Oil and Gas Leases. *Wall Street Journal*

TABLEAU 1

COMPARATIVE CLASSIFICATION OF CLIMATE STRATEGIES, PRESENTED BY OIL & GAS COMPANIES - *Source: Carbon Tracker Initiative, 2021*

RANK	COMPANY	METRIC	CHARACTERISTICS		COVERAGE		SCALE	
			END USE EMISSIONS	ABSOLUTE BASIS TO 2030 GOAL	FULL EQUITY SHARE BASIS (GLOBAL)	DOWN-STREAM PRODUCTS INCLUDED	2030 REDUCTIONS (ABSOLUTE)	2050 GOAL
1	ENI	Emissions of all products	Yes	Yes	Yes	Yes	25%	Net Zero
2	TOTAL	Emissions of products sold in Europe	Yes	Yes	Partial (Europe sales only)	Yes	30%	Net Zero
3	BP	Emissions from O&G production	Yes	Yes	Partial (excludes Rosneft)	-	30-40%	Net Zero
4	SHELL	Emissions intensity of all products	Yes	-	Yes	Yes	-	Net Zero
5	EQUINOR	Emissions intensity of all products	Yes	-	Yes	Yes	-	"Near zero"
6	REPSOL	O&G operational emissions intensity	Yes	-	Yes	-	-	Net Zero
7	OCCIDENTAL	O&G operational emissions intensity	Yes	-	Partial (Operated only)	Yes	-	Net Zero
8	CONOCO- PHILIPS	O&G operational emissions intensity	-	-	Partial (Operated only)	(n/a)	-	Net Zero
9	CHEVRON	O&G operational emissions intensity	-	-	Yes	-	-	-
10	EXXON-MOBIL	O&G operational emissions intensity	-	-	Partial (Operated only)	-	-	-

KEYS TO UNDERSTANDING

OIL MAJORS

The term "major" refers to the main private oil companies who used to be known as the "cartel of the Seven Sisters" after the major wave of mergers and acquisitions from the late 1990s-early 2000s. The IEA lists seven of them: ExxonMobil, Chevron, BP, Shell, Total, ConocoPhillips and ENI. We distinguish them from "independent" companies, of which there are more, and which are smaller (Repsol, Lukoil, Mitsubishi Corp, etc.). NOCs, or national oil companies, (such as Petrobras, Saudi Aramco, PDVSA and Sonatrach), focus their activities in the State's territory and they own most of the capital. They differ from international national oil companies (INOCs, such as Equinor, the Chinese CNOCC and CNPC, plus Gazprom), whose activities go beyond the borders of the State which owns most of their capital.This distinction is crucial for understanding the impact these companies have as they position themselves to make the best energy transition. In fact, the Oil Majors, of which only the Europeans have shown themselves to be open to volunteering up until now when it comes to diversifying their activities, represent only 12.3% of the world's reserves, 13.9% of production and 15.6% of the oil sector's investment (**fig. 2**). The overwhelming majority of reserves (67.5%) is owned by national companies (NOCs and INOCs). Dependant on oil profits to fuel their budget and social expenditures, the States which are running them do not seem willing to turn away from this financial godsend.[30]

A product of the collaboration between several NGOs defending the environment, petitioning for shareholders and financing, the *Big Oil Reality Check* report, edited by Oil Change International, analyses the climate strategies of BP, Chevron, Eni, Equinor, ExxonMobil, Repsol, Shell and Total. Ten criteria have been set, evaluating not only the ambition and transitional plans of companies, but also their 'integrity' (do they offer to put an end to lobbying over climate solutions, for example?).[29]

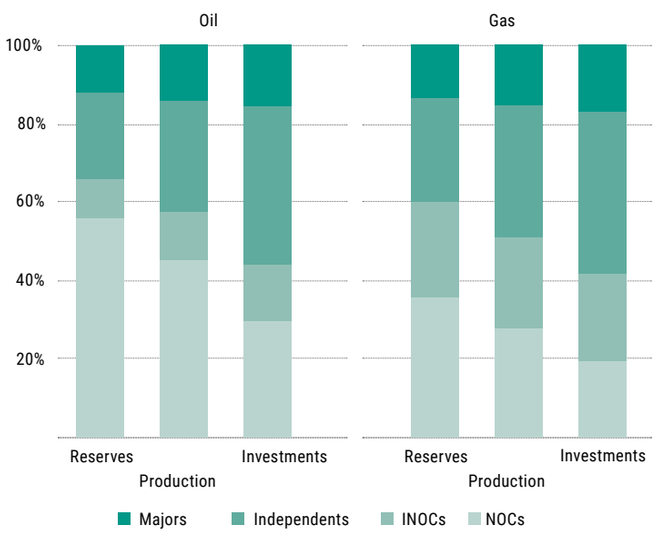
Seven companies in total have a fixed emission objective with Scope 3 for all of their projects, but in the cases of Shell, Equinor, Repsol and Oxy, the emission objectives are only expressed in terms of carbon intensity (CO_2/joule). In these conditions, a minor increase in their low-carbon energy portfolios would be enough for these companies to reach their objectives, without having to reduce all of their production, and therefore combusting oil. The same goes for the major American players, who haven't yet consented to reducing the carbon intensity of their operational activities (scopes 1 & 2). However, it is the accumulation of GHGs in the atmosphere which leads to global warming: the climate objective requires not only the development of low-carbon energies, but also the elimination of fossil fuels. Currently, only BP (-40% in 2030, based on 2019 figures) and Shell (-55% in 2030) predict a drop in their oil production, but none of the companies plan to cut it completely. In all of the other cases, production is set to increase between now and 2030.[29]

In all of the observed rankings, the Italian company Eni stands out by being the only company to have defined complete objectives for reducing emissions with intermediate deadlines across all of its products, covering even Scope 3. This point is essential, insofar as 81% of emissions from oil producing majors come from Scope 3.[i] Total and BP have also formulated intermediate objectives to reduce emissions before 2050.

There are several studies which highlight that these strategies also have the disadvantage of greatly relying on technologies which have not yet been developed on a large scale, so their efficiency is often the subject of debate, as is the capture, use and storage of CO_2 (CCUS). In comparison, several studies predict an increase in the production capacities for generating renewable energies.

FIGURE 2

THE SHARE OF RESERVES, PRODUCTION AND INVESTMENTS IN THE OIL AND GAS SECTORS PER COMPANY TYPE IN 2018 - *Source: IEA, 2020*



Note: NOCs = national oil companies ; INOCs = international national oil companies

i When discussing the emissions of a company, Scope 3 refers to emissions given off before the product's value chain, so during its distribution, storage, use or at the end of its life. For oil, this mainly relates to the emissions produced during combustion. Source: GHG Protocol, *Corporate Value Chain (Scope 3) Accounting and Reporting Standard.*

TABLE 2

CLIMATE AND ENERGY TRANSITION STRATEGIES OF THE THE SEVEN LARGEST OIL COMPANIES

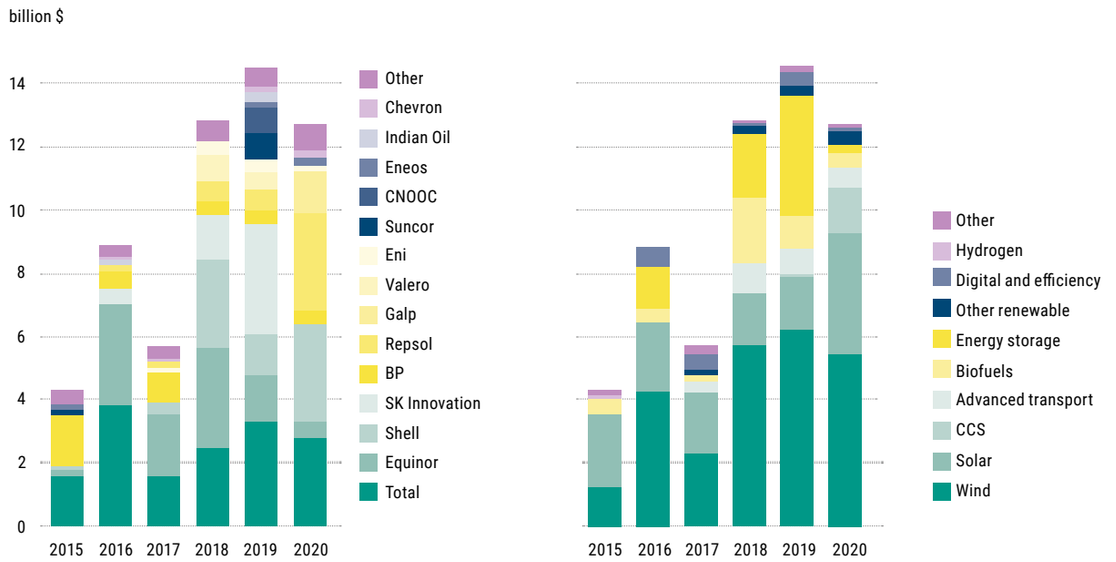
Sources: public documents from companies

COMPANY	BP	SHELL	ENI	TOTAL	EQUINOR	EXXONMOBIL	CHEVRON
DOCUMENT	BP SUSTAINABILITY REPORT 2020	POWERING PROGRESS	ENI'S EVOLUTION. LONG-TERM STRATEGIC PLAN TO 2050	VERS LA NEUTRALITÉ CARBONE	EQUINOR'S CLIMATE ROADMAP	UPDATED 2021 ENERGY AND CARBON SUMMARY	CLIMATE CHANGE RESILIENCE. ADVANCING A LOWER-CARBON FUTURE
DATE	Mar-21	Feb-21	Feb-21	Sep-20	Nov-21	Apr-21	Mar-21
NET ZERO TARGETS	2050 (Scope 1, 2, 3)	2050 (Scope 1, 2, 3)	2030 (upstream)	2050 (Scope 1, 2, 3)	2050 ("Near zero absolute GHG emissions" in Norway)	No	No
ABSOLUTE EMISSION REDUCTION TARGET	-30-35% in 2030 (Scope 1 & 2, base 2019)	No	-80% in 2050 (Scope 3)	-30% in 2030 (Scope 3, in Europe) Absolute reduction in the world	-70% in 2040 (Norway)	-30% in 2025 (Scope 1)	No
ABSOLUTE REDUCTION INTERIM TARGET	-20% in 2025 (Scope 1 & 2, base 2019)	No	-25% in 2030 (base 2018) -65% in 2040	-13% in 2025 (base 2015)	-40% in 2030 (Norway)	No	No
CARBON INTENSITY REDUCTION TARGET	-50% in 2050 (base 2019)	-100% in 2050 (base 2016)	Net carbon intensity (Scope 1, 2, 3, base 2018)	-60% in 2050	-50% in 2050 (Scope 1, 2, 3)	-15-20% (upstream, base 2016)	-35% in 2028
RENEWABLE ENERGY DEVELOPMENT TARGET	50 GW capacity (2030)	560 TWh power sales (2030)	60 GW capacity (2050)	100 GW capacity (2030), 15% of sales	12-16 GW of installed capacity (2035)	No	No
RENEWABLE ENERGY DEVELOPMENT INTERIM TARGET	25 GW (2025)		4 GW (2024), 5 GW (2025), 15 GW (2030), > 25 GW (2035)	35 GW (2025)	4-6 GW (2026)	No	No
CURRENT SITUATION	3.3 GW (2020)	255 TWh power sales (2020) 1 GW operating capacity	200 MW (2019)	7 GW 5% of sales (2020)	500 MW (2019)	n.d.	n. d.
OIL PRODUCTION REDUCTION TARGET	-40% in 2030 (base 2019)	-55% in 2030 (-1-2%/year by 2030)	Plateau in 2025	No	No	No	No
CCUS TARGET	Yes, n.d.	+25 Mtpa capacity in 2035	7 Mtpa capacity in 2030 50 Mtpa capacity in 2050	Yes, via the OGCI, n. d.	No	No	No
OFFSET TARGET	Not before 2030	120 Mtpa in 2030	40 Mtpa in 2050	5 $MtCO_2$/year by 2030	No	No	No

FIGURE 3

INVESTMENTS IN 'CLEAN ENERGIES' FROM OIL AND GAS COMPANIES, 2015-2020.

Source : BloombergNEF, 2021



Low-carbon services, an increasingly used strategy of oil companies

Over the course of the year, several Oil Majors have expressed their desire to no longer be considered as oil companies: "*The sole fact that [...] you refer to us as an oil company is symptomatic of the problems we have to face*", declared Ben van Beurden, the CEO of Shell, in an interview with Bloomberg in June 2020.[31] One year on, Total was renamed TotalEnergies.[32]

According to BloombergNEF, investments in "clean energies"[j] from the 34 biggest global oil companies have decreased by 12% between 2019 and 2020. Nevertheless, these investments are now focused on 6% of the sector's total capex, which is a record (**fig. 3**).[33]

Mergers and acquisitions (M&A) and capital-risk investments designed to increase the participation of oil companies in pre-existing renewable installation projects, are preferential leverage tools, via which Oil Majors intend to carry out their transition. In this respect, Total has spent almost six billion dollars on acquisitions between 2016 and 2020, notably thanks to purchasing electricity supplier Direct Energie, the battery manufacturer Saft and the Spanish subsidiary of the energy company EDP. In early 2021, this French giant also bought a 20% share of the Indian solar energy producing company Adani Green Energy, and it has multiplied this kind of operation ever since.[34] Nevertheless, as Wood Mackenzie's cabinet highlights, these M&As in "clean energies" are still just a drop in the ocean compared to the expenditure in oil & gas activities over the same period. That was only 16% in the case of Total (**fig. 4**),[35] which was the highest level amongst the major oil producers. 5% of its energy sales are now electricity (which was 1% in 2015), against 55% of oil products (66% in 2015) and 40% of gas (33% in 2015).[36]

Direct investments in new renewable production capacities, known as 'organic investments', are rarer. However, the introduction of oil companies and their unparalleled major investments relating to calls for tenders for offshore wind farms, could raise the prices of concessions to the detriment of traditional electricity companies. The recent excise duty in February 2021 was proof of that, with two sites amounting to a total capacity of 3 GW for BP and the German electricity company EnBW off the coast of the United Kingdom, for a record price of a billion pounds; almost fifteen times more than the previous call for tenders[37]. Two oil companies, BP and Equinor, also took over the market with a 2.49 GW offshore wind farm capacity near New York, after the English company contributed over a billion dollars to the concession[38]. Offshore wind farms are an obvious choice for oil companies who already have the expertise in prospecting, constructing and carrying out operations out at sea.

Although a majority of the investments are in solar and wind energy, the diversification strategies of the European majors is not limited to a single energy producing sector. With carbon neutrality becoming the guide for global climate action, European companies are even searching to become what could be called "low-carbon service businesses", rather than renewable energy producers.

j BloombergNEF is greatly accepting of "clean energies", including notably solar, wind power, CCUS, biofuels, energy storage, digital, hydrogen, new means of transport and other forms of renewable energy.

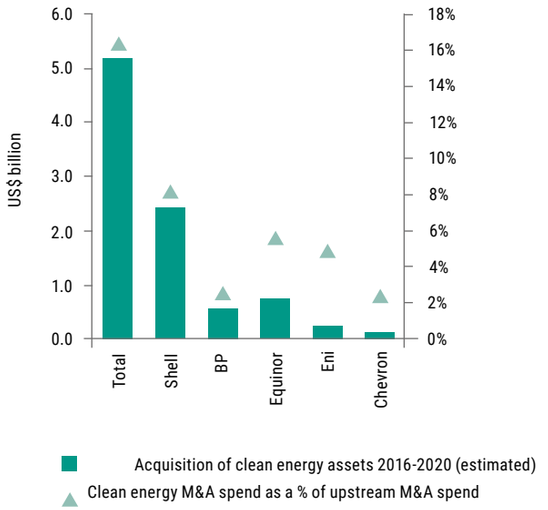
Shell's strategy is the perfect example of this. In its presentation to investors in early 2021, the company founded its strategy for growth, transition and investment around the concept of "*clean-power-as-a-service*": serving customers to help the reach their own carbon neutrality objectives by offering a wide range of low-carbon services, from hydrogen for recharging electric cars, to CCUS, with the aim of creating "integrated energy systems".[39] To achieve its objective of 500,000 charging stations in Europe between now and 2025, the Dutch firm notably bought NewMotion in 2017, which owned the largest network of charging stations on the continent in the Netherlands.[40]

The development of batteries and electricity storage technologies have also received major investments. In late 2020, Total joined forces with the car group PSA/Opel to create the Automotive Cells Company (ACC), a joint-venture aiming to become a global main player in producing batteries by 2023. Two "GigaFactories" will be opened in Douvrin in France and in Kaiserslautern in Germany. The project benefits from the public support of 1.3 billion euros from France and Germany, as well as European support via the research aid scheme IPCEI (Important Project of Common European Interest). This mechanism granted 3.2 billion euros in late 2019 to assist the European Batteries Alliance (known as the "Airbus of batteries") launched by the Commission in 2017.[41]

FIGURE 4

THE M&As AND INVESTMENTS IN CAPITAL-RISK FROM THE OIL MAJORS IN 'CLEAN ENERGIES', BETWEEN 2016 AND 2020

Source: Wood Mackenzie, 2020 - With regards to 'clean energies', Wood Mackenzie includes photovoltaic solar energy, onshore and offshore wind energy, CCUS, hydrogen and electric infrastructures.



Previously largely developed by ExxonMobil, CCUS now attracts its European counterparts **(see Industry Sector)**. As a result, Total, Shell and Equinor invested 650 million euros in the Northern Lights project in Norway last year, to enable CO2 emitted by cement manufacturers into the soil to be stored at 2,600 meters under the seabed.[42] In Great Britain, the Net Zero Teeside project was financed by the Oil & Gas Climate Investment consortium (OGCI, behind 30% of the world's oil) which includes BP, ENI, Equinor, Shell and Total. Although CCUS is still not all that developed, it must theoretically reduce the impact of carbon-emitting energies and even extend the lifespan of certain oil fields which are being depleted. It is also expected that the CCUS will support the development of hydrogen when produced from a gas. CCUS was the third largest low-carbon expenditure item of the oil & gas sector in 2020 (**fig. 3**).

KEY TAKEAWAYS

In the context of depletion of existing wells and increasing exploration and exportation costs of new fields, which are increasingly difficult to access, oil companies are now restricted to processing things faster to keep with the times. The dependence on oil represents a medium-term risk for the industry, which is looking to benefit from favourable trends in the energy transition, so that companies can carry out the transition along own economic models. However, the accelerated break-through of some of the major oil companies in renewable markets since 2018 has not resulted in the abandoning oil for the benefit of renewable electricity. It is precisely the cashflow created from oil producing activities which allows the Oil Majors to expand upon their activities, not only relating to renewable energy production, but across all of the low-carbon services in development. These strategies are more likely to lead to a desire to increase and preserve the interests of the shareholders with a genuine support for combatting climate change, as is proven by the weakness of their fixed objectives in their climate plans.

The main vehicle for this transition is the mergers and acquisitions carried out by the Oil Majors to buy low-carbon shares, which shape the renewable market, which is increasingly concentrated in the hands of very few of the dominant players. This is similar to the inflation in concessions prices for offshore wind farms, caused by the entry of oil companies in the bidding.

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SIGNALS

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

Business • By selling Suez, Engie frees up funds for renewables

The world's third largest energy group (excluding oil), Engie, is still lagging behind in renewable energy. By selling its 29.9% stake in Suez to Veolia, Engie has pocketed €1.8 bn in gains and affirms the intention to refocus its activities on renewable energy development and operation, low-carbon infrastructure and services, and gas. The group's new strategy is to invest 45% (~€7 bn) of its growth investments in renewables by 2023, accelerating their deployment from 3 GW/year today to 6 GW/year between 2026 and 2030. With a target of net zero emissions in 2045 (Scope 3), Engie intends to reduce the carbon intensity of its electricity production from 363 to 158 gCO_2/KWh, and to lower its emissions to 43 $MtCO_2$ in 2030, without specifying the current level of its emissions.

L'Usine Nouvelle, 30/11/2020

Justice • The Hague Tribunal calls on Shell to revise its plans

A landmark decision in climate justice: for the first time, judges have recognised that a company's lack of climate ambition can undermine human rights. On 26 May 2021, the Court of The Hague, hearing a case brought by seven environmental NGOs, ruled that Shell's greenhouse gas reduction strategy —a 20% carbon intensity reduction by 2030 compared to 2016 — was insufficient. The judges ordered Shell to reduce its greenhouse gas emissions by 45% by 2030. The group appealed in July, citing its net zero strategy presented in April 2021.

Financial Times, 26/05/2021

Justice • In North America, oil pipelines see dark times ahead

Canadian operator TC Energy Corp. and the Alberta government have announced the abandonment of the Keystone XL cross-border pipeline between Canada and the US. A major struggle by environmental activists and indigenous peoples resulted in President Joe Biden revoking the construction permit. Initiated in 2014, the project had been the subject of a colossal investment by Alberta (estimated at $1.1 billion). In Minnesota, thousands of protesters invaded the Enbridge Line 3 pipeline construction site. The state government responded with a brutal police crackdown and mass arrests. A few weeks later, in Alaska, a federal judge blocked an oil drilling permit granted to ConocoPhillips, despite the support of both the Trump and Biden administrations.

Inside Climate News, 09/06/2021

Youth • Multiplying student movements against fossil fuels

Student movements are denouncing the partnerships between their universities and fossil fuel giants. The Oxford Climate Justice Campaign (OCJC) has revealed that the prestigious British university has received almost 14 million euros from the petrochemical industry between 2015 and 2020. Its pledge to divest from fossil fuels, made in April 2020 under pressure from the OCJC, does not yet appear to be fulfilled. A similar student movement, Zero Carbon Cambridge, has also recently pushed the University of Cambridge to withdraw its investments in fossils. At the Universities of Laval (Canada), Cornell and Michigan (USA), student pressure has forced the universities to sever their ties with oil companies. Most recently, Harvard University announced in September that it would divest from fossil fuels. In France, students at the École Polytechnique and Sciences Po Paris are opposing the presence of the oil giant Total in their curriculum and even on their campus.

Vert, 22/04/2021

Wind • The soaring costs of investment of offshore wind

In 2021, 30 GW of offshore wind tenders have been launched (or planned) worldwide, almost equalling the capacity already installed (35 GW). The cost of securing a development site is skyrocketing, while competition for bids is becoming increasingly fierce. For example, last February BP and Germany's EnBW won concessions for two sites totalling 3 GW, requiring the payment of a £1 bn option fee to secure the site before making their final investment decision – cost that could not be borne by companies used to working offshore such as Iberdrola, Orsted and SSE. The oil companies are therefore well positioned on the market, but this increase in development costs could ultimately be passed on to the price of electricity paid by the consumer.

Reuters, 07/04/2021

Africa • IDB and Morocco join forces for renewable energy development

The Moroccan Agency for Sustainable Energy (Masen) and the Islamic Development Bank (IDB) have launched a joint initiative to develop strategic renewable energy projects in Africa. Several projects were presented at the launch of the initiative, including solar power plants in Dosso, Maradi and Diffa in Niger — for a total capacity of 30 MW, and a project for three solar power plants with storage in Djibouti. Other projects include a 150 MW solar power plant in Franceville, the 36 MW FE II hydroelectric project in Gabon and a 50 MW solar thermal plant in Senegal.

Afrik21, 06/01/2021

Business • Oil majors dethroned by the mining industry, with record profits

Commodity inflation in 2021 and the energy transition have benefited the mining sector. BHP Group, Rio Tinto Group, Vale SA, Anglo American Plc and Fortescue Metals Group Ltd. are on track to generate $65 bn in annual profits, 13% more than the five largest oil companies. Until 10 years ago, oil companies generated twice as much profit as mining companies. This trend is partly due to the explosion in the price of iron ore: sold for $200 on the market, a tonne costs only $20 to extract. Copper, which is essential for low-carbon technologies, has passed the symbolic $10,000/t mark. The prices of aluminium, nickel, tin, lead and zinc have also reached record highs.

Financial Post, 01/05/2021

Solar • Solar reaches a peak in West Africa

In Nigeria, Sunnyfred Global has signed an agreement with Singapore's B&S Power Holding PTE to finance the installation of the largest solar power plant in West Africa, with a capacity of 200 MW, in Ashama, in the south of the country. French start-up Qotto will receive financial support from the African Development Bank (AfDB) to electrify rural households in Benin and Burkina Faso using solar power. Sierra Leone and Uganda will benefit from a $16 bn investment from the NEoT Offgrid Africa (NOA) investment platform, created by French companies EDF and Meridiam, and the Japanese Mitsubishi Corporation. Over the year 2020, West Africa has received more than $142 bn in off-grid solar investments.

Commodafrica, 01/03/2021

Brazil • South America's largest electricity company is now privately-held

Brazilian MPs have voted to privatise Eletrobras, Latin America's largest electricity company, which supplies almost a third of Brazil's electricity. This is an important milestone in the policy of state disengagement promoted by President Bolsonaro. The state's majority stake in the company will be diluted by issuing new shares, reducing its share from 61% to 45%. The government hopes to gain nearly $11 billion from the expected rise in share prices, while the new capitalisation should allow the group to free up investment margins. The Itaipu hydroelectric plant, operated with Paraguay, and the nuclear plants will be separated from the group so that they remain under state control.

Le Monde, 22/06/2021

CASE STUDIES

CITY CASE STUDY

COUNTRY	CITY	POPULATION	MITIGATION TARGET	EMISSIONS IN 2016
SPAIN	CÁDIZ	120,000	REDUCING EMISSIONS BY 40% COMPARED TO 2030 BASELINE SCENARIO	305,681 tCO_2/YEAR

Cádiz, at the forefront of the municipalisation of energy

A port city of 120,000 inhabitants located in the south of Andalusia, capital of the eponymous province (1,200,000 inhabitants), Cádiz is considered as a model of municipal energy policy in Spain and in Europe. A signatory to the Covenant of Mayors for Energy and Climate in Europe since its launch in 2009, Cádiz committed to reducing its emissions by 21% in 2020, as compared to 2007. Though no results were reported, the city announced the publication of an adaptation plan and an Sustainable Energy and Climate Action Plan (SECAP) and the update of its emissions inventory at the end of 2021, with a target of reducing emissions by 40% by 2030. In 2016, it was estimated that the city's carbon footprint amounted to 305,681 tCO_2/year.

Participatory municipalisation of energy

The originality of Cádiz is based on the existence, since 2000, of the largest semi-public electricity distribution and supply company in the country, Eléctrica de Cádiz (EdC), which is 55% owned by the municipality (the rest by Endesa and Unicaja Bank).

Since 2015, EdC has encouraged active participation in the public management of electricity through the organisation of round tables on energy transition (MTEC) and against energy poverty (MCPE). A decision by an MTEC led EdC to supply certified 100% renewable electricity, thanks to guarantees of origin. This performance allowed EdC to claim a reduction of 58,500 tCO_2 compared to before.

Cádiz struggled for a long time to develop the production of electricity from renewable energy on its territory, even though the city benefited from one of the highest levels of sunshine in Europe – conducive to the development of photovoltaics. EdC does not produce its own energy and does not directly invest in renewable generation capacities. But it has encouraged self-consumption since 2018. In January 2020, a 50% exemption from the property tax was implemented by the municipality for all housing and premises which installed photovoltaic panels for their own consumption, in addition to a 95% reduction in the tax on constructions, installations and works.

The fight against energy poverty

Since 2015, the fight against energy poverty has become a priority for the government "del cambio", an alliance of the two coalitions "Ganemos Cádiz" and "Cádiz sí se puede". Hard hit by the economic crisis of 2008, Cádiz then had one of the highest unemployment rates in Europe (30%). A diagnosis revealed the municipality's energy wastage and citizens' lack of understanding of their energy bills. The new majority therefore launched a first "Shock plan against energy poverty". Three editions of this plan made it possible to provide personalised follow-up to 2,218 families, the organisation of 155 workshops on energy savings and understanding electricity bills (in which 1,670 people participated, including households suffering energy poverty). In 2017, an MCPE led to the adoption of a social tariff (Bono Social Gaditano), funded in equal parts by the municipality and EdC to reduce the energy bills of the most impoverished families.

In November 2020, EdC signed a new agreement with the municipality of Cádiz and the social services to establish the "Annual Energy Coverage" (Cobertura Energética Annual – CEA), a new aid intended to guarantee minimum access to energy to the neediest families who struggle to pay their bills. In return for this measure, which was trialled for a year in 30 families during a pilot phase, each beneficiary household must attend a training workshop on energy efficiency. The CEA also offers EdC a new pricing rationale for consumers. There is a national social tariff to which each of the country's 500 electricity suppliers contributes, but only a handful of "Benchmark suppliers" are entitled to distribute, thus favouring large national suppliers at the expense of municipal companies.

Source : Eléctrica de Cádiz

COUNTRY	POPULATION	MITIGATION TARGET	EMISSIONS IN 2018
VIETNAM	96,460,000 (2019)	-9% IN 2030 COMPARED TO BAU SCENARIO	257,860 $MtCO_2$

Vietnam's solar boom

The first half of 2020 saw considerable growth in renewable capacity in Vietnam, despite the Covid-19 pandemic and the lockdown. This growth increased further in the second half of the year and skyrocketed in the month of December (**figure**). According to IRENA, a staggering 11 GW of solar capacity was added in the country in 2020, making it now rank 7th in the world for total capacity. From 97 MW of capacity addition in 2018, Vietnam jumped to nearly 5 GW in 2019, and 16.5 GW in 2020, making Vietnam the country with the biggest solar boom in 2020. Most of these capacity additions are from rooftop solar PV, installed on residential and commercial structures.

Market reforms and coal's loss of profitability drive the solar sector into a frenzy

The most immediate cause for the sharp increase at the end of 2020 was the deadline for installations to be eligible for the second iteration of feed-in tariffs (FiT) being set as the 31st of December. Other policies such as income tax and land-lease payment exemptions, along with more flexibility for utility-scale PV developers have also contributed to this increase.

The implementation of the high-FiT solar PV policy was done by EVN, the state-owned electricity utility, which ceded part of its power generation monopoly in order to reduce costs, and as part of a larger push for market reforms in Vietnam. Rushing to fill this space were several smaller private firms, and even owners of residential structures and agricultural structures with installed rooftop panels.

This was despite disrupted supply chains in 2020 due to Covid, which otherwise meant cheaply available solar cells and modules from China. Vietnam's solar panel market is currently dominated by Chinese firms, who have manufacturing units in the country. The low-cost panels are thus assembled locally – another advantage for solar in the country.

Simultaneous to the high FiTs has been the reducing profitability of coal, with several foreign banks refusing to finance coal-fired power plant projects. Adding to this are protests from local leaders against the coal, due to concerns for air quality. Catching international attention were the protests against the Vung Ang coal-fired plants, which saw mobilisations right from local communities all the way to youth activists and NGOs around the world. Giants like the Mitsubishi Corp, Samsung and Kepco were criticised for their support of the Vung Ang 2 plant.

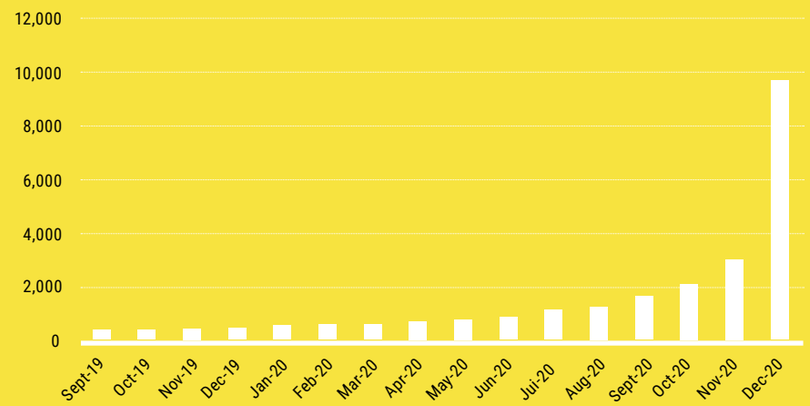
Distribution infrastructures lag behind the PV installation rush

While no concrete expansion of the FiT policy has been chalked out for 2021, the government has proposed a pilot Direct Power Purchase Agreement (DPPA) mechanism, which will allow businesses to be able to source 100% renewable energy directly from renewable energy developers.

The expansion of solar power in Vietnam has in fact been so rapid, that in many parts of the country, the infrastructure is lagging, with some regions having a surplus of energy and others receiving none for lack of efficient transmission. A revamping of the distribution grid, to ensure a more even distribution across regions might soon be needed moving ahead, to benefit from this boom in renewables. At the same time, Vietnam has set the precedent for the rest of the region, in a context where ASEAN member states have set a target to reach at least 23% renewables in their energy mix by 2025.

CUMULATIVE ROOFTOP PV INSTALLATIONS SEPTEMBER 2019 - DECEMBER 2020

Source : EVPG & ENV, as cited in PV Tech



CITY CASE STUDY

COUNTRY	CITY	POPULATION	MITIGATION TARGET	EMISSIONS IN 2019
AUSTRALIA	MELBOURNE	159,992 (GREATER MELBOURNE: 5 MILLIONS)	CARBON NEUTRAL IN 2020 (SCOPES 1&2)	4.9 $MtCO_2$

Melbourne to become 100% renewable-powered thanks to Power Purchase Agreements

Home to more than 5 million people, Melbourne's reported emissions amounted to 4.9 $MtCO_2$ in 2019, down by 14% from 5.8 $MtCO_2$ in 2014.[1] Changes of methodologies apart, the City of Melbourne identifies the surge of renewable energies over the last years as the main driver of this success (CDP, 2020). In early 2019, Melbourne claimed it became the first Australian Council to cover 100% of its infrastructural power consumption (universities, lighting, corporations, cultural institutions...) with renewable energies. An achievement consistent with the city's pledge to reach zero net emissions for all the Council's public operations by 2020. From 2011-2012 to 2018-2019, the municipality of Melbourne alone (i.e. the Council representing 159,992 inhabitants) reduced emissions from its operations by 54% (Scope 1, 2, 3), including a 65% drop in Scope 2 emissions, which includes electricity purchase.

2017-2020: two PPAs to support regional wind power generation

At the heart of this success is the use of Power Purchase Agreements (PPAs) to supply the city with electricity from renewable sources. In 2017, a first PPA signed under the aegis of Melbourne supported the construction of the new 39-turbine Crowlands Wind Farm, operated by Pacific Hydro firm in Western Victoria, some 200 km away from Melbourne. The new farm opened in early 2019 with a capacity of 80 MW and yearly generation of 264 GWh, of which 88 GWh were purchased by thirteen of Melbourne's biggest energy consumers. Gathered in a city-led consortium called Melbourne Renewable Energy Project (MREP), none of these actors had to make any direct capital investment into the project, as the agreement alone provides guarantee of financial returns on investment to Pacific Hydro. 40% will be purchased at a fixed price, while 60% will be a market-based price renegotiated every two years. In total, the PPA avoids the emissions of 96,800 tCO_2e a year in Melbourne, equal to the annual power consumption of 17,600 households or taking 22,500 cars off the road every year.

The project now supplies energy to power town halls, bank branches, universities and street lights.

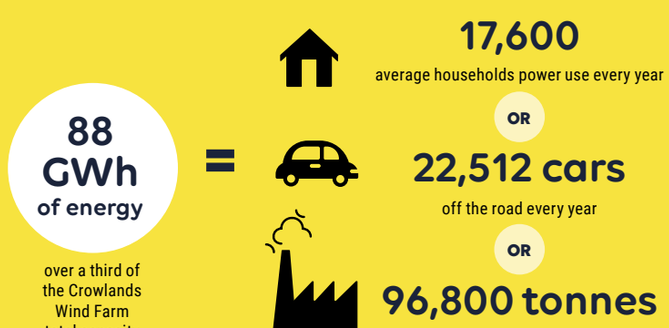
In June 2020, Melbourne facilitated the signing of a second collective PPA with seven local players including universities and businesses. The Melbourne Renewable Energy Project (MREP 2) will supply 110 GWh of renewable electricity per year to the purchasing group over 10 years, i.e. 22 GWh more than the first PPA. This electricity will supply fourteen shopping centres, nine office buildings, seven university campuses and four factories, equivalent to the consumption of 22,000 Australian households a year. MREP 2 is expected to reduce the equivalent of 2.7% of the city's emissions every year, i.e. 1 $MtCO_2$ over the 10-year lifetime of the project. This time, MREP2 sources power supply directly from existing Yaloak South Wind Farm, and the remaining from other wind farm projects in the state of Victoria.

Melbourne's approach is similar to the Community Choice Agreements (CCA) that exist in the United States. As a local government of a big city, taking the lead of a consortium strengthens the application of smaller actors of the city, but also outside the city boundaries: the deal made in the first MREP only covered one third of the annual amount of power generated of Crowlands Wind Farm, but secures enough outlet for the farm to supply power to other places not part to the deal.

1 Although these emissions are reported by the "City of Melbourne" in CDP database, we reckon these figures cover all Greater Melbourne Area regarding their proportion. The MREP is driven by the municipality.

CLIMATE AND ENERGY BENEFITS OF THE FIRST MREP

Source : Carbon Neutral Cities Alliance, City of Melbourne, n.d.



“2020 SHOWED MARKS OF SHORT-TERM UPHEAVALS THAT COULD HAVE A LASTING IMPACT ON THE FUTURE OF MOBILITY”

After nearly a year of stagnation, the transport world has started 2021 in a state of logistical and economic disorientation. But with greenhouse gas emissions down by 11% compared to 2019 and changes in practices favouring soft and electric mobility, 2020 showed marks of short-term upheavals that could have a lasting impact on this sector's future direction.

The automobile market, which has been in a slump for the past four years and has been severely affected by the pandemic, presents a very mixed picture in terms of its climate responsibility. The electric vehicle market is emerging as one of the few economic sectors to benefit from the crisis. Sales of electric cars have passed the symbolic level of 10 million units for the first time, boosted by European demand overtaking China as the largest market. To a lesser extent, buses are also part of the electrification trend, whose climate benefits are always dependant on the carbon intensity of the electric mix. This also applies to hydrogen vehicles, on which some manufacturers and the Tokyo metropolis are banking. **[CASE STUDIES]** But the benefits of this electrification are offset by the success of heavy and emissive SUVs, which continue to win over the public and manufacturers, and now occupy more than 42% of the main markets (Europe, United States, China, India). **[TRENDS]**

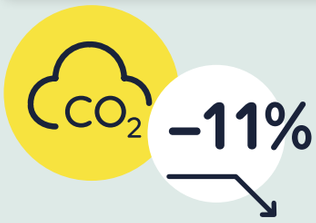
In cities, where 40% of transport-related emissions are concentrated, urban mobility is continuing to change: the continued use and promotion of bicycle lanes set up during the confinements, as in Bogotá **[CASE STUDIES]** have led to a boom in bicycle-use around the world. **[INDICATORS]** This has led to tensions in the global supply chains for spare parts, the production of which is concentrated in a handful of companies. A concentration of market power can be seen also in the free-floating market, where the main free-access bike and scooter companies are establishing their dominance in a market that is still struggling to find a stable economic model. **[TRENDS]**

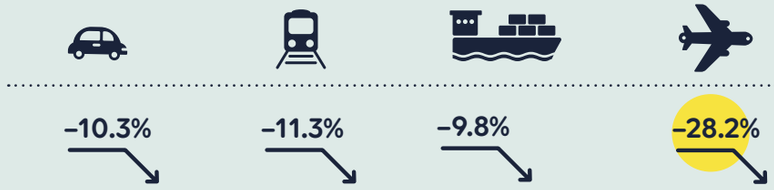
The same behaviour can be observed among the major shipping companies, which are taking advantage of the explosion in container freight prices to improve their financial health, place orders for new vessels and vertically integrate value chains. The stabilisation of oil prices has preserved the status quo in the climate strategies of shipping companies, which are still required to juggle the imperatives of reducing their greenhouse gas emissions and reducing sulphur pollution **[TRENDS]**. On the other hand, the all-out recovery in global demand for manufactured goods has disrupted international trade and lengthened maritime delivery times.

At the same time, China is almost single-handedly expanding the global rail network, deploying high-speed lines domestically and freight lines abroad as part of its Belt and Road Initiative. **[TRENDS]** In Europe, the return of the night train heralds a revival of rail mobility **[SIGNALS]**, while with its future "Regional Express Train", Dakar is poised to make a leap in mass transport capacity. **[CASE STUDIES]**

International air traffic, which lost three quarters of its passengers in 2020, remains sluggish; the future of the Corsia programme for offsetting the sector's emissions seems compromised in the medium term. **[TRENDS]**

STAGGERED ADVANCES IN LOW-CARBON MOBILITY



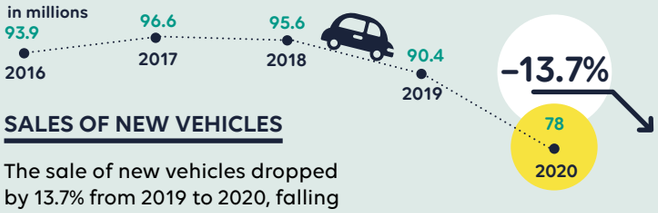


The civil aviation sector was the most affected, with 60% less passengers than in 2019. The reduction was more significant in the case of international flights (-74%) than domestic flights (-50%)
ICAO, 2021 ; IATA, 2021

EVOLUTION OF EMISSIONS FROM THE TRANSPORT SECTOR BETWEEN 2019 AND 2020 (EXCLUDING INTERNATIONAL TRANSPORT)

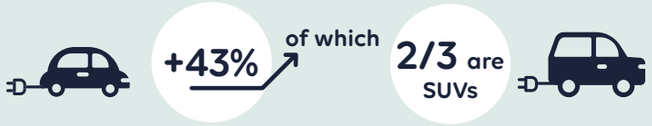
This reduction was mostly due the slowdown in activties caused by the Covid-19 pandemic. *Enerdata, 2021*

SUVs and electric vehicles emerge the best performers in a dark year for the automobile market



SALES OF NEW VEHICLES

The sale of new vehicles dropped by 13.7% from 2019 to 2020, falling from 90.4 million to 78 million. The sales had already fallen by 6.4% over two years. *OICA, 2021*



SALES OF ELECTRIC VEHICLES (EVs)

The sales of EVs (including hybrids), on the other hand, increased by 43.3% in 2020. EVs accounted for 4% of global sales in 2020, as against 2.5% in 2019. *IEA, 2021*

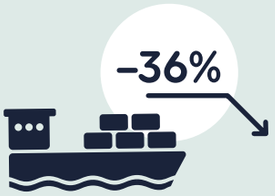
RANGE OF THE ELECTRIC MARKET

Nearly two out of three vehicles (63.4%) among the top twenty best-selling EVs in the world in 2020 were sedans or SUVs, vehicles heavier than the average.
CleanTechnica, 2021

SUV SALES

SUVs now account for 42% of the global market for new vehicles.
IEA, 2021

The disorganised recovery of international trade causes shipping freight rates to soar

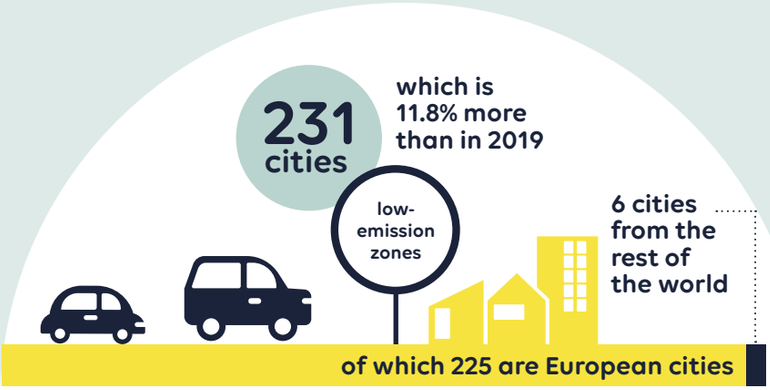


GOODS TRANSPORT

The global transport of goods diminished by 36% in 2020, while emissions fell by 30%.
SLoCaT, 2021

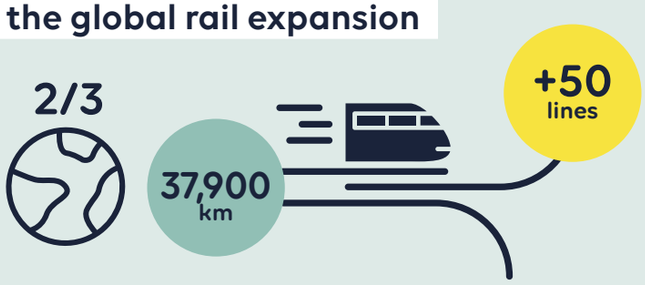
EVOLUTION OF FREIGHT RATES

The rates of maritme freight transport increased by 258% between July 2020 and July 2021, driven by a strong recovery of international trade and a dearth of containers.
Freightos Baltic Index, 16/07/2021



REN21, 2021

China leading the global rail expansion



HIGH-SPEED RAIL IN CHINA

More than 50 new high-speed railway lines have been opened in China, between 2018 and 2020. Its network of high-speed railways now adds up to 37,900 kilometres, that is around two-third of the global network. *SLoCaT, 2021*

Cycling gains ground thanks to the pandemic

NEW CYCLING INFRASTRUCTURE IN EUROPE

1,466.4 km of new cycle lanes were created in Europe between March 2020 and April 2021, out of 2,591 km initially announced by cities. *European Cyclists' Federation, 2021*

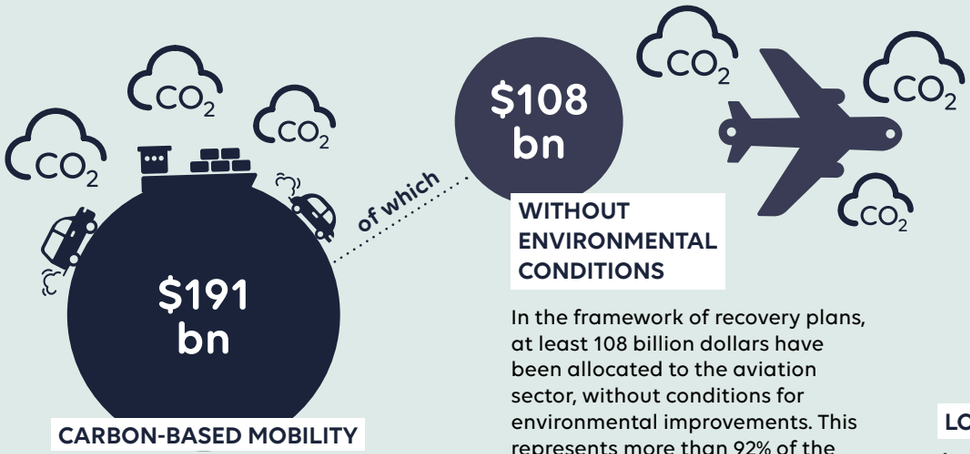
INCREASING FREIGHT TRANSPORT BETWEEN CHINA AND EUROPE

Despite the pandemic, the number of trains between China and Europe increased by 50% in 2020 compared to 2019, and increased by seven times compared to 2016. *Financial Times, 28/03/2021*

NUMBER OF BIKE-SHARE SYSTEMS OPENED AROUND THE WORLD

These are largely concentrated in Europe, in East China and North America. *bikesharingworldmap.com, 2021*

The G20's economic recovery benefits carbon-based mobility



CARBON-BASED MOBILITY

Amount allocated by the G20's recovery plans to the production or consumption of fossil fuels for transport.

WITHOUT ENVIRONMENTAL CONDITIONS

In the framework of recovery plans, at least 108 billion dollars have been allocated to the aviation sector, without conditions for environmental improvements. This represents more than 92% of the allocated recovery funds to the sector.

LOW-CARBON MOBILITY

Amount allocated by G20 recovery plans to the production or consumption of low-carbon energy for transport. Out of 147 billion dollars, 3 billion are allocated to soft mobility.

Energy Policy Tracker, 2021

TREND
ROAD TRANSPORT

2020: A Smooth Ride for the Electric Car Market, Despite the Pandemic

GHISLAIN FAVE • Energy-Climate Consultant

Despite the severe slump affecting the automobile industry following measures to stem Covid-19, the progress of electric cars carries on unabated and continues to attract both carmakers and consumers. Boosted by national recovery plans, stricter local regulations, and manufacturers' decarbonization programmes, the penetration of electric vehicles is nevertheless subject to another trend that undermines both climate targets and low-energy carbon-free transportation: the SUV boom.

DATA OVERVIEW

The auto-industry's electrification resists the dip in global sales

Road emissions increased by 0.8% in 2019 compared to 2018, to reach 6.1 $GtCO_2e$, slower than the 1.8% average growth per year from 2011-2018.[1] Emissions resulting from car traffic alone amounted to 3.2 $GtCO_2e$ in 2019. In 2020, following the economic and health crisis triggered by the Covid-19 pandemic, these figures went down for the first time, by 6%, totaling 3 $GtCO_2e$ according to the International Energy Agency (IEA).[2] Data consolidation by Enerdata even estimates this drop to be 10%.[3]

Restrictions on movement imposed as a response to the health crisis had a particularly strong impact on road transport, generating a 10% decrease in oil demand in the sector compared to 2019. At the height of restrictions, road transport activity plunged historically low, by over 80% in some countries (**fig. 1**).[4] In the second half of 2020, activity picked up again in emerging economies, but remained low in developed nations in comparison to 2019 levels.

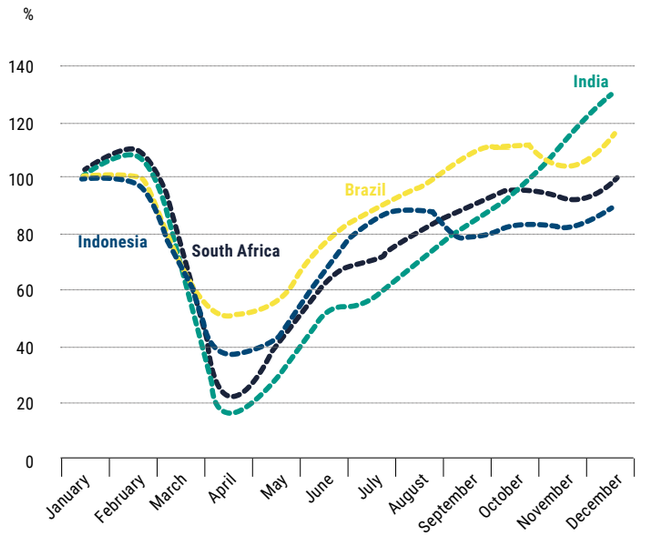
The pandemic has had an even greater impact on car sales. The automobile market was already shrinking, with global sales successively dropping by 2.9% and 6.3% in 2018 and 2019, despite an upswing in some regions (+1% in Europe in 2019). In 2020, the global downturn exceeded 15% and affected all of the leading markets (-21% in Europe, -28% in the United States and -6% in China).[5] Despite these record drops, electric vehicles (EV) performed well: sales reached a new record and the global fleet topped 10 million vehicles.[a] The 2020 Sector-based Report already pointed to encouraging sales of electric vehicles, up by 42% in the first half of 2020 in Europe. This trend was strongly confirmed with an increase of +137% over the whole of 2020 in the European market.[6] For the first time since 2015, sales in Europe (1,417,880 units) were even higher than in China (1,160,764 units). The EV market share rose sharply from 3.2% in 2019 to 10% in 2020, while it grew from 4.8% to 5.7%

a Including Battery Electric Vehicles (*BEV*) and Plug-In Hybrid Electric Vehicles (*PHEV*).

in China during the same period. In the space of one year, the Battery Electric Vehicle (BEV) market share more than doubled in Europe, from 3.5% in the second quarter of 2020 to 7.5% in 2021. Sales of plug-in hybrid electric vehicles (PHEVs) did even better, with 8.4% of the market, representing over half of the sales of all electric vehicles.[7] In the United States, sales are taking off slowly (only 10% of global sales), and EVs only represent 2% of the US market (**fig. 2**).[8]

FIGURE 1

ROAD TRANSPORT ACTIVITY IN SELECTED EMERGING COUNTRIES IN 2020 - *Source : IEA, 2021*



While these signs are encouraging, EVs still only represent a small share of the world's automobile fleet: only 0.9% of the vehicles circulating in the world are electric, compared to 0.7% in 2019. The results are only slightly better in the leading markets of China and Europe (1.7% and 1.1% respectively).[12] The transport sector is therefore still highly dependent on fossil fuels[9]: all modes of transport combined represent 60% of oil demand[10], and 97% of the energy used by transportation is of fossil origin[11]. In its road map entitled *Net Zero by 2050*, the trajectory promoted by the IEA to reach carbon neutrality in the sector is based on a rapid switch to electric mobility: by 2030, over 60% of new car sales will need to be those of electric vehicles (compared to under 5% in 2020 – **fig. 2**) and the automobile fleet will need to be almost entirely electric by 2050, amounting to two billion electric vehicles (i.e. 200 times more than the current figure).[12] Other key points in the road map include reduced transport demand, modal shifts, and improved energy efficiency.

As a result, states, local governments and carmakers are working to rapidly establish a market that was almost inexistent a few years ago. Yet, overshadowed by growth strategies and strict regulations, climate issues still take a back seat in this race for innovation. Auto-manufacturers are finding it fairly easy to adapt to incentive and regulation-based policies and continue to focus their sales strategies on images of power.

THE OBSERVATORY'S LENS

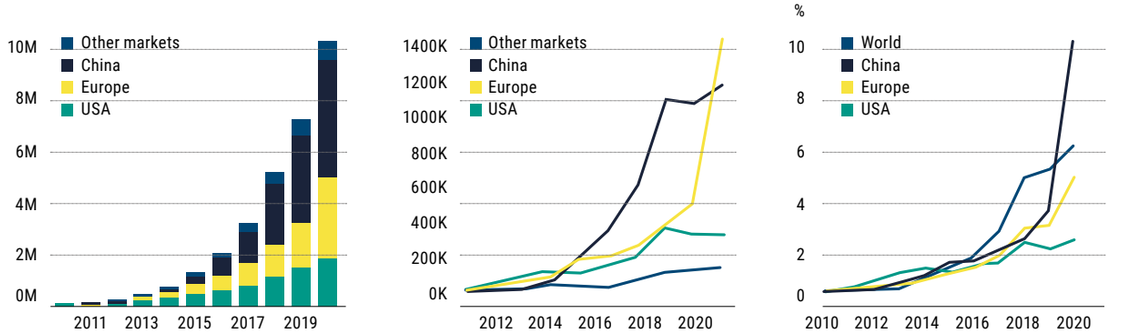
Accelerated electrification of the automarket: a winning hand for carmakers but not for climate

Along with the reduced cost of batteries (-13% in 2020),[13] the growth of electric car sales despite a flagging automobile market is largely thanks to policy support from the European Union and recovery measures in China. The establishment of numerous policies to boost electric vehicles in recent years has contributed to a rapid progression in their sales. Starting

FIGURE 2

EVOLUTION OF THE FLEET (LEFT), SALES (CENTRE) AND MARKET-SHARE (RIGHT) OF ELECTRIC AND HYBRID VEHICLES

Source : Compiled by the author using IEA database.



in 2009, the Chinese government set up a programme to subsidize purchases of EVs and compensate their high price compared to internal combustion engine vehicles. The cost of these subsidies is extremely high, and China was due to bring the programme to an end in 2020.[14] Yet, faced with a sharp drop in sales in the first half of 2020 (-42%), the country decided to extend the subsidies until 2022 to support the sector during the pandemic. These support measures will be progressively reduced and then replaced by a mandate applied to carmakers, obliging them to improve the energy efficiency of EVs and imposing a percentage of EV sales. The aim of this roadmap is that EVs will constitute a 20% market share by 2025.[15]

On the European market, recovery plans have been set up to support the sector, and in 2020 financial aid for purchasing EVs was increased in several countries. Germany has earmarked one billion euros to extend its financial aid programme for purchases of electric vehicles[16]. The French economic recovery plan devotes 1.9 billion euros to maintaining the "ecological bonus" (financial purchasing aid of up to 7,000 euros) and the conversion incentive from 2020 to 2022. The government has also set a target of creating 100,000 charging stations by the end of 2021[17]. In Italy, the budget earmarked for financial aid to purchase EVs was increased by 500 million euros in August 2020[18]. These different support mechanisms are largely responsible for record sales in the European market despite a morose economic environment (+137% over the year compared to 2019[5]).

In the United States, President Joe Biden is currently pushing for an envelope of 174 billion dollars to stimulate the adoption of electric vehicles and make up the gap with China. The programme includes tax rebates and incentives for the purchase of US-made electric vehicles, and subsidies to build a national network of 500,000 charging stations by 2030.[19] In an executive order signed at the White House in early August 2021 in the presence of US automobile manufacturers, Joe Biden established a non-binding target of increasing the share of electric vehicles to 50% of sales by 2030.[20]

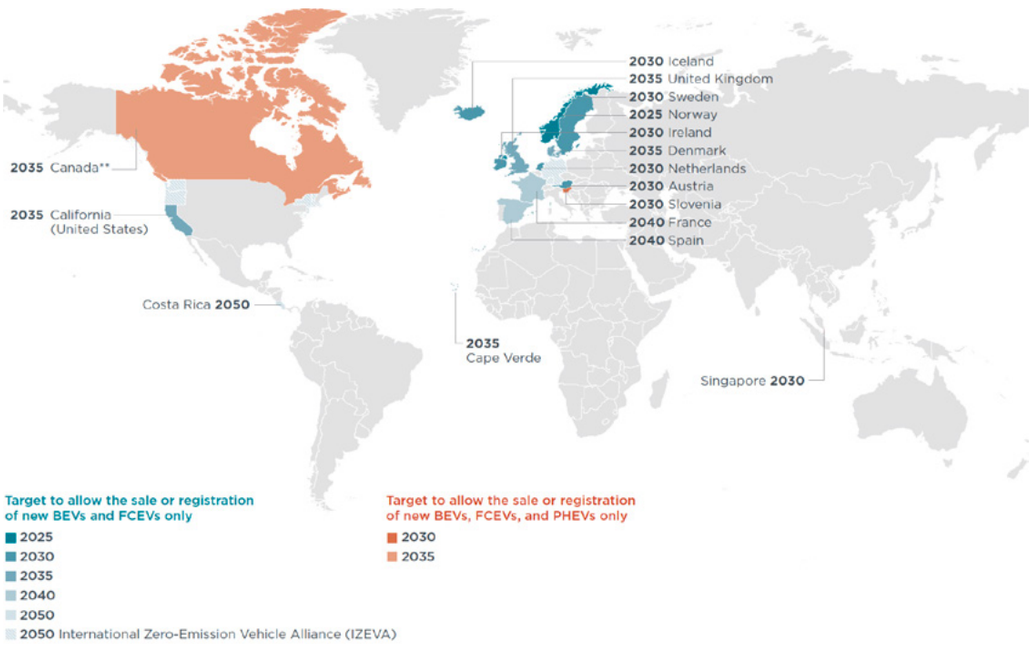
Beyond these incentive mechanisms, an increasing number of regulatory instruments are devised to encourage carmakers and consumers to make low carbon choices. More and more countries are setting objectives to phase out sales of internal combustion engine cars, sending out a clear message to consumers and automobile manufacturers. While most of these countries are in Europe, Cabo Verde is aiming to prohibit imports of gasoline and diesel cars from 2035, and Costa Rica has set a goal of banning sales of internal combustion engine cars within 30 years (**fig. 3**). In July 2021, the European Commission proposed prohibiting sales of gasoline and diesel cars by 2035.[21]

At the local level, sub-national states and regions continue to develop coherent policies to support electric vehicles: in California, the decree issued by Governor Gavin Newsom in September 2020 establishes an objective of 100% sales of "zero emission" vehicles by 2035.[22] Prior to this objective, California had already adopted a Zero Emission Vehicle (ZEV) programme, which obliges car manufacturers to sell a specific number of electric or plug-in hybrid electric vehicles every year and gradually increase their share. To date, nine other federal states (Connecticut, Maine, Maryland, Massachusetts,

FIGURE 3

NATIONAL AND LOCAL GOVERNMENTS WITH A TARGET TO BAN SALES OF INTERNAL COMBUSTION ENGINE CARS

Source : ICCT, 2020



New York, New Jersey, Oregon, Rhode Island, and Vermont) have adopted regulatory policies along the same lines.[23] Massachusetts, for example, has committed to ban sales of new internal combustion engine cars by 2035.[24] Several states have also created financial incentives, like Colorado, which offers a tax credit of 4,000 US dollars for the purchase of an electric vehicle, or Connecticut, which reduces registration fees for electric vehicles. Other incentives include tax credits for installing charging stations, subsidies for research projects, and low-carbon requirements for public vehicle fleets.[25] In France, the Bouches-du-Rhône Department offers financial aid of up to 25% of the cost of a new electric vehicle, capped at 5,000 euros and cumulable with the state ecological bonus. Six months after its launch, this measure has seen sales triple in the area. Due to its success, the programme's initial limit of covering 1,000 vehicles has been cancelled.[26] In China, the government of the Hainan province announced in 2020 that it would provide financial aid of 10,000 yuan (~€1,315) for the purchase of an electric vehicle.[27]

Cities employ various policies to encourage the adoption of electric vehicles. With the goal of reducing air pollution, big Chinese cities like Zhengzhou, Chongqing, Shenzhen and Guangzhou have set up their own subsidies for electric vehicle purchases. At least ten Chinese cities impose traffic restrictions from which electric vehicles are exempt.[28] To cushion the impacts of the pandemic on the automobile sector, some Chinese cities eased restrictions for purchasing vehicles in the second quarter of 2020. The combination of these local measures was the main driver of growth of EV sales in 2020 in China.[27] Cities also play a key role in the deployment of charging facilities: Berne, Liège and Tampere have introduced new subsidies to accelerate the creation of stations, and Malaga is installing stations in all of its municipal parking lots.[29]

In its analysis of the 22 metropolitan regions in Europe with the fastest progression in new electric vehicle registrations, the International Council on Clean Transportation (ICCT) underlines the role of coercive measures: half of these cities have created low emission zones (LEZ), and several are planning to introduce zero emission zones (ZEZ),[29] thus encouraging electric vehicles. On a global scale, REN21 lists over 225 cities that have at least partially restricted the circulation of internal combustion engine vehicles, and six that have adopted ZEZs.[9] Bergen, in Norway, also intends to create a ZEZ in 2023. The city of Lausanne recently committed to abolish internal combustion engine vehicles from its streets by 2030.[30] These restrictive measures are largely supported by urban residents: a survey of the inhabitants of 15 major cities in Western Europe showed that almost two-thirds of them were favorable to prohibiting sales of new gasoline and diesel cars in Europe after 2030.[31]

In contrast to these measures to support EVs, sometimes local governments create obstacles instead. In 28 US states, the registration fees for an electric vehicle are higher than for combustion engine cars, and 17 states have banned Tesla and other manufacturers from directly selling their cars to private individuals. The residents of these states have to pick up their electric vehicle from another state or have it delivered by a third party.[32] In Texas, a bill is under examination that aims at taxing the owners of electric vehicles, based on the justification that they do not pay the gasoline taxes that feed into the budget for investment in highway infrastructure.[33]

For car manufacturers, electrification makes it easier to respect emissions standards

The European regulation aimed at reducing CO_2 emissions from new cars came into force on 1 January 2020 (EU regulation 2019/631[34]). Rather than imposing sales targets for electric vehicles, it sets a limit of 95 gCO_2/km for emissions from all new vehicles sold from 2021 onwards. That means that the average emissions from all of the vehicles commercialized by an individual carmaker over one year must be lower than 95 gCO_2/km. As a result, it is always possible to produce and sell a vehicle that exceeds that limit, provided that the sale is compensated by a vehicle with lower emissions.

This regulation does, however, provide for "compliance mechanisms" aimed to help carmakers to reach their targets. Manufacturers can form a group, like Fiat-Chrysler which has got together with Tesla to reduce its average emissions, in exchange for a payment of 1.8 billion euros over three years. In addition, the emissions limit takes the mass of cars into account, making it possible to relax the CO_2 target for manufacturers that sell heavier-than-average vehicles, which gives them no incentive to reduce the weight. A bonus system is also applied to electric vehicles, which are counted several times in the average emissions calculations, thus making the emissions limit more flexible (1 EV counted for 2 vehicles in 2020, and 1.67 in 2021). Lastly, automobile manufacturers can win eco-innovation CO_2 bonuses by equipping their vehicles with innovative technologies.[35] Depending on these different adjustments, the emissions limit granted to an individual manufacturer by the EU can be significantly different: for example, it was 103 gCO_2/km for BMW in 2021.[36]

In 2019, manufacturers were still far from reaching their respective targets: average emissions had even gone up by 1 gCO_2/ km to reach 122 gCO_2/km, with wide disparities between carmakers. At that point, the Toyota-Mazda group boasted the lowest emissions per kilometre[37] and was the closest to its targets for 2021, although it had not reached them (**fig. 4**). But thanks to increased sales of electric vehicles in Europe, the average emissions of all manufacturers combined nevertheless dropped considerably in 2020 (for the first time since 2016), reaching 108 gCO_2/km.[38] With the help of compliance mechanisms, derogations and bonuses established by the European standard, the average had decreased to 96 gCO_2/km, and nine manufacturers out of ten (96% of the European market) had managed to reach their emissions targets. Excluding compliance mechanisms, only Volkswagen missed its target, by about 1 gCO_2/km, while the PSA group obtained the best average score (97 gCO_2/km).

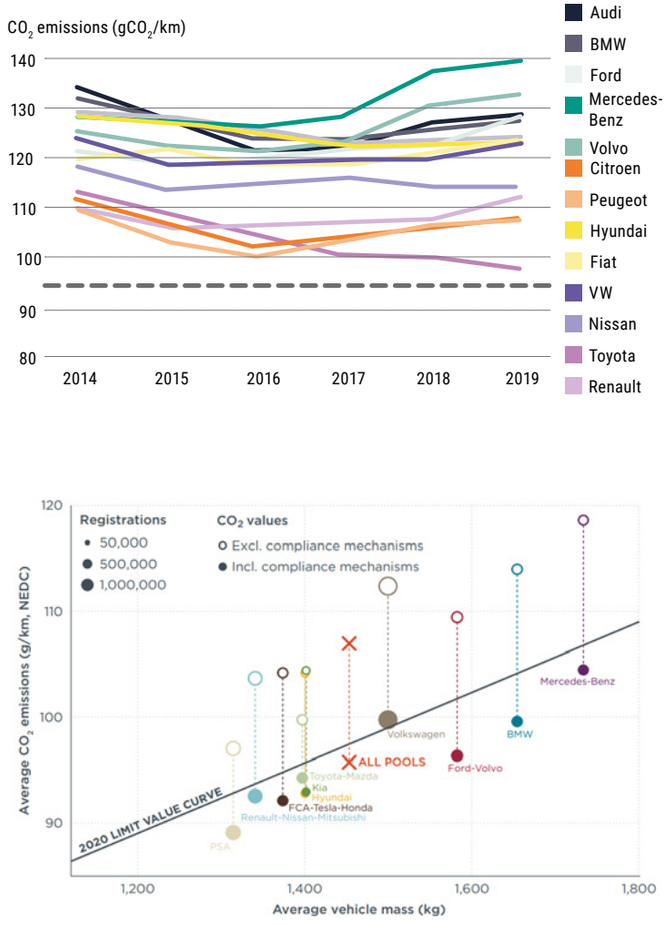
Not taking into account the compliance mechanisms, the figures clearly illustrate a shift, given that average emissions increased by 0.7 gCO_2/km per year from 2015 and 2019. For the first time in five years, electrification has therefore made it possible to reduce the average emissions of European

automobile sales. We can also see a fairly strong correlation between the weight of the vehicles put on the market by manufacturers and average emissions; the lightest vehicle manufacturers perform better than heavy vehicle manufacturers (**fig. 4**).[39] Nevertheless, it should not be forgotten that these figures were measured using New European Driving Cycle (NEDC) protocol, and as "Dieselgate" has shown, laboratory testing conditions for emissions can produce widely different results from real vehicle use on the road (up to 50% in 2020 according to T&E[40]). The data obtained with the new Worldwide Harmonized Light Vehicles Test Procedures (WLTP) international standard applied since 2021 could prove less advantageous to manufacturers.

FIGURE 4

CO_2 EMISSIONS PER MANUFACTURER IN THE EUROPEAN MARKET FROM 2014 TO 2019 (TOP), AND BY MANUFACTURER GROUPING IN 2020 (BOTTOM)

Source : Compiled by the author using data from ICCT, 2021



To meet with these standards, manufacturers have largely moved towards making electric motors. Battery electric vehicles (BEVs) already represented a significant share of the market in 2019 for some carmakers like Nissan and Hyundai (7% and 5% respectively in Europe – **fig. 5**). The trend accelerated in 2020 with the launch of 65 EV models on the European market, including 35 with all-electric motors (not hybrids).[41] Around one hundred new models have been announced for 2021[42] and registrations of EVs are rising steadily in Europe. In a single year, the market share of BEVs more than doubled, going from 3.5% in the second quarter of 2020 to 7.5% in 2021. Sales of plug-in hybrid electric vehicles (PHEVs) have done even better, with an 8.4% share of the market, representing more than half of all electric vehicle sales.[43]

PHEV sales have risen sharply, spurred on by manufacturers like Volvo and BMW, which have given these vehicles a central place in their strategy to conform with CO_2 standards. In 2019, they thus represented 8% of sales for Volvo (**fig. 5**), which had not yet launched an all-electric model. PHEV technology is well-suited to the vehicle ranges of these manufacturers with larger cars capable of housing both a combustion engine and an electric system. They are also favored by the super credit mechanism: when a PHEV sale takes place, it is counted twice, in the same way as a battery vehicle, allowing the manufacturer to bring down its average emissions score. However, the NGO Transport & Environment has issued a warning about the performances of these vehicles: the low-capacity batteries and the lack of fast charging makes 100% electric usage difficult, so that the real emissions are on average two to four times higher than announced by the manufacturers. According to the NGO, in their current state, sales of PHEVs are simply a compliance tactic that has no real impact on reducing CO_2 emissions from road transport.[44] Volvo recently changed its strategy: following the launch of its first BEV in 2020,[45] the manufacturer has committed to only commercializing battery vehicles by 2030 (**tab. 1**).

TABLE 1

MANUFACTURERS' PUBLIC TARGETS (JUNE 2021)

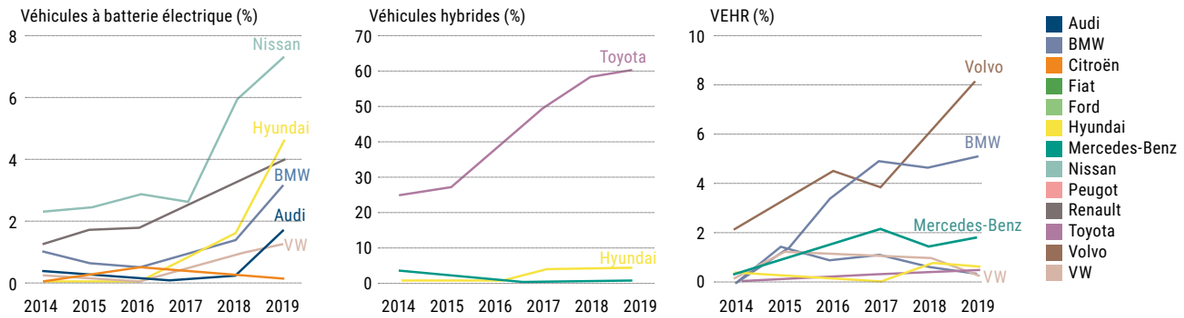
Source: Transport & Environment, 2021

ORIGINAL EQUIPMENT MANUFACTURER	2025 SALES	2030 SALES
BMW	33% BEV+PHEV	50% BEV/Mini Brand: 100%
DAIMLER	Up to 25% BEV	50% BEV + PHEV
FORD		100% BEV
HYUNDAI-KIA	Kia Brand: 20% BEV	Whole group: 25% BEV
JLR	Jaguar Brand: 100% BEV	Land Rover Brand: 25% BEV
RENAULT	Renault Brand: 30% BEV	Renault Brand: 90% BEV + PHEV
STELLANTIS	38% BEV + PHEV	70% BEV + PHEV/ Fiat Brand: 100% BEV
TOYOTA	10% BEV + FCEV	
VOLVO CARS	50% BEV + 50% PHEV	100% BEV
VOLKSWAGEN	20% BEV	Group: 60% BEV/VW Brand: 70% BEV

FIGURE 5

MOTORIZATION BY MANUFACTURER ON THE EUROPEAN MARKET (2014–2019)

Source : Compiled by the author using ICCT, 2021



Electric or internal combustion, cars are prey to notions of power

The Chinese carmaker Chongqing Changan was the first to announce, back in 2017, that it would stop manufacturing internal combustion engine cars before 2025.[46] Since then, numerous international auto manufacturers have committed to increasing the share of BEVs in their sales (**tab. 1**) with multiple announcements of investments in the production of electric vehicles. BMW has set a target of 50% of electric cars by 2030, and Mini will be 100% electric in 2030.[47] Renault, for which BEVs represented 12.7% of sales in 2020, aims at 90% electric vehicle production by 2030.[48] A production site with an annual capacity of 9 GWh of batteries will see the day in northern France in 2022 to produce the future electric *R5*.[49] The British group Jaguar Land Rover (JLR) has revealed a radical plan to enter into the electric vehicle market. Its strategy involves progressively abandoning diesel from 2026 and transforming Jaguar into a 100% electric brand by 2025. The group hopes to make 60% of its sales from "zero-emission" vehicles by 2030. To achieve this figure, it intends to invest £2.5 billion a year in developing electric and connectivity technologies for its cars. In 2020, JLR had to pay a £35 million fine for failing to meet with its EU emissions targets.[50] Volkswagen intends to make 60% of its European sales electric by 2030 and anticipates producing 240 GWh of batteries in six "gigafactories".[51] General Motors has announced the electrification of its entire range by 2035 and is set to invest $27 billion in electric and autonomous vehicles over the next five years. The US manufacturer has set itself a considerable challenge: electric vehicles only represented 0.8% of its domestic sales in 2020.[52] Announcements from actors in the sector are at times more ambitious than national objectives, going further for example, than France and Spain, which anticipate the end of internal combustion engines by 2040 (**fig. 3**). In total, the cumulative announcements made by car manufacturers amount to investments of about $345 billion.[53]

Lastly, of the main manufacturers, only Toyota, the largest automotive manufacturer by volume,[54] has not presented a clear vision in terms of BEVs. The entire strategy of the Japanese carmaker is currently based on hybrid cars (which represented 60% of its European sales in 2019 – **fig. 5**) and to a lesser extent on fuel-cell electric vehicles (FCEV) powered by hydrogen (**see Tokyo case study**). Despite its recent announcement of the launch of a BEV range,[55] deployment is proving slow. For Transport & Environment, the facts are obvious: "*Toyota has slipped from the leading green car company 10 years ago to being the least prepared for the electrification revolution that is underway.*" [56]

In its analysis of climate action undertaken by the 30 most influential car manufacturers, the World Benchmarking Alliance regrets manufacturers' lack of commitment to positive legislation on climate.[57] In March 2020, at the peak of the Covid-19 crisis in Europe, lobby groups from the European automotive industry even wrote to the president of the European Commission, Ursula von der Leyen, calling for less stringent objectives to reduce CO_2 emissions in the sector.[58]

The World Benchmarking Alliance also observes that the automobile industry makes insufficient efforts to guide consumers towards choosing low-emission vehicles. Higher prices and difficulties accessing charging stations still hold many consumers back, yet manufacturers could help remove these obstacles by making investments and changing the direction of their marketing strategies.[56] Marketing budgets still mostly focus on the heaviest vehicles. In France, the car industry devoted €1.8 billion to promoting SUVs in 2019, which was 42% of its advertising expenditure.[59] Advertising campaigns to launch the Subaru *Ascent* 2021, the manufacturer's biggest SUV to date, put the accent on the vehicle's enormous size.[60] In New Zealand, Ford spends 85% of its marketing budget on pickups, and 8 out of 10 cars sold in the country are SUVs.[61] Globally, it was not just electric vehicles that saw their sales go up in 2020 – SUVs also did well: for the first time, one car in two sold in the United States is now an SUV.[62] In Europe, SUV sales have also broken records, with a 44% market share in January 2021, its highest level following 40% in January 2020.[63]

The electric vehicle market does not escape from being associated with an image of power. While it was initially embodied by compact city cars that are still popular, like

Renault's *Zoe* and Nissan's *Leaf*, the EV market has taken advantage of its expansion to extend its ranges to include heavier, more voluminous models. Based on figures published by Clean Technica on the twenty best-selling electric vehicles in the world (BEV + PHEV), the Climate Chance Observatory calculated that 63.4% of electric sales are SUVs or sedans.[64] EVs also constitute a significant share of European sales of sports cars, like Porsche (16.5%) and MG (51.2%). Because their battery makes them heavier, the average weight of an EV on the market is 1,940 kg: one-third of them are over 2,000 kg, and more than half weigh between 1,500 and 2,000 kg,[65] which is a lot heavier than the average new vehicle in France (1,240 kg[66]), and even in the United States (1,857 kg).[67] This is while the energy efficiency of an electric car tends to decrease as its weight increases.[68]

KEYS TO UNDERSTANDING

EXTENDING BATTERY LIFE AND MANAGING END OF LIFE: THE NEW CHALLENGE FOR ELECTRIC MOTORIZATION

Another symptom of the increased power of vehicles, the autonomy of some EVs is starting to match that of traditional combustion engine vehicles. The Chinese automotive manufacturer GAC has announced the wide-scale production of its next electric SUV, the *Aion XL*. It will be the first electric car to run autonomously for 1,000 km, thanks to the introduction of new silicon anode battery technology, which increases the battery's power density while reducing its weight by 14% and its volume by 20%. Up until now, *Tesla S Long-range* held the autonomy record with 652 km.[69] On average, the autonomy of electric vehicles is around 350 km, which is 2.3 times more than in 2015.[28]

The manufacture of these batteries, which are complex alloys of critical metals, and the management of their end of life – in other words recycling the battery components – are two concerns that frequently oppose the development of EVs. In addition, the shortage of semi-conductors and the inflation of metal prices that have struck the globe since late 2020 underline the fragility of supply chains of electronic materials, in a world where the digital shift and the ecological transition have become interdependent[b]. During the last year, manufacturers have responded with a concentration and vertical integration of value chains, by bringing the automobile industry closer to the electronic industry. Reinhard Ploss, CEO of Infineon, the biggest European producer of semi-conductors, has even called on car manufacturers to drop the "just-in-time" management model promoted by Toyotism[c] in order to better plan their supplies.[70] Tesla has announced that it is prepared to make advance purchases of its electronic chips and is researching the production of its own batteries,[71] while at the other end of the chain, the Chinese electronics giant Foxconn, best known for producing *iPhones* in its factories in Shenzhen, is entering the automobile chassis production market for electric vehicles.[72] Volvo has also launched a joint venture with the Swedish start-up Northovolt to open a "gigafactory" with an annual production capacity of 50 GWh, which is enough batteries for 500,000 vehicles,[73] while Mobilize, the Renault subsidiary that specializes in electric hire cars (like *Twizy*), has signed a partnership with the German start-up Betteries, which will recuperate batteries from the cars and make them into mobile electric generators.[74]

KEY TAKEAWAYS

Electric vehicles have largely benefited from the reorganization of the automotive market, prompted by recovery plans, urban policies, and the strategies of car manufacturers waging on electrification and the programmed demise of internal combustion engine cars. Some manufacturers have even announced a move to all-electric that outpaces the strategies established by States.

Boosted by its new emissions standards, Europe has outstripped China as the leading global market for electric cars, while the trend is struggling to take hold in the United States. However, the existing fleet is still largely dominated by combustion engine cars, and electrification is only a drop in the ocean compared to another strong trend in the sector: almost one vehicle in two sold in the world today is an SUV, and the growth of their sales constituted the second source of increased GHG emissions before the pandemic, according to the IEA.

b For example, in its communication on the EU Green Deal, the European Commission talks of the *"twin challenge of the green the digital transformation"*.

c "Toyotism" designates a "lean" method for managing production lines, involving no stock and thus calling for very fast reactions from all stakeholders in the value chain. Initially employed by Toyota, this form of production organization was widely adopted by the entire automotive industry. "Just in time" is one of its components and involves synchronizing the supply of parts with the pace of production.

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TREND AVIATION

Between the Health Crisis and the Need to Decarbonise, the Aviation Sector is Caught in Turbulence

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The crisis that the aviation sector has been experiencing for over a year and a half is unprecedented. Hard hit by the pandemic and strongly criticised for its responsibility in terms of climate change, aviation is now struggling to recover. Although "zero carbon" commitments towards zero-carbon have increased, lack of political and financial support for decarbonisation of the sector, as well as the delay in setting up the CORSIA system, appear to be missed opportunities, confirming the weaknesses of the sector.

DATA OVERVIEW

2020, "the worst year in the history" of air traffic

Over the past two decades, aviation emissions have been rising steadily. In 2019, the sector emitted 905 million tonnes of CO_2 ($MtCO_2$), or more than 2% of global CO_2 emissions.[1] Taking into account all gases and the still uncertain effect of contrails, the sector's total contribution to radiative forcing[a] would actually be two to three times higher than the calculation considering only CO_2.[2]

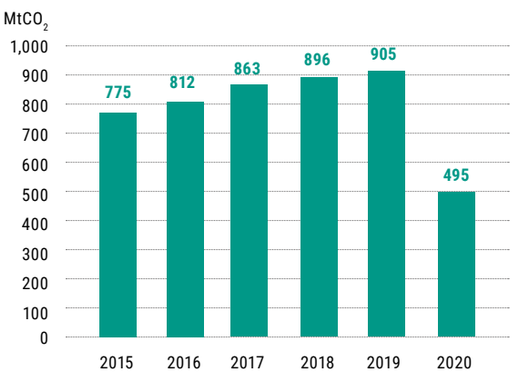
While an exponential growth in traffic and a tripling of emissions were expected by 2050,[3] the Covid-19 epidemic has cut the aviation sector off. Grounded by lockdowns all over the world, the number of passengers has fallen by 60% compared to 2019, i.e., a drop of more than 2.7 billion people. The International Air Transport Association (IATA)[b], calls 2020 *"the worst year in the history of air travel demand"*.[4]

International travel has been the most heavily affected by the crisis. While international air passenger traffic fell by 74% over the year as a whole (peaking at 98% in April 2020), the impact on domestic flights was "only" 49% (87% in April 2020). The Asia-Pacific region, which accounted for 34.7% of global traffic in 2019,[5] was the hardest hit, with traffic falling by 80.3% over the year, ahead of North America (-75.4%), Europe (-73.7%) and the Middle East (72.9%).[6] Aircraft have been grounded and are no longer using fuel: aviation bunker[c] has decreased by 45%,[7] with emissions falling by 45% compared to 2019, i.e. 410 million tonnes of CO_2 less (**fig. 1**).[8] The IATA initially expected emissions to rise by 2.3% that year.[9]

FIGURE 1

GREENHOUSE GAS EMISSION TRENDS IN THE AVIATION SECTOR

Source : IATA, 2021



a Radiative forcing is the change in energy at the top of the atmosphere due to an external agent (e.g. a greenhouse gas). A positive radiative forcing means an increase in the amount of energy entering the atmosphere, and can therefore lead to its warming.

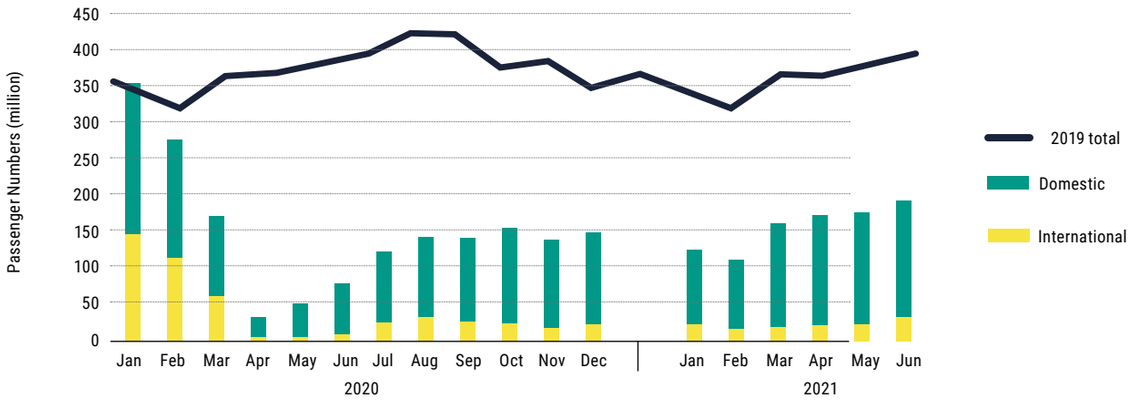
b IATA represents 290 commercial airlines and 82% of global traffic.

c The term "aviation bunker" refers to the energy consumption of aircraft.

FIGURE 2

EVOLUTION OF DOMESTIC AND INTERNATIONAL PASSENGER NUMBERS AT THE GLOBAL LEVEL

Source : IATA, 2021



Manufacturers have also been hit hard by the pandemic. Boeing's order books showed a negative balance of 1,026 aircraft in 2020: in other words, the American giant received more order cancellations than purchase orders. Airbus was less heavily affected but still only recorded orders for 268 new aircraft over the year, whereas this figure had been fluctuating between 700 and 1,000 in recent years.[10]

After the peak in April 2020, the sector showed a tentative recovery, with domestic flights picking up faster than international flights (**fig. 2**). However, traffic has still not regained its pre-crisis levels: the total demand for flights in June 2021 (measured in Revenue Passenger Kilometres, RPK) was still 60.1% less than in June 2019.[11] The IATA does not expect a return to pre-Covid passenger numbers before 2024 at least.[12]

Two notable exceptions are private jet travel and freight, which have been much less affected by the crisis. In a recent study, the NGO Transport & Environment (T&E) revealed that CO_2 emissions from these flights have risen sharply, by 31% between 2005 and 2019. The Covid-19 halt was short-lived: by August 2020, private jet traffic had returned to pre-pandemic levels.[13] Despite the fact that it was at its lowest point in 2020, air freight also rebounded strongly, reaching an all-time high in March 2021, with demand up by 4.4% from the pre-Covid level.[14] However, this represents only a tiny fraction (less than 1%) of global freight.[15]

Thus, while waiting for better days, airlines and manufacturers are trying to organize their resilience and meet the climate requirements enacted by the States and demanded by civil society. However, the CORSIA emissions offsetting program has also been weakened by the pandemic, and now seems to be at a standstill. Sometimes helped (or even forced) by public authorities, companies are hinging their economic and climate survival on one last asset: technological innovation.

THE OBSERVATORY'S LENS

The Future of Aviation: the great leap forward

CORSIA, a floundering international framework for offsetting emissions

In order to *"achieve carbon-neutral growth from 2020 and reduce its carbon emissions by 50% compared to 2005 levels"*[d] the international civil aviation sector has been organised around CORSIA since 2016, an emissions offsetting programme set up by the International Civil Aviation Organization (ICAO; **see Keys to Understanding**).

Since its creation, the CORSIA programme has struggled to respond to questions and criticisms about its real capacity to drive the sector's transition. An initial concern was that the number of carbon credits available to offset the sector's additional emissions could exceed demand, if the age of credits and voluntary offset programmes were not restricted. With supply exceeding demand, the cost of credits would not have created sufficient financial pressure for companies to prioritize investments to reduce their emissions. In March 2020, the ICAO Council agreed on two rules in this regard. On the one hand, only credits from six out of fourteen applicant Emission Reduction Certification Bodies qualified for the programme,[e] following the criteria set by the ICAO Technical Advisory Board (TAB). On the other hand, it introduced a «vintage restriction», prohibiting the use of credits related to projects that started before 1 January 2016. These decisions reduce the risk of offsetting abuses on dated projects, but still maintain the supply of credits at a level well above the demand for the pilot phase, according to the NGO Carbon Market Watch.[16] In particular, the inclusion of billions of credits available

d As stated by ICAO in the resolution adopted at its 39th Session in October 2016, thereby creating the CORSIA programme.

e These six programmes are: American Carbon Registry, China GHG Voluntary Emission Reduction Program, Clean Development Mechanism, Climate Action Reserve, The Gold Standard and Verified Carbon Standard.

under the Kyoto Protocol's Clean Development Mechanism (CDM) would be sufficient to cover demand, without offering any guarantee of additionality, i.e. real additional emission reductions enabled by the certification and purchase of carbon credits. This, combined with the low price of carbon credits internationally, would mean that airlines would lack incentives to find alternatives to decarbonise the sector or reduce their emissions.

Another concern is the timing of the programme. The voluntary phase ending in 2026 will only require offsetting on flights between two voluntary countries, reducing its scope to around 44% of total international aviation emissions[17]. As of July 2021, sixteen new countries have declared their participation in the voluntary programme from 2022, but China, Russia, Brazil and India are still among the notable absentees.[18]

Finally, there is a significant risk of double-counting emissions reductions if countries transferring credits to airlines do not make a "corresponding adjustment" to remove from their carbon balance the benefit of the emissions reduction enabled by the project that has been certified. The requirement to make such adjustments remains one of the biggest sticking points in the negotiations on the rules for implementing the Paris Agreement's Article 6 on "transferred mitigation outcomes".

The European Commission is particularly concerned about the risk of double counting. Since 2009, international flights within the European Economic Area (EEA) have been covered by the EU Emissions Trading Scheme (EU ETS). But in an October 2019 resolution, the ICAO stated that CORSIA "should be the only market-based measure applied to international flights".[19] However, a study directed by the Commission, which has not been published but was obtained and circulated by

KEYS TO UNDERSTANDING

CORSIA, THE CORNERSTONE OF INTERNATIONAL AVIATION'S CLIMATE STRATEGY

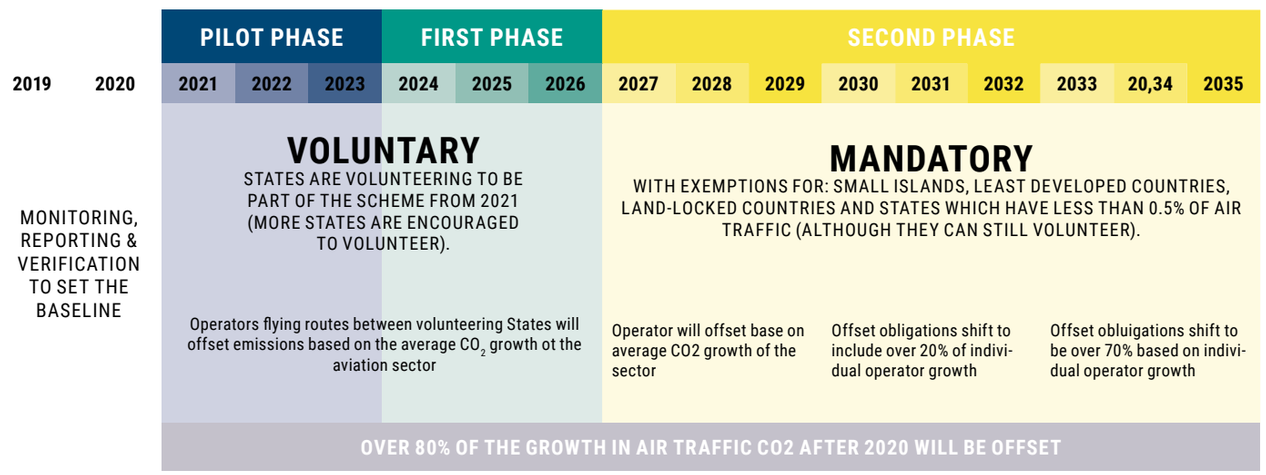
In 2015, international flights, which account for about 65% of the aviation sector's CO_2 emissions, were excluded from the scope of the Paris Agreement. Only emissions from domestic aviation (domestic flights, non-flight related airport operations, etc.) are subject to specific national measures and fall within the scope of the United Nations Framework Convention on Climate Change (UNFCCC). Today, however, only 5% of Nationally Determined Contributions (NDCs) that explicitly designate transport modes had identified aviation as a carbon mitigation sector. Against this backdrop, the International Civil Aviation Organization (ICAO), a UN agency created by the Chicago Convention in 1944, voted in 2016 to create the Carbon Offsetting Scheme for International Aviation (CORSIA), a programme that will provide for the offsetting of any annual increase in CO_2 emissions from international civil aviation above the average emissions that the sector will achieve between 2019 and 2020. Airlines will be required to purchase carbon credits on ICAO-recognised offset markets. The programme is broken down into three main implementation phases: the pilot phase (2021-2023) and the first phase (2024-2026) are voluntary, and it is only from the second phase (2027) onwards that the programme becomes mandatory (**fig. 3**). The pilot phase of the programme was launched on 1 January 2021, during which participating airlines will only have to compensate flights between countries that have volunteered to test the programme. More than 100 of ICAO's 193 member countries are participating, representing 76% of international activity. From 2027 onwards, the offsetting obligations will become mandatory for all international flights. In 2019 ICAO recalled in its resolution A40-18 that its permanent policy in the field of environmental protection also sets the objective of a 2% annual improvement in fuel efficiency from 2021 to 2050 and recalls in its recitals that IATA, along with other aviation industry federations, had committed at COP15 in Copenhagen (2009) to reduce their emissions by 50% in 2050 compared to 2005.

Source: PPMC, SLOCAT, 2016

FIGURE 3

IMPLEMENTATION OF THE CORSIA SYSTEM

Source : Aviation Benefits Beyond Borders, 2021



T&E[20] in March 2021, finds that none of the offsetting bodies and programmes selected by the ICAO provide sufficient measures against double counting. The study also points out that the CDM, CCER and Gold Standard programmes do not meet the additionality criterion, and that the number of credits available for the entire duration of the programme remains three times higher than the demand.[21] In December 2020, 33 NGOs called on the European Commission to take additional measures to regulate the sector, pointing out that non-CO_2 impacts (including contrail-induced cirrus clouds and NO_x) are not included in national inventories submitted to the UNFCCC, nor in the CORSIA system, nor in the EU ETS.[22]

The Covid-19 pandemic and its impact on air traffic did not help the situation. Due to the decrease in emissions during the first lockdown period, the ICAO Council decided on 30 June 2020 to activate a safeguard clause in the CORSIA agreement to change the baseline of the offset programme. Instead of the average of the sector's emissions in 2019 and 2020, airlines will now only have to offset the emissions produced beyond the level of 2019 alone. Without this decision, air operators would have been forced to offset a higher volume of emissions, an *"inappropriate economic burden"* in the eyes of the ICAO.[23] This decision delays the actual entry into the programme by three years, since with emissions levels below those of the base year, volunteer airlines will theoretically have no reason to offset additional emissions throughout the pilot phase.[24]

To inform carbon purchase decisions, the IATA launched the Aviation Carbon Exchange in late 2020, an electronic platform through which airlines can identify, select and trade voluntary and CORSIA-eligible emissions units.[25] JetBlue, a US low-cost 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.[26]

Major airlines around the world have added voluntary offset programmes to this system, several of which began in 2020. British Airways and Air France have committed to offsetting the emissions of all their domestic flights by investing in forestry projects from 2020, while Qantas rewards customers who agree to 'offset' their flights with loyalty points. However, in May 2021, an investigation published by Unearthed[f] and The Guardian showed how, in a selection of offset projects aimed at reducing deforestation, financed by British airlines and certified by Verra, the world's largest provider of carbon credits, the methodologies used did not allow for the conclusion of real reductions in CO_2 emissions.[27] In particular, the notion of "avoided deforestation", measured arbitrarily by the certifying body without any oversight from an independent central authority, was questioned.

Aviation taxation takes off with carbon neutrality on the horizon

This criticism cannot be ignored by governments, and several of them have already begun to develop taxes to incentivize the sector decarbonize, outside the context of the pandemic. In proposing a revision of the Energy Tax Directive as part of its 'Fit for 55' plan, the European Commission has aligned itself with a position defended by nine Member States since 2019: to put an end to the exemption and introduce a minimum tax threshold on aviation fuels.[28] The proposal is limited to intra-European flights, due to the 5,000 or so bilateral air services agreements signed between States which could be an obstacle to the uniform application of this tax to international journeys.[g]

Since January 2020, airlines have been paying a "green contribution" of between €1.50 and €18 on each ticket for flights departing from France.[29] This is already the case in six European countries (Germany, Austria, Italy, Norway, Sweden and the United Kingdom): in the UK it can be as high as €82 for the longest flights. The Netherlands also now applies a €7.45 tax to passengers departing from its airports. Switzerland has also introduced an incentive tax on airline tickets, which will vary between 30 and 120 Swiss francs (CHF) depending on the class of transport and the distance travelled,[30] as well as a tax on private and business flights, which will vary between 500 and 3,000 CHF depending on the duration of the flight.[h]

With the aim of reducing emissions from the sector, several states have voted to restrict air traffic. In April 2021, France, for example, voted to ban internal flights for which there is a train alternative of less than two and a half hours' duration, as part of its new "climate law".[31] In Austria, the €600 million bailout of Austrian Airlines was accompanied by the abolition of the Vienna-Salzburg route, compensated by an increase in ÖBB's rail services between the Vienna airport and the centre of Salzburg.[32]

At the same time, a lot of states have provided emergency aid to the aviation sector, whether through loans, rescue funds or tax relief, without binding climate or environmental conditions.[33] Germany, for example, released more than nine billion euros for Lufthansa, and granted a 550 million euro loan to Condor, with no mention of environmental conditions.[34] The same is true of Switzerland, which released CHF 1.275 billion for the airlines Swiss International and Edelweiss, with no explicit environmental requirements.[35]

The same is true of the stimulus packages. In the United States, eight billion dollars will be injected into airports to revive the sector and deal with the debts accumulated during

f Unearthed is a Greenpeace news initiative.

g Contrary to popular belief, the Chicago Convention does not prevent the taxation of kerosene. Such a tax would indeed be beyond the scope of its Article 15, which only stipulates that "*no fees, dues or other charges shall be imposed by any Contracting State in respect solely of the right of transit or entry into or exit from its territory of any aircraft of a Contracting State, or persons or property thereon.*" In Europe, neither the Energy Tax Directive nor bilateral conventions formally prohibit states from introducing such a tax in their country. See: Faber, J., O'Leary (2018). Taxing aviation fuels in the EU. *CE Delft*

h Equivalent to around €462 and €2,772 in July 2021. The tax will be levied directly on airlines: half of the proceeds will be redistributed to the public, and the other half will go to the Climate Fund.

the crisis, and $14 billion will be granted to airlines, without any environmental conditions.[36] Within ASEAN, ten of the 66 scheduled airlines in the ten member countries have received a total of $4 billion in combined bridge loans, soft loans and tax relief. There were no climate or environmental conditions attached to these loans. Four of these airlines have published sustainability reports mentioning the IATA's climate targets, without setting any targets of their own, with the exception of Singapore Airlines, which is focusing on reducing electricity consumption and increasing the use of solar power for its buildings.[37]

The French government is an exception, having announced the implementation of a 15 billion euro recovery plan for the aviation industry, of which 1.5 billion will be dedicated to research and development with three objectives: changing fuel, optimising trajectories and also reducing fuel consumption.[38] The United Kingdom government, in its Transport Decarbonisation Plan, has set a target of carbon neutrality for the sector by 2050, and possibly 2040 for domestic flights.[39] Three million pounds (~€3.5 million) will be made available between 2021 and 2022 for the Zero Emission Flight Infrastructure programme, a further £3 million to enable the UK to certify new sustainable aviation fuels, and £15 million to encourage the development of alternative fuels with the Green Fuels, Green Skies competition. These are paltry sums compared to the seven billion in annual subsidies that the sector receives.[40]

Despite the pandemic, many airport and terminal projects have been completed. Examples include Berlin Brandenburg Airport,[41] the new terminal at Bermuda L.F. Wade International which opened last December[42], Bahrain International Airport[43] and Batumi in Georgia. In France, some of the busiest airports (such as Nice, Montpellier and Lille-Lesquin) are planning to expand their infrastructure.[44] In the UK, the Supreme Court overturned a court ruling that the construction of Terminal 3 at Heathrow Airport was illegal because it did not comply with the Paris Agreement, arguing that ratification of the Agreement did not bind the government in this case.[45] The closure of Bromma Airport, Sweden's third largest airport, at a time when air traffic was already falling in the country before the pandemic, is still an exception.[46]

The aeroplane of the future struggling to take off

Faced with growing pressure, the sector is increasingly formulating carbon neutrality objectives for its activities in 2050. This is particularly the case for the largest players (such as the Airlines for America association or United Airlines), aircraft manufacturers (such as Boeing) or major international airports (such as Heathrow).[47] In Sweden, the ten airports of the Swedavia company claim to be carbon neutral.[48] However, the roadmaps for achieving carbon neutrality never mention limiting traffic to achieve carbon neutrality. The Destination 2050 collective, which brings together Europe's largest airline and service provider associations, estimates that it will be able to achieve carbon neutrality by increasing traffic by about 1.4% per year.[49] Therefore, the energy transition is not taken into account outside the economic growth of the sector.

Beyond market-oriented measures, and despite the sharp drop in traffic and fuel consumption as a result of the pandemic, the Sustainable Aviation Fuel (SAF) market continues to develop, with seven biofuel streams approved by the end of the year. These fuels are standardised by the American Society for Testing and Materials (ASTM), which sets various conditions concerning the fuel, such as its composition, volatility and fluidity.[50] Since 2011 and the first flight operated by KLM, 342,256 commercial flights have flown with SAF.[51]

In 2020, many European states changed their legislation with the idea of accelerating the transition to biofuels for the aviation sector. From 2022, France will require aircraft refuelling in the country to use at least 1% "sustainable" aviation fuel, rising to 2% in 2025, 5% in 2030 and 50% in 2050. Germany has published draft legislation that would require airlines to increase non-biogenic SAF to 0.5% by 2025, 1% by 2028 and 2% by 2030. Sweden requires a reduction in emissions from aviation fuels sold in the country of 0.8% in 2021 and 27% in 2030[52]. By 2020, 45 airlines had already tried using SAF.[53]

Although the availability of SAF is increasing (a continuous supply has been established in 2020 at San Francisco International Airport and London Luton Airport),[54] its production remains marginal: 100 million litres per year, or less than 0.1% of global jet fuel consumption.[55] Two to four times more expensive than conventional fuels, SAFs suffer from a lack of competitiveness, and the Asian Development Bank estimates that their price will not be competitive until 2035.[56] The Air Transport Action Group (ATAG) itself, as coalition group including all businesses across the industry, estimates that only 2% of total aviation fuel demand will be met by SAFs in 2025.[57]

Several initiatives have been launched to accelerate their adoption, such as the Council on Sustainable Aviation Fuels Accountability (CoSAFA), created in spring 2021 by industry federations to improve reporting and accounting practices around SAFs.[58] In parallel, the world's largest airline, United Airlines, has launched the Eco-Skies Alliance, a programme through which customers and associated partners will be able to invest in SAFs.[59] Manufacturers and airlines are themselves investing in the sector.[60] The world's largest private jet company, NetJets, has taken a stake in WasteFuel, a company that converts landfill waste into SAFs.[61] The oil company Total has started to produce aviation biofuel at its French sites, investing 500 million euros in production.[62]

However, biofuel production capacity poses major challenges, such as competition with land dedicated to agriculture, but also the climate impact due to land use change.[63] In 2019 in the EU, the majority of SAFs were still produced from food products such as soy or palm oil.

Another avenue being explored by the industry is the development of electric aviation. To date, the electrification of aviation has only affected small aircraft with low transport capacity due to the limited energy capacity of batteries. With an energy density of about 250 Wh/kg for commercially available lithium-ion batteries, compared to 12,000 Wh/kg for kerosene, there is considerable scope for progress in electrifying

commercial flights.[64] Hybrid aircraft are being developed to assist combustion engines during certain phases of flight, but most of the energy is still supplied by fuel.

Finally, the aviation sector has not escaped the hydrogen fever. According to a study published by the European public-private partnership Clean Sky 2 and Fuel Cells & Hydrogen Joint Undertaking,[65] hydrogen-powered aircrafts emit no CO_2 and have a 30-50% reduction in contrail and cirrus impacts compared to kerosene-fuelled aircrafts. The study estimates that burning hydrogen could reduce climate impact by 50-75% in flight, and by 75-90% using fuel cells.[66]

Airbus has made it a key tool in its zero-emission aircraft project. Investments have increased: the investment arms of Airbus and JetBlue Airways are among the companies that have invested a total of $20.5 million in Universal Hydrogen, the Paul Eremenko-backed company developing a hydrogen distribution and storage system.[67] In parallel, British Airways and Shell Ventures have invested $24.3 million in ZeroAvia, a developer of hydrogen-powered aircraft.[68] But once again, large-scale deployment of hydrogen is reportedly slow to materialise. After announcing the commercialisation of zero-emission aircraft in 2035,[69] Airbus has stated that hydrogen will not be used on a large scale until 2050.[70]

KEY TAKEAWAYS

After suffering the worst crisis in its history, the aviation sector is facing a gradual recovery. While the pilot phase of CORSIA is being undermined by falling traffic, the sector is facing increasing pressure from civil society and some States to address the climate impact of its activities. However, few governments have attached environmental and climate conditions to their support for airlines and manufacturers, and the few public investments announced, particularly in R&D, remain relatively modest compared to the unconditional subsidies granted. Invited to transform their engines, several companies are investing directly in the development of biofuels for aviation, and even in electric technologies. But the prospect of a "green aircraft" available on an industrial scale remains distant, and international traffic regulation is not among the measures to reduce emissions.

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TREND
MARITIME

In the Midst of a Perfect Trade Storm, Shipping Companies' Climate Ambitions Remain a Dot on the Horizon

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Following heavy disruption due to the pandemic, maritime freight transport needs to keep up with the frantic recovery of international trade. This erratic economic situation highlights the difficulties faced by the sector in responding to interational agreements on reducing pollution and emissions.

DATA OVERVIEW

The global recovery in consumer demand throws maritime freight off course

Greenhouse gas (GHG) emissions from the maritime sector increased by 9.6% from 2012 to 2018, according to the fourth study by the International Maritime Organization on greenhouse gases[1]. Following a 3.7% rise between 2016 and 2017, emissions from the sector dropped slightly by 0.75% from 2017 to 2018. In 2018, total emissions from the sector (including international transport, domestic transport and fishing) amounted to slightly over 1,076 $GtCO_2e$, which is 2.86% of energy-related global emissions. 98% of these GHG emissions were carbon dioxide (CO_2). However, the study reports that from 2012 to 2018, emissions of methane (CH_4) rose sharply (+150%), while the global warming potential (GWP) of this gas is 86 times greater than that of CO_2 over 20 years. Three classes of ship alone are responsible for 55% of CO_2 emissions from the maritime sector: container ships (23%), bulk carriers (19%), and oil tankers (13 %)[2].

Globally, the maritime sector is regulated by the International Maritime Organization (IMO), a specialized United Nations agency that currently counts almost 140 member countries. Like international aviation, international maritime transport does not fall within the scope of the Paris Agreement. However, in April 2018, over one hundred states meeting at the IMO in London adopted a strategy to reduce emissions by at least 50% by 2050 compared to 2008. More precisely, the agreement establishes emissions reduction, for all international transport activities, by at least 40% by 2030 and up to 70% by 2050[3].

For years, shipping companies been claiming to have made great progress in saving energy and decreasing carbon intensity by applying various measures with an exponential impact, like reducing the cruising speed of ships[a]. Indeed, the average carbon intensity of the entire sector, whether related to ships or journeys, is currently 21~30% lower than it was in 2008, according to the IMO's Energy Efficiency Operational Indicator (EEOI). The sector also claims to be the most efficient transit method in terms of greenhouse gas emissions by volume of goods per kilometre (**fig. 1**): shipping covers about 80% of the volume and 70% of the value of international trade, but only emits 21% of the total emissions from freight. Nevertheless, most of this progress in efficiency was made prior to 2012, and the carbon intensity of activities has not decreased by more than 1% or 2% since 2015.

Due to the impact of the Covid-19 pandemic in 2020, the volume of commercial sea trade dropped by an estimated 4.1% in 2020, according to the UNCTAD Review of Maritime Transport published in November 2020[4]. This was the first decrease since

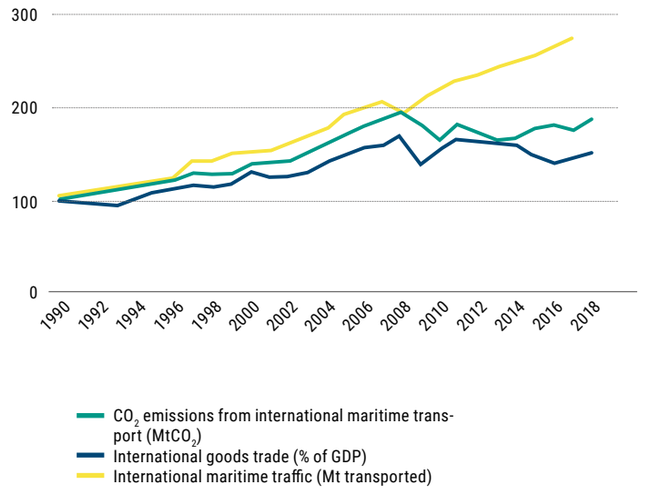
a There is in fact a cubic relationship between the reduction of a ship's speed and its fuel consumption: reducing speed by 10% brings down the required engine power by 27%. Therefore, covering an equal distance more slowly requires 19% less energy (Faber et al., 2017). Reducing speed is therefore a way for companies to decrease their emissions and save on fuel consumption. The Sector-based Report 2020 pointed out that numerous companies in the shipping sector support the proposal to make this measure compulsory, as presented to the IMO by the NGO Transport & Environment.

the financial crisis of 2008, mainly as a result of the interruption of supply chains triggered by successive lockdowns. However, figures were already pointing to a flagging shipping sector in 2019, when the growth in volumes transported slowed for the second year in a row, from 2.7% in 2018 to 0.5% in 2019. These figures are well below the average recorded from 1970 to 2017 (+3% a year). Global traffic of container ships, a key indicator of international trade performance, followed a similar decline, with growth slipping from 6.7% in 2017 to 2% in 2019[4, 5].

FIGURE 1

DECOUPLING OF EMISSIONS GROWTH AND INTERNATIONAL MARITIME TRANSPORT TRAFFIC

Source : Compiled by the author using IEA, UNCTAD and World Bank data



At the same time, the commercial vessel fleet had grown by 4.1% in 2019, primarily boosted by increased numbers of LNG carriers (+6.5%) and oil tankers (+5.8%)[4]. The sector therefore kicked off 2020 with an excess capacity for freight transport. This situation was highly detrimental to what is known as "freight rates", i.e., tariffs established by shipowners for the transport of goods: the greater the transport capacity, the lower the rates. For several years this situation had been reducing shipping companies' financial margins.

Covid-19 completely changed the situation. During spring 2020, oil tankers were called on to supplement storage capacities overflowing with excess oil supplies following reduced demand due to lockdown. This led to a spectacular increase in their freight rates, which then plummeted when the OPEC agreed to reduce its production.

Liquified Natural Gas (LNG), which at one point during the pandemic was the worst-performing energy product, went on to make up for its initial price drop with a moderate growth of 0.4% over the entire year, thanks to a pick-up in Asian demand (71% of global demand for LNG), in particular from China (+11.2%)[6]. Because it is liquified, LNG can be transported by sea, which is much more flexible than transportation through gas pipelines. The fleet of LNG carriers has therefore continued to grow (+7% in 2020) and now counts 572 ships around the world[7].

The recovery of international trade has had the biggest impact on freight transport by container ship. Demand for consumer goods and the reestablishment of production chains following the first lockdown measures led to a sudden increase in demand for maritime freight, to the point that it led to a shortage of containers in the first half of 2021, and probably longer. In fact, the problem was not so much the lack of containers as it was their unequal distribution on trade routes. Complications began when the anticipated recovery of Chinese production led to the delivery of manufactured goods (electronic, medical, etc.) ordered online during and after lockdowns in North America and Europe. Yet health restrictions imposed by China's main trade partners were still blocking their own production chains. Naturally, it was unthinkable for freight carriers to send empty containers back to China. As a result, ports in places like Los Angeles/Long Beach[8] and Auckland[9] found themselves piled up with empty containers, while ships were waiting offshore to be unloaded. In total, on 13 August 2021, 352 ships with a cumulated capacity of over 2.3 million tons in twenty-foot equivalent units (TEU)[b], were blocked at the entrance to a port somewhere in the world[10]. This global situation has also generated significant delivery delays that were occasionally exacerbated by crises like the six-day blockage of the Suez Canal[11], or the closure of ports in Yantian, Shenzhen[12], and Ningbo-Zhoushan[13] in response to new epidemic waves.

Large retailers were discontented with this general chaos, being obliged to deal with delayed deliveries and accumulate inventories, which was coupled with an increased demand for manufactured goods and online competition since the economic recovery. For example, the home furnishings specialist Home Depot, the multinational retailer Walmart, and the Swedish furniture store Ikea have had to take the exceptional measure of renting, and sometimes buying their own containers and chartering private ships in order to accelerate logistics[14].

The consequence of this situation is that container "freight rates" shot up by 258% from July 2020 to July 2021, according to the Freightos Baltic Index. For transit between eastern Chinese ports (Shanghai) and northern Europe (Rotterdam), the freight rate went up by as much as 666% over the same period: chartering a 40-foot container in July cost over $13,000[15], a record (**fig. 2**).

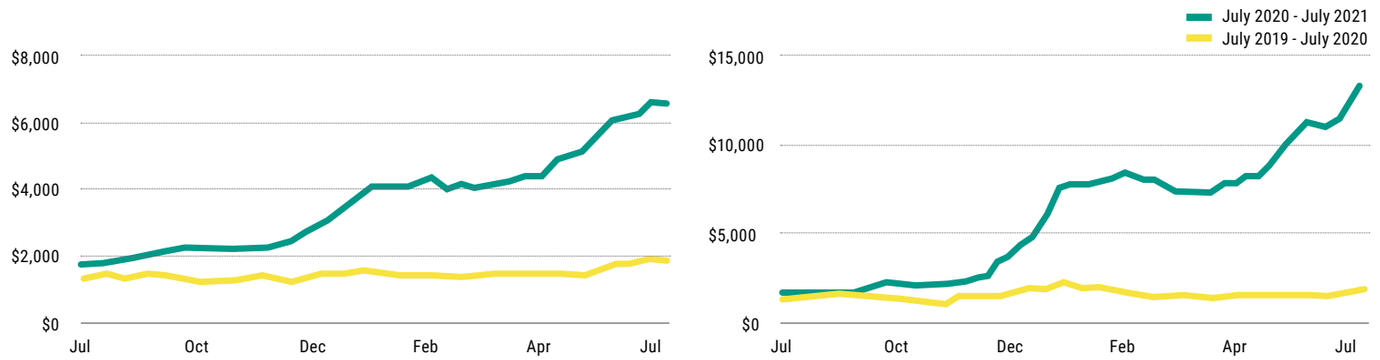
This situation therefore works to the advantage of major container shipping companies, which have been making record profits since the second half of 2020. In the first quarter of 2021, the earnings before interest and taxes (EBIT) generated per TEU reached a new high, in sharp contrast with the chronic

b A twenty-foot equivalent unit (TEU) is a unit of measurement that calculates the volume of merchandise transported based on the volume of a twenty-foot container. Forty-foot equivalent units are also used sometimes.

FIGURE 2

COMPARISON OF THE ANNUAL EVOLUTION OF THE INTERNATIONAL FREIGHT RATE AND THE FREIGHT RATE ON THE TRADE ROUTE FROM EAST CHINA TO NORTH EUROPE BETWEEN JULY 2019-JULY 2020 AND JULY 2020-JULY 2021

Source: Freightos Baltic Index, 2021



difficulties encountered by some companies like the Chinese shippers HMM and Cosco over the past decade and the Israeli ZIM (**fig. 3**). Less forthcoming about its financial results, which it does not publish, the Italian company MSC also appears to be in good shape since it is close to overtaking Maersk as the biggest container shipping group in the world in terms of capacity[16]. In all areas of maritime freight, orders for new vessels from shipyards increased by 119.7% during the first five months of 2021 compared to the same period in 2020. Orders for container ships in particular multiplied by twelve[17].

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 shippers start deploying strategies to implement them, these commitments sometimes reveal contradictions.

THE OBSERVATORY'S LENS

Faced with atmospheric pollution and climate change, maritime freight navigates between the devil and the deep blue sea

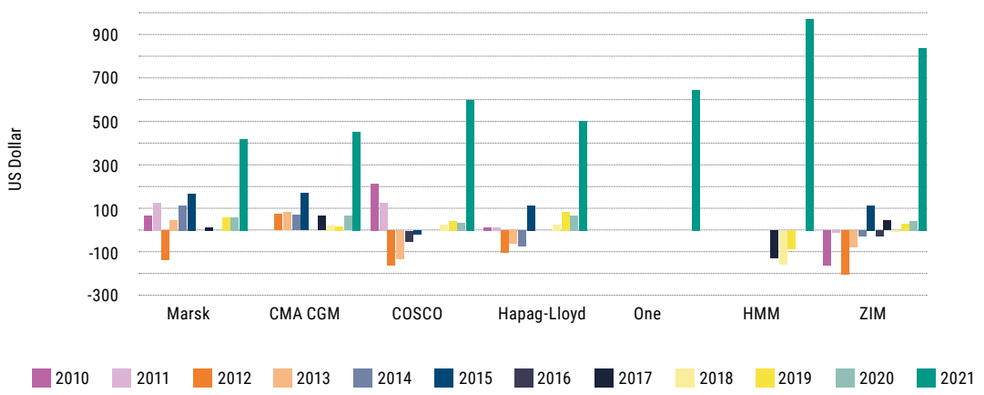
Scrubbers, a popular but double-edged technique to remove pollution

The IMO 2020 limit on emissions of sulfur oxides (SO_x) came into force on 1 January 2020. These particles are emitted by the combustion of HFO (heavy fuel oil), the fuel most commonly used by ships. Sulfur dioxide (SO_2) is well known for its harmful effect on human respiratory health and its role in the formation of acid rain. The IMO 2020 regulation reduces the maximum sulfur content permitted in fuel oil used on ships from 3.5% m/m (mass by mass) to 0.5% m/m. This new standard applies to all ships outside emissions control areas

FIGURE 3

EBIT PER TEU IN THE FIRST QUARTER OF 2021 FOR THE MAIN SEA CARRIERS

Source : Sea Intelligence, 2021



(ECAs): when they exist, ECAs can set even higher standards (0.1% m/m), such as in the Baltic Sea, the North Sea and the Caribbean maritime zone of the United States[18]. Voted in 2016 by the IMO's Marine Environment Protection Committee (MEPC), this new standard is an amendment to the International Convention for the Prevention of Pollution from Ships (MARPOL), adopted in 1973.

To meet these constraints, shipowners have several options: they can either replace HFO with a fuel that has a lower sulfur content but is much more expensive or requires technical adaptations, like VLSFO (Very-Low Sulfur Fuel Oil), MGO (Marine Gas Oil) or LNG (see below); or they can equip their ships with exhaust gas cleaning systems, known as "scrubbers", and continue to use HFO. The collapse of oil prices in the first half of 2020 — which greatly reduced the price spread between HFO and VLSFO, the main IMO-compliant alternative fuel — had cast doubt on scrubbers for a while, but they did capture the interest of shipping companies. In late 2020, over 4,000 ships around the world were equipped with a scrubber, which is twice as many as at the start of the year, according to BIMCO, a network of maritime actors that represent 60% of the global freight fleet[19]. Now stabilized at over $100/tonne, the spread between HFO and VLSFO is likely to continue to encourage sales of traditional fuel and so the installation of scrubbers in 2021[20]. Currently, demand for scrubbers is mainly boosted by numerous orders for new container ships from shipyards, explains Wärtsilä, a Finnish scrubber manufacturer[21].

Although it offers a solution to reduce atmospheric pollution, this technology does however raise other pollution issues. The most popular version on the market, which is cheap and easy to install, is the "open-loop" scrubber, which directly discharges cleaning water from the smokestack into the sea. This discharge is loaded with polycyclic aromatic hydrocarbons, nitrates, nitrites and heavy metals, contributing to the acidification of the sea and presenting a danger to marine life. Eighty percent of this cleaning water is discharged within the perimeters of Exclusive Economic Zones (200 nautical miles), within which sovereign states have the exclusive right to exploit resources[22]. For this reason, to date, over 32 states and port authorities have prohibited open-loop scrubbers, while others subject their use to certain conditions[23]. The Turkish Chamber of Shipping is one of the most recent bodies to have banned open-loop scrubbers[24].

The track record is not much better for VLSFO, with a recent study presented to the IMO revealing that it contains aromatic compounds that increase black carbon emissions by 10% to 85% compared to HFO[25]. Black carbon, which is dangerous for health, is a greenhouse gas with a short lifespan and a powerful radiative forcing effect. Resulting from the incomplete combustion of fuel, its global warming potential (GWP) is between 460 to 1,500 times greater than that of CO_2 during the four to twelve years that it remains in the atmosphere[26]. The main options open to shipping companies to remove pollution from their activities are therefore a double-edged sword in view of atmospheric pollution, as well as in contradiction with the climate targets established by the IMO.

Decarbonization options struggle to scale up

Since 2018, the IMO has been calling on shipping companies to reduce their GHG emissions by at least 50% by 2050 compared to 2008. Unlike air transport with Corsia (**see Aviation trend**), an emissions trading scheme is not yet in place in the maritime sector. But the subject reached the negotiation table this year, especially following pressure from the European Commission, whose Fit for 55 legislative package suggests including maritime transport in its carbon trading market[27]. The Marshall Islands, one of the three biggest ship registries in the world, joined forces with the Salomon islands to make a proposal to the Marine Environment Protection Committee (MEPC) at its meeting of June 2021 (**see Keys to Understanding**). The idea is to charge shipping companies $100 for each tonne of CO_2 equivalent their vessels emit starting from 2025[28]. Coupled with low-carbon technologies, a $100 charge would reduce emissions from the sector by 13% in 2030, estimates the fourth study by the IMO on GHG emissions[1].

KEYS TO UNDERSTANDING

MEPC 76: NEW TECHNICAL AND OPERATIONAL AMENDMENTS TO THE MARPOL CONVENTION TO REDUCE SHIPS' CARBON INTENSITY

During online meetings running from 10 to 17 June 2021, the 76th session of the IMO's Marine Environment Protection Committee (MEPC 76) ratified new technical and operational measures to guide the sector's efforts to reduce its carbon intensity. Voted in the form of amendments to the MARPOL convention, the decisions modify Annex VI of Chapter 4 of the convention, which includes instructions on the energy efficiency of ships. These new measures will come into force from 2023. An Energy Efficiency Existing Ship Index (EEXI) will apply to vessels of 400 Gt and over, to certify their energy efficiency in comparison with a reference value. Ships will therefore have to respect a particular level of EEXI, based on a reduction factor expressed as a percentage of the Energy Efficiency Design Index (EEDI), which already exists and applies to all new ships. The operational Carbon Intensity Indicator (CII) will apply to all ships of 5,000 Gt or over, which are already obliged to collect data on their fuel consumption. The CII will determine the annual reduction factor required to ensure continuous improvement of the boat's operational carbon intensity. Each ship's CII will be accompanied by a performance rating, and the IMO will leave it to the discretion of port authorities to create incentives to reach the highest ratings. Announced in autumn 2020, and supported by a coalition of EU Member States alongside Japan, China, South Korea and Norway, these new measures have not convinced NGOs. According to the International Council on Clean Transportation (ICCT), although limiting ships' engine power is theoretically the easiest way to respect the EEXI, in practice this power limitation will have little impact because ships already operate well below their maximum speed.

Source: IMO, 2021. ICCT, 2020

In the absence of more effective market instruments, the IMO is planning four other types of medium-term measures: the development of low-carbon (or even "zero-carbon") fuel, operational measures for the energy efficiency of ships, technical cooperation and capacity-building activities, and feedback mechanisms to share good practices[3].

Very few ships are powered by electricity at present, and those that are operate on low-volume and short-distance projects, like in the Norwegian fjords[29]. The *Yara Birkeland*, awaited since 2020 as the first battery-powered autonomous container ship, is still not in operation[30]. However, hydrogen-powered electric propulsion is an object of high expectations in the sector. Engine manufacturers like the Finnish company Wärtsilä and the German firm Man Energy Solutions are hedging their bets on the potentially massive use of decarbonized ammonia, a combination of nitrogen and hydrogen (NH_3)[31]. Japan, in particular, intends to develop its large-scale production by 2030. The shipping company NYK Line, the ship builder Japan Marine United Corporation (JMU), and the company ClassNK have signed a research and development (R&D) agreement to commercialize a ship running entirely on ammonia[32]. However, as pointed out by the International Chamber of Shipping, the energy density of ammonia is lower than that of oil, so much so that converting the entire international fleet would mean tripling production to reach 440 million tons, which would require no less than 750 GW of renewable electricity[33]. The processes currently used to produce hydrogen and ammonia mostly involve carbon and are much less competitive than VLSFO (**see Hydrogen trend**). A consortium of 26 companies and associations, led by the DNV GL consultancy company, has published a roadmap reflecting on regulation and safety issues concerning the use of hydrogen in ships[34].

At the moment, LNG is the preferred choice of shipping companies to navigate in ECAs and respect the IMO's new sulfur emission standard and low-carbon strategy. A total of 563 ships running on LNG are currently in operation or have been ordered, and another 199 are ready, according to DNV GL[35]. In early 2021, the number-two worldwide container shipper, CMA-CGM, launched the *Jacques Saadé*, the biggest container ship functioning on LNG in the world. With a capacity of 23,000 TEU, the *Jacques Saadé* corresponds to CMA-CGM's anticipation of the creation of an ECA in the Mediterranean Sea. It is the first vessel in a fleet of eight LNG-powered container ships planned by the French company[36].

Nevertheless, although LNG emits 25% less CO_2 than traditional ship fuels and contains almost no sulfur, the combustion of this gas is the reason for the increase in CH_4 emissions observed by the IMO in recent years[1]. These emissions are generated by the use of LPDF (low-pressure injection dual fuel) engines, the most widespread technology employed in LNG-powered ships, which gives off considerable methane fumes, in particular on ships carrying light loads[37]. According to a life cycle analysis by ICCT, the use of LNG with this technology generates 70% to 82% more GHG emissions than the alternative gas-based fuel, marine gas oil (MGO). In 100 years, provided a more effective technology is adopted, LNG could enable emissions savings of up to 15% compared to MGO; in 20 years, as climate action reaches a critical point, using LNG would generate 4% more emissions[38].

In a maritime transport market concentrated around three large alliances dating from 2017 (THE Alliance, Ocean Alliance and 2M Alliance represent 80% of global activities in volume), but whose financial results have fluctuated in recent years, the leading companies have embarked on a strategy involving the vertical integration of all logistics processes, based on their digital transition and the requirements of the low-carbon transition[39]. Cosco Shipping Lines, for example, has opened its first electronic platform in Spain to facilitate online reservations of transport space for its goods[40]. In Germany, A.P. Møller–Mœrsk began converting its entire rail transport network this year to connect the port of Bremerhaven to the economic centres of Nuremburg, Munich, Stuttgart and Mannheim, thanks to a partnership with ERS/boxXpress.de, which operates electric trains running on hydropower. The initiative, known as CapO2, is supported by the recently created Maersk Mc-Kinney Møller Center for Zero Carbon Shipping, and is waging on (hydrogen) fuel-cell locomotives to save up to 9,000 tCO_2/year, according to the company[41]. MSC is also launching a new multimodal service to create a rail connection between Turkish ports and the city of Ludwigshafen in Germany, passing through Trieste in Italy. The aim is to reduce delivery times of manufactured goods, although the energy that will be used to carry them has not been stipulated[42].

Lastly, like in many industries this year, the buzzword used to describe shipping companies' climate strategies is "carbon neutrality". Aware that all areas of the industry will need to contribute to reach GHG emissions reduction targets, a group of US and Canadian companies created the Blue Sky Maritime Coalition. This strategic alliance, which features a wide range of actors including the oil group Shell, the Chamber of Shipping of America, the industrial tool manufacturer Caterpillar, and the port authorities of Vancouver and Houston Bay, wants to facilitate collaboration between regional and international players in the industry to encourage the adoption of good commercial and technical practices aiming to follow a "net zero" trajectory[43].

Numerous port authorities have joined the list of ports committed to becoming "carbon neutral", like Esbjerg (Denmark), the biggest port in the North Sea, in cooperation with the company Atos[44]; Yokohama (Japan), which has become an LNG fuelling station[45]; and the port of Gothenburg (Sweden), which invites roll-on/roll-off ships at berth to refuel from an electric station (shore power facility) rather than keep their motors running. Gothenburg intends to extend this facility to tankers in 2022, which would be the first of its kind in the world and would potentially reduce emissions by 2,100 tCO_2/year per boat[46]. The relative efficiency of this type of facility depends, as always, on the share of renewable energy in the mix that produces the electricity, and obviously on the type of usage it targets. Thus, according to the Environment Protection Agency (EPA), the installation of a shore power facility in 2023 in a new terminal at the port of Miami should result in a 35% reduction in emissions. Yet the initiative, the result of an agreement between the port and six

cruise lines, may only be a drop in the ocean compared to the emissions from these vessels capable of transporting up to 5,000 passengers[47]. The same goes for their impact on atmospheric pollution: the 47 luxury cruise liners owned by a single company, the Carnival Corporation and PLC group, emit ten times more sulfur dioxide than the 270 million passenger vehicles circulating in Europe, according to an estimation by Transport & Environment in 2019[48].

KEY TAKEAWAYS

The intense recovery of international consumption of manufactured goods during and after lockdown measures have sent supply chains into the economic doldrums. Yet container ship companies have successfully ridden the storm, making record financial profits thanks to inflated freight rates, following a passage of several difficult years — an economic situation that they are using to extend their load capacities and integrate value chains rather than to reduce the environmental impacts of their operations.

Forced by the International Maritime Organization to find new solutions to reduce their sulfur and greenhouse gas emissions, shipping companies are proving slow to engage any real changes. Worse still, the most common solutions for reducing pollution (smokestack scrubbers) and for decarbonization (LNG fuel) are often contradictory and generate externalities that work against one target or another. To date, the IMO has shown little inclination to impose any of the more ambitious proposals put forward by some of its members, such as obliging ships to reduce their speed, regulating black carbon emissions, or setting up a carbon trading market.

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TREND
RAIL

Popular Among Industry, Civil Society and Public Authorities, Rail Continues its Expansion

SAMUEL LAVAL • Research Officer, Climate Chance Observatory

Trains play a sometimes-ambiguous game. On the one hand, their low carbon intensity makes them the preferred target of public policies for a modal shift, whether for short (urban rail) or long distances (high-speed lines). On the other hand, coal, metals and the various goods they transport are sometimes closely linked to industries that emit large amounts of carbon dioxide. China, in particular, continues to develop its rail network, deploying transport infrastructure around the world, and increasing its economic and political influence.

DATA OVERVIEW

Having reached the limits of efficiency, rail transport wages its bets on electrification and renewables to reduce carbon emissions

"*High speed, low carbon*"[a]. The French national rail company (SNCF) best known for its high-speed trains (TGV) has got the message: in a social and economic environment increasingly concerned about its carbon impact, the future may lie on the railway track. In fact, as a means of passenger transport, trains emit some of the lowest levels of greenhouse gases (GHG): on average, a train's carbon intensity is around 15 gCO_2e[1] per passenger-kilometre[b], less than a tenth of that emitted by large cars and planes[2], with similar efficiency levels for transporting freight. While railways represent about 9% of the global transport of passengers and 7% of global freight, trains only total 2% of energy demand from the transport sector, and 1.3% of its direct CO_2 emissions[3]. In 2019, direct global emissions from rail transport amounted to 101 $MtCO_2$, a very slight increase compared to 2018 (+0.4%). Taking into account the entire life cycle ("well-to-wheel") of trains and railroads (construction of tracks, tunnels and bridges, manufacture of trains, etc.), these emissions are between three and four times higher.[1]

This performance can be put down to the very high rate of electrification of the global railway network, which has led to a decrease in diesel-operated trains: the percentage of electrified rail tracks rose from 36.7% in 2015 to 40.2% in 2019. For passenger transport, it even reaches 75%[2] (60% in 2000).

In India, despite a slow start for the national railway electrification program, which aims at total electrification of the network (only 600 km having been electrified as of 2013-2014), as reported on 31 March 2021, over 6,000 km were electrified in 2020-2021, taking the total to 45,000 km, which is 71% of the network.[4] The country aims at "carbon neutrality" for its rail system in 2030, through electrification and the use of low-carbon energy. Some trains have been running on biodiesel since 2015. Urban railway management companies are also moving in this direction: in early 2020, the company that runs the metro rail in the city of Hyderabad announced a partnership with Amp Energy to install a solar park with a total capacity of 7.8 MW to power the metro.[5]

These electrification efforts only have an impact on GHG emissions reduction if they are fueled by low-carbon energy. **Figure 1** shows that a train running on electricity from coal-fired stations emits at least as much as a diesel train. Like India, France (via the SNCF) has set a target of increasing the share of renewables in its rail network: 40% to 50% of renewable energy by 2025. In early 2021, the renewables branch

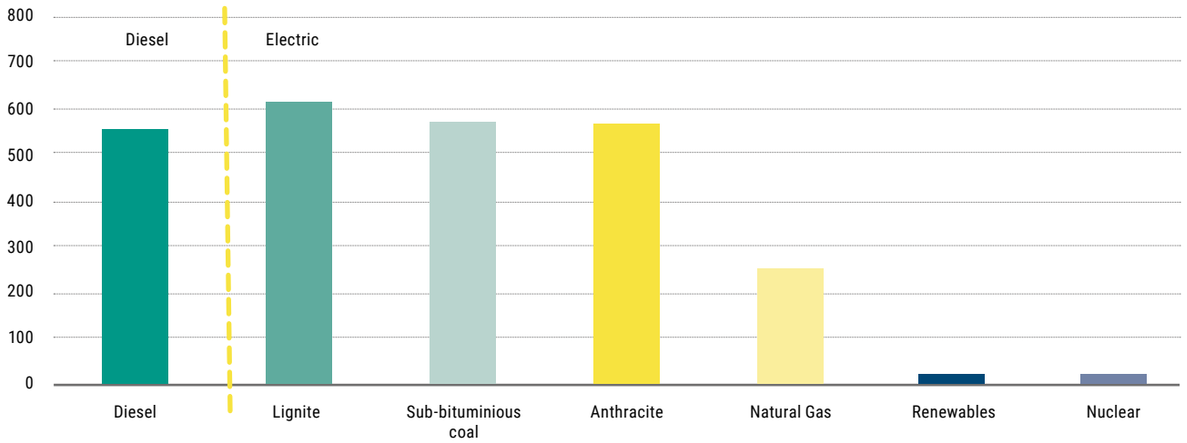
a Advertisement for the SNCF disseminated in France in 2021.

b A passenger-kilometre, which corresponds to the transportation of one passenger over one kilometre, is the reference unit to measure the volume of passenger transport. Similarly, a tonne-kilometer corresponds to one tonne of merchandise transported over one kilometre. These units therefore depend on the carbon footprint of the means of transport used and its fill rate (passengers or goods).

FIGURE 1

AVERAGE WELL-TO-WHEEL CARBON INTENSITIES FOR DIESEL-POWERED TRAINS, COMPARED TO ELECTRIC TRAINS USING VARIOUS PRIMARY SOURCES

Source : IEA, 2021



of Électricité De France (EDF) and the SNCF rail group signed a Power Purchase Agreement by which EDF committed to provide the rail company with production from a 20 MW solar farm for twenty years starting from 2023[6] (**see Energy sector**). The German company Deutsche Bahn has reported that its trains operated with 61% of renewable energy in 2020, and is aiming at 100% by 2038[7]. East Japan Railway, the biggest rail company in the country, has been investing in solar energy since 2013, and has announced new investments in early 2021 to reach carbon neutrality before 2050[5]. After the decommissioning of the country's nuclear power stations that followed the Fukushima disaster in 2011, the share of rail transport in Japan's GHG emissions went from 4.2% in 2010 to 5% in 2015[2]. Lastly, the British company Network Rail is also aiming at carbon neutrality by 2050, while Scotland wants to achieve the same objective before 2035. In total, almost 11% of the energy used to run trains comes from renewable sources[5].

However, the considerable investments required for electrification can be dissuasive for railway companies and states. To attempt to get around cost problems, the rail sector has started looking at hydrogen. Cheaper than infrastructure work, the industrial development of trains equipped with hydrogen fuel cells could enable a rapid transition from diesel to low-carbon trains because they can operate on non-electrified lines. Although hydrogen production currently emits high levels of GHG, since 2019-2020 it has attracted a great deal of attention, in particular because it can be produced by the electrolysis of water, which, if fuelled by renewable energy, could lead to low-carbon production (**see Industry sector**). Alstom, whose investments we reported on last year[8], has maintained its position as a market leader. Forty-one of its fuel cell trains, *Coradia iLint*, are to be put into operation in Germany following a two-year pilot phase. This model has already been subject to its first test journeys in Poland, where most trains currently run on diesel[9]. At the start of the year, the French major bought out Helion Hydrogen Power, a French SME covering the entire value chain of high-power fuel cells[10]. Other examples of the development of hydrogen trains have been observed in India[11], Spain, Germany, Italy and the Netherlands (**see Signals**). In France, four regions have placed orders with Alstom for dual-mode electric-hydrogen trains to replace dual-mode electric-diesel versions. Operations are due to start in 2025[12].

Investment capacities were also seriously undermined by the Covid-19 pandemic, which was detrimental to the sector's activities and financial results. In July 2020, the International Union of Railways (UIC) anticipated a 30% drop in global demand for rail passenger transportation over the year. The International Energy Agency (IEA) reported that in India all passenger rail services came to a standstill, along with 60% of freight transport — a pause that nevertheless enabled electrification works to be carried out. In Europe, rail operators registered financial losses of 2.5 billion dollars at the height of the first lockdown from January to April 2020, and losses of up to 19 billion dollars for Asian operators[13]. Over the whole year, the SNCF lost 14% of its turnover (-6.8 billion euros) and saw its operational margins dissolve[14], despite an emergency support plan of 4.7 billion euros from the French state and exceptional measures (furlough, investment postponements, etc.)[15]. Deutsche Bahn, the other major European rail operator, announced losses of 5.7 billion euros in 2020 due to movement restrictions[16]. East Japan Railway lost 41.4% of its revenues over the 2021 financial year that ended in March[17].

The American continent accounts for one-third of the world's railways (32% in km), but only 2% of passenger traffic[18]. The main operator, Amtrack, saw a 97% drop in passenger numbers during the first months of the pandemic, before going back to two-thirds of its pre-Covid level this summer[19]. Freight rail transport is, on the other hand, highly developed in the United States, mainly operated by the American Railway Association. Loads decreased by 12.9% from 2019 to 2020[20], with a shift from raw materials like coal towards manufactured goods[21].

In contrast, the economic rebound in Asia enabled operators to cover their losses, sometimes even exceeding the previous year's performance in the freight sector. Indian Railways, for example, the biggest rail company in the world, recorded over 5.1 billion dollars[c] of loss in income from passenger transport, but saw its annual freight revenues increase by 2% from 2019 to 2020[22]. China Railway also increased its gross revenues by 14.6% over the whole year[23].

Despite the effect of the pandemic, which generated a 11% drop in rail emissions in 2020 according to Enerdata, investments in decarbonization are not enough to compensate the structural increase in rail emissions over recent years (+13% between 2015 and 2019 according to Enerdata), in particular when taking their life cycle into account. This increase is related to the massive expansion of the rail network and railway activity at the global level, on every front: passenger transport, freight, and urban rail.

This expansion is sometimes the result of policies aimed at encouraging rail instead of other more emitting forms of transportation. The European Union declared 2021 the "European Year of Rail" and is organizing a series of initiatives to develop rail usage[d]. Night trains are even making a gradual comeback on the continent, after being dropped years ago (**see Signals**). To encourage the modal shift, the new French "climate law" adopted in early summer 2021 abolishes domestic flights for journeys where a train alternative under 2 hours and 30 minutes exists. Whether it involves conventional rail, high-speed or urban trains, the climate benefits of the modal shift towards rail will depend on several factors (construction work and materials used, operation by diesel or low-carbon electricity, user numbers, etc.) and in some cases could even turn out to be nil[24].

For several years, the vast majority of rail expansion has been at the initiative of a single country: China. Spurred by a strategy to boost its economic growth and geopolitical influence, China has been rolling out new passenger and freight transport lines in its own territory and around the world, without showing any real volition for a modal shift that would benefit the climate.

THE OBSERVATORY'S LENS

China sets the world on its tracks

China chugging ahead in rail activity growth

In 2018, the volume of passengers traveling by train exceeded four billion passenger-kilometres, 6% more than in 2016[2]. That is around 8% of motorized transportation of passengers in the world, concentrated in a handful of countries: 90% of passenger rail transport takes place in India, China, the European Union and Japan[24]. Its growth has been largely driven by the roll-out of high-speed and subway networks, in particular in China. In the space of just ten years, since 2010, China has built two-thirds of the world's high-speed railway tracks[26] (totalling 37,900 km, with another 3,700 km planned in the coming months[25]), along with the biggest underground network in the world, which overtook the European network in 2015[24]. The volume of high-speed passenger-kilometres multiplied by 15 from 2010 to 2019[2], outstripping the growth of air passenger transport[26]. More than 50 new high-speed lines were opened between 2018 and 2020[2]. In 2019, Chinese high-speed rail ensured 20% of rail traffic between cities, which is double its rate in 2010[2].

The high growth of rail freight in the world is also largely led by China: 11,000 billion tonne-kilometres were transported in 2018, 12% more than in 2010, and China is one of the regions where the increase in freight has been the greatest (almost double in 2016 compared to 2000 – **fig. 2**). The history of rail freight is closely related to that of coal, and mining industry development often goes hand-in-hand with rail network development. Even today, the Haoji line, the longest rail freight line in the world inaugurated in China in September 2019, exclusively transports coal. At a cost of 27 billion dollars, it measures 1,813 km and is designed to transport 200 million tonnes of coal per year from mines in the north of the country to thermal power stations in the south, replacing former transportation by sea[27]. At the global level, coal and fossil fuels represent 28% of rail freight[28]. In the United States, coal represents 30% of rail freight in volume and 13% of its revenues[29]. As a result, the global slowdown in coal consumption (**see Energy sector**) could threaten the economic models of some rail freight companies.

Although the growth in absolute value of rail freight has increased, it does show some signs of flagging. In fact, the modal share of "surface" rail freight (i.e. excluding air and sea)[e] dropped from 2000 to 2016[24], in all regions in the world (**fig. 2**). For a global average of 28% in 2016, it was about 30% in North America and India, 10% in Europe, and 75% in Russia, the country in which it is highest. The biggest decrease in modal share was in China (from over 50% in 2000 to 39% in 2016).

In reality, not content with just developing freight on its own territory, China has pursued multiple partnerships throughout the world to draw new trade routes, some of them railways, in the frame of its flagship economic project, the Belt and Road Initiative.

After a euphoric start, the Belt and Road Initiative is losing steam

Initiated in 2013 by Xi Jinping, the Belt and Road Initiative (BRI), sometimes referred to as the "New Silk Road", aims to

c The figure put forward is ₹38,017 crores, a unit used in India equivalent to ten million; thus ₹38,017 crore equals ₹38,017 billion, about $5.1 billion.

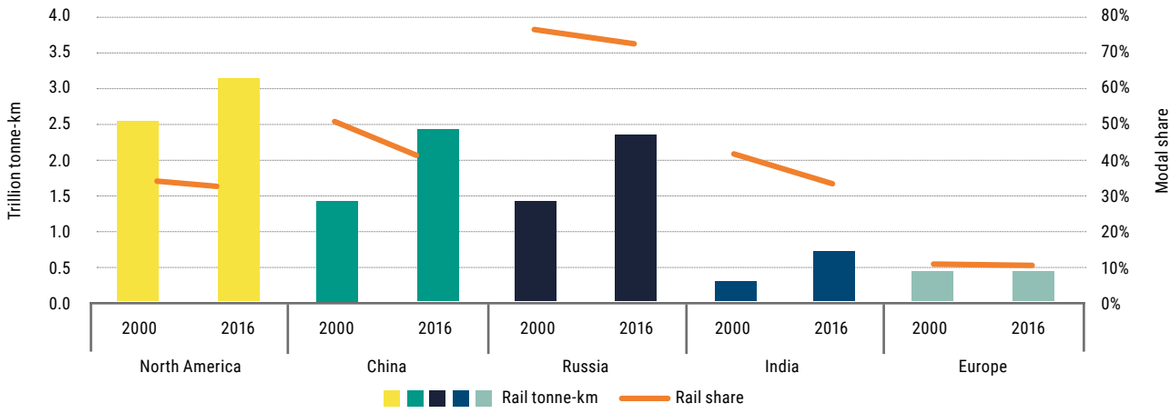
d The strategy comprises of several objectives, such as the creation of a standard European rail area, and the doubling of high-speed rail traffic by 2030 and freight traffic by 2050.

e Taking into account aviation and in particular maritime, which transports more than three-quarters of global goods in tonne-kilometres, the modal share of rail in goods transportation is 7%. Source: REN21, 2021

FIGURE 2

RAIL FREIGHT ACTIVITY AND MODAL SHARE OF SURFACE TRANSPORT OF GOODS

Source : IEA, UIC, 2019



develop commercial transport infrastructures on road, rail and sea between China and the rest of the world (**see Keys to Understanding**).

KEYS TO UNDERSTANDING

THE CHINESE BELT AND ROAD INITIATIVE

Sometimes called the "New Silk Road", the "One Belt, One Road" initiative, which has since become the "Belt and Road Initiative" (BRI) is a development program for trade routes and infrastructure initiated by the Xi Jinping government in 2013. Until now, its main lever has been the granting of loans to finance infrastructure projects via the two main Chinese "policy banks" (investment banks run by the Chinese state): the export-import bank (Eximbank) and the development bank (China Development Bank). The BRI is organized around major "corridors", like the China-Europe corridor and the China-Pakistan corridor (**fig. 3**), and generally involves trade agreements and/or trade facilitation and access to resources for Chinese companies.It is relatively difficult to establish the exact number of BRI projects and the amounts involved. Numerous projects labelled "BRI" have no strategic importance for Chinese trade, while other projects that claim no BRI connection seem to have all the appropriate characteristics. Currently, 138 countries have been associated with the BRI in one way or another, mostly as part of a project to build railways, ports, pipelines or communication infrastructures. In total, an estimated 460 billion euros of BRI loans have been granted since 2013.

Source: Financial Times, 30/04/2020

Following a peak of 75 billion dollars of loans granted in 2016, several experts agree that the BRI is losing steam around the world, and the pandemic could have accelerated the trend.[30] In 2020, many countries requested to postpone the reimbursement of their loans to China in order to devote public money to emergency measures to deal with the pandemic,[31] starting with Pakistan, in April 2021, two years after the start of construction of *Main Line-1*, the flagship project of the China-Pakistan corridor. In total, up to 40% of BRI-related projects may have been impacted by the pandemic (delays, postponements, cancellations),[36] and rail projects are no exception. In 2020, the railway between China and Malaysia and the high-speed rail project in Thailand were also put on hold.[32] The Kenyan parliament successfully called on the government to renegotiate the terms of its loan from China Eximbank for the construction of the Nairobi-Mombasa line, and the operating costs paid monthly to Afristar, which operates the subsidiary line of the China Road and Bridge Corporation that constructed the line.[33]

Despite these difficulties, numerous other major BRI projects were successfully completed in 2020. In Nigeria, the 157-kilometre Lagos-Ibadan railway line, built by a Chinese company, started operating in April 2020, several years after schedule. In Turkey, the first freight train on the China-Turkey corridor covering 8,693 kilometres set off for a 12-day trip in December 2020.[2] Projects in Cambodia (construction of the Phnom-Penh – Sihanoukville line and the extension of Phnom-Penh and Siem Reap airports) and in Laos (construction of a high-speed railway) have not been impacted by the pandemic.[34]

Globally, the impetus that BRI has given to rail freight is not about to stop, quite the opposite. Although global goods transport decreased by 36% in 2020,[2] trains have helped to get it back on track to recovery. In fact, maritime freight had difficulties establishing a solid recovery in international trade after the economy picked up again in late 2020; this was due to the unequal distribution of containers on trade routes, triggering a sharp rise in the cost of container transport (**see Maritime trend**). Taking advantage of this weakness in the system, 2,000 trains carrying manufactured goods arrived in Europe from China in January and February 2021, which is twice as many as during the same period the previous year, while, despite the pandemic, the number of trains running from China to Europe had already increased by 50% in 2020 compared to 2019, and had grown sevenfold compared to 2016.[35]

In Africa, strategic resources give rail a new boost

Africa possesses significant mining and energy resources and a market with considerable potential, making it a strategic hub for the BRI. In total, 40 of the 55 African countries have signed an agreement or developed a project in partnership with China in the frame of the BRI. At the end of 2020, about 90 projects connected to the BRI were underway in Africa.[36]

China is making investments in Africa to develop the railway network, facilitating trade with the continent. A key example is the Nairobi-Mombasa line inaugurated in 2017, financed by China Eximbank, the Chinese import-export bank, and built by Chinese companies as part of the Belt and Road Initiative. The railway line links the capital to the container port in Mombasa, whose activities reached record levels in 2019, and is due to be extended to Naivasha, to facilitate exchanges with Uganda and Rwanda.[37] In mid-2021, a 125 km line was opened in Guinea between Boffa and Boké by the Singaporean-Guinean-Chinese consortium SMB-Winning, the continent's leading producer and exporter of bauxite. This line, which connects the mines to a large inland port, will initially be exclusively devoted to transporting minerals, before being extended to transportation of other merchandise.[38]

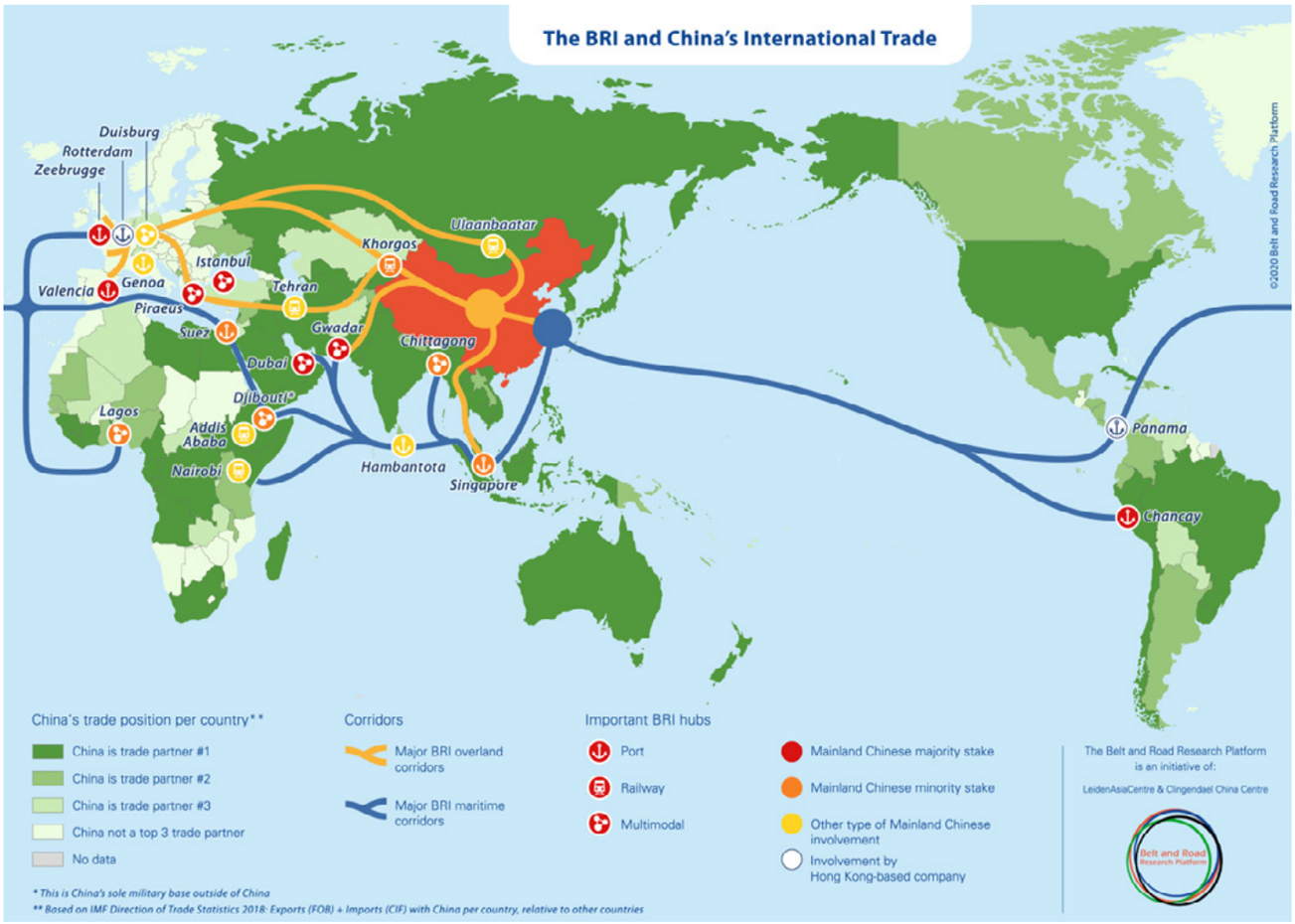
China is also involved in setting up urban rail systems (metro lines, trams and light railways) in Africa, where they have undergone considerable expansion. Most of the 501 urban rail systems in place in 2020 (compared to 478 in 2017)[2] are located in Europe, but the biggest growth over the last ten years has taken place in Africa (+333% since 2010), Asia (+69%) and Oceania (+50%). In Abuja (Nigeria), a series of Chinese loans and a technical partnership agreement with the China Civil Engineering Construction Corporation (CCECC) concluded in 2007 have led to the construction of an underground railway in operation since 2018 following a series of delays.[39] Addis-Ababa (Ethiopia) ordered 41 trains from the manufacturer China CNR to set up a light railway line in operation since 2015.[40] In Egypt, a railway from Cairo to the new administrative capital was financed by a 1.2 billion dollar loan from Eximbank. It is due to for launch at the same time as the inauguration of the new city, scheduled for the end of 2021, and will be operated by the French company RATP.[41]

In total, the Chinese Loans to Africa Database lists 274 Chinese loans to African states (or companies held by African states) from 2000 to 2019 in the transport sector (construction of roads, railway lines, ports, airports, metros, purchases of equipment, etc.), representing a total of over 46 billion dollars.[42] Transport

FIGURE 3

MAIN INFRASTRUCTURES IN THE BELT AND ROAD INITIATIVE

Source : Belt and Road Research Platform, 2021



is the main sector concerned by these loans (almost a third of the total amount lent since 2000), ahead of electricity ($38.0 billion) and the mining sector ($18.4 billion). But after reaching a peak of almost $29 billion in 2016, Chinese loans to Africa (in all sectors) dropped sharply the following year ($12.7 billion) and do not seem to have picked up again since ($9.9 billion in 2018, $7 billion in 2019).[42] The reasons for this include the failure of several key BRI projects, like Hambantota Port in Sri Lanka,[43] the fear of falling into debt and being too dependent on Chinese financing, and vociferous objections from civil society concerned by environmental impacts. One example is the project to open an iron mine in Guinea, where the construction of infrastructure to export bauxite to Ghana came up against strong opposition.[44] In Kenya, in November 2020, a widespread social movement succeeded in ensuring the cancellation of a coal-fired power station in the north of the country initiated by Chinese companies and mainly financed by the Chinese bank of commerce and industry[45].

KEY TAKEAWAYS

In passenger transport, freight and urban rail alike, China is moving quicker than the rest of the world. Even more so, China is behind the roll-out of the global railway network. Through its Belt and Road Initiative, a major program to develop roads and trade infrastructure initiated by the Chinese government in 2013, rail projects have mushroomed in Asia, Europe and Africa. The deal is always the same: China finances largescale projects (ports, railways, roads, airports, etc.) and in exchange obtains special access to resources and local trade. Undoubtedly, far from aiming at a modal shift from road or air freight, the development of Chinese rail is much more about economic and political strategy than climate concerns. Multiple failures, sometimes due to opposition from environmental associations, have nevertheless begun to curb the trend.

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TREND
SOFT MOBILITY AND PUBLIC TRANSPORT

In Cities, the Effects of the Pandemic Reveal a Concentrated Low-Carbon Mobility Market

SAMUEL LAVAL • Research Officer, Climate Chance Observatory

The organization of urban mobility is a key jurisdiction of local governments and ideal for testing out climate policies. In 2020, the pandemic jeopardized some of these strategies by putting numerous public transport operators in untenable financial situations, yet it also accelerated the roll-out of cycling infrastructure, to the point that the global bicycle market is struggling to satisfy demand, entailing the longest delivery times on record. The urban mobility resurgence currently revolves around concentrated hubs of dominant players.

DATA OVERVIEW

The pandemic has shifted urban mobility practices

With a fossil fuel reliance of 97%, the transport sector is currently responsible for about one quarter of greenhouse gas emissions (GHG) related to energy.[1] Forty percent of these emissions come from private vehicles, mostly used to transport passengers.[2] From 2000 to 2019, global emissions from transport increased by 17.2%, with wide variations between regions and sectors. Nevertheless, in 2015, while 166 of the Nationally Determined Contributions (NDCs) under the Paris Agreement recognized transport as a source of emissions, only 8% of them included reduction targets specifically concerning transport.[3]

In recent years, increasing numbers of public policies have aimed at reversing this trend. In 2020, 44 countries had adopted a national urban mobility policy (NUMP) to guide the organization of transport in urban environments.[1] Globally, from 2017 to 2020, the number of Sustainable Urban Mobility Plans (SUMPs) adopted locally to plan and deploy low-carbon transport in cities went from 1,588 to 1,686 (+6%), most of them in Europe (68%), although the biggest increase was in Latin America, which now accounts for 16% of these plans.[1]

In 2020, the Covid-19 pandemic drew this double trend to a halt. On one side, following measures to restrict movements in numerous countries to curb the spread of the virus, transport-related emissions dropped by 19.4% compared to the previous year according to SLOCAT,[1] mostly thanks to the massive adoption of remote working (almost 48% of the working population in the United States, the biggest emitter of greenhouse gases related to transport, at the peak of lockdown[2]). Yet on the other side, most urban public transport systems were hit hard by the crisis. Data from the Moovit journey planner app shows a drop in public transport usage of 93% in Lima, 85% in Bogotá and 72% in Los Angeles (**fig. 1**).[4]

In China, the number of public transport users halved from December 2019 to February 2020. In Brazil, where transport operators' financial equilibrium is highly dependent on large numbers of users due to a lack of state aid, the losses endured by the members of the National Association of Transport Companies totalled up to 184 million dollars a day.[2] By the end of 2020, operators in Salvador and São Paulo were bankrupt.[5] In numerous cities, public transport usage has still not returned to pre-crisis levels. Transport for London is expecting a deficit of about 8.9 billion dollars from 2020 to 2022. San Francisco recorded a drop in usage of 90% in April 2020, which was still 75% in October 2020,[6] and is not expected to return to pre-crisis levels before the end of 2022, according to the director of the San Francisco Municipal Transportation Agency.[7] These difficulties can be put down to high rates of remote working, lower normal public transport usage than in Europe and Asia (and already decreasing since 2014), and a more systematic shift towards cars.[5]

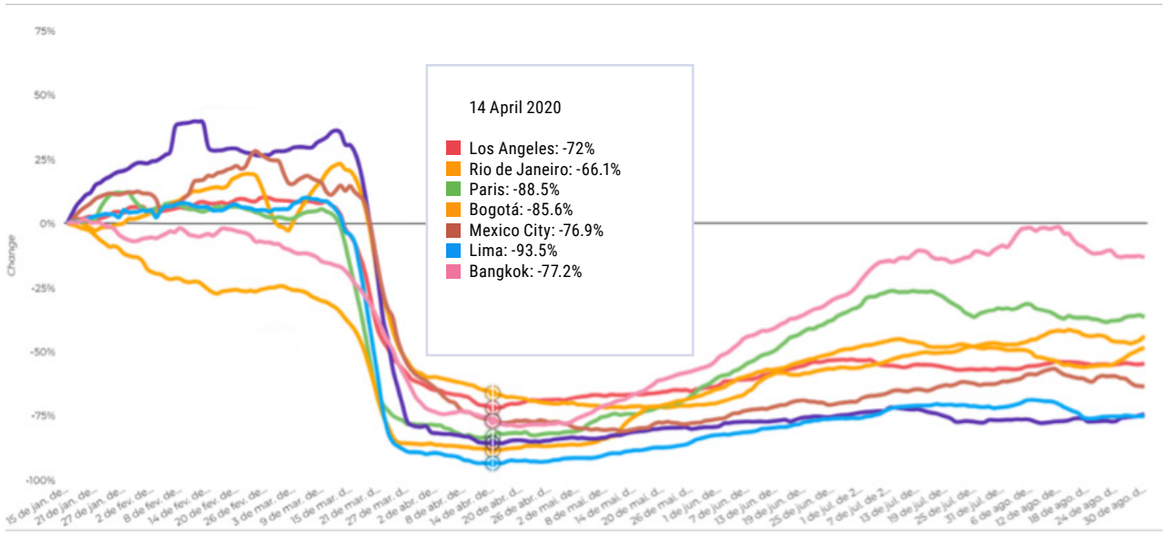
San Francisco is not the only place where cars have come out winners from the health crisis: in March 2020, at the end of the first lockdown, car traffic in China was higher than the 2019 average in Beijing, Shanghai and Guangzhou, and the number of subway users had dropped by 29% to 53% compared to pre-Covid figures.[2]

Another beneficiary of the "Covid effect" is walking. According to Moovit data, the average distance covered by foot

FIGURE 1

PUBLIC TRANSPORT USAGE FROM 15 JANUARY TO 30 AUGUST 2020 IN SELECTED CITIES

Source : Moovit



increased in numerous towns in 2019 and 2020, including in Curitiba (Brazil), Lima (Peru), Jakarta (Indonesia) and Istanbul (Turkey).[8] In the United Kingdom, the number of regular walkers has gone up by 20% since the pandemic.[9]

Several exceptions are however worth noting. In Seoul, the disinfection of all buses and subway trains at the end of each journey, the rapid systematic adoption of facemasks, temperature checks of people accessing transport, and tracking of infected people proved effective in reassuring inhabitants and limiting the drop in public transport usage to 30% at the peak of the pandemic, before it rapidly picked up a few months later.[5]

Globally, local governments have put a large range of measures in place aimed at countering the rise of car use and maintaining the resilience of their public transport system: bus electrification, free public transport, renewed interest in Bus Rapid Transit (BRT) systems, etc. But the biggest winner to emerge from this period is undoubtedly the bicycle. All over the world, sales have soared and infrastructure has been put in place to accommodate high numbers of new cyclists, resulting in a market that is still struggling to keep up with the pace.

THE OBSERVATORY'S LENS

Local urban mobility strategies face a slowdown in global supply chains

Reduced use of public transport has not curbed the surge in new equipment

The electrification of buses for public transport has grown remarkably over the last few years. According to BloombergNEF, 39% of bus sales were of electric vehicles in 2020, compared to 1% of vans and trucks and 4% of cars.[10] China, where electric buses represented 17% of the total bus fleet in 2017,[11] largely dominates the market, concentrating 97% of the 515,400 electric buses in service across the globe in 2020.[12]

On the other continents, the move to adopt electric buses is gaining ground. Despite the health crisis, global sales of electric buses went up significantly from 2019 to 2020 (+11.54%), while orders for the less-common plug-in hybrid (-20%) and fuel-cell models (-34 %) dropped dramatically.[13] According to the European Alternative Fuels Observatory, around 6,000 electric or hybrid buses were operating in the European Union in 2020, which is almost three times as many as in 2018 (**fig. 2**). Electric buses represented 6% of new bus registrations in Europe in 2020 according to the European Automobile Manufacturers' Association.[14] Denmark, Luxembourg and the Netherlands lead the way, with respectively 78%, 67% and 66% of their total bus fleet now running on electricity. Next come Sweden, Norway and Finland where 26%, 24% and 23% of buses, respectively, were electric in 2019.[15] A study of the city of Trondheim (Norway) published in 2021 shows that the conversion of some of its fleet to biofuel or electricity led to a 37% reduction in the carbon footprint of the entire fleet.[16] In Latin America, numerous cities have also embarked on electrifying their bus fleets: Bogotá purchased 406 electric buses in 2020 (**see Bogotá case study**), and Mexico bought 193.[17] In the Caribbean, the island of Barbados (300,000 inhabitants) has put 33 electric buses into circulation in its capital, Bridgetown.[14] In Africa, efforts to electrify bus fleets have been observed in South Africa,[18] Uganda[19] and Egypt.[20]

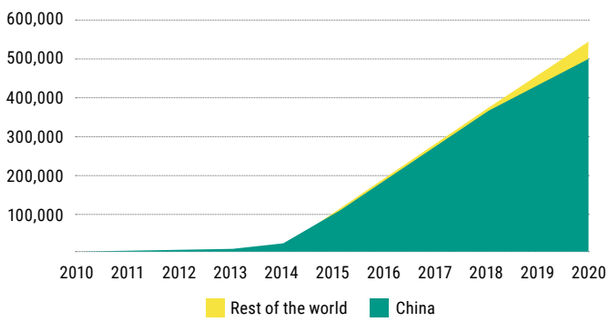
The electric bus market is largely dominated by Chinese manufacturers, and in particular BYD, one of the global leaders in lithium-ion batteries. The manufacturer produces most of the electric buses operating in developing countries, and occupies 20% of the European market.[21] In August 2021, for

example, BYD delivered 76 new electric buses to the Finnish operator Nobina, fulfilling the biggest order in the country, for a total of 119 vehicles.[22] The Chinese company also provided South Africa with its very first electric buses in the city of Cape Town.[23] In 2022, a protectionist law voted under the Trump administration in 2019 is due to come into force in the United States, prohibiting the use of federal funds to purchase buses, cars and trains from companies connected to a state. The measure in particular targets BYD and the Chinese locomotives manufacturer CRRC, both of which benefit from state aid to establish new battery production factories, according to a report by the American Congress, whose main conclusions are contested by BYD. While it is likely to give a boost to national manufacturers, like the Californian company Proterra, the measure could make it harder for the US to achieve its objective of electrifying 70,000 buses in the next eight years.[24]

FIGURE 2

GLOBAL ELECTRIC BUS FLEET, 2010 TO 2020

Source : Data compiled by the author from the Global EV Data Explorer, IEA, 2021



Lastly, after a peak in 2014 followed by a rapid decline, interest in Bus Rapid Transit (BRT) systems seems to have picked up since 2018. These bus lines can transport large numbers of passengers at high frequencies thanks to dedicated lines and infrastructure, coupled with specific amenities (e.g. priority systems at traffic lights and roundabouts). Nine new systems were put into service in 2019 and 2020, including in Salvador (Brazil), Fuzhou and Yongzhou (China), Peshawar (Pakistan) and Albuquerque and Oakland (USA). Some electric BRTs have been installed in France, in towns like Amiens and Bayonne.

Thus, the pandemic does not appear to have broken the trend of bus electrification, or discouraged municipalities from deploying BRT networks. In parallel, the crisis has considerably accelerated the development of individual mobilities other than public transport, and in particular the bicycle.

In the city, bikes have moved up a notch

At the start of the first lockdown measures to curb the pandemic, numerous cities put forward the bicycle as an ideal alternative to public transport, perceived as a potential hotbed for virus transmission.

From early 2020 and the start of the first anti-Covid measures, 1,800 cities in the world set up temporary infrastructure for cyclists and walkers, closed roads, or established other measures to encourage people to move around by foot or bike.[2] The European Cyclists' Federation (ECF) reports announcements of 2,591 km of infrastructure suitable for cycling on the european continent since March 2020, 1,466 km of which have already been installed (**fig. 3**). Most of them (77%) are bike lanes, and the remainder are lanes with reduced traffic (18%), or prohibited to cars. For example, the city of Lyon (France) has announced investments of 320 million euros to develop soft mobility up to 2026, which includes creating over 1,700 km of cycle lanes, and lending 10,000 second-hand bicycles to young people aged 18 to 24.[25]

In 2020, Zurich and Lisbon joined the CDF's Cities & Regions for Cyclists (CRC) network, the aim of which is to develop the use of bicycles in cities. These new memberships bring the total to 37 members from 19 countries, representing over 40 million inhabitants.[26] Bicycle infrastructure is starting to emerge on the African continent too, like in Nairobi (Kenya), which in 2015 committed to allocating 20% of its road infrastructure budget to non-motorized transportation,[27] a challenge undoubtedly facilitated by the nomination of a Bicycle Mayor responsible for developing cycling in the city. Following the election of Anne Luten in Amsterdam in 2016, this position now exists in 109 cities in the world, four of them in Africa (Nairobi, Gaborone, Cape Town and Kampala).[28] In 2019, Addis Ababa (Ethiopia) adopted a strategy to promote non-motorized transportation including the construction of 200 km of cycle paths.

Decreasing the maximum authorized speed not only makes public areas less frenetic and reduces the risk of fatal accidents, it also creates a more suitable environment for bike riding. In Spain, measures to limit car speeds established in Bilbao and Barcelona a few years ago, and Madrid, Valencia and Seville more recently, along with petitions by several municipalities and the Federación Española de Municipios y Provincias (FEMP) aimed at reducing road deaths, have encouraged the government to legislate in the same direction. Since 11 May 2021, 70% to 80% of Spanish roads have been limited to 30km/h. Starting from 30 August 2021, most streets Paris are now also limited to 30 km/h,[29] along with 250 towns in France.[30]

All of these measures helped encourage the bike boom when the first lockdowns came to an end. Bicycle sales increased by 25% in France in 2020, 45% in the United Kingdom, and 65% in the United States.[31] Measures like the "*coup de pouce*" program in France offering a 50 euro government voucher to repair a bike have also encouraged users to get their old bicycles out of the shed. Sales of electric bikes have shot up too. In 2020, they went up by 29 % in France[32] and by as much as 145% in the United States.[33] Purchase support programs set up by cities like Paris, Vienna, Guernsey and Madrid have certainly fuelled the trend. Electric bicycles are also increasingly used to deliver merchandise: 100,000 "cargo bikes" have been sold each year since 2018 in Europe, 11,000 of them in France in 2020 (+354% in a year).[34]

In addition, bicycles are riding on the micromobility wave that was further accelerated by the pandemic: the market included about 20 million vehicles in 2020, and is set to increase

by another 10% per year until 2025.[35] The sector is largely dominated by bicycles (98% of the fleet of shared vehicles in circulation), either organized into depot stations (often via cities) or free-floating (no stations). The *bikesharingblog* lists 1,882 bike-sharing systems (with and without stations) in the world, mostly concentrated in Europe, East Asia and North America.[36] In China, stiff competition between different market players keen to get on the bike-sharing bandwagon in the last few years has led to numerous bankruptcies, and seen thousands of bicycles abandoned at gigantic dumps.[37]

As observed last year, the concentration of the free-floating bike-share market between the hands of a few players has extended to motorcycles, triggering for example the recent bankruptcy of the American pioneer Skip, and Unicorn, as well as buyouts of Spin by Ford and Boosted by Lime.[38] At the same time, Bird,[39] the market leader, and Helbiz[40] have gone public with the aim of upscaling. In the face of this rapid proliferation, numerous cities have had to put rapid security measures in place, like in Paris, where the maximum speed limit for electric scooters is due to drop to 10 km/h in some areas.[41] Globally, short life cycles (under 30 days on average for an electric scooter[42]) and modal shifts that benefit soft and public urban mobilities less than cars raise serious doubts about the benefits of this equipment for the climate and the environment. A study carried out in the summer of 2019 in Paris showed that only 7% of kilometres covered by a scooter replaced a car, compared to two-thirds for public transport and one quarter for cycling and walking.[43]

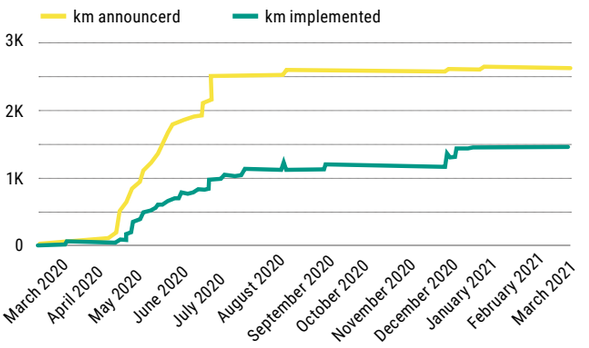
Coupled with decreased production caused by lockdowns, this hike in bicycle sales and usage has resulted in shortages of parts and longer delivery times. Like all players in the sector, Accell, the biggest European bicycle group, has seen demand soar for every type of bike (road, racing, electric, etc.), leading to tensions in supply chains for all parts. As a result, delivery times have become longer, ranging from a few weeks to several months. In September 2021, delays for some parts were still as long as 540 days.[44] The sector is particularly dependent on a few groups that hold a tight monopoly on some parts, most of them with production units in Asia. Delivery is therefore dependent on the successive availability and lack of availability of parts (frames, forks, brakes, derailleurs, tires, wheel rims, etc.) and the main suppliers (Shimano, Tektro, SRAM, Fox, Suntour, etc.), periodically interrupted by waves of lockdowns and closures of Asian factories. The new restrictions imposed in Southeast Asia in August 2021 herald new complications in the following months.

In particular, the Japanese company Shimano concentrates 65% of the global market for sprockets, cogs and brakes. Faced with demand up to 40% higher than in previous years,[45] the company is subject to a bottleneck along the entire chain, requiring up to 400 days to deliver some parts[46]. Anticipating that this high demand will persist, Shimano has invested 180 million dollars in extending its production capacities in Singapore.[47] Some market players are nevertheless concerned that the boom will quickly dry up and undermine a market that has organized itself to hike up production.[42] Consumers' frustration at having to wait up to several months to obtain parts could also dampen their enthusiasm. However, the durability of cycling infrastructure and investments in equipment could have the effect of sustaining these new user practices over time.

FIGURE 3

NUMBER OF KILOMETRES OF CYCLE LANES ANNOUNCED (YELLOW) AND INSTALLED (BLUE) IN EUROPE SINCE MARCH 2020

Source : European Cyclists' Federation



Imbalanced public investments in bicycles could accentuate two-tiered mobility

The bicycle is often described as a democratic, socially just means of transport. This is because it is one of the cheapest transport modes, both for municipalities and households, and is used more by the poorest households.[48] Promoting cycling could therefore be a way to reduce inequalities.

Yet public investments in the bicycle tend to concern town centres, inhabited by the wealthy, bringing the risk of accentuating social inequalities. In the United States, the urban geographer John Stehlin has shown that the development of cycling in Detroit, Philadelphia and San Francisco has gone hand in hand with gentrification, and deepened space, gender and race divisions.[49] In France, figures published by the national statistics institute (INSEE) show that some bicycle usages are correlated with the level of education: to get to work, PhD holders are one and a half times more likely to use a bike than holders of a Master's degree, and three times more than those with only a high-school diploma[50] (however, they are more likely to work from home[51]). Often, the emerging trend for cycling among the upper classes is coupled with that of a more precarious population that sees the bike as a cheaper means of transport.

Similar criticisms have been made about measures to make public transport free of charge. In the United States, for example, numerous municipalities made their public transport systems free during the pandemic, and pilot programs are due to start in New York, Chicago and Los Angeles to sustain this measure.[52] In France, 35 cities, four of them with more than 100,000 inhabitants, have established free public transport.[53] For example, in Dunkerque, the free transport initiated in 2018

has allowed at least 50% of users to take the bus more often, and 5% of them have even stopped using their cars, or decided not to buy a second one.[54] Estonia became the first country to make all public transport free in 2018, and Luxembourg followed suit in March 2020. But this free transport tends to benefit people living in town centres, who are generally better off and have easier access to public transport. It also requires considerable financial resources, which are diverted from other issues just as important for users (punctuality, access for people living on the outskirts of cities, etc.).[47]

Lastly, in general, men use bikes more than women. In Bogotá, only 24% of cyclists are women, and the proportion is similar if not worse in other cities in Colombia.[55] One of the main reasons is serious security problems on the road, where motorized vehicles still constitute a threat, street harassment is common, and the risk of theft is high. Bogotá has committed to attain gender parity for bicycle usage.

Setting up cycling infrastructure can be a way of counterbalancing these inequalities. The city of Los Angeles has invested in a number of cycling infrastructures, leading to a 22% increase in bike use since 2017. While women only represent 16% of bicycle users in the city, the number of female users of bicycle doubles in streets with cycle lanes.[56] In New Delhi, public transport was made free of charge for about one million women in 2019.[1]

KEY TAKEAWAYS

Two years after the start of the Covid-19 pandemic, the impacts of lockdowns are still putting pressure on the organization of urban transportation and mobility, while benefitting established companies. With the drop in their revenues, transport operators have had to adapt to a slow rebound in usage. Nevertheless, the electrification of buses continues and, having conquered China, is entering new markets in Europe and Latin America, led by the omnipresent manufacturer BYD. As the key measure marking the resilience of urban mobility, the bicycle is starting to pay the price of its success generated by soaring demand and municipal investments in cycling infrastructure. All around the world, bicycle users and sellers are having to cope with long delivery times and shortages of spare parts, in a market with only a few manufacturers. This market concentration can also be observed among emerging companies in the free-floating sector, dominated by a handful of players that are moving into a growing number of urban areas and absorbing their smallest competitors.

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IDEAS

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

Ride-hailing • Uber and Arrival: in partnership to develop electric ride-hailing

The ride-hailing giant Uber has tied up with British start-up Arrival to design a new electric vehicle (EV) model to go into production in 2023. The American ride-hailing platform aims to have a 100% electric fleet in London by 2025, before extending this goal to North America and Europe by 2030. Other such partnerships have been launched by Uber as part of its Clean Air Plan, which includes a grant to help London drivers convert to electric. The Uber Green option also allows for the specific ordering of an EV at no extra cost.

AFP, 04/05/2021

Rail • Egypt to get a "Suez Canal on rail"

Egypt has signed a contract for its first high speed rail line, for freight and passengers, with a consortium composed of Arab Contractors, Orascom Construction and Siemens Mobility. The three lines of the 1,825 km network will connect the port cities of Ain Sokhna on the red sea, and Marsa Matrouh and Alexandria on the Mediterranean. The total value of the contract is estimated at $4.5 bn, of which $3 bn is secured by Siemens Mobility. The German group is set to start delivering these trains from 2023.

Journal de la Marine Marchande, 02/09/2021.

Rail • In Europe, night trains see the light of day

This year being the European Year of Rail, night trains are making their comeback on the continent. On 27 June 2021, the first train to link Stockholm, Copenhagen and Berlin since the 1990s entered service. By the end of the year, the Paris-Munich-Vienna line is due to return, and the Paris-Berlin line from 2023. Spring 2022 will see the appearance of the Brussels-Liège-Berlin route via the Moonlight Express, while the young Dutch start-up European Sleeper has ambitions to run a night train from Brussels to Prague, serving stations in Amsterdam and Berlin. Meanwhile, Finnish rail operator VR has announced the purchase of 17 new trains for its night train services. The current fleet consists of 80 sleeping cars, and 33 car-carriers.

Electronics • From iPhones to electric vehicles: Foxconn shakes up the automobile market

Foxconn, the world's largest manufacturer of electronic products and a subcontractor to many consumer electronics firms including Apple, is entering the EV market. The Taiwanese firm first launched Mobility in Harmony (MIH) in October 2020, an open industrial R&D platform that now brings together over 1,200 companies. This was followed by a joint venture, Mobile Drive, to produce intelligent cockpits in partnership with Stellantis, the new automobile group resulting from the merger between Peugeot S.A. and Fiat Chrysler Automobile. In a context of electrification of automobiles, shortages of semiconductors, and a stock market fever around strategic metals, Foxconn has multiplied its strategic partnerships with players in the automotive sector in recent months.

Financial Times, 17/05/2021

Bicycles • Eco-Counter and GéoVélo aim to improve data on cyclists' movements

As cycling has exploded worldwide since the beginning of the pandemic, local authorities are organising themselves to manage the influx of new cyclists and ensure their safety on the roads. Eco-Counter, the world leader in bicycle and pedestrian counting devices, and GéoVélo, the French navigation application for cyclists, are joining forces to help local authorities refine data on cyclists' behaviour in cities and ensure better traffic management. The combination of GéoVélo's GPS tracks and Eco-Counter's traffic counts at strategic points in the city will allow the extrapolation of data on traffic speeds, trips taken and distances travelled.

Traffic Technology Today, 08/09/2021

Hydrogen • Industrialists try to catch up with Alstom in the development of hydrogen trains

In the European race for hydrogen trains, French giant Alstom is ahead of the game. Coradia iLint, its fuel cell train, is expected to run on several sections in Germany, France and possibly even Poland before 2025. Siemens also intends to position itself in the race. In partnership with the operator Transdev and the province of Bavaria, the German giant has announced plans to run its Mireo Plus train, equipped with a fuel cell and a battery produced by Saft (part of the TotalEnergies group), on the Augsburg-Füssen line by 2023. In Spain, hydrogen producer Repsol and railway equipment manufacturer Talgo have also signed an agreement to develop green hydrogen trains.

H2 mobile, 20/05/2020

United States • EV owners suffer in Connecticut

The state of Connecticut has rejected the EV Freedom Bill, which sought to lift the ban on direct sales of EVs in the state. Championed by owners' associations such as Tesla Owners Connecticut, who are often keen on heavy-duty segments such as electric Hummers, the proposed legislation was opposed by car dealers. In 28 US states, EV registration fees are higher than for internal combustion vehicles; 17 states prohibit direct sales to individuals within their borders, who must travel to a neighbouring state or have it delivered by a third party. In the name of justice, Texas is seeking to tax EV owners to make them contribute to the fuel tax (which they do not pay by definition) and which feeds the state's investment funds for road infrastructure.

Clean Technica, 20/06/2021

Just Transition • Near Toulouse, aeronautics employees think of a future without planes

In June 2020, employees from Airbus, Safran and Thales created the Icare collective (after Icarus), in order to think about the just transition of jobs in the sector, if it were to decrease in the face of the climate emergency. Working for the decarbonization and diversification of the sector, the employees took part in a wider reflection within the collective *Pensons l'Aéronautique de Demain* (PAD), which brings together local residents, students, economists and unionized employees. In a survey conducted by the CGT Aéronautique union in June 2020 among 1,200 Airbus employees, 78% of respondents felt it was necessary to diversify the group's activities and reduce the Toulouse region's dependence on the aeronautics industry. PAD and Icare are collaborating with NGOs such as Greenpeace and the Climate Action Network to develop concrete solutions to these demands.

Mediapart, 09/06/2021

CASE STUDIES

CITY CASE STUDY

COUNTRY	CITY	POPULATION	EMISSIONS REDUCTION TARGET	CO_2 EMISSIONS FROM TRANSPORT IN 2018
JAPAN	TOKYO	14,000,000	-50% GHGs FROM TRANSPORT BY 2030 (BASE 2000); NET ZERO BY 2050	9.64 $MtCO_2$

Hydrogen fuels the flame of the Tokyo Olympic Games

In 2017, Japan was one of the first countries to adopt a national hydrogen strategy in which mobility is the core concept. In two years, the government has doubled its investment in hydrogen research and development to $300 million. Japan has set a target of putting 320 hydrogen stations and 200,000 fuel-cell electric vehicles (FCEVs)[a] into operation by 2025. As of 2020, 116 hydrogen stations were already operational across Japan.

Japan's national 'hydrogen economy' project

In Tokyo, mobility accounts for 17% of total CO_2 emissions, 80% of which is from road transport. Transport emissions in Tokyo have already decreased by 45% between 2000 and 2018. As part of its Zero Emission Strategy, the Tokyo Metropolitan Government (TGM) wants to establish 150 hydrogen stations by 2030. To this end, it has established the Research Centre for a Hydrogen Energy-Based Society (ReHES) at Tokyo Metropolitan University, which brings together multi-sectoral researchers to develop a hydrogen-based society. In 2020, the Fukushima Hydrogen Energy Research Field (FH2R) launched the world's largest green hydrogen[b] production project. A collaboration between the New Energy and Industrial Technology Development Organization (NEDO) and Toshiba Energy Systems & Solutions Corporation, Tohoku Electric Power and Iwatani, the 10 MW project uses 20 MW of solar power generation capacity on a 180,000 square meter site. The project was partly used to supply energy for the Olympic Games this year, and is expected to generate 200 tonnes of green hydrogen each year.

The 2021 Olympics as the start of a "hydrogen society"

The 2020 Summer Olympic and Paralympic Games Organising Committee has set itself the goal of supplying the Games with 100% renewable electricity, and of having them contribute to the creation of a "hydrogen economy" in the long term. The TMG has therefore set up a ¥40 bn (~$360 mn) fund to support efforts leading up to the Games. As an official partner of the Games and the world leader in FCEVs, Toyota has provided a fleet of 500 Mirai models, identical to the one used at the International Olympic Committee's headquarters in Switzerland, to help transport staff between the different parts of the Olympic site. To fuel these vehicles, the TMG has set up 35 hydrogen stations around the city. Some of the Olympic flames and cauldrons were co-combusting with the hydrogen and propane normally used. During the Olympics, hydrogen produced in the FH2R is also used to power the Relaxation House; after the Games, the village is to be transformed into a hydrogen-powered mini-community, including flats, a school and shops.

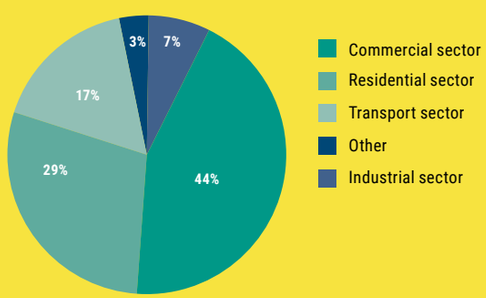
However, despite the efforts made, the Olympic Games, which were initially intended to demonstrate the potential of hydrogen, highlighted the fragility of this energy, whose initial investment costs remain high. Of the 100 Sora buses (with a capacity of 79 passengers) that were supposed to transfer athletes and visitors, only a few were able to be put into service, and on shorter routes than those originally planned. This is because installing a hydrogen refuelling station costs about five times as much as a conventional refuelling station, while a fuel cell bus as supplied by Toyota costs four to five times as much as a diesel bus and has a much shorter lifespan. Reducing costs to increase the competitiveness of hydrogen remains a major challenge at the moment and Japan is trying to stimulate interstate cooperation to create an international supply chain.

a Mobility is said to be "clean": in the fuel cell, hydrogen reacts with oxygen to produce a stream of electricity, releasing only water as a waste product.

b Produced by electrolysis using renewable energy .

CO_2 EMISSIONS PER SECTEUR IN TOKYO IN 2018

Source : Tokyo Metropolitan Government, 2021



CITY CASE STUDY

COUNTRY	CITY	POPULATION	EMISSIONS REDUCTION TARGET	EMISSIONS IN 2017
COLOMBIA	BOGOTÁ	7,000,000	-15% BY 2024; -50% BY 2030; CARBON NEUTRALITY IN 2050	11.4 $MtCO_2$ (SCOPE 1 + 2)

Soft and electric mobility: the transformation of Bogotá's transport system

In April 2021, the municipality of Bogotá presented a 2020-2050 Climate Action Plan (CAP), with the aim of becoming carbon neutral by 2050. To support this plan, says the mayor, *"the best investment […] is to base our Mass Transport System on an electric, free, clean, sustainable network, not only urban but also regional"*. In 2017, transportation accounted for 48% of the city's emissions. With 133 annual hours wasted driving and an average speed of 17 km/h in the last kilometre, Bogotá is the most congested city in the world. In order to restrict car use, the speed limit in the city was recently reduced to 50 km/h. Among other things, the CAP aims to reduce kilometres travelled by vehicles by 5% in 2030 and 10% in 2050, and is considering urban planning measures to reduce distances, and thus transport demand around new developments. The Colombian capital has been very active in transforming mobility in the city for several years now.

Electrification of the TransMilenio

Bogotá now has the largest Bus Rapid Transit (BRT) network in the world, operated by TransMilenio. However, the network has major service and pollution problems: 87% of Bogotá's TransMilenio users say they are dissatisfied with the service. While waiting for the city's first metro line, which has been on the table for 77 years and on which work finally began in 2020, Bogotá is working to electrify the TransMilenio network.

As per its CAP, Bogotá plans to convert 100% of its BRT bus fleet to electric (50% by 2030). Since 2019, the city has placed numerous public orders for electric buses, mainly won by the Chinese manufacturer BYD, which is active throughout the continent. Today, more than 5% of the city's bus fleet is electric (484/9,003). With the latest tenders, BYD should have at least 1,472 e-buses in Bogotá by 2022, reducing emissions by 83,433 tCO_2 per year. Another €874 mn contract has been signed between TransMilenio and the Transdev group for the operation and maintenance of 406 e-buses from November 2021.

A pioneer cycling policy

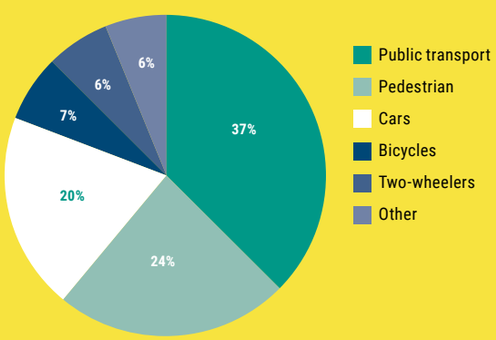
With a 7% modal share, cycling is an important choice for mobility given Bogotá's urban density. The city has over 600 km of cycling infrastructure. Launched in 1974, the "Ciclovía" car-free Sunday brings together 2 million people every weekend on a network of 127 km of streets closed to car traffic. Bogotá was also among the first cities in the world to open more than 80 km of temporary lanes to promote cycling during the lockdown, reaching up to 16% modal share by summer 2020. More than 20 TransMilenio stations now offer free bike parking, promoting multimodal integration. While only 24% of the city's cyclists are women, Bogotá is also committed to achieving parity in cycling.

In partnership with the C40 Cities Finance Facility and the cities of Medellin, Cali and Monteria, Bogotá is also running a bike-share system project.

With the support of the World Bank, the Secretariat of Mobility launched the Bicicarga project at the end of 2020, aiming to equip 10 freight companies and 5 logistics operators with electric tricycles to reduce congestion, accidents and air pollution generated by freight in the last few kilometres of delivery. Already in 2019, the municipality had provided 89 electric tricycles to recycling organisations, allowing them to load up to 300 kg.

SHARE OF TRANSPORT MODES IN BOGOTÀ

Source : Alcaldía de Bogotá, 2019



CITY CASE STUDY

COUNTRY	CITY	POPULATION	EMISSIONS REDUCTION TARGET:	TRANSPORT EMISSIONS IN 2016
SENEGAL	DAKAR	3,938,358	'LOW CARBON' BY 2050	1.058 $MtCO_2e$

Dakar: Decongesting traffic to meet the challenge of sustainable urban mobility

Dakar is home to 25% of Senegal's population, while occupying less than 0.3% of the territory. The transport sector is responsible for more than one million tonnes of CO_2e, i.e. , around 40% of the city's total emissions. These emissions are linked, among other things, to the age of the car fleet (80% of cars are more than 5 years old) and to fuel consumption. Road transport accounts for 99.8% of the sector's total emissions, of which 14% can be attributed to public transport. Emissions from rail transport are estimated at 0.2%, or 1,100 tCO_2e, of which 78% is produced outside the city. Therefore, to mitigate emissions from the sector, the city is working towards Transit-Oriented Development (TOD).

In a context of rapidly accelerating urbanisation of the Dakar agglomeration, increasing traffic congestion and the intermingling of powers between local actors and institutions, the city created the Executive Council of Urban Transport of Dakar (CETUD) in 1997. Endowed with an Urban Transport Development Fund, CETUD's mandate is to implement and monitor the application of the sectoral urban public transport policy for the Senegalese region. Today, 80% of motorised journeys in Dakar are made by public transport; nevertheless, the multiplication of public transport actors and operators — the public operator Dakar Dem Dikk, the operators of the *Association de Financement des Professionnels du Transport Urbain* (AFTU), the small-scale minibuses Cars Rapides and Ndiaga-Ndiaye, and the "clando taxis" [a] — as well as rapid and uncontrolled urbanisation have all made the public transport network disorganised.

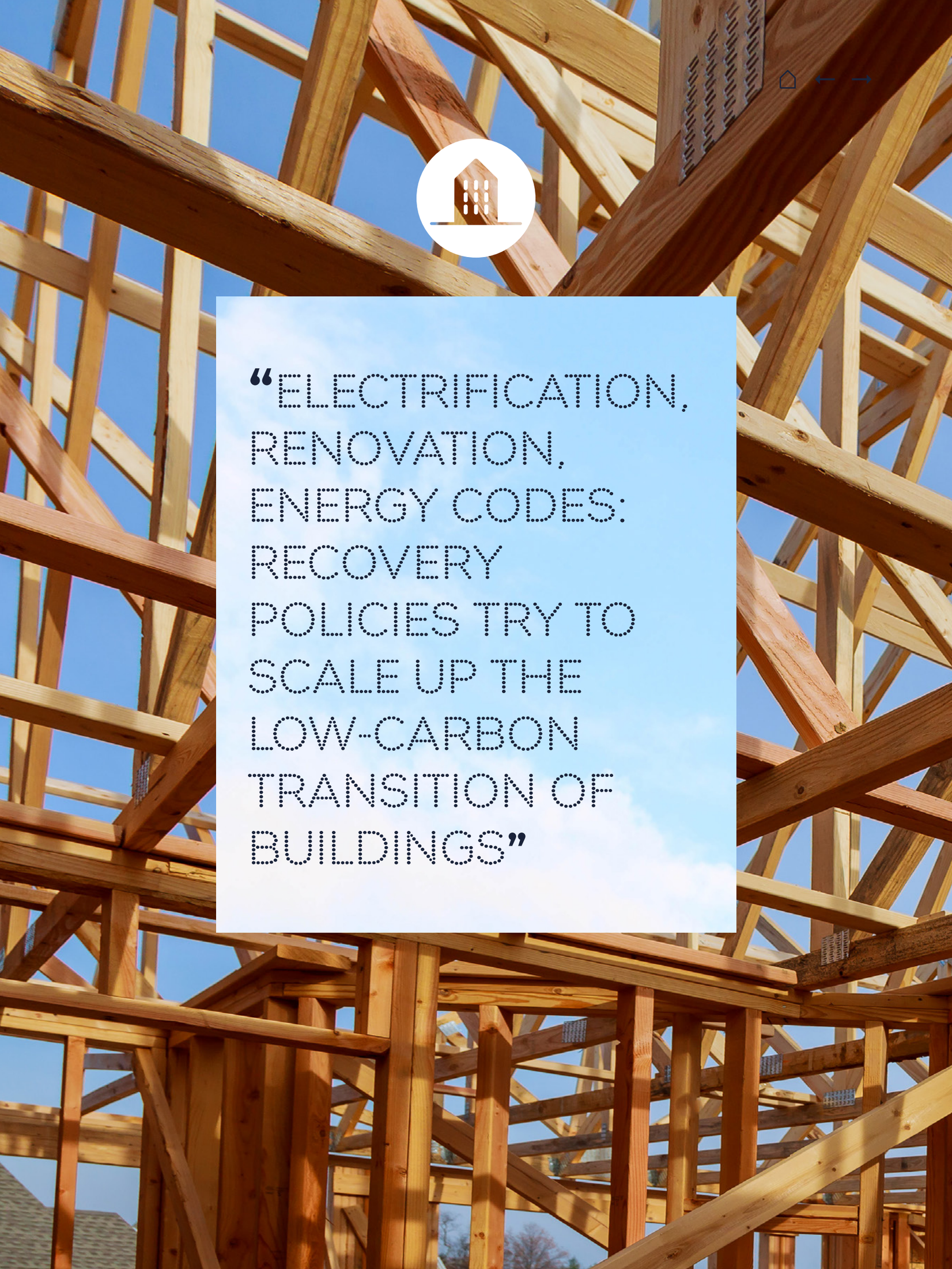
Restructuring the public transport network for sustainable, resilient and inclusive mobility

In 2003, the AFTU was created by the Senegalese government to "upgrade the artisanal sector": in partnership with CETUD, and supported by the World Bank's PAMU (*Programme d'Amélioration de la Mobilité Urbaine* — Programme to Improve Urban Mobility) and PATMUR (*Projet d'Amélioration de la Mobilité Urbaine* — Project to improve Urban Mobility), several programmes have been implemented to train and professionalise the actors of the artisanal transport sector — operators, drivers and conductors, controllers and route supervisors.

To address road congestion and reduce greenhouse gas emissions, CETUD developed a Dakar Urban Transport Plan (PDUD) in 2007, which was replaced in 2020 by the Sustainable Urban Mobility Plan (PMUS) for 2035. In May 2017, the city of Dakar joined the Mobilise Your City network, thanks to which it benefits from technical and financial support aimed at accompanying CETUD in the revision of the 2007 PDUD. This support is financed by the French Global Environment Facility and implemented with the support of the French Development Agency.

However, the implementation of urban services is struggling to keep up with the sustained pace of urbanisation. Created in 1987, the *Petit Train de Banlieue* now carries 15,000 passengers a day, but it still does not play its role as the "backbone" of public transport in Dakar. Therefore, two structural projects are underway to relieve traffic congestion: the Regional Express Train (TER) and the Bus Rapid Transit (BRT). The TER aims to provide the Dakar agglomeration with a rapid mass transit rail system, and to carry passengers from Dakar station to the new urban hub of Diamniadio (phase 1) and to the Blaise Diagne International Airport (phase 2). The cost of the project is estimated at €1 billion, with financing from the Islamic Development Bank, the African Development Bank, AFD and Bpifrance. Once Phase 1 is commissioned, scheduled for the end of 2021, the TER will carry 110,000 passengers per day and is expected to reduce greenhouse gas emissions by 19,000 t/year. From 2022, the BRT, financed by the World Bank and the European Investment Bank, should carry 300,000 passengers thanks to a fleet of 144 articulated buses on 18 km of reserved lanes.

a In some areas of Dakar, the lack of inter-city transport has encouraged the emergence of clandestine taxis, commonly known as "taxis-clandos", which are faster and cheaper than traditional taxis.



“ELECTRIFICATION, RENOVATION, ENERGY CODES: RECOVERY POLICIES TRY TO SCALE UP THE LOW-CARBON TRANSITION OF BUILDINGS”

The pandemic and subsequent activity restrictions have significantly changed the use of buildings: their "operational" emissions, arising from energy use, which account for more than a quarter of global emissions, have fallen by almost 10% (from 9.6 $GtCO_2$ in 2019 to 8.7 $GtCO_2$), mainly due to the reduction in use of non-residential buildings. Construction emissions have been even more affected: from 3.6 $GtCO_2$ in 2019, they have dropped by 15%, to 3 $GtCO_2$ in 2020 **[INDICATORS]**. However, after these initial shocks, the construction and renovation sector saw a rapid rebound in late 2020 and in 2021 in many countries, boosted by the recovery plans that followed the initial impacts of Covid-19. In the G20, at least 44 billion dollars have been allocated to the construction sector in the recovery plans. Overall, the construction market is expected to grow by 5.7% in 2021.

From a climate and energy standpoint, this sector is still only weakly regulated. Firstly, emissions from the industries that manufacture the primary materials for buildings are often counted separately, and the codes that govern new constructions rarely include provisions on the embodied carbon in these materials. Some initiatives are emerging, particularly in Europe and the US, to try to control the carbon impact of the construction phase **[TRENDS]**. The development of the bio-sourced materials sector and pilot projects for bioclimatic buildings are opening up new possibilities **[SIGNALS]**.

The International Energy Agency's roadmap for achieving carbon neutrality by 2050 relies mainly on two factors for the decarbonisation of the final energy consumption of buildings (once they are built): increased energy efficiency and electrification.

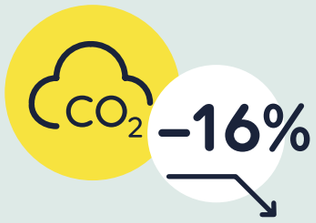
Renovation, a major theme of the recovery in G20 countries where most of the built environment of 2050 already exists, is trying to scale up up with the help of major strategic plans such as the European Union's Renovation Wave or the Build Back Better Act in the US **[TRENDS]**.

However, energy efficiency gains, through improved equipment performance or renovation, are not sufficient to offset the increase in energy demand. In particular, the regulation of building temperatures, whether for heating or cooling, still depends very heavily on fossil fuels, often gas, but also coal, thus adding not only to CO_2 emissions, but also to dangerous air pollution, as is particularly prominent in Ulaanbaatar **[CASE STUDIES]**.

Electrification could help to decarbonise the hard-to-abate energy demand, provided that it is coupled with a strong expansion of renewables. In particular, the deployment of heat pumps makes it possible to envisage the rapid electrification of heating systems. However, where the political will is strong, as in many Californian cities, the resistance of gas companies is just as strong and is slowing down the movement **[TRENDS]**. Electricity is already widely used to regulate the temperature of buildings: in total, the 1.75 billion air conditioners in 2019 were responsible for 8.5% of the world's final electricity consumption and the direct or indirect emission of 1 $GtCO_2e$. In an attempt to reverse this trend, fifth-generation district heating and cooling networks are being created **[TRENDS]**, particularly in the Middle East and in Europe, as in the case of Heerlen in the Netherlands **[CASE STUDIES]**. From reflective paints to the use of heat from data centres, there is no shortage of innovations to adapt heating and cooling needs to the new conditions of climate change **[SIGNALS]**.

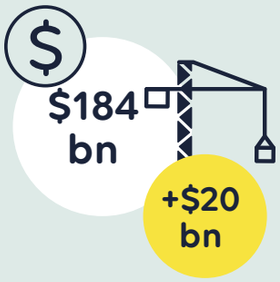
THE BUILDING SECTOR IS UNDERGOING A RENEWAL, BUT ITS FOUNDATIONS REMAIN CARBON-INTENSIVE

After the shock of the pandemic, construction picks up at full speed



A DROP IN EMISSIONS FROM THE CONSTRUCTION SECTOR IN 2020

This drop was mainly due to the slowdown in activities to stop the spread of the Covid-19 pandemic. *GABC, 2021*



A GLOBAL INCREASE IN INVESTMENTS IN BUILDING RENOVATIONS IN 2020

This increase of 20 billion dollars is almost entirely driven by Europe, and particularly by Germany, where the public bank KfW doubled its energy efficiency programme (from 15 to 30 billion euros).

IEA, 2021

Often counted separately, emissions linked to construction are being increasingly integrated into the Building sector

SHARE OF THE BUILDINGS AND CONSTRUCTION SECTOR IN GLOBAL ENERGY-RELATED EMISSIONS IN 2020

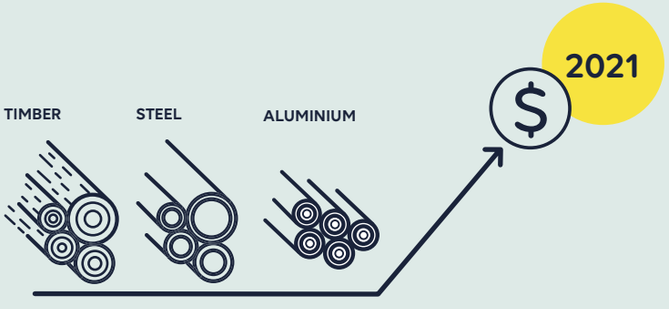
In absolute terms, these emissions fell by around 10% (from 13.2 $GtCO_2e$ to 11.8 $GtCO_2e$) in one year, due to Covid-19. Their share in global emissions, however, remained stable. *GABC, 2021*

GHG EMISSIONS FROM THE BUILDINGS AND CONSTRUCTION SECTOR IN 2020 (IN $GTCO_2E$)

- CONSTRUCTION
- DIRECT EMISSIONS (MAINLY FROM HEATING)
- INDIRECT EMISSIONS (MAINLY FROM ELECTRICITY)

INCREASE IN THE PRICES OF CONSTRUCTION MATERIALS

The recovery has led to disruptions in the supply of many construction materials. As a result, after slight price drops in the first half of 2020, strong price inflations have been observed: between June 2020 and May 2021, the price of wood has quadrupled, and those of steel and aluminium have doubled. *Trading Economics, 2021*



NUMBER OF COUNTRIES IN EUROPE INTEGRATING A LIFE CYCLE ANALYSIS APPROACH IN THEIR BUILDING REGULATIONS

This approach allows for the integration of emissions due to the construction of buildings. *GABC, 2021*

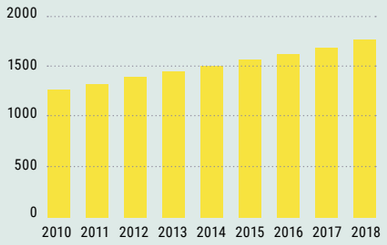
Electricity gains ground in the heating and cooling of buildings

1.76 billion

GLOBAL AIR CONDITIONER STOCK IN 2018

In total, in 2018, 1.76 billion air conditioners were responsible for 8.5% of global final electricity consumption, and direct or indirect emissions of 1 $GtCO_2e$. *IEA, 2019*

NUMBER OF AIR CONDITIONERS IN MILLIONS OF UNITS



+50 million

AN INCREASE IN THE NUMBER OF PEOPLE LACKING ACCESS TO COOLING

The combined effects of the Covid-19 pandemic and heatwaves in 2020 have exposed an additional 50 million people to a lack of cooling. *SEforAll, 2021*

11.7%

SHARE OF ELECTRICITY IN THE MEETING THE HEATING DEMAND OF BUILDINGS IN 2019

10 years previously, this figure was only at 9.6%. At the same time, the share of electricity generated from renewables in the heating of buildings has doubled. *REN21, 2021*

+5% EUROPE **+6%** CANADA **+10%** UNITED STATES

THE EXPANSION OF THE MARKET FOR HEAT PUMPS IN 2020

In contrast, government support for gas-fired boilers to replace coal-fired heating has slowed the heat pump market in China in 2020. *REN21, 2021*

49 CALIFORNIA

NUMBER OF CITIES IN CALIFORNIA THAT HAVE ADOPTED MEASURES SUPPORTING THE ELECTRIFICATION OF HEATING IN NEW CONSTRUCTIONS

In August 2021, Fairfax became the 49th Californian city to adopt a measure supporting electrification or prohibiting gas in new buildings. *Sierra Club*

Regulating the new, renovating the old: the challenge of large-scale decarbonisation of buildings

3.57 bn m^2 **+20%**

SURFACE AREA CERTIFIED BY MEMBERS OF THE WORLD GREEN BUILDING COUNCIL

This is 20% more than in 2019, and three times more than in 2018. This figure includes reference programmes for energy efficiency in buildings, such as the LEED certification created by the US Green Building Council, or the French HQE certification.

World GBC, 2021

5,175

NUMBER OF PASSIVE HOUSES

The Passive House Database lists 5,175 passive houses, buildings whose structure, orientation, insulation and airtightness allow them reduce their energy requirement.

Passive House Database

336

NUMBER OF CITIES REPORTING THE IMPLEMENTATION OF BUILDING EMISSIONS MITIGATION TO CDP

These actions include renovation, adoption of energy codes, standards or regulations for construction or renovation, or even a programme for reporting emissions. *CDP, 2021*

$44 bn

AMOUNT IN THE G20'S RECOVERY PLANS DEDICATED TO THE BUILDING SECTOR

At least 44 billion dollars are dedicated to the building sector in the recovery plans of the G20 countries. Nearly 60% of these are"green" investments, according to Energy Policy Tracker.

Energy Policy Tracker, 2021

TREND
ELECTRIFICATION

US Cities Embark on an Anti-Gas Battle to Electrify Buildings

SAMUEL LAVAL • Research Officer, Climate Chance Observatory

Fossil fuels are the preferred energy source for heating buildings, making them a major source of greenhouse gas emissions worldwide. However, in recent years, electricity has emerged as a serious rival, driven by the boom in renewables, which makes it an essential decarbonisation tool. For the past two years, this rivalry has been illustrated very concretely in the United States, where cities and states have been clashing over this climatic, but also economic and political issue.

DATA OVERVIEW

Heating buildings is still largely dependent on fossil fuels

Thermal energy[a] consumption, which accounts for half of global final energy consumption ahead of transport (30%) and electricity production (20%), experienced a historic decline of 3.1% in 2020 because of the Covid-19 pandemic.[1] This decline is primarily due to many industrial activities coming to a halt, which are responsible for half of the total thermal energy consumption. To a lesser extent, buildings, which account for the bulk of the other half, were also responsible for this decrease, mainly due to the reduced use of non-residential buildings.

In total, thermal energy accounts for more than three quarters (77%) of global building energy consumption.[2] 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.[3] The share of renewables in the heat consumption of buildings is slowly increasing (from 7.8% in 2009 to 10.4% in 2019).[2] This increase is mainly driven by the electrification of heating systems, coupled with the rise of renewables in the global electricity mix (**see Energy sector**): 11.7% of building heat demand was met by electricity in 2019, up from 9.6% in 2009.[2] To achieve carbon neutrality, the International Energy Agency (IEA) recommends ramping up this trend: the share of buildings heated with natural gas would need to increase from 30% today to 0.5% in 2050, and that of buildings heated with electricity from 20% today to 55% in 2050.

This electrification can be achieved through the installation of electric radiators or heat pumps[b], depending in part on regulatory policies or incentives put in place by governments. However, the number of countries with targets for renewable heating and cooling has fallen considerably since last year, in particular because of targets not being renewed after the 2020 deadline: from 49 in 2020, there are only 19 in 2021 (compared to 165 for renewable electricity).[2]

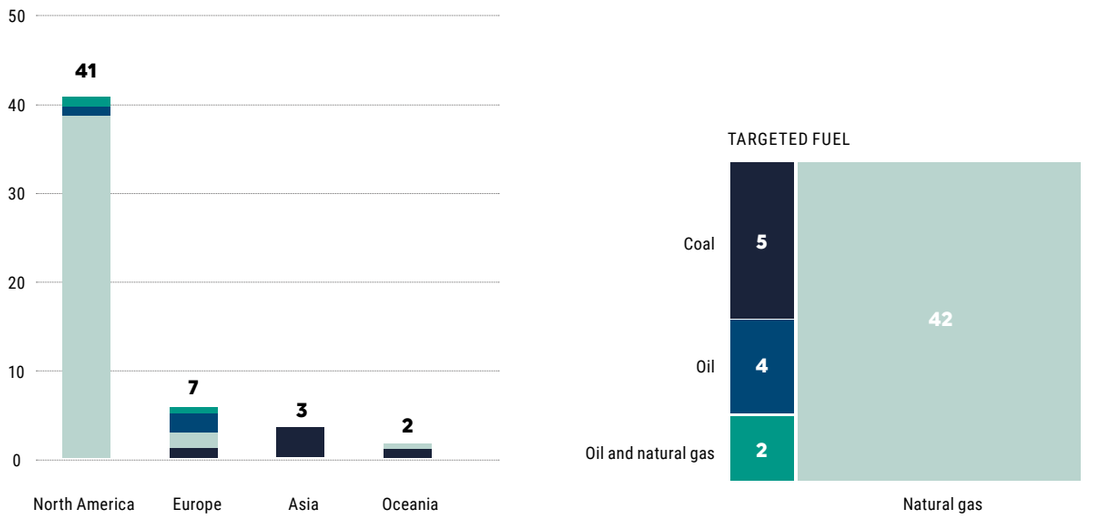
a Thermal energy, or heat, refers to energy used for heating air and water, air conditioning, cooking, drying and industrial processes... In other words, thermal energy is any energy that is not used for electricity generation or transport.

b Heat pumps are thermodynamic devices that use heat from a medium (air, water, soil) to release it into a space to be heated or cooled. They require auxiliary (electrical) energy to operate. When reversible, heat pumps can produce heat from a cold medium (heating function), or cold from a warm medium (cooling function). Under optimal conditions, the most efficient systems can produce up to five times more thermal heat than they consume in electricity (see REN21, 2021).

FIGURE 1

NUMBER OF CITIES IMPLEMENTING BANS OR RESTRICTIONS ON THE USE OF FOSSIL FUELS IN BUILDINGS IN 2020

Source : REN21, 2021



In contrast, heat pumps have received strong public support in recent years: they now meet 5% of the world's demand for space heating,[4] and have benefited from a higher increase in investment in 2020 than in the previous five years, from $45 billion to $51 billion.[5] In Europe, nearly 14.8 million heat pumps were heating buildings in 2020,[6] and 1.6 million units were sold in 2020, nearly half of which in France (394,000 units), Italy (233,000 units) and Germany (140,000 units), three countries that have introduced purchase subsidy schemes.[2] In Germany, the installation of heating systems based on renewable energy (solar heating, electric heating powered by renewables, etc.) has even been compulsory for new buildings since 2016, as it has been for its Danish neighbour since 2013.[2] However, these two countries are not included in the list of seven European countries that have stopped subsidising fossil fuel heating systems (mainly to help replace oil boilers with gas boilers): Croatia, Estonia, Ireland, Lithuania, Luxembourg, Malta and the Netherlands.[7] Similarly, the subsidies introduced by the Chinese government under the Electric Heating Policies since 2015 led to the sale of more than half a million units in 2018,[8] but conversely, government support for gas boilers to replace coal-fired heating slowed the heat pump market in 2020.[2] However, in northern China, where rural populations heat mainly with coal, the electrification of heating leads to higher emissions, due to China's still highly carbon-intensive electricity mix.[9] The climate benefit of electrification depends strongly on the local energy context.[10]

According to REN21, it is mostly local governments that have taken initiatives and adopted policies to promote renewables in building heating systems.[2] For example, Carlsbad (California), Luanzhou (China), Sao Paulo (Brazil) or Montevideo (Argentina) made the installation of solar water heaters for new buildings mandatory. Many cities (Mexico City, Berlin, Leicester, Jiazuo…) offer subsidies or price reductions to help convert heating systems from gas to electricity.

Finally, some cities have gone so far as to ban the use of fossil fuels for heating new buildings (air and water) (**fig. 1**), in order to accelerate their electrification from renewable sources.[11] By the end of 2020, REN21 counted 53 such cities in over 10 countries. For example, in Europe, Vienna took the lead in June 2020 by banning the use of fossil fuels in new buildings in certain districts.[12] But it is in the United States that the movement has gained the most momentum. Since 2019 many cities have adopted local legislations favouring electric heating, to the detriment of a powerful rival: gas.

THE OBSERVATORY'S LENS

Gas vs. electricity, cities vs. states: the story of an American battle for the energy supply of buildings

Driven by a very favourable market in the early 2010s, natural gas was set up as a "bridge fuel" in the United States, supposed to enable a gradual energy transition and act as a buffer between the abandonment of coal, which is a major emitter of greenhouse gases, and the deployment of renewable energy. As a result, 85% of the coal-fired power plants repurposed to burn other types of fuels between 2011 and 2019 have been converted to gas-fired plants.[13] Gas in now the country's leading energy source (35% of the energy mix, 39% of the electricity mix[14]). However, whether it is used for electricity production or heating, gas remains a major

emitter of greenhouse gases.[c] Based on this observation, but also on economic and political considerations, some cities are trying to stop gas from being used for heating and instead, to 'electrify everything', with the idea being using renewables to power the equipment.

2019: Californian cities open the race

The Berkeley City Council kicked off the movement in July 2019 by passing a law banning the use of gas in new residential and non-residential buildings, in line with California's goal of achieving 100% renewable electricity by 2045.[15] Shortly before, the California State Energy Commission had estimated in a report that electrification of buildings offered "*the most promising path to achieving emission reduction goals at the lowest cost*".[15] Many Californian cities quickly followed suit, sometimes replicating the Berkeley measure almost identically (San Jose in September, San Francisco in December), sometimes requiring electrification readiness for new buildings (San Luis Obispo in August) or imposing higher energy efficiency thresholds for gas-fired buildings (Davis in September).

The reaction of the gas industry was swift: the American Public Gas Association, which groups and represents gas distributors, called the bans *"extreme"* and *"heavy-handed"*, saying they *"eliminate consumer choice, stifle innovation, and diminish the flexibility to respond to GHG emission goals, with least-cost solutions for consumers"*. In turn, the powerful American Petroleum Institute stated in March 2020 that it would fight the spread of such bans.[19] In June 2020, Mother Jones magazine revealed that the American Gas Association is conducting an intense campaign on social networks, including paying influencers to promote the use of natural gas for cooking behind the hashtag *#cookingwithgas*.[16]

Early 2020: Conservative States fight back

As of February 2020, these gas lobbies found a sympathetic ear in some states. Prompted by the public gas supplier Southwest Gas, Arizona, which borders California, adopted a law prohibiting its cities from taking such measures, despite the protests of several large cities such as Phoenix and Tucson.[17] In the eyes of the environmental NGO Sierra Club, which defends the gas ban, this law is a clear sign of the close links between state administrations and the gas lobbies.[18] Following Arizona, the states of Missouri, Mississippi, Minnesota, Oklahoma and Tennessee announced they were considering similar measures. This movement is reminiscent of the tensions that arose a few years earlier when Texas, Oklahoma and Colorado prevented cities from banning hydraulic fracking.

At the same time, there was a tug of war in Massachusetts: the Boston suburb of Brookline, inspired by the nascent Californian movement, voted to electrify heating systems for all new buildings in November 2019.[19] But a few months later, in July 2020, the Massachusetts Attorney General overturned this decision, ruling that it was not within the city's jurisdiction.[20] However, she asked the state to study the future of the gas industry in light of its climate commitments. In response, a dozen Massachusetts towns (Belmont, Somerville, etc.) joined forces with the think tank Rocky Mountain Institute to create the Massachusetts Building Electrification Accelerator. This initiative serves as a framework for advocacy for building electrification (via local petitions for example) and the redefinition of decarbonisation strategies at the local level (through the implementation of incentive zoning).[21] In December 2020, Massachusetts published a climate roadmap, which proposed a new local code promoting the electrification of buildings and carbon neutrality of the sector,[20] but the governor vetoed it a few weeks later, judging it unsuitable for the development of the real estate market.[21]

In Seattle, the largest city in Washington State, the city administration also declared its intention to ban the connection of new buildings to the gas network at the beginning of 2020 but was met with strong resistance from the gas lobbies. After many months of fighting, particularly against Puget Sound Energy, the city's main natural gas supplier,[22] it was forced to abandon its project. A 2018 study commissioned by the city had shown that buildings were responsible for a quarter of the city's GHG emissions, half of which came from commercial buildings, and had increased by 8% compared to 2016.[23]

This example is indicative of the tensions these bills raise with incumbent gas suppliers in cities, who are often major employers and thus polarise the debate between the climate argument and the economic one. In addition to the challenge of decarbonising Philadelphia Gas Works (PGW), manager of the oldest gas network in the United States, supplier to more than 500,000 residents and responsible for 22% of the city's emissions, there is the retraining of 1,600 workers and the risk of price increases for the poorest households at stake.[24] In New England,[d] Eversource, the region's largest gas supplier, has committed to becoming "carbon neutral" by 2030 and is investing heavily in offshore wind. Yet the company is still investing in gas, and fighting against the electrification of city heating systems, including as co-leader of the Consortium to Combat Electrification, a lobby group in Washington.[25]

Results: electrification is progressing, so is resistance

Despite resistance from some states and gas companies, many cities have succeeded in mandating the electrification of new buildings. In California, 49 cities have adopted measures to reduce the use of gas in new buildings.[26] In Massachusetts, Brookline passed a new measure in June 2021 restricting the use of fossil fuels in new construction (this time not going as far as a blanket ban), on which the Attorney General has six months to give a ruling.[27] In total, 160 towns in Massachusetts have expressed a willingness to adopt similar measures.[27] New York City is currently considering a bill to ban the use of natural gas in new buildings.[28] The Seattle City Council fi-

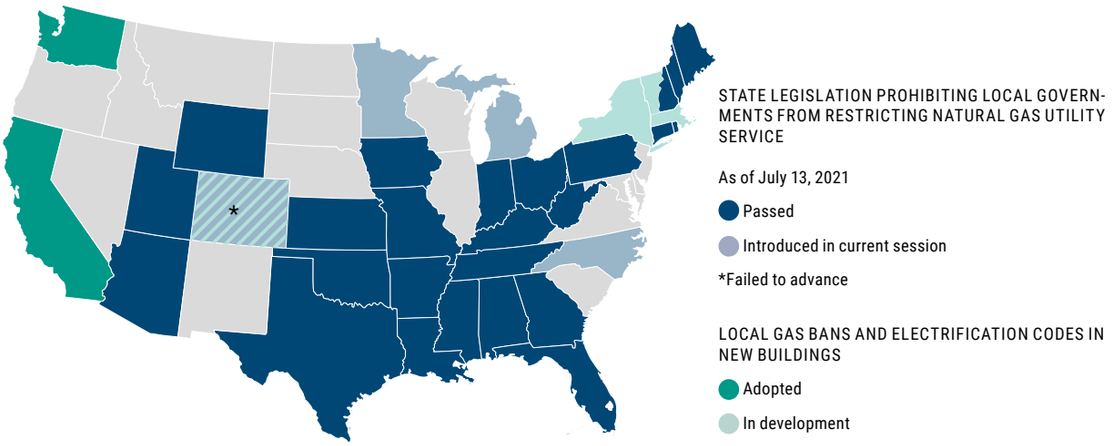
c As an order of magnitude: in 2019 in the United States, according to calculations by the Energy Information Agency, coal emitted an average of 1,002 gCO_2/KWh (2.21 pounds/KWh) of electricity produced, compared to 412 gCO_2/KWh (0.91 pound/KWh) for natural gas. The EIA considers the other sources of production (biomass, solar, wind, hydro) to be carbon neutral. Source: EIA (up. 15/12/2020). How much carbon dioxide is produced per kilowatthour of U.S. electricity generation?

d New England refers to a region on the east coast of the United States, covering the states of Maine, Vermont, New Hampshire, Massachusetts, Connecticut and Rhode Island.

FIGURE 2

US STATES THAT HAVE PASSED (OR ARE PREPARING TO PASS) BANS OF LOCAL LAWS RESTRICTING THE USE OF GAS IN NEW BUILDINGS

Source : S&P Global, 2021



nally adopted a new building energy code in early 2021 that includes a ban on natural gas for new commercial buildings and residential buildings over three stories high.[23] However, it will still be possible to use natural gas for cooking.

Other types of pro-electrification measures have been taken in other cities, without going as far as banning gas heating: the cities of Boulder (Colorado), New York City and Washington D.C., for example, have partnered with manufacturers, distributors and government agencies to install heat pumps fuelled by renewable energy.[11] This is also the case of Denver, Colorado, which has teamed up with the giant Xcel Energy to help the poorest households acquire heat pumps.[29] The city plans to require the installation of electric heating systems for new buildings within 3 years. Colorado considered prohibiting gas bans by local governments, but the law did not pass.[30]

In contrast, Washington State considered banning gas for heating in new commercial and residential buildings, which would have been a first for any state, but this law didn't pass either.[30] New York State is currently only considering the role of gas in its energy transition.[31] The State of Maine has taken a different approach, setting a target of installing 100,000 heat pumps per year by 2025 (there are around 500,000 homes in the state), and doubling the purchase subsidies for this equipment.[19]

Eighteen states, mainly republicans, have followed Arizona in banning the gas ban (**fig. 2**),[30] sometimes pushed by the blurred lines between politics and the oil and gas industries. For example, David McCormick, a member of the House of Representatives in Louisiana and head of the oil and gas company M&M Oil, has introduced bills to make his state a 'sanctuary for fossil fuels'.[32] In Michigan, Representative Michele Hoitenga, who until February ran an oil and gas consulting firm, is now spearheading a bill to prohibit local governments from banning gas-fired equipment in residential buildings.[33] Many of these states, particularly in the South and Northeast, are home to active gas wells, and are sitting on gas reserves that can be exploited for many years to come.[e] After West Virginia, Ohio became the second of the three Appalachian basin states (home to huge shale gas reserves) to restrict gas bans, and Pennsylvania is preparing a similar law.[30] The overview provided in **Figure 2** is clear: the "Electrify everything" movement is still not for everyone.

KEY TAKEAWAYS

While the electrification of heating systems is now recognised as an effective lever for the decarbonisation of buildings (provided that they are supplied with low-carbon electricity), the policies implemented by the States remain weak overall, and place more emphasis on abandoning oil-fired boilers, even if it means subsidising gas-fired boilers, gas still being presented as a "bridge fuel".

At the same time, helped by economic, political and energy contexts that are generally favourable to renewables, around fifty cities in the United States have taken the lead, over the last two years, by each banning or restricting the use of gas in new buildings. The response from gas suppliers and producers was swift: intense lobbying campaigns led about twenty federal states to prevent their municipalities from taking such measures. These conflicts put at stake the just transition of employment in regions dependent on crude oil production, as well as the access of the majority to affordable and decarbonised energy, while putting the preservation of jobs and the protection of consumers first.

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TREND
CONSTRUCTION

Recovering from the Pandemic, the Construction and Renovation Sector Rethinks its Foundations

SAMUEL LAVAL • Research Officer, Climate Chance Observatory

After the first shocks linked to the Covid-19 pandemic, the construction of new buildings and the renovation of existing buildings resumed at full speed in the second half of 2020 in Europe and the United States, to the point of causing supply shortages and dramatic inflation in the prices of many building materials. However, the production of these materials is highly greenhouse gas-emitting, especially cement and steel. In recent years, initiatives have been implemented to give priority to renovation, and to take the "embodied carbon" into account in new constructions.

DATA OVERVIEW

Rapid recovery of construction projects puts pressure on material supply chains

The pandemic and the lockdowns that followed have brought many construction sites to a halt. As a result, emissions from the construction industry fell by 15% (from 3.6 $GtCO_2$ in 2019 to 3 $GtCO_2$ in 2020). Yet after these initial shocks due to Covid-19, the building and renovation sector bounced back quickly at the end of 2020 and in 2021 in many countries, boosted by the recovery plans that followed. Within the G20, at least 44 billion dollars were channelled into the building sector in the recovery plans.[1]

In Europe, after falling 25.4% in March and April 2020, building activity returned to 97% of its pre-pandemic level as early as May 2020, then stagnated without ever getting back to its February 2020 level.[2] In France, the sector saw an activity increase of 7% in the first quarter of 2021 compared to the same period in 2020 (when Covid had not yet struck).[3] The energy renovation market is up 3.3% in the first half of 2021 compared to the same period in 2019, undoubtedly due to the spread of remote working after the initial lockdowns, which increased time spent at home for some.[4]

In Asia, in 2020, building markets fell by 36% in Singapore, 20% in Malaysia, 30% in the Philippines, 3.3% in Indonesia. In 2021, they are expected to rise by 30% in Singapore and 11% in Malaysia. In contrast, the resurgence of the virus in the Philippines and Indonesia is keeping the sector at a low level in 2021. In China, after a 17.5% drop in the building market in the first quarter of 2020 compared to the same period in 2019, activity quickly picked up: the following quarters saw an increase of 7.8%, 8.1% and 6.6% compared to the same periods in 2019, totalling an overall growth of 3.5% over the year as a whole compared to 2019.[3]

In the United States, economic plans have boosted the building sector, which has reached levels not seen since 2007.[5] Over the first nine months of 2020, the total value of constructions increased by 4% compared to the same period the previous year.[6] Spending on construction increased more in the residential sector than in the non-residential sector. The cement sector illustrates this trend well: despite the interruption in the activities of many production projects in March-April 2020, the American cement industry slightly increased its production volumes over the year as a whole (from 89 Mt to 90 Mt).[6]

In the lumber sector which constitutes the main building material for family houses in the United States (90% of them had a wooden structure in 2019[7]), the impact of the rapid recovery has been significant. While the pandemic had shut down many sawmills and production plants, it also transformed the uses of housing by encouraging remote working, thereby inducing new requirements in renovation and construction. In Canada too: the number of building permits for residential buildings jumped to nearly 50,000 in June 2020, well above the 20,000 average of 2019.[8] This imbalance between supply and demand, combined with a spectacular rise in freight rates (**see Transport sector**) has led to high price inflation. In February 2021, the symbolic mark of $1,000 for 1,000 board

feet[a] of lumber was passed on the Chicago Stock Exchange, and a peak of $1,600 was even reached in early May, before it dropped just as sharply back to around $400, close to pre-crisis levels.[9] Thus, in May 2021, the price of building a wooden house had climbed by $35,000 in the United States,[7] and in Canada, the price of a new house was up by 9.1% in 2020, the largest increase in at least 30 years.[10] In a May 2021 survey conducted by the US National Association of Home Builders (NAHB), more than 90% of respondents said they faced shortages of structural lumber, oriented strand board, and plywood.[11]

In addition to wood, many building materials (steel, glass, cement) have also seen their delivery times increase and their prices skyrocket.[12] In mid-March 2021, steel, which cost $440/t on average in 2020, cost over $1,300/t in the United States – an all-time high.[13] In Canada, the price rose by 60% between the beginning of 2020 and May 2021[10]. This situation can be explained by a sharp drop in supply: except in China, steel production fell in all the main steel-producing countries in 2020, in India (-11 Mt), Japan (-16 Mt) and the United States (-15 Mt).[14] Overall, global steel production recorded one of its lowest growth figures since 2000 (+4 Mt in 2020), driven almost solely by the performance of the industry in China, which produced a record 1,065 Mt in 2020 (+70 Mt). In total, the steel industry accounts for nearly 15% of the country's greenhouse gases (GHG) emissions. Driven by the dynamic global building sector, and by high prices, production rose again in the first half of 2021, making the Chinese government's objective of capping its production at 2020 levels, to limit its emissions, difficult to achieve.[15] In France, the state has decided not to apply penalties for delays in public works projects as a result of the price of materials or shortages.[12]

In total, the construction market should grow by 5.7 % in 2021.[3] However, it is still very poorly supervised and regulated from an energy and climate point of view.

The adoption of specific regulatory instruments promoting energy efficiency in buildings continues, but at a slow pace. By the end of 2021, building energy codes[b] were in place in 80 countries, around ten more than in the previous year.[16] Many of them only cover certain types of buildings (public, residential, commercial), are not compatible with a 2050 carbon neutrality target, and only about half are mandatory. The recovery plans adopted by states to respond to the initial shocks of the Covid-19 pandemic nevertheless demonstrate an effort to intensify decarbonisation and increase the energy efficiency of buildings. Of the 44 billion dollars committed by the G20 countries to stimulate the recovery of the building sector in the second half of 2020, only the 9 billion granted by Turkey lacks energy or climate considerations.[17]

According to REN21, it is mostly local governments that have taken initiatives and adopted policies to accelerate the decarbonisation of buildings.[18] A census carried out in 2020 by CDP, a climate action reporting platform, counted nearly 2,400 decarbonisation actions planned, currently being implemented or already implemented by 336 cities, in the buildings sector.[19] These actions often relate to the installation of renewable energy production systems (typically, the obligation to install solar panels) or the introduction of energy efficiency thresholds for new buildings.

However, both at national and local level, these codes have shortcomings that sometimes make them ineffective in reducing emissions. For the most part, they apply only to new constructions: few countries have building codes that cover the existing building stock, according to the Global Alliance for Building and Construction (GABC).[20] In addition, most often, only "operational" emissions from buildings (i.e. greenhouse gases generated in their use) are regulated, without taking into account the emissions resulting from their construction. To overcome these shortcomings and improve the effectiveness of building codes, public initiatives are being implemented, mainly in Europe and the United States.

THE OBSERVATORY'S LENS

Renovate more, build better: life cycle analysis, a new approach to accelerate the decarbonisation of buildings

More and more public policies to stimulate renovation

In the United States, more and more local governments are trying to transform local legislation on renovation: in July 2021, Indianapolis joined[21] the forty or so American cities were reviewed by the *Building Rating* platform,[22] which are introducing benchmarking and transparency requirements for the energy performance of existing buildings (**fig. 1**). These requirements can then serve as a basis for the development of Building Performance Standards (BPS), legislations defining short, medium and long-term energy performance thresholds for existing buildings, and leaving it up to the owners to decide on how and when carry them out. The city of Tokyo had adopted the first mechanism similar to a BPS in 2010, the second phase of which (2015-2019) had made it possible to reduce the emissions of the 1,200 buildings concerned by nearly 21.9 $MtCO_2$, mainly thanks to the installation of more energy-efficient equipment and the supply of renewable electricity and heat.[23] The most recent in the United States, the Colorado BPS, adds to those of New York City, Washington, DC, St. Louis and Washington State.[24] It plans to set up a task force in October 2021 to set energy performance standards in order to reduce greenhouse gas emissions from buildings by 7% between 2021 and 2025, and by 20% by 2030.

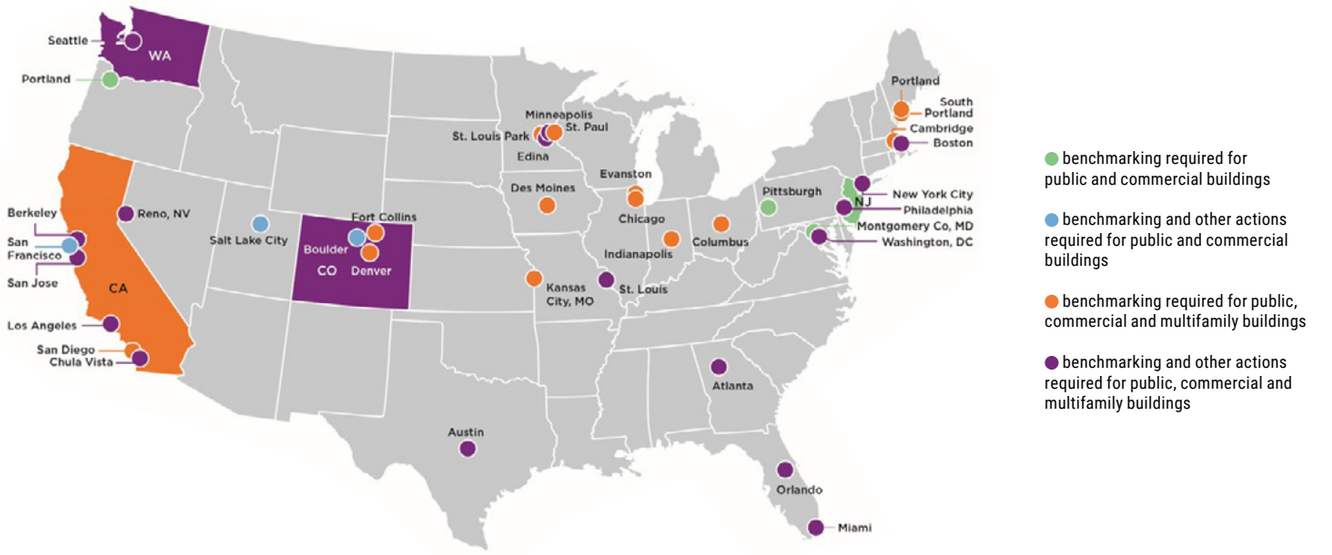
a The board foot is a volume measurement unit used for wood, primarily in the United States and Canada. 1,000 board feet are equivalent to approximately 2.36 m^3.

b National energy codes or standards for buildings, whether mandatory or voluntary, make it possible to set standards for the construction of buildings, offering better energy performance. They are one of the tools favoured at national level for reducing energy consumption, and therefore greenhouse gas emissions from buildings.

FIGURE 1

AMERICAN CITIES, COUNTIES AND STATES THAT HAVE ADOPTED A POLICY OF BENCHMARKING, TRANSPARENCY AND MORE FOR EXISTING BUILDINGS

Source : Institute for Market Transformation, 2021



These initiatives made their mark on the 2020 US presidential campaign: on their campaign website, Joe Biden and Kamala Harris said they want to extend the introduction of BPS to the whole of the United States.[25] The Build Back Better Act, the national plan to invest $7 trillion in the economy and infrastructure, has settled, for the moment, for earmarking $300 million to encourage US states and local governments to adopt building energy codes that comply with the "zero-energy" standards of the International Energy Code Council, a provision that has been met with strong opposition from the National Association of Home Builders (NAHB), which fears a repercussion on construction prices.[26]

The European Union, for its part, launched its Renovation Wave strategy last year, which aims to double the energy renovation rate, currently at 1% per year, with the aim of reducing buildings' GHG emissions by 60% by 2030. For several years now, Europe has been the continent where investments favouring energy efficiency are the highest, and mainly concern renovation projects (**fig. 2**). In 2020, the increase of $20 billion in renovation investments worldwide (thus reaching $184 billion in total) is almost entirely attributable to Europe, and above all to Germany where the public bank KfW has doubled its energy efficiency programme (from 15 to 30 billion euros), a decision taken before the outbreak of Covid-19.[27] According to the Building Performance Institute Europe, however, the rate of "deep renovation" (which reduces a building's energy consumption by at least 60%) in Europe is stagnating at 0.2% per year, whereas it needs to be 3% to achieve the European Commission's objective.[28] The institute therefore calls on the Commission to use the review of the *European Performance of Buildings Directive*, scheduled for the end of 2021, to raise its ambitions.[29]

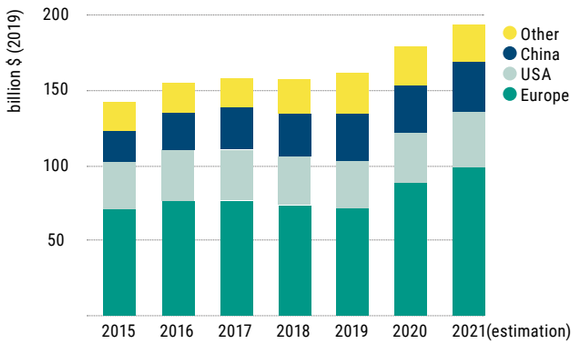
Finally, China, in its 14th Five-Year Plan (2021-2025), the first since the announcement of its objective to be carbon neutral by 2060, is highlighting the importance of building "low-carbon cities" and setting itself the objective of favouring renovation over demolition-construction (which emits more GHGs and consumes more resources), and of using "green" building materials for construction and renovation.[30]

Indeed, both renovation and construction require the manufacture of high GHG emitting materials. This "embodied carbon" is far from negligible: it is typically between 250 and 400 $kgCO_2e/m^2$ during the construction of a building. It can go up to 200 $kgCO_2e/m^2$ in case of a major renovation, thus taking several decades to be offset by the emissions avoided through renovation. By choosing low-carbon materials and carbon-free energy sources, this offset period can be shortened to three years.[31]

FIGURE 2

INVESTMENTS IN THE ELECTRIFICATION AND ENERGY EFFICIENCY OF BUILDINGS

Source : IEA, 2021



Thus, failure to take into account the carbon embodied in materials can lead to a significant under-estimation of their climate impact. The share of embodied carbon in the carbon footprint of buildings is more than a quarter, mainly due to steel and cement manufacturing. With the renovation actions of the coming years, which would reduce the "operational" emissions resulting from the energy consumption of a building during its use phase, embodied carbon could end up being the main source of GHG emissions from buildings constructed over 2020-2050.[32] According to the World Green Building Council, to comply with the Paris Agreement, all new buildings, infrastructure and renovations must have 40% less embodied carbon by 2030, and must have close to zero embodied carbon by 2050.[33] In addition to the mention in the Chinese government's plan, many initiatives have emerged in recent years to take better account of these "hidden" emissions. In August 2020, for example, New Zealand adopted the *Building for Climate Change* programme to improve the energy performance of existing and new buildings, which includes a framework for action to reduce emissions embodied throughout buildings' life cycles.[34] Nevertheless, it's in Europe and the United States that this dynamic is most vigorous.

Increasing consideration of embodied carbon in the United States and in Europe

As with the introduction of energy codes for buildings and the electrification of heating systems (**see Electrification trend**), local governments in the US are taking the lead. The Carbon Leadership Forum, a partnership between companies and researchers initiated by the University of Washington, identified two states, two counties and ten cities that have adopted legislations that take embodied carbon into account.[35]

Colorado recently passed a law to limit the carbon footprint of construction materials used in public works (public buildings, roads, bridges, etc.).[36] These limits will come into effect for projects starting on or after January 1 2024, and will be reviewed and adjusted every four years. This approach has also been adopted by the Buy Clean California Act, passed in 2017, which is expected to come into force in July 2022. It is also being considered at federal level.[37] Similar laws have been drafted in the states of Oregon, Washington and Minnesota, but have not been passed.

Cities in the United States have also taken measures in this regard. In its Green Building Programme, the city of Austin (Texas) encourages the use of low-carbon materials for new constructions. In California, the cities of San Francisco, Los Angeles, Oakland, Dublin and Albany have drawn up climate plans that take embodied carbon into account. In Portland, Oregon, a limit on the carbon footprint of materials for public works projects has been set.

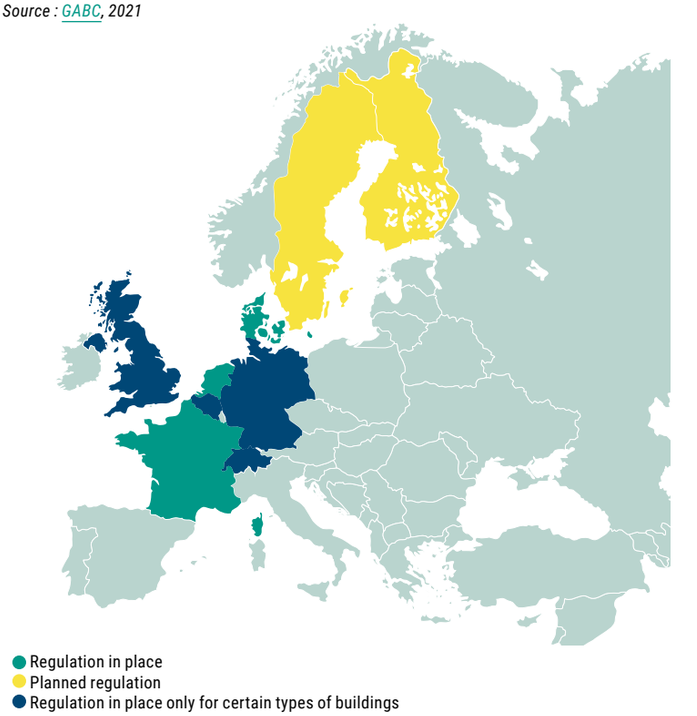
In the European Union, nine countries have introduced (or plan to introduce) a life cycle analysis approach, taking embodied carbon into account in their regulations for new buildings (**fig. 3**).[38]

Finland and Sweden planned carbon impact limits for new builds for 2025 and 2027 respectively. Belgium has also introduced a database to assess the carbon impact of building materials, with the intention of passing laws in this regard in the coming years. In the Netherlands, it has been mandatory to calculate and publish the carbon impact of the entire life cycle of buildings over 100 m^2 since 2017. In early 2021, Denmark adopted a new law which sets a maximum threshold for GHG emissions for new buildings from 2023 onwards, throughout their entire lifecycle. Set at 12 $kgCO_2e/m^2$/year, this limit will be gradually lowered to 7.5 $kgCO_2e/m^2$/year in 2029.[38]

FIGURE 3

NATIONAL REGULATIONS ON BUILDINGS TAKING INTO ACCOUNT THEIR ENTIRE LIFE CYCLE

Source : GABC, 2021



In France, in January 2022, a new environmental regulation for buildings (RE2020), which includes a section on the carbon footprint of buildings throughout their entire life cycle, will come into force. This new regulation replaces the RT2012 regulation, which focused on energy efficiency. This new approach could favour electric heating over gas heating, which is a concern for the historical French gas supplier Engie, worried about the economic repercussions of such a measure,[39] adopting an argument very similar to that used in the gas sector's battle against the electrification of heating systems in the United States (**see Electrification trend**). With just months to go before its implementation, data on certain materials is still lacking to perform precise life cycle analyses.[40] Anticipating an increase in demand, the French giant Bouygues Construction set up its subsidiary WeWood in 2020, with the aim of having 30% of all of their construction projects with wood by 2030, and the whole lumber industry is gaining ground (**Signals**).[41]

Germany, Switzerland and the UK have each recently adopted building lifecycle carbon impact guidelines for public buildings.[7] In the UK, the Architects Climate Action Network recently petitioned the government to encourage it to extend this measure to all buildings.[42]

These new regulations are sometimes based on existing certification programmes that already take embodied carbon into account. In France, for example, the E+C- label (Positive Energy Building with Carbon Reduction) was set up by the State in collaboration with the HQE-GBC alliance, the French branch of the World Green Building Council (WGBC). Other national branches have implemented such certifications, such as Canada ("Zero Carbon"), Ireland ("House Performance Index"), Germany ("DGNB System"), Australia ("Green Star Performance") and Sweden ("NollCO_2"). The Swedish NollCO_2 certification goes even further, and imposes a limit on the carbon embodied in buildings and allows these emissions to be "offset" through the production of renewable energy on site. In the Netherlands, Brazil and India, the "Paris Proof", "Zero Energy Standard" and "Net Zero Energy Buildings" labels, respectively, will soon be updated in order to take embodied carbon into account in their criteria.

Through the Advancing Net Zero initiative, the WGBC aims to create "net-zero" programmes, certifying buildings with high energy efficiency and of which the total energy, consumed during their life cycle comes from renewable energy (where possible taking embodied carbon into account). A total of 804 buildings have had certified "net-zero" through the initiative's certification programmes in June 2021, twice as many as in the previous year. The initiative now has 141 signatories (up from 95 last year), the majority of which are companies. There are also 28 cities (Paris, Copenhagen, Johannesburg, London, New York, Medellin, Sydney, etc.) among the signatories.

Soon, taking embodied carbon into account could spread to other European countries and cover even renovation, since the Renovation Wave intends to look into "*life cycle thinking and circularity*".[43] However, Europe and the United States are not the regions where most construction is going to be carried out over the coming years. Africa, China and India will in fact account for more than half of the surface area built in the world between 2017 and 2060. In total, the GABC estimates that two thirds of the buildings that will be built in the coming years will be in a country that does not yet have an energy code.[44]

KEY TAKEAWAYS

From the second half of 2020 onwards, construction sites reopened as quickly as they had closed at the beginning of the year, and the construction sector ended the year with overall growth. After the outbreak of the pandemic, the building industry has split the world in two. On the one hand, the constructed surface area in Africa, China and India will double or even triple by the middle of the century. However, there are still only few regulatory instruments in these countries to regulate building projects, in terms of either materials or energy efficiency. Recent actions by the Chinese government, however, gives us reason to hope for a more ambitious framework in the coming years. On the other hand, existing buildings will account for most of the built environment in 2050 in the countries of the Global North, and the challenge is therefore to reduce emissions arising from their use. The pandemic recovery is going strong in these countries, supported by recovery plans that target investments in energy renovation, and local laws that appear, particularly in the United States, to make certain renovations compulsory. However, the pace still seems too slow for the challenges. In addition, many initiatives are arising to consider the carbon impact of the manufacture of constructions and renovation materials, primarily cement and steel.

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TREND
AIR CONDITIONING

In the Face of Global Warming, Air-Conditioning is Locked in a Market Model That is Costly for the Climate

TANIA MARTHA THOMAS • Research Assistant, Climate Chance Observatory

DATA OVERVIEW

Global warming through spatial cooling: global air conditioner demand unaffected by concerns of energy efficiency

The emissions from the space cooling sector totalled around 1 gigatonne of carbon dioxide equivalent ($GtCO_2e$) in 2019, tripling from the 1990 level[1]. Space cooling is, in fact, the "fastest-growing end-use in buildings".[1] As of 2016, the worldwide final energy use for space cooling in residential and commercial buildings combined was 2020 TWh, with cooling accounting for 18.5% of total electricity use in buildings, and around 8.5% of overall electricity use. This figure of final energy use represents electricity used for air-conditioning units, fans and dehumidifiers, as well as natural gas used for chillers, the latter representing only 1% of energy use in 2016.[1,2] Tracking these figures from 1990 to 2016 (**fig. 1**) shows a steadily increasing trend, with space cooling having taken up an increasing share in final electricity use, and as a share of overall building energy use.

As of 2018, 1.76 billion AC units were in use[3] – and around 2 billion units as of 2020– with the demand for units by 2030 expected to increase by another two-thirds, with the residential sector accounting for the largest share.1 Out of all ACs in use, around 70% are "Room ACs" or RACs– individual mini-split or self-contained AC units.[a] These are particularly popular in developing markets due to their lesser cost. RAC sales in 2020were estimated be 94.3 million units as per a study by Research And Markets, are expected to touch a record compound annual growth rate of 5.6% by 2026.[4] In a business-as-usual scenario, another study estimates the stock of RACs to reach 4.5 billion units by 2050, with China and India having the largest stocks, and accounting for more than half the expansion in number, followed by the US, Indonesia, Japan and Korea, the European Union, the Middle East, and Brazil.[5]

1.09 billion people around the world were identified as being at-risk due to a lack of access to cooling in 2021. In the same period, 2.34 billion people from the lower-middle income category will be able to afford an air conditioner or refrigerator, but one that is less energy efficient, because of higher costs.[6] At the present rate of increase, without major improvement made to the energy efficiency of cooling equipment, electricity demand for cooling in the building sector could increase by up to 50% by 2030.[1]

The African continent presents a unique picture, where the rates of AC use are presently low but set to increase exponentially in the coming years, driven by a warming climate and increasing incomes. The need for cooling will become a matter of survival, but also a key to ensuring the productivity of the workforce.[5] Currently, the largest market share in the air conditioning market is from South Africa (40%), followed by Egypt, while rapidly rising incomes in Nigeria are also expanding the market. In West Africa, the import of second-hand appliances from Europe is a major trend, which offers consumers cheaper options, at the cost of energy efficiency.[7]

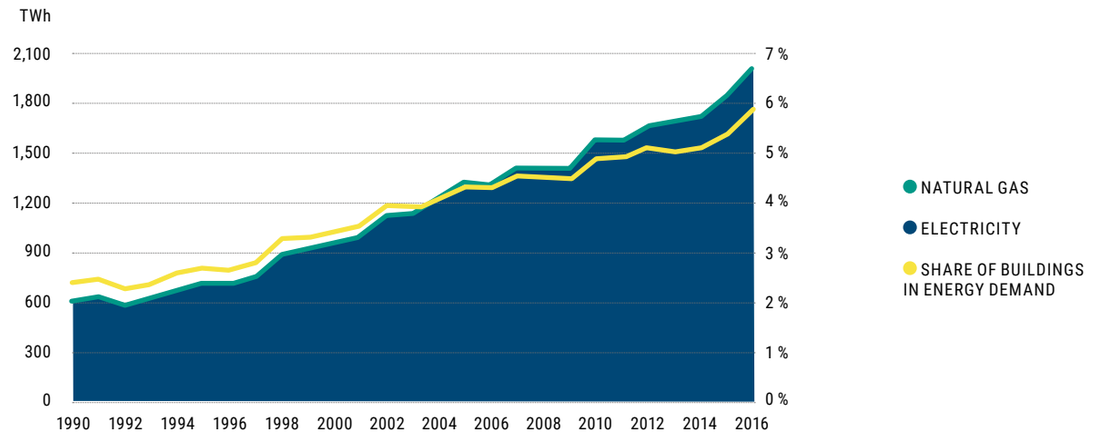
Looking at demand for cooling through unit sales, China, the US, and Japan dominated the cooling equipment (ACs, fans, chillers, etc.) market in 2019, with nearly 60% of the sales concentrated in these countries, while India and Indonesia have been seeing increasing yearly rates of AC installation, at 15% and 13% respectively.[1] There are several factors that affect the demand for cooling equipment, including the warming

a Mini-splits are air conditioners comprised of a single outdoor compressing/condensing unit and indoor air-handling unit, and have no need for air conditioning ducts. They are used to control the temperature in a single enclosed space – such as in an individual room – most commonly in the residential sector, but also in the commercial sector.

FIGURE 1

GLOBAL ENERGY CONSUMPTION FOR SPACE COOLING IN BUILDINGS, 1990 – 2016

Source : IEA, 2018.



global temperatures (measures in CDDs, or Cooling Degree Days[b]), increasing rates of urbanisation, a growing global population, and growing incomes.

An Enerdata study cited in Climate Chance's 2019 Sector-based report[8] found that income level, expressed as GDP per capita, had a higher correlation with air conditioner ownership than changes in climate, expressed in CDDs (**fig. 2**). Past trends in climatic conditions show that in most countries studied, even the warmer ones, AC ownership is not strongly affected by an increase in CDDs. Countries like the USA, Japan and South Korea seem to be nearing a saturation point in AC ownership, with little and slow increases observed between 2010 and 2018. Trends which could not be explained by climatic, or income factors were due to cultural influences, as in the case of China, as found in the study.[9]

Social and behavioural factors do Indeed play a large role in influencing energy demand for cooling in the residential sector. In the US, socio-economic factors like income proved to be intrinsic to household cooling energy consumption, with household income, size of the household and age of the occupants playing an important role, along with occupant behaviour, which in turn affected the frequency of air conditioner use and the number of air-conditioned rooms.[10] Socio-economic factors also often have an influence on the age and energy efficiency of air conditioners used. A study of seven cities from various climatic regions in China also highlighted the role of household income and size in influencing air conditioner use, along with characteristics of the dwelling itself such as the area, and the orientation of the building – in keeping with Chinese residential customs, most buildings are either North or South facing (rather than East or West), with South facing buildings recording higher temperatures.[11] In Saudi Arabia, where over 96% of properties studies were air-conditioned, thermal comfort (or its perception) and awareness about the existence of energy efficient or sustainable models also affect air conditioner use and demand.[12]

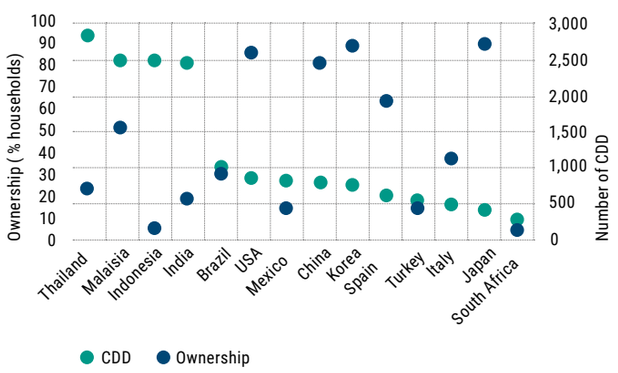
At the same time, the energy efficiency of space cooling equipment, most notably ACs, has been increasing. The Seasonal Energy Efficiency Ratio – SEER (**see Keys to Understanding**) – of residential and commercial ACs increased by 50% and 57% respectively, between 1990 and 2016[2]. While highly efficient units are available in the market presently, which could cut cooling energy demand in half if widely used, the typical units being sold are just 10-60% more efficient than the available minimum.[1]

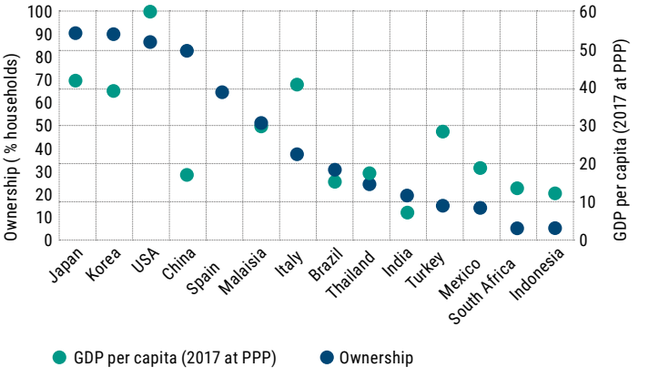
b Cooling Degree Days, and Heating Degree Days or HDDs, are a measure of how hot or cold the outside temperature is (measured in degrees) and for how long (measured in days). It is the difference between the mean temperature of the day, and a reference temperature of 18°C. It is useful in calculating the heating or cooling energy requirements of buildings. An increase in CDDs would mean an increase in warmer days, and an increase in the need for cooling.

FIGURE 2

CLIMATE (COOLING DEGREE DAYS), GDP PER CAPITA AND AC OWNERSHIP PER COUNTRY

Source : Enerdata, 2019





KEYS TO UNDERSTANDING

ENERGY EFFICIENCY MEASUREMENTS OF ACs

ACs remove heat from a given space rather than transform it to another form. Thus, the energy efficiency of an AC is generally measured as a ratio of the amount of heat it removes from a space to the amount of power it consumes. Conventions vary geographically, with the metric changing based on the units used in each country – the metric system or imperial system – and also based on the purpose behind the measurement. One of the most commonly used metrics is the Energy Efficiency Ration or EER, which compares output cooling energy to input energy. For example, in the US, the EER is calculated as how many British Thermal Units (Btu) per hour are removed for every watt of power consumed, it is generally calculated using an outside temperature of 95°F (35°C), an inside temperature of 80°F (27°C) and relative humidity of 50% [2,13]. The Seasonal Energy Efficiency Ratio or SEER measures the efficiency of the AC over an entire season, usually keeping the inside temperature constant but varying the outside temperature over a given period. These measures are often adapted to the country or region-specific climates (see **fig. 2** for examples of different regional metrics), and are often not inter-convertible. Different test conditions could also mean that ACs can have different EERs and SEERs.

FIGURE 3

EFFICIENCY RATINGS OF AC UNITS AVAILABLE IN SELECTED MARKETS, BY REGIONAL METRICS

Source : IEA, 2020

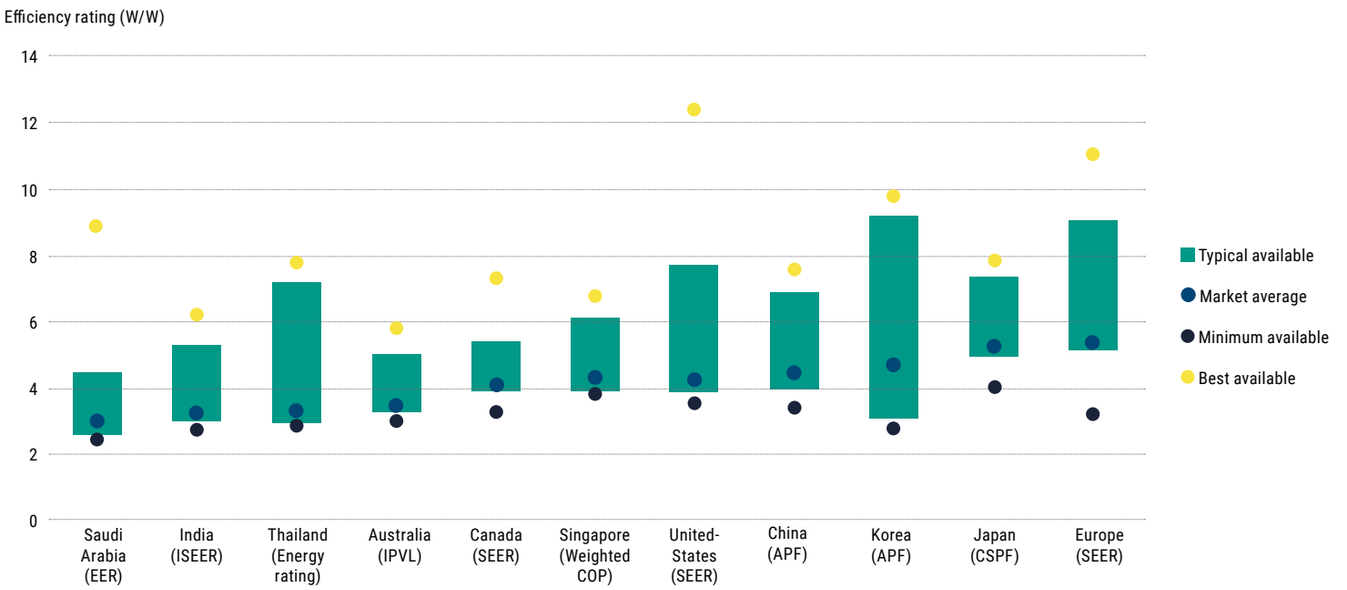


Figure 3 shows the range of efficiency of the most commonly available AC units in the selected countries, along with the market average and the available minimum and maximum ratings per market. In most cases, the market average is not much higher than the minimum, while more efficient alternatives do exist and remain available. The most significant barrier to the adoption of more efficient units was identified to be "consumer sensitivity to upfront costs", and a lack of awareness about the benefits of more efficient ACs[1].

Besides emissions arising from their energy usage, air conditioners can also impact climate change through refrigerant leakage – most commonly-used refrigerants are composed of hydrofluorocarbons (HFCs), whose Global Warming Potential[c] can be between hundreds to thousands of times as much as that of CO_2.[14] The Kigali Amendment to the Montreal Protocol, adopted by the United Nations in 2016, seeks to gradually phase down the use of HFCs in order to mitigate global warming cause by them, by cutting down on their production and consumption.[15] A three-step phase down has been agreed to, dividing the parties into three categories. Accordingly, developed countries have an earlier freeze date and are ti reduce HFC consumption by 85% by 2036 from their baseline. Developing countries are divided into two groups, both having a longer phase down schedule, later freeze dates, and later deadlines for 80-85% reductions from their baselines. The second group of developing countries consists of ones with high ambient temperatures, and higher demands for cooling, and this group has the longest schedule (Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates).[16]

Thus, the demand for air conditioning is largely driven by cultural, social and climatic factors, less so by concerns about the energy efficiency of the equipment. Faced with the failure of individual choices to favour low-carbon air-conditioning solutions, some cities are trying to provide collective alternatives and curb the explosion in demand.

THE OBSERVATORY'S LENS

Cities cooling the fever pitch of air-conditioning

There are several actions being taken around the world, both to ensure access to cooling and to increase the sustainability of cooling solutions. On the part of national governments, most countries have already laid down Minimum Energy Performance Standards (MEPS) for air-conditioners, which act as qualifying conditions to sell AC units in the market. However, there remains a lack of harmonisation between various national standards. Several countries like Cuba, China, India, Panama, Rwanda and Trinidad and Tobago have published National Cooling Action Plans, while many other countries' Action Plans are in the pipeline, having been delayed by the Covid-19 pandemic.[17] These Action Plans work to identify vulnerable groups of population, ensure energy efficiency of cooling and to develop financial mechanisms to promote sustainable cooling.

Playing it cool, and circular: 5th generation networks for heating and cooling

At the local level, besides requirements in building or energy codes, a solution that is gaining ground is district cooling, and district energy systems that are adapted to both heating and cooling. District networks initially began as district level heating, powered by steam generated by coal, as early as the 1880's. These First Generation District Heating Networks (1GDH) have evolved over time, with the second generation shifting to the use of superheated water, and thus requiring less energy, to the third generation, popularised from the 1980's onwards, using water with lower supply temperatures to provide heating, and thus allowing for the inclusion of a wider variety of waste-heat sources such as industrial waste heat.[18,19]

The most recent developments have been the Fourth Generation District Heating (4GDH), and Fifth Generation Heating and Cooling (5GDHC) networks. 4GDH presents an evolution from the previous generations, incorporating more renewable energy and recycled heat, keeping the supply temperature levels as close as possible to the demand levels, and making wider use of thermal storage and heat pumps[19]. Fifth Generation networks are a simultaneous development, implemented almost parallelly to 4GDH, that use energy balancing and interaction between buildings to provide to both heating and cooling.[20]

5GDHC networks have so far mainly been piloted in smaller scales across Europe (**see Heerlen case study**). These demand-driven, decentralised networks are close to ground temperature, and use direct exchanges of warm and cold return flows, and thermal storage to maintain the desired

c The Global Warming Potential (GWP) of a gas is the amount of heat absorbed by it, presented as a multiple of the heat absorbed by an equivalent quantity of carbon dioxide. These figures are what help to calculate emissions in carbon dioxide equivalent (CO_2e).

temperature in buildings.[21] It prevents energy loss within the system by being a closed loop, and uses low-grade energy sources like shallow geothermal, industrial waste flows, conversion of waste, waste from cooling processes, sewage, etc.[22] A study of 40 selected 5GDHC networks in Europe, where they are in their initial phases, showed that they are most common in Germany and Switzerland, and more than two-thirds of these systems are regenerative (i.e. energy can be returned to the network); an analysis of the sources of energy in these systems showed that heat or cold from the ground and from various sources of water are the most common.[23]

While district heating has already been around and continues to grow in popularity, district cooling networks are increasingly gaining ground. The District Energy in Cities Initiative, for example, which is coordinated by the UN Environment Programme and SEforAll, works with 45 partners across private sector companies, international and national organisations, industry associations, city networks, and academic institutions to support market transformations to have renewable-powered and energy-efficient heating and cooling in cities. As of 2020, it had worked in 36 cities across the world, including Cartagena, Marrakesh, Belgrade, Pune, Coimbatore, Ulaanbaatar, Astrakhan and others, and had a projected reduction of 290,000 tCO_2/year in emissions.[24]

In the US, as part of Colorado's wider attempt to reduce GHG emissions from heating and cooling, the city of Denver is promoting the replacement of older natural gas-powered heating with electric heating and cooling, notably in the 30% of the residences, which fall in the low-income category, and do not have access to air conditioning. The city's plan offers seven full or partial electrification options, and Xcel Energy, an American electricity utility, offers rebates, even full rebates in certain conditions. According to a study by the City's Office of Climate Action, Sustainability and Resiliency, switching to renewable-powered electric heating/cooling works out to be around the same cost as natural gas.[25] Several American cities have taken measures in similar directions since 2019 (**see Electrification trend**).

District cooling networks have also been used by cities like Paris, which through the French utility Engie, runs a cooling grid which uses water from the river Seine, to cool hospitals, hotels, museums, and department stores. The Parisian network also offers an example of cool storage at the night, to be discharged at peak hours, which saves around 200 $kgCO_2$ a day.[26]

District cooling in the Middle East is one of the fastest expanding, with the market expected to cross a value $15 billion by 2027, dominated by Qatar, Saudi Arabia, and the UAE, led by eminent players like Tabreed, Empower, Emicool, DC PRO Engineering, Marafeq Qatar and Ramboll Group A/S.[27] Empower holds more than 70% market share in in the UAE, while the Engie, through its 40% stake in Tabreed is expanding its market across the region, and even to Egypt, India and Turkey.[28] In the GCC countries, district cooling and stand-alone air or water chillers represent 15-25% of installed cooling capacity, thanks to more recent real estate development, and the need to cut down on cooling energy demand. Additionally, 10% of the building stock in the region could eventually be retrofitted and connected to district cooling networks.[29] District cooling, while not new, is also gaining more ground in other parts of Asia as well, across China, Japan, and more recently, Southeast Asian countries. Singapore has also recently been investing in district cooling systems, such as in the financial districts, or more recently in the residential Tampines.[30]

Alternatives to air-conditioning in the conception and design of built environments

Making the best use of passive design principles and natural ventilation to replace automated HVAC systems is another key solution[31]. Using natural ventilation can reduce building energy consumption by 10 – 30%,[32] by using principles of air pressure to regulate the flow of cooler and warmer air currents in a building. For example, the design of the Japan National Stadium used for the 2020 Olympic Games at Tokyo, built largely with wood, and built to maximise airflow from the outside, helped bring temperatures down.[33] Several indoor venues for the games made use of 'green air tech' air-conditioning, which pushes air down in spirals to the lower parts of the building, and requires 40% less energy.[34]

Passive houses are buildings that are designed to capture and regulate naturally received heat and thus use up to 90% less energy than conventional houses.[35] They also have building envelopes that are designed for better insultation, and strategically placed windows and ducts. The Passive House Database lists 5,174 buildings that are certified as Passive Houses and are already completed or in the construction phase.[36] At the same time, the geographical distribution of certified buildings, as seen on the Passive House International database shows a concentration of these buildings largely in Europe, followed by North America, East Asia, Australia and New Zealand.[37]

The vast majority of identified Passive Houses are single-family homes and other small, low-rise buildings,[38] although larger applications have been made. The world's largest complex of passive houses is in construction in Gaobeidian, in China, which will consist of 30 high-rise buildings and house around 7,000 people.[39] The city of Brussels is another leading example in passive buildings, requiring all new constructions after 2015 to be passive, and also incentivising the construction 243 low-energy "exemplary" buildings, or BatEx.[40]

Reflective paint and "green" surfaces (surfaces with vegetation), particularly roofs, were identified in the 2020 Sector-based report[41] as popular requirements for new constructions. Planting vegetation in cities has shown to reduce temperatures by up to 45° F (~25° C),[42] while "ultra-white" reflective paint has been identified as reflecting excessive sun light and helping to cool buildings. This is not a new idea – white-painted buildings have been found traditionally in various regions with hotter climate. The calcium sulphate in white paint is responsible for reflecting solar radiation, and new studies identified barium sulphate as even more effective. The extraction of barium ore and producing barium sulphate, nevertheless, is energy consuming and has a rather large carbon footprint.[43]

The Million Cool Roofs Challenge was an initiative created to this end. By changing a dark roof to a white one, the temperature in the top floor can be reduced by 2-3 degrees. By increasing solar reflectance of the roof from 10-20% to 60%, net annual energy use for a single-story, air-conditioned building can be reduced by 20%.[44] The challenge, launched by the Kigali Cooling Efficiency Programme, SEforAll, the Global Cool Cities Alliance and the foundation Nesta, is providing $2 million in grants, between August 2019 and August 2021 to proposals for cool and solar-reflective roofing in countries affected by heat stress and low access to cooling. Finalists of the challenge who implemented the challenge in the Kerail slum in Bangladesh saw cool roofs reducing indoor temperatures by around 7°C. Similar results were yielded by adopting simple, reflective roofs in Jakarta, Indonesia.[6]

KEY TAKEAWAYS

The issue of cooling in buildings faces a double question of ensuring access to cooling in the face of rising temperatures and thus rising demand on the one hand, and on the other, the need to ensure energy efficiency and reduce GHG emissions. While innovation in cooling technology has been progressing, an equivalent advancement in equipment available for use in the residential and commercial sectors has not yet been made, nor has demand caught up. At the same time, the role social and behavioural factors in air conditioner use and purchase remains a large policy blind spot. District cooling, while not yet as widespread as district heating, is catching on, and remarkably so in the GCC, as the growing market invites energy giants from around the world to invest. Space cooling that capitalises on the design and conception of buildings is on the rise, as seen in the growth in passive houses, super-reflective surfaces, and green and cool roofs.

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SIGNALS

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

Datacentres • In Norway, waste heat from datacentres feeds into district heating

As the use of the internet widens and data centres convert much of the electricity they use into heat, the idea of connecting data centres to heating networks is gaining popularity. In Norway, as the government implements the 2021 amendment to the EU's renewable energy directive requiring large energy users to reuse their waste heat, data centres with a capacity greater than 2 MW will be required to connect into district heating providers. Data centre operator DigiPlex, for example, has signed heat reuse agreements with district heating providers in the Scandinavian countries, such as Fortum Oslo Varme in Norway, and Stockholm Exergi in Sweden.

Data Center Dynamics, 2018

Bio-sourced materials • In France, the timber industry is gaining ground

In November 2020, as part of the FIBois IDF initiative, 28 developers and project owners committed to building up to 40% of new buildings or renovations with wood and/or other bio-sourced materials (totalling a surface area of 1.2 million m^2) over the next four years. The new environmental regulation (RE2020), which will come into force in January 2022, will support this objective and favour bio-sourced materials (such as wood), which act as carbon stocks. Nevertheless, these projects remain few and far between. The timber industry is also caught in the middle of massive log exports to China. In a context of shortage, 9,000 companies have signed a petition asking the leaders to take measures against the outflow of these materials, which endangers the French sawmills and industry.

Le Monde, 12/04/2021

Bioclimatic buildings • The rise of bioclimatic architecture in Ho Chi Minh City

Making use of innovative architectural techniques, available renewable energy, natural ventilation and minimal mechanisation: this is the promise of the bioclimatic architecture that is emerging in Vietnam. In Ho Chi Minh City, the architectural firm G8A has completed the first phase of construction of Concrete Waves in 2019, a building housing the offices of FPT Software, the largest Vietnamese digital company. The building's perforated materials allow air to pass through for natural ventilation and sunlight to illuminate the corridors. The second and third phases will include two inner courtyards with tropical vegetation and porous structures. In parallel, the company Tropical Space is offering bioclimatic houses that do not require air conditioning and are affordable for the middle classes. A first such house was inaugurated in May 2021, about ten kilometres from the capital.

Wallpaper, 11/08/2021

Namibia • IFC partners with Bank Windhoek on green building certification

In a partnership with Bank Windhoek, the International Finance Corporation (IFC), a subsidiary of the World Bank Group, has launched Edge – "Excellence in Design for Greater Efficiencies" – software for digital certification of green buildings to facilitate their access to finance in Namibia. The software assesses available solutions for reducing the electricity consumption of buildings and the management of running and wastewater. Certified buildings are expected to achieve a 20% reduction in water and energy consumption. Edge is part of a larger green bond programme in Namibia through which Bank Windhoek has raised over $4 million to finance clean energy projects for the private sector.

Afrik21, 02/09/2020

Renovation • A project by European cities to measure the impact of the Renovation Wave

In May 2021, 24 new European cities (including the capitals Madrid, Rome and Zagreb) joined the BUILD UPON^2 project funded by the European Horizon 2020 programme. These cities will work with national Green Building Councils, BPIE and the Climate Alliance network of local governments to develop and implement the measurement and monitoring of the impacts of building renovation on several dimensions: energy efficiency, energy poverty, employment. This project is part of the Renovation Wave, a European strategy launched in 2020 that aims to double annual energy renovation rates over the next ten years.

BPIE, 11/05/2021

Australia • In Wilton, lighter roofs to combat heat islands

With extreme heatwaves accelerating and temperatures reaching 50°C in the summer, the western Sydney suburb of Wilton is banning dark roofs on new properties, which will have to be lighter and more reflective. The measure in the Wilton Growth Area Development Control Plan 2021 is part of new plans by the state of New South Wales to move away from dark roofs in a bid to bring down the temperature of buildings and cities more widely. This type of measure has already been implemented, for example, in New York (CoolRoofs programme) or Ahmedabad in India (Heat Action Plan). In Wilton, residential lots will have to be large enough to allow for the planting of a tree in the courtyard or garden. 9,000 new climate-resilient homes are planned in the coming years.

dezeen, 27/08/2021

New Zealand • A new programme to promote low-carbon constructions

Reducing the carbon emissions associated with the construction of buildings and reducing operational emissions during their lifetime are the two main objectives of the new Building for Climate Change programme of the New Zealand Ministry of Trade, Innovation and Employment. The building sector accounts for 20% of the country's total emissions. As a result, the Building Code will be amended to meet the goal of carbon neutrality by 2050, including the introduction of caps on operational emissions. New requirements have already come into force at the beginning of the year concerning glazing and insulation: thermal regulations will have to be reduced from 80-90 kWh/m^2 to 30 kWh/m^2 from 2027, and to 15 kWh/m^2 in 2035. The programme, which is to be implemented over two decades, will still have to cope with a lack of skilled labour in the sector, which could delay the implementation of these new measures.

Architecture Now, 21/09/2021

Adaptation • In China, "sponge" cities in the face of frequent flooding

To cope with increasing flooding and rising sea levels, the Chinese government is supporting the development of "sponge" cities. Designed to absorb, store, filter and purify excess stormwater, these sponge cities rely on infrastructure such as gardens, wetlands, and permeable pavements. Water is stored in underground tanks and tunnels until the flooding has stopped. The concept, invented some 20 years ago, is gaining momentum in China: 30 pilot cities have been experimenting with a sponge cities programme since 2013, and another 600 are expected to follow. In China, 98% of the largest cities regularly experience flooding.

World Economic Forum, 08/07/2021

CASE STUDIES

IN PARTNERSHIP WITH

COUNTRY CASE STUDY

COUNTRY	POPULATION	MITIGATION TARGET	EMISSIONS IN 2019
THE NETHERLANDS	17,280,000	-49% IN 2030 (BASE YEAR 1990); -95% IN 2050	181 MTCO$_2$E (-18% SINCE 1990)

Long-term strategies of local authorities in the Netherlands to phase out fossil fuel use in heating

The important role of local authorities in increasing building renovation rates in Europe is getting more widely acknowledged, whereby long term renovation strategies are key instruments to guide local action. This is illustrated in the Netherlands, where local authorities play an essential role in strategic planning for the decarbonisation of the built environment.[1] Increasing earthquake intensity in the natural-gas rich province of Groningen, and signing the Paris Agreement were main reasons for the Dutch Government to commit to heating all buildings without fossil fuels by 2050. The Dutch government has also committed to the intermediary target to decarbonise 1.5 million buildings before 2030.

The Heat Transition Vision strategies

To achieve these goals, all Dutch municipalities are required to write a long term strategy describing how they intend to decarbonize the complete building stock in their jurisdiction and send these strategies to the government. Similar to national long term renovation strategies[2], these 'Heat Transition Vision ' (HTV) strategies describe how buildings will be heated without fossil fuels, but focus on the municipal level. Moreover, the HTV must contain a roadmap describing how each district will be decarbonised, for example by connecting buildings to renewable district heating or renovating buildings to go all-electric. Once these strategies are completed, district implementation plans will be written in 2022 in collaboration with involved building owners and local stakeholders. In practice this means all 352 municipalities will draft an HTV by the end of 2021. As of March 2021, 50% of the municipalities responded to a survey about the status of their HTV (**figure**).

20 of them had already approved their HTVs, completely (16) or conceptually (4), planning to renovate or decarbonise more than 100,000 residential buildings and 5,000 non-residential buildings. The other 332 municipalities were still working on their HTVs in preparation for the late 2021 deadline. If the combined plans do not achieve the 1.5 million buildings target by 2030, the national government has certain additional measures it could take.

A multilevel governance framework to speed up the fossil-heating phase-out

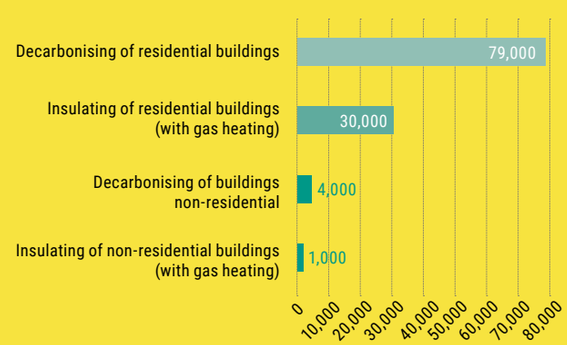
The HTVs are written in parallel to 'regional energy strategies', which divide the available potential renewable electricity and heat sources among municipalities, and the 'natural gas-free districts programme', where selected municipalities have already started decarbonising districts to generate lessons that will help to accelerate the transition in the rest of the country. Thus, together with these two strategic processes, the HTVs should result in a feasible and concrete strategy to decarbonise the Dutch building stock while facilitating tailored local solutions and the participation of stakeholders. A digital interactive map shows all municipalities from which an HTV has been accepted and links to the strategies themselves, such as the HTV from the city of Utrecht.

The implementation of these long-term decarbonisation and renovation policies also faces certain challenges. Critical reviews of the National Audit Chamber and the Economic Institute for Construction and Housing (EIB) highlight technical challenges, the complexity of public-private partnerships, and a lack of public support faced in pilot districts, which increase the financial burden and delay the implementation of envisioned renovation projects. Although significant delays are occurring, the first residential buildings have already been disconnected from the gas grid in the municipality of Purmerend.

1 In the Netherlands, decarbonisation relates to fuel switching from the predominant natural gas heating to renewable sources.

2 Which all European Member States are required to write under article 2A of the Energy Performance of Buildings Directive.

NUMBER OF BUILDINGS TO BE DECARBONIZED OR RENOVATED BEFORE 2030 IN THE 16 APPROVED PLANS (MARCH 2021)



COUNTRY	POPULATION OF THE CITY	NATIONAL MITIGATION TARGET	NATIONAL EMISSIONS IN 2019
THE NETHERLANDS	86,832 (2019)	-49% BY 2030 (BASE YEAR 1990); -95% BY 2050	181 $MTCO_2E$ (-18% SINCE 1990)

In Heerlen, a "5th generation" heating and cooling network

In 2005, with funding from the European Union and the Dutch government, the city of Heerlen drilled five wells to draw benefit from old coal mines and use them as sources of heat and cold. These mines contain underground lakes whose water is naturally heated by geothermal energy – an energy source the city wanted to take advantage of, along with the area's industrial past. Thus, in 2008, 50,000 m² of floor space in buildings was connected to an initial heating and cooling network centred on this source.

Heat exchanges between buildings

As the network grew, the geothermal capacities of the mines could no longer cover the increasing number of buildings. They had to be enhanced, and energy storage solutions developed, in order to extend the network. This is why, in 2013, the city created the company Mijnwater BV, responsible for developing a heating and cooling network covering the entire city. The company has connected buildings to each other, and uses the heat and cold generated by each of them, to in turn cool or heat the others: this is the principle of a 5th Generation District Heating and Cooling network (5GDHC). With the development of the network, the mines have become an inter-seasonal storage solution, making it possible to conserve the heat produced by air conditioners in summer in order to heat buildings in winter.

The network now supplies up to 20 TJ/year of heating and 20 TJ/year of cooling to 250,000 m² of offices, businesses, supermarkets, residential and public buildings. The network can capture heat from wastewater, air conditioning or digital devices. The collected energy is then redistributed according to the needs of each building, thanks to very precise digital monitoring, and to a network of heat pumps and storage solutions. In total, about half of the energy consumed by users for heating and cooling comes from the customers themselves. For example, the school is heated by the heat from a pension fund data centre. This type of network is scalable: at the start, it is possible to connect just a few buildings to each other, gradually expanding the network. The Heerlen network continues to expand, and also incorporates renewable energy sources (such as geothermal energy). The network has reduced the urban energy demand by 50%, and CO_2 emissions by 65%; powered by renewable energy, the balance could fall to zero emissions.

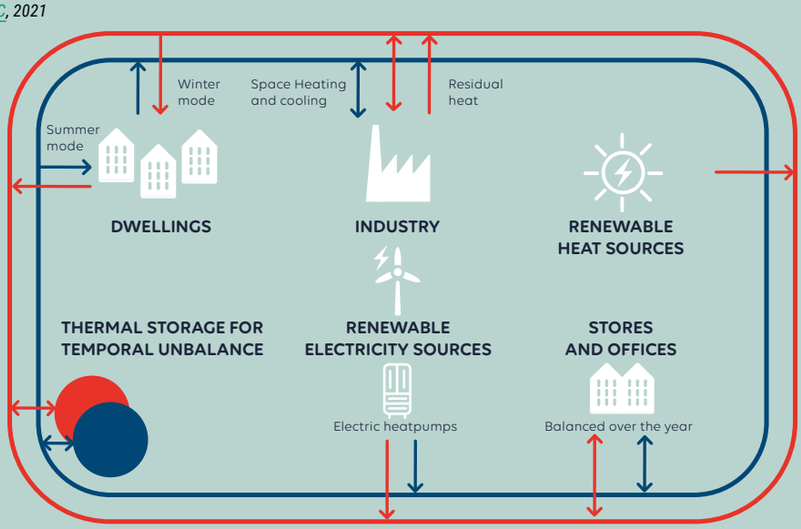
An increase in local energy autonomy

This type of network strengthens local energy autonomy and improves resilience to variations in the national grid. It limits overconsumption and prevents energy loss thanks to its closed-loop operation and energy recovery from the buildings. The development of storage solutions in addition to the network, and the large-scale roll-out of the network have been pinpointed as success factors of the project. While generations of urban heating and cooling networks have succeeded each other at the pace of technological innovation (**see figure**), the Heerlen network heralds the advent of a 5th generation based more on a qualitative rather than a technological leap. Since 2018, Mijnwater BV has become the main partner of the European D2Grids project, which aims to develop 5GDHC similar to that of Heerlen, at 5 pilot sites: Paris-Saclay (France), Bochum (Germany), Brunssum (The Netherlands), Glasgow and Nottingham (United Kingdom).

Sources : Construction21.org ; District Energy Awards

5GDHCs, A CLOSED ENGERY LOOP BETWEEN DIFFERENT HUBS OF URBAN ACTIVITY

Source : 5GDHC, 2021



COUNTRY	CITY	POPULATION	MITIGATION TARGET	NATIONAL EMISSIONS IN 2015
MONGOLIA	ULAANBAATAR	1,400,000	TO CONTRIBUTE TO HALF OF THE EFFORTS MADE BY THE MONGOLIAN GOVERNMENT (-14% OF EMISSIONS COMPARED TO THE BAU SCENARIO IN 2030)	37.6 $MTCO_2E$

In Ulaanbaatar, Geres is creating an ecosystem for the thermal insulation of precarious housing

More than 50% of Mongolians live in the capital, Ulaanbaatar. The coldest city in the world, its heating needs make it the city with the highest level of air pollution in the world. The heating season lasts 8 months and a majority of the population heats and cooks with cheap, low-quality charcoal, especially in the Ger area, a semi-formal settlement area consisting of fenced plots with one or more ger (yurts) and/or houses made of modern materials, poorly insulated and heated with low-efficiency stoves that emit fine particles.

More than 60% of the city's population live in this area. Each year, around 80% of the city's air pollution is caused by the 600,000+ tonnes of coal used for cooking and heating, between November and March. Such was the situation that in early 2017, the government declared a state of emergency in Ulaanbaatar, with the intent of exploring solutions to this problem.

The Switch Off Air Pollution project

After 10 years working in the energy field in Mongolia, the NGO Geres launched the Switch Off Air Pollution (SOAP) project in 2018 for a 4-year period. SOAP aims to create an insulation market, with certified materials and work carried out by micro, small and medium-sized building enterprises (MSMEs), trained and supported in order to fight air pollution in Ulaanbaatar by improving the energy efficiency of housing in the Ger area, reducing respiratory infections, fuel costs and GHG emissions. Insulation techniques are standardised, with quality materials and quality installation. A step-by-step approach is made possible, ranging from simple low-cost solutions to comprehensive insulation, and loans suitable for low-income households are offered by local financial agents.SOAP is implemented with the Building Energy Efficiency Center of the Mongolian university, the Mongolian National Construction Association and the Czech NGO People In Need, in partnership with local banks and with the financial support of the European Union, the Abbé Pierre Foundation and French and Czech Development Agencies.

Promising results

Initially, a comprehensive study made it possible to 1) determine the attitude of the inhabitants on these matters and their socio-economic situation, 2) establish a typology of housing with 4 categories according to their building envelopes, and 3) compile a database on the skills and resources of MSMEs in the 6 districts of the capital.

On the supply side, standardised and progressive technical solutions and recommendations for energy-efficient houses have been established and distributed to building professionals and households. On the demand side, a website has been created to promote insulation and coordinate the various actors involved by tracking and recording all stages of work. In addition to this website, there is a Facebook account and a functioning call centre.

By the end of 2020, 30 houses had been insulated, 10 of them with a green loan from Xac Bank. Delayed by the pandemic, a campaign to promote simple insulation solutions was launched in late 2020 in two districts, with the support of 22 local Red Cross volunteers. 375 households were thus able to carry out small jobs at a low cost, resulting in energy efficiency gains of around 8%. When these households can prove that they have persuaded five others, they win a 5 cm-thick roof insulation (providing energy savings of the order of 15%), a strategy aimed at increasing the number of homes improved and households brought into the loop.

By the end of 2022, the insulation of 1,000 homes is expected to save at least 800 tonnes of coal and avoid the emission of 3,000 tCO_2. This will improve the living conditions and the purchasing power of households, stimulate local employment and improve the local and global environment.

A project from which the entire nation can draw inspiration

To support the project, the Mongolian National Construction Association has created a new branch to recruit, train and support its members in the thermal insulation field. It is working closely with public authorities to include this approach in local and national policies. In mid-2020, the Ministry of Construction and Urban Development modified its standards on the thermal insulation of buildings, based on the techniques developed by the project. This new regulation came into force in January 2021.

“HYDROGEN, CCUS… FACED WITH A DEAD-END IN THEIR PATHS TO DECARBONI-SATION, HEAVY INDUSTRIES TAKE RECOURSE TO BREAKTHROUGH TECHNOLOGIES”

The chemicals, steel and cement sectors are responsible for two-thirds of industrial CO_2 emissions, which in turn account for nearly a quarter of all global emissions. In the 2019 and 2020 editions of its Global Synthesis Report on Climate Action by Sector, the Observatory showed the difficulties of these three sectors in decarbonising their production: rates of energy efficiency that are already close to their thermodynamic thresholds, processes of circularity that are too dependent on market price fluctuations, and the fact that slowing down or decreasing production remains outside the options open to manufacturers. As for renewables, they hardly penetrate the most emitting industries, which in any case generate a large part of their emissions during the transformation processes, independent of electricity consumption **[INDICATORS]**.

Faced with these barriers, these industrial sectors are relying on breakthrough technologies that previously suffered from a lack of competitiveness and political support. Firstly, CCUS technologies allow them to consider business as usual: emissions would simply be captured at source and transported to be stored forever, or re-used in other activities. However, at present, captured CO_2 is mainly issued in enhanced oil recovery: the gas is injected into an active oil reservoir to boost production. Despite these uncertainties with regard to the climate, more and more companies are counting on the deployment of these technologies as part of their decarbonisation strategies **[TRENDS]**. As a result, investment had surged in 2020, driven in particular by oil and gas companies seeking new low-carbon operations, the Longship project in Norway being an example **[CASE STUDIES]**.

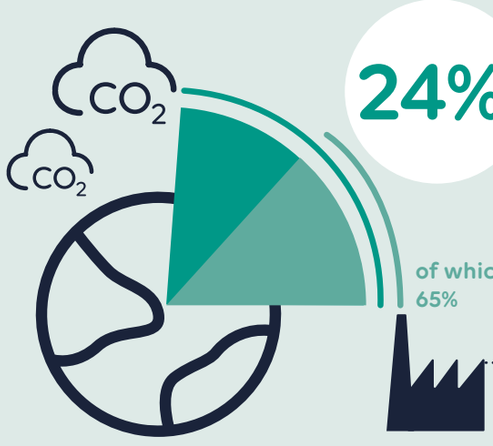
The second breakthrough on which manufacturers are heavily counting is hydrogen. Since 2019, and even more so with the States' recovery plans adopted in 2020, hydrogen has been promised a radiant future, supported by unprecedented investment announcements – although these have not yet been converted into real investments. At the same time, the lion's share of hydrogen is expected to be used in transport. Applications for industry are still in the experimental stages, except perhaps in the case of steel, where the first tonnes of low-carbon steel, manufactured using low-carbon hydrogen, have been produced by the Hybrit project in Sweden **[TRENDS]**.

Cobalt, nickel, lithium, rare earths… Big mining companies are establishing themselves as indispensable to transition technologies, such as batteries and photovoltaic panels. In 2020, their profits exploded following strong demand and unprecedented inflation: the world's top five mining companies recorded profits which for the first time were higher than those of the five largest oil companies. Faced with these instabilities, States are trying to create industries within their territories, and high-tech companies dependent on these strategic metals are securing their supplies by concluding long-term contracts or by integrating value chains **[TRENDS]**.

This new economic configuration conceals another more structural one: with resources concentrated in a few countries (China, the DRC, Chile, Australia, etc.), access to minerals useful for the low-carbon transition has become as much a political issue as an environmental and climate issue **[SIGNALS]**.

HYDROGEN, CCUS... THE INDUSTRIAL SECTOR BETS ON DISRUPTIVE TECHNOLOGIES FOR ITS DECARBONISATION

Dominated by steel, cement and chemicals, the industrial sector seems stuck above a certain emissions ceiling



GLOBAL GHG EMISSIONS FROM INDUSTRY IN 2018

Direct industrial emissions (including industrial processes) totalled 8.5 GtCO2e in 2018, which was 24% of all emissions. *IEA, 2020*

65% of these industrial emissions came from the three most emitting industries: chemicals, steel, and cement. *REN21, 2021*

EVOLUTION OF STEEL, CEMENT AND AMMONIA PRODUCTION IN 2020

STEEL

2019	1,874 Mt
2020	1,878 Mt

The 4 Mt increase in the production of steel in 2020 is the lowest since 2000. Production in China reached a record high of 1,065 Mt in 2020, offsetting the slight decrease in the rest of the world. *Worldsteel, 2021*

CHEMICALS

2019	142 Mt
2020e	144 Mt

Industrial production of ammonia, one of the main sectors of the chemical industry, has been little affected by the Covid-19 pandemic, and may even have increased by 2 million tonnes compared to 2019.

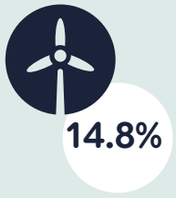
CEMENT

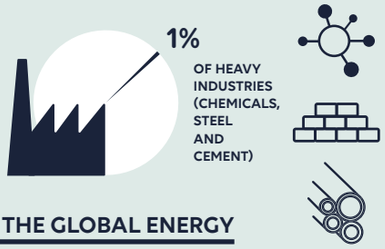
2019	4.1 Gt
2020e*	4.1 Gt

Despite the slowdown in activities in several parts of the world due to measures taken to limit the spread of Covid-19, cement production in 2020 likely reached the same level as in 2019. *USGS, 2021*

* 2020e : estimations for 2020

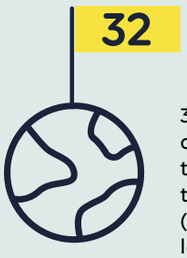
Renewables have hardly penetrated the most emitting sectors





SHARE OF RENEWABLES IN THE GLOBAL ENERGY DEMAND OF THE INDUSTRIAL SECTOR

Heavy industries (chemicals, cement, steel) use only about 1% of renewable energy for their activities, compared to 30% in the paper industry, and 25% in the tobacco industry. Bioenergy represents the majority of these renewables. *REN21, 2021*



32 countries in the world have adopted a policy supporting the deployment of renewable thermal energy for industries (subsidies, tax reductions, loans...), including Argentina, Canada, China, Japan, the United States and many European countries. *REN21, 2021*

Despite its production being highly emissive, hydrogen raises the hopes of decarbonising the industrial sector

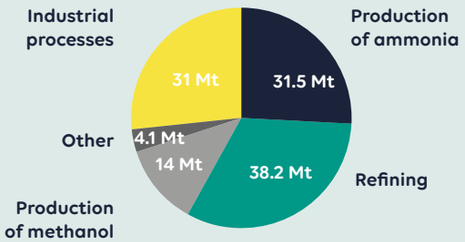
120 Mt H_2

830 $MtCO_2e$ CO_2

PRODUCTION AND USE OF HYDROGEN

This production is responsible for 830 $MtCO_2e$ of emissions per year.
Hydrogen is mainly used for the refining of crude oil and the production of ammonia. Only 0.01 Mt is currently used as a fuel for transportation. *IEA, 2019*

HYDROGEN DEMAND IN 2018



1.4% Share of low-carbon hydrogen

98.6%

0.3%	1.1%	1.9%	96.7%
RENEWABLE-POWERED ELECTROLYSIS	METHANE REFORMING OR COAL GASIFICATION, WITH CAPTURE AND AND SEQUESTRATION OF EMISSIONS GENERATED	FOSSIL-POWERED ELECTROLYSIS	METHANE REFORMING OR COAL GASIFICATION

Global CCS Institute, 2021

$189 mn HYDROGEN FROM ELECTROLYSIS

INVESTMENTS IN THE PRODUCTION OF HYDROGEN FROM ELECTROLYSIS

168 million dollars were invested in 2019, which increased to 189 dollars invested in 2020.
BloombergNEF, 2021

$19.8 bn LOW-CARBON HYDROGEN

POLICIES SUPPORTING LOW-CARBON HYDROGEN

Since the start of the pandemic, 10 countries (Canada, France, Australia, the United Kingdom, Poland, Russia, New Zealand, Spain, Germany, Norway) and the European Union have committed to invest a total 19.8 billion dollars for the deployment of the production of hydrogen.
Energy Policy Tracker, 2021

Yet to majorly penetrate public debate, CCUS techniques draw the interest of carbon-heavy industries

+212%

In 2020, investments in CCUS touched 3 billion dollars, which was a 212% increase from the 2019 levels.
BloombergNEF, 2021

65 CCUS installations in the world

26 operational projects

20 projects financed through EOR

financed through Enhanced Oil Recovery (EOR), i.e. the injection of captured CO_2 into a crude oil reservoir to facilitate its extraction.

40 $MtCO_2$ /year

allowing for the capture of 40 MtCO2/year

TRENDS
MINERALS

Yes, in my backyard! Under Pressure, International Competition for Strategic Minerals Required for the Energy Transition Intensifies

ANTOINE GILLOD • Coordinator, Climate Chance Observatory

While global economic growth sets off again at full tilt, the disorganisation of logistics chains and the high demand for low-carbon technologies have led to a spike in the prices of metals that are strategic to the energy transition, to the point of generating shortages of essential electronic components and jeopardising production in some industrial sectors. To achieve the climate objectives of the Paris Agreement, guarantee their geopolitical independence and secure their material supplies, States and businesses are sharpening their elbows to create integrated industrial sectors, from mining to battery production.

DATA OVERVIEW

The electrification of end-uses is in excess of the supply of strategic metals

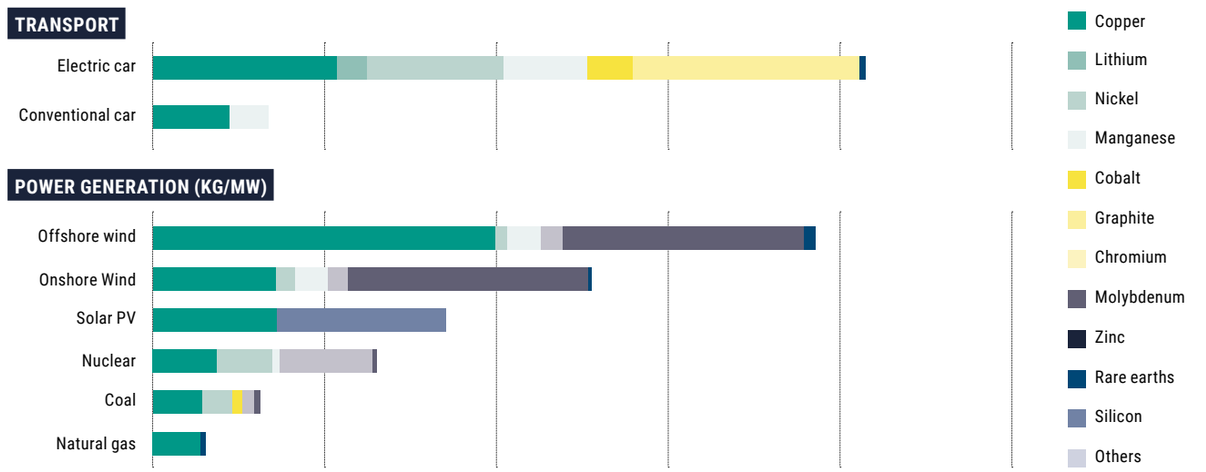
"We are moving from the era of oil into one of metals". With these words, Christel Bories, CEO of the French mining company Eramet, reminded us that the economic and social transformations necessary to achieve the objectives of the Paris Agreement are primarily materials-based and will require large amounts of raw materials.[1]

The International Energy Agency (IEA) makes no mistake about this. In May 2021, it published a special report entitled "The Role of Critical Minerals in Clean Energy Transitions", stressing that most of the technologies necessary for the low-carbon transition require much greater quantities of metals than their carbon-intensive alternatives (**fig. 1**): six times more for an electric car than for a conventional car, for example, and nine times more for wind power than for a gas-fired power plant with equal energy production levels. Since 2010, in line with the increased share of renewables in the electricity mix, the metal-intensity for each new unit of electrical power generation capacity has increased by 50%. A scenario where the world achieves carbon neutrality in 2050 would require a six-fold increase in metal production by 2040.[2] In 2020, the World Bank was already talking about the need to increase the production of metals six-fold, in particular, non-ferrous metals such as cobalt, graphite and lithium, to meet the needs of low-carbon technologies in 2050.[3]

Record sales of electric vehicles (**see Transport sector**) in 2020, the exponential growth

FIGURE 1

MINERALS USED IN A SELECTION OF CLEAN ENERGY TECHNOLOGIES - *Source: IEA, 2021*



of the capacities of renewable energy production facilities (**see Energy sector**), and also the high demand for consumer goods during lockdowns and during the economic recovery, have increased pressure on the supply of raw materials and semi-finished electronic products. The nickel market, for example, experienced a supply shortfall of 34,900 tonnes during the first four months of the year. Initially falling by 20% in 2020 due to the pandemic, global nickel demand increased by 9.2% in the first six months of 2021, while supply grew by only 5.8%. Japanese company Sumitomo Metal, which produces batteries for Tesla and supplies cathodes to Panasonic, estimates that global nickel demand for batteries will increase by 18% over the year.[4] Australian investment bank Macquarie estimates the lithium deficit to be 2,900 tonnes in 2021, and Credit Suisse expects it to grow to 248,000 tonnes in 2025.[5]

The costs of most strategic metals have therefore been subject to very high inflation since the second half of 2020. Between September 2020 and September 2021, nickel prices jumped 27.7%, lithium carbonate 48.5% and cobalt 51.9%[6] (**fig. 2**). These three materials are the most important components of lithium-ion batteries, currently the most popular and efficient energy storage technology for electric cars. 50 to 70% of the price of these batteries is now determined by the price of the raw materials, as against 40 to 50% five years ago, according to the IEA. In turn, 30 to 40% of the cost of an electric vehicle depends on the battery price. A doubling of lithium or nickel prices could result in a 6% increase in battery costs, which would then have repercussions on all sectors dependent on them and useful for the transition, warns the agency.[2]

Prices of polysilicon, a conductive material essential for solar panels, have also increased by more than 300% between early August and the end of September 2021 ($35/kg), due to the Chinese government's enforced shutdown of refining plants in the middle of the energy crisis in early autumn 2021.[7] Indeed, while China's electricity mix is 73% coal-based, a complex combination of domestic and geopolitical factors led to rationing the plants' production. Price inflation for coal, in the context of a rebound in demand and of emissions mitigation policies, no longer allows coal-fired power stations to produce within the nationally-regulated tariff without incurring economic losses. Several industrial sites were then forced to close in order to rebalance supply and demand.[8]

Thus, in August 2021, in the Yunnan province, silicon producers were only operating at 10% of their usual output. Five Chinese companies, among the world's biggest manufacturers of solar modules (LONGi Green Energy, JinkoSolar, Trina Solar, JA Solar and Risen Energy), then called for solar panel installation projects to be postponed,[9] while investments in solar power continued to grow in the first half of 2021.[10] Inflation and shortages of metals threaten to pull the brakes on the production rate and therefore, on the adoption of low-carbon technologies, while on the contrary, climate objectives call for it to be sped up.

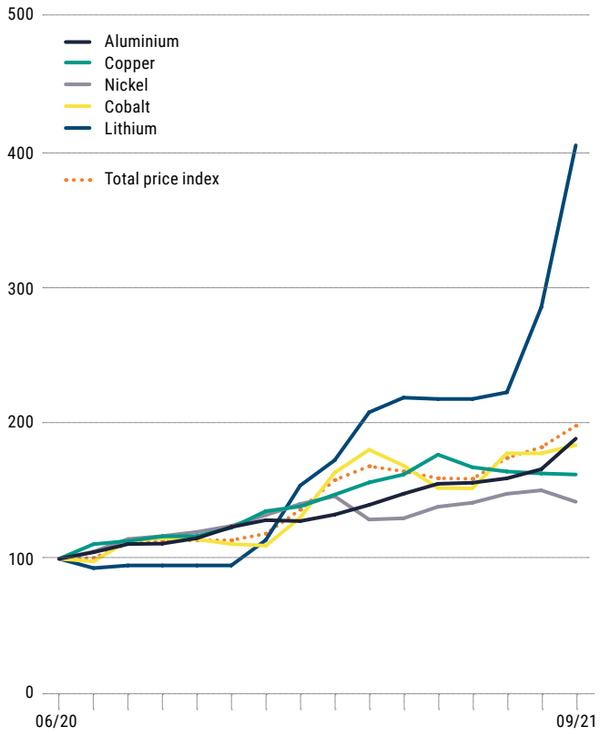
Here and there, political events have occasionally contributed to this price inflation in raw materials: aluminium prices, for example, reached a record level after the coup in Guinea, the second largest bauxite producer in the world.[11] The arrival in power of the Taliban in Afghanistan could also have medium-term repercussions on the global lithium supply (**see Signals**).

The widespread inflation in prices of strategic metals benefits mining companies, with soaring profits for the five largest of them (**tab. 1**), to the point of overtaking those of the five largest oil companies, Bloomberg estimates. 10 years ago, oil companies were still generating profits twice as high as mining companies.[12]

FIGURE 2

CHANGES IN THE PRICES INDEX OF SEVERAL STRATEGIC METALS BETWEEN JUNE 2020 AND SEPTEMBRE 2021

Source: compiled by the author based on data from FMI, 2021



Added to this cyclical increase in demand are the risks posed by the structural configuration of the metals supply market, which marked by a very strong geographical and market concentration of raw material reserves and production capacities for finished and semi-finished products. Although they are abundant in the earth's crust, many of these metals are considered "critical" by governments across many criteria (**see Keys to Understanding**). For example, the Democratic Republic of Congo (DRC) mines 67% of the world's cobalt, China 52% of its rare earth metals[a], and Australia 46.4% of its lithium. The DRC also has 52.2% of the world's cobalt reserves, China, Brazil and Russia 69% of its rare earth reserves, while Chile and Australia hold almost three-quarters of the world's lithium reserves underground.[13] The landscape is even more impressive downstream of the supply chains, since China alone accounts for the vast majority of the refining and processing capacities of all of these metals[b], as well as for a very large share of the production capacities of the finished products necessary for the energy transition (lithium-ion batteries, solar panels, wind turbine nacelles, blades and towers, etc.).[14]

In a context of growing geopolitical tensions between the United States and China, this hyper-concentration of the means of production of critical metals and of their transformation into finished and semi-finished products is a fundamental challenge to the autonomy of regions and businesses wishing to carry on their energy transitions. Over the past decade, awareness of their geostrategic vulnerability has led the world's largest economies to launch new regional industrial programmes aimed at diversifying their supplies, controlling value chains and thus strengthening their resilience to potential shocks, whether economic or political.

KEYS TO UNDERSTANDING

THE CRITICALITY OF METALS, A RELATIVE NOTION

Two factors make up the "criticality" of each metal: the risks threatening its supply (geological availability, its mining and production concentrations, political stability of producer countries, etc.), and the importance of said metal for economies. The variation in the appraisal of these factors leads to different evaluations of the criticality of metals according to the economic area, context and period: the latest list drawn up by the European Union in 2020 qualifies 30 materials as "critical", as against only 14 in 2011, whereas the United States had 35, Japan 34 and China 24. These lists include both geologically rare metals as well as metals that are abundant but subject to extreme pressure because of future demand (copper, bauxite, and "rare earths"...), or the political and environmental contexts of their mining when it is highly geographically concentrated (cobalt in the Democratic Republic of Congo – DRC).

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

THE OBSERVATORY'S LENS

The market concentration in industrial sectors strategic to the low-carbon transition

States in battle order to increase their material sovereignty and reduce their geostrategic dependence

The rare earths crisis at the dawn of the 2010s left a lasting impression. As part of its Rare Earths Industry Development Plan 2009-2015, China had at that time decided to ration its rare earth exports by imposing quotas and taxes on its producers with the aim, it told the World Trade Organisation, of *"protecting its natural resources and ensuring their sustainable economic development"*. China having become the market's price-maker, the prices of certain rare earth elements

a "Rare earths" are a group of 17 metals which are not rare in the strict sense of the word, but whose concentrations in the earth's crust are very low, which makes their extraction energy intensive. They are remarkable for their catalytic, magnetic, electrical, chemical, optical and heat-resistance properties, which make them essential materials for many technologies such as smartphones, LCD screens, energy saving light bulbs, LEDs, lasers, permanent magnets in wind turbines, especially offshore, and also in armaments also.

b 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

TABLE 1

PROFITS OF THE FIVE LARGEST MINING COMPANIES IN THE FIRST HALF OF 2021 AND IN THE FIRST HALF OF 2020

Source: compiled by the author based on company financial reports

Measured in EBITDA: earnings before interest, taxes, depreciation

RANK	S1 2020	S1 2021	VARIATION	SOURCE 2021
BHP	9,700	23,000		Estimations by Bloomberg[12] in May 2021. Semester-wise data unavailable in the BHP annual report.
RIO TINTO	9,640	21,037	118%	Rio Tinto Interim Results 2021
VALE	6,627	19,706	197%	VALE S.A EBITDA 2006-2021 MacroTrends
GLENCORE	4,833	8,645	79%	2021 Half-Year Report
ANGLO	3,350	12,140	114%	2021 Interim results

had then increased by up to 2,000% by 2011.[15] By doing this, China intended to force foreign industries to set up on its soil in order to benefit from technology transfers and facilitate the domestic sector's upswing towards high value-added activities, revealing in the process, the vulnerability of global supply chains to Chinese supply.[16] For the first time in history, the United States, the European Union and Japan then filed a joint complaint with the WTO's dispute settlement body to protest against the obstruction of free trade. Although the WTO finally forced China to lift its barriers rare earths have never lost their strategic power, as seen when Xi Jinping let a theoretical embargo on rare earth exports to the United States hang in the air right in the middle of the 2019 trade war.[17]

Since then, Japan has greatly reduced its dependence on China for its supply of rare earths. From over 90% in 2010, it now imports no more than 58% of its rare earths from its neighbour. This is the result of a diversification policy brought by the government, mainly through the independent public administration of the Japan Oil, Gas and Metals National Corporation (Jogmec). As far back as 2011, Jogmec rescued Australian mining company Lynas from bankruptcy in exchange for a priority position for Japan in long-term rare earth sales contracts. The agency is also investing in rare earth mining projects abroad, such as in Namibia, through a joint venture with the Canadian Namibia Critical Metals group.[18]

In Europe, the problem is all the more acute as the European Commission is now intending to tackle *"the double challenge of the green and digital transformations"*, while recognising in its communication on the Green Deal that *"[European industry] remains too linear and dependent on a flow of new materials mined, exchanged and transformed into goods, and ultimately disposed of as waste or emissions. Only 12% of the materials used come from recycling.*[19]" However, although tricky from a technical point of view, recycling strategic metals potentially represents a non-negligible resource for economies seeking to diversify their supplies.[20]

This is why the EU has launched a series of initiatives aimed at developing regional and circular industrial sectors in strategic domains to achieve digital and low-carbon sovereignty at all levels of the value chain, from raw material production through to recycling. Thus, in 2017, the European Commission inaugurated the European Battery Alliance aimed at creating a top international level supply chain for the manufacture and recycling of batteries.[21] While the European Union became the leading market for electric vehicles in 2020 (**see Transport sector**), it has very little lithium-ion battery production capacity within its borders. Then, in September 2020, the European Raw Materials Alliance (ERMA), was set up within the framework of the Action Plan on Critical Raw Materials aiming once again to reduce European dependency by creating regional sectors.[22] Led by France, six EU Member States and 17 businesses, the first "Battery Airbus" project obtained European Commission support, which called it an "Important Project of Common European Interest" (IPCEI) in December 2019, authorizing €3.2 billion in State public aid. A second European Battery Innovation program was launched in early 2021 and now involves twelve States and 42 businesses including car manufacturers (Tesla, BMW, Stellantis, etc.), battery manufacturers such as Northvolt, and raw materials and chemicals players, such as Arkema and Solvay. With €2.9 billion in public funds, the project hopes to raise €9 billion in additional private investment.[23]

Finally, in June 2021, a new Industrial Alliance for Processors and Semiconductor Technologies was set up in order to create an industrial ecosystem in electronic production and unlock new manufacturing capacity for micro and nanotechnologies.[24]

Lines are moving on the other side of the Atlantic too. After taking office as president of the United States, Joe Biden quickly ordered a review of the supply chains of American pharmaceuticals, semiconductors, rare earths and batteries.[25] The audit resulted in the announcement of a 2021-2030 National Plan for Lithium Batteries by the Department of Energy, and

other policies aimed at increasing investments and creating jobs in this sector.[26] The White House has also let it be known that it was envisaging the introduction of tariff barriers on the import of permanent neodymium magnets essential for wind turbines, whose production is largely dominated by China.[27] The recent reopening in California of the Mountain Pass mine, which at one time was the biggest rare earths mine in the world, results from this rationale (**see Signals**).

Indonesia has the world's largest nickel reserves (22%), according to the US Geological Survey.[28] Refined nickel sulfate is an essential element in cathode manufacture for household batteries and the lithium-ion batteries used in electric vehicles.[29] As part of its nationalist resource management policy, the government of President Joko Widodo has placed this geological asset at the heart of what economists call a "*policy of industrialisation through import substitutions*", aimed at developing an integrated national economic sector covering the steps from mining to battery production, rather than just exporting the raw materials. Thus, the first thing the government did was to put an end to nickel exports in January 2020.[30] Then in April this year, the Korean LG Energy Solution (LGES), a dominant player in the rechargeable battery market, signed a memorandum of understanding with four Indonesian public companies to form the Indonesian Battery Corporation. The holding brings together the mining companies Antam and MIND ID, the national oil company Pertamina and the electricity company PLN. LGES will invest $9.8 billion in all stages of the value chain, from mining through metal processing and refining to cathode production.[31] In early September, LGES and Hyundai Motor Group inaugurated the construction of the very first lithium-ion battery manufacturing plant for

KEYS TO UNDERSTANDING

THE SEMICONDUCTOR SHORTAGE

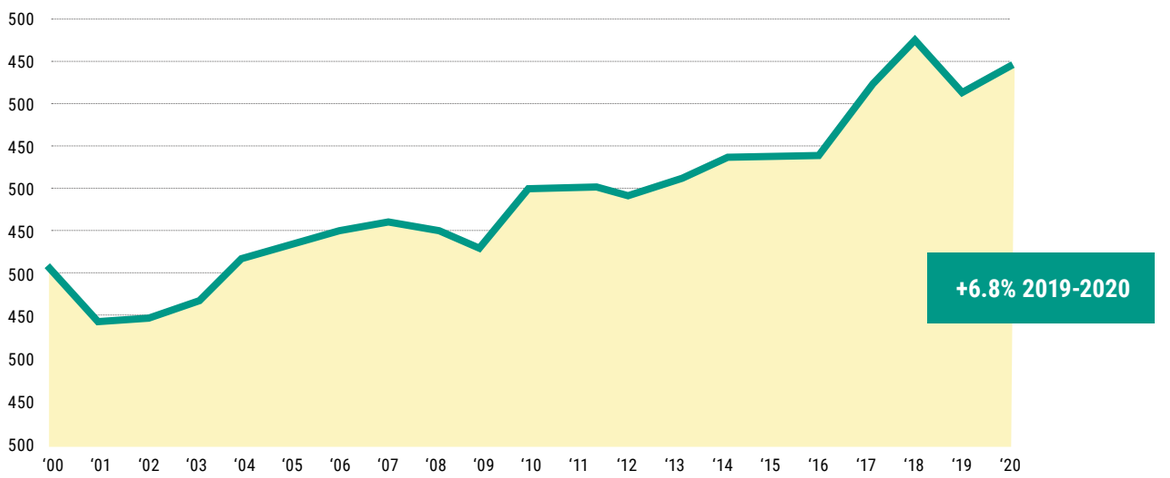
Semiconductors are a group of chemical elements with low conductivity, halfway between that of metals (conductors) and that of insulators. These chemical elements include Silicon (Si), Germanium (Ge), Antimony (Sb) and Gallium (Ga). They are materials crucial in the manufacture of transistors, an essential component of electronic circuits, and their importance for the world economy has grown almost unceasingly over the last twenty years (**fig. 3**). Semiconductors are the 3rd largest US export sector behind aviation and oil, but production capacity for microchips and integrated circuits is concentrated in Asia. The Taiwan Semiconductor Manufacturing Co. (TSMC) occupies nearly 50% of the world market. In early 2020, the deployment of the first 5G networks and the high demand for electronic products of all kinds during the lockdowns (computers, smartphones, gaming consoles...) exceeded semiconductor production capacity. At the same time, several semiconductor production sites had to close during the lockdowns. The main factories, also called fabs, have been quickly forced to invest in opening new production sites. Thus, TSMC has planned to earmark more than $100 bn for opening new factories in the next three years, while Intel is set to spend $20 bn on upgrading its factories this year. The US recovery plan will also earmark $50 bn for this, almost as much as the current value of US semiconductor exports. This semiconductor shortage has brought in its wake a worldwide industrial crisis in the automobile sector, which increasingly uses electronic components. Toyota's production fell 40% in September, while many factories have closed in Europe and the United States. The Boston Consulting Group estimates that nearly 9 million vehicles may not have been manufactured in 2021 because of this crisis.

Source: Market Watch, 17/04/2021 ; Financial Times, 20/08/2021 ; Le Monde, 01/09/2021

FIGURE 3

WORLD SALES OF SEMICONDUCTORS (IN BILLIONS OF DOLLARS)

Source: World Semiconductor Trade Statistics, cited by Semiconductor Industry Association, 2021



electric vehicles in Karawang, near Jakarta.[32]

Companies in search of security of supply

For the time being, therefore, supply chains for metals and semi-finished products remain very highly concentrated in Asia. Several companies producing technology useful for the low-carbon transition have demonstrated their eagerness to secure their supply of strategic metals and semi-finished products, particularly since the main markets for these technologies are tightening up their environmental and climate requirements: for example, the EU envisages that only batteries with a disclosed carbon footprint will be marketed in the common market in 2024.[33]

Faced with growing pressure on demand, the car manufacturer Toyota signed a trade agreement in early October 2021 with BHP to secure nickel sulphate supplies for its Japanese factories. The new factory opened by the mining company in Kwinana, near Perth in Australia, supplies the nickel required by Prime Planet Energy & Solutions, a lithium-ion battery manufacturer joint-owned by Toyota and Panasonic. Alongside this trade deal, the two companies also signed a memorandum of understanding aimed at decarbonising the battery supply chain.[34] Nowadays, it is not uncommon to see trade agreements in this sector accompanied by measures aimed at reducing the upstream environmental impact of the supply chain to the benefit of all the contracting parties seeking to improve their reputation, and to the detriment of Chinese supply chains which are laxer on issues of pollution and human rights.[35]

In June 2021, therefore, Tesla reached an agreement with BHP to secure its nickel supplies in order to reduce its dependence on Chinese suppliers, while improving the environmental performance indicators of its supply chain at the same time. This is the third contract of this kind signed by Elon Musk's firm in eight months following agreements reached on the one hand with the Brazilian company Vale, and on the other hand with the Goro mine in New Caledonia which was recently sold by Vale to the brokerage company Trafigura.[36] On the BHP side, the signing of these agreements is part of a strategy to focus the company's business on minerals strategic to the low-carbon transition since its new CEO, Mike Henry, took office in early 2020.[37] LG Energy Solution is also engaged in a rearguard action, signing a six-year contract with Australian Mines Ltd to secure its access to 71,000 tonnes of nickel and 7,000 tonnes of cobalt.[38]

Energy Fuel, a US company specialising in uranium refining, has spearheaded the very first US-European rare earth supply chain, which saw the light of day in 2021. Midway through 2020, Energy Fuel partially converted White Mesa Mill (Utah), the only Uranium refinery in the United States, into a rare earths refining site.[39] In December 2020, Energy Fuel signed a three-year partnership with the American company Chemours to acquire at least 2,500 tonnes/year of monazite, a composite ore containing rare earths, but also uranium, extracted from a mine in the state of Georgia. The monazite is now refined at the White Mesa Mill site to produce rare earth carbonates,[40] the first container of which Energy Fuel shipped to Estonia in June 2021. The Canadian company Neo Performance Materials treats the carbonate there to separate out the elements in its Sillamäe plant,[41] enabling it to diversify its rare earth supply sources for the European market and to ship the uranium back to Energy Fuel.

Upstream of the supply chains, mining companies told to stay in tune with the ecological transition

The mining industry today accounts for 6.2% of the world's energy consumption and 22% of the industrial sector's CO_2 emissions, according to REN21.[42] Like the big oil companies (**see Energy sector**), mining companies are therefore being increasingly urged to present ambitious and demanding climate plans. Environmental and cultural scandals such as the destruction of sacred aboriginal sites by the Australian company Rio Tinto in May 2020 during the extension of an iron mine,[43] and the formation of a toxic lake near the rare earth mines in Baotou (China)[34] have heightened the pressure on mining companies to meet their social and environmental responsibilities. Considering the requirements of the transition and the increasing use of digital devices in everyday life, this sector's energy consumption and emissions are set to increase. So, the big challenge for the mining industry is to present a positive net balance between the pollution and direct emissions generated by its activities and the indirect benefits for society enabled by the deployment of low-carbon technologies.[44]

A growing number of widely different mining companies of all kinds are now keen to increase the exposure of their business portfolios to metals useful in the manufacture of lithium-ion batteries, including nickel. Driven by the acceleration in the sale of lithium-ion battery cars and the demand for metals, competition is also intensifying on the supply side. Furthermore, just like the oil & gas sector with low-carbon energies and services, mergers and acquisitions (M&A) are the preferred vehicle for mining companies when positioning themselves on the nickel market as for other metals.

For example, the South African mining company Sibanye-Stillwater, a gold specialist, has positioned itself to buy the French company Eramet's nickel processing plant in Sandouville in Normandy.[45] The group also bought stakes in two lithium mines, one in Keliber, Finland, and one in Nevada.[46] The Australian company IGO is trying to take over the nickel specialist Western Areas, while Rio Tinto has been participating since 2018 in a joint venture in a nickel mine developed by Talon Metals in the United States as is PolyMet, controlled by Glencore, in Minnesota. In Ontario, Noront Resources is the target of a takeover battle between BHP and Australia's Wyloo Metals. The Canadian province has the benefit of a largely carbon-free electricity mix thanks to hydroelectric power, a substantial advantage in view of the growing environmental and climatic requirements of production chains. In Argentina, which has big lithium reserves, the Chinese battery manufacturer CATL has succeeded in acquiring the Canadian Millenial Lithium Group, which a few days earlier had rejected an offer from its compatriot Ganfeng Lithium.[47]

In 2019, the World Bank, in partnership with the International Finance Corporation (IFC), launched the Climate-Smart Mining (CSM) initiative, a programme aimed at decarbonising and optimising the use of metals necessary for the manufacture of production technology for renewable and low-carbon energy in general. The initiative promotes the integration of renewable energy into mining operations, the decarbonisation of supply chains and the prevention of deforestation, and other practices aimed at improving the sector's social and environmental performance.[48]

In early October 2021, the International Council on Mining and Metals (ICMM), which brings together 28 of the world's biggest mining companies, published an open letter declaring that all of its members were committed to reducing their emissions and to aiming at being "carbon neutral" by 2050.[49] Several of its members had already adopted climate plans with the "carbon neutral" objective several months prior to this.

In February 2021, Rio Tinto's new management unveiled new climate objectives aimed at reducing the carbon intensity of its activities by 30% between 2018 and 2030, lowering its absolute emissions by 15% during the same period, and investing $1 billion in climate-related projects between 2020 and 2024. In terms of strategy Rio Tinto, the second biggest mining company in the world, with emissions estimated at 519 $MtCO_2e$ in 2020, has turned over a new leaf by recognising its responsibility to reduce its Scope 3 emissions – basically, those of its customers. In order to go about this, the Australian group has been racking up research partnerships into breakthrough technology with industry and research actors such as the Chinese group Baowu, world leader for steel, Tsinghua University, the Nippon Steel Corporation and the American aluminium producer Alcoa.[50]

At the end of September 2021, the fate of the Climate Transition Action Plan of BHP, the world's largest mining company, was more uncertain. The Glass Lewis voting advisory agency called on the group's shareholders to vote against this climate plan proposed by management, arguing that its scientific foundations were not clear in the absence of certification from an organisation such as the Science-based Targets Initiative. Furthermore, while Asian steelmakers accounted for 75% of its Scope 3 emissions (402.5 $MtCO_2e$), BHP has kept them out of the "carbon neutral" objective that it has set for its customers for 2050.[51] BHP has, furthermore, committed to reducing its operational emissions compared by 30% by 2030, compared to 2020 levels, and becoming "carbon neutral" by 2050.[52]

Overall, companies in the mining sector seem to have become aware of their strategic role in providing the raw materials necessary for the low-carbon technological transition. Thus, their climate plans are based on three strategic approaches: completely disinvesting from or gradually reducing carbon-intensive energy in their asset portfolios (Anglo will end its thermal coal production in South Africa before 2023,[53] while BHP is envisaging withdrawing from oil and gas); reducing the carbon intensity of their mining activities and of the entire supply chain; and finally, prioritising the exploitation of metal mines intended to supply low-carbon markets and thus contributing to the energy and technology transition downstream of supply chains during the stages of raw materials transformation into finished or semi-finished products.

As an example of this last approach, Rio Tinto and Alcoa formed a joint venture in 2018, Elysis, to develop an aluminium production process free of CO_2 emissions. This involves using "inert anodes" in alumina electrolysis (the Hall-Héroult process) instead of traditional carbon anodes, which enables only oxygen to be released, without having it combine with the carbon from the anode which breaks down to form CO_2.[54] The project is financially backed by Canada and the province of Quebec, each to the tune of CA$60 million. Apple, which is participating in the joint venture, bought a first batch of this aluminium at the end of 2019, specifying neither the products in which it would be used nor the amounts and volumes of the transaction.[55] Elysis intends to market its "zero-carbon" aluminium in 2024.

KEY TAKEAWAYS

In this time of energy transition, the global competition for the raw materials needed for low-carbon technologies is intensifying. The meteoric growth in renewable energy production and the electrification of mobility has highlighted the geostrategic vulnerability of States and supply chains with regard to the concentration of resources, of the production and of the transformation of the metals required for low-carbon technologies (wind turbines, photovoltaic panels, electric cars, etc.). The economic recovery and the high demand for electronic goods have increased pressure on lithium, cobalt, nickel, rare earths and also semiconductors, which have been subject to high price inflation since the second half of 2020. Supply is failing to keep up with demand, and this is already resulting in supply deficits. Consequently, this imbalance could in the medium term jeopardise the transition of sectors whose decarbonisation depends on electrification and on electronics.

In order to strengthen their geostrategic autonomy and provide themselves with the means to achieve the objectives of the Paris Agreement, the European, American, Japanese and Indonesian governments are working to diversify their sources of supply and to shorten value chains by developing regional supply chains for the manufacture of low-carbon technologies. Held to account for their environmental and climate impacts, large mining companies are using mergers and acquisitions to increase the exposure of their business portfolios to the metals required for the energy transition. They are also creating bonds further downstream in the supply chains, where companies producing batteries and low-carbon technologies are seeking to establish long-term contracts for their raw material supplies.

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TRENDS
HYDROGEN

Boosted by the Recovery, the "Hydrogen Economy" Gains Credibility

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Largely unknown to the general public a few years ago, hydrogen now enjoys strong public support, based on the hope that it will become a strategic energy vector in a low-carbon world. But where do things actually stand? Are today's hydrogen projects really centred on decarbonization? Have the numerous announcements been followed up by numerous investments? With carbon neutrality acting as the new international climate barometer, oil and gas companies concerned by the need to diversify have rapidly positioned themselves on the hydrogen market. The hydrogen boom also brings new hope for sectors that seemed to be unable to reduce their emissions, i.e., heavy industries.

DATA OVERVIEW

Still in its nascent stage, low-carbon hydrogen garners the support of several States

Cars and planes that only emit water vapor, "zero-carbon" steel, heating for buildings, storage of electricity produced from intermittent renewable energy: recent years have seen multiple discussions about the promising ways in which hydrogen can be employed to shift to a low-carbon economy.

Current hydrogen production is nevertheless far from being low-carbon: in 2018, it was responsible for emitting about 830 megatons (Mt) of CO_2.[1] In fact, 98% of current production is qualified as "gray",[2] which means that it comes from processes that use fossil fuels (methane reforming or coal gasification) (**fig. 1**), generating around 10 $kgCO_2e$ for every kilogramme of hydrogen produced.[3] The remaining 2% is produced from the electrolysis of water, a process that operates on electricity, most of which comes from fossil fuels. The share of "green" hydrogen, in other words produced by electrolysis from renewable electricity, is no more than 0.3%, while "blue" hydrogen, produced at sites equipped with Carbon Capture, Utilization and Storage (CCUS),[4] represents barely 1.1% of global production. As a result, only 1.4% of the hydrogen currently produced is "low-carbon", due to its relatively uncompetitive production costs compared to high-carbon alternatives (**fig. 2**).

Additionally, low-carbon hydrogen applications are still few and far between. In 2018, the IEA estimated that about 120 Mt of hydrogen was produced in the world: 75 Mt of "pure" hydrogen, mostly used in oil refining (38.2 Mt) and ammonia production (31.5 Mt); and 45 Mt of hydrogen that is "mixed" with other gases to produce synthetic gases, used for example to produce methanol (14 Mt), an intermediate product in plastic production among other things, or in industrial processes (e.g. steelmaking).[4,5] The Covid-19 pandemic caused a drop in this production. In Europe, demand for pure hydrogen decreased by about 10%, while demand for mixed hydrogen went down by over 25%, mainly due to a slowdown in hydrogen-consuming activities like oil refining and the chemical industry.[6]

2020 marked a turnaround for the industry: low-carbon hydrogen took pride of place in announcements of post-lockdown investments in both the private and public sectors. Several sources have attempted to list and monitor the different announcements promoting hydrogen.

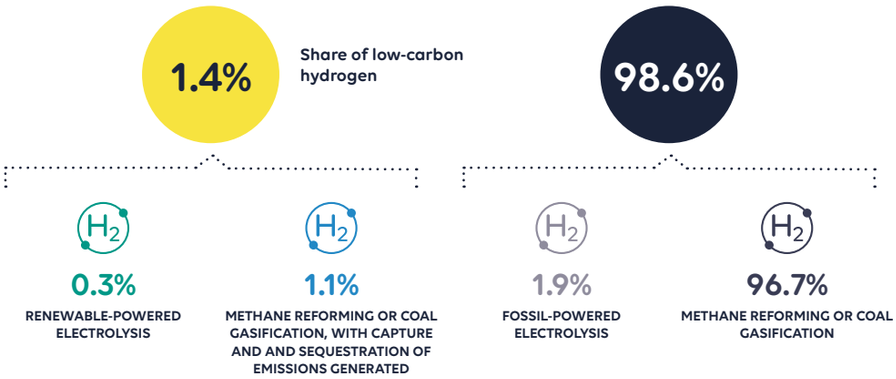
According to Energy Policy Tracker, since the start of the pandemic, ten countries[a] and the European Union have committed to investing around 20 billion dollars in hydrogen.[7]

REN21 counts 12 jurisdictions (11 states and the EU) that have put forward targets and policies on low-carbon hydrogen.[8] For example, in Europe, Portugal has announced that it is investing €7 billion in "green" hydrogen, while France has pledged €9 billion, targeting the installation of 6.5 GW of electrolyzer capacity by 2030. The United Kingdom hopes to attract £4 billion to develop the use of hydrogen in building

a Canada, France, Australia, the United Kingdom, Poland, Russia, New Zealand, Spain, Germany, and Norway

FIGURE 1

SHARE OF DIFFERENT HYDROGEN PRODUCTION METHODS - *Source: Climate Chance, based on Global CCS Institute, 2021*



heating (combining it with natural gas to reduce the amount of gas used), decarbonize heavy industries, and develop hydrogen-powered transport.[9] In Australia, the government has committed to investing AU$284 million to support the development of green hydrogen projects. In the United States, the government has planned to inject $64 million into developing 18 green hydrogen projects.

The International Energy Agency (IEA) lists 17 states that have adopted a hydrogen strategy, totalling investments of $37 billion, compared to only three in 2019 (France, Japan and South Korea).[10] Chile, which has multiplied its renewable energy production capacity by five over the last six years, published a strategy for developing green hydrogen in 2020, with a scheduled budget of $50 million.[11] Canada has also published a hydrogen strategy[12] that aims to have 30% of low-carbon hydrogen by 2050.

Green hydrogen also receives strong political backing in Africa, with multiple announcements of projects and partnerships over the last year. In June 2020, Morocco concluded an agreement with Germany for a green hydrogen project led by the Moroccan Agency for Solar Energy. While recent political tensions between the two countries have slowed the project down, Morocco and IRENA declared in June 2021 that they had signed an agreement aimed at driving the development and consumption of green hydrogen in the kingdom.[13] The German government has also granted Namibia a funding of €40 million to support research and development in the green hydrogen industry.[14] In Mauritania, the government and the renewable energy company CWP Global have signed a protocol to develop an electrolyser with a capacity of 30 GW using wind and solar power and covering 8,500 square kilometres in order to produce green hydrogen and its derivatives, such as ammonia.[15] Lastly, as part of its "Energy Strategy 2035", the Egyptian government has announced that it intends to invest $4 billion in producing green hydrogen, in partnership with Siemens.[16]

In addition to developing production facilities, states are pumping a large share of their investments into the transport sector. For example, the German hydrogen strategy aims to inject 3.6 billion euros into transport out of the 12 billion earmarked for developing hydrogen.[17] Japan is also making mobility central to its hydrogen strategy, with a target to produce 800,000 fuel cell cars by 2030 (**see Tokyo Case study**). To this end, the government is subsidizing the purchase of new vehicles by up to $18,000, while prefectures are granting up to $9,000, which is 42% of the price of a standard hydrogen vehicle.[18] Similarly, France will devote 27% of the 3.4 billion euros allocated for the period 2020-2023 as part of its National Hydrogen Strategy on decarbonization of the heavy mobility sector.

According to IEA figures, government investments are only a drop in the ocean compared to the $300 billion announced by the private sector.[10] In particular, oil and gas companies and heavy industries are making hydrogen part of their low-carbon strategies and are counting on its large-scale deployment for their decarbonization.

THE OBSERVATORY'S LENS

When the old meets the new: Hydrogen offers a glimpse into a green future for the largest emitters

The Oil and Gas industry sets its sights on hydrogen

Oil and gas companies are particularly active in installing hydrogen production capacities, drawing from their investment capacities and their willingness to diversify (**see Energy sector**), and also from their transport infrastructures, since hydrogen can be transported by gas pipeline. For example, the European Hydrogen Backbone initiative, launched by twelve European transmission system operators, aims to create an immense network for transporting hydrogen throughout Europe based on converting two-thirds of the existing gas grid.[19] In the United Kingdom, the project Zero Carbon Humber,

implemented by Equinor, British Steel and other partners, intends to convert the gas network at the Humber Estuary to transport hydrogen, and at the same time capture CO_2 from the hydrogen production installation and store it in the North Sea.

Blue hydrogen is of particular interest to these companies, as seen in the case of the Quest Project, set up by Shell in 2015.[20] This is primarily because blue hydrogen will undoubtedly remain cheaper to produce than green hydrogen, in regions rich in gas or coal and with high CO_2 storage potential, like the Middle East, North Africa, Russia and the United States (**fig. 2**),[21] where oil and gas companies play a central role in the energy sector.

In addition, blue hydrogen production facilities produce much bigger quantities than electrolyzers. Sturgeon and Nutrien, the two blue hydrogen production projects launched in 2020 (bringing the total to seven), have respective production capacities of 240 tonnes and 800 tonnes of hydrogen per day.[22] Both are connected to the Alberta Carbon Trunk Line, a 240 km pipeline that crosses the Canadian province, and can transport and store 14.6 $MtCO_2$ per year, $305 million of which is being financed by World Carbon Solutions, a company affiliated to the midstream oil and gas provider company Wolf Midstream.[23] In comparison, green hydrogen production projects are more numerous (the IEA counts about fifty currently in operation[24]), but their total production capacity is lower. The biggest green hydrogen production station began operating in 2020 in Fukushima, Japan, with a capacity of 10 MW, and it produces an average 2.4 tonnes of hydrogen a day.[25]

Previously little-known, blue hydrogen has therefore suddenly become the focus of considerable interest. In Russia, the world's biggest gas producer Gazprom announced in late 2020 that it was creating a new subsidiary, the Gazprom Hydrogen Company, which will notably construct a blue hydrogen plant at the German end of the Nord Stream gas pipeline.[26] Saudi Aramco, the biggest oil producer in the world, has committed to massive investments in blue hydrogen projects in China.[27]

Petroleum companies are also benefiting from the development of hydrogen in Japan, which, as part of its low-carbon growth strategy for 2050, intends to produce 20 million tonnes of hydrogen per year by 2050. In September 2020, the Saudi company made its first delivery of ammonia produced from blue hydrogen in Japan to feed power plants (**see Keys to Understanding**).[28] A few months later, Saudi Aramco signed a memorandum of understanding with the biggest refinery in Japan, ENEOS, to develop a supply chain for blue hydrogen and ammonia.[29] The Abu Dhabi National Oil Company (ADNOC), the leading oil company in the United Arab Emirates, has concluded a joint study agreement with Japanese oil and energy companies and an independent administrative institution, the Japan Oil Gas and Metals National Corporation (JOGMEC), to explore the commercial potential of producing blue ammonia in the Middle East.[30]

At least fifteen blue hydrogen projects are scheduled to come into operation by 2027 in the United Kingdom, Germany, Norway, the Netherlands, and Sweden.[31] If all of the blue hydrogen projects are implemented on time, production should reach 1 Mt by 2030, which is close to the level forecast by the IEA in its *Net Zero By 2050* scenario.[10]

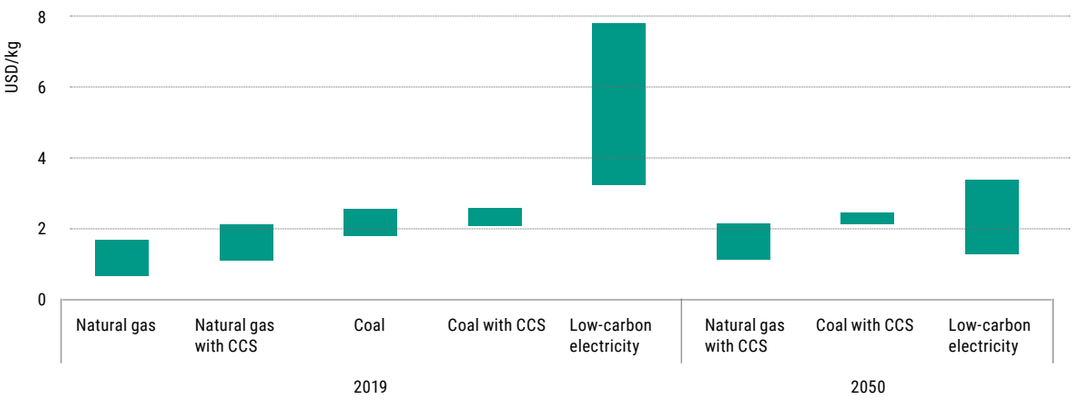
However, in terms of reducing GHG emissions, blue hydrogen production is not an obvious contender. A recent study published by researchers at Stanford and Cornell Universities estimates that the emissions from the entire life cycle of blue hydrogen are only 9% to 12% lower than from gray hydrogen.[32]

It seems that despite its high cost, green hydrogen is not out of the running. In 2020, according to the IEA, new capacities installed for the production of hydrogen by electrolysis amounted to almost 65 MW, a record, and over 400 million dollars were invested in electrolyzers for hydrogen production, which is almost four times more than in 2018.[10] BloombergNEF observed a rise in investments in installations to produce hydrogen by electrolysis amounting to $168 million in 2019 and $189 million in 2020.[39] New capacities for production by electrolysis could surge to over 275 MW in 2021.[33] The average

FIGURE 2

AVERAGE COST OF HYDROGEN PRODUCTION BY ENERGY SOURCE AND TECHNOLOGY IN 2019 AND 2050 (FORECAST)

Source: IEA, 2020



size is also increasing: almost 80 projects are aiming at a capacity of over 100 MW, and 11 are even targeting a capacity of more than 1 GW.[10]

Here once again, oil and gas companies are active players of the market. In early 2021, Shell began operating an electrolyzer with a 10 MW capacity, which is the same size as the one in Fukushima.[34] The British major BP has partnered up with Iberdrola, the Spanish renewables giant, to build a 20 MW green hydrogen power plant near Valencia, which is due to start operating in 2023.[35] In France, Total and Engie have signed a cooperation agreement to develop a 40 MW green hydrogen project with a daily capacity of five tonnes in the south of the country.[36]

KEYS TO UNDERSTANDING

AMMONIA, AN "ALTERNATIVE" FORM OF HYDROGEN FOR THE ENERGY TRANSITION

The production of ammonia (NH_3) is one of the main uses of hydrogen, and well known for its use as a fertilizer in farming. Ammonia takes the form of a gas at room temperature and can be stored as a liquid when compressed (at -33°C, compared to -253°C for hydrogen). It is also cheaper to store in the long term ($0.5/kg-$H_2$ compared to $15/kg-$H_2$ for hydrogen), and up to trice as cheap to transport by pipeline and up to a third cheaper by boat. As a result, more and more actors are thinking of using ammonia as an alternative fuel, similar to hydrogen, for transport or in power plants for example. In fact, its combustion only generates water and nitrogen, and emits no carbon molecules or soot particles. Japan in particular is relying on this molecule to decarbonize its maritime industry, transport hydrogen, and store energy. In November 2020, the Japanese Ministry for Energy, Trade and Industry (METI) announced the creation of a Council to work on employing ammonia as an energy product. By 2030, Japan's ambition is to import three million tonnes of "clean" ammonia and to accelerate its international cooperation (in particular with the Middle East, Australia and New Zealand) to achieve it.

Source: Conférence des Présidents d'Université, 25/11/2020; Ammonia Energy Association, 25/02/2021

In Egypt, ENI has signed an agreement with the Egyptian authorities to produce and export green hydrogen.[37] In Mauritania, the government has granted an exclusive offshore concession of 14,400 km² to the British company Chariot with the aim of studying the feasibility of producing low-carbon energy to operate "Nour", a new green hydrogen project with a total planned capacity of 10 GW.[38]

Nevertheless, even considering recent announcements that seem to point to a new era for green hydrogen, the IEA observes that the industry is far off track. Even if all of the projects recorded in September 2021 are to be implemented, they would still only reach a production of around 2 MtH_2, which is barely one-third of the recommendation in the *Net Zero By 2050* scenario.[10] Added to that, actual investments are still well below the 337 billion dollars in public and private pledges counted by IEA. According to BloombergNEF, only $1.5 billion were invested in low-carbon hydrogen in 2020, most of it ($1.3 billion) on fuel cell vehicles (cars, buses, etc.) and for installing charging stations (**see Transport Sector**).[39]

Hydrogen rekindles hopes of decarbonizing heavy industries

While announcements and actual investments are still way off-target, it is clear that the low-carbon hydrogen industry is slowly taking shape. This new type of production carries high expectations from sectors in which decarbonization seems difficult. The most prominent sector, transport, is banking on hydrogen for cars, trucks, public transport, trains and even airplanes, although for now attention is centred on electrification (**see Transport Sector**).

However, hydrogen is also entering into the low-carbon plans of sectors that the public are less aware of, but in which dead-ends for reducing greenhouse gas emissions are a cause for concern, i.e. heavy industries. In fact, three industrial sectors alone represent 65% of GHG emissions from industry: cement, steel and chemicals. They only use about 1% of renewable energy in their activities, which is negligible compared to an average of 15% for the industrial sector as a whole.[8]

On the one hand, industries based on hydrogen can push to decarbonize its production. For example, half of the emissions related to manufacturing ammonia, one of the biggest uses of hydrogen, result from the production phase of the hydrogen used. In Spain, a pilot project to produce ammonia from green hydrogen is due to launch in late 2021, led by Iberdrola and Fertiberia.[10]

The steel industry has high decarbonization hopes from hydrogen, taking a different approach: hydrogen could be a way of decreasing the consumption of coal, which is a key fuel in steel production, and responsible for most of the sector's emissions. In Sweden, the first tons of decarbonized steel were produced in the first half of 2021 (**see Signals**) by the Hybrit project, which gathers the steelmaker SSAB, the mining company LKAB, and the public electricity production and distribution company Vattenfall. Hybrit employs a procedure to manufacture Direct Reduced Iron (DRI), which can then be transformed into iron or steel in an electric furnace, using only hydrogen. The use of this kind of procedure combined with "green" hydrogen would considerably reduce emissions from the manufacture of steel. Several other iron and steel companies, like ArcelorMittal, also intend to develop this production process.[40] The iron production company Fortescue aims at producing 15 million tonnes of hydrogen by 2030 in order to help its steelmaking clients decarbonize their steel production (scope 3).[41] Other pilot projects to decarbonize cement and glass production are also being developed.[10]

By offering new avenues for gas production, blue hydrogen also opens up possibilities for another breakthrough technology that had been left to a side in public and entrepreneurial spheres – CCUS technologies. Conversely, hydrogen could benefit from CCUS rollout: 1.8 $GtCO_2$ related to hydrogen production could be captured and stored by 2050 (**see CCUS Trend**).[42]

KEY TAKEAWAYS

Investments in hydrogen picked up strongly in 2020 with a view to use the gas in highly emitting sectors that are currently difficult to decarbonize: transport and heavy industry. Oil and gas companies looking for ways to diversify into low-carbon services have got the message, and rapidly positioned themselves on hydrogen markets, taking advantage of their pipeline networks and investment capacities. Green hydrogen, produced from renewable electricity still remains much less competitive than its blue equivalent, produced from the combustion of gas and capture of CO_2, which is less beneficial for the climate. Announcements of funding for blue and green hydrogen projects and partnerships between industries have also flourished in line with the pace of government commitments, pointing to a favourable situation for this breakthrough technology which many are counting on to decarbonize the economy.

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TRENDS
CCUS

CCUS Reaches a Turning Point

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By endorsing the goal "*to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of the century*", the Paris Agreement made States and non-state actors adopt the concept of carbon neutrality and to engage with the idea of "negative emissions". In this way, not only has the issue of offsetting emissions grown in importance, but also, to a lesser extent, that of capturing carbon for its geological storage or use (Carbon Capture, Utilisation and Storage – CCUS). Currently, most international reference scenarios regarding carbon neutrality (IEA, IPCC) include CCUS technologies to varying degrees, but in view of the past and current difficulties in implementing them, uncertainties remain as to whether they can be rolled out at the scales envisaged.

DATA OVERVIEW

An unprecedented boom in investment driven by the oil and gas sector

CCUS technologies are aimed at capturing CO_2 from industrial smoke or smoke from fossil-fuelled power plants and transporting it to a storage point in order to permanently sequester it in deep geological strata, or to reuse it (for the production of crude oil, fizzy drinks, synthetic fuels, greenhouses or building materials).[1] At the end of 2020, there were 26 CCUS projects in operation in the world.[2] Together, they capture the equivalent of 40 million tonnes of CO_2 ($MtCO_2$) per year with different processes of capture (post-combustion, oxy-combustion, pre-combustion), transport (trucks, boats, pipelines), storage and use — these processes themselves having varying degrees of technical maturity and economic viability. Currently, the main use of captured CO_2 is Enhanced Oil Recovery (EOR) in wells that have become unproductive: of the 26 projects in operation worldwide, 20 are financed through EOR (**fig. 1**).[2]

Several countries have recently issued or revised roadmaps for decarbonising their economies, that include CCUS technologies. These include Australia, Canada, China, the Netherlands, Norway, the United Kingdom and the United States of America.[3] To these, we must add countries that have made CCUS an instrument of their Nationally Determined Contributions (NDCs) to reduce climate change after 2020 under the Paris Agreement: Bahrain, Egypt, Iran, Iraq, Malawi, Mongolia, Saudi Arabia, South Africa and the United Arab Emirates. For example, after a period of inactivity, the United Kingdom published a roadmap in 2018 entitled Clean Growth Strategy aiming to make it a world leader in CCUS technologies. There could also be a large-scale relaunch of R&D based on CCUS in the EU via the Innovation Fund program (2020-2030), in order to stimulate the roll-out of new projects in decarbonisation. In the USA, several programs have recently been set up to help get this type of technology off the ground. For example, in 2016 the Carbon SAFE initiative was launched aiming to develop geological storage sites with a capacity of over 50 $MtCO_2$ and, in 2018, the 45Q tax credit, having been in place since 2009 but with problems in its application, was extended. This mechanism enables companies launching CCUS projects to obtain, under certain conditions, a $30/t tax credit when CO_2 is captured for EOR and $50/t when it is captured for geological storage.

This strategic context thus favours the launch of new projects at an industrial scale. According to figures provided by the IEA, between 2017 and 2020 more than 30 CCUS projects were announced worldwide.[4] If all the announced projects were to be implemented, storage capacities could go from 40 $MtCO_2$/year to 130$MtCO_2$/year. Between early 2020 and May 2021, a total of $12 billion in investments in CCUS projects were announced by governments and industry.[5] In 2020, effective investments in CCUS took off to reach $3 billion (up by 212% from 2019), mainly thanks to a few flagship projects devoted to heavy industries and driven by oil and gas companies.[6]

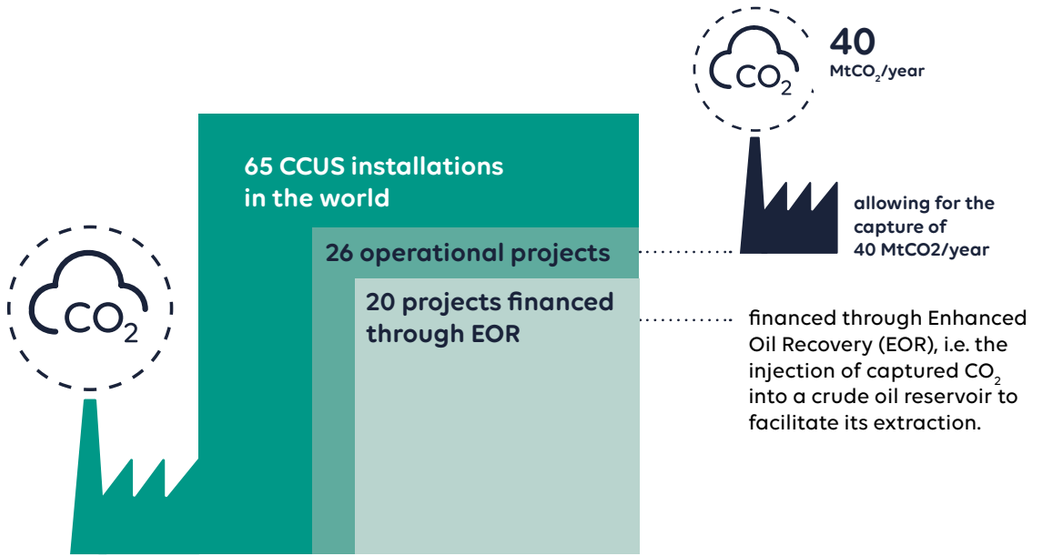
Among the recent projects in Europe, we can cite the Northern Lights project in Norway, combining the creation of transport infrastructure with carbon storage. It is driven by Equinor, Shell and TotalEnergies, a partnership resulting from a public consultation launched by the Norwegian Government, with the objective of storing 0.8 to 1 $MtCO_2$/year during the first phases of development, and then increasing this to 5 $MtCO_2$/year by receiving CO_2 from different European sources.[7] The project was supported by the Norwegian government, which injected $1.8 billion into it in 2020 to tie the Longship project in with it, a project that captures emissions from a cement plant and a waste incinerator (**see Case Studies**).

In Great Britain, the oil giants BP, ENI, Equinor, Shell and Total have formed a consortium to finance Net Zero Teesside, a

FIGURE 1

CURRENT STATUS OF CCUS PROJECTS UNDER DEVELOPMENT AND IN OPERATION

Source: Global CCS Institute, 2020



project which aims to decarbonise the Teesside industrial valley and its numerous chemical industries. Further south, Equinor, the steel company British Steel and ten or so other partners are joining forces in the Zero Carbon Humber initiative to decarbonise the Humber industrial basin using hydrogen and CCUS.

The Netherlands has also included CCUS in several strategy documents (a specific roadmap in 2018 and the national climate plan in 2019) and relaunched a hub project in the port of Rotterdam (the Porthos project) for the capture and storage of 2 to 5 $MtCO_2$/ year.

In France, the 3D project, launched in 2019 in Dunkirk, brings together manufacturers such as Axens, TotalEnergies, ArcelorMittal and the French Institute of Petroleum and New Energies (IFPEN, *Institut Français du Pétrole et des Energies Nouvelles*), with several objectives: to demonstrate the efficiency of the capture technology developed by Axens/IFPEN, to prepare the deployment of CCUS on the ArcelorMittal steel site in order to capture 0.5 to 1 $MtCO_2$/year, and to study the feasibility of a CO_2 collection hub in the Dunkirk region (mainly to store CO_2 under the North Sea).[8]

Outside Europe, North America takes up the mantle as a CCUS leader, since 80% of capture capacity is in the USA, with a dozen sites in operation, and approximately double this if we count the development phase projects that have been announced. China, partly trailing behind up to now, with only one CCUS operation on a commercial scale (CNPC Jiling capturing 0.6 $MtCO_2$/year), has announced two new projects in this domain. However, outside the EU, operations launched between 2015 and 2020 are still relying heavily on EOR to remain economically viable. The IEA believes, nonetheless, that the future projects will be less dependent on this type of outlet.[4]

All in all, CCUS was placed third as a low-carbon expenditure item in the oil and gas sector in 2020 (**see Energy sector**). Of the 66 CCUS projects already in operation or planned in Europe in the coming decade, more than 50% are financed by oil and gas companies that are members of IOGP, the International Oil and Gas Producers association.[9]

This rekindled interest in CCUS, driven largely by oil and gas companies, comes after years of effort by stakeholders to get CCUS recognised as a fully-fledged solution in the transition to a low carbon economy. However, its actual roll-out at a large scale is still far off.

THE OBSERVATORY'S LENS

From 1990 to today: the long battle of CCUS to become recognised as a viable, legitimate and feasible decarbonisation solution.

From the 1990s to the mid-2010s: the pilot projects... and the initial difficulties

The first intended CO_2 capture projects with the aim of combating climate change, or to meet a carbon requirement (taxation, emission quotas), date back to the 1990s. In Norway, Statoil (now Equinor), forced by carbon taxation on its offshore crude oil exploitation, began injecting CO_2 at Sleipner in 1996. This was the first industrial-scale carbon storage project in Europe and, because it was the first, it went hand in hand with R&D programmes to meet the technical and safety challenges posed by this new activity. Almost at the same time, in Hawaii, an international project involving North American, Norwegian and Japanese teams was launched, but strong local opposition, supported by the NGO Greenpeace, led to its abandonment in 2001.[10]

With the first data collected at Sleipner, demonstrating the feasibility of geological storage, CCUS technologies were garnering interest on a global scale in the early 2000s, and there was even a Special Report of the Intergovernmental Panel on Climate Change (IPCC) on this question in 2005.[11] This report explored the potential use of CCUS technologies on the basis that fossil fuels would continue to play a large part in the global energy mix for decades to come and that the necessary changes in behaviour and means of production would be difficult to achieve. The figures proposed were therefore very ambitious: CCUS could trap 20 to 40% of global emissions (including 30 to 60% of emissions linked to energy production and 30 to 40% of those from industry) and could account for 15 to 55% of global mitigation activities in 2100, necessitating the rapid deployment of thousands of capture systems.

A few years later, the development of CCUS technologies was the subject of other experiments, mainly in North America and Europe, however taking different trajectories.

On the European continent, at the beginning of the 2010s, the EU was seeking to stimulate CCUS demonstration projects through various mechanisms, principally by setting up a reserve fund (New Entrant Reserve or NER 300) corresponding to 300 million quotas of CO_2 emissions issued through the Emission Trading System (ETS)[a], i.e. the equivalent of 4.5 to 9 billion euros for a CO_2 price ranging from 15 to 30 euros per tonne in order to finance projects fighting global warming. This strategy was relatively ambitious since it provided for the establishment of a dozen industrial-scale demonstration projects by 2015. However, for a number of observers it was a failure since in the end no CCUS project was funded by the NER 300, and other nationally launched projects in this domain also ran into a number of difficulties.[12] In France, for example, the few demonstration projects on an industrial scale launched at that time were all abandoned: this is the case, for example, of the ULCOS (Ultra Low Carbon Dioxide Steelmaking) project for capture on an ArcelorMittal blast furnace in Florange and its storage in saline aquifers near Verdun. However, a smaller-scale experiment with a complete CO_2 capture, transport and storage chain was carried out by Total (now TotalEnergies) in Lacq between 2010 and 2013, which finally enabled storage of 51,000 tCO_2.[13] In the neighbouring European countries, the Barendrecht and ROAD projects in the Netherlands and the Altmark project in Germany also had to be abandoned. In the United Kingdom, a strong supporter of CCUS from the outset, a government program to support industrial projects involving Shell (Peterhead) and the White Rose consortium (Drax) was discontinued in 2015. This was the second withdrawal on the part of the British government in this domain since 2010.

Several factors can explain this failure of the CCUS sector's deployment in the EU in the first half of the 2010s. One of them concerns economics: because of successive decreases in carbon prices in the ETS, these projects suffered from profitability problems, and it was more viable to buy carbon credits than to invest in these technologies. Furthermore, this period was marked by an unexpected growth in renewable energies, which gradually became the preferred solution of the public authorities in terms of decarbonisation.[14] To this was added a lack of political support[15] as well as local opposition (a factor often cited to explain project failures in the Netherlands and Germany) because of the various risks posed by CCUS (such as of leaks, or even induced seismicity), but also because of the energy transition model they underpin by maintaining a large share of fossil fuels in the energy mix and competing with renewables and other solutions based behavioural changes.[16]

On the European continent, only Norway continued to invest in CCUS with a second industrial project undertaken in Snøhvit in 2010 with a storage capacity of 0.7 $MtCO_2$/year operated by Statoil (now Equinor). CCUS was developed in this country thanks to a high carbon tax (in any case higher than that of the EU), but also due to strong political will: carbon storage, in Norway, is referred to as the national "mission to the Moon".[17] Thanks to this project and the one at Sleipner, the country currently stores 1.7 $MtCO_2$/year and is the only European country with industrial CCUS projects in operation.

In North America, the deployment of CCUS has had more success, in particular because a number of projects are associated with EOR, which makes them economically profitable. Nevertheless, this practice poses problems in terms of carbon footprints since the oil thus obtained, once consumed, releases more CO_2 into the atmosphere than the amount of CO_2 injected

a The CO_2 emissions trading system in the EU and European Free Trade Association (EFTA) countries set up in 2005, covering around 40% of European emissions.

into the reservoir and stored[b]. The problem is accentuated when the CO_2 used is of natural and not anthropogenic origin, which is the case in 70% of the EOR projects currently underway in the USA[4]: as the CO_2 is not removed from the atmosphere or industrial smoke, but is produced, amongst other things, to stimulate oil production, the carbon footprint is therefore even more negative. For these reasons, but also because it enables the use of fossil fuels to be extended, EOR, even if it pursues a final storage goal which is achieved relatively quickly, is considered a "taboo" in the EU.[18]

One of the flagships North American EOR projects in early 2010s (and still today) was the Weyburn-Midale project in Canada. Considered at the outset as an industrial project for oil production stimulated by CO_2 injection, it then gave rise to a research project on geological carbon storage (the IEA-GHG Weyburn-Midale CO_2 Monitoring and Storage research project from 2005 to 2012, then SaskCO_2USER from 2013 to 2015). Since 2014, a part of the CO_2 has come from the smoke of the Boundary Dam coal-fired power station in the Saskatchewan province. This CCUS chain enables the capture of 1 MtCO_2/year. The Weyburn-Midale project is also known for the controversy over suspected leaks, investigations having subsequently proven that the CO_2 present at the surface was of natural origin.[19]

Moreover, in North America, industrial and commercial CCUS projects have had more political support than in Europe. Accordingly, projects developed there in the 2000s and early 2010s benefited from different public funding mechanisms. For example, the Quest project (carried out by Shell) received grants from the Alberta Government (CA$740 million) and the Canadian federal government (CA$120 million) for carbon capture and storage connected with the transformation of tar sands and hydrogen in Edmonton (with a capture capacity of 1.2 MtCO_2/year, i.e., 30% of the site's emissions). Furthermore, in the United States, some projects have benefited from research and development funds, the U.S. Department of Energy (DOE) offering such funding for CCUS since 1997. However, this has not prevented certain projects from running into serious difficulties: this was the case of FutureGen 2.0 (in Illinois), a project to capture and store CO_2 from smoke from a coal-fired power station which, after many assembly problems and several suspension phases, was definitively abandoned in 2016 after losing its federal funding for not having implemented the scheduled work in the time allotted by the DOE.[20]

Elsewhere in the world, there were relatively few initiatives until mid-2010s: for example, the EOR projects of the Petrobras group in Brazil (3 MtCO_2/year) and Uthmaniyah in Saudi Arabia (0.8 MtCO_2/year), which are still going on.

The end of the 2010s: a rekindling of interest

At the end of the 2010s, the IEA and the Global CCS Institute, the main association for CCUS related manufacturers, discussed reviving CCUS, and fine tuned emission reduction scenarios focusing on a revival of the sector at a global scale. In the IEA's so-called "Sustainable Development" Scenario which models reaching carbon neutrality in 2070, 9.5 GtCO_2/year would have to be captured and stored, and 0.9 GtCO_2/year captured and used: 40% would be captured from the energy sector (mainly Bioenergy, Coal, Gas), 25% from heavy industry, 30% from fuel supply (hydrogen and biofuels) and 7% from direct air capture (DAC).[4]

In its new scenario for achieving carbon neutrality objectives in 2050, the IEA was even more ambitious and estimated that CCUS could capture 7.6 GtCO_2/year by 2050 (5.6 GtCO_2/year in the "sustainable development" scenario), with a similar distribution (**fig. 2**).[5] The EU would have to take a leadership role in this domain, alongside the USA and China: the IEA encourages it to invest heavily in CCUS and Negative Emission Technologies (NETs), using the recovery plans as an opportunity not to be missed. For the IEA, therefore, CCUS projects are vital for achieving carbon neutrality within a reasonable timeline. To support its line of argument, it produces scenarios with a small share of this type of technology in decarbonisation efforts,[21] which show that an energy transition without CCUS would be more expensive and take longer because it would require big investment in disruptive technologies that have not yet been developed.

Furthermore, CCUS is also regaining a certain legitimacy thanks to the IPCC's special "1.5°C" report, which includes these technologies and the NETs in three of the four major categories of scenarios considered.[22] Some advocates of these technologies have seen it as the ultimate proof of their inevitability, since the IPCC scenarios generally serve as a global benchmark for the implementation of climate policies.

In addition to these scenarios promoting CCUS, other factors are also causing renewed interest in these technologies. The first are political, since State commitments to achieve "carbon neutrality" have flourished since the signing of the Paris Agreements, commitments which have revived the discussion about technologies that can complement "natural" means of carbon sequestration.

The other factors are economic: in addition to the rise in the price of carbon, which could make CCUS operations more profitable (increase from €25/t in January 2020 to over €50/t in summer 2021 on the European carbon market), the oil and gas sector sees new economic opportunity in the development of this sector as their know-how could be invaluable, especially on the transport and storage side.

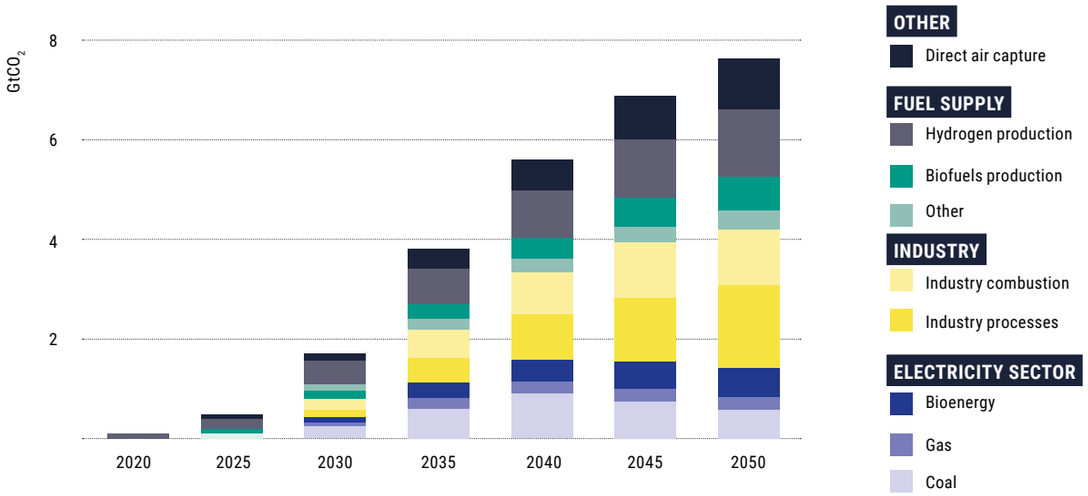
In society, perceptions of CCUS seem to have changed, although it is still largely overlooked by the general public

b Farret (2017) estimates that one tonne of CO_2 makes it possible to recover on average 0.25 tonnes of oil which, when burned, will produce around 2 tonnes of CO_2.

FIGURE 2

CO_2 CAPTURE BY SOURCE IN THE INTERNATIONAL ENERGY AGENCY'S (IEA) "NET ZERO BY 2050" SCENARIO

Source: IEA, 2021.



and the political class. Its principal advocates have changed their discourse to make it more acceptable and legitimate in the energy transition scenarios envisaged. In the beginning of the 2000s and 2010s, it was presented as useful for the "greening" of energy production based on conventional fossil fuels (particularly coal), which led to its rejection by a large number of players wishing to get out of fossils. Today, however they place emphasis on its potential in terms of reducing the "incompressible" emissions from heavy industry, i.e., after integrating decarbonised energy sources and optimising production processes.[23] In fact, three industrial sectors (cement, steel and chemicals) alone account for 65% of industrial GHG emissions, using only 1% of renewable energy in their processes.[24] Their decarbonisation might appear unattainable without disruptive technologies like CCUS or hydrogen (**see Hydrogen trend**).

According to their proponents, CCUS technologies could enable preventing the relocation of industries that have failed to complete decarbonisation, thereby becoming a group of technologies that could save jobs nationally and reduce dependence on exported industrial production.[25] The association with NETs also contributes to this operation of upgrading CCUS, since their development could pave the way for other processes that could remove carbon from the atmosphere and help stick to the 1.5°C objective (with the possibility of deploying more NETs if needed).[26]

Finally, the theoretical roll-out of uses for captured carbon other than EOR (say in building materials[27] or plastic objects[28]) echoes the concerns about material recycling and waste matters.[14] However, these new outlets for CCUS may also raise new concerns. As to its uses, as previously mentioned in case of EOR, uncertainties remain about the final carbon footprint, due to the CO_2 not being permanently sequestered and returning to the atmosphere in most cases in the more or less short term – say, at the end of the life-cycle of the manufactured product. As for NETs, there are many uncertainties about the possibility of actually implementing them, and also about their social and environmental sustainability. For example, Bioenergy with Carbon Capture and Storage (BECCS), which requires significant agricultural extension and intensification in order to produce the biomass that will be used in the power plants, raises issues of competition for space with other forms of land use (agricultural production, natural vegetation), pressures on biodiversity and also pollution.[29]

For the IEA, the next ten years will be crucial for rolling-out CCUS and NETs. It considers the proliferation of industrial and R&D projects as one of the means of lowering costs and demonstrating the relevance of these technologies to achieve the climate targets set.[4] But is upscaling in this way to reach 1.6 $GtCO_2$ captured in 2030 and 7.6 $GtCO_2$ in 2050 really feasible?

The beginning of the 2020s: significant obstacles to the large-scale roll-out of CCUS remain

The answer to this question is far from simple, even for a staunch proponent of CCUS like the IEA. On the one hand, it believes that rolling out these technologies in an exponential way is possible, citing the example of flue gas desulfurisation techniques in thermal power plants which has grown dramatically in 30 years (1972-2012). On the other hand, it is aware of the fragility of the current economic situation: the economic crisis of 2008 put the brakes on the first wave of CCUS projects, and it is possible that the one resulting from the Covid-19 pandemic could have the same consequences.[4] For example, the Petra Nova project, a recent US showcase of CCUS, also based on EOR, was put on hold because of the fall in oil prices in 2020. Some analysts, such as R. Farret, see CO_2 capture for EOR as a springboard for developing CCUS technologies since it could lead to their technical improvement, lower cost and the general public becoming more familiar with this type of technology.[12] Recent IEA recommendations on stopping further exploration of oil fields by 2025[30] and the announcements of certain governments in the same vein may indeed favour a multiplication of CCUS systems for EOR

purposes, to extend the life of existing oil wells. However, the likely fall in oil prices in the coming years may also have the opposite effect.

Another factor of uncertainty relates to the social and political support for this type of technology. From a social point of view, CCUS and NETs remain largely unknown to the general public. They arouse much less interest and cause less controversy than nuclear or renewable energies.[31] However, these are technologies that generate concern over the risks – industrial, leakage or induced seismicity.[32] Furthermore, their assimilation with geoengineering technologies,[33] which are subject to a certain amount of mistrust, and the fact that they are presented as solutions that serve only industrial and oil and gas lobbies does not make their acceptance by the general public any easier.[34]

In the political arena, some authors describe CCUS as "orphan technologies" (in other words, they have neither strong supporters nor or strong opponents).[17] In general, up to now, the political class has had little time for debates about CCUS, apart from a few specific nations such as the USA, Canada or Norway, countries with a strong tradition of exploration of geological resources on their territory. As there are quite a lot of uncertainties about these technologies (how they are received by society, the environmental risks, whether there are real climate benefits), taking a stance on this topic may be dangerous for a politician.

In the big environmental NGOs, such as those making up the "green lobby" in Brussels (the "Green 10")[c], support is also far from strong. Greenpeace is the only one to have campaigned against CCUS during the first wave of projects, because it was associated with the idea of maintaining a large share of fossil fuels in the global energy mix.[35] Today, its position seems to have changed: it is not against marginal use of these technologies once all other possible decarbonisation options have been exhausted.[36] This position is also held by the Climate Action Network, even though one of its recent notes tries to warn of the danger of having too much faith in NETs.[37, 38] For the moment, these NGOs are focusing their attention on questions that attract broader engagement, such as the climate commitments of certain States or economic actors and keeping fossil fuels in the future energy mix, which may lead to them making the odd criticism of CCUS technologies, but it is not their main target.[39] This may be linked to its status as a "bridge technology", with CCUS sometimes being put forward as an interim solution in order to ensure the transition from the current phase, which is heavily dependent on fossil fuels, to the desired phase, that of an economy globally fuelled by renewable energy.

Advocates of CCUS, therefore, still need to find convincing arguments, which is not easy given that promises of economic development, jobs or technological competition no longer allow for easier acceptance of industrial projects.[40] The IEA and certain analysts wish, for example, to abolish the distinction between "natural" and "technological" carbon sinks in order to facilitate public support as well as that of the political class, and to avoid criticism of "techno-fixes" (technological solutions to problems created in part by technological development itself).[41] Another trend that we are currently seeing emerge is the emphasis on the role that CCUS could play in the production of carbon-free hydrogen (or "blue hydrogen"), an energy source that has a rather positive aura (**see Hydrogen Trend**).

Last but not the least, the main question remains the feasibility of this type of technology. For its advocates CCUS poses no particular problems. On paper, geological storage opportunities broadly cover our needs. For example, the IEA estimates that the North Sea can store 80 years' worth of current emissions from the EU.[42] For the industrial sector, geological storage is a simple procedure and one that is completely achievable, given that if they can extract crude oil from a reservoir, then they can store CO_2 in it.[43]

However, when it comes to the localisation of CCUS, in other words, concretising its implementation in one or more given areas, there are many uncertainties and difficulties to be overcome. In France, ADEME, the public agency for ecological transition, published a document seeking to precisely determine where it would be possible to capture and store carbon on the French mainland territory. Taking geographical (distance between emitter/well), economic (cost and profitability of the various links in the chain depending on the volumes emitted, transported and stored) and social (low acceptability of onshore storage) constraints into account, it concluded that the roll-out of CCUS should be limited to three areas (Dunkirk, Le Havre and Lacq), and invited manufacturers located outside these areas to consider other decarbonisation processes.[44] The initial assumptions made by ADEME have been criticised by some players in the sector, considering that the costs may fall and that other transport solutions (reuse of existing gas pipelines) and other storage solutions (for example in the Mediterranean) could be envisaged in the more or less short term, with major investments from private stakeholders and public authorities.[45]

Another problem is the extent of the work and the expenditure necessary for CCUS deployment to transition to the scales envisaged in certain IEA or IPCC scenarios. For CO_2 transport, for example, there are few figures and projections available. In Europe, a 2011 modelling carried out for the European Economic Area and based on a scenario forecasting the capture of 1.39 $GtCO_2$/year by 2050, estimates that 18,728 km of pipeline would be necessary for transporting and storing CO_2 if this is configured optimally (cost/distance between emitters and sinks). These facilities would represent a cumulative investment of 28 billion euros up to that date.[46] However, the target of the Net Zero By 2050 scenario (7.6 $GtCO_2$/year in 2050) is 5.4 times higher than the assumption in this scenario. This quantity of pipeline seems far from negligible, and yet it is

c This designation refers to the following NGOs: Greenpeace Europe, CEE Bankwatch, Birdlife International, Climate Action Network Europe, WWF Europe, Naturfriends International, European Environmental Bureau, Health and Environmental Alliance, Friends of the Earth Europe, Transport and Environment.

still low compared to the networks used in Europe for natural gas (200,000 km in 2005[47]). Based on the observation that this has already been implemented for crude oil production, the deployment of several thousand kilometres of pipeline for CO_2 remains a plausible hypothesis. However, the existing networks have been developed because the products conveyed had real economic value and represented potential benefits for manufacturers or operators, which is not the case with captured carbon, since for the moment it is still mainly a constraint (apart from its use for EOR).

It remains to be seen, therefore, whether public authorities and the private sector will agree to finance all of this work.

KEY TAKEAWAYS

Since 2015, there has been a resurgence of interest in CCUS and conditions once again appear favourable for its deployment. But due to a number of uncertainties of an economic (viability of CCUS), technical (safety during the various stages of the production chain) and strategic (the relative share of CCUS in decarbonisation strategies) nature, private actors and public authorities are still hesitant to embark on industrial-scale projects or infrastructure financing. Currently, although CCUS is increasingly presented as relevant for certain business sectors (such as for reducing emissions from heavy industries) and certain applications (especially for NET deployment), it is still considered by political actors as a secondary solution or a back-up solution if the other decarbonisation mechanisms fail. At a social level, it is not the subject of lively debate and continues to be largely ignored outside certain specific spheres (NGOs, bodies specialising in the energy transition) or during attempts to implement local projects. Few political, institutional and regional players have thrown their weight behind it. For these reasons, large-scale deployment at least of the order of a gigatonne per year from 2030 as envisaged by the IEA or in certain IPCC scenarios, is unlikely.

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SIGNALS

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

Textiles • Fast fashion slowed down by Covid-19

Closures at Nike's production plants have forced the brand to slow down production. Two of Nike's suppliers suspended production in July 2021, following an outbreak in Vietnam's Dong Nai province. Changshin Vietnam, a Korean company, closed two of its three sites near Ho Chi Minh City, which employ 42,000 workers, while Taiwanese manufacturer Pou Chen also suspended operations for several weeks. 50% of the firm's shoes are produced in Vietnam. The disruption of production lines comes on top of the disruption caused by the global logistical bottleneck caused by container ships. GHG emissions from the production and use of textile clothing and footwear are estimated at 2.1 $GtCO_2e$ per year on a life-cycle basis, or about 4% of global emissions. Transportation of these goods accounts for only 3% of this total.

Reuters, 15/07/2021

Steel • The production of steel in China is now a "political issue"

The CEO of Baowu Group, the world's largest steel producer, has pledged to limit the group's steel production in the second half of 2021, at the request of the Chinese government. The government has set itself the target of capping its steel production at the 2020 level (1,065 Mt) in order to limit the increase in greenhouse gas emissions resulting from steel production. However, spurred on by the dynamic global construction sector and by high prices, production rose again in the first half of 2021, 10% more than in the same period the previous year. Limiting steel production is now "*a political issue that leaves no room for negotiation*", according to the CEO. *Reuters, 10/08/2021*

Hydrofluorocarbons • China to ratify the Kigali amendment to the Montreal Protocol to eliminates HFCs

Following a meeting with French President Emmanuel Macron and German Chancellor Angela Merkel, Chinese President Xi Jinping announced the ratification of the Kigali Amendment to the Montreal Protocol, which calls for a decrease in the production and consumption of hydrofluorocarbons (HFCs). Mainly used as refrigerants in air conditioners or refrigerators, HFCs are greenhouse gases that are up to 15,000 times more powerful than CO_2 and contribute massively to global warming. China, which is responsible for 70% of the global production and is the largest emitter, will soon have to follow the example of the 119 other signatory states and reduce the production and consumption of HFCs by 85% by 2047.

Le Monde, 22/04/2021

Heat • Renewable energy certificates make their debut in renewable heat supply in the industrial sector

Renewable energy certificates for heat could appear in the coming months, based on the same model as Energy Attribute Certificates for renewables in electricity (**see Energy sector**). In the European Union, the standardisation bodies CEN and CENELEC are considering the possibility of including renewable heat in the system of guarantees of origin, which currently only covers electricity. In the United States, the California-based Center for Resource Solutions is developing a new branch of its Green-e standard to certify the consumption of renewable natural gas, often from landfills. Power Purchase Agreement (PPA) projects to source biomethane have also emerged, again based on the model of direct electricity sales contracts: after achieving 100% renewables in its electricity supply, L'Oréal USA entered into a 15-year Gas Purchase Agreement with the Big Run landfill in December 2018, to cover the thermal needs of its production and distribution activities. *IRENA, 2021*

CCUS • The largest direct air CO_2 capture plant to go into operation in Iceland

The Swiss company Climeworks has commissioned the Orca project south of Reykjavik (Iceland). Consisting of eight "collectors" each equipped with twelve blades, Orca will absorb the ambient air and remove the CO_2 using a chemical agent. Mixed with water, the carbon dioxide will be buried "forever" in underground cavities. Ultimately, Orca aims to capture 4,000 tCO_2/year, making it the largest Direct Air Capture (DAC) project in operation. By financing the project with $10 mn over 10 years, the insurance company SwissRe is taking credit for the emissions captured by Orca, in what is being pitched as the first long-term direct CO_2 capture purchase agreement. If this business model proves successful, DACs could then be deployed on a larger scale. Even larger projects have already been announced in the US and UK by Carbon Engineering, a competitor of Climeworks. For the time being, the cost per tonne of CO_2 removed is still very high, and forecasts are fairly pessimistic about the possibility of lowering it…

Yale E360, 25/08/2021

Steel • Production of the first hundred tonnes of low-carbon steel using hydrogen

In Sweden, Hybrit's pilot plant produced its first 100 tonnes of low-carbon steel in the first half of 2021. This project, which brings together the steel manufacturer SSAB, the mining company LKAB and the public electricity production and distribution company Vattenfall, aims to create a completely decarbonised steel production chain before 2026, through the production of Direct Reduced Iron (DRI) from "green" hydrogen (obtained from electrolysers powered by renewable energy, see the **2020 Sector-based report**). On an industrial scale, this project will require large quantities of low-carbon electricity: 15 TWh would be needed annually for the current level of SSAB production using this process (Sweden produces about 160 TWh of electricity per year). The car companies Volvo and Mercedes have already shown interest and signed partnerships with Hybrit to build cars from low carbon steel. Several other steel companies, such as ArcelorMittal, also intend to develop this production process.

Hybrit, 21/06/2021

Afghanistan • The Taliban are redefining the politics of mining

For some years now, the Taliban have been able to finance themselves through the control of coal and metal mines in Afghanistan. By taking political power in Afghanistan, the Taliban are now sitting on one of the world's largest reserves of lithium, a material essential for lithium-ion batteries. While many Western countries cut off diplomatic relations with the country upon their arrival in Kabul, Russia, China, as well as Turkey and Pakistan have already begun discussions about these resources. The China-Pakistan Economic Corridor, on which work is underway despite delays caused by the pandemic (**see Transport sector**), could accelerate these exchanges. Until now, due to the instability of the country, the reserves on Afghan territory have not really been exploited. In 2007, China had obtained a 30-year concession for a copper mine south-east of Kabul, but extraction never began.

Quartz, 16/08/2021

Rare earths • MP Materials restarts the Mountain Pass rare earths mine after 20 years

Industry consortium MP Materials is re-launching operations at Mountain Pass, California, the US only rare earths mine, which was closed in 2002 due to a lack of competitiveness against Chinese rivals. The listing of MP Materials on the stock exchange in July 2020 was the first time a US rare earths company had gone public since Molycorp, the former operator of Mountain Pass, whose assets MP Materials bought back after its bankruptcy in 2015. However, the US industry is still too dependent on China for downstream rare earth processing. A bill proposed in the House of Representatives would therefore grant tax exemptions to companies producing permanent magnets on US soil, which are essential for the production of electric batteries and wind turbines. The EU, which recently launched two strategic alliances on batteries and raw materials, is following the same strategy of localising the production of strategic equipment for the low carbon transition. *Les Echos, 22/06/2021*

CASE STUDIES

COUNTRY	CO_2 STORAGE CAPACITY	COST
NORWAY	1.5 $MtCO_2$/YEAR IN PHASE 1	NOK 25.1 BN (€2.4 BN)

The Longship project: CCS to decarbonise heavy industries

In 1996, Statoil, the Norwegian state-owned oil company, launched the first commercial carbon capture and storage (CCS) project to decarbonise the natural gas it produces[1]. By 2015, 15.5 $MtCO_2$ had been stored underground. In 2012, the largest technology centre for testing CCS technologies (TCM) was opened in Mongstad, Norway. As early as 2014, Norway developed a strategy for CCS aimed at identifying measures to promote the use of these technologies. Based on this, the Norwegian state-owned company Gassnova conducted a pre-feasibility study in 2015 which identified several emission sources and carbon storage sites.

Longship: the result of close collaboration between the government, industry and oil companies

In autumn 2020, the government announced the launch of the Longship project. A collaboration between Gassnova and oil giants Equinor (new name for Statoil), Shell, and Total, the project aims to capture CO_2 from two industrial sources in the Oslo Fjord region: the Norcem cement plant and a waste incineration plant in Oslo, the Fortum Oslo Varme's CO_2 capture project. In 2019, the global cement industry emitted 2.3 $GtCO_2$, i.e., around 5% of global emissions. Phase 1 of the Longship project will see the installation of CCS infrastructure at German cement giant HeldeibergCement's Norcem plant in Brevik. In 2013, the plant set a goal of becoming the first net zero cement plant in the world by 2030. In 2019, Norcem alone emitted 900,000 tCO_2: the company wants to build an infrastructure capable of capturing 400,000 tCO_2/year, less than half of its emissions. Construction of the project is due to start in autumn 2022, with commissioning expected in 2024. Total investment and operating costs over ten years are estimated at €2.4 billion. The Norwegian government, which is committed to reducing its national emissions by 50-55% by 2030 compared to 1990, is investing €1.6 billion, more than two-thirds of the total project cost.

Northern Lights: The backbone of CCS in Europe

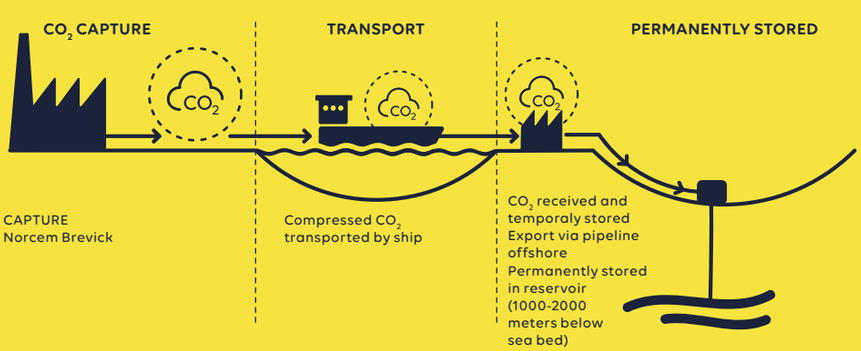
Once captured, the CO_2 will be transported by ship, stored temporarily in Northern Lights's facilities in the Øygarden industrial zone, and then transported by pipeline 100 km off the coast and 2,500 m under the sea via Northern Lights, a huge CO_2 transport and storage project. Led by the three oil companies, it has an initial annual storage capacity of 1.5 $MtCO_2$, with the possibility of increasing this to 5 $MtCO_2$ depending on market demand. In December 2020, the three companies decided to invest in the Northern Lights project (NOK 6.9 billion, or €680 million), closing the study phase in which they were involved. The Northern Lights project also paves the way for the production of blue hydrogen, facilitating its production from natural gas with CCS. Equinor, for example, is already producing blue hydrogen in Hull, England as part of the Zero Carbon Humber CCUS project. Northern Lights aims to capture emissions from the ArcelorMittal group's steel plants in Dunkirk, Hamburg and Fent, the Preem refineries in Lykesil and Gothenburg in Sweden, and eventually more than 21 companies across Europe. The first office opened in September in the port city of Stavanger.

As part of the first phase of the CO_2 transport and storage, Northern Lights is building two CO_2 carriers, designed to transport liquid CO_2, with a cargo size of 7,500 m^3 and a length of 130 meters. These ships will be built by Dalian Shipbuilding Industry Co., Ltd, and will use LNG as their primary fuel. The ships will also be equipped with a wind assisted propulsion system and air lubrication to reduce carbon intensity by approximately 34 % compared to standard systems and are expected to be delivered by 2024.

1 The gas contained in the reservoir contained 9% of CO2, and had to reach a level of 2.5% to meet standards and allow for its export.

IMPLEMENTATION OF CCS ON THE BREVICK CEMENT PLANT

Source: Euractiv, 2019



REGION CASE STUDY

COUNTRY	STATE	POPULATION	ENERGY PRODUCTION TARGET	ENERGY PRODUCTION IN 2020
AUSTRALIA	SOUTH AUSTRALIA	1,771,000	100% RENEWABLE BY 2030; 500% BY 2050	60% RENEWABLE

Scaling up battery storage in South Australia to a new dimension

As a leader in renewable energy in the country, the state of South Australia is expanding the foundations of its electricity storage industry. By 2020, South Australia generated 60% of its electricity from renewables. From almost no renewable generation in 2003, the state now has over 2 GW of installed wind capacity and around 2.5 GW of solar PV capacity. South Australia has set a target of generating 500% of its renewable energy needs by 2050 as part of its Climate Action Plan 2021-2025, with the aim of exporting the surplus to other Australian states, and internationally. This ambition hinges on the development of energy storage.

Subsidising local storage in order to balance out the grid

In the absence of hydro storage capacity, South Australia is funding and playing a key role in industry partnerships to develop large-scale battery energy storage projects. As early as 2017, as part of its Energy Plan, South Australia established an AU$150 million Renewable Technology Fund, which among other things enabled the state to acquire the world's largest lithium-ion battery, the 100 MW Hornsdale Power Reserve. Installed and managed by Tesla, it can store up to 129 MWh of electricity. Thanks to the Grid Scale Storage Fund, renewable energy producer Neoen received AU$15 million to increase the project's capacity by 50% over the year 2020.

With government funding of AU$100 million, the Home Battery Scheme (HBS) has provided access to grants and low-interest loans, provided by the Clean Energy Finance Corporation, an Australian government-owned finance bank, to grid-connected South Australia residents since October 2018. This help to purchase home batteries and a new solar power system if needed. These batteries work by storing excess power generated through the solar panels, ready to be used at other times, such as during cloudy periods or when the sun goes down, or when there are peaks in demand on the grid. The aim is to reduce pressure on the grid during peak demand by storing the domestically generated surplus of solar energy. 29% of all domestic batteries installed in Australia in 2020 were installed in South Australia. The government is supporting the project with a grant of AU$2 million, a loan of AU$20 million from the Renewable Technology Fund and a grant of AU$10 million through its Grid Scale Storage Fund. The trial phase completed in 2019 saw 1,100 homes equipped with solar and home battery systems, with over 50,000 homes expected to benefit in the future.

The Renewable Technology Fund has also enabled the development of a virtual power plant (VPP) in partnership with Tesla and electricity retailer Energy Locals. A VPP is a network of small, distributed energy sources — such as houses with solar systems and batteries - that work together as a single power plant through a computer system. VPPs allow for better control of production in response to changes in demand.

Multiplying end-uses to decarbonise the industrial sector

Given South Australia's aforementioned absence of hydro storage capacity, battery storage can stabilise intermittent power systems, facilitate the decarbonisation of energy-intensive industries, and provide significant cost savings. By allowing for a better supply-demand balance on the grid, Tesla's giant battery has saved AU$150 million in its first two years of operation, while the average price of a battery system purchased through the HBS programme has dropped by AU$5,000 since its launch. Possessing over 68% of the country's copper resources, SA is also relying on battery storage to decarbonise its mining industry. The AU$1 million state-subsidised Carrapateena gold and copper mine will test a hybrid plant using a 250 kW lithium-ion battery, a 250 kW photovoltaic system and a 10 kW wind turbine, integrated with a diesel power plant and a light electric vehicle charging station.

COUNTRY	CITY	GLOBAL EMISSIONS FROM THE TEXTILE SECTOR	MEMBERS IN 2021
FRANCE	PARIS	2.1 $GtCO_2$ IN 2018	100

Paris Good Fashion, making Paris the capital of sustainable fashion

Sustainable fashion is a relatively recent concept. Apart from a few pioneering brands such as Eileen Fisher, created in the United States in 1984, the notion only appeared in the early 2000s. Initially confined to the margins, with a few designers particularly in Scandinavian countries, the sustainable fashion movement began to be structured from 2009 onwards in Copenhagen with the Fashion Summit and the support of the Ellen MacArthur Foundation, both united by the McKinsey company. In 2013, the collapse of the Rana Plaza factory in Bangladesh, which resulted in the death of 1,127 employees, acted as a catalyst for awareness.

Awareness accelerated by the consumer

The shift did not take place until 2019, and was primarily driven by consumer pressure. In China, consumers are increasingly demanding transparency about the origin, materials and manufacturing conditions. In France, the AGEC law is accelerating the emergence of circular economy players and launching the first efforts on environmental labelling, and Europe is preparing its textiles strategy. Finally, new requirements are also emerging from investors and investment funds. Thus, in a few months, what was still considered a "marginal" subject by companies, has become a priority and transversal, penetrating all the departments of companies in the sector.

The association Paris Good Fashion was founded in January 2019 under the impetus of the City of Paris, but is completely independent of it. About ten founding members are thus involved: Eyes On Talents, the Federation of Haute Couture & Fashion, Galeries Lafayette, the French Fashion Institute, LVMH, NFP, the Sidièse agency, in connection with the Ellen MacArthur Foundation.

As of 2021, PGF gathers 100 members, from Chanel to Chaussettes Orphelines, from the Eram group to Vestiaire Collective, as well as institutions, schools, tech start-ups, affiliated associations, partners, small and medium-sized enterprises and microenterprises, all committed to a common ambition: to accelerate the environmental and social transition of fashion and textiles.

Sharing and caring: A dynamic network to share experiences and co-construct solutions

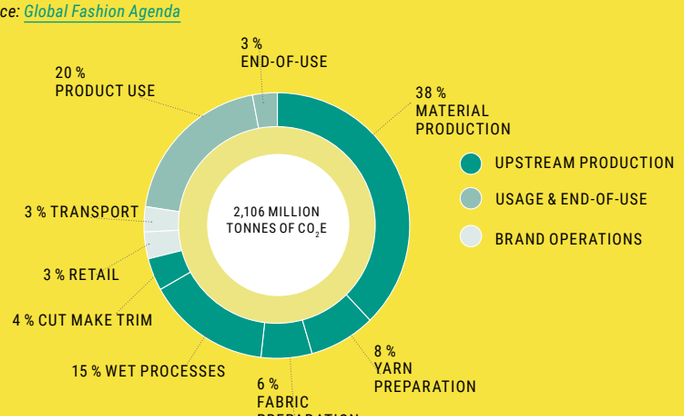
PGF is at the same time an ecosystem where everyone can meet and share their problems, a showcase to promote the numerous sustainable fashion initiatives in the "fashion capital", and finally, a laboratory of concrete solutions. Ten or so working groups, based on the voluntary participation of members, have been formed to address the problems at their source and to collectively find concrete solutions: mapping the sustainable fashion actors in Paris and the Ile-de-France region, guiding young brands in sustainable development, supporting the reindustrialisation of the wool industry in France, developing tools to ensure that fashion events (fashion shows, fairs, presentations, etc.) adopt sustainable processes, organising a citizen consultation to involve 107,000 participants in defining the priorities of the transition, etc.

PGF's approach is based on co-construction, respect for the points of view of all members (from LVMH to Who's Next, each one holds a part of the solution), the desire to share and the requirement to identify and implement concrete solutions. PGF relies on collective intelligence to face the challenge of global warming and the social destabilization it brings with the rise of inequalities.

From recycling to reuse, to the replacement of plastic hangers and polybags, to reusable packages, PGF has multiple projects to amplify the movement and create a systemic change. The association is making its work and resources available to propose to other cities and other fashion actors in Europe and elsewhere, to duplicate or be inspired by good practices.

GHG EMISSIONS FROM THE PRODUCTION AND USE OF CLOTHING AND FOOTWEAR IN 2018

Source: Global Fashion Agenda



"IN A CONTEXT OF GEOGRAPHICALLY CONCENTRATED RESERVES AND PRODUCTION CAPACITIES, THE RECYCLING OF CRITICAL MINERALS RESPONDS TO BOTH ECOLOGICAL AND GEOPOLITICAL NECESSITIES"

In 2018, the World Bank estimated that the management of more than 2 billion tonnes of waste generated worldwide caused 1.6 $GtCO_2e$ of emissions. Of this waste generated, a very small portion is recycled or composted: just 19% globally, and up to 48% in Europe. In all regions of the world, landfilling and dumping are still the main methods of waste treatment **[INDICATORS]**.

The United States, Canada, Europe and Japan used to export a large part of their waste abroad, particularly to China and South-East Asia, for recycling. But since 2018, the Chinese decision to set quotas and strict standards on the quality of imported waste to combat illegal trafficking, quickly followed by other countries in the region, has pushed the Northern countries to find new outlets: Turkey for European waste, Latin America for the United States. To address their limited local recycling capacity, governments in the North have also undertaken investments and strengthened their policy frameworks to improve their recycling rates **[TRENDS]**.

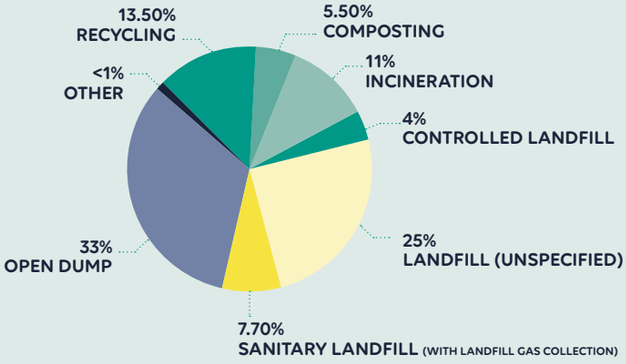
Local governments, which have jurisdiction over waste management, are sometimes ahead of the states in finding solutions to the situation. Driven by a coalition of federal states, inspired by the work of NGOs, the very first extended producer responsibility (EPR) schemes could soon be launched in the United States, in Maine, California and Oregon **[SIGNALS]**. This model has already been widely adopted in Canada and has proved to be successful, for example in the packaging and printed paper sector in British Columbia **[CASE STUDIES]**. In Europe, Flanders, a territory with few natural resources, relies on its industrial base to invest in research and development of the bioeconomy, in order to create circularity in the use of biological resources, and reduce its material footprint **[CASE STUDIES]**.

Developing countries are also forced to adapt to the new international situation on the flows of waste. Restrictions on the entry of foreign waste into their territory have caused industries in importing countries to lose an important resource of "secondary raw material". In China, Thailand and South Africa, legislation is being relaxed to facilitate the import of certain solid wastes that feed local industries, from plastic to copper to paper **[TRENDS]**. Where collection and processing are often informal, reducing transparency on the real conditions and efficiency of recycling, improving the infrastructure can improve both the environment and the working conditions of informal waste workers. In the province of Mendoza (Argentina), while landfills are still the norm in South America, social inclusion and environmental protection go hand in hand in the integrated urban solid waste management project **[CASE STUDIES]**.

Finally, the electrification of end-uses, the deployment of low-carbon technologies and the race to digital technology pose new challenges to the circular management of raw materials. In particular, the recycling of the critical metals contained in lithium-ion batteries (lithium, graphite, nickel, cobalt, etc.) responds to both ecological and geopolitical necessities. In a context of concentration of reserves and production capacities, securing mineral supplies requires the development of secondary deposits. In this respect, Quebec, with its low-carbon electricity mix and leading industrial players in recycling, intends to become the "green battery of North America" **[TRENDS]**.

THE PANDEMIC REVEALS THE DELAYS IN THE WASTE SECTOR IN ADAPTING TO RESTRICTIONS IN SOUTH ASIA AND TO THE TRANSITION

Greenhouse gases accumulating in our dustbins



GREENHOUSE GAS EMISSIONS FROM WASTE

The World Bank estimates that 2.01 billion tonnes of solid municipal waste was generated in 2016, the management of which emitted around 1.6 $GtCO_2e$, mostly in the form of methane emitted from its decomposition.

World Bank, 2018

GLOBAL WASTE MANAGEMENT PRACTICES

More than half of all waste produced in the world ended up in landfills or open dumps. Only 13.5% was recycled. Up to 75% of waste goes to dumps in South Asia, while in Latin America, 68% ends up in landfills.

World Bank, 2018

Recycling struggles to take off

WORLD "CIRCULARITY" INDICATOR

Of the 100 billion tonnes of material entering the economy in 2020, 8.6% came from circular processes. Two years earlier, the figure was 9.1%.

Circle Economy, 2021

RECYCLING AND COMPOSTING RATE OF MUNICIPAL WASTE IN THE EUROPEAN UNION

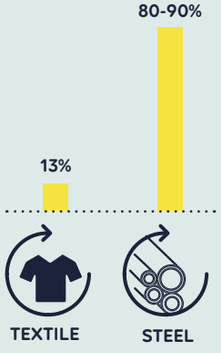
Globally, the average was 19% as of 2016: 13.5% of recycling, 5.5% of composting.

Eurostat, 2021, World Bank, 2018

NUMBER OF CITIES PART OF THE ZERO WASTE EUROPE INITIATIVE

Zero Waste Europe aims to accompany cities and communities in their zero-waste transitions.

Zero Waste cities 2021



RECYCLING RATE OF TEXTILES AND STEEL

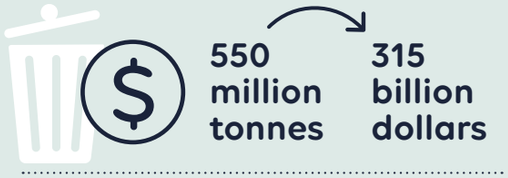
Between 80 and 90% of steel scrap is recycled in an electric furnace.

IEA, 2020

1% of discarded clothes are recycled into new clothes and 12% 'downcycled', i.e. recycled into lower value products that cannot then be recycled into clothes.

Ellen MacArthur Foundation, n.d.

After China's National Sword Policy, the global waste market tries to reorganise itself

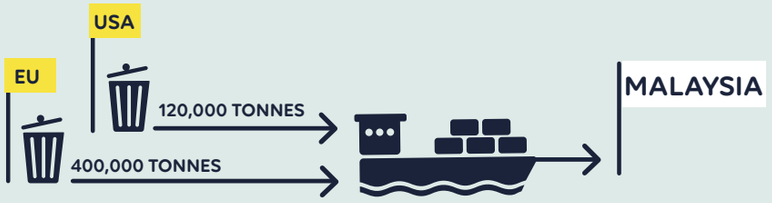


INTERNATIONAL TRADE IN WASTE IN 2019

Exchanges of waste generated 315 billion dollars globally. *UNCTAD, 2021*

WASTE EXPORTED BY EU COUNTRIES TO COUNTRIES OUTSIDE THE EU IN 2020

Including 17.4 Mt of steel and iron, and 6.4 Mt of paper and cardboard. This is 2 Mt more than in 2019. Turkey is the main importer of European waste (13.7 Mt). *Eurostat, 2021*



EXPORTS OF PLASTIC WASTE TO MALAYSIA

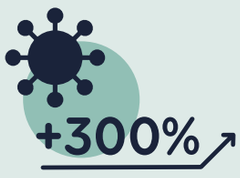
As a result of China's National Sword Policy, Malaysia has become a major export destination for plastic waste. The US exported 120,000 tonnes of plastic there in 2020, and the EU almost 400,000 tonnes. *Statista, 2021*, *Zero Waste Europe, 2021*

Between 2019 and 2021, 267 illegal containers loaded with plastic were returned by Malaysia to their country of origin. *Reuters, 2021*

The pandemic exacerbates the waste crisis

3.4 BILLION OF SINGLE-USE MASKS DISPOSED PER DAY

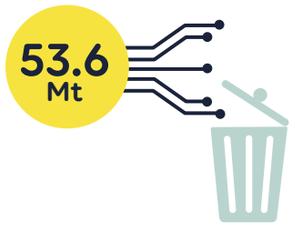
EVOLUTION OF THE CONSUMPTION OF SINGLE-USE PLASTICS DURING THE PANDEMIC



In 2020, 585 million tonnes of plastic waste was generated from single-use medical equipment. *PACE, 2021* ; *La fabrique écologique, 2021*

E-waste, the symptom of an economy that has shifted to the digital space

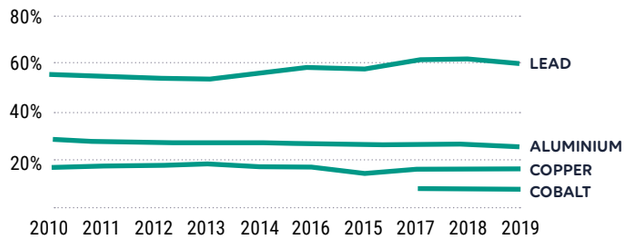
E-WASTE GENERATED IN THE WORLD IN 2019



This is 21% more than in 2014. 17.4% of e-waste collected was recycled. Asia accounts for over 46% of e-waste generation.
The Global E-waste Monitor, 2020

RECYCLING RATES FOR SELECTED METALS AND MINERALS IN E-WASTE

In 2019, recycling rates for aluminum, copper, lead, and cobalt were all trending down from 2018. While the recycling rate for aluminum is close to 60%, the recycling rate for cobalt was still below 10%. *IEA, 2021*



NUMBER OF COUNTRIES HAVING LEGISLATIONS ON THE DISPOSAL OF E-WASTE IN 2019

This is 11 more than in 2017.
The Global E-waste Monitor, 2020

TRENDS
INTERNATIONAL EXCHANGES

In the Absence of Circularity, the Dustbins of the Global North Spill Over into the South

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ANTOINE GILLOD • Coordinator, Climate Chance Observator

From the United States to Europe, the ban on waste imports by Asian countries since 2018 has revealed a severe lack of recycling capacities in the exporting countries, as well as the dependence of industries on the inputs of materials to be recycled coming from abroad. Meanwhile, the countries of the North have found new drop points at which to dispose of the waste they produce. The closure of Asia's borders to imports has increased the illegal waste trade and uncontrolled exports. Nevertheless, importing countries are turning back from the bans in the face of pressure from industries in the sector wishing to capitalise on new markets for recyclable materials.

DATA OVERVIEW

Since implementation of the National Sword Policy, the countries of the North are looking for new outlets for their waste

After several years of increasingly restrictive policies against the movement of uncontrolled trans-border waste, the Chinese government took repressive action by announcing the implementation of the National Sword Policy (NSP) in February 2017, in order to completely halt the import of 24 types of recyclable solid waste, incllluding non-industrial plastics, mixed papers, textiles, and slag from vanadium, a rare metal used in steelmaking.[1] Prior to the implementation of this policy, China and Hong Kong alone imported 72% of global plastic waste produced between 1992 and 2016, much of it through illegal channels.[2] Due to fairly low standards for the quality of waste accepted, recyclable and non-recyclable waste often ended up mixed.[a] So it was left up to the Chinese treatment facilities to manage all this unusable waste. By January 2019, following the NSP, Chinese imports of plastic waste had fallen by 99% (**fig. 1**), and those of paper by more than a third.[3]

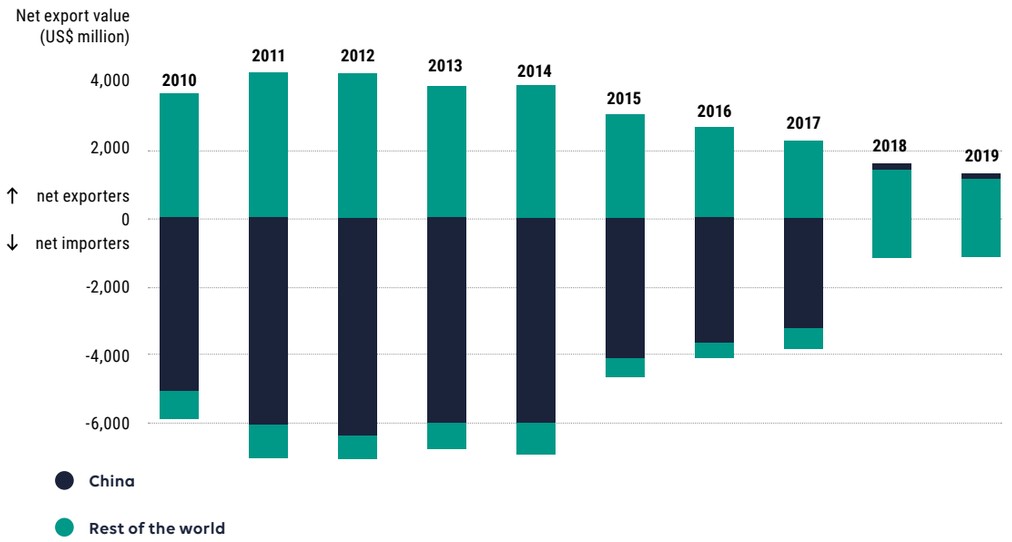
Destabilised by these restrictions, the countries of the North have tried to direct their exports to other destinations. Since 2018, Malaysia, the Philippines, Vietnam and Thailand have become the new outlets for plastic waste from the United States, Japan and Germany.[4] But these new destinations have in turn passed their own legislation to limit the waste entering their territory,[5] and have quickly begun to return to the senders' entire containers of waste that do not comply with contamination rules. By lowering the authorised waste contamination thresholds to near-unattainable levels, these countries have made export impossible for the countries of the North.

a This is what is called "contamination", implying recyclable waste is contaminated with non-recyclable waste.

FIGURE 1

WORLD PLASTICS TRADE

Source: Secretariats of the Basel, Rotterdam, Stockholm (BRS) Conventions, 2021

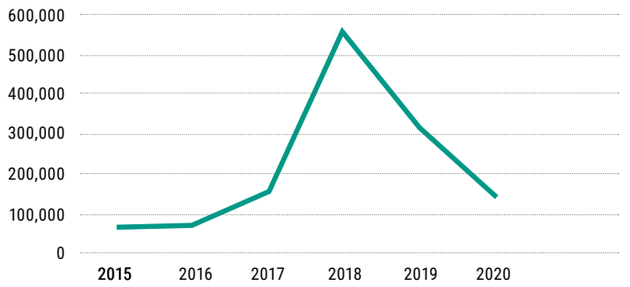


In Thailand, for example, after a sharp increase and a peak in plastic waste imports in 2018 (550,000 tonnes), the volumes entering the territory fell by more than 70% between 2018 and 2020 (**fig. 2**) as an immediate consequence of the ban on plastic and electronic waste imports introduced in June 2018.[6] Vietnam has followed pretty much the same path: while it imported around 20,000 tonnes of plastic waste in 2016, a peak in imports in the country was reached in November 2017 (100,000 t). Then, when several Vietnamese ports were banned from accepting foreign plastic waste,[5] imports dropped sharply to 7,000 tonnes in mid-2018.[7]

FIGURE 2

QUANTITY OF PLASTIC WASTE IMPORTED BY THAILAND (IN TONNES)

Source: Break free from plastic, 2021



In this context of restrictions, the pandemic has set waste exports climbing again. In Europe, exports of waste outside the European Union have exploded since 2004 (up 75%), although Regulation (EC) No 1013/2006[8] on trans-border waste shipments was supposed to restrict shipments of hazardous waste to non-OECD states. After a period of relative stability between 2017 and 2019, they started to rise again in 2020.[9]

While exports to China plummeted from 10.1 to 0.6 Mt between 2009 and 2020 (including a more recent drop in the amount of plastics and paper), Turkey has emerged as the top market for European waste: in 2020, of the 33 million tonnes of waste exported to non-European countries, Turkey received 13.7 Mt (20% more than in 2019[10]), a long way ahead of India (2.9 Mt).[11] In particular, imports of plastic waste by Turkey have multiplied 200 times since 2004, especially since China implemented the National Sword Policy. Malaysia, Indonesia and India have also increased their imports of European waste (**fig. 3**).

While exports of plastic waste from the United States have been on a downward trend since 2018, they increased again by 7% in the first quarter of 2021, reaching 333 million pounds (over 150,000 tonnes) exported.[12] The United States continues to send a large amount of its plastic waste to Southeast Asia, and Malaysia remains the number one destination in Asia, with 263 million pounds (or about 120,000 tonnes) exported in 2020 (**fig. 4**). In 2020, although Canada remains the top destination with 349 million pounds of plastic imported (i.e., more than 158,300 tonnes),[13] the United States sent 137 million pounds (or about 62,000 tonnes) of their plastic waste to Mexico (**fig. 4**). Thus, Latin America and the Caribbean have joined Asia as emerging destinations for plastic waste from the United States. Between January and August 2020, 44,173 tonnes of plastic waste arrived from the United States in fifteen Latin American countries, and exports of plastic waste to Mexico increased by 135%, while those to Ecuador increased by 137%.[14]

FIGURE 3

EXPORTS OF PLASTIC WASTE FOR RECYCLING FROM THE EU TO IMPORTING COUNTRIES, JANUARY 2016 TO JUNE 2020

Source: Eurostat, 2020

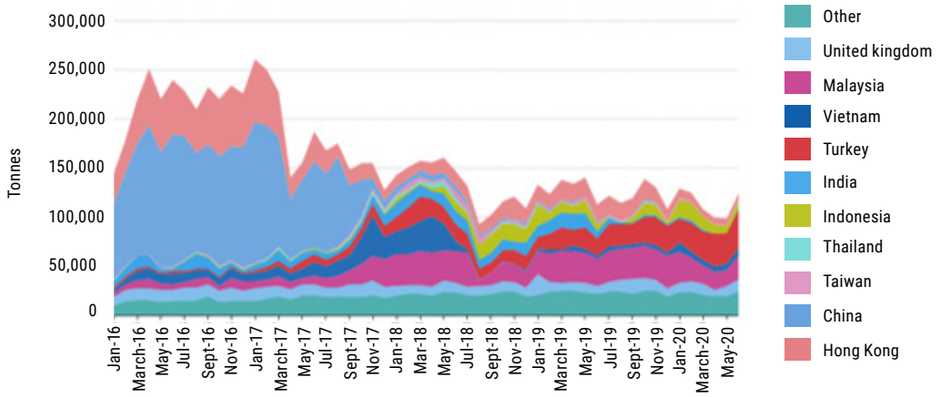
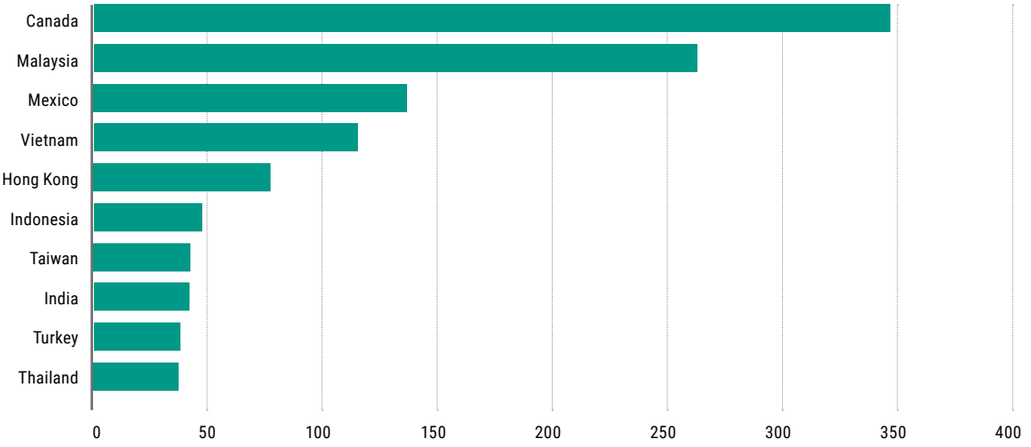


FIGURE 4

THE UNITED STATES' PLASTIC WASTE EXPORTS IN 2020, IN MILLIONS OF POUNDS

Source: Statista, 2021



Japan, for its part, has exported less and less plastic waste over the past four years, but the quantities remain enormous: in 2020, Japan exported some 821,000 tonnes of plastic waste, and Malaysia remained its top importer. Moreover, Vietnam is becoming a destination of choice for Japan, having increased its imports by 160% between 2016 and 2020, reaching 174,000 tonnes of plastic waste imported in 2020.[15]

THE OBSERVATORY'S LENS

The slow transformation of local recycling capacities has not curbed the illegal waste trade

In the North, industries and governments are trying to adapt their local recycling capacities

The waste crisis has revealed the structural weakness of collection and sorting capabilities, obsolete recycling infrastructure and a lack of awareness, which prevent countries like the United States from effectively managing their waste at the domestic level.[16] This is why governments and companies have stepped up their investments to modernise their domestic recycling capacities and make them more efficient.

In 2019, the International Energy Agency (IEA) estimated that $332 million was invested in plastic recycling worldwide, almost seven times more than in 2018.[17] This trend has been confirmed over the last two years.

In Great Britain, UK Research and Innovation (UKRI), a public entity, invested £20 mn ($25.8 mn) at the end of 2020 in four plants to increase the UK's recycling capability and expand the range of recycled plastics. Carried out within the framework of the Industrial Strategy Challenge Fund, to which more than £65 mn ($84 mn) in private investment has been added, this is the largest investment the UK has ever made in the recycling of plastic packaging.[18] In Sweden, Swedish Plastic Recycling (SPR) is an organisation that manages the collection and recycling of plastics for companies subject to extended producer responsibility (EPR). In August 2021 SPR announced an investment of one billion Swedish kronor (~€100 mn) in the Motala recycling centre, to double the centre's recycling capability for plastic packaging collected from households and to supply it with renewable energies to achieve "carbon neutrality".[19]

In Japan, the multinational PureCycle Technologies announced the signing of a memorandum of understanding with the trading house (*sōgō-shōsha*) Mitsui & Co., the first step in the development and operation of a recycling centre to transform waste polypropylene (PP) into ultra-pure recycled polypropylene (UPRP).[20] During the seventh environmental policy dialogue held by the Japanese Environment Ministry and the Asian Development Bank, the bill on promoting the recycling of plastics-related resources in Japan was presented, and the importance of the transition towards a circular economy was stressed.[21] At the same time, the Japanese government has set itself the goal of reducing single-use plastics by 25% by 2030. It is also seeking to make the reuse and recycling of all plastic containers and packaging mandatory by 2025, to achieve a 40% recycling rate for these items by 2030, and to achieve "*100% effective utilization of used plastics by 2035*".[22]

The Canadian government is stepping up funding to improve the infrastructure and methods used for recycling. In September 2020, the government announced it was investing CA$225,000 (US$180,000) in Evergreen Recycling, a local recycling company, to improve the speed and efficiency of container sorting.[23] Then in early 2021, the Canadian Plastics Innovation Challenges, a competition to stimulate technological innovation in recycling, awarded CA$150,000 (US$120,000) to four companies for their projects in the recycling, packaging and textile sectors.[24] Finally in October, 70 non-state actors, including NGOs, public organisations and members of the plastics industry published a "Roadmap to 2025", an action plan aimed at building a circular economy for plastics packaging. These stakeholders are members of the Canada Plastics Pact, the Canadian version of the Ellen MacArthur Foundation's Plastics Pact Network.[25]

In July 2020, in the United States, a group of major consumer brands and corporate foundations committed more than $54 million to support additional recycling infrastructure.[26] They include Keurig Dr Pepper, PepsiCo, the Walmart Foundation,Colgate-Palmolive and Coca-Cola,[b] identified by the NGO Break Free from Plastics as among the ten biggest polluters in the world.[27] A year later, the national network Recycling Partnership called for a public-private investment of $17 billion over five years, in order *"to completely transform the U.S. residential recycling system, maximize its potential and make it as accessible to all households as trash service"*.[28]

In addition to these investments in waste treatment, new anti-plastics policies and laws are attempting to prevent the over-consumption of plastics. Canada intends to ban single-use plastics by the end of 2021 by amending the Canadian Environmental Protection Act.[29] Following a meeting of environment ministers from different jurisdictions in April 2021, Australia presented a plan to ban eight single-use plastic items by 2025. Six of Australia's eight states are already in the process of phasing out certain single-use plastics.[30]

In April 2021, the United States Environmental Protection Agency (EPA) unveiled its first-ever national recycling targets (50% by 2030[31]). Based on the work of the NGO Break Free from Plastic and drawing on local legislation, two elected officials submitted a new federal bill, the Break Free From Plastic Pollution Act of 2021 which aims to phase out plastic and make producers more responsible in the design, collection and recycling of packaging.[32] It succeeds a similar bill submitted in 2020. At the same time, the U.S. Plastic Waste Reduction and Recycling Act was presented to Congress in 2021.[33] This bipartisan bill proposed in June 2020 aims to increase research and development and to plan the strengthening of plastic waste treatment capabilities on American soil.

Building on the 2018 European strategy for plastics, the European Green Deal and the Circular Economy Action Plan, the revisions of the Packaging and Packaging Waste Directive (PPWD) aim to promote the reuse, recycling and other forms of recovery of packaging waste in the European market by 2030.[34] At the same time, PlasticsEurope, the European association of plastics producers, supports the European Commission's proposal for a mandatory European target of recycled content for plastic packaging, of 30%, by 2030.[35]

While Asian restrictions have led the countries of the North to process larger quantities of different types of plastic at home,[36] recycling rates nevertheless remain low: in 2020, the EU had still not reached the 50% recycling rate target it had set itself,[37] and only 12% of plastics was recycled in the United States.[38] Consequently, waste from the countries of the Global North is still massively exported to developing countries, legally or illegally.

b Since the fund was set up, Amazon, Danone North America, Danone Waters of America, Nestlé Waters North America and Starbucks have also joined.

KEYS TO UNDERSTANDING

THE "PLASTIC AMENDMENTS" TO THE BASEL CONVENTION

The Basel Convention is an international treaty signed in 1989 which came into force on 5 May 1992, aiming to protect human health and the environment from the harmful effects of hazardous waste. The Parties to the Convention are bound to observe fundamental principles such as proximity of waste disposal, priority for waste recovery, and prior informed consent to the import of potentially hazardous substances. On 10 May 2019, the 187 countries party to the Convention decided to amend the treaty to impose greater transparency on waste exports, and to allow countries to refuse imports if they are toxic or non-recyclable. Exporting countries will therefore have to secure the agreement of the host countries before sending them their waste. Since 1 January 2021, the prior agreement procedure provided for hazardous plastic waste (Annex VIII) has been extended to household plastics requiring special consideration (Annex II): thus, any cargo of this type will now have to wait for an authorisation from the country of the receiving port. Hong Kong has transcribed the amendment into national law, as has the European Commission in a new regulation stipulating that only non-hazardous and easily recyclable plastic waste can be exported to countries outside the OECD. The new rule has been transcribed and harmonised in the OECD Control System for waste bound for recovery, which means that even the United States, not party to the Basel Convention, is now subject to this rule.

Sources: French Ministry of the Ecological Transition, 24/02/2021; AIDF, 07/12/2020

While awaiting more efficient recycling systems, waste traffic continues relentlessly

In a report released in August 2020, Interpol analysed emerging criminal trends in the global plastic waste market since China began to implement its policy in January 2018. Based on data and intelligence from 40 countries, Interpol identifies a number of widespread illegal practices: transfers of illegal waste shipments to other destinations, illegal dumps, illegal incinerations, and administrative fraud are some of the alternative channels that have opened up in the absence of domestic recycling capacities in countries hitherto dependent on China.[39] In 2020, port and air cargo control units intercepted 630 tonnes of illegal waste.[40] Thirteen of the 24 countries that were destinations for illegal exports were located on the Asian continent. Many countries on all five continents have also seen illegal waste management increase on their territory.[c]

The reclassification, since 1 January 2021, of certain types of household plastics as "hazardous plastics" within the framework of the amendments to the Basel Convention has helped remove many waste shipments from legal export frameworks, without prior authorisation from the importing country (**see Keys to Understanding**).

In the United States, customs records show that U.S. exports of plastic waste to developing countries totalled some 25,000 tonnes and 4,700 containers of plastic waste for the month of January 2021 alone, roughly at the same level as in January 2020, before the amendments to the Basel Convention entered into force.[41] Malaysia tops the list of destinations, followed by Vietnam and Indonesia.[42]

In April 2021, Malaysia reported it had returned 267 containers of illegal plastic waste to their country of origin since 2019.[43] In theory, imports have been banned since October 2018, but the government has failed to stop trafficking: smuggling involves many different players, some of whom are part of organised crime and specialise in the false declaration of transported waste and its destination.[44] While Senegal is still trying to improve the management of its annual plastic waste production, estimated at 200,000 tonnes,[45] in May 2021 customs seized a container of 25 tonnes of plastic waste coming in from Germany.[d] Having become a destination of choice for toxic or unusable waste, Romania received 3,700 tonnes of waste in August 2021. On its control at the border, toxic waste was declared as plastic waste, like these 70 containers exported from Belgium, when it actually contained wood, metal waste, or other materials considered hazardous.[46]

Thus, civil society continues to rally to attract governments' attention and see stricter measures put on waste imports. In February 2021, the Consumers' Association of Penang (CAP) and the Eco Waste Coalition called on the countries of the ASEAN to implement a more robust regional policy against the illegal import of waste and thus protect the health of the public and ecosystems.[47] In its report "Waste Trade in Southeast Asia: Legal Justifications for Regional Action", published in August 2021, the Eco Waste Coalition, in collaboration with the International Network for the Elimination of Pollutants (IPEN),[e] denounces the inadequacy of the current legal and political responses of ASEAN member states to stop the entry of illegal waste. The report stresses that the international waste trade is exacerbating existing waste management problems, and that a response from the ASEAN to this crisis would help countries to protect the region's ecosystems and biodiversity.[48]

c These include France, Italy, Spain, Sweden, the Czech Republic, Ireland, Romania, Thailand, Malaysia, Australia, Chile and Malawi.

d In addition to re-exporting the shipment, the shipping company Hapag-Lloyd will have to pay a fine of 2 billion CFA (€305 mn).

e A network of public utility organisations, non-governmental organisations and associations.

In an attempt to curb the increase in illegal shipments of plastics and hazardous waste, the World Customs Organization (WCO) and the United Nations Office on Drugs and Crime (UNODC) have launched a new project within the framework of the container control program (CCP), on "*the fight against the illegal trafficking of hazardous waste*", within which framework port control and specialised air cargo units have been set up and trained in major airports and seaports. Partly funded by the Norwegian Agency for Development Cooperation (Norad), the project aims to improve the capacities of organisations working to tackle illegal shipments of plastic and hazardous waste in the international goods trade.[49]

For their part, European countries are trying to step up the fight against illegal waste trafficking, but victory is still far off: between 1 and 31 March 2021, Europol and Frontex coordinated an operation bringing together 300 agencies from 67 countries to fight marine pollution and illegal waste trafficking. In March alone, 130 cases of waste trafficking were recorded in ports.[50] Thus, trans-border movements of waste still largely pass through the legal frameworks in force, endangering the health of populations and ecosystems.

At the same time, importers do an about-face

As environmental groups call on governments to demand tougher laws and limit the importing of waste, some importing countries are doing just the reverse. Indeed, some countries are now relaxing their regulations to facilitate the supply of "secondary raw materials" essential for their industries to operate.

This is true of Turkey, for example. At the beginning of May 2021, a Greenpeace investigation[51] revealed that significant quantities of plastic waste from European countries were not being recycled but were ending up being incinerated or placed in Turkish landfills instead.[f] Britain was singled out for exporting 209,000 tonnes of waste to Turkey in 2020, 17 times more than in 2016. The Turkish Ministry of Commerce therefore announced a ban on all imports of plastic waste[g] as of July 2, 2021.[52] Just days after the ban was applied, the government lifted this restriction on PET plastics: this type of waste now falls into the "controlled waste", rather than prohibited waste[53] category, which is what the plastics industry wanted.[54]

Thailand also went back on its decision and postponed the ban on plastic waste for another five years: for the year 2021, the country still authorises the import of 250,000 tonnes of plastic. A network of 107 civil society environmental groups called on the Thai government to ban imports and prioritise domestic plastic waste for recycling. In early August, the network issued a joint statement calling on agencies to officially announce a policy to ban imports of plastic waste within the year, as well as amend laws and regulations to fill loopholes that allow the use of plastic waste imported into the plastics recycling industry. This move has as yet proved fruitless.[55]

In South Africa, which recycles only 14% of its plastic waste, the Department of Forestry, Fisheries and the Environment is issuing new import requests to meet the needs of the plastics industry,[56] in accordance with the Basel Convention. This decision is part of the South African government's broader policy on plastic waste management: leaked Environment Department documents reveal that the government will not back the new UN treaty to fight plastic.[57] As for Indonesia, which in 2019 had announced a maximum contamination rate of 0.5% for the import of "recovered fibre", the government reversed its decision by setting a contamination rate four times higher than that initially set, in particular to allow the import of British waste paper.[58]

In China, while the Ministry of the Environment and that of Trade had stated that "*any import of solid waste, by whatever means, will now be prohibited*"[h] from 1 January 2021,[59] the government has given the go-ahead for the import of high-quality scrap metal that meets new standards, and which has been reclassified as "resources". Similarly, in February, the China Nonferrous Metals Industry Association (CMRA) published a second list of 26 companies authorised to export copper and aluminium waste to China.[60] China is thus permitting the import of aluminium and copper waste from European, Asian and American companies. The governments of importing countries, which up to then seemed determined not to become the waste bins of the world, are doing u-turns and relaxing their regulations to meet industries' demands, revealing their domestic industries' dependence on the input of materials for recycling from abroad.

KEY TAKEAWAYS

While the countries of Southeast Asia are gradually closing their borders to new waste, the exporting countries have found themselves caught between their massive consumption of waste and their inability to recycle it on their own territory. While the amendments to the Basel Convention were aimed at limiting the export of difficult-to-recycle plastic waste to developing countries, the governments of the Global South, giving in to the needs of industry, have begun to relax the laws to once again allow waste to be imported more freely into their countries. In Europe, the United States, Canada and Japan, efforts to invest in new local recycling capabilities and the tightening up of recycling standards and targets are part of a long-term strategy that does not eliminate the short-term need to export waste, sometimes in defiance of international rules.

f The Microplastic Research Group, a team of Turkish academics, also indicated in a study that in the first half of 2021, at least 68 waste fires were reported in Turkish plants, as against just eight in 2016.

g This specifically includes polyethylene plastics; PET water bottles, plastic caps, polypropylene (PP) pots and tubes are not covered by the ban.

h With the exception of ferrous waste (including cast iron or steel).

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TRENDS
RECYCLING

Recycling Lithium-ion Batteries, the New Frontier in the Electrification of Mobility

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From mobility to the digital transition, the electrification of end-uses relies on precious minerals whose production lies in the hands of a limited number of actors. Countries can only benefit from these minerals if they have the capacity to develop and exploit them or, in the absence of virgin resources, if they can develop secondary resources from recycling and recovery. In particular, the high demand for lithium-ion batteries, which are essential for the widescale deployment of electric vehicles, increases competition to access strategic metals like cobalt, nickel and lithium. Battery recycling tends to take a backseat in industries' regionalization strategies. Yet the Canadian province of Quebec stands out for providing proactive public support to the emerging battery recycling industry.

DATA OVERVIEW

Li-ion batteries, a globalised product at the heart of national energy transitions

Enthusiasm for "emission-free" vehicles soared in 2020. The trend continued during the first half of 2021, with global sales of electric vehicles (EVs) up by 168% compared to the previous year.[1] The market is stimulated by national targets to increase the share of electric vehicles in automobile fleets, the exclusion of internal combustion engine vehicles from some cities, and incentive measures aimed at citizens and car manufacturers (**see Transport sector**). Ultimately, the juxtaposition between these public and private objectives and the growth of autonomous grid storage will boost demand for alternative technologies, including lithium-ion batteries.

Since lithium-ion batteries were first marketed in 1991, their price has dropped by 97% (**fig. 1**). On average, each time battery production doubles, the price falls by a quarter.[2] From 2010 to 2020, the average price of lithium-ion batteries dropped by 89%, from $1,100/KWh to $137/KWh.[3]

Lithium-ion batteries have several advantages: they are very dense, energy efficient, and long-lasting. Lithium has a high electrochemical potential that means it can store considerable electrical loads. On the downside, this type of battery is heat sensitive and requires circuit protection to limit the voltage and current, which makes end-of-life management more complex. Some of the battery components can represent a risk for the environment and human health. Lithium, for example, can explode when it comes into contact with combustible material or water. According to a study carried out by the consulting firm Golder, thermal runaway can also produce smoke and toxic substances, including hydrogen fluoride, which is irritating and corrosive for skin, eyes and the respiratory tract, with potentially serious symptoms depending on exposure conditions.[4] Although living organisms need minerals like copper, manganese, and cobalt to ensure numerous nervous, vascular, immunity and bone functions, excessive doses can trigger allergies, poisoning, and sometimes severe cardiac and respiratory disorders.[5]

TABLE 1

CURRENT AND PROJECTED PRODUCTION OF MINERALS CRITICAL TO BATTERY PRODUCTION

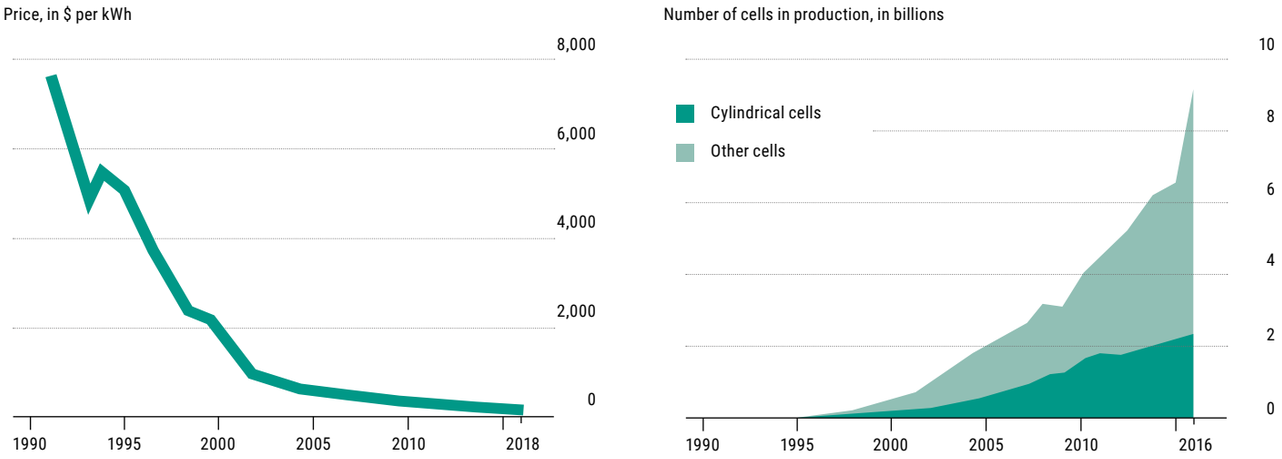
Source: World Bank, 2021

	PRODUCTION EN 2018 (MT)	PROJECTED DEMAND IN 2050	
		MT	VARIATION FROM 2018
LITHIUM	85	415	+388%
COBALT	140	644	+360%
MANGANESE	18,000	694	-96%
NICKEL	2,300	2,268	-1.4%
GRAPHITE	930	4,590	+393%

FIGURE 1

EVOLUTION OF LITHIUM-ION BATTERY PRICES ($/KWH) AND PRODUCTION OF LITHIUM-ION CELLS (BILLIONS)

Source: Ziegler, M. S., Trancik, J. E., 2021. Figure adapted from The Economist, 31/03/2021



The latest reports by the World Bank (2020)[6] and the International Energy Agency (2021)[7] make it evident: a low-carbon future will require high quantities of minerals to develop clean technologies (**see Industry sector**). In particular, the composition of lithium-ion batteries relies on five main minerals: lithium, cobalt, manganese, nickel and graphite. As shown in the table generated using data from the World Bank report, demand for three of these is set to surge over the next few years (**tab. 1**).

This rising demand is moving the pieces on the geopolitical chessboard. Actors that benefit from easy access to these materials and to industrial capacities for transforming them into finished and semi-finished products are one step ahead (**see Industry sector**).

Take lithium, for example. In its natural state it comes in two forms: either in the form of brine in salt flats, or in solid form. Several salt deposits, known as *salars* are present in South America, China and the United States. Groundwater containing lithium is first pumped to the surface, then placed in evaporation ponds for up to 18 months depending on climatic conditions (humidity, wind and solar radiation). Lithium is then precipitated in the form of carbonate. The residual components that remain after evaporation are processed in factories to separate them into, among others, sodium chloride (salt), magnesium chloride and lithium carbonate.[8]

The South American region in the Andes covering the Altiplano-Puna plateau and comprising of Bolivia, Argentina and Chile, constitutes the biggest source of lithium, mainly from the Salar de Uyuni salt flat in Bolivia with a surface area of 10,000 km^2. The lithium resources of these three South American countries represented over 53% of global reserves in 2019.[9]

The potential of the Salar de Uyuni is enormous, with an estimated 21 million tonnes of reserves, in addition to the Coipasa and Pastos Grandes salt flats.[10] Bolivia, which initially closed the door on foreign partnerships, intending to nationalize the resource, is now attempting to create a vertically integrated value chain going all the way up to battery production, or even electric vehicles, by selecting experienced international partners.[11] The joint-venture signed in December 2018 between the state company Yacimientos de Litios Bolivianos (YLB), founded in 2017, and the German firm ACI Systems was finally cancelled in November 2019 by the government of Evo Morales.[12] The agreement comprised investment in a high-tech complex in the Salar de Uyuni to produce up to 40,000 tonnes of lithium hydroxide a year over seventy years, controlled 51% by Bolivia. The country's new president, Luis Arce, elected in 2020, appears highly favourable to reinitiating his predecessor's plan to produce lithium and batteries in the country by establishing strategic alliances with international partners. In 2021, the new Bolivian government launched several calls for international projects to recommence extraction on its three sites.[13]

Like Chile and Argentina, Bolivia does not yet possess what China has established, i.e., a sizeable industrial ecosystem for manufacturing batteries. As the world's number three lithium producer (14,000 tonnes in 2020),[14] China also possesses considerable quantities of graphite and rare earths, which are critical minerals for producing batteries. The country has invested massively since the 1980s to exploit its mineral resources and produce lithium-ion batteries. In early 2019, China represented 70% of global battery production capacity.[15] To ensure a stable flow of lithium for battery suppliers and car manufacturers, strategic alliances and commercial partnerships have been established between technology firms and mining companies.

As in many industries, a concentration of production capacities leads to a concentration of recycling capacities, and batteries are no exception.

THE OBSERVATORY'S LENS

Often overlooked in the value chain, the recycling of lithium-ion batteries is getting growing attention in North America

Current global trends for lithium-ion battery recycling

When it comes to strategies to move upstream in the battery production sector, end-of-life management tends to take a backseat. According to the International Energy Agency, global recycling capacities in 2021 amounted to 180,000 t/year, half of it concentrated in China.[6] Japan, France and Germany make up most of the remaining current or announced recycling capacities (**fig. 2**). Whatever the case, global recycling capacities remain well below what is required given the quantities put on the market. In the best-case scenario, the International Energy Agency estimates that recycling will, for example, reach 12% of global demand for cobalt, and 5% for lithium in 2040.[6] In the European Union, currently only 12% of aluminium is recycled, along with 22% of cobalt, 8% of manganese, 16% of nickel, and almost no lithium.[16]

For the most part, the main recyclers are mining companies, cathode producers, and battery manufacturers. Independent recyclers are less common and have much lower capacities for recycling (**tab. 2**).

TABLE 2

EXAMPLES OF COMPANIES INVOLVED IN RECYCLING LITHIUM-ION BATTERIES

TYPES OF COMPANIES	EXAMPLES OF COMPANIES
MINING COMPANIES (LI, CO)	GLENCORE, HUAYOU COBALT, LITHIUM AUSTRALIA
CATHODE PRODUCERS	L&F CO, UMICORE, AURUBIS
BATTERY PRODUCERS	BYO, PANASONIC, LG CHEM, FOXCONN, BAK, CATL, JOHNSON CONTROLS
INDEPENDENT RECYCLERS	BRUNP RECYCLING, ACCUREC, RECYCLAGE LITHION, REDUX, AMERICAN MANGANESE, INC.

According to the projections of the TIAM-IFPEN model developed by the French think tank IFP-Énergie Nouvelles, in a climate scenario that limits the temperature rise to 2°C, the main metals that make up Li-ion batteries are subject to variable criticalities: higher for cobalt due to the concentration of its deposits in the Democratic Republic of Congo and its price, average for nickel, and relatively lower for lithium due to its geological abundance.[17] The development of lithium-ion battery recycling should nevertheless take off for other environmental, economic and social reasons:

- Environmental, because extracting minerals involves damage, and because a lack of recycling could undermine all our efforts to reduce the impact of consumption patterns. Water usage is also a major issue since production processes, in particular in *salars*, require considerable quantities of freshwater drawn from local water courses.[8] The impact of pumping groundwater and the effects on surrounding ecosystems are also unknown.

- Economic, because in the summer of 2021, the price of some minerals like lithium hit a three-year high in reaction to increasing demand for electric vehicles and a relatively low supply of the mineral (**see Industry sector**).

- Social, because in some parts of the world mineral exploitation violates numerous human rights codes, including slavery and child labour; NGOs like Amnesty International regularly denounce the working conditions in cobalt mines in the Democratic Republic of the Congo, which concentrates 90% of cobalt exploitation.[18]

According to a Bloomberg annual ranking, Canada currently ranks fifth in the world for manufacturing lithium-ion batteries over the entire value chain, partly thanks to its mining resources, while the United States comes second, due to its manufacturing capacity and domestic demand.[19]

To ensure good end-of-life battery management, several countries apply the principle of extended producer responsibility (EPR). In North America, although for the moment no regulatory framework applies to the recovery and recycling of batteries from electric vehicles, the EPR route is under study, and is currently in force for household batteries and batteries from electronic devices. Over the last three years, the Canadian organization Appel à Recycler has transported and recycled almost 170,000 smartphones a year in North America. Through the same program, Appel à Recycler has collected and recycled over 3,600 tonnes of regular and lithium-ion batteries.[20]

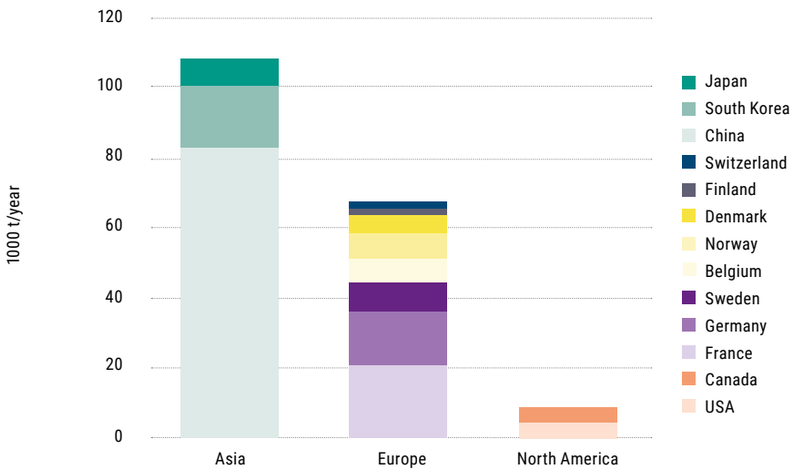
In France, manufacturers are obliged to organize and pay for the collection and processing of the waste they generate. They can establish understandings with recyclers to manage the end-of-life of car batteries, while EU regulations currently require a minimum recycling rate of 50%.[21]

The recycling performance of lithium-ion batteries is difficult to evaluate. Moreover, the growth in their use in electric vehicles is a recent phenomenon, and most have not yet reached the end of their useful life. In its report, the World Bank publishes figures from 2011 on the recycling rate of minerals, which does not exceed 70% in very rare cases. In the case of lithium, it is even below 1%.[5]

FIGURE 2

CURRENT AND ANNOUNCED CAPACITIES FOR RECYCLING LITHIUM-ION BATTERIES

Source: IEA, 2021



The review of existing literature conducted by the authors identifies three main factors holding back the growth of the lithium-ion battery recycling industry:

- The low return on investment for some types of battery: the selling price of materials recovered from some batteries does not necessarily cover the recycling costs.
- The generation of residual matter: current recycling technologies generate high quantities of waste, and the processes require significant amounts of chemicals.
- The complexity of processes: current technologies require highly refined wet chemistry processes or heating at very high temperatures, which bring a number of chemical, electric and thermal runaway risks.

Lithium-ion battery recycling operations take place in four stages.[22] First, *stabilization* aims to discharge the battery pack. Next, *pre-processing* involves opening up the battery pack to isolate the modules. Following this stage, the modules are either dismantled or crushed before separating the different materials. A "black mass" is then obtained that contains hydrophobic carbon and hydrophilic metal oxides.

Two processes can be used at this stage to recycle lithium-ion batteries: *hydrometallurgy* or *pyrometallurgy*. The latter is the most common procedure and basically consists of heating the battery to a high temperature to recuperate a metal alloy.[23] This is a standard metal recycling technique that has been adapted to electric vehicle batteries. Nevertheless, the yield of the operation is limited since it is difficult to extract high added value metals from the alloys, such as cobalt, lithium, nickel and manganese.[6]

An emerging technique for recycling batteries, hydrometallurgy, consists in dissolving the black mass in solvents (leaching) to isolate the different metals sought. Hopes are pinned on this second technique to put the strategic minerals contained in batteries back into circulation. The Quebec Plan for the Development of Critical and Strategic Minerals clearly aims at this target.

In Quebec, a regional ambition to build an integrated battery industry

Quebec intends to become a leader in the energy transition. Its Energy Transition, Innovation and Efficiency Master Plan 2018-2023, extended to 2026, sets out measures to reach the objectives established in the 2030 Energy Policy, voted in 2017. In particular, the latter includes a 40% reduction in the quantity of petroleum products consumed, and a 25% increase in the total production of renewable energy. The contribution of the 2030 Energy Policy to reducing GHG emissions is estimated at 16 $MtCO_2e$. Quebec, which emitted 83.7 $MtCO_2e$ in 2019, pursuing a rising trend,[24] has set a target to reduce emissions by 37.5% by 2030 compared to 1990.[25]

To achieve its objectives, the province can also count on an electricity mix featuring 95% hydropower.[26] Hydro-Québec, the state company responsible for electricity production, operates 61 hydropower stations with an installed capacity of 37.2 GW, along with 28 reservoirs with a combined storage capacity of over 176 TWh,[27] making the province a net electricity exporter. This position inherited from the nationalization of electricity production in the 1960s has prompted the prime minister of Quebec to express his ambition of making the province the "green battery of North America".[a]

a Tweet by François Legault, 7 November, 2020

The electricity mix in Quebec is therefore suitable for the electrification of end-uses, in particular transport, which concentrates 43% of the province's emissions.[2] The 2030 Plan for a Green Economy, which came into force in April 2021, establishes a figure of 1.5 million EVs in circulation in Quebec in 2030, or 30% of the automobile fleet.[28] Already, since January 2018, the ZEV (zero-emission vehicle) standard requires carmakers to sell a set proportion of light-duty, zero-emission vehicles with the aim of reaching 100,000 electric vehicles in circulation by 2020, featuring in the Action Plan 2015-2020 for Electrification of Transportation (PAET). On 30 June 2021, over 110,000 electric vehicles were registered in the province, which is almost half of all electric vehicles sold in Canada,[29] while Quebec only represents 25% of the total population. From only 0.7% in 2015, the market share of EVs now amounts to 7% of new vehicles sold.[30] This growth is not restricted to automobiles. For example, the company Lions Electric commercializes numerous heavy-duty electric vehicles, such as buses and delivery trucks, while electric bicycles are increasingly common in Quebec, representing 26% of total bike sales in 2020 bringing the total to 365,000 in circulation.[31] More widely, an estimated 70% of the North American vehicle fleet is expected to become electric in 2050, including light-, medium- and heavy-duty vehicles.[32]

To ensure its targets, the Quebec government recognizes the crucial role of ensuring a supply of "strategic and critical metals" (SCMs). In August 2020, the prime minister transferred to the Ministry for Energy and Natural Resources (MERN) the jurisdiction of the Quebec Energy Transition, a public company created in 2017 to stimulate the transition and ensure integrated governance with stakeholders.[33] The same ministry initiated the Quebec Plan for the Development of Critical and Strategic Minerals (QPDCSM).[34] The aims of this plan, launched in October 2020, including taking advantage of the region's mineral resources (lithium, cobalt, graphite, nickel, etc.), creating a research and development network gathering all actors in the sector, and developing recycling and re-use of critical and strategic metals.

In March 2021, the ministries and partner organizations of the QPDCSM met for a first overview of the plan's application.[35] To support the recycling of SCMs, the government has granted financial aid amounting to CA$850,000, of which CA$500,000 are earmarked for a new factory to be opened by Rio Tinto Fer et Titane (RTFT) in summer 2021 to produce scandium oxide. Among other uses, scandium is employed in aluminium alloys for the aerospace industry. The process used by RTFT extracts scandium from the residues of titanium oxide production without requiring additional extraction, according to the group.[36] The factory could meet 20% of global demand on its own, spurring Quebec's ambition to establish itself as the leader of this niche market. In March 2021, the finance minister also announced a reform of the Mining Tax Act with the aim of earmarking a portion for recovering SCMs.[37]

A study published in March 2020 by Propulsion Québec, an industrial cluster for electric transportation, estimates that somewhere between 3,000 and 7,000 tonnes of batteries will reach the end of their useful life before 2025; this quantity is estimated at 90,000 tonnes for the whole of north-eastern America.[17] For the time being, batteries from electric vehicles are not subject to EPR. Nevertheless, in January 2021, Appel à Recycler, the eco-organization responsible for recycling and recovering batteries, launched a program to recycle electric batteries from bicycles and scooters. Currently, batteries from electric cars that have reached their end-of-life are dispatched outside the province, mostly to British Columbia.

The provincial government has therefore supplemented the QPDCSM with the Quebec Strategy for Developing the Battery Industry.[38] The aim is to position Quebec among the global leaders at all stages of the industry, from the extraction of minerals from its rich subsoil right up to the manufacture of batteries, and including assembly and manufacturing of anodes and cathodes. The province's public investment company, Investissement Quebec, has announced through its CEO that it intends to invest "*from [CA$] one to two billion from public funds and four to six billion from private investments [...] over the next two to three years.*"[39]

The industry for managing the end-of-life of batteries is taking shape, both for recycling and reconditioning. In November 2020, the Quebecois company Recyclage Lithion patented a process for recycling lithium-ion batteries using hydrometallurgy. The company claims that the process will enable 95% of battery components to be recovered and processed.[40] Considered as a start-up, Lithion was founded by a consortium of public and private stakeholders with established expertise in the field. Seneca, an industrial process engineering firm, has already applied hydrometallurgy to other sectors. Lithion is also supported by the *Centre d'étude des procédés chimiques du Québec* (CEPROCQ), Hydro-Québec's Center of Excellence in Transportation Electrification and Energy Storage, and Appel à Recycler.

A first demonstration factory, at an estimated cost of CA$12 mn, started operating in 2020 in Anjou, a district of Montreal, and is capable of recycling up to 200 tonnes of batteries per year. The Quebec government is closely involved in the project. In 2018, Lithion received initial support amounting to CA$3.8 mn from Sustainable Technology Development Canada (STDC), a foundation to support technological innovation in SMEs,[41] followed by a government grant of CA$4.8 mn to support the opening of its first demonstration site.[42] Lithion plans to open its first commercial factory in 2023, with an annual processing capacity of 7,500 tonnes of batteries, which is the equivalent of 20,000 electric vehicles. To support the project, the Quebec government recently granted additional aid of CA$2 mn.[43] The Canadian branch of Hyundai, which is targeting 100% electric sales by 2040, is the first automobile manufacturer to have signed an agreement with Lithion to supply it with end-of-life batteries with a view to opening the commercial factory.[44] Earlier in the year, New Flyer Industries, an electric bus manufacturer based in Winnipeg, also signed a partnership with Li-Cycle, the biggest battery recycling company in North America, based in Ontario.[45]

Another approach involves reconditioning batteries. CycloChrome is a social enterprise based in Montreal that specializes in bicycle repairs and also trains young people, in order to

combat school drop-out rates. It has a contract to maintain and repair BIXIs, the bicycles used in the city's bike share scheme, and other fleets of corporate bicycles, like those used by the Montreal city police service. With the growth in electric bikes, Cyclochrome is also seeking to develop its expertise to recondition batteries. The technique aims at removing used battery cells and replacing them with new ones to extend the lifespan of bicycles. For BIXIs alone, the biggest electric bicycle fleet in Canada, this involves managing 1,725 end-of-life batteries.[46]

The future of end-of-life battery management therefore looks bright. Not only are the minerals they contain highly sought-after, but the techniques employed to recondition and recycle them are developing fast.

KEY TAKEAWAYS

In autumn 2020, the government of Quebec launched its "Quebec Plan for the development of Critical and Strategic Minerals: a More Electric Future for an Eco-Friendly Quebec". What made a jurisdiction at a regional level of governance take on such an ambitious plan in the face of state and private giants? The answer lies in market dynamics, which clearly correspond to the evolution of economic models, particularly in electric mobility and renewable energy production. It can also be put down to proactive public authorities aware of their geological assets and the challenges involved in deploying electric vehicles. Recycling and recovery take a backseat in the regional integration strategies of battery manufacturing industries, but are receiving strong support from the Quebec government, based on a local industrial network whose ambition is to position itself as the leader of north-eastern America – a strategy that is taking shape on the field.

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SIGNALS

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

Wales • A Circular Economy strategy that goes Beyond Recycling

In March 2021, the Welsh government published a new circular economy strategy called Beyond Recycling. From a current recycling rate of 65%, the country aims to reduce the amount of waste going to landfill to zero by 2025, and will place a moratorium on any new waste-to-energy projects. In 2021, a population-wide survey was conducted on the introduction of a deposit system for plastic bottles and a reform of extended producer responsibility (EPR). The political declaration accompanying this strategy states the desire to place circularity at the heart of public procurement.

Welsh government, 2021

Plastic • Giants in the petrochemical industry under pressure from their shareholders to disclose their plastic impact

Shareholders of chemicals giant DuPont overwhelmingly passed (81.2%) a resolution filed by shareholder advocacy group As You Sow, calling on the company to measure its involvement in plastic pollution, particularly through "*the spills of plastic pellets released into the environment*". This is a record for an environmentally oriented shareholder proposal that was opposed by management. Six other petrochemical companies have committed to do the same, under pressure from the shareholder group As You Sow. Of these, only Dow-Chemical and Exxon's chemical arm have begun to disclose data. The equivalent of 15 billion plastic bottles are released into the environment each year in the form of plastic pellets.

As You Sow, 03/05/2021

United States • Tentative advances in Extended Producer Responsibility

The state of Maine has approved a bill introducing extended producer responsibility (EPR), whereas no such programme exists in the US. Introduced to legislators in the summer, it will require packaging producers to contribute to a fund to cover the costs of managing and recycling municipal waste. A system for tracking packaging production in the state is also planned. Businesses with revenues of less than $2 million could be exempt, as well as those that implement their own recycling or packaging reduction programmes for their products. The cost of recycling in Maine is 67% higher on average than landfilling and is passed on to local taxes. Legislators have until May 2022 to vote on the proposal, at which point Maine would be the first US state to implement the system, with California and New York potentially following. In all, nine states have coordinated to submit EPR proposals in 2021.

Recycling Today, 27/05/2021

Wind Turbines • The first recyclable wind turbine blades enter the market

The German industrial group Siemens Gamesa has begun marketing the first 100% recyclable wind turbine blades. Today, 85% of the components of a wind turbine are recyclable. But the blades, made of thermosetting materials, are very difficult to reuse for the same purpose. Produced at a factory in Aalborg, Denmark, the chemical composition of the resin used by Siemens Gamesa to bind the blade components can be dissolved in acid and more easily separated to recover the materials. Zebra, a research project led by the Jules Verne technological research institute in Nantes and supported by Arkema, has also made progress on the design of a resin called Elium® ; Danish company Vestas also claims to have made progress on the subject. In an appeal to stop their disposal in landfills, launched in June 2021, the trade association WindEurope estimated that 25,000 tonnes of wind turbine blades will reach the end of their operational life by 2025.

Financial Times, 07/09/2021

Greenwashing • California bans the use of misleading symbols on non-recyclable items

California legislators have passed a law preventing the use of the three-arrow recycling symbol unless the product meets California's recyclability criteria. The law states that the California Department of Resources Recycling and Recovery (CalRecycle) must, by January 1, 2024, provide information to the public to determine whether a product or package is recyclable in California and whether it is composed of materials that can be used as raw material for new products and packaging. This law echoes recent legislative initiatives in other US states. Oregon has created a task force to "investigate and evaluate misleading or confusing claims" about the recyclability of certain products, and in New York a bill proposes the prohibition of the sale of products or packaging containing a misleading or deceptive claim about the recyclability of the product or packaging.

Recycling Today, 11/09/2021

Solar panels • Australia's first recycling plant is now operational

Australia's first solar panel recycling plant, the construction of which was completed in September 2020, is now in operation in Thomastown, Melbourne. Operated by the Lotus Energy Co-operative, the plant boasts the ability to recycle 100% of photovoltaic panels without chemical processes. It is expected to be followed soon by a second plant in Adelaide, according to an announcement by Reclaim PV Recycling in February 2021, three years after the first such plant was opened in Europe by Veolia in France. Some of Australia's sunniest states are relying heavily on solar for their energy transition (see **South Australia case study**). The recycling of solar panels is all the more strategic as Australia is among the world leaders in the development of photovoltaic energy (17,342 MW of installed capacity in 2020, according to IRENA).

Interesting Engineering, 10/05/2021

Ghana • The launch of the Zero Waste Accra initiative

The La Dade-Kotopon Municipal Assembly (LaDMA) and the Green Africa Youth Organization (GAYO) have partnered to launch "Zero Waste Accra", an initiative to engage the community in the implementation of a zero waste strategy. Waste will be collected from beaches and mangroves to be stored and then handed over to recycling companies. In Ghana, informal collectors play an important role in solid waste collection. The city is home to the world's largest e-waste dump, Agbogbloshie. The Zero Waste Accra project is part of a presidential commitment to make Accra the "cleanest city in Africa", and is inspired by the Sustainable Community Project launched in 2018 by GAYO, which aims to create a circular economy model in the Andani South district in partnership with SMEs and the government

Afrik21, 09/09/2021

Canada • Plastic is now considered toxic

The Canadian government has recently added plastic to the list of toxic substances in the Canadian Environmental Protection Act (CEPA, 1999). As a result, the government is obliged to take legal action, and is expected to ban six single-use plastic products: straws, stirrers, cutlery, six-pack rings, Styrofoam bags and plates, and take-out containers. The plastics industry, including the Chemistry Industry Association of Canada (CIAC), the American Chemistry Council (ACC) and the Plastic Industry Association (of the US), has overwhelmingly opposed the government's fall 2020 bill, and is arguing for increased public spending on recycling instead.

Recycling Today, 14/05/2021

Waste Dumps • Kuwait starts recycling 42 million discarded tyres

The Gulf State has begun to tackle one of the world's largest tyre graveyards: located less than 7 km from a residential suburb, the site contained some 42 million old vehicle tyres. The government wants to use the site to build 25,000 new homes, so the tyres had to be moved to a new site, where EPSCO Global General Trading, a recycling company, began transforming the tyres into flooring tiles. The company started operations in January 2021, and estimates that it could recycle up to three million tyres per year.

Reuters, 07/09/2021

CASE STUDIES

COUNTRY	REGION	POPULATION	MATERIAL FOOTPRINT	MATERIAL FOOTPRINT REDUCTION TARGET
BELGIUM	FLANDERS	6,600,000	29.1 TONNES /INHABITANT (2018)	-30% BY 2030; -75% BY 2050

In Flanders, the development of a comprehensive strategy for the bioeconomy

The material footprint of Flanders is 29.1 tonnes per inhabitant; the UNEP International Resource Panel estimates that that the overall material footprint would be sustainable at 7 t/capita. In its Climate and Energy Plan 2021-2030, Flanders wants to reduce this footprint by 30% in 2030 and 75% in 2050. To achieve this, Flanders intends to become one of the main bio-economic regions in Europe by 2030, an economic model for the production of biological resources (biomass, agricultural products, fisheries resources, etc.) in proportions that allow for their renewal, use and residual flows. In order to bring the local actors together to work on achieving this objective, Flanders has developed its multi-stakeholder governance around R&D.

At the outset of the Flemish vision for a sustainable and competitive bioeconomy in 2030

In Belgium, the bioeconomy is the responsibility of the regional authorities, so there is no national bioeconomy strategy. As early as 2013, the Flemish government adopted a regional strategy for the bioeconomy aimed at developing a sustainable and competitive bioeconomy in 2030, before it became a cross-cutting theme of the Smart Specialisation Strategy (S3) in the fields of sustainable chemistry, advanced materials, agri-food, energy, environment and clean technologies. Then in March 2016, the circular economy, which includes the bioeconomy, became one of the seven transition priorities identified by the government in its Vision 2050.

In order to develop the circular economy, "Circular Flanders" was created in January 2017 and entrusted to the Public Waste Agency of Flanders (OVAM). It is a partnership bringing together government agencies, companies (Agoria in the manufacturing, digital and telecom sectors, etc.) and professional federations (Fedustria for the textile, wood and furniture industries, Fevia for the Belgian food industry, Febelfin for the financial sector, etc.), members from civil society and research centres (VITO, VIB, etc.). The Circular Economy Policy Research Centre (CE Center) is responsible for producing a monitoring and evaluation system for the circular economy by the end of 2020.

2020, a year of circular change

In July 2020, a new cross-cutting governance structure was created to link the circular economy to all policy areas of the Flemish government, and to create a roadmap through interdepartmental collaboration involving research centres, clusters, federations, and pilot infrastructures. New thematic work programmes are added to the existing Circular Flanders, one of which is on the bioeconomy, coordinated by the Department of Economy, Science and Innovation (EWI), in collaboration with the Department of Agriculture and Fisheries.

The bioeconomy agenda is based on 4 pillars: 1) a research agenda; 2) economic development; 3) innovative collaborations between industry, primary producers and intermediaries; 4) support to and alignment of policy actions. Pillar 3 must ensure that farmers are interested in creating new value chains and are willing to cooperate with industry. Pillar 4 involves the coordination of the EWI to develop cross-cutting skills and competences. The programme covers new themes such as non-food biomass production, industrial biotechnology applications and the marine economy. In 2021, the Flemish government also approved a new biomass policy plan, which covers waste prevention (food waste prevention, eco-design, reuse) and the more traditional applications of biomass in the bioeconomy (wood processing, composting, digestion, animal feed, novel foods, etc.). The bioeconomy agenda and the biomass policy plan are complementary, with each reinforcing the other.

The bioeconomy, a priority in the transition to the circular economy

To develop the bioeconomy, Flanders can count on industrial clusters in the chemical (Catalisti), agri-food (FF Flanders' Food), biotechnology (VIB) or marine economy (Blue Cluster) sectors. It also has large universities with strong R&D capacities. The government strongly supports the sector through grants and subsidies, in addition to an R&D-friendly tax system: 2.89% of Flanders' GDP is spent on R&D investments, compared to a European average of 2%.

The region has three pilot plants: LignoValue to produce "bioaromates" from lignin wood, Food Pilot for food and Bio Base Europe for biobased products. These projects stimulate innovation in the bioeconomy and enable the transition from laboratory and semi-industrial trials to feasible commercial or industrial innovations.

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REGION CASE STUDY

COUNTRY	REGION	POPULATION	MATERIAL FOOTPRINT REDUCTION TARGET	MATERIAL FOOTPRINT
CANADA	BRITISH COLUMBIA	5,100,000	-30% BY 2030 ; -75% BY 2050	29.1 TONNES/ INHABITANT (2018)

Operational EPR at the heart of "Zero Waste" and the Circular Economy in British Columbia

As a concrete application of the polluter-pays principle, extended producer responsibility (EPR) makes companies responsible for managing the waste generated by the products they put on the market. Organised by sector (packaging, electronic waste, etc.), there are two types of EPR. In the so-called "financial" EPRs, contributory or financial agencies collect eco-taxes from producers and distribute them to the local authorities responsible for waste management. In "operational" EPRs, the agencies use the funds to manage waste directly with service providers who collect, transport, sort and treat the waste.

Operational EPR programmes in British Columbia

In British Columbia (BC), the first EPR programme for paint producers was established in 1994. Ten years later, the adoption of the Recycling Regulation replaced all previous legislation to set common requirements for the schemes and the requirements for the implementation of an EPR. From then on, producers of products covered by an EPR must draw up a plan, which is reviewed every five years and must be reported on annually, and implement a programme for the collection and recycling of the product when it reaches the end of its life. In 2001, the BC Product Stewardship Council (BCPSC), a coalition of districts responsible for waste management and reduction, was created to implement large-scale schemes. To date, BC has 17 EPR programmes based on the OECD model. Producers can designate agencies (Producer Responsibility Organizations –PROs) responsible for implementing their EPR plan and reporting performance results. This system allows producers to have a strong influence on how waste is collected, transported and treated. For waste collection, the agencies mostly work with local governments.[a]

An example of successful EPR: packaging and printed paper

In 2014, BC launched the first EPR scheme in North America where waste producers take full financial and operational responsibility for the residential recycling of printed paper and packaging (PPP). Producers were given until 2017 to submit a plan in compliance with the PPP regulation. In order to meet their waste management obligations, companies that are members of Recycle BC, the agency responsible for PPP recycling, report annually the quantities of materials they place on the market and pay an equivalent fee. The companies are manufacturers of food products and consumer goods. Recycle BC publishes two tenders: one for municipal agencies to collect, and one for sorting and processing the waste. Once collected, the waste is sent to storage sites across the province. In partnership with GFL Environmental, the materials are then transported to a sorting and recovery centre.[b] There, the packaging and recycled paper are prepared for the end markets.

In 2020, Recycle BC estimates that the entire PPP management and processing chain released 53,304 tCO_2e, about 5% more than the previous year.[c] During the pandemic, citizens produced more residential waste: 203,213 tonnes of PPP, 11% more than in 2019. The recovery rate was 85.8% in 2020, 8.4% higher than in 2019. In 2020, PPP producers paid CA$121.8 million in fees, 24% more than in 2019, and 1.86 million (99%) households accessed Recycle BC services. As part of the amendment to the Recycling Regulation, the BC government expanded the number of products to be recycled. Packaging containing dairy products from February 2022, and other single-use items (such as straws, cups, etc.) from January 2023, will now be subject to EPR. In addition, as part of its commitment to the Canadian Council of Ministers of the Environment's Canada-wide Action Plan for Extended Producer Responsibility (CAPER, 2009), the British Columbia government hopes to increase the number of PROs from 12 in 2021 to between 20 and 25 over the next three to six years. CAPER aims to assist provinces in harmonising their practices and coverage of EPRs across Canada.

a The agencies are also responsible for informing citizens about waste recycling programmes.

b Recycle BC's post-collection network includes 38 facilities across the province – 36 receiving facilities, and two primary materials recovery facilities located in Richmond and New Westminster.

c This increase is mainly due to the fact that more material was transported via roadways.

REGION CASE STUDY

COUNTRY	PROVINCE	POPULATION	WASTE MANAGEMENT TARGET	WASTE GENERATION
ARGENTINA	MENDOZA	1,235,708	100% MUNICIPAL SOLID WASTE TREATMENT AND DISPOSAL; 50% RECYCLING (NO DATE MENTIONED)	1,400 TONNES OF WASTE/ DAY IN 2012

Promoting a socially inclusive model of comprehensive waste management in Mendoza

In 2019, the provincial government of Mendoza launched the "Integrated Urban Solid Waste Management Project" (Proyecto Gestión Integral de Residuos Sólidos Urbanos, PGIRS) to achieve 100% urban solid waste treatment in the metropolitan area of Mendoza and the Uco Valley, with two goals: environmental protection and social inclusion of informal workers in the sector. The seven municipalities of the Mendoza metropolitan area[a] generate about 70% of the waste produced in the province, which is about 1,400 tonnes of waste per day. In 2015, 40% of waste generated was disposed of in open dumps, where materials were collected informally for recycling by "urban waste workers". The PGIRS therefore plans to permanently close and clean up all open dumps[b] and eventually recycle 50% of this waste.

From collection to processing, formalising waste management

The $20 million project is based on the construction of two main infrastructures: the Maipú waste separation plant and the El Borbollón Environmental Centre, in the department of Las Heras, around an impermeable sanitary landfill. Still under construction, the centre will be equipped with separation and composting plants, as well as a system to capture the biogas generated by the landfill. Three new transfer stations will manage waste from the more remote towns in the Uco Valley, grouped together in an Inter-Municipal Consortium for Integral Urban Solid Waste Management (COINCE), at a cost of $5 million. In 2019, 90% of urban waste was already disposed of in the El Borbollón landfill. "Green Centres", or *Centros Verdes*, are to be opened to sort recyclable materials, and will be operated by the informal waste workers who work in the landfills. Eventually, more than 1,000 jobs will be created.

Supporting informal waste workers

In addition to these environmental and health objectives, the PGIRS 'Social Inclusion Plan' aims to formalise the professional situation of waste workers, restoring their source of income by improving their working conditions and quality of life. The Civil Association of Urban Waste Workers of the province of Mendoza (ACRUM), which brings together six waste workers' cooperatives, won a $1,800,000 grant from a Mendoza trust fund in early 2020, to improve its equipment, technical capacity and work infrastructure. As part of the *Ser Cooperativo* programme, reclaimers can attend training and literacy workshops.

In 2019, the municipality of Guaymallén inaugurated its *Centro Verde*, la Planta de Clasificación de Residuos Sólidos Urbanos fracción seca in the Jesús Nazareno district. The centre relies on different collection sites and methods, such as mobile "green points" (to allow the collection of recyclable waste), containers in different neighbourhoods, municipal delegations and the commitment of more than 50 companies to sort solid waste. The project was developed with the support of Danone (through its Global Ecosystem Fund), the Regional Initiative for Inclusive Recycling of the municipality of Guaymallén and the National Ministry of Social Development. Eventually, more than 100 waste collectors will have their work formalised.

In 2021, the municipality of Luján de Cuyo also inaugurated its *Centro Verde* for collecting the recyclable waste produced in the department (mainly paper, plastic, cardboard, glass, textiles, and metal containers). This is the first public facility for the segregation, collection, packaging and recycling of municipal solid waste in the department. The centre is managed by the waste collectors of the "La Fortaleza de Mi Tierra" cooperative, which now has 19 members trained to operate the centre. The municipality has also set up 100 new "green points" on public roads. With the creation of the "Argentina Recicla" programme in May 2021, the national government is following in Mendoza's footsteps for the social and economic integration of waste workers.

a Ciudad de Mendoza, Godoy Cruz, Guaymallén, Las Heras, Lavalle, Luján de Cuyo and Maipú.

b Those in Campo papa, Puente de Hierro, and Cacheuta.

“THE EVOLUTION OF PRODUCERS’ STANDARDS PARTLY RESPONDS TO THE DEMANDS OF CONSUMERS AND FOREIGN MARKETS FOR TRANSPARENCY AND TRACEABILITY OF COMMODITIES THAT CAUSE DEFORESTATION”

After three years of decline, the rate of forest loss has increased again: almost 12.2 million hectares were lost in 2020. In particular, nearly 4.21 million hectares of primary tropical forests disappeared in 2020, 12.3% more than in 2019. From the expansion of agricultural activities to forestry, fires and urbanisation, the causes are multiple and vary by continent and forest type. Although "megafires" are becoming increasingly frequent in certain regions and require the preparation of the local population, improved urbanisation and the adaptation of major infrastructure networks, carbon dioxide emissions from forest fires have been on a downward trend since the early 2000s, thanks to better fire management and prevention measures. **[TRENDS]**.

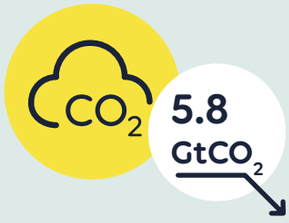
Brazil's Amazon and the forests of central Africa are suffering increasing losses, in contrast to Indonesia, where deforestation has been steadily slowing since 2016, according to the observations of the government and of Global Forest Watch **[INDICATORS]**. This positive trend is partly the result of the establishment of an important normative framework around the palm oil sector which, despite resistance and difficulties in governance, is permeating the culture of producers and companies in the sector in Indonesia and Malaysia **[TRENDS]**. However, apart from palm oil, 43% of companies producing high forest risk commodities (soy, beef, cattle, paper, etc.) still have no commitment to combat deforestation, according to Forest 500 **[INDICATORS]**.

The evolution of standards among producers is partly a response to the increasing demands of consumers and foreign markets, for transparency and traceability for products with a high environmental impact. The fight against deforestation at the local level is still strongly anchored in international cooperation, such as in Cambodia to combat illegal logging and poaching in the Cardamom Forest **[CASE STUDIES]**. Financing mechanisms such as REDD+ or international technical cooperation are often essential where climate policies rely heavily on support from the international community, such as in Africa where 85% of NDCs contain international funding conditionalities.

Community forest management is recognised as much as a response to international climate issues as it is to the needs of people living in and around forests. Local communities and indigenous peoples manage about 24% of the total carbon stored above ground in the world's tropical forests. Community-based management models are gaining ground in central Africa, where the countries of the Congo Basin have developed legal frameworks to involve local communities in the use and protection of forests, but face funding and governance challenges **[TRENDS]**. Political decisions, such as the lifting of the moratorium on new logging concessions in the Democratic Republic of Congo or on oil palm cultivation in Indonesia, are not conducive to community forest management **[SIGNALS]**. Where successful, forest conservation in turn generates new sources of income, as in Rwanda, which has reduced the vulnerability of mountain gorilla populations through funding from local communities, and is developing its tourist appeal by capitalising on luxury tourism and the attraction of Western visitors to the megafauna **[CASE STUDIES]**. In Pakistan's Sindh province, the restoration of mangroves is increasing carbon sinks, while also benefitting local economic activity **[CASE STUDIES]**.

COMMITTMENTS FALL BEHIND AS DEFORESTATION PICKS UP AGAIN

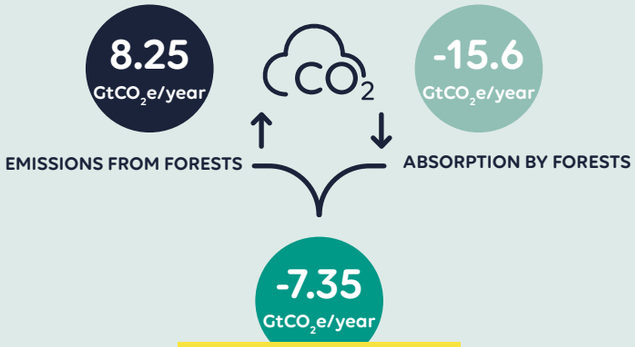
Diminishing net emissions from forests in 2020



NET CO_2 EMISSIONS FROM LAND-USE IN 2020

This figure was 6.6±2.5 $GtCO_2$ in 2019, and has dropped by around 12%, largely due to a wet year in Indonesia, causing fewer peat fires.

Global Carbon Project, 2020

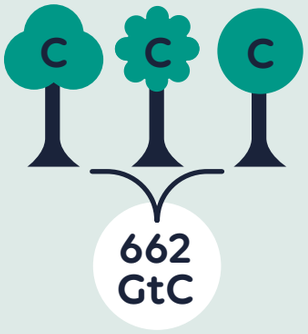


Global Forest Watch, 2021

EMISSIONS FROM AGRICULTURE IN 2018

Ce chiffre comprend les émissions des opérations agricoles et le changement d'affectation des terres.

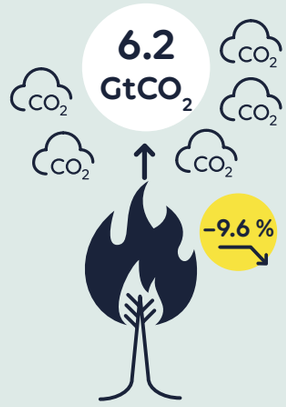
Tubiello, F. N. et al., 2021



TOTAL STOCK OF CARBON STORED IN FORESTS

662 gigatonnes of carbon were stored in forests as of 2020, a reduction from 668 gigatonnes in 1990.

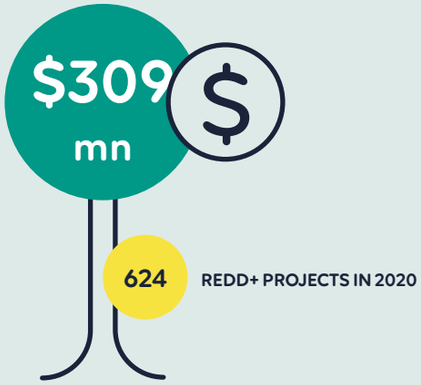
FAO, 2020



CO_2 RELEASED INTO THE ATMOSPHERE FROM FOREST FIRES IN 2020

While 2020 saw several large forest fires, global emissions from these were 9.6% less than in 2019 (6.86 $GtCO_2$), thanks to better fire management and mitigation services.

Copernicus, 2020



APPROVALS OF REDD+ PROJECTS IN 2020

In 2020, 309 million dollars were approved for REDD+ projects around the world, higher than the average of the last five years (263 million dollars). This increase is due to increased funding from the Green Climate Fund (GCF).

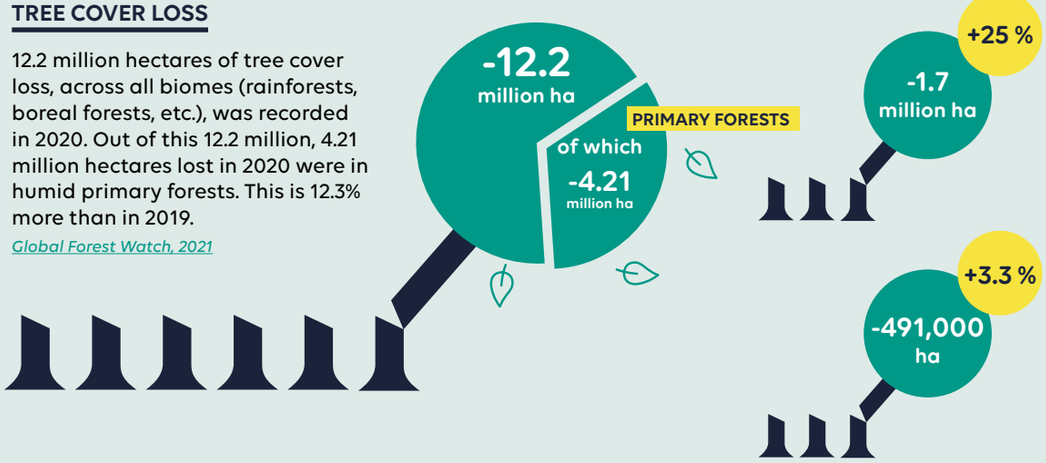
Heinrich Böll Stiftung, 2021

2020 was the third most damaging year for primary forests, but revealed contrasting regional trends

TREE COVER LOSS

12.2 million hectares of tree cover loss, across all biomes (rainforests, boreal forests, etc.), was recorded in 2020. Out of this 12.2 million, 4.21 million hectares lost in 2020 were in humid primary forests. This is 12.3% more than in 2019.

Global Forest Watch, 2021



INDONESIA

The donwtrend has continued over the last four years in Indonesia: from 926,000 ha lost in 2016, to 340,000 ha in 2017-18, and 324,500 in 2019. 89% is the extent of primary forest remaining in the country.

Global Forest Watch, 2021

BRAZIL

After a sharp slowdown since the record high in 2016 (2.83 Mha), the rate of deforestation is increasing again compared to 2019 (1.36 Mha), and 2018 (1.35 Mha).

Global Forest Watch, 2021

DEMOCRATIC REPUBLIC OF CONGO

The trend has been averaging between 400,000 to 500,000 ha/ year for the last five years, a drastic increase compared to the average between 2002 and 2015 (207,000 ha/ year).

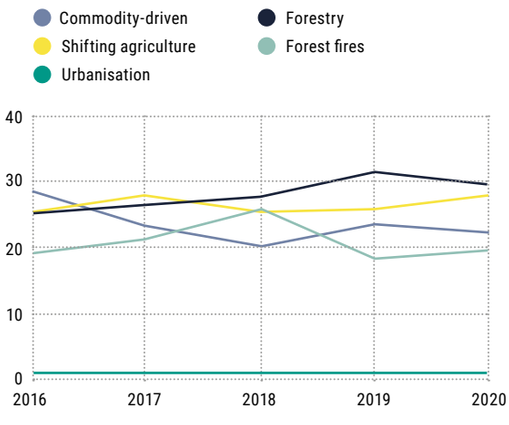
Global Forest Watch, 2021

Agriculture and forestry, the main drivers of deforestation

SHARE OF THE MAIN DRIVERS OF TREE COVER LOSS BETWEEN 2016 AND 2020

Forestry and shifting agriculture were principal drivers of deforestation in 2020, followed by commodity-driven deforestation. Cattle, soy, palm oil, coffee, cocoa, rubber and wood fibres are among the commodities driving deforestation.

Élaboration basée sur les données de Global Forest Watch, 2021.



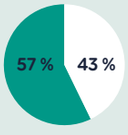
The palm oil industry increases its commitments, carbon offset investments in forests skyrocket

INVESTMENTS IN CARBON OFFSETS CHANNELLED TO FORESTS, JANUARY TO AUGUST 2021

In the first 8 months of the year alone, this is already twice as much as in 2020 ($269.4 million). Forests attracted almost 80% of the voluntary carbon market in 2021.

Ecosystem Marketplace, 2021

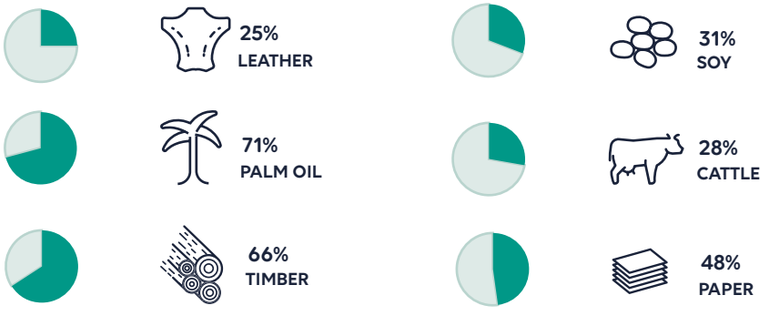
ENGAGEMENTS DES ENTREPRISES ET INSTITUTIONS FINANCIÈRES EXPOSÉES À DES RISQUES LIÉES À LA DÉFORESTATION



57% of the 500 companies and financial institutions in forest risk supply chains assessed by Forest 500 had a commitment on deforestation, up from 52% in 2019.

Forest500, 2021

COMPANIES WITH DEFORESTATION COMMITTMENTS FOR FOREST-RISK COMMODITIES



Forest500, 2021

TRENDS
DEFORESTATION

Megafires Push Cities and Businesses to Shift Their Strategies

AUDE VALADE • Researcher, CIRAD

Beset by agriculture, extractive activities, and numerous economic, technological and political factors, the world's forests are subject to accelerating deforestation and degradation. In recent years, another enemy triggered by climate change has put forests in considerable peril: megafires. While record losses of tree cover have been reported over the past few years, firefighting solutions reveal a lack of preventive and anticipatory measures in the long term. In an attempt to preserve the lungs of the planet, different techniques are progressively emerging that draw on the knowledge of indigenous populations and scientific expertise.

DATA OVERVIEW

Tropical rainforest degradation is causing emissions to rise

The LULUCF (land use, land-use change and forestry) sector as a whole was responsible for net emissions of about 11.6 gigatonnes of CO_2 equivalent ($GtCO_2e$) in 2018, or about 22% of global greenhouse gas emissions.[1] Changes in land use and management account for 47% of these emissions (5.4 $GtCO_2e$ annually in 2018, 6.1 $GtCO_2e$ in 2019).[2] This category includes deforestation and degradation of forests (the biggest emitters), conversion of grassland to crops and farmland to forests, peatland drainage and fires, timber harvesting and soil respiration due to agricultural practices.

In 2020, the planet lost 25.8 million hectares (Mha) of forest cover, 12.2 Mha of which were in the tropics (forests and plantations), and 4.2 Mha in primary rainforests (**fig. 1**), a 12% increase compared to 2019 and equivalent to 2.64 $GtCO_2$ of emissions.[3] Brazil and the Democratic Republic of the Congo are the two countries that lost the most forest area in 2020. Since 1990, the world's primary rainforests have reportedly lost 17% of their surface area due to human and natural factors.[4]

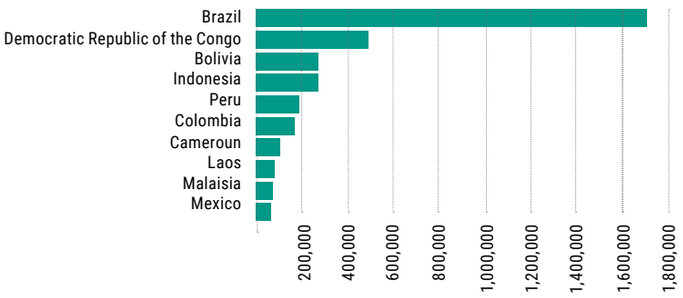
In addition to this loss of forest area, several scientific studies published in 2020 and 2021[4, 5, 6, 7] point to a second crucial mechanism: forest degradation, a term that covers occasional disturbances due to timber extraction, small fires and storms. In January 2020, of the 1,071 Mha of remaining tropical rainforests, an estimated 10% were degraded. Forest degradation is reportedly responsible for about 73% of biomass loss and 44% of carbon emissions related to land use, compared to 27% and 56% respectively for deforestation.[6, 7] In addition to considerable CO_2 emissions, these degraded zones are more likely to go on to be deforested. According to researchers, 7.5 years after such disturbances, almost 50% of degraded forests have been deforested.[4]

The drop in energy demand related to the Covid-19 pandemic drastically reduced CO_2 emissions from the main emission sectors in 2020. For the land-use sector, on the contrary, the restricted surveillance activities resulting from lockdowns, coupled with people's return from urban centres, brought the fear of an increase in illegal deforestation. Nevertheless, although deforestation continued its upward trend, no sign of an increase linked to Covid is observable in the latest data from Global Forest Watch.[3] This paradox can be explained by the offset between, on the one hand, a shortage in supply and decreasing global demand, and on the other hand, economic

FIGURE 1

LEFT: PRIMARY FOREST LOSS BY COUNTRY IN 2020 (HECTARES)
RIGHT: GLOBAL TROPICAL PRIMARY FOREST LOSS FROM 2002 TO 2020 (HECTARES)

Source: Weisse and Goldman, 2021



support policies and the resilience of the drivers of illegal deforestation.

Responses to deforestation are still too weak to deal with the intensifying drivers. According to Forest Trends, 60% of tropical deforestation is related to commercial agriculture, and 69% of this farmland conversion is illegal.[8] The drivers behind deforestation and forest degradation however vary depending on the region, and evolve over time in response to global markets, investment trends, and national and local policies.

A report published in 2020 by WWF looks at the evolution of deforestation drivers and the responses made through an analysis of 24 fronts of tropical deforestation.[9] Nine types of drivers are analyzed in the report, broken down into direct drivers (agriculture, extractive activities, infrastructure, others) and indirect drivers (demographic, economic, political, technological and environmental), along with two types of responses: area-based and sector-specific.

Soy, palm oil and cattle rearing are the most common culprits of illegal deforestation (although other crops like rubber, coffee and corn also account for large areas[8]). In South America, agricultural activities are the main cause of deforestation, and the trend is worsening, with animal rearing overtaking crops, both at industrial and smallholder scales. Infrastructure expansion is an indirect and less widespread driver, although it is also worsening on most fronts. Africa is subject to drivers that are different from the ones in South America because industrial agriculture is secondary compared to smallholder farming. These two drivers are worsening on most deforestation fronts, with the exception of West Africa, where industrial agriculture is decreasing. However, extractive activities are driving deforestation on every front, led by the extraction of firewood and by coal mining, but also timber extraction, mostly at a smaller scale. At the scale of the African continent, these drivers have on the whole remained at relatively stable levels for several years, but are worsening in Zambia and Central Africa. In Asia and Oceania, large-scale cultivation and industrial tree plantations dominate the direct drivers while infrastructure development is a secondary driver.

Action carried out at different scales also varies depending on the region. The development of protected areas is the most common widescale action in all areas, accompanied by the development of REDD+ projects. The Brazilian Amazon and Indonesia stand apart for having established moratoriums on deforestation, while sectoral "zero-deforestation" projects stand out in Indonesia and Cambodia. However, this kind of action is not enough, as underlined in the report on the progress of the New York Declaration on Forests.[10] An analysis of the nationally determined contributions (NDCs) that followed the Paris Agreement reveals that only five countries have included commitments to combat deforestation in their NDCs (Indonesia, Colombia, Papua New Guinea, Guyana and the Republic of the Congo). Consequently, only 11% of the global economic potential for reducing deforestation is met by state commitments. On the other hand, numerous commitments have been made concerning afforestation and reforestation.[a]

The weaknesses revealed in the WWF report on commitments to "zero deforestation" and traceability of supply chains are in line with the conclusions of the 2021 report by Forest500, which analyzes the commitments of the main international companies in raw material sectors posing a risk of deforestation.[11] Only 25%, 28% and 31% of companies exploiting raw materials to produce leather, beef and soy respectively have established commitments. Palm oil is an exception, with 71% of the companies concerned having made commitments to combat deforestation (**see Agriculture trend**).

To tackle the difficulty of evaluating the trends and drivers behind the deforestation and degradation of forests in Africa, a joint initiative involving the FAO and CAFI (Central African Forest Initiative) should open up new perspectives. The CAFI/FAO DDD project aims to make an in-depth study of changes in forest cover and its drivers in six countries in the Congo

a Afforestation consists in planting trees on land that was not previously planted, while reforestation involves planting new trees on a previously planted area.

basin, while developing a methodology that could be used on a global scale. The uniqueness of the study lies in the wide range of partners involved, with six ministries from CAFI partner countries working with 14 research centres and NGOs to pool their data and improve methods.

THE OBSERVATORY'S LENS

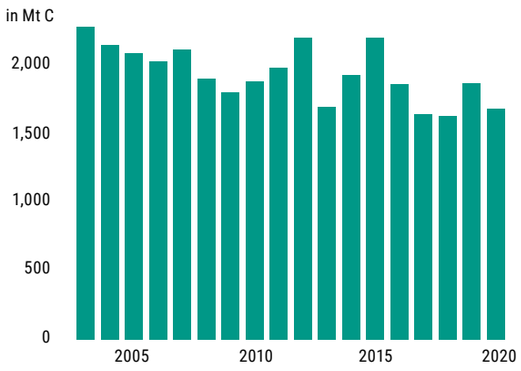
The start of an era of megafires reveals inconsistencies and shortfalls in the way forest fires are managed

In addition to disturbances due to human activity (agriculture, extractive activities, etc.), climate irregularities also affect the state of forests, further worsening their situation and undermining their potential for absorbing carbon dioxide. Droughts, storms, fires, insects, and diseases are having adverse effects on the world's forests. Of these climate-induced disturbances, the best known and monitored are forest fires, mostly thanks to satellite data that reveal their complexity and highlight paradoxical situations. Firstly, from a geographic point of view: while the Arctic and the United States saw record areas of land burn in 2020, Canada and tropical Africa had minimal fire outbreaks. Secondly from a temporal aspect: 1.7 gigatonnes of carbon (GtC) were released into the atmosphere by forest fires in 2020, which is less than the 1.9 GtC released in 2019, continuing a global downward trend of carbon dioxide emissions from forest fires since the 2000s (**fig. 2**).[12]

FIGURE 2

ANNUAL CARBON EMISSIONS FROM FOREST FIRES FROM 2003 TO 2020

Source: Copernicus, 2020



These apparent paradoxes can be explained by interactions between the control mechanisms of fire regimes: the quantity of combustible material, humidity, ignition (fire outbreak), and suppression (fire extinction). Climate change extends fire seasons, causing drier vegetation and higher temperatures, but the quantities of combustible matter, risks of ignition, and the intensity of suppression practices follow less uniform trends. In most cases, they are triggered by humans, whichever be the region (**see Keys to Understanding**).

KEYS TO UNDERSTANDING

IDENTIFYING RESPONSIBILITIES FOR FIRE OUTBREAKS

While forest fires are becoming more probable and more intense in response to drier, hotter climatic conditions, they are usually caused by human acts and negligence. In southern Europe, 98% of fires are of human origin, and in the United States, 84% of fires are triggered by human activity. In California, the main electricity operator, PG&E, was taken to court for having triggered the Camp Fire in November 2018. The gigantic fire, which killed 85 people and burned the city of Paradise to the ground, was caused when a pylon fell onto electricity lines, causing sparks that set fire to the surrounding vegetation. PG&E's shortfalls in maintaining its power lines and pruning nearby vegetation saw the long-established company brought before the courts, where it was judged guilty of involuntary homicide and ordered to pay tens of millions of dollars in compensation to the victims. PG&E went on to declare bankruptcy, qualified by Wall Street as the "*First climate-change bankruptcy, probably not the last*". Since then, following new accusations of responsibility for the 2020 Zogg Fire and the 2021 Dixie Fire, PG&E, which recovered from bankruptcy in 2020, has announced plans to bury 10,000 miles of power lines, a project due to last over a decade at a cost around 20 billion dollars.

Sources: Balch et al. (2017) ; New York Times (18/06/2020) ; Wall Street Journal (18/01/2019)

An analysis of fire regime mechanisms points to a change in the regimes that differs by region: in tropical rainforests and the boreal forests of the Urals, a decrease in available biomass is naturally accompanied by a drop in humidity, two factors that offset each other to limit the increase in expected burned area in response to climate change.[13] In the Mediterranean, on the other hand, an increase in available biomass and ignitions leads to a higher risk.

These fire regime changes coincide with the emergence of a new type of fire that is more complex and harder to control. To describe this shift, a new name has been coined for these extreme fire events: "megafires". Megafires are characterized by their intensity, swift spread and unpredictable behaviour. Their exact definition varies depending on the region: over 100,00 acres (40,500 ha) burned according to the US Interagency Fire Center, over 500 ha in general in Europe.[14] The size and intensity of these fires even creates a microclimate that feeds them, generating clouds called procumulus and lightning capable of setting off new fires.

Surface areas of burned land establish new records every year, and 2020 and 2021 were no exception. For California, 2020 was the worst fire season on record, with over 4% of its land area burned, which is almost 1.8 million hectares.[15] The "August complex" that began with 38 different fires following

lightning strikes is the biggest fire ever observed in California. The complex alone burned nearly 418,000 hectares of vegetation.[16] In 2021, the Dixie Fire with 275,000 hectares burned ranks second in the modern history of large fires in California.[17] In 2021, records were also beaten in Siberia. The Sakha Republic in particular saw its tundras burn from early June right through to the start of September. In total, the fires of 2021 in Russia emitted 806 $MtCO_2$ over this period.[18]

To combat these devastating fires, different solutions are gradually emerging, yet with some significant shortfalls.

Firefighting budgets favour short-term suppression rather than long-term prevention

In September 2021, the flames of three fires raged dangerously close to the Sequoia National Park in California, and to its trees, some of which are the biggest, oldest trees on the planet. In addition to combatting the flames with water and flame retardants, and the controlled burning of grass at the foot of trees, firefighters employed an innovative technique: the bases of some trees were enveloped in fireproof aluminium blankets. The protection of giant sequoias using these exceptional means illustrates the increased investments in emergency firefighting. Yet investments in preventing fires have not grown to the same extent. Governor G. Newsom has in fact been criticized for cutting prevention budgets while expenditure on emergency action has surged, exceeding one billion dollars for the first time in 2021.[19]

In the highly urbanized Mediterranean region, a 2019 WWF report describes forest fire action centred on suppression rather than prevention.[20] Out of total forest fire expenditure of about 2 billion euros a year for Spain (1.3 billion euros), France, Greece, Portugal and Turkey, on average 80% is spent on emergency action and 20% on prevention. The report points out the difficulties caused by national borders in combating fires in Europe, complicating cross-border assistance between countries (loan of equipment and/or personnel). The WWF analysis highlights the larger scale of suppression policies at the cost of prevention action based on land use and urbanization, faced with specific risks in the region generated by dry vegetation, the disappearance of orchards and crops, and the proximity between scrubland and urban areas.

The same observations had already been established by the European Commission in 2018, which recognized the imbalance between prevention and suppression and suggested developing an integrated forest fire management system.[21] The European Union set up the Resc'EU system in 2019, which works alongside the EU civil protection system to finance and make available to Member States a European resource fund including a fleet of water bomber airplanes and helicopters. Resc'EU is operating with a fund of 1.9 million euros for 2021-2024.[22] Prevention action is a lot less developed but does include the setting-up of a European network of knowledge-sharing on civil protection. The objective is to put experts in contact with associations working in the field in order to communicate their knowledge and provide support to all stakeholders throughout the disaster management process. This network is still in its early days, but has already organized expert exchange programmes, full-scale exercises, and expert training.[23]

Lastly, civil society and private companies can sometimes make up for gaps in public action to manage forest fires. In Russia and Indonesia, when national services impacted by budget cuts cannot deal with fires, associations organize funding and logistical campaigns to set up voluntary fire brigades, such as in Siberia in 2021, in camps supported by Greenpeace and Sinet-Spark.[24] In 2019, peatland fires in Indonesia in the Pulang Pisau district witnessed the mobilization of international volunteers to work alongside local communities, local authorities, and 29,000 agents from official firefighting services, soldiers and the police.[25] While equipment for volunteers and water are lacking, one of the tasks for reinforcement teams is to raise the awareness of local people about the danger of slash-and-burn cultivation during the dry season.

In September 2021, Google announced that it was integrating a new layer in its Maps application, on which users can see fires taking place thanks to data exchanges with the National Interagency Fire Centre. The fires it shows are the main fires that involve evacuations, for which the application provides information. For the United States, and soon Australia, these data also include updates on control of the fire, the surface area burned, and roads closed.

Although increasing numbers of initiatives are taking place, they are not enough to provide an effective solution for more intense and frequent megafires. To attempt to curb fires and contain them, forest restoration techniques calling on the knowledge of indigenous people and scientific knowledge are gradually being tested in different countries prone to fires.

Restoring forests to reduce their vulnerability

While the droughts and heatwaves observed in different regions round the world due to climate change create the conditions for these ecological and human disasters, the ecosystem management implemented in recent decades often makes things worse. Fires are in fact part of the natural cycle of forests: they regulate the quantity of biomass and thus reduce the risk of larger, uncontrollable fires. For some trees, fires are even essential to their reproduction. For example, only heat from fire can cause the cones on Jack pines to explode and release their seeds, while the heat or chemical composition of fire causes the seeds to sprout on coffeeberry and redberry shrubs. The ponderosa pine has a thick bark that enables it to resist frequent fires of low intensity.[26] Progress in knowledge of the causes of fire and the impacts of systematic suppression are leading to more long-term strategies that fit in with the natural rhythm of forests, based on the ancestral practices of indigenous people, on the development of the timber industry, or on the financing of integrated research.

In many regions, attention is turning back to traditional indigenous practices (**see Forestry trend**). Traditional crop farming often involves controlled slash and burn to clear undergrowth, promote certain species, and increase soil fertility. In California, the Karuk and Yurok tribes are working with forestry services:[27] the frequent slash and burn employed by these tribes

encourages the growth of hazelnut trees that the locals use to weave baskets, fostering both ecosystem functioning and the socio-economic balance of indigenous people.

In Australia, indigenous populations traditionally avoided major fires by creating cool-burning, knee-high blazes in the bush during periods when it was not dry.[28] As a result of selecting which plots to burn, for how long, and how often, a patchwork of trees and grassland was created that was resistant to bushfires and attracted marsupials that could be hunted. The abandonment of these once illegal practices has resulted in overgrown, thick vegetation that is more likely to propagate fire. Recently, partnerships between indigenous peoples and firefighters have applied these ancient practices, first on indigenous peoples' territories and then gradually in the rest of the country. The limitations of the system include the difficulty of obtaining the right conditions of humidity, temperature and wind to get the benefits of controlled burning.[28]

In the southwest of the United States in 2010, faced with sizeable risks, a widescale initiative to restore the ecosystem was set up, covering four national forests and grouping thirty stakeholders from the forest lumber industry, including local authorities, companies and associations: the Four Forest Restoration Initiative (4FRI). The project concerns 970,000 hectares of ponderosa pine forests and involves different types of action, two of which aim to reduce the quantity of biomass that could act as a fuel for fire – the creation of clearings and controlled fires. The overall objective of the programme is to structure and operate forests in line with the natural dynamic of fires by which the ecosystem self-regulates. After ten years, the results of the programme are mixed. While the restoration of habitats and catchment areas is judged significant, objectives to reduce biomass have not been reached.[29] Of the annual 12,000 hectares of preventive clearings planned, only about one-third have been created due to difficulties in developing a timber processing industry that is ill-equipped to handle small-scale timber. In Arizona, for example, the timber yards that secured contracts have not reached their timber targets due to insufficient investment in the necessary machines.[29] Some voices are calling to implement controlled burning rather than mechanical timber harvesting to deal with dense forests.

In Canada, the approach is to develop scientific knowledge on new fire regimes. A strategic research programme on forest fires was recently launched, called Blueprint Canada.[30] The programme's objectives are to improve understanding of delays in scientific knowledge, establish research priorities, and develop scientific and technological tools to make Canadian forests more resilient to fire. Blueprint Canada is run by the Canadian Forest Service, which coordinates exchanges between government partners and indigenous groups, academics and associations.

KEY TAKEAWAYS

As forest degradation and deforestation worsen, a new type of forest fire is emerging: megafires. The budgets and means allocated to fight these fires remain concentrated on suppression, and often overlook the vital aspect of prevention. Private companies and associations sometimes supplement the means implemented by public authorities, through numerous initiatives, such as funding campaigns and logistical assistance. At the same time, and with a view of limiting forests' vulnerability to fire, governments, scientists and indigenous communities are working closely together to find more successful, controlled ways to restore forests.

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TRENDS
FORESTRY

Community Forestry in Central Africa: Still a Fragile Sustainable Forest Management Model

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With proven benefits in terms of conservation, development and the mitigation of climate change, the link between community forestry and international commitments on climate and the fight against deforestation is attracting growing support from NGOs and international organisations. While the global area of forest managed by indigenous peoples and local communities has increased over the past two decades, the record of community forestry in Central Africa remains mixed. The reasons behind it: significant legal constraints, land grabbing and revenue capture by certain elites, but also unequal political support, all of which are undermining this sustainable management model.

DATA OVERVIEW

Community forestry, still a marginal model in an Africa plagued by deforestation

With a net loss of forest area of 3.94 Mha/year between 2010-2020, deforestation in Africa now exceeds that in South America (2.60 Mha/year).[1] Central Africa, in particular, is home to the Congo Basin forest, the second largest rainforest in the world after the Amazon, a huge carbon sink with an annual absorption potential of 1.5 billion tonnes of CO_2e.[2] However, a large part of this forest is in the grip of deforestation,[3] bringing in its wake the release of the carbon stored into the atmosphere: in Gabon, logging and deforestation was still responsible for the release of more of 25 $MtCO_2e$ in 2017.[4] In 2020, the Democratic Republic of the Congo (DRC) accounted for the largest share of deforestation, with a loss of forest cover estimated at over 490,000 hectares, adding up to a loss of 5.3 million hectares of forest since 2002. In total, the primary forest of the Congo Basin lost 600,000 ha in 2020, 9% more than in 2019 (**fig. 1**).[5] After 2016, 2020 has proved to be the second worst year for the region since 2002.

The imperatives of development and economic diversification identified by the riparian states of the Congo Basin, [a] such as investments in infrastructure, large-scale agriculture and industrial logging, are threatening these forest areas.[6] The forestry sector represents the largest land-use in Central Africa with approximately 600,000 km^2 of forests under concession, i.e., approximately 15% of the total land area under concession (**fig. 2**). The LULUCF sector accounts for a significant share of the GDP in most of the Congo Basin countries (between 2 and 5% in Cameroon, the Central African Republic and the Republic of Congo).[7] About 100 million people inhabit the Central African region, over 60% of whom live in rural areas in or around the forests on which their livelihoods heavily depend.[8]

However, only a minor part of the total area of national forests is managed by local communities: in Gabon,[9] Cameroon[10] and the DRC,[11] active community forests account for only 236,000 ha of tree cover, i.e., about 1% of the countries' forested areas.

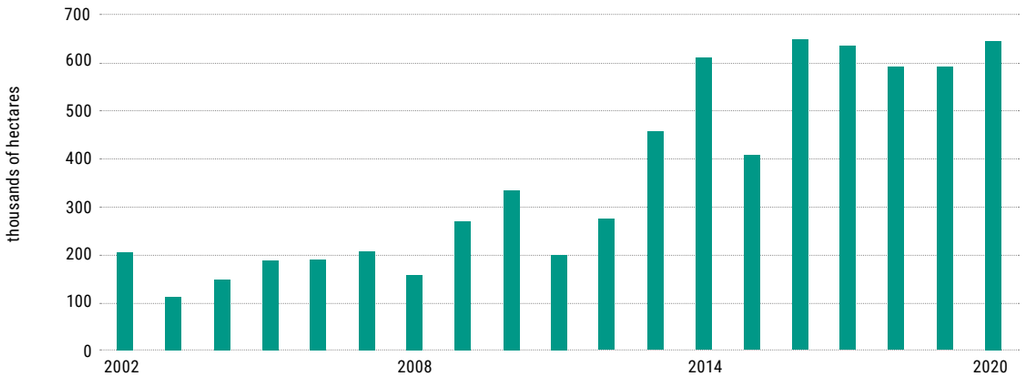
Yet, research[12] tends to demonstrate that community-based forest management can help combat deforestation and illegal logging,[13] while generating substantial socio-economic benefits through a more equitable sharing of income from logging.[14] It is now recognised that local communities and indigenous peoples (LCIP) have carried out sustainable management of forest resources for centuries through various forms of community management.[15] In Brazil, the deforestation of indigenous community forests would have been 22 times greater if these communities had not been legally recognised. In the Yucatan in Mexico, the results are even more striking: the rate of deforestation within community forests was 350 times lower than in other areas.[16] Indeed, in Mexico, a highly decentralised country, 80% of forest areas are under community management.[17] In the Asia-Pacific region, 15 million

a The Congo Basin includes Cameroon, the Central African Republic (CAR), the Democratic Republic of Congo (DRC), the Republic of Congo, Equatorial Guinea and Gabon. It covers almost 70% of Africa's forest land. Of the 530 million hectares in the Congo Basin, 300 million are forested: 99% of them are primary or naturally regenerated forests, as opposed to plantations (Megevand et al.).

FIGURE 1

TREE LOSS COVER IN THE COUNTRIES OF THE CONGO BASIN, 2002-2020

Source: Global Forest Watch, 2021



hectares (Mha) are managed on a community basis, an area equivalent to the size of Cambodia.[18]

LCIP are particularly dependent on forest resources: custodians of 80% of the world's biodiversity, they manage around 24% of the total carbon stored on the surface in the tropical forests of the world[19] and around 28% of the world's land surface, including the most ecologically preserved forest areas.[20] In 2015, indigenous peoples, peoples of African descent and local communities legally owned 10% of the land in the world, a paltry share if we consider that these peoples, as natives, hold and use more than half of the land in the world.[19]

Thus, community-based forest management[b] is recognised as a response strategy to international climate issues and to the needs of populations living in and around forests.[21] It aims to ensure that rural populations, caught between a forest sector long monopolised by private companies and the extension of protected areas within the framework of environmental and nature conservation policies, can strengthen their land rights and their access to forest resources.[22]

As COP26 (November 2021) was approaching, the interest in nature-based solutions (NBS) was growing. The UK Presidency of COP26, in this regard, has identified the protection of communities and natural habitats through the "protection and restoration of ecosystems" among the conference's main objectives.[23] Article 5 of the Paris agreement stresses the Parties' duty to sustainably manage forests and fight against deforestation in order to "*conserve and, where appropriate, expand greenhouse gas sinks*". Community forestry has gradually emerged as a model of sustainable and inclusive development, but its implementation is being hampered by issues that are rife in the region.

THE OBSERVATORY'S LENS

Community forestry in Central Africa:

The advent of community forestry in the 1990s was part of the decentralisation dynamic, triggered by the democratisation processes encouraged by financial backers (including the World Bank and the IMF). The latter stressed the need for decentralised management of the resources of Sub-Saharan African countries in order to promote rapid social and economic development.[24] This decentralisation was extended to environmental policies by including the LCIP: with regard to forests, the concept of local communities thus became integral to forest management (**see Keys to Understanding**).[25]

Community forestry was first introduced in Cameroon in 1997: village associations were able to legalise the exploitation, processing and trade of forest resources in areas of up to 5,000 hectares.[26] Community forestry was then taken up in Gabon in 2013,[c] in the CAR in 2015,[d] and in the DRC[e] in 2016.[27] At the regional level, in 2010 the Central African Forests Commission (COMIFAC) adopted the "Sub-regional guidelines on the participation of local and indigenous populations and NGOs in the sustainable management of Central African fo-

b This is a term popularised by the FAO and the World Bank.

c With the adoption in 2013 of a decree adding to the existing legal and regulatory framework.

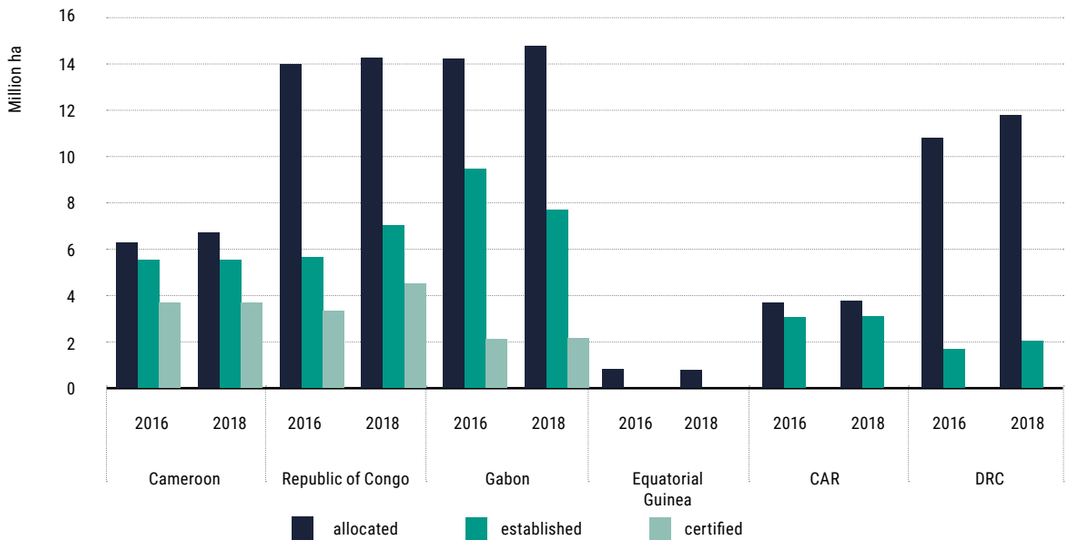
d In the CAR, the concept of community forestry was made into a law in 2008, and translated into the regulatory framework in 2015. It was created at the end of a special consultation process between the administration, the private sector, civil society and LCIP.

e In the DRC, community forestry was only made into a law in 2014, then translated into the regulatory framework in 2016. Local community forest concessions (LCFC) permanently confer land ownership on local communities by virtue of custom 18 and allow multiple uses to be made of the forest as a space within which to develop a range of socio-economic and ecological activities.

FIGURE 2

TOTAL SURFACE AREA OF FOREST CONCESSIONS IN SELECTED COUNTRIES, 2016-2018

Source: COMIFAC, 2018



rests." The text points to the need to involve LCIP "*in the forest management decision-making process*".[28]

The first forest laws governing community forestry were criticised by NGOs for their restrictive nature. The NGOs argued that these laws would not allow any real inclusive management and would limit the rights of beneficiaries, the spaces to be assigned and the support, mainly due to a lack of institutional capacities and appropriate structures.[29] The legislation puts significant restrictions on logging operations (inventory and development plans), which have led to difficulties in bringing the technical and financial capabilities of local communities up to the mark. These shortcomings can lead LCIP to get into debt by contracting third-party forest operators for logging and NGOs for technical support, thereby generating a strong dependence on third-party actors.[30] Beyond the relative profitability of the economic operations, the corruption and embezzlement observed in the management of community forests has held back the initial efforts made.

The application of these laws is also hampered by a number local issues: in the Central African Republic, the demarcation of community forests in the southwest of the country (where most of the tropical forest cover is) remains blocked by the existence of industrial logging concessions and protected areas. In Cameroon, the limited financial impact on rural livelihoods and complex administrative procedures have hampered the expansion of community forests. Logging has met with a number of difficulties and has never been done in full compliance with the law: in 2013, a group of researchers[31] showed that no community forest was fully adhering to the legal framework. The Support Service for Local Initiatives (SAILD)[32] confirmed this diagnosis by drawing up an inventory of logging issues in the following areas: falsification of stock data, unlimited felling of unauthorised species and wood trafficking. The forestry administration receives new requests for community forests every year, but the consolidation of rights to permanent agreements is making much slower progress (**fig. 3**).

A diagnostic study published in partnership with Fern[33] reports the failure to revise the "Simple Management Plans" (SMP), which is mandatory every five years for many community forests. Thus, in February 2020, the Cameroonian Minister of Forests and Wildlife declared in a circular sent to his regional delegates that "*it is repeatedly emerging that the exploitation of community forests is fuelling the laundering of illegally logged timber*" and requires a rapid diagnosis of the situation.[34]

In many ways, the path taken in Gabon, with an emphasis mainly on logging, has met with the same pitfalls as in Cameroon. 51 statutory forests were created between 2013 and 2017; however, faced with the numerous reported cases of illegal operations, in 2017, the Ministry responsible for forests called for the allocations to be temporarily suspended.[35] A recent study set out to demonstrate the lack of compliance with the legislation in force concerning the exploitation of community forests, as well as the extremely limited traceability of the wood from these forests, due to administrative largesse, the failure of the authorities to enforce the laws, ignorance of the laws, and poor control and monitoring of logging activities.[36]

After decades in operation, the results are mixed; participatory forestry does not yet fully play the role it has been vested with, in terms of both preserving forest resources and improving the livelihoods of local populations.[37] As Guillaume Lescuyer, associate researcher at the CIFOR says, "*the failure of community forestry in Cameroon is worrying because the model was copied about 15 years ago in all Central African countries, in particular Gabon, the DRC and the Central African Republic*".[38]

KEYS TO UNDERSTANDING

COMMUNITY FORESTRY "BY THE PEOPLE AND FOR THE PEOPLE"

Community forestry can be seen as "forestry for the people and by the people," in the words of Alain Karsenty and his colleagues. According to the Food and Agriculture Organisation of the United Nations, community forestry is a sub-category of participatory forestry in which communities or groups of people have specific rights over forests, such as the right to establish, implement and enforce rules governing access to and use of these forests. These rights can be formal legal rights, or traditional or customary rights, which can be legally recognised by the state. Thus, from a legal point of view, it is a transfer, by the state authority, of the forest decision-making and management responsibilities to local communities. This broad definition of community forestry reflects the variety of community forest management models that exist in Central Africa: community forests (Cameroon, Gabon, the Central African Republic, the Republic of Congo) and local community forest concessions (DRC). In Nepal, community forests are, from a legal point of view, former state-owned forests that have been assigned to communities to promote conservation. Communities receive use rights for a maximum, renewable period of 10 years. Thus, community forestry can take the form of management of natural forests and woodlands, but also of community or collective wood plantations.

Sources: Karsenty, A., et al., 2010 ; FAO, 2016 ; Ott Duclaux-Monteil, C., 2016

Business partners and civil society are working to strengthen the normative frameworks

Aid to "participatory" local development, applied according to a top-down logic and often perceived by populations as paternalistic, has slowed down the sustained entrenchment of community management. While it should allow choices to be expressed locally on the basis of the expectations of the LCIP and their social and natural capital, the influence of the forest administration, elites, donors, national civil society organisations and international NGOs compromises the LCIP's appropriation of the management methods, for which they are nevertheless expected to be responsible. The lack of knowledge and understanding of the laws adds to these difficulties. The formal establishment of community forests is therefore dependent on the limited technical, human and financial capacities of the administrative bodies. Competition from non-official logging operations, weak infrastructure, remoteness of markets, high transaction costs and an often-unsuitable tax structure are all factors that reduce the incentives for stakeholders to commit and invest.[27]

Thus, various civil society projects are attempting to strengthen the management capabilities of communities and are pushing to have these laws revised, in particular through the African Network on Community Rights and the CoNGOs consortium.[39] Efforts, whose results are still uncertain, are underway, particularly in the CAR for the establishment of "inclusive" community forests, that is to say located within forest concessions.[40] The DRC is moving towards a similar model,[41] with pilot projects aimed at replicating the Central African experience and taking it further; but to date, no formal implementation has taken place because the implementing decrees for the new forest code have not yet been drawn up. Other civil society actors are committed to supporting approaches based on the development of an economic and business model in order to support communities in "*formalising and professionalising their business activities in the long term and thus improving the livelihoods of small and medium-sized forestry companies*"[42] NGOs like ClientEarth,[43] the International Institute for Environment and Development, and Fern have recently affirmed the urgency of a change of approach. These set out to test the existing legal tools by monitoring compliance with the rights of LCIP who hold existing forests and by setting up pilot forests.

The Brazzaville Roadmap, drawn up by the FAO in 2018 with contributions from NGOs, governments, research institutes and the private sector,[f] is an example of a multi-stakeholder initiative to embed a new vision of participatory forestry, and hence of community forestry. This roadmap intends to contribute to the objectives of the Convergence Plan of the Central African Forests Commission (COMIFAC) for the sustainable management of forest ecosystems in Central Africa (2015-2025) including to "*promote community and decentralised management of forest resources*" and "*strengthen the active participation of vulnerable populations in the management of forest resources* ". Its objective is to propose *"actions to be put in place to unleash the potential of participatory forestry and enable millions of people who depend on the forest for their livelihood to sustainably manage resources while improving their livelihoods – thus contributing to the achievement of the United Nations Sustainable Development Goals."*[37]

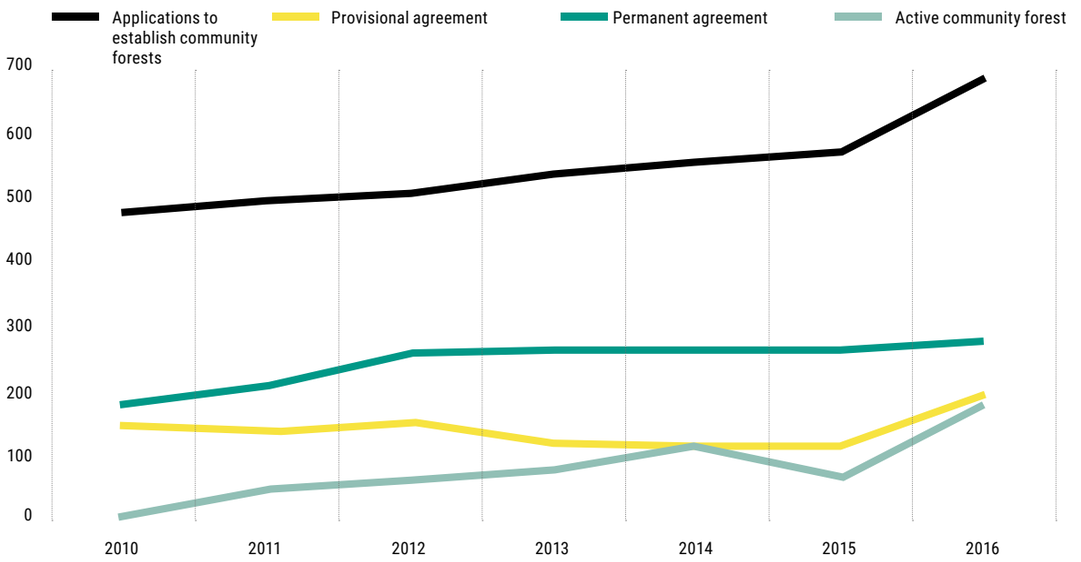
The normative requirement of foreign markets can also help transform the transparency and practices of countries that export logging products. In order to prevent uncontrolled deforestation and the illegal sale of its timber, all the countries of the Congo Basin have signed VPAs (voluntary partnership agreements) with the European Union. These bilateral agreements are provided for in the FLEGT (Forest Law Enforcement, Governance and Trade) action plan, adopted by the EU in the form of a regulation in 2005, in order to strengthen the

f More than a hundred actors contributed to the drafting of the Roadmap.

FIGURE 3

EVOLUTION OF THE NUMBER OF COMMUNITY FORESTS IN CAMEROON

Source: SAILD, 2017



traceability in the trade of forest products intended for the European market and prevent any import of illegally felled timber.[44] One of the pillars of the FLEGT is the tightening up of the law, including strict compliance with all regulations and procedures relating to the extraction, processing, exploitation and marketing of products. This innovative legal framework has made it possible for the communities themselves to launch forestry initiatives in Cameroon and Gabon following interventions led by governments or development partners through NGOs.[27]

Polymorphous international funding that is still insufficient

International financial investments appear to be a necessity for the development of community forests in Central Africa. 85% of the objectives set by African countries in their NDCs are conditional to the inflow of international financial aid.[45] The commitments made by many African forest countries do not necessarily include forest governance in achieving the climate goals. On the other hand, the cost of establishing a community forest remains a major obstacle: in the DRC, between $100,000 and $160,000[38] is needed to create a community forest in accordance with regulations.[9] Thus, the potential of community forestry under the REDD + mechanism (Reducing Emissions from Deforestation and Forest Degradation) has aroused donors' interest. Furthermore, the clarification and securing of land rights are among the key objectives of REDD+ projects, alongside securing livelihoods and generating income and jobs.[46]

However, in the DRC, for example, members of LCIP who have benefited from land in perpetuity under local community forest concessions (LCFC) can decide whether or not to participate in a REDD+ programme and to benefit from the corresponding funds. However, the Congolese government has so far focused on community access to forests, while failing to carry out the underlying work to strengthen their technical capacities to manage these forests.[47] As a result, communities are more readily turning to private companies to harvest their timber and receive direct compensation in return.

At the international level, the Central African Forests Initiative (CAFI), launched by Norway at the United Nations Summit for Sustainable Development in September 2015, intends to help the countries of the Congo Basin to implement reforms and to strengthen investment frameworks to support the sustainable use and conservation of their forest resources, in particular through the implementation of REDD + activities. CAFI aims to achieve a number of goals, such as improving governance, land-use planning and reducing pressure on forests. It is both a multi-donor trust fund that provides direct investment on the ground, and a negotiating platform that aims to promote political dialogue.

Through 30 programmes, the six countries[h] participating in the initiative received $202 million. In contrast, forest management, governance and monitoring captured only 18% of investments made in 2020 (**fig. 4**). At the same time, CAFI is negotiating and encouraging political commitments, such as the Republic of Congo's ban on agro-industrial activities of

g These costs include the costs of meetings, the training of the coordination committees, studies to create demarcation lines and maps, and other administrative procedures.

h Cameroon, the Central African Republic, the DRC, Equatorial Guinea, Gabon and the Republic of Congo.

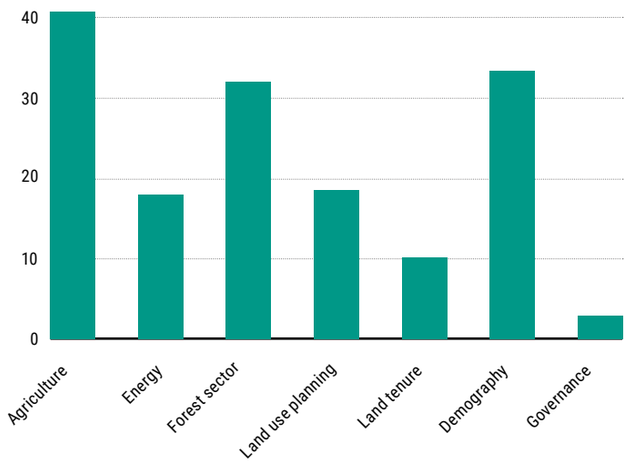
over 5 ha in forests, Gabon's commitment to avoid or limit the conversion of forests with a high carbon stock and with high conservation value, and the DRC's commitment to integrate the forestry and land-use sector in its nationally determined contribution.

In its 2016-2020 forestry action plan, the World Bank renewed its commitment to clarifying forest land rights: securing the rights of LCIP is highlighted as an important criterion for the approval of the Bank's interventions.[48] The Bank embraces three of the top five multilateral recipients of European aid (EU and Member States) in the forestry sector worldwide, behind the United Nations REDD Program (UN-REDD) and the Global Environment Facility (GEF, which the Bank administers): the Forest Investment Program (FIP), the Forest Carbon Partnership Fund (FCPF).

FIGURE 4

DISTRIBUTION OF CAFI INVESTMENTS PER SECTOR, IN MILLIONS OF DOLLARS, AS OF 31 DECEMBER 2020

Source: CAFI, 2021



However, these commitments in principle are not leading to the prioritisation of support for forest communities and their forest management practices. In addition, the financing of land rights and forest management in tropical countries as a whole remains low. Between 2011 and 2020, an average of $270 million was allocated each year for this purpose. This figure is equivalent to less than 5% of total official development assistance (ODA) for general environmental protection and less than 1% of ODA for climate change mitigation and adaptation over the same period. In comparison, since 2008, more than $5 billion has been pledged to multilateral climate funds under REDD+ programmes.[49] Most funds earmarked for community land tenure and forest management go through intermediaries rather than the communities themselves – consequently, the latter are still not considered key players in the fight against climate change and the loss of biodiversity, which they have nevertheless preserved for generations.[50]

KEY TAKEAWAYS

Over the past twenty or so years, the community forestry model developed in the Congo Basin has had rather incongruous results, and has not fully played the role it was initially assigned. We can therefore see a different concept taking shape, with the need to secure the rights of local communities and indigenous peoples. Although international aid and European agreements have enabled significant progress to be made, the political will and internal cohesion to make community forestry a model for sustainable and inclusive development is still lacking. Significant challenges remain, which several organisations such as CIFOR, Fern and the Rainforest Foundation have attempted to address by making recommendations, such as the need to strengthen independent monitoring of forests by civil society, and the consequent need to improve forest management, access to digital technologies, the fight against corruption, and the improvement of the existing legal framework to promote the creation and use of community forests that are adapted to the needs and capacities of the communities (and which remain non-discriminatory to towards women).

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TRENDS
AGRICULTURE

A Matter of Trust: How Palm Oil Supply Chain Actors Respond to the Evolving Sustainability Standards

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Palm oil, as a cheap and versatile ingredient used in many processed goods, has been and continues to be a major driver of deforestation in Southeast Asia. To regulate its production, local and global NGOs pushed for the implementation of rigorous environmental standards. Although the palm oil industry did not welcome these new standards with great enthusiasm, and accused Northern countries of waging a trade war, this dichotomy evolved into the establishment of a strong normative framework, resulting in a slowdown in the tree cover loss.

DATA OVERVIEW

The palm, the profit, and the planet

Palm oil, obtained from oil palm trees (*Elaeis guineensis*) is an important commodity which almost all of us consume, knowingly or unknowingly. It can be in our dinner, chocolate snacks, cosmetics, soap, shampoo, and even in the fuels that run our machines. The vast industrial and consumer uses of the commodity make it known as a 'global flex crop'.[1] Since it can be used for various purposes, it is not surprising that palm oil is the most widely consumed vegetable oil in the world today (**fig. 1**).

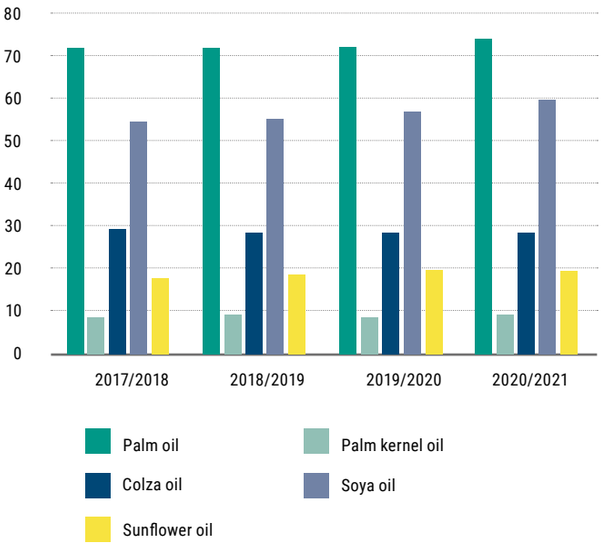
Its flexibility is also supported by its lower production cost and higher yield compared to other seed-based oils, making it competitive in the global vegetable oil market.[2] About 2.8 tonnes of palm oil can be produced from each hectare of land. In comparison, sunflower or rapeseed oil can get 0.7 tonnes of oil per hectare, and coconut or groundnut oil only get 0.2 t/ha.

As a tropical tree, it is produced mainly by developing countries (**fig. 2**), which often identified them as a "strategic commodity." In 2020/2021, around 84% of palm oil is produced in Indonesia and Malaysia while other countries are trying to increase their shares (**fig. 2**). In both countries, the majority of the palm oil production came from private estates. In Indonesia, 54.42% of oil palm plantation area is owned by private estates, 4.23% by government estates, and 41.35% is owned by independent smallholders.[3] In Malaysia, private estates control 61.1% of the plantation area, while government-owned estates composed 5.5% of the plantation area. Smallholders in Malaysia are divided into organized smallholders, who own around 16.6% of the plantation area, and independent smallholders, who own 16.7% of the plantation area.[4]

FIGURE 1

CONSUMPTION OF SOME MAJOR VEGETABLE OILS, WORLDWIDE, 2017/2018-2020/2021, IN MILLION METRIC TONNES

Source: United States Department of Agriculture, August 2021



With a global export value of $27.7 billion in 2019, many in these countries see it as a reliable and easy source of economic growth. In Indonesia, palm oil contributed $16.5 billion of exports, and contributed to 10.3% of total non-Oil & Gas exports in 2018.[5] The government estimated that oil palm industrial estates provided jobs for 4.2 million people directly, and 12 million people indirectly, while 4.6 million people

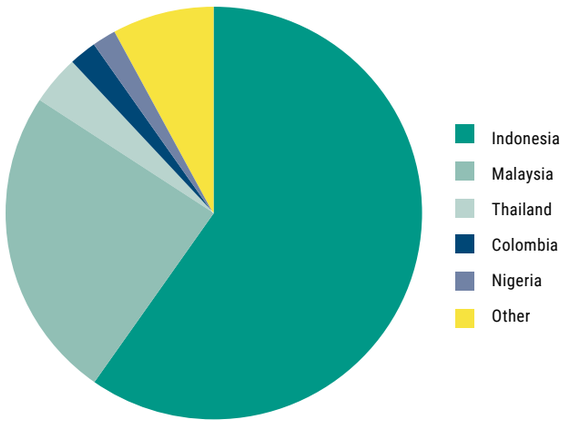
are involved as independent smallholders.[6] Palm oil is also Malaysia's main agricultural export, accounting for up to 2.7% of its GDP.[7]

Palm oil is considered as an instrument for rural development, with expansion supported by the World Bank and Asian Development Bank since 1980s as part of their developmental assistance. Programs such as PIR (Perkebunan Inti Rakyat, People Nucleus Estate) were supported by these financings. In the PIR scheme, the Indonesian government supported the establishment of contracts between smallholders in surrounding area of a plantation with the estate through various incentives such as logging rights and special rate credits for the companies and subsidies for smallholder plantings and initial living costs of the transmigrant smallholders.[8,9]

FIGURE 2

SHARE OF GLOBAL PALM OIL PRODUCTION BY COUNTRY, 2020/2021

Source: United States Department of Agriculture, August 2021



As the demand for palm oil grows, the area used for oil palm plantation is also expanding rapidly (**fig. 3**). Since these countries are in the tropics, the home of important tropical rainforests and peatland areas, such trends created worries that oil palm expansion was causing deforestation and other environmental and social externalities. As a consequence, palm oil is one of the world's most profitable, yet most controversial agricultural commodities.

While Indonesian and Malaysian government officials, as well as palm oil industry associations, frequently argued that palm oil is an instrument for progress and development (the Indonesian Palm Oil Association even called it "*God's Blessing for Indonesia*"[10]), NGOs such as Greenpeace blame the expansion of oil palm plantations as the main driver of deforestation and thus, of climate change.[11, 12, 13, 14] The main source of emissions in the sector is when the expansion of oil palm plantations leads to destruction of carbon-rich forests and peatland drainage, causing sequestered carbon to be released into the atmosphere.[15] In a recent study, Cooper et.al. (2020) estimated that conversion of peat swamp forest in Indonesia and Malaysia is contributing to 16.6-27.9% (95% confidence interval) of the combined total national GHG emissions from Indonesia and Malaysia, and 0.44-0.74% (95% CI) of annual global emissions.[16] Another study by Guillaume et. al. (2018) found that converting one hectare of rainforest land into oil palm resulted in a loss of 174 tonnes of carbon (equivalent to 530 people flying from Geneva to New York in economy class).[17] According to statistics provided by the Global Forest Watch, based on the University of Maryland (UMD) data, Indonesia lost 27.7 Mha of tree cover during 2001-2020 period, including 9.75 Mha of humid primary forests (36%) from 2002 to 2020. The total loss is equal to a 17% decrease in tree cover and 19.0 GtCO-e emissions (**fig. 4**).[18] In the same period, Malaysia lost 8.39 Mha of tree cover, emitting 4.82 $GtCO_2e$, and amount to a 29% decrease in tree cover since 2000. In both countries, commodity driven deforestation, mostly from oil palm plantation, is the primary driver of permanent deforestation.[19]

Apart from environmental problems, NGOs such as SawitWatch and Transformasi Untuk Keadilan (TUK) Indonesia also blame palm oil industry for social problems such as human rights violations, land conflicts, and repression of local communities.

Despite the controversies, the palm oil industry continues to grow. Although the pandemic did hit the demand and production a little bit, the global palm oil production already rebounded back to its growth trajectory (**fig. 3**).

These controversies led to continuous struggles to shape the governance of the palm oil industry at multiple scales, leading to the establishment of sustainability standards such as the Roundtable on Sustainable Palm Oil (RSPO) or the No Deforestation, No Peat, No Exploitation (NDPE) principles;[a] as well as producer country-based standards such as Indonesia Sustainable Palm Oil (ISPO) and Malaysia Sustainable Palm Oil (MSPO).

THE OBSERVATORY'S LENS

The evolution of sustainability standards in the palm oil sector

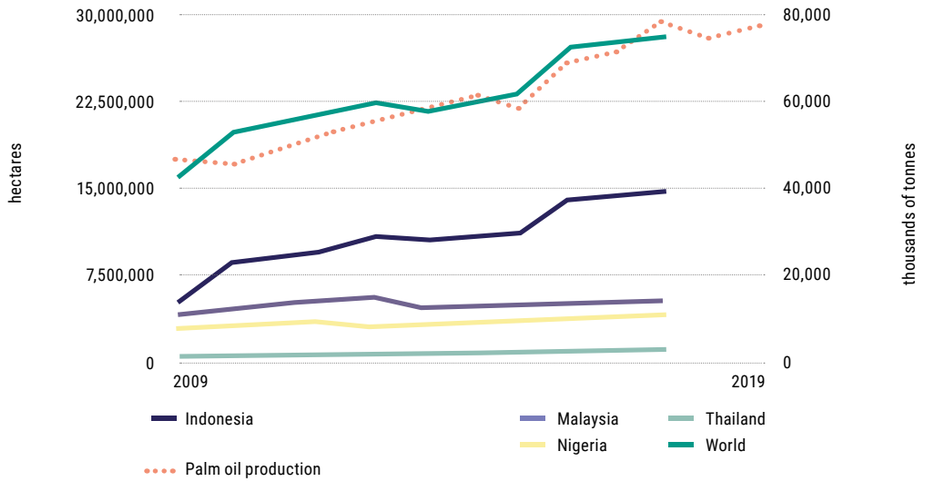
Despite gloomy long-term trends in deforestation, in March 2021, the Ministry of Environment and Forestry, Republic of Indonesia claimed in the media that Indonesia had successfully reduced the deforestation rate. Global Forest Watch and

a 'No Deforestation, No Peat, No Exploitation' (NDPE) commitments are commitments adopted by palm oil companies that aim to ensure the sustainability of their palm oil beyond the requirements of certification. The name itself is self-explanatory: 'No deforestation' means protecting forests with High Conservation Value (HCV) and High Carbon Stock (HCS), 'No Peat' means avoiding planting on peat, and 'No Exploitation' means respecting and protecting human rights, workers' rights and the rights of local communities and customary peoples. As a commitment beyond legal or certification requirements, it is controlled by a standard body like the RSPO. See this explanation by EFECA.

FIGURE 3

OIL PALM PLANTATION AREA IN SELECTED COUNTRIES, 2009-2019, IN HA AND GLOBAL PALM OIL PRODUCTION, 2009-2021, IN 1000 TONNES

Sources: FAO, 2021, except production for 2019-2021 (October-September) from Oil World, August 2021 (2020 and 2021 are estimates)



World Resources Institute described Indonesia and Malaysia as "*bright spots of hope for forests*." According to WRI, Indonesia experienced declining rate of primary forest loss for the fourth year in a row in 2020 and successfully got out from the top three countries for primary forest loss.[20] The Ministry of Environment and Forestry of the Republic of Indonesia mentions 115,460 hectares of forests lost due to deforestation during 2019-2020, down from 462,500 ha in 2018-2019 and 439,400 ha in 2017-2018.[21] While putting different numbers due to methodological reasons, the data presented by Global Forest Watch (**fig. 4**) also indicates that there is indeed a consistent decline in deforestation in the last five years.

Furthermore, the declining contribution of the palm oil industry towards deforestation is also showing that while still far from ideal, the industry is changing. Data shows that oil palm plantations' contribution to deforestation peaked in 2008-2009 (reached almost 40%), but it then consistently declined to less than 15% (**fig. 5**).

The creation of the RSPO

Following the rapid expansion of the palm oil industry in Indonesia after the post-Asian Crisis liberalization in the early 2000s, which also resulted in deforestation (**fig. 4**, especially 2001-2009 period which shows rapid and increasing trend of tree cover loss), NGOs such as Sawit Watch, Forest Peoples, Transformasi untuk Keadilan, WWF and Greenpeace, as well as scientists, started to link palm oil to climate change, raising public awareness about the impact of oil palm expansion to the environment and how multinational companies and financial institutions (mostly based in Europe) enabled its expansion. These NGOs started to call for more sustainable business practices,[22] using different strategies to raise public attention. In 2007, eight local Greenpeace activists put a huge banner saying that "*Palm Oil Kills Forests and Climate*" on a tanker carrying palm oil in the Indonesian province of Riau, the largest producer of palm oil in the country. Greenpeace's ship, the Rainbow Warrior, was also coming to the proximity of the palm oil tanker.[23] NGOs also 'name and shame' companies both upstream and downstream of the palm oil value chain to force them to act more responsibly. In the early 2000s, WWF ran the "Lipstick from the Rainforest" campaign. In the mid-2000s, the NGOs started to point their fingers more clearly. A Greenpeace report, 'How the palm oil industry is cooking the planet,' accused palm oil industry of being the main contributor of the destruction of Indonesia's forests, with 1.8 billion tonnes of greenhouse gas (GHG) emissions being released annually. The report also clearly mentioned global companies such as Unilever, Nestlé and Procter & Gamble (P&G) of being complicit with this environmental crime.[11] In 2008, Greenpeace accused Unilever and its suppliers as the destroyer of forest and peatlands in Kalimantan and demand the global company to clean up the trade.[12] In 2010, Greenpeace accused Nestlé, another major user of palm oil, as benefitting from the burning of tropical forests and destroying the habitat of the critically endangered Orang Utans.[13] These campaigns have proven to be effective. In May 2008, Unilever declared its commitment to clean up the company's supply chain. It cancelled $30 million contract with Golden Agri Resources Limited (GAR), a subsidiary of Sinar Mas, which was accused of unsustainable practices, in December 2009. Another global company, Kraft, followed Unilever's decision in March 2010. Burger King, a major international fast-food chain, also halted their cooperation with the Indonesian palm oil company.[24]

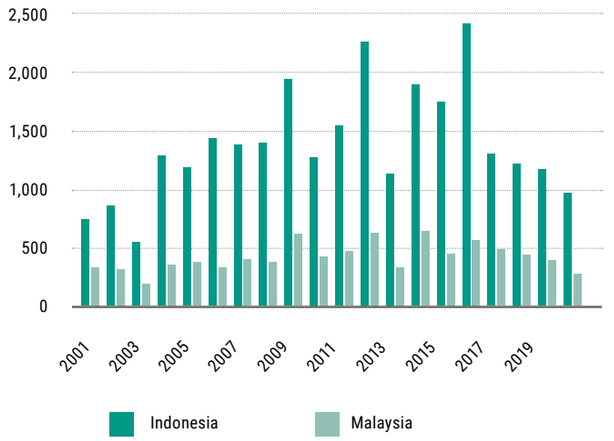
Responding to this development, a group of stakeholders with diverse backgrounds agreed to establish the RSPO in 2004, with the aim to involve all key players in the palm oil supply

chain to develop a win-win solution through the promotion and production of sustainable palm oil. Its beginning could be traced to the Forest Conversion Initiative (FCI), an initiative of the WWF launched in 2001.[23] Thus, the recognized initiators of the RSPO are WWF, Migros, Unilever, Sainsbury, Aarhus United UK, Golden Hope Plantation, the IOI Group and eventually the Malaysian Palm Oil Association (MPOA), after dealing with some internal dissents.[23] The RSPO accepts membership from different sectors, from oil palm producers, processors or traders, consumer goods manufacturers, retailers, banks/investors, and environmental and social NGOs.[25]

FIGURE 4

LOSS OF TREE COVER IN INDONESIA AND MALAYSIA, 2001-2020, IN KHA

Source: Global Forest Watch, 2021



Since the beginning, the RSPO has been mired with governance issues and distrust between stakeholders. On the one hand, the producers complain that the RSPO is shifting from its earlier commitment as a multi-stakeholder platform and quickly becoming a one-sided mechanism which shifts the burdens only to the producers without understanding the complexity on the ground. There is a general perception among them that the RSPO is "made in Europe" and gives more heed to European interests rather than the producers in developing countries.

On the other hand, the NGOs are suspicious that the RSPO would only be used as a license for "certifying destruction,"[26] and continuously demand for stricter standards and stronger enforcement. During the review process, Rainforest Action Network (RAN) and OXFAM, (both members of the RSPO), collaborated with Greenpeace, a non-RSPO member, to push for the inclusion of the prohibition to plant in the peatland areas in the revised version of the P&C. Although unsuccessful, this collaboration led to the establishment of Palm Oil Innovation Group (POIG) coalition, which includes like-minded NGOs and multinational corporations. The POIG obligated its members to obtain RSPO certification and to adhere to additional norms, introduced as No Deforestation, No Peat, No Exploitation (NDPE).[27]

Concerned about its eroding legitimacy, the RSPO responded to such development by introducing a new initiative called "RSPO-NEXT" in 2015, a voluntary initiative which contains stricter additional criteria including No Deforestation, No Fire, No Planting on Peat, Reduction of GHGs, and Respect for Human Rights and Transparency. After the most recent revision of the RSPO P&C in 2018, the RSPO's Board of Governors decided to "retire" the initiative in 2020, as P&C now incorporates RSPO-NEXT criteria and add other advancements such as protection of human rights defenders, legality of third-party sourced fresh fruit bunches, and new rules on pesticides.[28]

KEYS TO UNDERSTANDING

THE RSPO SUSTAINABILITY STANDARDS FOR PALM OIL

The RSPO establishes standards for sustainable practices in the palm oil sector that all its members must follow, especially those that take legal ownership, produce, or handle palm oil. These standards are formalized as the RSPO Principles and Criteria (RSPO P&C), which is reviewed every five years. The third version was ratified and adopted at the 15th Annual General Assembly (GA15) by RSPO members in 2018. The P&C sets up 8 Principles: (1) Commitment to transparency; (2) Compliance with applicable laws and regulations; (3) Commitment to long-term economic and financial viability; (4) Use of appropriate best practices by growers and millers; (5) Environmental responsibility and conservation of natural resources and biodiversity; (6) Responsible consideration of employees and of individuals and communities affected by growers and millers; (7) Responsible development of new plantings; and (8) Commitment to continual improvement in key areas of activity.[b] To ensure that members are adhering to these standards, all members must undergo a process of certification. If they meet the RSPO P&C, their palm oil is considered as sustainable and identified as Certified Sustainable Palm Oil (CSPO).[c] Through this process, it aims to affect the supply chain in two directions: towards the consumers, the certification is an assurance that consuming RSPO-certified palm oil are not harming the people and the planet (and thus keeping palm oil industry grow), while towards the producers it pushes them to leave unsustainable practices by arguing that the market does not want unsustainable palm oils.

Producers' responses: persistent suspicion and hedging strategies

In general, the introduction of the RSPO did not disturb the growth of the palm oil industry in Indonesia and Malaysia. It continued to expand at a rapid pace in 2000s, especially in Indonesia, which overtook Malaysia as the largest producer of palm oil during this period. Yet the reception of the RSPO was contrasted among the industry, as the hope to obtain

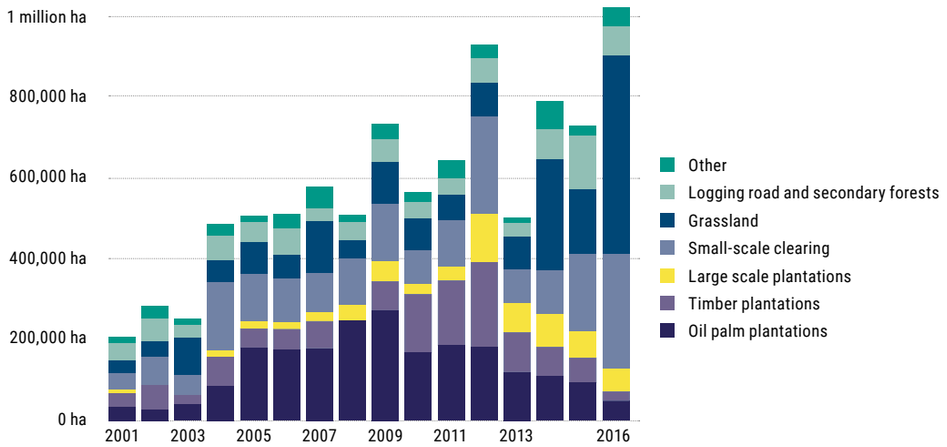
b The RSPO P&C can be read here.

c More details on the process can be read here.

FIGURE 5

DRIVERS OF DEFORESTATION IN INDONESIA, 2001-2016

Source: Our World in Data, 2020 (data from Austin, K. G., et.al., 2019)



competitive edge to enter environmentally conscious markets such as the EU soon yielded to doubts as a gap between supplies and sales appeared (**fig. 6)** and the RSPO P&C evolved to be more comprehensive and stringent.

Producers in Indonesia and Malaysia responded with "hedging strategies": many of them joined the RSPO and implement its standards, but at the same time trying to limit the RSPO's power.

The Indonesian Palm Oil Association (GAPKI), which consists of large and small private and state-owned companies, has become the platform to voice the feeling that the RSPO's costs to producers overcome its benefits. GAPKI members includes giant private companies such as Sinar Mas and Bakrie Plantations, as well as state-owned companies such as Perkebunan Nusantara. Apart from GAPKI, another vocal coalition which often criticized the RSPO is the Indonesia's Oil Palm Smallholders Association (Asosiasi Petani Kelapa Sawit Indonesia, APKASINDO).

However, some segments of the producers welcome the introduction of the RSPO as a positive development, especially because they give some protection to smallholders. Oil Palm Smallholders Union (Serikat Petani Kelapa Sawit, SPKS) even included support for RSPO certification for smallholders in their programs. Some pro-RSPO farmers and smallholders also established the Indonesian Sustainable Palm Oil Farmers Forum (Forum Petani Sawit Berkelanjutan Indonesia, FORTASBI), which work together with NGOs such as Sawit Watch and WWF. Nevertheless, GAPKI and APKASINDO, a smallholder association with close link to GAPKI, are having stronger influence.

In 2011, the formation of the Compensation Task Force despite producers' explicit objections triggered a feeling that the producers are being excluded or at least treated unfairly in the RSPO's governance. The NGOs vocal campaign inside and outside the RSPO to push for stricter standards, including by criticizing the RSPO in public, irked members with producer backgrounds. Palm oil producers were also anxious that such steps illustrate the RSPO's shift from multistakeholder platform to a one-sided one with NGOs become the dominant voices.

Representatives from producers often accused the General Assembly of the RSPO as going beyond its role by creating adjustments (usually stricter) to the P&C through voting, undermining the credibility of the standard and process.[29] They also complained that some people continue to focus on shortcomings rather than achievements and efforts, as if there were no progress.[30]

The biggest disappointment is probably the perception that non-producer members are shifting the burdens to the producers. While the standard has been getting stricter and more costly, only the producers, who are in developing countries, are paying for the costs. In the 3rd RSPO General Assembly, producers once proposed a resolution to share the burdens by making audit, certification, and verification costs can be shared among producers, buyers, and consumers.[31] The proposal was rejected by the Chairman of the General Assembly, arguing that such proposal would violate the RSPO Antitrust Guideline.[32]

Although producers are making sacrifices to make CSPO, the sales hovers at only around 50% of production (**fig. 6**). Indonesian and Malaysian producers also complained that the costs and efforts to fulfil the sustainability standard of the RSPO

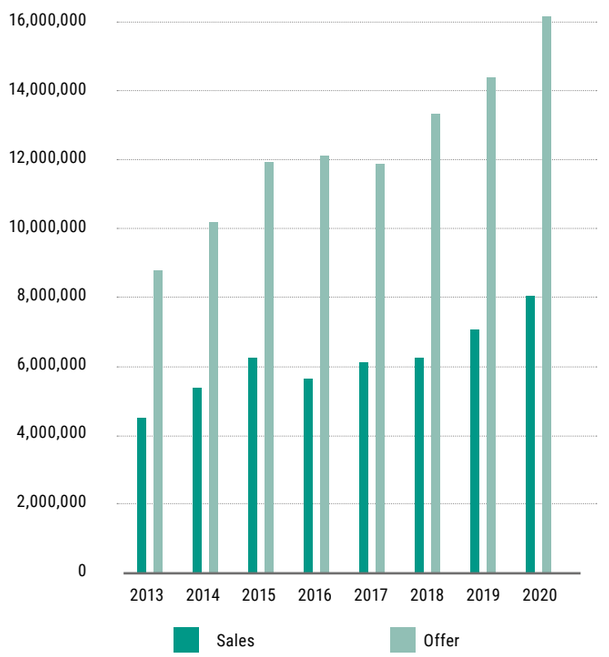
were not resulted in the increase of the premiums or their palm oil sales. A Bloomberg report captured this well: "*The World has loads of sustainable palm oil…but no one wants it.*"[33] The producers argued that the low uptake shows that the downstream companies are not really committed to sustainability. In the eyes of GAPKI, the downstream companies in EU joined hands with NGO to make stricter standards but then did not buy it because they were only concerned about their image in front of the environmentally conscious consumers.

This growing distrust led the GAPKI to pull out from RSPO in 2011. The Malaysian Palm Oil Association (MPOA) threatened to follow suit, but never actually withdrew.[34] Many companies, such as Golden Agri Resources, Bakrie Sumatera Plantations, and state-owned PTPNs, remain as members of RSPO, practicing hedging strategies by trying to develop alternatives to the RSPO while keeping their feet in it to prevent the introduction of non-favourable standards and to keep them in the game if the alternative sustainability standard is not taking off.

FIGURE 6

SUPPLY AND SALES OF CERTIFIED SUSTAINABLE PALM OIL BY RSPO, 2013-2020, IN METRIC TONNES

Source: RSPO, 2021



This is why GAPKI and MPOA, through their strong connection with the government, pushed for the development of alternative sustainability standards that they feel more comfortable.[29] Both the ISPO and the MSPO borrow many aspects of the RSPO's P&C but modified many of them to be more flexible, or even exclude some criteria, making it less strict than the RSPO.[35] Furthermore, the close connection between the industry and the governments in Indonesia and Malaysia makes them able to negotiate the enforcement. This is also an attempt to create leverage within the RSPO. If the ISPO or MSPO have a significant acceptance in the market, they have more bargaining voice in the RSPO, since the RSPO is no longer the only game in the town. Yet "hedging" does not capture all the complexity attitudes of the producers towards the RSPO. While the ISPO and MSPO were certainly built as alternatives to the RSPO, those sustainability standards also exhibit impacts of norm diffusion of global sustainability promoted by the RSPO. Not only that the RSPO P&C is the main reference point for developing the ISPO and MSPO, but there are also genuine concerns about sustainability practices that are more applicable to Indonesia. Rather than outright resistance to the RSPO, we can see ambiguities within these sustainability standards. There are even some voices to develop a combined audit mechanism.[36] These ambiguities are also present in the government responses towards North-based sustainability standards, and it is even more evident, since the government should not be seen as a unitary actor.

Government response: between reform and resistance

On Friday, 5 February 2021, the heads of the governments of two largest producers of palm oil met at the Indonesian presidential palace. Multiple issues were covered, but palm oil did take a significant part of the discussion. During the press conference after the meeting, both President Joko Widodo of Indonesia and Prime Minister Muhyiddin Yasin of Malaysia iterated the need for cooperation for palm oil diplomacy. The then-Prime Minister of Malaysia, Muhyiddin Yasin expressed his discontent towards what he called as "*anti-palm oil campaign, especially in Europe, Australia and Oceania*," which he said was "*baseless and does not reflect the sustainability of the world palm oil industry*" and *"against the EU and WTO commitments.*"[37]

The producer countries' responses towards sustainability standards such as the RSPO is overshadowed, and further complicated, by suspicion towards an alleged "trade war" waged by powerful and rich developed countries. There is a popular perception shared by government officials and business alike that such sustainability standards were imposed towards palm oil to curtail its competitiveness.[38] "*Why only palm oil?*" a senior official in the Indonesian Ministry of Foreign Affairs once demanded, rhetorically. A sense of postcolonial trauma makes policymakers and politicians tend to see criticisms from developed countries on the palm oil industry not as a genuine expression for environmental concerns, but as another case of bullying from their former colonial rulers.[d]

One of the most important policies perceived as a trade war against palm oil was the EU's Renewable Energy Directives, launched in 2009 as part of the regional institution's strategy for climate change and environment. While not directly talking about palm oil, the RED established sustainability criteria for using biofuels to meet renewable energy targets. Based on this sustainability criteria, palm oil was excluded.[2]

d Based on the author's experience and discussions with government officials.

The continuation of the RED, the RED II, launched in December 2018, opened the possibility to phase out palm oil use for biodiesel due to its high Indirect Land Use Change (ILUC) risk as 45%[39] of the expansion of palm oil took place in high carbon stock areas[e]. Indonesia and Malaysia now bring the case to WTO Dispute Settlement mechanism.[40] Apart from RED I and II, there are also anti-dumping accusations and legal cases, which these officials must deal with. All those experiences shape their perceptions towards the RSPO, leading a significant segment in the bureaucracy to believe that the RSPO is part of the same "anti-palm oil campaign."

Nevertheless, there are reformers within the Indonesian and the Malaysian governments which see the RSPO, as well as other external pressures on the palm oil sector, as an important opportunity to push more reforms. Many of them come from activist backgrounds or have good connections with civil society. They also achieved some significant results. In Indonesia, the moratorium on forest conversion was enacted since 2011 and made permanent in 2019. Based on a Presidential Instruction introduced by the President Yudhoyono in 2011, the moratorium prohibits the conversion of primary natural forests and peatlands for oil palm, pulpwood and logging concessions. Another moratorium, on oil palm plantation permits, was introduced in 2018. Yet its expiration in September 2021, with no extension voted, makes NGOs fear that economic interests may takeover forest protection and prevent Indonesia from reaching its commitment for 17% reduction of the emission in forestry sector by 2030.[41] Few days before, Indonesia unilaterally ended a funding agreement signed in 2010 with Norway, arguing "lack of concrete progress" in negotiations for the delivery of the first payment rewarding forest and peatland conservation in the archipelago.[42]

These different perceptions shape multiple responses of the state towards the RSPO, as seen in the ISPO or MSPO. In the ISPO itself, the Presidential Decree mentioned that the aim of the Indonesian version of sustainability standard is for: (1) ensuring and improving the management and development of oil palm plantation in accordance with ISPO P&C; (2) Improving the acceptance and competitiveness of Indonesian palm oil in national and international markets; and (3) Improving the acceleration of emission reduction efforts. Developmental, environmental, as well as defence against trade war narratives are all accommodated in the official document. On the ground, competition between these different priorities continues. For example, the initiative to consolidate the currently overlapping maps on oil palm plantation through One Map policy is still running, but at a much slower pace then what is expected due to the involvement of many interests.

Both Indonesia and Malaysia also consolidated their "palm oil total diplomacy". In the WTO, Indonesia won the dispute settlement case DS480 on anti-dumping measures by EU. Indonesia and Malaysia are now bringing the RED II to WTO dispute settlement (DS593). The two countries supported the creation of the Council of Palm Oil Producing Countries (CPOPC) in 2015, and promote the ISPO and as sustainability standards. Furthermore, to ensure that palm oil is not singled out with strict sustainability standards while its rivals are free, the two countries are endeavouring to develop Voluntary Guidelines for Sustainable Vegetable Oils in Support of SDGs in the framework of Committee on Commodity Problems in the Food and Agriculture Organization (FAO). Indonesia wrote and presented the white paper during the 31st Session of the Intergovernmental Group on Oilseeds, Oils, and Fats, March 4-5, 2021. Since the proposal was still in an early stage, the guidelines were not quite here yet, but Indonesia seems to be committed to push this agenda forward.

"*Bright Spots of Hope for Forests*": Multiple forces are at play, and sustainability standards did help

Despite the tensions within itself, the RSPO has been a significant force in shaping the industry's practices. While producing countries like Indonesia and Malaysia tried to develop their own version of certification mechanism, the RSPO is still the most widely accepted sustainability standard in the palm oil sector.

In 2018, it surpassed the milestone of 4,000 members from 92 countries. As of 2021, the RSPO has 5,124 members from 102 countries, although Indonesia and Malaysia do not count among the 10 countries with most the RSPO members. In terms of certification impact, the RSPO claims that 19% of palm oil in the market (19.1 million tonnes) are CSPO, showing that it has some traction in influencing the palm oil supply chain. Its influence is also seen in the size of the certified area, which reached 4.45 million hectares in 2021, mainly from Indonesia (2.27 million hectares), and Malaysia (1.26 million hectares). The CSPO production area grew from merely 106,384 hectares in 2008 to 3.27 million hectares in 2021.[43] Although it is still far below the total palm oil plantation area (28.31 million hectares in the World and 14.6 million hectares in Indonesia), it means that at least a significant portion of the industry is following RSPO standards, which includes no deforestation.

Its impact may also go beyond the amount of CSPO production area, since the RSPO is seen as the "global" standard. Even if the ISPO and MSPO, which were developed by Indonesia and Malaysia partly due to the suspicions and disappointments of the producers towards the RSPO are using RSPO P&C as the main reference point, they modified it to be more flexible and less stringent. Thus, global sustainability standards also work indirectly through stage setting by putting "sustainability" as a dominant discourse in the governance of palm oil industry.

Deforestation is still happening at a large scale in Indonesia and Malaysia and the impact on the climate is still enormous. Nevertheless, the dialectic of environmental NGOs and major palm oil producers, as well as the synergy resulting from

e High carbon stock forests refer to areas that are considered as storing high amount of carbon and biodiversity, based on the type of vegetative cover. Through satellite data and ground survey measurements, the High Carbon Stock Approach stratifies the vegetation in an area of land into six different classes: High Density Forest, Medium Density Forest, Low Density Forest, Young Regenerating Forest, Scrub, and Cleared/Open Land. From these six, the first four categories are assumed to potentially be high carbon stock areas. See this explanation.

diplomacy between producing and importing countries, has led to the establishment of a powerful normative framework for more climate and environmentally friendly palm oil production. This is fully reflected in the new producer-driven ISPO and MSPO standards based on the RSPO standards, as well as the establishment of the moratorium on forest conservation by the Indonesian government. Although it is difficult to calculate their exact contribution to reducing deforestation and thus mitigating climate change, it is safe to say that sustainability standards did matter in reducing the pace of deforestation in major palm oil producing countries.

KEY TAKEAWAYS

Deforestation is still happening at a large scale in Indonesia and Malaysia and the impact on the climate is still enormous. Nevertheless, the dialectic of environmental NGOs and major palm oil producers, as well as the synergy resulting from diplomacy between producing and importing countries, has led to the establishment of a powerful normative framework for more climate and environmentally friendly palm oil production. This is fully reflected in the new producer-driven ISPO and MSPO standards based on the RSPO standards, as well as the establishment of the moratorium on forest conservation by the Indonesian government. Although it is difficult to calculate their exact contribution to reducing deforestation and thus mitigating climate change, it is safe to say that sustainability standards did matter in reducing the pace of deforestation in major palm oil producing countries.

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IDEAS

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

Great Green Wall • The International Olympic Committee launches the "Olympic Forest"

As part of the Great Green Wall and the organisation of major sporting events such as the Youth Olympic Games planned for Dakar in 2026, the International Olympic Committee (IOC) is launching an "Olympic Forest" initiative. This forest will cover 2,120 hectares across Mali and Senegal, and will pass through 90 villages. The forest could sequester 200,000 tCO_2e, more than the estimated emissions of the IOC between 2021 and 2024, which has committed to reducing its emissions by 45% in 2030 compared to the 2016-2019 average (53 $MtCO_2e$/year). The creation of this forest is also intended to be a tool to raise awareness among young people about climate challenges. Planting is scheduled to start in the in later months of 2022, and is expected to include a wide range of native species of trees.

Afrik21, 25/06/2021

The Amazon • The Forest now emits more CO_2 than it absorbs

According to a study published in Nature on 14 July, for the first time ever, scientists claim that the Amazon rainforest is now emitting more CO_2 than it is absorbing. The researchers based their findings on 590 vertical measurements of CO_2 concentration made between 2010 and 2018 in the lower troposphere using small aircraft over four sites. The south-eastern Amazon, in particular, has become a net source of GHG emissions, driven by deforestation, warming, increasing humidity and intensifying dry seasons. Most of the emissions are from fires caused by cattle and soy development.

The Guardian, 14/07/2021

Indonesia • Restoring former oil palm plantations

A major palm oil producer has announced a plan to rehabilitate 38,000 hectares affected by deforestation due to oil palm cultivation. According to a 2018 Greenpeace investigation, the company KPN cleared 21,500 hectares of rainforest in the Indonesian provinces of Papua and West Kalimantan between 2013 and 2018. Rehabilitation by KPN Plantation will be achieved through reforestation, helping local communities gain land and resource access rights, and rewetting peatlands – a technique whose CH_4 emissions appear to be offset by long-term CO_2. gains. However, NGOs are calling for vigilance to ensure that the project is properly monitored, and to expand the project beyond the cleared plantation areas.

Mongabay, 28/07/2021

Urban Forests • Microforests, the carbon sinks at the heart of Middlesbrough

In Middlesbrough, in the North East of England, the Mayor of the town has announced the planting of a microforest in the heart of each of the town's neighbourhoods, amounting to 21 microforests. Each micro-forest is about the size of a tennis court and is relatively dense, about 600 by 250 square metres, and contains a wide range of different species. Planted using a method invented by a Japanese botanist, these microforests, also known as Miyawaki forests, regenerate land faster than conventional forests and can store up to 40 times more carbon than trees of a single species. This initiative is in line with the city's nomination earlier this year as one of the "Tree Cities of the World".

The Northern Echo, 25/06/2021

Diplomacy • The Alliance for the Conservation of Rainforests gains momentum

At the World Congress of the International Union for Conservation of Nature (IUCN), Gabon and France presented a new initiative for the creation of a "*business forum for the establishment of sustainable value chains in Africa*", which will be launched at COP26 in Glasgow. It aims to mobilise the private sector to operationalise the Alliance for the Conservation of Rainforests and Tropical Forests, acts as a political platform between donor and forest countries launched at the One Planet Summit 2020, which now brings together 25 countries. The business forum will be guided by the Alliance's charter, which sets out the principles of public-private partnerships to create low-carbon value chains that prevent the drivers of deforestation.

Afrik21, 14/09/2021

DRC • The Environment Minister announces the lifting of the moratorium on new forest concessions

The DRC's Deputy Prime Minister announced in early July 2021 the lifting of the moratorium on new logging concessions that had been in place since 2002 to combat deforestation and corruption. The ten-point action plan adopted by the Council of Ministers could allow for the industrial commercialisation of an additional 70 million hectares of forest, with a view of "sustainable management of natural resources". Greenpeace Africa's Congo Basin campaign is critical of the purpose of lifting the moratorium, given that earlier ministers had already granted illegal forest concessions to domestic and foreign companies since 2018. In the eyes of the NGOs, this decision goes against President Tshisekedi's commitments to restore the national forest cover and the objectives pursued by the Central African Forest Initiative (CAFI).

REDD Monitor, 15/07/2021

Canada • A historic investment supporting indigenous people in land conservation

The federal government has announced CA$340 million in funding over five years to support indigenous leadership in nature conservation. This funding is in addition to an initial CA$25 million in federal funding established in 2018 under the Indigenous Guardians Pilot program. More than CA$173 million will be allocated for the development of a network of Indigenous Guardians stewards, who will act as the "eyes and ears" of the land and water within their territories. The government will also allocate CA$166 million for Indigenous protected or conserved areas (IPCAs), ecosystems capable of storing large amounts of carbon, monitored or preserved in ways decided by indigenous people.

National Observer, 16/08/2021

Malaysia • Abandonment of the Kuala Langat North Forest Reserve Development Project

Activists are enthusiastically welcoming the Selangor state government's decision to cancel the development project and the acquisition of a forest reserve by a private company. In May, Selangor's government degazetted 54% of Kuala Langat North Forest, triggering public outcry. Of the 537 hectares covered by the forest, 495 hectares were promised to the private company Gabungan Indah Sdn. Bdh. for housing development. Selangor is the only state in Malaysia with legislation requiring public review of plans to convert protected forests to other uses. Campaigners are now calling for this regulation to be adopted on a wider scale. Of the 7,246.96 hectares declared as "permanent forest reserve" in 1927, only 13% has been preserved today

Mongabay, 14/09/2021

CASE STUDIES

REGION CASE STUDY

COUNTRY	REGION	NATIONAL EMISSIONS IN 2016	SHARE OF THE FOREST AND LAND-USE SECTOR IN EMISSIONS
CAMBODIA	THE CARDAMOMS	125.2 $MTCO_2E$	61%

Involving local communities to protect the Cardamom range

In the framework of its REDD+ programme, Cambodia has fixed an objective of a 50% reduction in its deforestation rate between 2017 and 2026, relative to the reference levels measured between 2006 and 2014. Situated in the Gulf of Thailand, and spread over 20,000 km^2 in the southwest of Cambodia, the Cardamom range is the site of Southeast Asia's largest rainforest, and 29% of the country's forest cover. Under significant pressure due to the illegal logging as well as poaching, the Cardamoms are an important habitat of several plant and animal species, and include several protected zones, among which are four national parks[a].

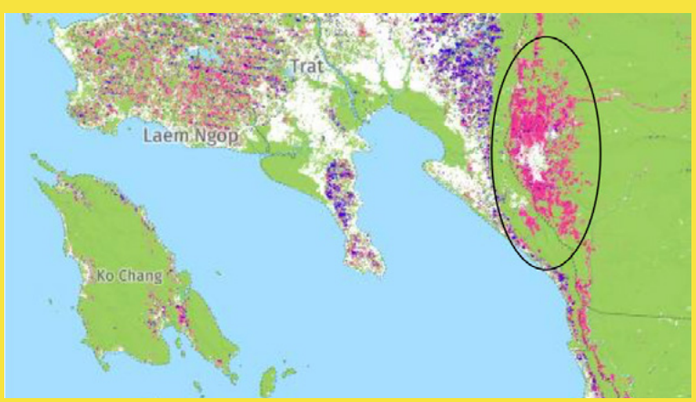
NGOs take up the fight against illegal deforestation

Due to the difficulty of enforcing land ownership laws over such a large area, multiple illegal clearings take place in the forest. At the same time, the increase in the number of legal land concessions granted by the Cambodian authorities allows timber and plantation companies to exploit protected forests. Between 2001 and 2019, according to Global Forest Watch, the Cardamom Forest lost 148,000 hectares of vegetation cover, which is 8.6% of its surface. Thus, since the early 2000s, several NGOs have been working to protect the Cardamoms. The Central Cardamoms Protected Forest (CCPF) initiative, launched in 2002 by Conservation International, and renamed the Central Cardamom Mountains National Park (CCMNP) in 2016, works to protect the 400,000 ha of the forest by helping the government develop a legal framework, and by providing financial and technical support to forest guards who patrol the park to discourage illegal logging activities.

Local action to protect the lungs of Southern Cambodia

The CCMNP programme supported by Conservation International, directly engages 2,700 people in conservation agreements, which provide economic benefits to local communities in exchange for wildlife protection and monitoring. In 2016, Wildlife Works, a leading global REDD+ programme development and management company, and Wildlife Alliance, in partnership with Cambodia's Ministry of Environment established the Southern Cardamom REDD+ project: the project relies on local communities and indigenous peoples, among others, to preserve the forest by replanting trees, developing sustainable agriculture and demarcating protected forests. Wildlife Alliance and Wildlife Works protect 8,347 km^2 of forest across the Cardamoms, with 131 rangers active 24/7. In 2018, these rangers patrolled 129,415 km, seized 2,039 logs and 325 m^3 of luxury wood and confiscated 553 chainsaws. As a result, the project avoids the emission of more than 12.8 $MtCO_2$/year. The project also works with 15 villages across the Cardamom range to develop community-based ecotourism. For example, Wildlife Alliance manages the Chi Phat Community Based Ecotourism (CBET) project launched in 2007: villagers who once roamed the forest cutting down trees are now employed as guides for hiking, mountain biking tours, or to run campsites. These projects are financially supported by the World Bank, who in 2019 launched the Sustainable Landscape and Ecotourism Project and committed $50 million to promote ecotourism and develop non-timber value chains in the Cardamom Mountains.

SATELLITE VIEW OF THE DEFORESTATION OF THE CARDAMOM RANGE, IN PINK WITHIN THE OVAL, BETWEEN 2001 AND 2019 - *Source : Global Forest Watch, 2021*



a The Central Cardamom Mountains National Park (CCMNP), the Southern Cardamom, the Botum Sakor and the Preah Monivong Bokor

REGION CASE STUDY

COUNTRY	PROVINCE	RESTORATION IN 2020	OBJECTIVE FOR 2075	NATIONAL EMISSIONS IN 2019
PAKISTAN	SINDH	75,000 HA	350,000 HA OF MANGROVES PROTECTED AND RESTORED	249 $MTCO_2$

Restoring mangroves to augment carbon sinks in the Indus Delta

In 2020, Pakistan's Prime Minister announced a 'blue economy policy' for Pakistan, aiming to maximise the region's immense 'blue carbon' potential. Under the Paris Agreement and the implementation of Nationally Determined Contributions (NDCs), blue carbon ecosystems have been proposed as Nature-based Solutions to mitigate climate change. Blue carbon refers to "carbon stored in coastal and marine ecosystems", amounting to a global store of 27-88 $GtCO_2e$. This blue carbon is mainly composed of mangroves, tidal marshes and seagrass beds.

The great potential of Pakistan's Blue Carbon for climate change mitigation

Pakistan currently has 1,464 km^2 of mangroves that sequester approximately 76.4 $MtCO_2e$. The National Climate Change Policy (NCCP) adopted in 2012 recognises the value of mangroves for their sequestration potential. Sindh Province, located on the Arabian sea is home to 95% of the nation's mangrove forests. The seventh largest arid mangrove ecosystem in the world, its area has undergone massive deforestation and intensive degradation, due in part to freshwater diversion, over-exploitation (timber, fodder and grazing) and soil pollution. If these forests are degraded or damaged, however, the sequestered carbon is released into the atmosphere and contributes directly to climate change. It is estimated that globally, mangroves are disappearing three to five times faster than terrestrial forests.

Restoring Sindh's mangroves through REDD+ projects

In 2015, the provincial government launched the Delta Blue Carbon Project through a public-private partnership with Indus Delta Capital and the REDD+ programme. The 60-year project will eventually protect and reforest 350,000 ha of mangroves, as well as maintain biodiversity and improve the economic lives of local communities in the Indus Delta region, in the districts of Thatta and Sujawal. The reforestation is being carried out jointly with local communities, and is expected to eventually create 21,000 full-time jobs by engaging community members in a variety of natural resource management activities, ranging from protecting existing mangrove forests under Mangroves Stewardship Agreements to propagule collection, nursery maintenance, planting, community and infrastructure development, and survey and data collection work. For example, coordination with the REDD+ office in Pakistan is helping to improve field data and better estimate blue carbon stocks and potential. By the end of 2020, 75,000 ha had already been restored, and another 100,000 ha (of original or restored forest) are being monitored by the programme. To date, the project is estimated to have absorbed 1 $MtCO_2e$ between 2015 and 2020, and additional plantings could remove 25 $MtCO_2e$ by 2050, and 150 $MtCO_2e$ by 2075. Finally, in 2018, the provincial government, as part of the federal Ten Billion Tree Tsunami Project (TBTTP), set a target of planting 10 billion trees between 2018 and 2023, of which 1.5 billion will be in mangrove areas.

ESTIMATED BLUE CARBON STOCK IN THE WORLD (LEFT) AND IN PAKISTAN (RIGHT)

Source : World Bank, 2021

GLOBAL STOCK OF BLUE CARBON	NATIONAL STOCK OF BLUE CARBON
10-24 GtC / 27-88 $GtCO_2e$	21 MtC / 76.4 $MtCO_2e$
MANGROVES	
5.3-10.4 GtC	19.8 MtC $873 mn - $1.4 bn
TIDAL MARSHES	
1.4-6.5 GtC	1 MtC $44.4 mn - $74.1 mn
SEAGRASSES	
3.5-8.4 GtC	n.a.

CASE STUDY COUNTRY

COUNTRY	POPULATION	FOREST RESTORATION TARGET	STATE OF RESTORATION IN 2019
RWANDA	12,630,000	2 MHA BY 2030 (BONN CHALLENGE)	708,629 HA UNDER RESTORATION (29% OF THE TARGET)

"Visit Rwanda", from a soft power strategy to a profitable business for forest and wildlife conservation

In 2011, Rwanda joined the Bonn Challenge, a global initiative led by IUCN, and pledged to bring 2 million ha under forest landscape restoration (FLR) by 2030. Amounting to 82% of its territory, this target is the highest national proportion committed under the Challenge. In the early 2010s, the Government of Rwanda also included a 30% national forest cover target by 2020 in multiple economic and development policies. In 2019, the country was estimated to have 708,629 ha under restoration, meaning 29% of its target is achieved. Efforts are estimated to have led to the sequestration of more than 100 $MtCO_2$, according to IUCN calculations. $531 million were invested, including 51% from domestic public expenditure ($275 million) and 36% from co-financing of public funds and international grants. Private sector investment remains below 1%, but new tourism policies might be a game-changer.

Visit Rwanda, a communication strategy to attract visitors and private investments

Football fans across Europe might have felt a little bit closer to Rwanda these last years. Since 2018, players of Arsenal FC – President Kagame's publically supported favorite team – have been wearing a "Visit Rwanda" logo on their sleeves, quickly followed by Paris Saint-Germain, which has displayed the message in Parc des Princes stadium and on its training shirts since 2019.

These prestigious sponsorships with two of the most popular football clubs in the world are the results of a new strategic, soft power campaign launched by the Rwanda Development Board (RDB), the government's institution dedicated to accelerating economic development through private sector growth. Visit Rwanda aims at promoting the country as a touristic destination for the global public. While 1.7 million people visited Rwanda in 2018, according to RDB, the country's image abroad still suffers from the memories of the genocide. Both sponsorships were signed for a huge amount of money: US$40 million over three years to Arsenal FC, and US$8 to 10 million per year to PSG. An investment that raised public concern in the United Kingdom, as the UKAid provides US$80 million a year to Rwanda for development. But the government hoped for a return on investment and help to the private sector on the consolidation of the structuring of the tourism sector. And the strategy seems to work, as revenues indeed spiked by 17% from 2018 to 2019, after a surge of 42% from 2017 to 2018.

Luxury tourism to protect forests and gorillas

The campaign echoes a sustainable tourism strategy of the "Land of a Thousand Hills" to attract visitors, betting on luxury and gorilla tourism to generate more revenues rather than mass-market tourism. "*Rwanda aims to become the leading ecotourism destination on the African continent and is building a reputation as a luxury, high quality, low footprint destination*", reports Francophone media Jeune Afrique. Indeed, tourism is currently the country's largest source of foreign exchange. For that purpose, the country relies on its green landscapes and exotic megafauna to appeal foreign holiday visitors. According to RDB, Rwanda is home to nearly 35% of the world's mountain gorilla population. In May 2017, the price of permits for gorilla trekking in the Volcanoes National Park was raised from $700 to $1,500. 15,132 of them were issued in 2018, increasing the revenues from gorilla tourism by 25% in 2018, and 14% from 2018 to 2019. Revenues from park visits grew by 260% from 2008 to 2019, up to US$498 million. Luxury resort hotels were also opened like the One&Only Gorilla Nest, next to Volcanoes National Park, with prices ranging from US$3,000 to 15,000 per night. Two years ago, RDB also signed a 25-years concession agreement with Imizi Ecotourism Development Ltd for the development of a multi-phased conservation and tourism management program in Gishwati-Mukura National Park. Opened to the public in December 2020, the GMNP was designated a "biosphere reserve" by the UNESCO in October 2020.

Since 2005, €5.2 million have been used to finance local community projects, including to safeguard and protect wildlife, as a governmental policy dedicates 10% of the revenues from park visits to local women of close community. The conservation policy also benefits the fauna: in 2018, IUCN changed the status of mountain gorillas on its Red List from "critically endangered" to "endangered", as the population across Congo, Uganda and Rwanda raised from 680 individuals in 2008 to over 1,000 in 2019.

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