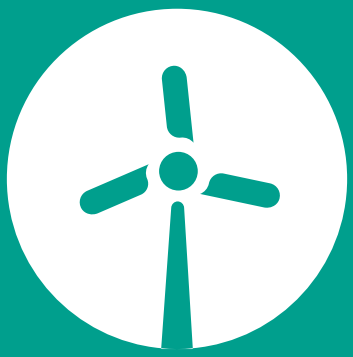
CLIMATE CHANCE

2018 GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION



ENERGY

BOOK 1

Sector based action

**PUBLISHED BY CLIMATE CHANCE ASSOCIATION,
NOVEMBER 2018**

Citation
**CLIMATE CHANCE (2018)
« SECTOR-BASED ACTION »**

**BOOK 1 OF THE ANNUAL REPORT
OF THE GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION**

REVISED AND CORRECTED VERSION - DECEMBER 2018

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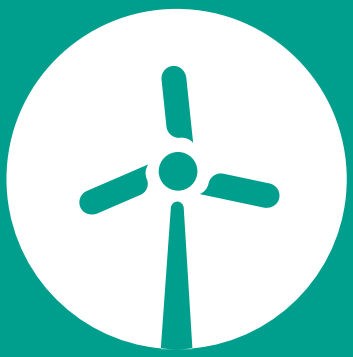

ENERGY

ELECTRICITY AND HEATING 4

SECTOR PROFILE 4
The long road to low carbon energy

KENYA 20
Kenya: innovation at the service of low-carbon electrification

CHINA 30
Decarbonising the chinese power mix: a daunting challenge

GERMANY 42
Germany, a model under construction?

CANADA 54
Canada, the long road towards decarbonisation of the electricity mix

PORTUGAL 66
Portugal: a blazing energy transition hampered by the resilience of coal

UNITED-STATES 78
The United States: towards a bottom-up climate leadership?

FUGITIVES EMISSIONS 90

SECTOR PROFILE 90
Fugitive emissions:a blind spot in the fight against climate change

CARBON CAPTURE AND STORAGE 102

SECTOR PROFILE 102
Carbon capture and sequestration: a solution that is struggling to materialise

The long road to low carbon energy

With an electrification rate of 87%, electricity has become a part of everyday life for the vast majority of people around the globe. The production of electricity and heat plays a central role in improving living conditions and economic development, but is also responsible for almost a quarter of man-made greenhouse gas emissions. Achieving a drop in emissions from this sector is therefore a major challenge in limiting the scale of global warming

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CONTENTS

1 • EMISSIONS PUSHED UP BY DEMAND FOR ELECTRICITY

• Evolution of emissions levels

• Electricity demand continues to grow

• Evolution of the electricity mix

2 • GLOBAL POLICY TRENDS

• In 2016, electricity became the top recipient of fossil energy subsidies

• Policies in favour of renewables

3 • ECONOMIC STAKEHOLDERS AND THEIR ENVIRONMENT

• Traditional operators in trouble

• Increasing influence of new operators and solutions

4 • LOCAL INITIATIVES: A CRUCIAL ASPECT OF THE TRANSITION

• Local governments: supplementing state efforts through innovation

• Civil society reclaiming its electricity

1 • EMISSIONS PUSHED UP BY DEMAND FOR ELECTRICITY

Following a slight drop in 2015, global CO2 emissions in the electricity and urban heating sector rose again in 2016, increasing by 0.4 % to a total of 44 million tonnes of CO2. Preliminary data for 2017 indicates that this rise accelerated last year: within G20 countries, which were responsible for 80% of emissions in this sector in 2016, emissions rose by 1.9% in 2017 (Enerdata).

• EVOLUTION OF EMISSIONS LEVELS • Greenhouse gas emissions linked to the production of heat and electricity have risen by an average of 1.1% over the last 10 years. Emissions levels reached 11.5 billion tonnes of CO2 equivalent in 2016, or around a quarter of global emissions.

The breakdown of emissions is heavily lopsided, with the planet's six largest emitters (China, the US, the EU, India, Russia and Japan) responsible for 70% of global emissions. Even within these groups, emissions are subject to diverging trends - emissions levels are trending downwards in the European Union and the United States, but rising in India and China, and holding steady in Russia. Japan, meanwhile, experienced an emissions peak in 2012 and 2013, due to the increase in thermal electricity production following the Fukushima disaster and the loss of the nuclear power plant there.

These varying dynamics have led to shifts in the ratio of power on a global scale: North America, which has historically been the biggest emitter, was overtaken by Asia in 2000. OECD countries were caught up by non-OECD countries in 2005; India and China are now by far the world's biggest emitters, and their "lead" is set to increase even further in the coming years.

TABLE 1 - GREENHOUSE GAS EMISSIONS (MTCO2E) FROM PRODUCTION OF HEAT AND ELECTRICITY

(source : Enerdata)

	2005	2010	2016	2017
World	**9,638**	**10,910**	**11,591**	**n.a.**
China	2,167.2	3,077.7	3,731.2	3,890.0
USA	2,439.4	2,267.3	1,812.6	1,745.4
European Union	1,294.5	1,175.3	948.9	n.a.
India	494.7	676.2	946.7	974.9
Russia	530.6	544.9	535.3	534.1
Germany	305.5	288.8	273.7	264.9
South Africa	200.0	233.2	231.0	232.9
Saudi Arabia	108.1	142.6	158.0	159.8
Indonesia	71.4	92.9	136.8	146.1
Canada	119.9	101.5	83.4	85.6
United Kingdom	171.9	152.0	73.2	64.1
Brazil	20.7	26.4	44.8	47.8
France	37.4	42.6	22.4	26.8
Morocco	15.7	15.6	22.0	n.a.
Colombia	5.85	9.80	11.84	5.3
New Zealand	8.82	5.31	2.99	3.6
Kenya	1.50	2.08	1.13	n.a.
Fiji	0.275	0.334	0.342	n.a.
Iceland	0.003	0.003	0.002	n.a.
Ethiopia	0.010	0.055	0.002	n.a.

• ELECTRICITY DEMAND CONTINUES TO GROW • These developments are determined by two fundamental variables: demand for electricity and heat, and the respective carbon intensity of each resource.

In 2017, electricity consumption rose by 2.8% compared to the previous year. This increase is

comparable to the rises observed over the previous decade (2006 - 2016): an average of 2.7% per year (BP Statistical Review, 2018). At the same time, global population increased by 1.2% per year, a net increase in electricity consumption per inhabitant of over 1% per year.
This increase is explained by the progress of electrification: between 2006 and 2017, the proportion of the global population with access to electricity increased from 81.2% to 87.4%. This indicates that in 2017, 1.2 billion more people were consuming electricity than in 2006.

Organisation of private electrification

Historically, electrification has been achieved via access, through a national or regional electrical grid, to a centralized electricity production sector. This approach, which is highly capital-intensive, often takes significant time to implement and generally requires strong public support. Renewable energies now allow the creation of small production devices, through which it is possible to produce electricity at the level of an individual household (solar lanterns, solar home system, etc.) or a local area (micro-grid fed by a solar installation or a hydraulic micro-turbine, for example), without requiring access to the national electrical network.
These systems generally emit only low levels of greenhouse gases, but more importantly they enable individuals and small organisations to invest in their own electricity production facilities. Moreover, they are often designed and installed by local companies whose technical skills and equipment needs are much more limited than those required for conventional electrification. Conversely, this type of electrification also poses new problems, notably in terms of ensuring the quality of equipment and installations.
Such problems have been observed, for example, in the development of solar energy in Zambia: imported materials were often of mediocre quality, sales agents provided insufficient advice to users, and there was a general lack of technical skills needed for the installation and maintenance of solar systems. In order to limit these risks without hindering private initiative, the Energy Regulation Board of Zambia implemented a licensing system for importers and installers of solar materials. A code of best practices was established in partnership with companies in the sector and the Zambian bureau for standardization, and a certification training program was set up for technicians.

Source : Energy regulation board of Zambia

TEXT BOX 1

Due to the combined spread of electrification and high birth rates, the fastest growth rates in electricity consumption are found in countries with low levels of economic development. The growth rate has topped 11% in Cambodia, Ethiopia, Myanmar, Laos, Mali, Cape-Verde, Sudan and Côte d'Ivoire. However, consumption in these countries remains very low in absolute terms.

In emerging and industrialized economies, the increase in electricity consumption is linked, above all, to economic growth. In China, electricity consumption rose by 6% in 2017, at almost the same rate as gross domestic product (7%). Chinese electricity production has doubled in 10 years.

In India, the two phenomena are mixed: the growth in demand for electricity exceeded 12% in 2017, well over the 7% growth in economic activity. This difference can be explained by the progress achieved in electrification, with half a billion people gaining access to electricity since 2000 and an access rate that has almost doubled from 43% in 2000 to 82% today (OECD/IEA, 2018).

Together, China and India represented 70% of the global growth in demand for electricity, with a further 10% originating in other emerging economies in Asia.

Even though electricity continues to acquire new uses (mobility, heating, etc.) which can push up consumption rates even in mature economies, developed countries account for only 10% of global consumption increases, with growth rates in electricity demand of less than 1% on average. In the United States, electricity demand fell by almost 80TWh in 2017, compared to 2016 levels. In the European Union, the 2.3% growth in demand (or 75TWh) is equal to the level of economic growth. Demand for electricity also fell in Japan, by roughly 15TWh (OECD/IEA, 2018).

However, it should be noted that rates of consumption per inhabitant remain highly disparate between different countries. As such, electricity consumption per inhabitant in India was only 7.5% of the figure recorded in the United States (ENERDATA, 2017).

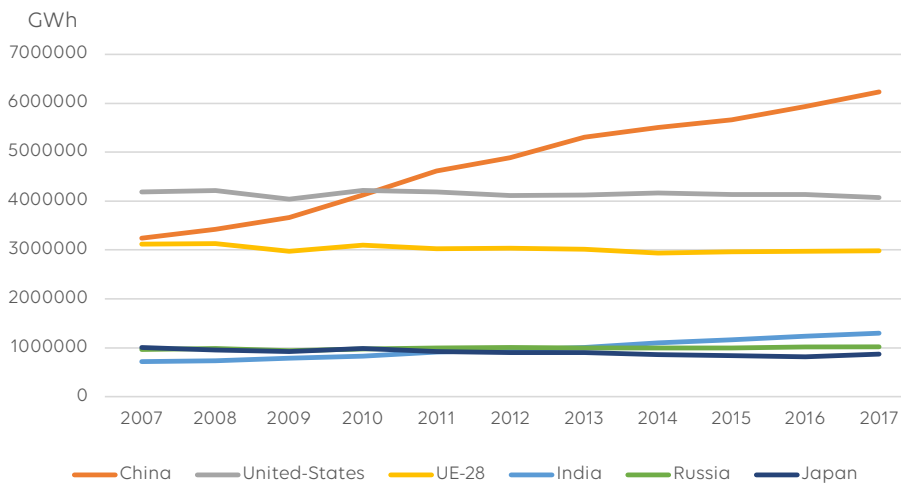

FIGURE 1. PUBLIC ELECTRICITY PRODUCTION

(Source Enerdata)

• EVOLUTION OF THE ELECTRICITY MIX • The carbon intensity of electricity production is the second factor in the explanation of the evolution of emissions levels. Electricity is supplied by a range of sources (or an "electricity mix"), some of which emit high levels of greenhouse gases, such as coal (roughly 880 grams of CO2 per kilowatt-hour produced) or oil (710gCO2/kWh), while others such as gas emit lower amounts (390gCO2/kWh). Finally, the carbon footprint of renewable energies and nuclear is zero in terms of direct emissions, and remains very low if we view these sources in terms of their full life cycle: estimates vary from 18 - 180gCO2/kWh for solar, for example, or from 7 - 56 for wind and 4 - 110 for nuclear (IPCC, 2014).

The proportion of each of these sources in the electricity mix determines the carbon intensity of global electricity consumption. This carbon intensity level has been stagnant for 10 years, despite significant progress in China, the USA and within the European Union.

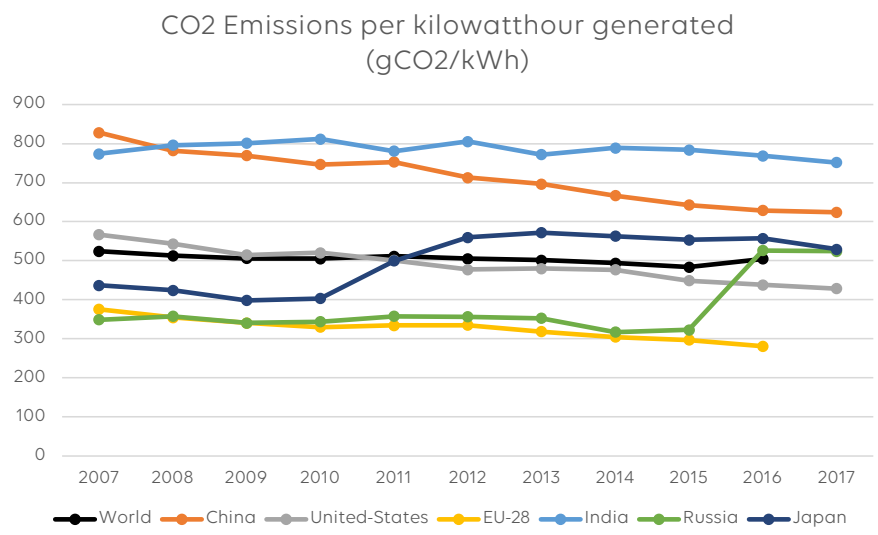

FIGURE 2. CARBON INTENSITY OF THE ELECTRICITY MIX

Data source : ENERDATA

The use of coal is by far the greatest source of emissions: it accounts for around 74% of emissions from this sector, even though coal produces only 38% of the world's electricity and 42% of its heat (IEA, 2018). In 2017, coal-based electricity production increased by 3% (280TWh) globally - a figure which represents a third of the total increase in electricity production, and more than cancels out the 250TWh reduction observed in 2016. The growth in coal-based electricity production occurred primarily in China and India. The growth of coal in Asia has only been partially offset by the decreases recorded, in particular, in the USA and Europe.

Gas is next in line, with 21% of emissions for 23% of electricity production and 42% of heat production; Gas-based electricity production increased by 1.6% (95TWh), or almost 15% of total growth, with the most significant contributions coming from the European Union, China and South-East Asia (IEA, 2018). Oil products accounted for 5% of emissions for 4% of heat and electricity production.

Decarbonized energy sources (renewables and nuclear) are responsible for 35% of global electricity production (mostly through hydroelectricity, nuclear and wind) and 8% of heat (mostly through biomass and waste).

		Electricity	Heat
Fossil fuels	Coal	38.3%	42.1%
	Oil-based products	3.7%	4.3%
	Gas	23.1%	42.3%
Fissile	Nuclear	10.4%	0.2%
Renewables	Biomass	1.8%	4.1%
	Waste	0.4%	3.2%
	Hydroelectricity	16.6%	0.0%
	Geothermal	0.3%	0.3%
	PV solar	1.3%	0.0%
	Thermal solar	0.0%	0.0%
	Wind	3.8%	0.0%
	Marine energy	0.0%	0.0%
Other		0.1%	3.5%

TABLE 2. SHARE OF VARIOUS ENERGY SOURCES IN ELECTRICITY AND HEAT PRODUCTION IN 2016

(Source: IEA, 2018)

Renewable energy sources supplied almost half of additional electricity production in 2017, bringing their share in global production to a record level of 25%, up from 18% ten years ago. In 2017, renewable energies taken together were the second-biggest electricity source on the planet, behind coal but ahead of gas an nuclear.

Hydroelectricity: at the crossroads of mitigation and adaptation

Hydropower is the only renewable energy source to have been employed on a wide scale since the early days of electricity production. Today, it remains the largest source of decarbonized electricity, far ahead of nuclear and other renewable energies. Hydroelectricity therefore plays a significant role in limiting emissions in the sector, but this method of power production also requires water resources of sufficient quality and quantity, making it vulnerable to climate change, which can cause changes in rainfall levels, limiting the production capacities of existing facilities and increasing the risk factor for new ones. It can also affect water quality: melting ice caps, for example, increases the presence of sediment and therefore causes turbines to wear out faster.

Built in the 1930s, the Hoover Dam is an icon of hydroelectricity in the USA, and serves to exemplify these hazards: its production capacity is regularly reduced by the drought ravaging the western United States. Other sources of energy, in particular gas power stations, are left to fill the resulting gap, while also increasing costs and CO2 emissions.

Developing countries are even more vulnerable to these types of threats: in Tanzania, hydroelectricity represented 90% of electricity production in the 1990s. The drought that began in the early 2000s had major repercussions for electricity production, and therefore for the country's population and economy. In 2011, an energy crisis left inhabitants without power for 12 - 16 hours per day, leading the IMF to lower its growth forecast for Tanzania's GDP: the country did not have sufficient production capacities to stand in for its hydroelectric power stations. Faced with the uncertainty surrounding hydroelectricity, Tanzania has now chosen to develop its thermal production sector. Today, hydroelectricity accounts for only a third of the Tanzanian electricity mix, equal to natural gas and oil.

Hydroelectric plants are also sensitive to excess rainfall. In 2018, the Saddle dam in Laos, which was under construction, collapsed following a period of heavy rainfall, flooding villages downstream and killing over a hundred people. The NGO International Rivers criticized the construction of structures which were "incapable of withstanding extreme climate conditions" at a time when these were "becoming more and more frequent."

TEXT BOX 2

Finally, nuclear production increased by 3%, or 26TWh, in 2017. Nevertheless, the addition of new reactors around the globe only counteracts a small proportion of those shut down in 2017: the restarting of Japanese reactors having been offline since 2011 is responsible for 40% of the growth in production.

2 • GLOBAL POLICY TRENDS

Global energy policies remain contradictory: on the one hand, governments massively support fossil energies, and on the other, measures in favour of decarbonized energy and greater efficiency are becoming more and more widespread.

• IN 2016, ELECTRICITY BECAME THE TOP RECIPIENT OF FOSSIL ENERGY SUBSIDIES • Public involvement in the electricity sector is widespread. In particular, it takes the form of subsidies, a significant proportion of which are allocated to greenhouse gas-emitting energy sources: in 2016,

the consumption of fossil energy was subsidized to the tune of 260 billion dollars, 41% of which was designated to the electrical sector - making it the primary recipient, surpassing oil and gas for the first time (40%). The development of renewable energies, meanwhile, received 140 billion dollars in 2016 (IEA, 2017). Global energy policies therefore continue to incentivize the consumption of fossil energy.

These policies are justified in the name of development, employment, allowing electricity-consuming companies to remain competitive, or efforts to combat energy instability. However, they are often short-sighted, disproportionately benefitting the wealthier portions of society who consume more energy. Such policies can therefore have the effect of encouraging consumers to waste energy, and throwing public budgets off balance (Shirai, 2017).

In addition to direct financial incentives, energy policies use numerous other measures to support fossil energies: price controls, quotas, subsidized prices, guarantees, direct investments, research and development, technical restrictions, etc. (IEA/OECD/World Bank, 2010). In the USA, for example, an obsolete regulatory framework enables non-competitive coal-fired power stations to remain in service (Carbon Tracker, 2017). Capacity markets and strategic reserves, designed to keep Europe's little-used thermal power stations available for production, are another example of indirect support for fossil energies (Zimmermann, 2017).

These measures are even more harmful when their effects are long-lasting: two thirds of fossil subsidies were introduced before 2000 (OECD, 2018), and a thermal power station has a lifespan of over 30 years.

Measures in favour of fossil energies are being partly counterbalanced by the increasing appearance of Carbon Markets (notably the Chinese market, which was launched during the COP23) and taxes on energy carbon content. These measures have the effect of making fossil energies - particularly coal - less competitive. They have been shown to be particularly effective in the UK, where the doubling of the carbon price floor to £18/TCO2e in 2015 led to a two-thirds reduction in the proportion of coal in the electricity mix (Carbon Brief, 2016).

• POLICIES IN FAVOUR OF RENEWABLES • Policies in favour of fossil energy are also being counterbalanced by the increasingly widespread appearance of pro-renewable energy measures. When they are built upon coalitions uniting public bodies, industrial groups, civil society and international organisations, these policies can even take root in developing countries rich in fossil resources, such as Mexico, Thailand or South Africa (Rennkamp, 2017).

Investments in renewable energies, especially solar and wind power, were initially encouraged through Feed-in tariffs. In 2017, over 80 countries were using this system. The main difficulty involved is setting tariffs at a level that is sufficiently high to attract investors, while also remaining sustainable (IRENA, 2018). This difficulty has led a growing number of countries, including China and Germany, to turn towards an auction system.

This change of tack has significant consequences for operators in the energy sector: energy auctions are well-suited to benefit major projects and large companies, but are difficult to access for smaller developers or non-professionals (individuals, farmers, cooperatives, etc.) However, the auction system does enable a faster drop in the price of renewables by encouraging companies to adopt more aggressive strategies. To ensure success, these companies set their prices by taking account of cost reductions expected during development of their project. This competition can result in the failure of overly-ambitious projects: in the UK, for example, solar projects selected during a 2015 call for tenders at a cost of less than 60£/MWh were all later abandoned (Energie et Développement, 2017).

Other incentive instruments may also be employed, notably including quotas that require certain operators to employ a minimum amount of renewable energies. These requirements have been applied in India and the UK, for example, as well as in 29 US states, and are often accompanied by a certification system enabling producers of renewable electricity to enhance the value of their

output. Non-regulatory measures also exist, such as financial or fiscal instruments to encourage investments in renewable energies. (IRENA, 2018)

Finally, it should be noted that support is lagging behind for the production of renewable heating and cooling: in 2016, 126 countries had implemented polices to incentivize the development of renewables in the electricity sector, compared to only 29 in the heating sector (IRENA, 2018). Policies in favour of renewable heating and cooling are mostly based around quota systems.

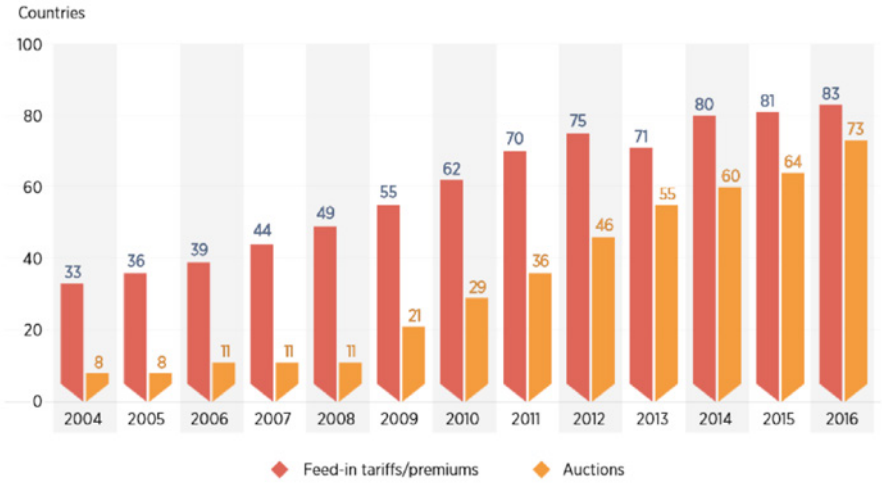

FIGURE 5. NUMBER OF COUNTRIES USING FEED-IN TARIFFS AND/OR AUCTIONS

(Source: IRENA, 2018)

3 • ECONOMIC STAKEHOLDERS AND THEIR ENVIRONMENT

The production of electricity and heat, as well as their transmission, distribution and associated services requires the involvement of a large number of companies, varying greatly in size: local, national and international producers, suppliers of equipment and services, financiers, etc. The challenges of moving towards a low-carbon energy system are different in each of these categories, as are the respective strategies to be applied in each one.

• TRADITIONAL OPERATORS IN TROUBLE • Large electricity companies play a central role. Generally, these companies are the remnants of former national monopolies, having seen their production, transport and distribution activities separated around the early 2000s as part of a wider effort to open the sector up to competition. Some companies remain entirely public (such as the State Grid of China, the world's largest electricity company), but many have been partially or totally privatized, as is the case with Enel and EDF, the 2nd and 3rd largest companies in the sector. They operate with a high degree of independence, although most remain under the control of a government or regulator given their role as a public service provider.

These electricity companies manage infrastructures characterized by very long lifespans - over half a century for coal power stations and hydroelectric dams, and several decades for nuclear reactors and gas power stations. Despite this level of inertia, they must adapt to a political - and above all, economic - context (rise in the cost of fossil energies, disinvestment campaigns, competition from renewables) which has been changing shape at increasing pace over the past two decades. This temporal disparity poses a significant risk to such companies: with their generation plants no longer suitably equipped to meet market demand, these companies would be left with non-competitive assets (or "stranded assets"). A fifth of the world's electrical power stations could find themselves in this position if the objectives of the Paris Agreement are met (Pfeiffer, 2018). In Europe and in the USA, the electricity sector has already been hit by the depreciation in value of major assets, which has reduced the profitability of large electricity companies and led to the loss of hundreds of billions of euros in capitalization (IRENA, 2017).

Faced with this situation, the strategies adopted by these companies tend to fall into one of two categories:

• "addition" strategies, which involve adapting existing infrastructures to new requirements: carbon trapping and storage, enabling emissions from thermal power stations to be cancelled out, including where these already exist, or intelligent networks within this category.

• "substitution" strategies, which aim to replace existing systems - this is particularly the case in renewable electricity production.

All the major energy developments of the 20th century were dominated by addition strategies, and this remains the case today: an analysis of the patents submitted by the 6 largest European electricity companies shows that they continue to favour this approach, even while renewable energies (accompanied by intelligent networks) are considered the technological priority for the European electrical sector (Buttigieg, 2016).

Large companies in this sector are also adapting to market changes via business reorganization: the number of merger-acquisitions in the European electricity sector increased by 30% in 2017. These operations often aim to re-centre the company around its core activity and get rid of peripheral business lines, especially where these involve fossil energies (IEA, 2018). German company Uniper, for example, has cut off its upstream gas and petrol operations, while France's Engie has relinquished gas power stations in the USA and the UK, as well as a coal power station in Australia.

Restructuring of the German electrical sector

Germany's two biggest electricity companies, Eon and RWE, were both severely affected by the withdrawal from nuclear energy and decline of coal, which represented the vast majority of their electricity production assets. They also suffered a significant drop in the wholesale price of electricity, which fell from an average of €60/MWh in 2011 to 35 today. Finally, the rapid development of renewable energies led to the appearance of new competitors, with a more decentralized production network.

Germany's big electricity companies have been slow to turn to renewable energies. In 2013, when renewables already represented almost 40% of Germany's production capacity, they made up only 18% of Eon's production and 6% of RWE's.

Faced with these difficulties, Eon decided to divide up its business operations: on the one side emerged a new Eon that would focus on renewables, electricity distribution and services, while on the other side was Uniper, which took over the fossil energy stock to manage its end-of-life phase. Initially, Uniper was also supposed to take on Eon's nuclear reactors, but the German government, worried that Eon was attempting to renege on its responsibilities, refused to allow the transfer to go ahead.

This separation has formed two companies with highly different profiles: the new Eon hopes to revive itself through growth and concentrate on investments, while Uniper must pay higher dividends to its shareholders in order to compensate for declining asset values. The separation took place in 2016, and in 2018 Eon turned a definitive corner by selling its shares in Uniper to the Finnish company Fortum for €3.8 billion. This transaction should enable Eon to finance its transformation.

By contrast, RWE initially rejected the idea of a split, choosing instead to focus on cost reduction: 2400 jobs were cut in 2014, investments were reduced, and the company's oil and gas businesses were sold off in 2015. But in 2016, the company finally placed its business operations for renewables,

networks and distribution into separate affiliates, which were then launched on the stock market.
The next step consists of a merger between the two companies: Eon will acquire 76.8% of Innogy, RWE's affiliate for renewables. In return, RWE will acquire a 16.67% stake in Eon, thereby becoming the biggest shareholder in its historic rival.

Source: Financial Times

TEXT BOX 3

The evolution of the electricity mix and the strategies of electricity companies also have consequences for equipment suppliers. Producers of turbines for use in thermal power stations, such as German company Siemens or GE in the USA, are having difficulty maintaining their production chains, and are attempting to develop into the renewable energy sector. The same is true of industrial groups in the nuclear sector, which are facing difficulties due to restructuring: this was the case for French firm Areva, which was dismantled in early 2018,as well as Japanese company Toshiba, which sold its bankrupt nuclear subsidiary Westinghouse.

• INCREASING INFLUENCE OF NEW OPERATORS AND SOLUTIONS • The difficulties experienced by large companies in the sector have facilitated the emergence of new operators; alternative producers and developers, manufacturers of equipment and batteries for the renewables sector, etc. This was the case with French group Neoen, which was created in 2008, and within a decade has become one of the biggest producers of renewable energies on the planet. Neoen notably operates the world's largest battery, the Hornsdale Power Reserve in Australia, which was developed in partnership with Tesla. Other companies have also used the transition of the electricity sector as a chance to reinvent themselves, such as Danish company Ørsted (formerly DONG Energy). Founded in 1972 to explore oil and gas resources in the North Sea, around 2010 the company established itself as a champion of wind energy and biomass: Ørsted now owns almost a quarter of the world's off-shore wind turbines.

The transition of the electricity sector has also led to the emergence of entirely new economic activities and models, particularly in electricity supply services.

Two technical and economic innovations: load management and PAYG

Load management (or demand-side management) involves voluntarily reducing electricity consumption during periods of high demand or low production, in order to help achieve network balance. With the development of variable renewable energies such as wind and solar, this type of operation could become indispensable. Mechanisms have been implemented in the USA, Russia and several European countries to reward consumers who contribute to balancing the electricity supply in this way. Technical solutions allowing individuals and companies to automatically offset a proportion of their consumption have appeared in recent years. These are operated by load management aggregators, which coordinate and sell their subscribers' reductions in consumption.I n France, load management's potential is equivalent to the production capacity of 6 - 10 nuclear reactors, and this untapped resource has given rise to a number of startups: Voltalis, Energy Pool (belonging to Schneider Electric), BHC Energy (a subsidiary of Total), Actility, Smart Grid Energy, Hydronext, etc.
In Africa, the development of the network is the main challenge, rather than supply management. The use of a domestic solar power device is one solution providing rapid access to electricity. The difficulty with these projects resides in their financing: users do not always have the necessary savings or credit to invest in these systems, whose costs can vary from

$100 to over $1000, and companies are reluctant to invest without reliable means to cover their costs. The pay-as-you-go (PAYG) model can resolve this problem.
While a number of variations of this system exist, in general it involves a company renting a full domestic solar power kit to an individual or household (solar panel, battery, electronics and connections, and sometimes also equipment such as bulbs and televisions). The company also performs the installation and maintenance of the system in exchange for an initial payment of 0 - 30% of the value of the kit, followed by a daily, weekly or monthly payment, often made via telephone. The sale and installation of these systems is often carried out by local operators, which has the effect of boosting business. In the event of non-payment the system can no longer be used, but unlike with a bank loan there is no financial risk for the user.
The PAYG model enables renewable electricity to be brought to households which previously had no electrical supply. Companies active in this field, such as Baobab+, Mobisol, M-Poka and Lumos, have already raised $360 million and have 750,000 customers, mainly in east Africa. For the companies, this business model has the advantage of creating a sustainable relationship with their customers. Some of these companies are creating added value via options and improvements to the solar kits: For example, Fenix, a Ugandan company purchased by Engie in 2017, offers a battery whose storage capacity can be increased via a simple activation code.

Source: Ademe, 2017 and Hystra 2017

TEXT BOX 4

Finally, the rapid development of the sector is stimulating the emergence and development of think-tanks and specialist consultancy firms. This is the case, for example, with New Energy Finance, a supplier of data on renewable energy for the finance and energy sector: founded in 2004, the company was purchased by Bloomberg in 2009 following 5 years of rapid growth.

The role of the financial sector

Given that electricity projects remain highly capital-intensive, the transition of existing operators and the emergence of new enterprises requires support from the financial sector. This sector is becoming more and more reluctant to invest in coal-based projects, and in fossil fuels more generally: In mid-2018, 1000 institutional investors managing 6240 billion dollars in funds had committed to divesting from fossil energies, which is twelve times the number observed 4 years ago (Arabella Advisors, 2018).
The divestment movement took shape in 2011 in the American universities managing major funds: Harvard, for example, possesses an investment fund worth almost 40 billion dollars, which the university ceased investing in fossil energies in 2017 following years of campaigning from students and professors. However, divestment is no longer limited to militant investors: among the organisations currently divesting from fossil fuels are the World Council of Churches (which unites 348 religious organisations), cities such as San Francisco and Berlin, insurers such as Axa and Allianz, and GPFG, the largest sovereign wealth fund on the planet.
Divestment is not the only tool available to financiers for influencing company choices. Other strategies also exist, including:
- «Best in class», which in theory does not exclude any given sector, but within each sector investments are only made in companies posting the best results. This is the approach taken by the DJSI World (Dow Jones Sustainability Index): this index, offered by RobecoSam and Standard & Poor's, is based

on an annual questionnaire sent out to the 3400 biggest companies on the planet, before selecting the 10% of highest-performing companies in each sector. Regional and national DJSI indexes also exist.
- Shareholder activism, which involves harnessing the power of shareholders to influence company strategies. This method is often employed by non-governmental organisations in order to make their voices heard during AGMs, but can also be used by major financial operators: during their 2017 AGMs, for example, Goldman Sachs voted in favour of half of all climate-related resolutions, up from 39% en 2016; JP Morgan, meanwhile, supported 16% of these initiatives compared to 5% the previous year (Bloomberg, 2018).
While these types of movements are gaining ground, they do not seem to be slowing down fossil fuel projects: alongside emerging green finance, plenty of brown financing remains available.

TEXT BOX 5

4 • LOCAL INITIATIVES: A CRUCIAL ASPECT OF THE TRANSITION

The development of renewable energies is generally based around production facilities operating on a smaller scale than conventional power stations, and the reduction of electricity consumption is achieved through local projects. The transition of the electricity sector therefore has the effect of handing the initiative to local regions and operators: local governments, associations, cooperatives, etc.

• LOCAL GOVERNMENTS: SUPPLEMENTING STATE EFFORTS THROUGH INNOVATION • Action at local level can enable local governments to experiment with, supplement or bypass policy implemented at the national level. In China, for example, carbon markets were created in 2011 by cities such as Beijing and Shanghai. A national system is due to be established based on these experimental initiatives. In France, the national government has chosen to give local governments the lead role in the implementation of the energy transition: most inter-communal councils are expected to produce their own Regional Climate-Air-Energy plan by the end of 2018, notably including actions to manage local energy demand and develop the production of renewable energy. In the United States, by contrast, it is the federal government's hostility to fighting climate change that hands the initiative over to state governments. This is the case, for example, with the Regional Greenhouse Gas Initiative, via which nine states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont) have established a carbon market in order to reduce greenhouse gas emissions from power stations by 65% by 2030, or the Powering Past Coal Alliance which includes 7 states (California, Connecticut, Hawaii, Minnesota, New York, Oregon and Washington) and two cities (Honolulu and Los Angeles) among its members. The role of local governments does not just supplement the efforts of the State: the re-emergence of more decentralized energy systems gives cities and regions a more central role to play in renewable energy policies. Local involvement in favour of renewable energy is stimulated by the economic advantages brought about by green energy, as well as the potential to mitigate climate change, improve air and water quality at the local level, and create jobs.

Municipal government, regulator and electricity company: the experience of Cape Town

As is the case with many municipal governments, the city of Cape Town manages a large proportion of electricity distribution in its local area: the

city serves over 550,000 private consumers, or 75% of households, with the remainder falling under the responsibility of the national electricity company Eskom. In 2008, during a national electricity shortage, Cape Town sought to use this prerogative to make better use of its renewable potential and limit its energy dependence.

Lacking experience and a regulatory framework, the city decided to proceed step by step. The government first approached the South African electricity regulator, NERSA, to study the feasibility of its plans and obtain authorisation to carry out a pilot project. In 2011, following a new request, NERSA clarified its regulatory framework by authorizing governments to distribute electricity produced by facilities of 100kW or less in their local area; in exchange, the producers could deduct the electricity supplied to the grid from what they purchased. This version therefore assumes that producers would remain net consumers of electricity. Despite this limitation, it encouraged South African local governments to promote the installation of small renewable energy production facilities in their local regions. In 2013, Cape Town extended its program to support GreenCape investments, whose vocation is to stimulate the launch of renewable energy projects. At the same time, the city elected to replace its electricity meters, and worked with Eskom and the electricity industry to develop a pre-paid meter capable of recording electricity consumption and production with equal accuracy.

In 2014, NERSA raised the maximum capacity of projects managed by local governments from 100kW to 1MW. In addition to the increase in electricity tariffs, this reform led companies to put forward large-scale projects. The contract for the first 1.2MW solar project was signed in September. In order to obtain NERSA authorisation, the project was registered as two 0.6MW projects.

In 2015, NERSA initiated a broad-scale consultation process with local governments in South Africa, with the aim of introducing a new regulatory framework (currently in development). In the meantime, Cape Town is continuing to develop its own procedures: in 2016, it published its guidelines for the installation of roof-mounted solar panels; a metering methodology and buy-back tariffs were also put in place.

Source: Hermanus, 2017

TEXT BOX 6

With responsibility for regional development and management of public services, local governments are also on the front lines when it comes to deploying innovative technology in the electricity and heating sectors. They can therefore become drivers for the transition of other sectors, for example by encouraging the integration of electric vehicles, modernizing public transport fleets, and making the use of biofuels or solar water heating mandatory in order to meet municipal heating needs. In addition, lessons learned at local level often help clarify issues in the construction of national policies.

Hundreds of local governments have made commitments to achieving 100% renewable electricity, as is the case with the UK100 in Britain, which unites 90 local decision-making authorities. In 2017, municipal leaders in Japan published the Nagano Declaration, in which they committed to working towards achieving 100% renewable energy for their cities. Similarly, new objectives for 100% renewable energy or electricity were set by eight US cities in 2017, bringing the total number to 48.

Cities have also taken collective measures to consolidate the effects of their efforts. In 2017, over

250 mayors in the USA committed to achieving the objective set by the United States Conference of Mayors for 100% renewable energy by 2035 (although not all the conference's objectives have been transposed into legislation). In Germany, over 150 districts, municipalities, regional associations and cities have committed to producing 100% renewable energy by the end of 2017, by way of a network of 100% renewable energy regions. The European initiative known as the "Compact of Mayors" plays a major role in the reinforcement of dynamics throughout European towns and cities. Initiatives such as C40 Cities also stimulate collaboration, enabling cities to share best practices and drive their energy transitions forward.

• CIVIL SOCIETY RECLAIMING ITS ELECTRICITY • Beyond local public stakeholders, the transition to lower-carbon electricity is achieved via a multitude of private operators.

In the past, action by local stakeholders was often limited to NIMBY («Not in my backyard»), meaning the rejection of major infrastructures likely to disturb local ways of life. This phenomenon remains significant - as was the case with the rejection of the extension of the Hambach lignite mine in Germany, or opposition to the coal power plant at Lamu in Kenya, for example - but the decentralization of electricity production means that local operators can now play a more active role, and take back control of their electricity production.

Renewable energies make it possible for non-professionals to produce their own electricity: roof-mounted solar for individuals, wind turbines or biogas for farmers, etc. The production of heat and cold is also possible via solar water heaters and geothermal heat pumps. On a wider scale, production cooperatives or the co-financing of projects via local credit unions can help enable the development of renewable energies and facilitate their acceptance.

Shared Energy

Due to the major influence of nuclear energy, France's electricity production network remains highly centralized; however, this has not stopped the emergence of citizens' initiatives in favour of renewable energy. As early as 1991 in Chambéry, the firstroof-mounted solar device connected to the national grid was installed in France, thanks to a subscription scheme launched by the Phébus association (later to become Hespul). In the early 2000s, wind turbine projects launched by inhabitants were set up in Brittany with the Éoliennes en Pays de Vilaine association, and in the east of the country by the Agence Locale de l'Énergie des Ardennes.

In 2008, an investment fund was created to finance the installation of solar generators, and soon wind turbines as well (Solira Investissement, which in 2010 became Énergie Partagée Investissement). Among its original members were some of the major organisations in the field of renewable energies and solidarity - Enercoop, the GERES, the Nef, etc. - as well as local stakeholders. Énergie Partagée Investissement is a limited joint-stock partnership, operating under a supervisory council elected by its investors. This companies offers individuals the opportunity to invest in renewable energy projects, while sharing the risk and ensuring the application of best practices (democratic governance, local foundation, no financial speculation, etc.). The fund works closely with the Energie Partagée ("Shared Energy") Association, which is responsible for supporting project backers, along with Énergie Partagée Études (which co-finances the development phase of renewable energy projects), and with regional initiatives.

In 2011, Énergie Partagée Investissement obtained the approval of France's Financial Markets Regulator to collect investments from citizens for projects

in the field of renewable energy and energy efficiency. In one year, over 2.6 million euros were raised this way. At the beginning of 2018, Energie Partagée passed the threshold of 15 million euros raised from over 5000 shareholders. The Energie Partagée network supports over 270 projects.

Source: ENERGIE PARTAGÉE, 2017 ACTIVITY REPORT

TEXT BOX 7

CONCLUSION

Demand for electricity is continuing to increase: over the course of the last 20 years, the electricity sector has been responsible for 70% of the increase in primary energy consumption (BP, 2018). Although progress has been made, this increase in consumption has not yet been offset by a decline in carbon intensity, and emissions are continuing to rise. However, behind its infrastructural inertia, the electricity sector is experiencing a phase of rapid restructuring, characterized by the loss of influence of central governments and major electricity companies, with power being ceded to local governments and new economic operators. This transformation is contributing to the emergence of economic models with lower levels of emissions, and could perhaps prefigure the transition towards fully-decarbonized production of electricity and heat.

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Kenya: innovation at the service of low-carbon electrification

Despite a low population density (42 million in habitants in a surface area of 580,000km²) and a human development index of 0.555, putting it in 152nd place in the world, over the last 10 years, Kenya has made rapid progress in electrification. Emissions from electricity generation have remained stable throughout that period. How has the country achieved these results? Can it be used as a model for low-carbon electrification?

Head editor • **THIBAULT LACONDE** • *Consultant, Energy & Development*

CONTENTS

1 • LOW EMISSIONS

• A low-carbon electricity mix

• Significant use of traditional energies

2 • KENYA'S STRATEGY FOR LOW CARBON ELECTRIFICATION

• Situation of the Kenyan electricity sector

• Government's strategy and action

3 • MOBILISATION OF ECONOMIC STAKEHOLDERS OF ALL SIZES

• A strategy of large projects

• Solar kits, mini-grids, pay-as-you-go...

4 • CIVIL SOCIETY: VIGILANT AND INNOVATIVE

• Perception of projects by civil society

• The role of civil society in innovation

1 • LOW EMISSIONS

In 2016. emissions related to electricity and heat production in Kenya stabilised at 1.1 CO_2 mteq. This level is comparable to that of 2015. the lowest since the mid-2000s. It represents a decrease of 55% compared to the 2013 record. No data are available for the year 2017.

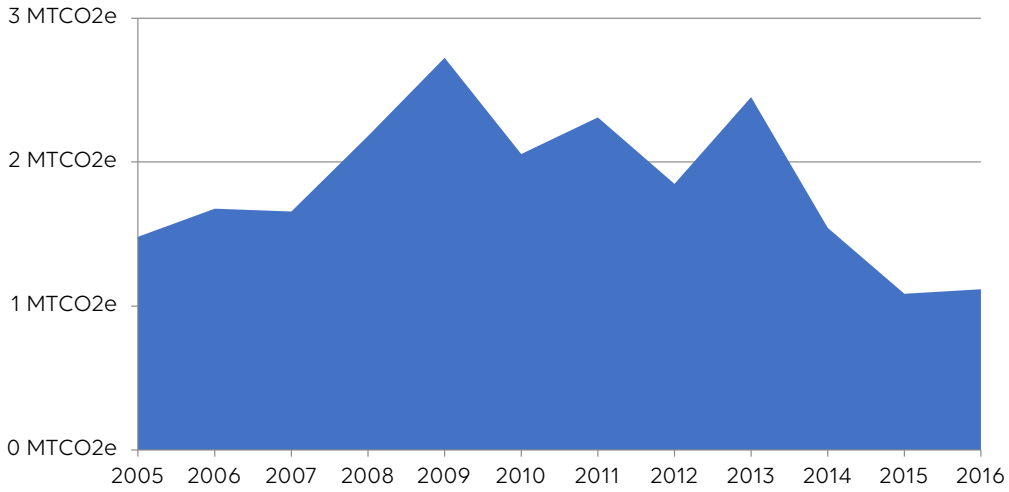

FIGURE 1. EMISSIONS FROM THE PRODUCTION OF ELECTRICITY AND HEAT

(Source: Enerdata)

• A LOW-CARBON ELECTRICITY MIX • Kenyan power sector emissions are particularly low: Spain. which has a similar population to Kenya. for example emits 67 $MtCO_2eq$ per year for its electricity and heat production. This cannot be explained solely by the country's level of development. In 2016. the carbon intensity of Kenyan electricity was 116 grams of CO_2 per kilowatt hour produced. So. to produce the same amount of electricity. Kenya emits. for example. six time fewer greenhouse gases than China or four times fewer than the United States (Ang. 2016).

This good performance can be explained by the composition of the electricity mix: Kenyan electricity generation is historically based on hydropower. with a share of geothermal energy that has grown strongly over the past decade. Fossil production. mostly based on liquid hydrocarbons. completes the mix and. during droughts. offsets the hydroelectric production deficit.

In 2016. despite relatively low hydropower generation. electricity production was 80% renewable. placing Kenya among the top 20 performers in the world for this indicator (IEA. 2018).

		2015		2016	
		Electricity production	Share of the mix	Electricity production	Share of the mix
Fossil fuels	Oil-based products	1,206GWh	12.5%	2,020GWh	20.7%
Renewables	Biomass	122GWh	1.3%	123GWh	1.3%
	Hydroelectricity	3,787GWh	39.2%	3,341GWh	34.3%
	Geothermal	4,479GWh	46.4%	4,204GWh	43.1%
	PV solar	1GWh	0.0%	1GWh	0.0%
	Wind	57GWh	0.6%	63GWh	0.6%

TABLE 1. KENYAN ELECTRICITY MIX

(Source: IEA. 2018)

• SIGNIFICANT USE OF TRADITIONAL ENERGIES • At the same time. emissions across the country are steadily increasing. Excluding emissions related to land use. changes in land-use and forestry (LULUCF). the country emitted 18.3 $MtCO_2eq$ in 2016. an increase of 116% since 2000 and 40% since 2010.

When the LULUCF sector is included. emissions were 73 $MtCO_2eq$ in 2010. i.e. three quarters of the country's emissions. According to Kenya's second official communiqué on its emissions. with increasing fossil fuel demand. this sector is the main contributor to the increase in emissions between 1995 and 2010 (Government of Kenya. 2015).

This finding offsets the good performance of the electricity sector which can be partly explained by a shift of certain emissions linked to energy consumption towards the LULUCF category: in the absence of access to energy such as electricity or natural gas. wood is used to meet heat and lighting needs. Currently. electricity still accounts for only 4% of Kenya's final energy consumption compared to 68% for biomass.

2 • KENYA'S STRATEGY FOR LOW CARBON ELECTRIFICATION

Like many African countries. Kenya faces a challenge: in expanding access to electricity while controlling emissions from the electricity sector.

• SITUATION OF THE KENYAN ELECTRICITY SECTOR • Despite the progress in electrification. demand for electricity remains constrained by insufficient supply and consumption per customer is decreasing.

Kenya's electricity sector is facing several problems. The share of hydroelectricity. whose production depends on weather conditions. makes production difficult to predict. Power cuts are frequent: around six 5-hour breaks per month in urban areas (GOGLA. 2018). Electricity is expensive. about $0.15/ kWh compared to $0.04/ kWh in South Africa. and this burden is poorly distributed. with rates favouring large consumers to the detriment of individuals and small businesses (Institute of Economics Affairs. 2015).

Organisation of the Kenyan electricity sector

At the end of the 1990s. the Kenyan government decided to separate electricity generation. transmission and distribution activities (so-called unbundling policies). The Kenyan power sector is organised around the three major public companies resulting from this split: Kenya Electricity Generating Company (KenGen) for production. Kenya Electricity Transmission Company (KETRACO) for transmission and Kenya Power for distribution and sale.

KenGen produces three quarters of Kenyan electricity. 30% of the company's share capital was offered for sale in 2006 and it is now listed on the Nairobi Stock Exchange. as is Kenya Power. Most of Kenya's electrical installations are owned by KenGen (69%). with a fraction also owned by the rural electrification agency (1%).

Kenya licensed another three companies (Aggreko. Cummins and Deutz) to produce and sell their electricity during the 2000 drought in order to make up for the sharp fall in hydroelectric production. A dozen independent producers (IPP) have since set up in the country: in 2008. they owned 11% of the Kenyan electricity system and by 2017 their share had reached 30%. The production of IPPs is predominantly fossil-based. mainly diesel. The additional cost related to the purchase of fuel is transferred to consumers through a levy on their bills - the IPPs are therefore accused of increasing electricity prices. The government frequently threatens not to renew their 20-year licenses.

An independent Energy Regulatory Commission. the Electricity Regulatory Board. was created in 1998. An Energy Tribunal was established in 2006. primarily to function as body to hear appeals against ERB decisions.

Sources: Kengen annual report. Daily nation

TEXT BOX 1

In Vision 2030. its development programme adopted in 2008. the Kenyan government recognises the difficulties of the electricity sector. The programme prioritises increased production and efficiency gains. To achieve this. it plans to continue energy sector reforms with the creation of a robust regulatory framework and incentives for private investors. It also envisages the creation of interconnections with neighbouring countries with surpluses and the development of new energy resources. including geothermal energy and renewable energies. as well as coal. There has been a major delay in this area: while the plan provided for a capacity of 5.5 MW in 2017 (Government of Kenya. 2013). it has not even reached half of this target with 2.4 MW (KenGen. 2017).

• GOVERNMENT STRATEGY AND ACTION • The 2017-2022 development plan drafted by the Kenyan Energy Regulatory Agency is a continuation of Vision 2030. Between 2018 and 2024. it plans the to build 1277 MW in geothermal power plants. 841 MW wind power. 703 MW solar but also three coal-powered plants of 327 MW.

Kenya is also planning to acquire a nuclear power plant with a target of 1.000 MW in 2027 and 4.000 MW in 2033. The country has signed cooperation agreements in this area with China. Russia. Slovakia and South Korea. Under this latest agreement. signed in September 2016. 16 Kenyan students were sent to Korea to obtain a master's degree in nuclear engineering.

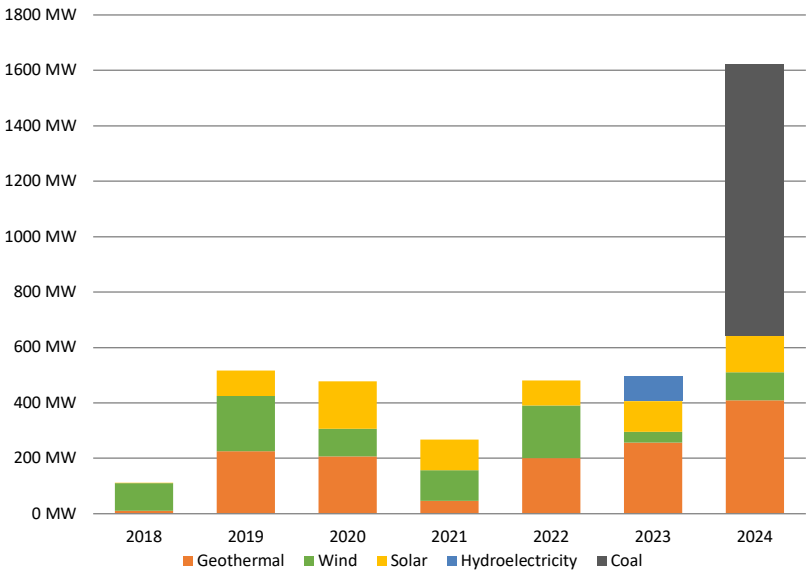

FIGURE 2. NEW COMMISSIONING PLANNED BETWEEN 2018 AND 2024

(Source: Kenya Energy Regulation Commission)

To develop its electricity production. in 2008 Kenya introduced guaranteed feed-in tariffs for electricity. These tariffs. which have been updated since then. provide investors with income for 20 years. In spring 2018. the Kenyan government announced its intention to replace this mechanism with a bidding system in the hope that competition will bring down the price of electricity.

Control of energy demand is also an important factor. Indeed. geothermal installations. which can operate continuously. provide almost half of the electricity and while it is not stored. a significant share of the production is lost during the night and off-peak consumption periods. To encourage companies to shift their consumption. in December 2017 the government created a reduced tariff of 50% for electricity consumed between 10.00 PM and 6.00 AM («time-of-use plan»). By mid-2018. 800 companies had subscribed to this tariff.

Finally. the rural electrification plan seeks to increase the electrification rate from 22% to 65% between 2013 and 2022 and. reaching 100% in 2030. This is the remit of a rural electrification agency created in 2006. In 2016. the electrification rate was 56% (World Bank).

3 • MOBILISATION OF ECONOMIC STAKEHOLDERS OF ALL SIZES

Kenya's electricity policy assigns an important role to the private sector. both in project development and public policy design. For example. the Kenyan government consulted extensively with the business community before launching the Kenya Off-Grid Solar Access Project for Underserved Counties (K-OSAP) to help companies investing in disadvantaged areas (GOGLA. 2018).

• A STRATEGY OF LARGE PROJECTS • The development of Kenyan power generation involves a policy of large projects. often unique on a continental or even global scale. In 2016. the country inaugurated the largest geothermal power plant in the world: Olkaria (280 MW). In 2017. the Lake Turkana wind farm (310 MW) was commissioned - the largest wind farm in Africa and the largest private investment in Kenya's history (REN21. 2017).

These projects are generally part of a broader development policy. The construction of the Lake Turkana wind farm. for example. was accompanied by the creation of road access. fibre optic links and local electrification projects.

Due to their size. these large projects are reserved for large multinationals or the KenGen public electricity company. The Canadian company SkyPower. for example. signed a $2.2 billion deal in

2015 for the development of 1.000 MW of solar power. while the American company GE is building the Kipeto wind farm as part of a 15-year construction and service. Similarly. KenGen produces 100% of the geothermal electricity (Government of Kenya. 2015) and for the time being is the only player capable of supporting the initial investment required for this production.

Innovation in Kenyan geothermal energy

Kenya. home to the Great Rift Valley in the west of the country. benefits from an ideal geological environment that provides it with an estimated geothermal potential of 10.000 MW. The country is concentrating these efforts on this energy to counterbalance the hazards of hydroelectric production: in terms of installed capacity. it is the 9th country. ahead of Japan. In 2016. Kenya installed 6% of new world capacity. although no new installations were established in 2017 (REN21. 2018).

KenGen does restrict itself to implementing existing technologies - the company innovates to accelerate the deployment of new productions. It has therefore developed a technology know as wellhead (because the turbines are installed close to boreholes without the requirement for the creation of a heating system).

The technology was trialled in the Olkaria region from 2012. It involves installing small turbines (2 to 5 MW) as soon as the drilling is completed so that production can start without waiting for the construction of a permanent power station. These turbines can be containerised or assembled on trailers and their installation requires little civil engineering work. They can therefore be moved easily to new projects when the permanent installations are completed.

The wellhead system enables geothermal electricity production to start in a few months. compared to 2 to 3 years for a conventional power plant. Moreover. this system can facilitate the development of geothermal energy by lowering the initial investment and providing the operator with income earlier in the project cycle.

Finally. wellhead type turbines could be used permanently to supply electricity to an isolated grid for which investment in a conventional geothermal power plant would not be justified.

Source: Saitet. 2015

TEXT BOX 2

A difficulty encountered by these major projects comes from the separation between generation and transmission activities that makes coordination more difficult. For example. the power line to convey production from the Lake Turkana wind farm is still being constructed (Daily Nation. 3 May 2018).

• SOLAR KITS. MINI-GRIDS. PAY-AS-YOU-GO... • The *Last-Mile Connectivity* project. funded by the African Development Bank. plans to connect 314.200 households located within 600 meters of a transformer to the grid. For the other non-connected households. the costs of extension of the grid. which are too high compared to the potential demand for electricity. encourage the use of decentralised electrical systems. This off-grid electrification is accessible to companies of modest size and is producing a proliferation of initiatives.

In 2016 and 2017. Kenya was the world's second largest market for solar kits behind India: 1.2 million systems were sold in 2016 and 900.000 in 2017. due to the drought that limited Kenyan revenues (GOGLA. 2018). The distribution of these systems involved a dense network of retailers and enabled revenues to be generated locally. Now more than a third of homes not connected to the electricity grid have a solar system that can meet basic needs such as lighting and phone charging (REN21. 2017). This market is of interest to foreign companies: BBOXX (Great Britain) and Mobisol (Germany). companies specialising in the production of solar kits. raised $20 million in 2017 to expand operations in Kenya. Rwanda and Tanzania.

Access to these systems may involve new business models. such as «pay-as-you-go». which has been developed in several African countries. including Kenya. This business model involves leasing a solar kit to households. The kit includes a battery. a charge controller. a solar panel. LED bulbs and a telephone charger. or even a television. Consumers pay on a daily. weekly or monthly basis which limits recovery costs for the business and avoids the use of a household loan. The payment is made by telephone. and if the payment is not registered. an integrated system interrupts the operation of the kit and the supply of electricity. These PAYG companies have electrified about 500.000 homes in Kenya and Tanzania. but are mostly financed by foreign investors. Local commercial banks are still very reluctant to finance these projects. which are deemed too risky. thus depriving local investors of capital (Sanyal. 2017).

Rural electrification also involves creating micro-grids. The creation of a local-scale grid not connected to the national power grid makes it possible to supply it with limited investments. In the past. however. this alternative was unattractive because the use of generator sets. with high fuel and maintenance costs. made electricity expensive. The lower cost of renewables is changing this situation. enabling the development of mini-grids in non-electrified areas. The Kenyan government recently obtained €33 million from the French government for the installation of 23 mini solar power plants in the north of the country. aiming for a production of 9.6 MW. Private companies are also involved in this field: PowerGen Renewable Energy. a Kenyan company specialising in the implementation of small power grids. raised $4.5 million in 2016 to invest in Kenya and Tanzania.

Micro-grids in Kenya

The public operator Kenya Power manages about twenty micro-grids powered by generators mainly in the north of the country. These facilities will soon have to be upgraded to integrate a share of solar production.

Private companies are also allowed to produce and distribute off-grid electricity. Payment by mobile phone. promoted by companies such as M-Pesa. Airtel Money or Orange Money. have played a crucial role in the development of these services.

In 2017. 40% of existing commercial micro-grids in sub-Saharan Africa were in Kenya (65 out of 150). The country will host at least a third of the new micro-grids built in Africa by 2021. Thanks to the fall in the price of photovoltaic modules. these projects should mainly be powered by solar energy. Small hydropower systems will also be developed.

Source: GORDON. 2018

TEXT BOX 3

At the end of 2016. Kenya joined Lighting Global. the programme set up by the World Bank to test and ensure the quality of off-grid solar systems.

4 • CIVIL SOCIETY: VIGILANT AND INNOVATIVE

Electrification and the development of Kenyan electricity generation respond to significant social demand. Civil society actors. however. remain sensitive to the impact of projects on living conditions and can also play an active role in finding new solutions.

• PERCEPTION OF PROJECTS BY CIVIL SOCIETY • Public opposition is often an obstacle to the development of new energy projects. In Kenya. as elsewhere. debate on these projects is divisive and polarised between the positions of developers and those of opposition groups. Access to land is one of the recurrent points of conflict. especially when projects have little local economic benefit. Communities sometimes express suspicion towards projects: risk of corruption. hazards and pollution (risk of electrocution. noise. etc.). impact on the environment and tourism. etc. These fears often reflect insufficient stakeholder commitment in the upstream phases (Johnson. 2017).

Mobilisation against the Lamu Coal Plant Project

Kenya plans to install its first coal-fired power plant on Lamu Island in the Indian Ocean. The plant is to be built under a partnership between Kenya and China. supplied with South African coal.

Those living in the vicinity of the future plant are worried about the consequences of the project on the environment and the local economy. especially fishing and tourism: the island. whose old town Lamu is a World Heritage Site. attracts many visitors. They also feared that the benefits of the project would not be distributed fairly. They gained the support of several local and international NGOS (Greenpeace Africa. 350 Kenya. Kenya National Commission on Human Rights. etc.) and personalities including Nobel Prize winner Joseph Stiglitz.

Kenyan activist Okiya Omtatah Okoiti fought against the project in the Kenyan courts. in particular by denouncing the consultation carried out by the Energy Regulatory Commission and the impact study conducted by the Kenya National Environmental Management Authority. His appeal was dismissed in February 2018.

On 5 June. World Environment Day. a charity event was held in Nairobi - a first in the history of Kenya. The demonstrators protested against the Lamu project and the coal mines in Kitui County in the middle of the country.

Source: Daily nation. Decoalonize

TEXT BOX 4

• THE ROLE OF CIVIL SOCIETY IN INNOVATION • Non-state actors. including non-profit organisations. play an important role in technical and economic innovation for the diffusion of new sources of energy. These innovations often arise at community level - a group of young people or women facing the same problems come together to try to devise a solution together. These groups can then be assisted by external actors. most often NGOs. who will advise or fund them (Muok. 2015).

The use of solar lanterns. for example. was initiated in the mid-2000s by Evans Wadongo. a student at the Jomo Kenyatta University of Agriculture and Technology. aged 18 at the time. Inspired by his childhood in a non-electrified region in the west of the country. he designed a solar lantern that was simple and suitable for the needs of Kenyan families. The lamp is made locally from recycled materials. In an example of economic innovation. communities have organised themselves into village banks to grant microloans for poor families to acquire equipment such as improved

stoves or solar kits.

Microcredit and access to energy

The use of renewable energies. especially solar. for basic needs such as lighting. is generally less expensive than the use of a generator or kerosene lamps that require the purchase of fuel. However. it requires an initial investment which is an insurmountable obstacle for households which do not have any savings or the guarantees and documents needed to obtain credit. Microcredits make it possible to get around these difficulties.

In 2013. Equity Bank. a leading Kenyan bank with 10 million customers. teamed up with the US company MicroEnergy Credits to create EcoMoto. a lending solution specifically designed to enable the distribution of energy products. These credits are used to purchase solar kits (solar lanterns or solar home systems) from Greenlight Planet. d.light. Fenix and Orb brands as well as improved cookstoves.

Loans range from $10 to $600 over a period of up to 12 months with an interest rate of 14%. The repayment rate is calculated to be less than the fuel price that would have been required without the purchased system. Savings over six months are usually sufficient to repay the loan.

In its initial version. the loan could be obtained in 24 hours with a one-page form. A mobile phone accessible version was launched last year in partnership with the operator Equitel. and funds are now released in minutes.

This project is supported by the US Development Agency. USAID. and the NGO Winrock International.

Source: Winrock International. 2017

TEXT BOX 5

CONCLUSION

Kenya's electrification is progressing rapidly without an increase in emissions from power generation. This success is explained by the importance of renewable resources and by the government's favourable policy. but also by the mobilisation of non-state actors. Large and small companies. local communities. NGOs. etc. are all contributing to the proliferation of projects that are making Kenya one of the most dynamic and innovative countries in terms of access to energy. Nevertheless. the possibility of the significant use of coal from 2024 could undermine this virtuous circle. The project. financed in this case by China. also highlights all the inconsistencies of international climate policies. especially on funding.

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Decarbonising the chinese power mix: a daunting challenge

China's vast population, economic weight and global influence make it naturally important for China to play a leading role in global efforts to combat climate change. Although these efforts are currently insufficient to offset the rapid growth in electricity demand, there has been remarkable progress in the carbon intensity of Chinese electricity. Contrary to what one would expect from a country with an authoritarian regime and a managed economy, non-state actors – in particular civil society, local authorities and businesses – play an important role in China's electrical transition. What strategy has the country adopted and what lessons can be learned from it?

Main autor • **THIBAULT LACONDE** • *Consultant, Energie & Développement*

CONTENTS

1 • EMISSIONS FROM THE ELECTRICITY SECTOR RISE AGAIN

Emissions weigh heavily on the Chinese and worldwide assessment

The diversification of the Chinese mix is progressing

Carbon intensity drops but emissions continue to rise

2 • A STRONG POLITICAL AMBITION

Taking a stand on the national and international scene

The modes of intervention of the Chinese government

3 • THE ROLE OF LOCAL AUTHORITIES

Project manager of local climate policy

The risks of competition between local author

4 • AN IMPETUS FROM CIVIL SOCIETY

5 • BUSINESSES AND ECONOMIC CIRCLES

A sector largely controlled by the government

The place of local and private initiative

1 • EMISSIONS FROM THE ELECTRICITY SECTOR RISE AGAIN

After a sharp rise from 1.4 billion tonnes of CO_2 equivalent in 2000 to 4.3 today, emissions from the Chinese power sector saw two years of slight decrease. A new rise began in 2017 and seems to be continuing in 2018.

• EMISSIONS WEIGH HEAVILY ON THE CHINESE AND WORLDWIDE ASSESSMENT • Between 2000 and 2016, Chinese emissions increased by 6.8 billion tons of CO_2, from 3.6 GT CO_2 eq to 10.4. At the same time, global emissions have increased by 10.2 GT CO_2 eq (Janssens-Maenhout, 2017). China's contribution to this increase is therefore massive. Electricity production accounts for almost half of China's emissions, meaning that it contributed significantly to this growth, and in 2007, China became the world's largest emitter of greenhouse gases.

In 2011, the country also became the largest producer and consumer of electricity. Beyond its own emissions, the Chinese electricity sector has a lot of weight in the evolution of the worldwide power mix.

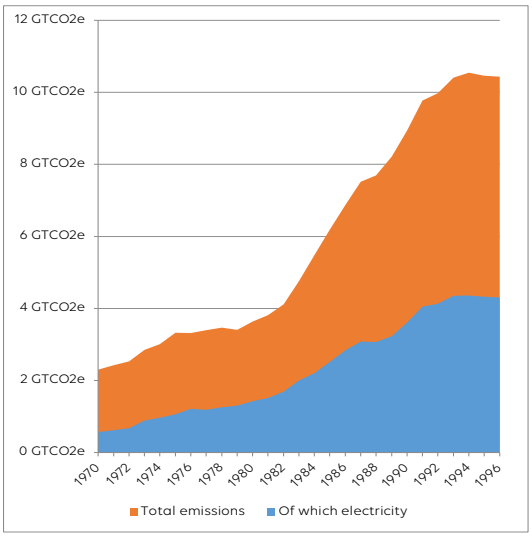


FIGURE 1. EVOLUTION OF CHINESE EMISSIONS

The increase in China's greenhouse gas emissions accelerated in the early 2000s, a period that coincided with its admission to the World Trade Organization. **This trend is linked to its role as the "factory of the world":** in 2011, international trade was responsible for a net transfer of emissions of 760 million tonnes of CO_2 between the United States and China and 640 million tonnes between the European Union and China (Men, 2014).

The rate of the increase slowed down from 2010 when Chinese growth went from double-digit rates in the 2000s to around 7% a year – what President Xi Jinping called the "new normality" of the Chinese economy. Emissions, however, remain on the rise: they increased by 1.4% in 2017 (NBS, 2018) and according to preliminary data, by 4% per year in the first quarter of 2018 (Greenpeace, 2018).

• THE DIVERSIFICATION OF THE CHINESE MIX IS PROGRESSING • At the origin of these emissions is an power mix that remains largely derived from fossil fuels: in 2017, fossil fuels accounted for 70.9% of electricity production. **This proportion is not exceptional, but China is characterised by an overrepresentation of coal.** In 2016, the latest year with available data, only 4.4% of China's fossil electricity came from gas plants (CEC, 2016). This feature places the Chinese mix among the 10 most carbon-focused on the planet. To reduce emissions from electricity production, China must diversify its mix.

Hydropower is China's second largest source of electricity after coal. In 2017, it accounted for 18.6% of the Chinese power mix, i.e. just under two-thirds of the carbon-free production. Despite an increase in production, the share of hydropower in the power mix has stagnated since 2014. This is the energy that has grown the most slowly in 2017, both in production and installed capacity. Despite major projects (Baihetan with 16 GW, Wudong 8.7 GW), the Chinese government does not expect a significant increase in capacity in the coming years.

Wind energy has been developing steadily in China for the last ten years. Wind generation increased by 64 TWh in 2017, making it the largest source of zero-carbon electricity in absolute terms. After surpassing nuclear power in 2016, it now ranks second in carbon-free energies after

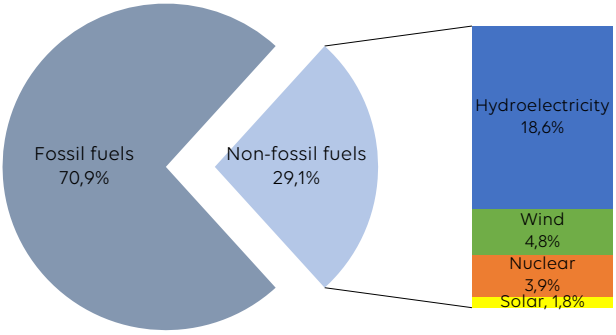


FIGURE 2. THE CHINESE POWER MIX IN 2017

hydropower.

The share of nuclear power has increased significantly since the beginning of 2010 from less than 2% to 3.9% in 2017. However, nuclear projects have slowed down in recent years. Since 2015, no new projects have been approved and only one project launched in 2017, compared with 2 in 2016 and 6 in 2015. Nuclear power has attracted 39.5 billion renminbi (€5 billion) in investments in 2017 – almost twice as much as in 2012. Beyond electricity generation, China plans to use nuclear energy to power district heating networks in the north of the country. The Chinese administration approved the construction of the first reactor for this use at the end of 2017 based on a demonstrator made in the 1980s.

China was little interested in solar photovoltaic power before 2010, but it has now been developing it at an impressive speed: An output of 53 GW was installed in 2017 alone – more than the entire park of the second best endowed country (Germany with 41 GW in 2016). The Chinese solar park reached 130 GW in 2017, in a single year surpassing the 110 GW target that the country had set for 2020. Solar electricity production in 2017 is estimated at 118.2 TWh – an increase of more than 75% over the previous year. However, solar photovoltaic energy represents only approximately 2% of Chinese electricity production and therefore contributes only marginally to the decarbonisation of the mix.

In total, the share of carbon-free energy in China's power mix increased from 16.4% in 2007 to 29.1% in 2017.

• CARBON INTENSITY DROPS BUT EMISSIONS CONTINUE TO RISE • This development of carbon-free energy lowers the carbon intensity of the Chinese power mix – i.e. the production of 1 kilowatt-hour emits less carbon dioxide. However, at the same time the demand for electricity is growing rapidly. In 2016 and 2017, it grew by 5.2% on average and reached a little over 6300 TWh. This growth is driven by the tertiary sector (+ 10.9% per year) and residential consumption (+ 9.3%) with a relative decline in industry. This evolution reflects the changes in the Chinese economy.
This is why fossil electricity production has started to grow again: after a period of stability in 2014 and 2015, fossil production increased by 97 TWh in 2016 and 224 TWh in 2017. The installed power has never stopped progressing: 50 to 80 GW of new thermal power plants are connected to the grid each year. Over the past 10 years, 120 billion renminbi (€16 billion) have been invested each year in fossil fuel energy production, making it the best-funded energy overall.
This growth in production is strongly correlated with the growth in electricity consumption: China's expansion of electricity needs is now still very largely supported by coal. Last year, fossils alone accounted for 57% of Chinese electricity production growth. **Taking command of the demand is therefore a prerequisite for the decarbonisation of the Chinese power mix.**

2. A STRONG POLITICAL AMBITION

This upward trend of greenhouse gas emissions goes against the commitments of Chinese officials both domestically and internationally.

• TAKING A STAND ON THE NATIONAL AND INTERNATIONAL SCENE • The Chinese government has been gradually addressing environmental issues in the 2000s. China established a national environmental protection agency in 2008. It was initially not competent in the fight against climate

change, which was placed under the responsibility of the powerful National Development and Reform Commission. A reorganisation announced in early 2018 put an end to this fragmentation by entrusting the climate to a large ministry of ecology.

In 2014, Prime Minister Li Keqiang declared a "war on pollution" which resulted in the modernisation of the measuring system, information for the public and more binding emission standards. This policy primarily targets local air pollutants (NOx, SO_2, PM, etc.) but has climate co-benefits.

On the international scene, China's size and influence in developing countries plays a central role in climate negotiations. The agreement reached between Presidents Xi Jinping and Barack Obama on 12 November 2014 was a major factor in the success of the Paris Conference. On this occasion, China made confirmed commitments to its Intended Nationally Determined Contribution (INDC) for the following year, including: **reaching its maximum level of greenhouse gas emissions no later than 2030 and reducing its CO_2 emissions per unit of GDP by 60% and 65% in 2030 compared to 2005 levels.**

These political ambitions were set out in the 13th Five-Year Plan, which sets out China's objectives for the 2016–2020 period. In particular, it plans the following:

- To limit energy consumption to 5 billion tonnes of carbon equivalent by 2020 from 3.5 billion in 2015.
- To reduce the energy intensity of the Chinese economy by 15% and carbon intensity by 16%.
- To develop the production of carbon-free electricity.

Evolution of carbon-free electricity production during the 13th Five-Year Plan

The 13th plan sets the planned park size for the main carbon-free energies in 2020:

- Hydropower: 340 GW installed in 2020 (from 320 GW in 2015). This goal has already been reached in 2017 (341 GW installed).
- Nuclear: 58 GW installed and 30 under construction in 2020 (from 27 GW installed in 2015), this target will not be reached, no new nuclear project has been approved since 2015.
- Wind power: 210 GW in 2020 (131 GW in 2015).
- Solar photovoltaic: 110 GW in 2020 (42 GW in 2015). This goal was exceeded in 2017.

Sources : energy and developpement

TEXT BOX 1

• THE MODES OF INTERVENTION OF THE CHINESE GOVERNMENT • In addition to planning a gradual transition of its power mix towards carbon-free energies, the central government relies on two main means of action: the creation of increasingly stringent performance standards and the use of financial incentive mechanisms (guaranteed rates and future carbon market).

The use of the regulatory tool is illustrated by the change in the Chinese heat park. Permitted limits for air pollutants are already equivalent or more restrictive than the American or European counterparts. By 2020, performance standards will come into effect: new plants will have to consume less than 300 grams of coal

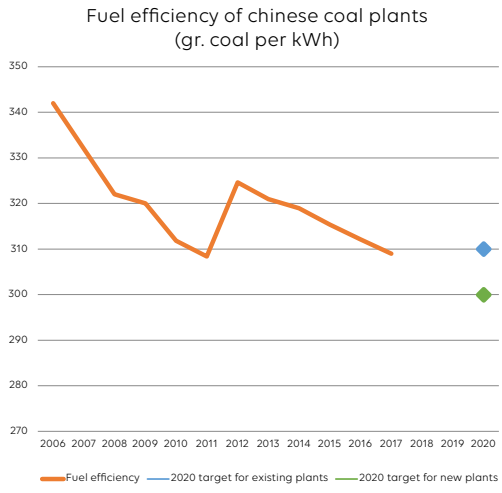
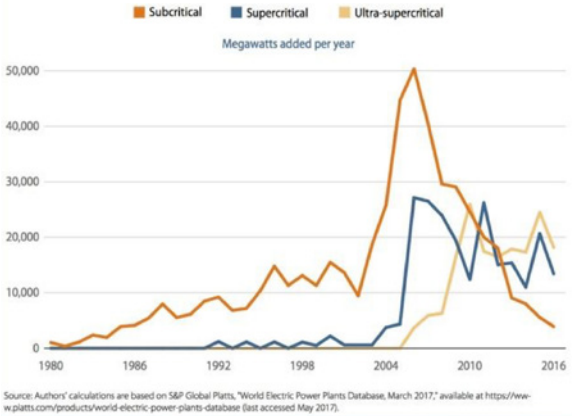


FIGURE 3. NEW CHINESE COAL POWER PLANTS BY TECHNOLOGY

per kilowatt-hour, existing plants will have to consume less than 310 grams or close down. In comparison, the 100 largest US coal plants currently in use consume an average of 375 g/kWh and none would meet future Chinese standards (Center for American Progress, 2017).

These standards lead to the rapid adoption of less emitting technologies that will make the Chinese heat park one of the newest and most efficient on the planet. In particular, this results in a large proportion of supercritical power plants, i.e. plants operating at a temperature of more than 565°C and a pressure of 250 bar, or ultra-supercritical plants, in which the temperature reaches 585°C and the pressure reaches 300 bar. These plants offer better energy and environmental performance than their subcritical counterparts. Approximately 19% of Chinese coal plants are ultra-supercritical, 25% are supercritical and 56% are sub-critical. In comparison, the United States has only one supercritical coal power plant (Platt's, 2017). In addition, China has set up quality standards for its coal production and a systematic control system (Bai, 2017).

FIGURE 3
China's shift toward cleaner coal-fired power technology
Technical makeup of China's coal-fired power capacity additions, 1980–2016



Source: Authors' calculations are based on S&P Global Platts, "World Electric Power Plants Database, March 2017," available at https://www.platts.com/products/world-electric-power-plants-database (last accessed May 2017).

These standards have significantly reduced the consumption of coal and therefore CO_2 emissions per unit of electricity produced: in 2006, it took more than 340 grams of coal to produce one kilowatt hour, today it takes on average less than 310 grams. In the 100 most efficient plants, coal consumption dropped to 286 g/kWh.

To reduce emissions from power production, the Chinese government is also employing economic incentives. These include guaranteed feed-in-tariffs for solar and wind energy – in mid-2018 it was announced that it will be abandoned in favour of a bidding system.

Reform of incentive mechanisms for solar energy

The faster than expected propagation of solar photovoltaic installations threatens to create an excessive cost for consumers. These facilities benefit from a guaranteed feed-in tariff financed by a levy on electricity bills. In 2017, this mechanism was in deficit of more than 100 billion renminbi. Since 2017, China has taken steps to slow down the growth of solar photovoltaic energy. The feed-in tariffs for solar electricity have been lowered and the Chinese government has set up a regulatory system for the construction of photovoltaic solar installations: according to criteria such as the price of land and the erasure rate, some areas of the territory have been ordered to halt their projects (mainly in the north-west) and others to halve them (the western two-thirds of China and the south-east coast as well as Beijing, Tianjin and Shanghai). These measures have not been effective enough: in the first quarter of 2018, 9.7 GW of solar photovoltaic systems were installed in China. In early June, the government announced the suspension of the feed-in tariff for most new installations. A bidding system is to be created instead. A similar announcement was made mid-May for wind energy.

TEXT BOX 2

China is also preparing to create a national carbon market. Seven local pilot projects have been implemented since 2011 in the municipalities of Beijing, Shanghai, Tianjin, Shenzhen and Chongqing and the provinces of Guangdong and Hubei. These pilot projects covered nearly 3,000 installations in 20 industrial sectors and up to a quarter of the Chinese gross domestic product (EDF, 2018). Following these experiences, a national system was formally launched in December 2017, but it will only truly come into operation in 2020. Its operation still contains many unknowns, in particular the sectors in question and the timeframe, the emission ceiling and the mechanism for allocating carbon credits. At least initially, the Chinese carbon market should only concern the production of electricity, but even when limited to the electricity sector, it will be the largest carbon market in the world, covering 1.5 times more emissions than the EU ETS.

3 • THE ROLE OF LOCAL AUTHORITIES

China has a decentralised administrative organisation in which provinces, prefectures and districts have real autonomy – control from Beijing is often exercised a posteriori when needed. These communities play an important role in implementing China's energy and climate policy.

• PROJECT MANAGER OF LOCAL CLIMATE POLICY • It is increasingly common for emission reduction plans to be adopted at the urban scale. Consultation with local stakeholders is an integral part of this process, which allows diverse points of view and conflicting interests to be expressed. However, it often leads to the formation of coalitions between policy makers, industrialists and real estate developers who support the status quo and prioritise economic development. This trend is sometimes counterbalanced by the intervention of experts and researchers asked to support the local authorities. They can exert a considerable influence on the process and be the spokespersons for marginalised concerns in the environment, agriculture, tourism and other fields. They also facilitate communication and exchanging experience at the provincial and national levels (Westman, 2017).

In addition to traditional regulatory tools, the implementation of which is not always effective, local emission reduction plans regularly call for the development of low-carbon public services and facilitation measures. In the latter case, the local authority partially replaces the non-governmental organisations protecting the environment, which are not very present in China.

The climate policy of the municipality of Rizhao

The city of Rizhao in the Shandong Province has set itself the goal of achieving carbon neutrality. For this, it uses several types of tools. The first is regulatory: for example, real estate projects not planning to install solar water heaters are refused. This policy has made it possible to achieve a solar thermal equipment rate of 99% in the centre of the city but is less efficient in the periphery where only 30% of homes are equipped with it.

A second means of action is the creation of low-carbon public services: for example, public transport has been developed to provide more stops and more frequent passages leading to an increase in the number of trips taken. At the same time, the bus fleet has been updated by eliminating the most polluting vehicles for the benefit of hybrid and electric ones.

Financial incentives have been used to encourage the development of "eco-activities" such as easier access to land and more favourable taxation. These measures allowed the sector to grow twice as fast as in the rest of the province: + 15% per year on average between 2010 and 2013.

Finally, various incentive schemes (awareness-raising, training, benchmarking, etc.) have been put in place, in particular to limit the consumption of energy in the industrial and residential sectors.

Sources : Westman, 2017

TEXT BOX 3

These actions are very often developed in partnership with companies, research centres and international organisations. Local climate action is therefore an opportunity for real networking of Chinese and sometimes foreign sub-state actors.

• THE RISKS OF COMPETITION BETWEEN LOCAL AUTHORITIES • The Chinese government wants to give local authorities a growing role in investment decisions in their territory. In this context, each community seeks to stimulate its economic development through major projects and to acquire infrastructures that will enable it to attract investors. This competition can have perverse effects with overbidding resulting in overcapacity and potentially an increase in greenhouse gas emissions.

Thermal overcapacity – a side effect of decentralisation

In October 2014, the Chinese government authorised the provinces to launch coal power plants without prior approval. This reform was designed to ease administrative procedures and better take into account local needs and impacts, but it had perverse effects that required the central government to take back control.

Provincial governments have anticipated increasingly restrictive regulations that would make new projects difficult to carry out. In order not to see its development limited in the future by limited electricity production or dependence on imports, each province tried to over-equip itself. In addition, the wholesale price of electricity remains administered, and it has been slow to adapt to the lower cost of coal which has made these projects attractive for investors. Between 2013 and 2017, China's fossil fuel park increased by 27% while fossil energy consumption grew only by 8%. As a result, the load factor of the thermal park – already relatively low at 57% – has fallen to 48%, meaning that Chinese coal plants operate on average only 175 days a year.

In 2017, the central government had to intervene to prevent these overcapacities from worsening: it canceled nearly 150 projects, some of which were already under construction, and instituted a moratorium on the construction of new thermal power plants over a large part of the country.

Sources : Yuan et Alii, 2017, Yu et Alii, 2018

TEXT BOX 4

4 • AN IMPETUS FROM CIVIL SOCIETY

Civil society has played a major role in raising awareness of environmental issues and their appropriation by the central government and local authorities. In the 2000s, the degradation of the environment became one of the main subjects of discontent and agitation of the Chinese population: between 2000 and 2013, pollution was the reason for half of the "mass incidents" having attracted more than 10,000 participants (Steinhardt, 2015).

The popular movements against pollution of spring 2015

In February 2015, Chai Jing, a former Chinese national television presenter, shared an air pollution survey on the internet. The 103-minute documentary entitled "Under the dome" has been viewed 75 million times since the first day of its broadcast. In April, the explosion of a paraxylene plant in the Fujian Province resulted in the evacuation of 30,000 people and brought industrial risks to the attention of the public. Several movements against pollution and coal projects in particular were reported in the weeks that followed.

In mid-April, for example, several thousand protesters gathered in Heyuan near Canton to demand the abandonment of a planned extension of a coal

power station. The week before, a violent demonstration in the same province led to the abandonment of an incinerator project. At the same time, in the Naiman banner in the Inner Mongolia coalfield, the crackdown on a demonstration against pollution reportedly lead to one death and the arrest of 50 people. This period also saw mobilisations in Shanghai (against a chemical factory project), in Tianjin (against a steel mill), etc.

The Chinese authorities pay close attention to these movements. They try not to give them time to become structured, often by combining suppression and concessions. Protesters therefore regularly win and the projects are canceled or displaced.

Sources : Chinadialogue, Forbes, The Guardian, Reuters

TEXT BOX 5

Beyond these movements motivated by opposition to local projects, civil society and academia can influence China's energy and climate policy at the national level. For example, creating nuclear power plants inland was strongly criticised in 2014, which led to a de facto moratorium: since 2015, no new projects have been approved. This pause is tantamount to abandoning the goal of developing nuclear energy in the 13th Five-Year Plan.

Finally, environmental concerns are reflected in consumer preferences: 87.9% of urban Chinese would like to know the origin of their electricity and 97.6% would prefer to buy "green electricity" including, for 90.6% of them, if it is more expensive (CREIA, 2016).

FIGURE 5. INTEREST IN BUYING GREEN ELECTRICITY AND WILLINGNESS TO PAY

5 • BUSINESSES AND ECONOMIC CIRCLESS

The mobilisation of civil society and the increasing attention of consumers and authorities has led companies to adapt their practices and communicate better. For example, the performance of thermal power plants has become a crucial issue for the companies that operate them, some of which even display live emission levels on light panels near their facilities (Center for American Progress, 2017).

Climate action of the State Grid of China

State Grid of China was established in 2002 to manage the Chinese power grid and has since expanded internationally to the Philippines, Brazil, Portugal, Australia, Italy, etc. It employs 1.72 million employees and supplies electricity to more than 1.1 billion customers with a turnover of 360 billion dollars in 2017. According to Fortune magazine, it has the largest turnover among power companies and the second largest turnover of all companies worldwide. According to its sustainable development report, State Grid's climate commitments firstly concern the efficiency of its network: reducing line losses, allowing the integration of new renewable capacities, facilitating exchanges of electricity between provinces, developing storage means, particularly pumped storage, etc. The company also promotes energy efficiency and the electrification of transport and heating – even if the climate balance of these actions is questionable given the dependence of the Chinese power mix on coal. State Grid is also responsible for the recovery and recycling of 70 tonnes of sodium hexafluoride per year – a potent greenhouse gas used as insulation in high-power electrical installations.

State Grid is also a member of many international groups and initiatives for climate and sustainable development: Global Compact, World Business Council for Sustainable Development, Global Sustainable Electricity Partnership, etc.

Sources : State Grid, 2018

TEXT BOX 6

• A SECTOR LARGELY CONTROLLED BY THE GOVERNMENT • The large Chinese electricity companies are mostly public and are generally part of the approximately hundred Chinese companies placed under the direct supervision of the government through the State-owned Asset Supervision and Administration Commission. This is the case of the network operators (State Grid of China and China Southern Power Grid), the five major electricity producers (China Datang Corporation, China Guodian Corporation, China Huadian Group, China Huaneng Group, China Power Investment Corporation) as well as the operator of the Three Gorges Dam, mining companies active in the field of electricity (Shenhua Group and China Resources Group) and leading nuclear specialists (China National Nuclear Corporation, China General Nuclear Power Group and China Nuclear Engineering and Construction Group). Many of these companies have listed subsidiaries, for example China Yangtze Power for China Three Gorges Corporation.

In total, **these public enterprises under government control account for more than three quarters of China's electricity production.** Despite the trend towards liberalising the economy, energy is a sector in which the Chinese government intends to maintain and even deepen its control (Cunningham, 2015).

In theory, China stands out by its subordination of a large part of the electricity sector to the government. In practice, public companies and especially their subsidiaries have a certain autonomy. Because of their size and their historical links with ministries, they can even exert a significant influence on the regulatory body and influence China's energy policy (Andrews-Speed, 2010).

• THE PLACE OF LOCAL AND PRIVATE INITIATIVE • Smaller private companies exist – for example Chint Group in the field of electricity distribution. There are also public enterprises owned by local governments such as the Shenergy Group in Shanghai. These small, generally local producers owned a little less than 30% of the Chinese electric park in 2010 (Wang, 2012).

These companies are poorly represented in nuclear power and hydropower, and they have also suffered from the closure of the worst-performing coal plants ordered by the government in the early 2010s: among the 72 GW that were shut down, the majority were owned by local businesses.

Developing new energies is therefore an opportunity for them. While large state-owned companies have served as a vehicle for Chinese wind energy investments which they widely control, solar photovoltaic energy is largely private (Bergsager, 2016).

Solar thermal energy – success of a private initiat

China is characterised by a massive and old use of domestic solar thermal energy: it comprises 324 GWth, which is more than 71% of the world park. The country has nearly 80 million of these facilities using solar radiation to produce hot water generally at the scale of a household. According to the estimates of the International Energy Agency, they allow avoiding the emission of 90 million tonnes of CO_2 each year (Weiss, 2018) – i.e. the equivalent of total emissions of a country such as Colombia. New installations have slowed down: from 44.5 GWth/year at their highest number in 2013 to 27.7 GWth in 2017, but China continues to dominate this market since 75% of new solar thermal installations in 2016 took place in this country.

Unlike solar photovoltaic energy, solar thermal energy was developed in China to meet local needs. The research benefited from public funding in the 80s and 90s, but the move from the technology to mass production and its very wide distribution was done virtually without financial or political support from the government.

Sources : Urban, 2016

TEXT BOX 7

CONCLUSION

The Chinese government has a central role in determining and implementing emission reduction targets in the electricity sector. However, its decisions can only be understood in the light of the impetus given by civil society. In the same way, achieving the objectives is dependent on the action of local authorities and companies, who in practice enjoy large autonomy from the central power. If regulatory intervention remains one of the tools available to the Chinese government, the implementation of its climate ambitions will also largely depend on the effectiveness of this dialogue between the state and non-state actors.

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Germany, a model under construction?

At the turn of the 2000s, Germany embarked on a transformation of its electricity production that is still ongoing today. While the fight against climate change requires rapid decarbonation of the overall electricity mix, the energy transition led by the world's fourth largest economy is one of the few large-scale experiments which can be used as a model.

Main autor • **THIBAULT LACONDE** • *Consultant, Energie & Développement*

CONTENTS

1 • THE EVOLUTION OF THE GERMAN ELECTRICITY SECTOR

Downward-oriented issues

A remarkable evolution of the electricity mix

2 • A STRONG POLITICAL IMPULSE

Building an alternative and a consensus

Post-Fukushima

3 • THE ROLE OF CIVIL SOCIETY AND SUB-NATIONAL ACTORS

Citizens, communities, NGOs … The role of local initiatives

Intense academic activity

Seeking alliances with economic actors

4 • NEW CHALLENGES

Towards the end of coal

The problem of changing the scale of energy decentralisation

1 • THE EVOLUTION OF THE GERMAN ELECTRICITY SECTOR

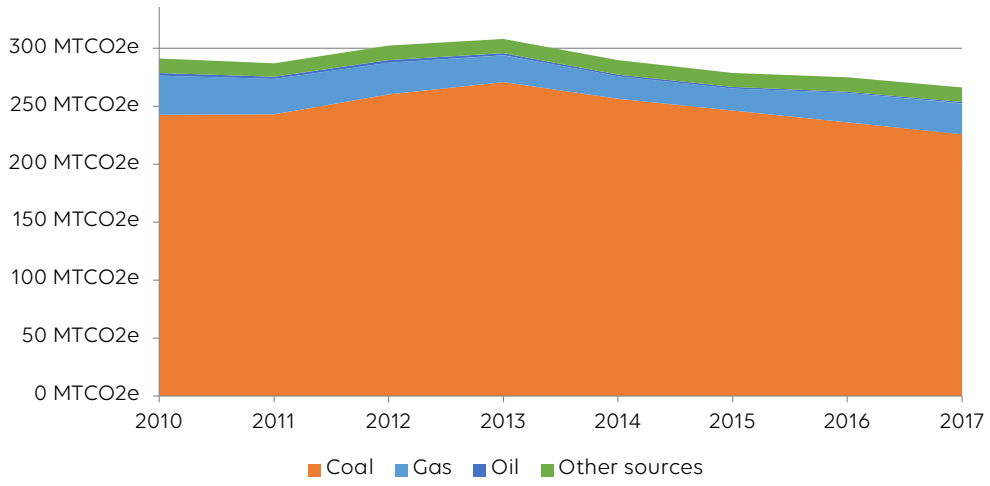
• DOWNWARD-ORIENTED ISSUES • In 2016 and 2017, emissions related to electricity and heat production in Germany decreased by 3.9 and 8.9 CO_2 mteq, respectively.

This decline, which came after an increase in 2011 to 2013, confirms a long-term downward trend observed since the 1990s, the rebound in the early 2010s being explained by cyclical causes: the return of growth after the 2008 crisis and acceleration of the shutdown of nuclear power plants in the aftermath of the Fukushima accident.

Since 2013, the sector's emissions have begun to decline again at a steady pace: between 2013 and 2017, annual emissions fell by 41.4 CO_2mteq or 14.2%. This decrease is due to the decline in emissions from coal-fired power plants (-45.1 CO_2mteq/ year between 2013 and 2017) partially offset by increases in gas use (+ 3.7 CO_2mteq/ year). This gas-coal substitution has accelerated over the last two years.

The fall in emissions is even greater when compared to the amount of electricity actually generated. Indeed, German electricity generation has increased markedly over the last twenty years, from 576.6TWh in 2000 to 654.8TWh in 2017. This increase has seen Germany, an importer of electricity in the late 90s, become the largest electricity exporter in Europe.

Between 2015 and 2017, German electricity generation increased further by 6.7TWh. Consequently, while electricity sector emissions fell by 4.6% over this period, the carbon intensity of electricity declined even more rapidly: in 2017, generating a megawatt hour of electricity in Germany emitted 5.6% less CO_2 than in 2015.



	2013	2014	2015	2016	2017
Total	306.2477	288.6509	277.6279	273.7003	264.8552
Coal	270.9566	256.3565	246.2193	236.3306	225.8448
Gas	23.0119	19.5899	19.3029	25.149	26.7576
Oil-based products	1.9132	1.3156	1.293	1.2058	1.2125
Other	12.2792	12.7045	12.1057	12.2207	12.2528

FIGURE 1. EMISSIONS FROM ELECTRICITY GENERATION AND URBAN HEAT BY FUEL ($MTCO_2E$)

(source : Enerdata)

• A REMARKABLE EVOLUTION OF THE ELECTRICITY MIX • This drop in emissions and carbon intensity is significant, but it is not commensurate with the evolution of the German electricity mix, which has undergone a profound transformation over the past two decades.

Since 2000, Germany has experienced a rapid development of renewable energies, from just a

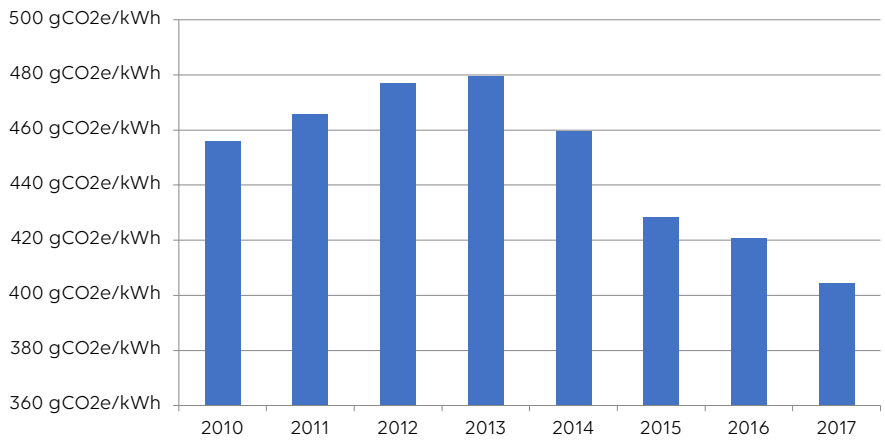


FIGURE 2. CARBON INTENSITY OF GERMAN ELECTRICITY

Sources : Enerdata and AGEB

few percent to today, when they represent more than one third of the electricity mix. This increase has more than offset the 3-fold decline in the share of nuclear power, which led to a 10-point drop in the share of fossil fuels in the electricity mix.

These transformations have continued in recent times. Between 2015 and 2017, renewable energies increased from 29.1% to 33.3% of the electricity mix and even to 40% in the first 35 weeks of 2018 (Energy charts, Fraunhofer Institute). This change is being driven mainly by the development

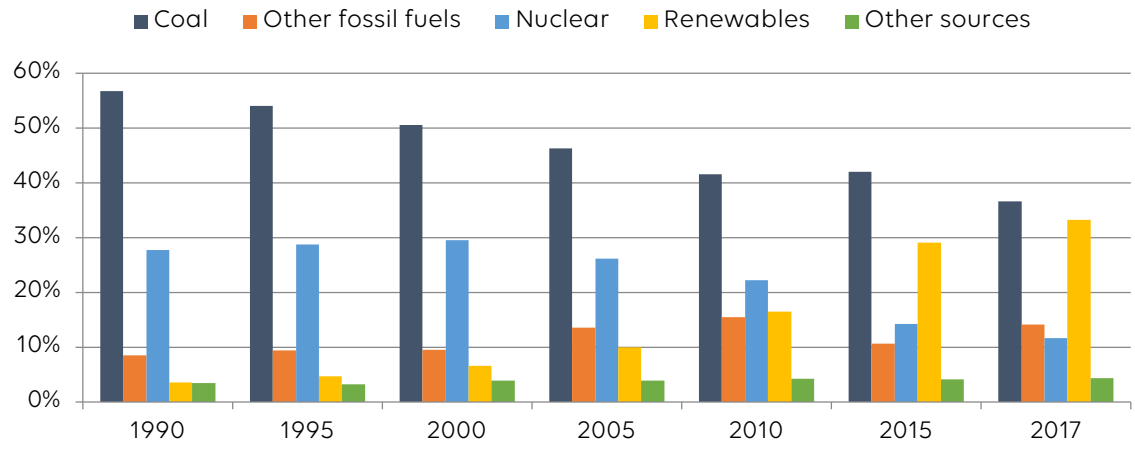


FIGURE 3. EVOLUTION OF THE GERMAN ELECTRICITY MIX

(Source: AGEB)

of off-shore wind power, for which generation has more than doubled in 2 years.

At the same time, coal (-5.4 points) and nuclear power (-2.5 points) continued to decline. The decline of coal is slower for lignite, which pollutes more but is produced locally, than for bituminous coal, which has all been imported since the closure of the last two German mines in 2018: -1.3 points in 2 years for lignite vs. -4.1 points for bituminous coal. Finally, the last two years have seen a rapid increase in gas, which has increased by 3.6 points in the German electricity mix. This increase is not entirely new but it accelerated sharply in 2016.

2 • A STRONG POLITICAL IMPULSE

This evolution of the German electricity mix is the result of an energy policy devised in the 1980s and continued throughout the 2000s despite unforeseen circumstances and political alternations.

• BUILDING AN ALTERNATIVE AND A CONSENSUS • In the 1980s, the German electricity mix was dominated by fossil fuels (about 65% with a large majority of coal) and nuclear (about 30%) with a small share of renewables, mainly hydroelectric.

It was at this time that the energy transition project that Germany is now implementing began to take shape. This shift originated in the anti-nuclear movement, which was very active in the 1970s. In the mid-1980s, it achieved its first success with a moratorium on the construction of new reactors. In connection with economic actors investing in renewable energies and part of the government, the movement then began its metamorphosis towards an energy and political project that was an alternative to the traditional pro-coal position of the SPD and pro-nuclear position of the CDU/ CSU (Aykut, 2015).

In East Germany, the environment was at the heart of the challenge of the communist model: the Umweltbibliotek («environmental library») was created by dissidents in East Berlin in 1986 and dismantled the following year by the Stasi. Reunification gives Germany the opportunity to rethink its industrial fabric. In the East, energy demand collapsed with heavy industry, five nuclear reactors closed and thermal power plants were modernised.

An important step was taken in 1990, when the Kohl administration established a guaranteed purchase tariff and priority access to the network for renewable energies. These principles are the two foundation blocks of the German energy transition. At the turn of the millennium, the consensus in favour of a gradual exit from nuclear power was sufficiently strong for it to be ratified by the Convention of 14 June 2000. This agreement between the ruling Green-SPD majority and the four nuclear power plant operators, limits the amount of electricity that can be produced by German reactors. The closure of the last of them was then planned for 2020. At the same time, the *Erneuerbare-Energien-Gesetz*, the law on renewable energies, allows for an acceleration of new installations, notably solar and wind.

This policy was initially criticised by the right which campaigned for an «exit from the exit». But the slogan was not reflected in practice: In 2010, while the CDU/ CSU governed without the SPD or the Greens, the Energiekonzept, a major law on energy, set ambitious targets for the middle of the century - a 50% drop in primary energy consumption in 2050 compared to 1990, an 80% reduction in emissions, an 80% share of renewables, etc. - and put back the end of atomic power to 2036. The timetable for the exit from nuclear was relaxed but the principle was not questioned.

• POST-FUKUSHIMA • This postponement of the exit from nuclear was fleeting: the following year, the Fukushima catastrophe persuaded Angela Merkel to think again. As of 15 March, 2011, 4 days after the earthquake, the law extending the lifespan of the power plants was suspended and 7 reactors were shut down by decree. The Energiewende, a new «energy package» of 11 laws, was passed by the Bundestag in June 2011 by a very large majority.

These texts return to a definitive end for nuclear power in 2022 and accelerate the process by confirming that the 7 decommissioned reactors, plus the Krummel reactor, which was experiencing repeated failures, would not be recommissioned. They also planned to reduce electricity consumption by 10% between 2010 and 2020, to double renewable production to 35% of the electricity mix in 2020 and to spend 3.5 billion euros on renewable energy research between 2011 and 2014 (an increase of 80% compared to the previous period). Finally, they confirmed the renewable targets and emission targets for 2050.

This policy comes at a cost: 15 to 40 billion euros per year or 0.5 to 1.2% of German GDP (Agora Energiewende, 2017), 60% of which is borne by households. Despite these investments, Germany will

largely miss its emissions targets for 2020 (BMU, 2017): the country targeted 751 CO_2mteq in 2020, or -40% compared to 1990, but it was still at 905 in 2017. This failure is not attributable solely to the electricity sector, which accounts for only one third of German emissions, but it does cast doubt on Germany's exemplary nature in this area.

Be that as it may, the political consensus around the German energy transition was completed by the volte-face of the main right-wing party in 2010-2011 and it remains solid - only the far-right party AfD today voices any opposition to this project. For its part, the vast majority of the population supports this policy: 93% of Germans think that the *Energiewende* is important, only 8% think that renewable energy is developing too quickly and 58% think, conversely, that it is too slow. The Germans are optimistic about the next stage of their energy transition: 63% think that it will be possible to replace coal-fired power stations with renewable production (BDEW, 2018).

3 • THE ROLE OF CIVIL SOCIETY AND SUB-NATIONAL ACTORS

In spite of these difficulties, unforeseen circumstances and political alternations, for nearly 20 years Germany has followed the energy policy which it defined in 2000. The electricity mix is evolving slowly, but this stability is indispensable to its transformation. It is largely explained by the role that non-state actors have played in the design and implementation of the country's energy policy.

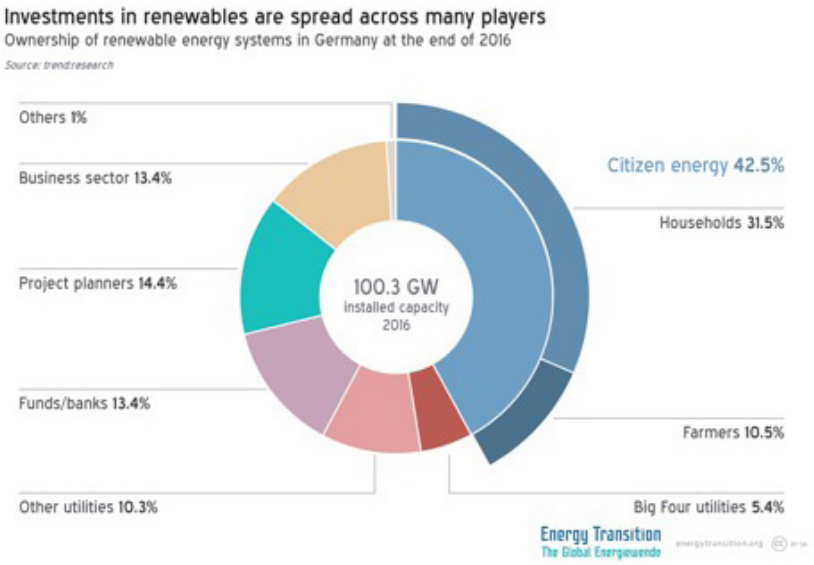


FIGURE 4. TYPES OF INVESTORS IN GERMAN RENEWABLE ENERGY PROJECTS (ENERGY TRANSITION)

(Energy Transition)

• CITIZENS, COMMUNITIES, NGOS ... THE ROLE OF LOCAL INITIATIVES • Building on a tradition of local energy management, the development of renewable energies has led to the emergence of numerous cooperatives and a reappropriation of electricity production by consumers. Today about half of renewable capacity is privately owned or farmed, compared to only 5.4% for large energy companies (Trend Research, 2017). This ownership of the energy transition by local communities promotes project buy-in and redistributes part of the costs of the German energy policy.

Local initiatives are not limited to seizing the development opportunities offered by the energy policy decided at the federal level - it often goes much further: many communities are committed to achieving 100% renewable energy or carbon neutrality.

The Baden Wurtemberg energy and climate policy

Located in the industrial heartland of southwestern Germany, the Baden Württemberg Land is one of the most prosperous regions in Europe. It contributes about 0.3% of world greenhouse gas emissions.

In its 2013 climate protection law, Baden Württemberg set itself the goal

of reducing its greenhouse gas emissions by 25% between 1990 and 2020 and by 90% by 2050. These objectives are to be achieved at the same time as the exit from nuclear, on which the Land is historically highly dependent: atomic power provided 48% of its electricity in 2010. To compensate for the disappearance of nuclear, it has targeted 38% renewable electricity in 2020, 12% of which is solar and 10% wind, and 86% in 2050. Its regulations have been revised to this end - planning rules, for example, have been relaxed to accommodate the installation of wind turbines.
To reconcile industrial prosperity and climate protection, energy will also have to be used more efficiently. The Energiekonzept 2020, adopted by Baden Wurtemberg in 2007, provides for a reduction in the energy intensity of the local economy of 2% per year. Electricity demand will be stabilised and primary energy consumption will fall. Several initiatives have been launched to achieve this, such as the Zukunft Altbau to raise the awareness of homeowners, the energy check (EnergieSparCheck) that co-finances the study of energy efficiency in the residential sector and the KlimaschutzPLUS scheme which subsidises local investment in the renovation of public buildings.
In 2008, Baden Wurtemberg was the first Land to pass a law on renewable heat. This law imposed a share of renewable energy in the heating for any renovation of residential buildings.

Sources : Ministerium für umwelt, klima und energie wirtschaft baden-württemberg

TEXT BOX 1

These proposals are not always unanimously accepted. In this case, German civil society is also able to reclaim political and economic ownership of the levers for the specific implementation of the energy transition at the local level.

The battle for control of Berlin's electricity grid

To overcome the resistance of some companies and communities, it is sometimes necessary to control the distribution network. This strategy was initiated by the «Schönau rebels» who took control of electricity distribution in a Black Forest village in 1997. Today Elektrizitätswerke Schönau, the company created for the occasion, supplies more than 30,000 homes with renewable energy.
The same battle is taking place on a different scale in the German capital. Privatised in 1997, the Berlin power grid became the property of the Swedish electricity company Vattenfall at the beginning of 2001. The Berlin Senate, theoretically responsible for the regulation of the grid, rarely exercised its powers and the local authority was regularly criticised for its failure to act, while the development of renewable energies would require a modernisation of the electricity grid. In the early 2010s, Berlin was ranked last for the integration of renewable energies and the capital was still mainly supplied by 3 coal power plants.
In response to this situation, two citizens' initiatives were put in place to regain control of the grid: the Berliner Energietisch, formed in summer 2011, and Bürger Energie Berlin, created in December 2011.
In pursuit of the same objective, these two initiatives illustrate different means of action available to German citizens. The Berliner Energietisch is an informal collective of associations and citizens that set itself the goal of imposing stricter regulations on the grid operator through a popular referendum. Bürger Energie Berlin is a cooperative whose goal is to take direct control of the grid, initially when the concession was renewed in 2014. These strategies also correspond to different forms of citizen engagement: participative demo-

cracy in the first case, cooperative economy in the second.
The Berliner Energietisch initiative sought to collect 20,000 signatures in 4 months for submission to the Berlin Senate. It collected 30,000 but the project was rejected due to opposition from the majority CDU. 172,000 signatures were needed to reverse this decision - 228,000 were collected, forcing the authority to hold a referendum. This was originally scheduled for 22 September 2013 at the same time as the parliamentary elections but was postponed until 3 November, which made it possible to defeat the proposal: although 83% of voters, or 24.1% of those registered, voted for the proposal, at least 25% of registered voters were required for its adoption.
In 2014, Bürger Energie Berlin raised nearly 12 million euros from 2,500 Berliners, which enabled it only to make an offer for a minority stake in the distribution grid. The call for tenders was again awarded to Stromnetz Berlin, a subsidiary of Vattenfall.
The battle continued with the 2016 election of a new SPD - Die Grünen - Die Linke majority which was in favour of remunicipalisation.

Sources : www.buerger-energie-berlin.de et Blanchet, 2014

TEXT BOX 2

• INTENSE ACADEMIC ACTIVITY • The design of the German energy transition is the result of groundwork carried out in part by universities and think tanks. Since the 1980s, the Öko-Institute, a research institute specialising in the field of the environment and from the anti-nuclear movement, has published a book entitled: «Energiewende: Growth and prosperity without uranium or oil» (Buchan, 2012).

Technical research organisations have played a key role in the development and demonstration of renewable technologies. For example, in 1987 the Fraunhofer Institute created the first European mountain refuge entirely powered by solar power (the Rappenecker chalet in the Black Forest). In 1992, the Fraunhofer built the first solar house not connected to the electricity grid in Freiburg, to demonstrate that a family can meet its domestic energy needs from renewable energies.

Today Germany has some of the most influential energy policy research organisations: Fraunhofer Institute, Agora Energiewende, Adelphi, Potsdam Institute, etc. These bodies help to shape the German energy transition and energy exports.

• SEEKING ALLIANCES WITH ECONOMIC ACTORS • The German energy transition is inseparable from the emergence and development of companies specialising in new energy technologies: these entities contributed to the design and promotion of the project in the 1990s and were able to change scale thanks to the rapid development of renewable production from 2000. The energy policy has therefore had the side effect of making Germany one of the industrial champions in the field: in onshore wind, for example, three of the top ten global manufacturers are German (BNEF, 2017). It is also a source of employment: in 2015, the renewable energy sector employed more than 300,000 Germans, twice as many as in 2004 (BMWI, 2016) - which is why German workers' unions generally support the project while keeping a watching brief on its effect on the fossil fuel sector.

The role of unions

The powerful German unions are important energy transition stakeholders. They have national influence because of their traditional alliance with the Social Democratic Party, but their members are also often active in implementing the transition on the ground.
German unions are generally in favour of the energy transition and the new employment it creates. From 2011, the president of the IG BCE, the energy and mining union, which has more than 660,000 members, declared that nuclear power had no future in Germany.
The union's position is more ambiguous on fossil fuels. In 2014, they supported Energy Minister Sigmar Gabriel in opposing a rapid exit from coal, even stating that it would be acceptable for Germany to fail to hit its targets for 2020.

In general, trade unions seek to maintain a balance between opposition to job losses in conventional power generation - a sector in which they are well established - and improved working conditions in the sectors experiencing strong growth such as renewable energies or energy efficiency. At its congress in May 2018, the DGB, the association of German trade unions, which has 6 million members, for example, reiterated its support for the Paris Agreement objectives and called for a «fair Energiewende» that ensures affordable energy for all and creates quality employment.

Sources : Clean energy wire

TEXT BOX 3

Companies involved in the energy transition, from large companies such as Siemens, Enercon or SMA, to cooperatives and Stadtwerke (municipal boards), innumerable SMEs and startups, contribute to the definition of the country's political approach, through associations such as the Bundesverband Erneuerbare Energien (German Renewable Energy Federation), Agentur für Erneuerbare Energien (Renewable Energy Agency) or the wind (BWE), solar (BSW) and biomass (BBE) energy unions.

Siemens, a successful transition at company level

Founded in 1847, Siemens is one of Germany's leading energy companies. In the 1970s and 1980s, Siemens was a major player in nuclear construction in Germany and a regular target of opponents of atomic power. The company permanently withdrew from nuclear construction in 2011 in the aftermath of the Fukushima disaster and turned resolutely towards green technologies.

Siemens undertook a reorganisation to take advantage of the development of these activities by breaking away from some of its historical branches, such as railways or lighting. At the end of 2017, the company cut 6,900 jobs in its gas and electricity division. The same year it merged its wind division with its competitor Gamesa to form a global wind turbine manufacturer. Siemens is also active in smart grids, electric vehicles, energy efficiency, etc. The proceeds of this «environmental portfolio» represent half of its revenues and the company estimates that they led to reductions in greenhouse gas emissions by 570 million tonnes in 2017, the equivalent of 70% of German emissions. The company has set up a dedicated start-up development division (Next47) and is now developing innovative projects for the further development of renewable energies in Germany, such as the Wildpoldsried renewable micro-grid. This does not mean that Siemens cannot take part in debates on the German energy transition, which its CEO considers «good on principle but poorly managed» (open letter to Martin Schulz, 22 November 2017). For example, the company has informally contributed to discussions by the ecologist party, Die Grünen (the Greens), on exiting from coal, and in early 2018 it offered to help the Lusatian mining region convert to electric mobility.

In 2016, Siemens joined the Carbon Pricing Leadership Coalition, the World Bank's carbon price initiative. In 2017, the Corporate Knights organisation recognised Siemens as the most sustainable world company, particularly for its commitment to renewable energy and its own energy performance. Siemens wishes to achieve carbon neutrality in 2030 and is the first global industrial group to have made this commitment.

Source : Siemens

TEXT BOX 4

Not all energy companies have benefitted from the German energy transition. Since the 1990s, the four main electricity producers (RWE, Eon, EnBWE and Vattenfall) have expressed their opposition to the development of renewables in the press and courts. However, this has not prevented

the German government from involving them in the decisions. In particular, the exit from nuclear power was negotiated with these four companies and the agreement specified the amount of electricity that could be produced by each reactor before its closure to enable them to plan and adapt. Be that as it may, the adoption of the Energiewende in 2011 led to a period of crisis for the major German power companies, resulting in multiple reorganisations (Kungl, 2018).

Finally, the government has sought to maintain the competitiveness of the manufacturing industry, which accounts for almost a quarter of the country's production. For both the majority of the political class and the powerful German professional organisations, maintaining German industrial competitiveness is seen as one of the keys to the success of the energy transition. Energy-intensive industries are generally exempted from the additional costs associated with the energy transition and, conversely, benefit from the fall in the wholesale price of electricity.

4 • NEW CHALLENGES

Despite its progress, the German energy transition is not complete. Germany faces new challenges if it wants to continue reducing its emissions through renewables and to become a benchmark.

• TOWARDS THE END OF COAL • Despite dropping sharply in the electricity mix, the residual share of coal and, in particular, of lignite, which emits more carbon dioxide, makes the German electricity mix one of the main sources of emissions in Europe. A coal exit project, similar to the nuclear exit project adopted in 2000, is essential if Germany is to meet its emissions targets after 2020 and maintain its credibility in the fight against climate change.

The country is trying to replicate the successful method of the 2000s, but the political consensus that has driven the transition until today no longer exists, mainly due the economic and social importance of coal in the disadvantaged Länder of the East.

Building consensus on the exit from coal

A commission on exiting coal was set up by the government on 6 June 2018. It has to make proposals to the coal regions in October and make recommendations in December so that Germany can move closer to its emissions targets for 2020. Its final report is expected by the end of the year; it must contain a roadmap for the exit from coal and set the date for the closure of the last plant.

The commission has 4 co-chairs, 8 ministry representatives, 6 representatives of coal regions, 3 members of parliament and 24 qualified individuals. Its membership reflects the search for the widest possible consensus. Länder coal producers will play an important role: in addition to the 6 regions represented (North Rhine-Westphalia, Saxony, Brandenburg, Saxony-Anhalt, Lower Saxony and Saarland), former leaders of Brandenburg and Saxony are among the four co-chairs and representatives of local coal-dependent local authorities are among the qualified individuals, such as the president of the association of mayors of Lusatia, another coal-mining region.

The qualified individuals are from the business world (companies, trade unions and business associations) and the academic world (one of the co-chairs is a former leader of Agoraenergiewende). An important place is also reserved for NGOs (such as Greenpeace and Friends of the Earth) and for local citizen movements.

Sources : www.cleanenergywire.org/factsheets/germanys-coal-exit-comission

TEXT BOX 5

• THE PROBLEM OF CHANGING THE SCALE OF ENERGY DECENTRALISATION • Decentralised initiatives have played an important role in the German energy transition - indeed, they are among its most notable aspects. But progress in these modes of energy production and distribution must also accept a growing role in running the network and in the electricity market, so a tighter framework will become necessary (Beermann, 2017).

In order to reduce the cost of renewable energy development, the 2017 Renewable Energy Law replaced the old feed-in tariff guaranteed by an auction mechanism. This complex and competitive system has a high failure rate that sometimes discourages projects led by non-professionals: preliminary data suggest that the number of citizen projects has dropped by 25% (Trend Research, 2017). The 2017 law also made the definition of citizen projects more flexible, which seems to have enabled some developers to obtain this label.

The reform of the renewable energy support mechanisms and the growing institutionalisation of production could therefore encourage large groups to the detriment of citizen projects, which will stop one of the main drivers of the German transition.

CONCLUSION

It is now very likely that Germany will complete the replacement of all its nuclear production by renewable energies in 2022, thus completing a transformation of its electricity mix that was planned at the end of the 1990s. But this success is but a first step: to honour its climate commitments, Germany must now commit to exiting from coal. If it manages to do this, it will show that its method is replicable, thus reinforcing its ambitious energy policy model based on consensus and leaving a large space for civil society.

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Canada, the long road towards decarbonisation of the electricity mix

Canada needs to achieve total decarbonisation of its electricity production by 2050 if it is to achieve its climate commitments. Fossil fuel power stations emitted 79 megatonnes of CO_2eq (carbon dioxide equivalent) in 2015, which represents 10.9% of the 722 Mt of total GHG emissions in Canada[1]. Yet this country is the second producer of hydroelectricity in the world, after China and at the same level as Brazil. Canada's hydroelectric reservoirs can provide balancing services to enable wind and solar power to be better integrated into the electric power grid. Geothermal energy and biomass also offer significant potential for both electricity and heat production. The new renewable energies also facilitate the gradual decentralisation of Canadian electricity systems, offering new opportunities for both public and private businesses and for community initiatives.

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CONTENTS

1 • THE GRADUAL DECARBONISATION OF THE ELECTRICITY MIX

2 • FEDERAL POLICIES ARE QUITE AMBITIOUS YET NOT YET SUFFICIENT

3 • THE CENTRAL ROLE OF CANADIAN LOCAL AUTHORITIES

4 • A HIGHLY CONCENTRATED INDUSTRY FACED WITH NEW INNOVATIVE BUSINESSES

5 • THE MEDIA, USERS AND THE SOCIAL DIMENSION OF THE TRANSITION: THE EXAMPLE OF SMART NETWORKS

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1 • THE GRADUAL DECARBONISATION OF THE ELECTRICITY MIX

Because of its geography and very severe climate, Canada is one of the countries with the highest energy consumption per person[2] on the planet. With 17 tCO_2/capita in 2017 (emissions due to energy), it is also one of the highest emitters per person, just below the United States and Australia and over twice the level of the EU (data from ENERDATA, 2018).

This sector is a leader in the decarbonisation efforts of the Canadian economy, in stark contrast to other sectors such as transport. After peaking between 2000 and 2002, CO_2 emissions due to public energy and heat production have shown a downward trend. **The decrease in electricity produced from coal and oil, along with the increase in hydroelectric and wind power, and to a lesser extent nuclear, explain the 31% decrease in emissions by the sector between 2007 and 2017 (Figure 1).** This movement has been strongly supported by Ontario, which completed the closure of its coal-fed power stations in 2014 (Division des inventaires et rapports sur les polluants du Canada [Division of inventories and reports on pollutants in Canada], 2018). The 2.6% increase in 2017 is accounted for by a steep increase in electricity consumption (7%)[3] and by the accompanying increase in average production (7%) of gas-fired power stations.

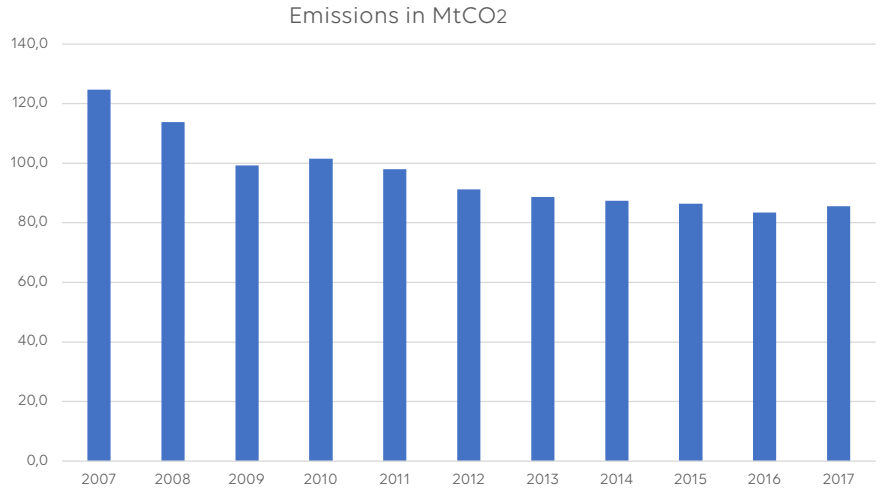

FIGURE 1. CO_2 EMISSIONS FROM THE PUBLIC PRODUCTION OF ELECTRICITY AND HEAT

Source : drawn up by the author using data from ENERDATA.

The declassification of old power stations and the addition of renewable capacity has taken the green energy share of electricity production in Canada from 63% in 2015 to 64.7% in 2017. Over the same period, the share of renewable energies other than hydroelectricity increased from 6.3% to 7.9%. This is explained by the surge in wind power from 26,060 GWh in 2015 to 35,995 GWh in 2017, and to a lesser extent by solar power which went from 2,900 GWh to 4,430 GWh. Electricity produced from coal has decreased (from 65,943 GWh to 63,706 GWh) whereas that produced from gas has increased (from 56,408 GWh to 62,763 GWh) and oil-based electricity has remained stable. **Hydroelectricity clearly remains the principal source with 349,664 GWh in 2015 and 37,164 GWh in 2017 whereas nuclear has shown a slight decrease from 101,423 GWh in 2015 to 99,343 GWh in 2017.**

2 - In 2017, energy consumption was 7.84 toe/capita and electricity consumption was 15.6 MWh/capita, among the highest levels in the world.
3 - The reasons for this rise are not yet fully established but are likely to be linked to the increased pace of economic growth, which reached 3% in 2017, as well as to climate change factors.

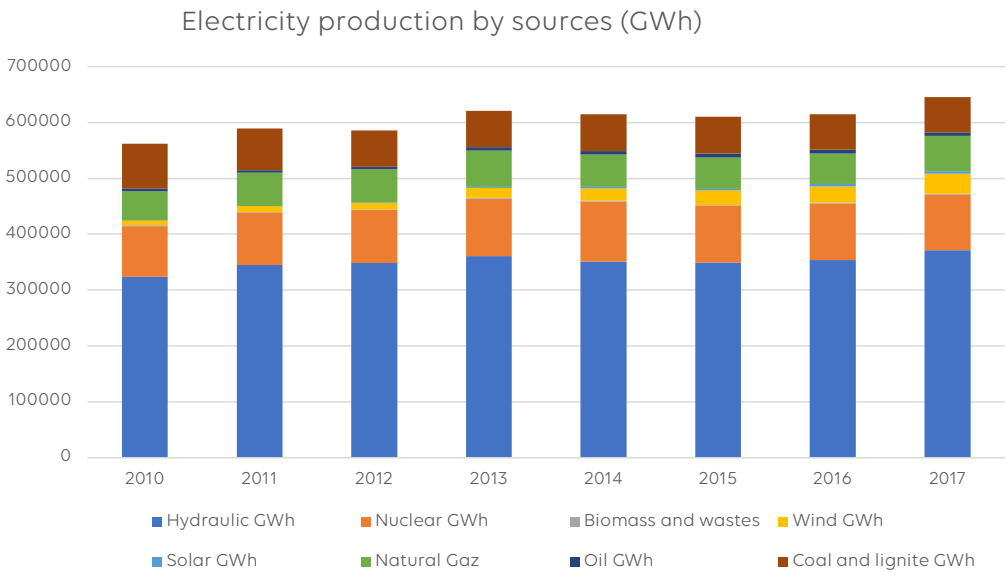

FIGURE 2. EVOLUTION OF THE CANADIAN ELECTRICITY MIX

Source : drawn up by the author using data from ENERDATA

This evolution in the energy mix allows us to position the carbon intensity of public energy production in Canada (CO_2 emissions per kWh produced) well below the world average (Figure 3). Radical decarbonisation suggests that a carbon intensity close to zero could rapidly be reached, at the same time as electricity use becomes widespread in other high carbon sectors such as transport.

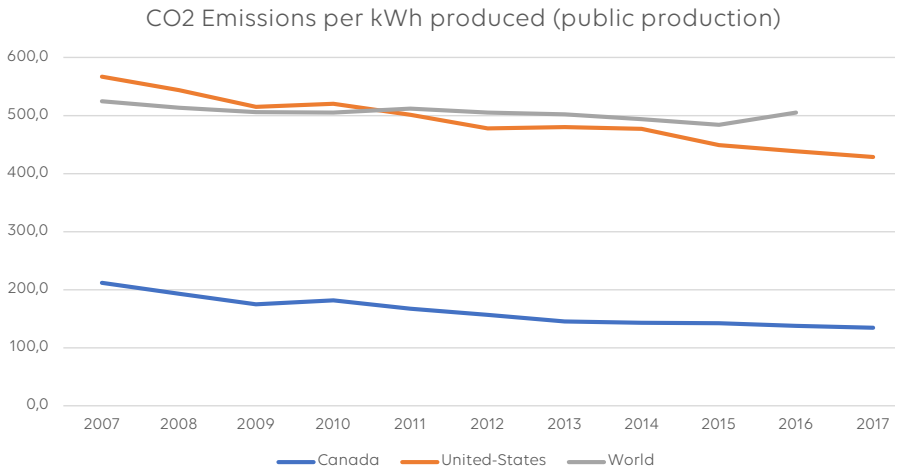

FIGURE 3. CARBON INTENSITY OF THE ELECTRICITY MIX

Source : drawn up by the author using data from ENERDATA

2 • FEDERAL POLICIES ARE QUITE AMBITIOUS YET NOT YET SUFFICIENT

According to the terms of the Paris Agreement, Canada has committed to reducing its GHG emissions to 30% below 2005 levels by 2030, a target equivalent to 523 $MtCO_2eq$ per year, that is, a decrease of 28% compared to 2015, when the total GHG emissions in Canada were 722 Mt CO_2eq.

In 2016, Canada published the 'Pan-Canadian Framework on Clean Growth and Climate Change' whose central element is **a plan to impose a compulsory tariff on carbon, requiring all provinces and territories in Canada to set up either a capping and emissions trading system or a price-based system, such as a tax on carbon.** Compliance with the pricing systems proposed by the provinces and territories to meet the federal standard will be evaluated, so that they come into force in 2019.

A federal ceiling price of 20 CAN/tCO_2$eq (15 US/tCO_2$eq) will also come into force on 1 January 2019 for provinces that have not yet proposed a system or a satisfactory minimum value. This benchmark price will progressively increase up to 50 CAN/tCO_2$eq by 2022 (Climate Action Tracker, 2018).

Carbon tax and 'carbon dividend'

The federal carbon tax has been a subject of heated debate in Canada[4] , especially because of the uncertainties surrounding its impact on the economy and household incomes. On the other hand, this law on the pricing of GHG emissions obliges the federal government to transfer all revenue generated by this pricing to the province or territory from which it originates, in the form of payments to provincial governments or rather, as suggested by the federal government, directly to private individuals and businesses. This approach, consisting of taxing carbon and then transferring the tax directly to households in the form of 'dividends' is called a 'fee and dividend' or 'carbon dividend' and has become popular in the United States with associations such as the Citizens Climate Lobby and the Climate Leadership Council. A recent study shows that households could receive more money on average than they had paid via the tax (Sawyer, 2018), a fact which was not enough to persuade all the Canadian provinces. Ontario and Saskatchewan were strongly opposed to the federal government initiative and instigated legal action to challenge the federal government's legal authority to impose such a tax. However, four provinces had already put in place a system for carbon pricing – British Colombia and Alberta (carbon taxes) and Quebec and Ontario (emissions trading system).

TEXT BOX 1

The Pan-Canadian Framework also proposes supplementary measures to further reduce emissions across the whole of the economy while accelerating the pace of innovation and job creation. The Low Carbon Economy Fund (LCEF) makes available 2 billion Canadian dollars (1.34 billion Euros) to support implementation of the Framework in the territories. 70% of this Fund will help provinces and territories to reach the objectives they set in the Framework, and 30% is to help stakeholders in Canadian society (provinces and territories, local authorities, governments and local community organisations, businesses and NGOs) to devise and implement innovative projects. In addition, in the autumn of 2017, Canada co-founded the Powering Past Coal Alliance to accelerate the elimination of electricity produced from coal. In February 2018, the Minister of the Environment and Climate Change announced modifications to the existing rules, aimed at ending electricity produced from coal by 2030, together with a revision of the standards for electricity produced from natural gas (Environnement et Changements climatiques [Environment and Climate change] Canada, 2018).

Despite all this, Canada's commitment to the Paris Agreement is considered "highly inadequate" by NGOs and academics. "*Commitments with this rating fall outside the fair share and are not at all consistent with holding warming to below 2°C let alone with the Paris Agreement's stronger 1.5°C. If all government targets were in this range, warming would reach between 3°C and 4°C*" (Climate Action Tracker, 2018). **There is also a fundamental tension between Canada's climate objectives and its place in the hydrocarbon market:** "Implicit in the national discourse about the intersection of our historically resource-based economy and the challenge of decarbonisation is the message that Canadians do not have to make choices: we can decarbonise domestically while still benefiting from the global market for conventional and non-conventional fossil fuels. Extensive citizen

4 - See for example the following report : www.cbc.ca/news/canada/carbon-tax-canadians-cost-prices-1.4753664

dialogues as part of the Generation Energy process[5] , however, challenge the logic and wisdom of this assumption" (Burch, 2018).

Carbon pricing and the development of wind power

Several studies show that the considerable technical and economic potential of wind power in Canada could enable electricity production to be radically decarbonised more rapidly and at a lower cost (Dolter & Rivers, 2018; GE, 2016). Canada has several regions where the annual average wind speed at an altitude of 50 metres reaches 7 m/sec or more, including the plains of southern Alberta and Saskatchewan, southern Ontario and northern Quebec. Hydroelectric reservoirs can provide balancing services to enable wind and potentially solar power to be better integrated into the electric power grid. This potential may be supported by carbon pricing, and the authors estimate that a carbon price of 50 $/tonne of CO_2eq (planned for 2022) could reduce GHG emissions in the electricity sector by 20 to 21% in comparison with 2005. Nevertheless, if Canada wishes to substantially decarbonise the electricity sector by 2030, the price of carbon will have to continue increasing beyond 2022..

The optimal composition of electricity production in Canada changes as the price of carbon increases. Investment in energy from wind power offers an inexpensive way to reduce emissions and becomes increasingly attractive as the price of carbon increases (Fig. 4). At 200 $/tonne of CO_2eq, wind power makes up almost 30% of the optimal production mix. In scenarios of 100% decarbonisation, wind power represents 35% of production when electricity trading between provinces is possible and 33% when it is not. These levels of penetration by wind power are comparable to the 35% of production judged technically achievable by the GE study (2016).

The study also highlights the relevance of increasing energy exchange between the Canadian provinces (from east to west) to facilitate balancing the electricity system when faced with the variability of wind power

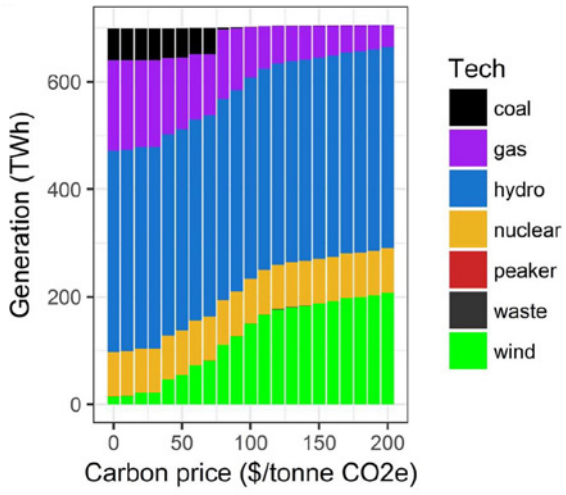

FIGURE 4. ANNUAL ELECTRICITY PRODUCTION IN CANADA IN THE CARBON PRICING SCENARIO

Source : Dolter et Rivers (2018)

TEXT BOX 2

3 • THE CENTRAL ROLE OF CANADIAN LOCAL AUTHORITIES

Hydroelectric power stations are a major source of energy for electricity production in Quebec, Newfoundland and Labrador, Manitoba and British Colombia. Provinces that depend on coal and natural gas include Saskatchewan, Nova Scotia, New Brunswick and Alberta. Geographically, each province where electricity is produced from fossil fuels is adjacent to a hydroelectric province. **Nevertheless, the existing transport structure only allows a limited number of east-west inter-province connections, which limits electricity trading between provinces and therefore the integration of renewable energy sources**. Figure 5 below shows the huge contrast in the energy mix of two adjacent provinces.

Canadian provinces have advanced skills in environmental matters and some have been very active in carbon pricing. British Colombia, Quebec, Ontario and Alberta introduced different

5 - Voir : www.nrcan.gc.ca

arrangements for carbon pricing. They also implemented various mechanisms to support the roll-out of clean energy for electricity production (see Text box 2)

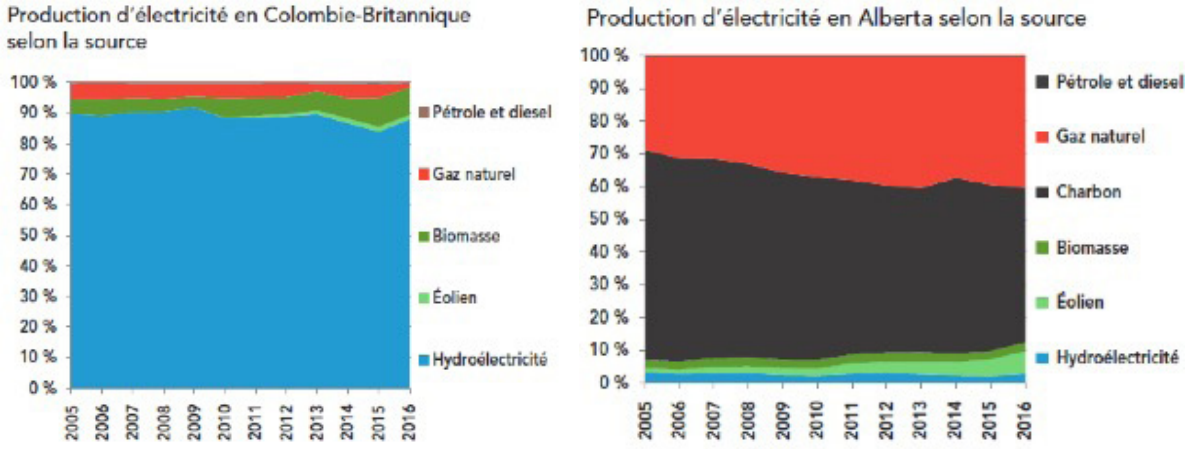

FIGURE 5. EVOLUTION OF THE ELECTRICITY MIX IN ALBERTA AND BRITISH COLOMBIA

Source : National Energy Board 2017

In addition, several Canadian cities such as Toronto, Vancouver, London, Edmonton and Windsor have set objectives and put in place actions for mitigation, in particular for the production of electricity (or electricity and heat) locally and from renewable energy sources.

The provinces in action

The 'First Annual Summary Report' of the 'Pan-Canadian Framework for Clean Growth and Climate Change' was published in December 2017. It highlights specific actions undertaken by the Canadian provinces during 2017.

• **Newfoundland and Labrador** continue working to complete the hydroelectric project at Muskrat Falls. When it is finished, 98% of the province's electricity will come from renewable sources. The surplus will be exported to Nova Scotia and elsewhere. The Holyrood Thermal Diesel Generating Station, which produces over a million tonnes of GHG emissions per year, will be declassified.

• **The North-West Territories** have installed 55 kilowatts of solar energy with an efficient variable-speed generator in the community of Aklavik, and are undertaking design works for large-scale wind turbines at Inuvik. They are also trialling the combined production of heat and electricity on a small scale from biomass at Fort Simpson to reduce diesel use in these far-flung indigenous communities which are off the grid.

• **Prince Edward Island** is one of the world leaders in the field of developing energy from wind power. Wind power energy meets twenty-four per cent of the energy requirements of Prince Edward Island and future expansion is planned by 2020 and 2030.

• **Alberta** has announced the Renewable Electricity Act and launched a renewable electricity programme aimed at creating a renewable energy production capacity of 5,000 megawatts by 2030. The province has also announced that 35 million dollars has been set aside for financing leadership initiatives in climate change, especially solar and renewable energy projects in the communities of the First Nations and the Métis Nation.

• **Quebec** has announced an action plan for its 2030 energy policy in which it commits to increasing its capacity for renewable energy production by 25%. This province also created Transition Energétique Québec (TEQ) (Quebec Energy Transition) to support, stimulate and promote energy transition, innovation and efficiency, and to finalise the implementation of all the programmes and measures necessary to reach its energy objectives.

Source : Pan-Canadian Framework for Clean Growth and Climate Change (2017).

TEXT BOX 3

In 2012, in partnership with Toronto Hydro, the capital city of Ontario launched the first phase of a programme that will enable buildings belonging to the city to be equipped with solar photovoltaic (PV) panels. The first phase of the feed-in tariffs was completed in June 2014 and the second phase in 2016, which led to the installation of 20 PV solar systems on the roofs of the city's buildings, with a total installed power of 2.5 MW. On an annual basis, phases 1 and 2 combined make it possible to reduce GHG emissions by approximately 147 tonnes and generate more than 3,300 megawatts (MWh) of electricity, which is equivalent to the energy consumption of around 280 households. In October 2016, Toronto began the third phase of the FIT programme, which will see the installation of over 40 PV solar systems for total installed power of 6.0 MW. These installations will produce approximately 7,800 MWh of electricity per year - the equivalent of the consumption of some 350 households - and will reduce GHG emissions by around 353 tonnes each year.

The city of Vancouver is internationally recognised as one of the most ecological cities on the planet. The capital of British Colombia has a long history of support for climate action, from the Clouds of Change reports in 1990 to the Community Action Plan for Climate Change in 2005 and the Greenest City 2020 Action Plan in 2011, and now the Renewable City Strategy and Plan. This plan, whose aim is to achieve a city with 100% of its energy supplied from renewable sources by 2050, targets buildings, transport and waste as well as cross-cutting opportunities, and also the reduction of energy consumption. The results of the plan's progress are published annually[6] . In addition, the city strongly opposed the expansion of the TransMountain oil pipeline between Edmonton and Burnaby, recently relaunched by the federal government. "*Vancouver's path to be the greenest city in the world started decades ago. Thanks to the passion of the people who choose to call Vancouver home, it will continue long after 2020*" (Greenest City 2020 Action Plan Part Two: 2015-2020).

Flexible nuclear reactors for New Brunswick - a sustainable choice?

The government of New Brunswick has signed an agreement with the American company Advanced Reactor Concepts which seeks to develop small flexible reactors in this province of eastern Canada. Thanks to the Point-Lepreau power station, nuclear power has played a significant role in the electricity production of New Brunswick since the 1980s. The provincial government strongly supports scientific research to develop small nuclear reactors which are seen by certain stakeholders as a decarbonisation solution but remain very much criticised by other stakeholders.

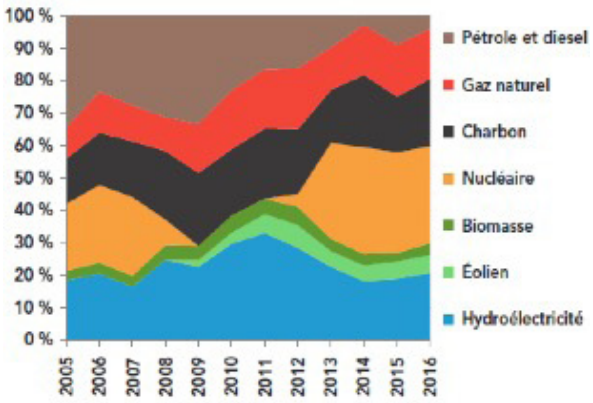

FIGURE 6. ELECTRICITY PRODUCTION IN NEW BRUNSWICK

Source: National Energy Board, 2017.

With a surface area of 72,908 km² and a population of 747,101 (2016), New Brunswick is one of the smallest provinces in Canada. In 2016, it produced its electricity from various sources and 29.9% of these were renewable. However, the continuing high percentage for coal (20.7%) largely explains the fact that the level of GHGs in electricity production, at 280 g of GHG per kWh, is double the Canadian average (National Energy Board, 2017).

Following the agreement with the provincial government, Advanced Reactor Concepts (ARC) announced an investment of 5 million dollars in R&D activities in New Brunswick and will open an office in Saint-Jean to develop reactors

6 - https ://vancouver.ca/files/cov/greenest-city-action-plan-implementation-update-2017-2018.pdf

with a capacity of 100 MW. This company is seeking to develop and market a sodium-cooled reactor of metal construction. It uses the technology of GE Hitachi Nuclear Energy. The company's reactor could be on the market from 2028. The provincial government will not invest finance in this specific project, but it recently announced financing of 10 million Canadian dollars for a nuclear research group formed by the New Brunswick Energy Solutions Corporation, a partner in the project[7] .

According to ARC, this new type of reactor has several advantages. One is that the modular components of the reactor may be transported as separate parts to an assembly site and rapidly brought into service. In addition, the reactor may be used for non-traditional purposes, such as in desalination plants for seawater and sites extracting shale gas. However, these new agreements in favour of nuclear have been the subject of fierce criticism from various NGOs and political groups, such as the Green Party of New Brunswick[8] . They stress the risk of accidents, the ever-present problem of radioactive waste, the non-renewable nature of these resources and the high cost.

TEXT BOX 4

4 • A HIGHLY CONCENTRATED INDUSTRY FACED WITH NEW INNOVATIVE BUSINESSES

The Canadian electricity sector is organised around provincial public companies. In fact, the provinces have constitutional jurisdiction over natural resources. The process to partially liberalise the markets in the 1990s modified certain industry parameters, for example the functional separation of electricity production, transport and distribution activities. Most provincial governments are still directly involved in the electricity market as managers of a more or less significant part of the electric power network.

A number of local authorities manage local distribution networks in their territory. Some municipally-owned companies, such as EPCOR in Edmonton, are major players in electricity production, under their corporate name or through their management of companies listed on the stock exchange.

Over recent years, the partial or total deregulation of wholesale electricity sales has created a number of independent producers, who build and manage electric power stations and sell their production over the long term - using contracts with a duration of up to 35 years - or on the electricity market, where such a market exists.

The principal companies in the sector are grouped together in the Canadian Electricity Association which has been in existence since 1891. This association publishes an annual report, Sustainable Electricity, which evaluates progress in the sector in matters of economic, social and environmental sustainability. Among the initiatives undertaken by businesses in the sector in 2016-2017, the following may be noted:

• **Capital Power is reducing coal consumption and CO_2 emissions thanks to renewable biomass.** The private company Capital Power is actively pursuing co-combustion of biomass (wood waste) with coal at its Genesee power station, located to the west of Edmonton. This is the first time a trial of this size has taken place in Canada, involving the co-combustion of woody biomass and coal in an electricity power station. Integrating biomass into the fuel mix at Genesee has the potential to reduce coal consumption to 30%.

7 - ICI.Radio-Canada.ca, 9/07/2018, Research into small nuclear reactors in New Brunswick.
8 - Acadienouvelle, 10/07/2017. Mini nuclear power stations: a 'mad adventure' to be avoided

• **Nova Scotia Power has focused on developing renewable energy over the last ten years.** Nova Scotia Power has tripled its production of renewable energy to 28% thanks to biomass and wind power, and has reduced its GHG emissions by over 30%. It is set to achieve a 58% reduction in emissions, compared to 2005 levels, by 2030, a performance that is almost twice the level of national objectives. A major reduction in GHG emissions is expected when Nova Scotia becomes linked by sea to the hydroelectric plant under construction at Muskrat Falls in Labrador.

• **Alectra and Enbala are working together on the management of smart electric mini-networks.** Alectra provides the advanced technology necessary to ensure the operational stability of electricity networks by managing the power of the energy distributed. Enbala's real-time energy balancing platform offers an extremely flexible approach to create energy resources that can be controlled and distributed via flexible loads, energy storage (including electric vehicles) and renewable energy sources. In 2013, Alectra set up a project for a pioneering micro-network in Vaughn, Ontario, to rise to the challenge of renewing the workforce on the large-scale electricity distribution networks and show that renewable energy can effectively meet the growing demand for electricity.

As far as the development of geothermics is concerned, Canada is lagging behind in respect of the enormous potential that exists for the production of heat and electricity, especially in the west of the country. Businesses in the sector and political representatives of the provinces of western Canada both[9] stress that the expertise and skills of the oil industry can be used to advance projects for geothermal power plants. Among the latest initiatives is that for a power plant near the town of Estevan headed by the company *DEEP Earth Energy Production* which had carried out several conclusive tests since 2014. It plans to sink the first wells from June 2018. In the area of Estevan, Saskatchewan has aquifers on which DEEP is conducting its geothermal operations. They contain a subterranean layer of brine - extremely salty water - preserved beneath permeable rock 3 kilometres from the surface. To release energy or geothermal heat from this, all that is required is to draw out this water at a high temperature (120 degrees Celsius), then pass it through a turbine which will extract the heat or energy. The cooled water is then reintroduced into the aquifer. It reheats rapidly on contact with the rock on its journey to the depths (*Source: DEEP Earth Energy Production*). The Saskatchewan State company *SaskPower* signed a contract in the spring of 2017 to purchase electricity from DEEP, which could produce 5 megawatts per power plant. One single power plant will be able to supply 5,000 homes with electricity. DEEP is planning to build more than ten of them.

5 • THE MEDIA, USERS AND THE SOCIAL DIMENSION OF THE TRANSITION: THE EXAMPLE OF SMART NETWORKS

The challenges of a transition towards an economy of low carbon emissions are largely social and political rather than technical (Burch, 2018). To achieve this, there is a need for deliberate policies at various levels on the one hand, and, on the other, proactive behaviour on the part of citizens. Other stakeholders such as the media or NGOs also play an important role as intermediaries as well as opinion formers on this subject. Smart grids have been known for several years and are a revealing example of the role of users and the media in the energy transition because they incorporate technologies that can directly affect our daily life.

In recent years, several research teams in Social Sciences have focused on analysing the rather problematic establishment of smart networks in Canada and the United States[10] . Smart networks are designed as a cutting-edge tool aimed at transforming the ways societies produce, distribute and consume electricity. A smart grid is a network that links producers and consumers to ensure a safe, sustainable and economically efficient electricity supply. It includes tangible and intangible information and communication technologies (ICT), such as smart meters, real-time information

9 - Voir : //ici.radio-canada.ca/nouvelle/1023713/geothermie-reconvertir-puits-petrole-orphelins-budget
10 - Consulter : (Peters et al. 2018 ; Mallett et al., 2018a ; Mallett et al., 2018b ; Jegen et Philion, 2018 ; Winfield et Weiler, 2018 ; Meadowcroft et al., 2018).

for consumers, dynamic pricing and the incorporation of electric vehicles into the networks. For their supporters, smart networks constitute a key element of the transition to sustainable energy, aimed at mitigating climate change, improving energy security and preventing surges in energy prices (Jegen and Philion, 2018).

The development of smart grids is relatively recent in Europe and North America. In Ontario, a strategy of rapid roll-out for smart meters was launched in 2004 and is still to this day considered the most advanced experiment in terms of the formulation and implementation of policies for smart networks in Canada (Winfield and Weiler, 2018). In this province, smart grids have been put on the policy agenda as an ambitious strategy to improve the network while mitigating climate change. In contrast, in the neighbouring province of Quebec, the roll-out of smart networks occurred later, lacked political relevance and was limited in its scope. The principal objectives linked to their introduction were the security of the supply and economic efficiency, with little stated ambition for a more fundamental change in the way the energy industry works.

In 2011, Hydro-Québec - a public monopoly - launched its programme to replace 3.75 million traditional meters with smart meters. Although the new infrastructure was designed to enable bi-directional communication, the meters are in fact used by Hydro-Québec to collect data on the use, voltage and quality of electricity, yet no hourly rate has been introduced and consumers cannot check and adapt their energy use in real time. Furthermore, the authors show that key players in the electricity sector of Quebec did not establish any link between a smart network and strategic challenges such as climate change and energy transition. Media analysis shows, however, that the media coverage on smart networks was generally negative and mainly focused on the potential detrimental impacts of smart meters.

The analyses by Mallett et al. (2018) start from the observation that different provinces in Canada continue to promote the integration and expansion of smart networks within their electricity systems, but roll-out rates vary despite them having similar policies and programmes. To try to understand the reasons for this discrepancy, they focus on the way smart grids are perceived by users and reflected in the written media. The authors emphasise the fact that the media coverage of smart networks began as generally positive but this was reversed some time later. In other words, and according to the theory of Gartner's 'hype cycle', there is first a bias in favour of innovation when support for new technology increases rapidly in a more abstract and general way, then decreases as users experience these new technologies in reality. The negative perceptions of these technologies were greater in British Colombia and Quebec, two provinces where users had more negative experiences with the way they were initially introduced to smart meters (often in a letter from their public service informing them that their analogue electricity meter would be subject to compulsory change). On the other hand, media coverage was more positive in Ontario, where the fact that there are more local electricity distribution companies helps put in place strategies that are better adapted to the characteristics of each territory.

Peters et al. (2018) finally highlight the fact that 'environmental scoping' was largely absent from the socio-political discourse (citizens, media and key participants) during the establishment of smart grids in British Colombia. A clearly communicated vision of the way smart networks can help mitigate climate change may increase acceptance and participation by citizens. To sum up, the results of these studies remind us that political decision makers must pay particular attention to the dynamics and characteristics of each territory in order to enhance the success of the policies and programmes involving new technologies.

CONCLUSION

The provinces of Canada have very strong prerogatives in terms of energy and the environment. Most of the provinces have therefore set objectives to reduce GHG emissions and have taken measures towards achieving them. All these actions are harmonised in a federal plan aimed at the total decarbonisation of the electricity sector in the decades to come. Municipal authorities are also active in the climate field, urged on by citizens who are increasingly concerned. Finally, new technologies associated with renewable energy facilitate the decentralisation of energy systems, which opens opportunities for new businesses in various areas such as geothermal and the smart management of networks.

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Portugal: a blazing energy transition hampered by the resilience of coal

Portugal, a country that is home to 10 million people, has become one of the European champions of renewable energies for electricity production, thanks to the growth of onshore wind, hydro-electricity, biomass and - more recently - solar energy. The spread of renewable energies also encourages new operators to emerge, both domestic and foreign, in a sector that is traditionally oligopolistic. However, the intense decarbonisation of the Portuguese electricity system has been faced with several challenges, requiring action from public and private operators at different levels. For example, the need for a rapid "exit" from coal, the physical interconnection with the rest of Europe, and the development of smart grids are some of the main challenges.

Head Editor • **GERMÁN BERSALLI** • *Researcher, Univ. Grenoble Alpes, CNRS, INRA, Grenoble INP, GAEL*

CONTENTS

1 • MOVING TOWARDS THE DECARBONISATION OF ELECTRICITY PRODUCTION?

• The Portuguese electricity mix: the growth of wind power vs the resilience of coal

• A somewhat ambitious national policy framework

2 • THE DEVELOPMENT OF RENEWABLE ENERGIES AND THE DIVERSIFICATION OF OPERATORS

• Consolidation of onshore wind energy

• Solar PV takes off

3 • THE CHALLENGES OF INTEGRATING A GROWING SHARE OF INTERMITTENT ENERGIES

• The Portugal - Spain - France interconnection

• Smart grids for smart cities: example of the city of Évora

1 • MOVING TOWARDS THE DECARBONISATION OF ELECTRICITY PRODUCTION?

Following the 2015 Paris Agreement, Portugal has been committed to achieving a carbon neutral economy by 2050. Since October 2017, the government has been working on a roadmap that aims to identify and analyse the implications of the trajectories that are most effective for pursuing the national goal of carbon neutrality. Despite an advance in renewable energies for generating electricity, continuing with coal prevents true decarbonisation of the sector.

• THE PORTUGUESE ELECTRICITY MIX: THE GROWTH OF WIND POWER VS THE RESILIENCE OF COAL • Despite significant investment in renewable energy over the past ten years, reducing CO_2 emissions from public electricity and heat production has proved to be a struggle (Figure 1). **On the one hand, we have seen an increase in electricity production, which pushes up the level of emissions, and, on the other hand, an opposite effect: a decrease in the carbon intensity of the electricity mix thanks to progress in renewable energies occurring at a faster rate than in fossil fuels. However, the second effect is barely enough to offset the first, which explains why the level of emissions only dropped very slightly over a ten year period**. Chart 1 also shows a large fluctuation in the level of emissions from one year to another. This can be explained by the significant variations in rainfall patterns and therefore hydro-electricity production, offset by increased use of fossil fuels. As such, CO_2 emissions decreased by 9% in 2016 but bounced back by 20% in 2017. Last year's emissions reached 17.1907 million tonnes of CO_2, 76% of which came from coal-powered power plants, 20% from gas-powered plants and 4% from diesel power plants.

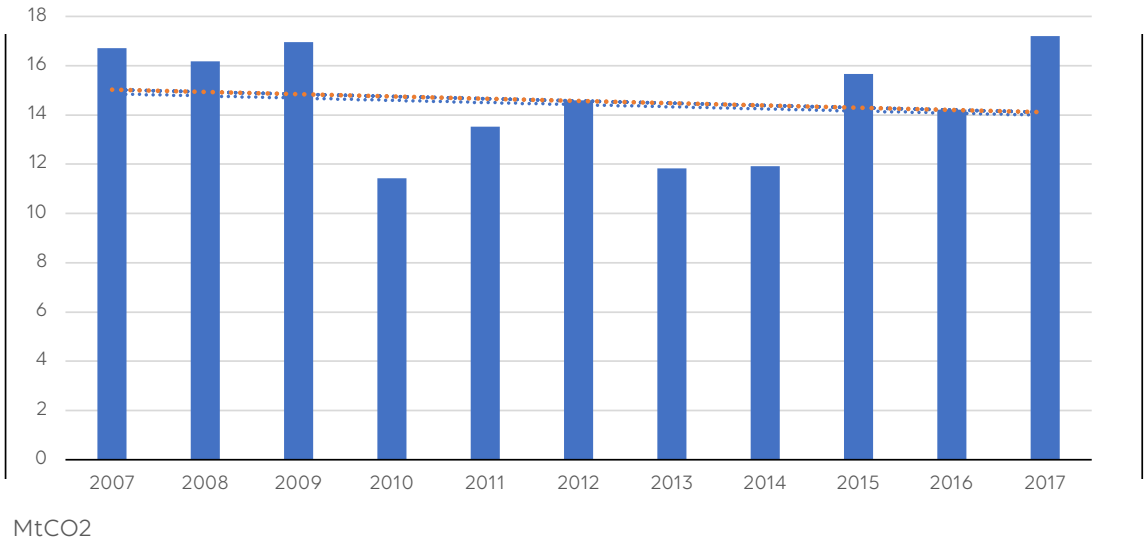


FIGURE 1. CO_2 EMISSIONS FROM THE PUBLIC PRODUCTION OF ELECTRICITY AND HEAT.

Source: Compiled by the author using data from ENERDATA

Public electricity generation in Portugal amounted to 49,447 gigawatt hours (GWh) in 2017, slightly lower than the record 51,983 GWh in 2016. The country has a fairly diversified electricity mix (Figure 2). In 2017, natural gas represented 32.9%, followed by coal (24.9%) and wind energy (20.3%). The remainder of the electricity mix was composed of: hydro-electricity (12.4%), biomass (5.7%), oil (1.9%), solar (1.4%) and geothermal (0.3%). Over the past decade, wind energy production has increased substantially; however, this has not been accompanied by a nominal decrease in production by coal-powered plants. As for gas-powered plants, their production levels vary from one year to the next to offset the fluctuations in hydro-electricity. The latter's share ranged from a maximum of 30.6% in 2010 to a minimum of 12.4% in 2017. **Finally, it should be noted that the share of**

wind energy in Portugal's electricity mix was the fourth highest in the world in 2016, behind Denmark, Lithuania and Uruguay. Solar energy, on the other hand, is still struggling to carve out its place in the Portuguese electricity mix.

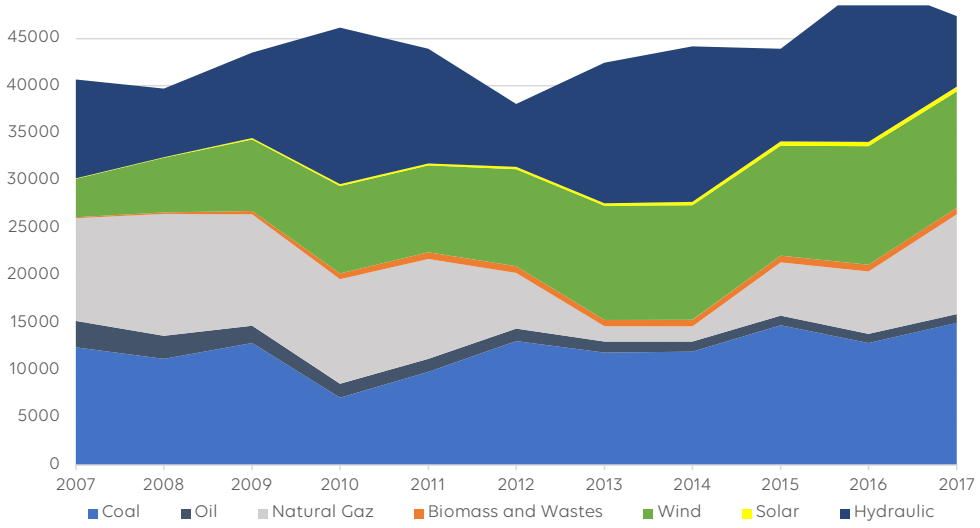


FIGURE 2. ELECTRICITY GENERATION BY SOURCE (GWH/YEAR)

Source: author's compilation using data from ENERDATA

Given the growth of wind power and the high variability of hydro-electricity production (from one year to another), the carbon intensity of Portugal's electricity mix (Figure 3) has experienced a slight downturn, but still demonstrates considerable fluctuations. With an intensity of around 300 grams of CO_2 per kWh, the country (like the majority of its European neighbours) still has a lot of work to do in order to achieve a fully-decarbonised electricity production sector.

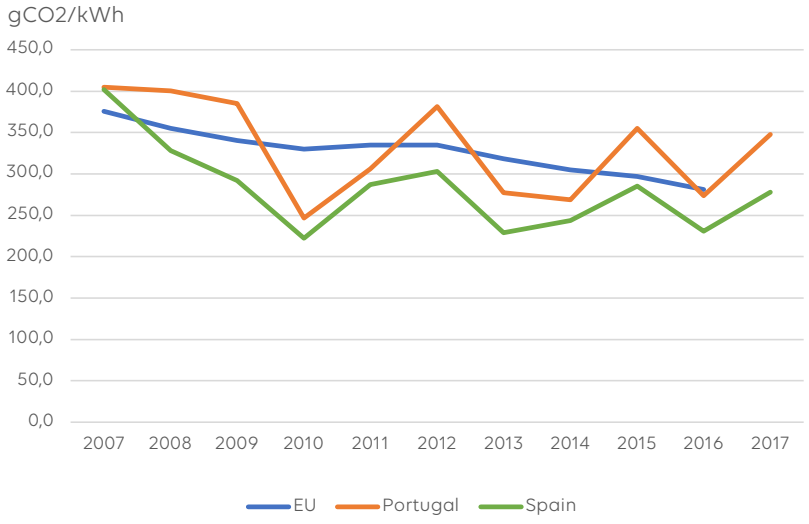


FIGURE 3. CARBON INTENSITY OF THE PORTUGUESE ELECTRICITY MIX.

Source: Compiled by the author using data from ENERDATA

• A SOMEWHAT AMBITIOUS NATIONAL POLICY FRAMEWORK • The purpose of the *Programa Nacional para as Alterações Climáticas 2020/2030* (National Climate Change Programme 2020/2030) is to ensure the reduction of greenhouse gas emissions, in order to achieve a goal of -18% to -23% in 2020 and -30% to -40% in 2030 compared to 2005 levels, ensuring compliance with national commitments in terms of mitigation and bringing Portugal in line with European objectives. It

sets specific targets for emissions reduction, and identifies a set of sectoral measures and policy options for development in the future. In this way, integrating mitigation objectives into sectoral policies is encouraged and a dynamic approach to planning is recommended, giving each sector (transport, energy, agriculture, forestry) greater autonomy in identifying policy tools.

As such, Portugal has adopted the 2020 target of sourcing 31% of its energy from renewable sources in final energy consumption, including 10% in transport; a general energy efficiency target of 25% for 2020 (more ambitious than the 20% target set by the EU) and a specific 30% energy efficiency target for public administration. Furthermore, in "*Compromisso para o Crescimento Verde*" the country committed to achieving 40% renewable energy in final energy consumption by 2030.

Given the strong potential of renewable energy in Portugal, the electricity sector, which includes dedicated production and cogeneration, is one of the main driving forces behind reducing national emissions. The most important way of encouraging renewable energy is a feed-in tariff for existing facilities. **A remuneration scheme came into force in 2015 for new small production facilities. Generally speaking, all technologies used in the generation of renewable electricity are eligible for support.** In addition, connections to the network are provided for renewable energy producers. Currently there is no direct assistance programme for renewable energies in the heating sector (in January 2017). Furthermore, Energy Efficiency Funds have provided grants for investments in solar water heaters through "Efficient Buildings 2016", which started in July 2016.

In November 2016, the Portuguese Minister of the Environment confirmed that the country's power plants would cease burning coal by 2030. This was reiterated when the roadmap for carbon neutrality by 2050 was launched in October 2017. The Sines power station in Portugal, inaugurated in 1985, is one of the EU's most climate-damaging coal-powered plants[1].

2 • THE DEVELOPMENT OF RENEWABLE ENERGIES AND THE DIVERSIFICATION OF OPERATORS

The development of renewable energies in Portugal has largely been led by EDP Renováveis (EDPR), which was established in 2007 as an independent company of the incumbent operator, EDP (Energias de Portugal). **By the end of 2017, EDPR was ranked fourth in the world in terms of wind energy production. Small start-ups have been emerging alongside this giant in a Portuguese electricity sector that is particularly dynamic in wind power and, more recently, solar power.**

• CONSOLIDATION OF ONSHORE WIND ENERGY • The power generation sector - which has long been oligopolistic - has four major players, including the EDP. **However, over the past decade this company has seen its market share decrease due to the emergence of several new renewable energy producers. In 2013, they already accounted for 40% of electricity on the wholesale market (IEA, 2016).**

Portugal has been experiencing spectacular development in onshore wind energy since the 2000s. **The country's installed capacity has grown from 100 MW in 2000 to 5,269 MW in 2017 (Figure 4), which has been made possible by a very generous feed-in tariff system (Figure 5).** A portion of the extra cost is passed on to electricity consumers, while another portion increases the deficit - and accumulated debt - of the electricity system. This prompted critical reactions (Peña et al., 2017), and the government decided to end this support system in late 2012. As such, plants put into operation from 2013 onwards could no longer receive these grants, which slowed down the sector's growth. However, a new promotion scheme came into force in 2015 for self-generators and small production facilities with a maximum installed capacity of 250 kW. As far as offshore wind power is concerned, there are as yet no turbines operating off the Portuguese coast because the ocean floor is too deep. Offshore wind power will be achieved via floating wind farms, a dozen of which are in the planning stage.

1 -Europe Beyond Coal Overview: National Coal Phase-Out Announcements in Europe, 2018

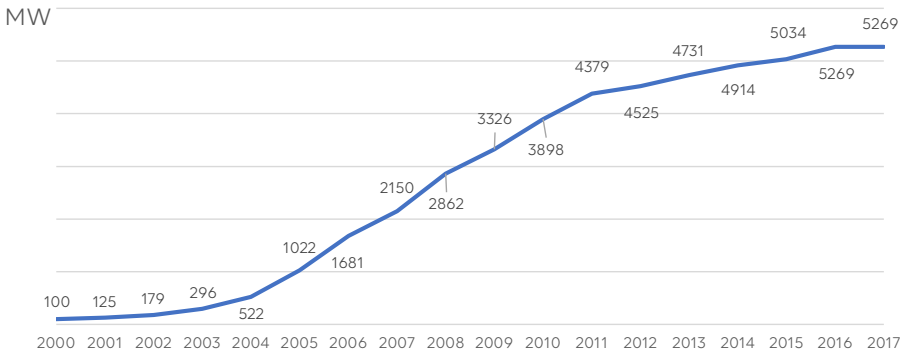


FIGURE4. INSTALLED WIND POWER CAPACITY, PORTUGAL.

Source: compiled by the author using data from ENERDATA

Three major operators dominate the wind energy market: ENEOP2, EDP Renováveis and Iberwind, who account for 45% of the total installed wind power capacity (Peña et al., 2017). In addition to these large operators, there are several hundred small renewable energy producers, the majority of which are part of the Portuguese Renewable Energy Association (APREN). The Omniflow scheme (see box 1) demonstrates the potential technological innovation of these small businesses, and is beginning to spread throughout Portugal and beyond.

According to APREN estimates (2018), renewable sources for electricity generation represented 1.8% of national GDP in 2017. **The technology which has contributed the most to this statistic is wind energy, due to the existence of a value chain that includes the production of industrial components as well as a range of R&D services. The sector accounts for 55,000 jobs, and there are 400 researchers working in this field.**

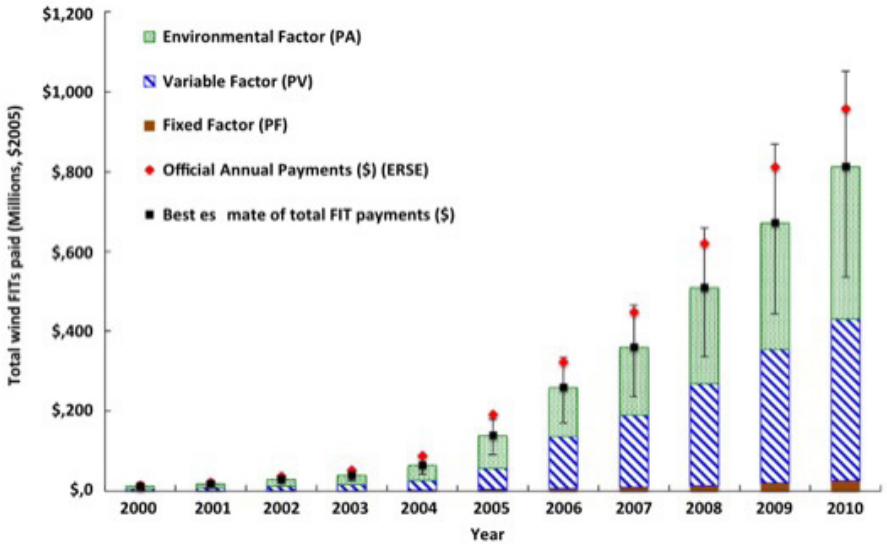
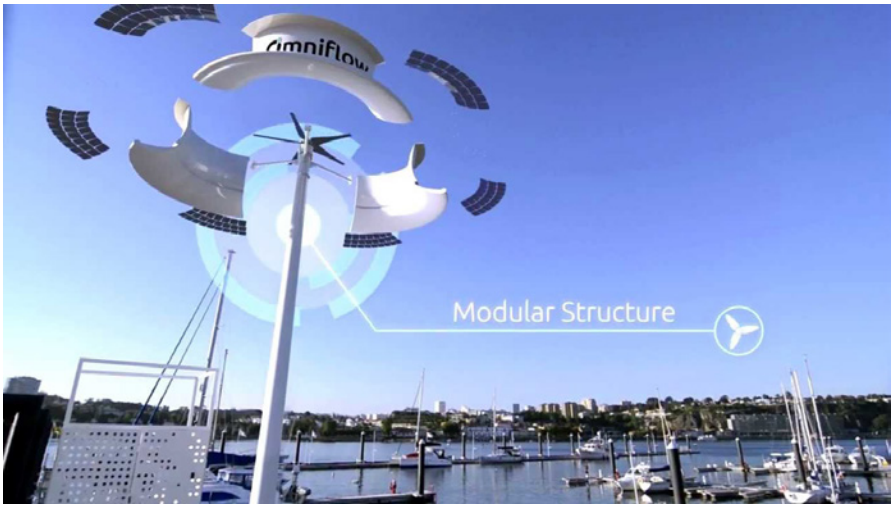


FIGURE 5. REMUNERATION PAID TO WIND ENERGY PRODUCERS

Source: Peña et al., 2017.

Omniflow, an innovative technology which combines wind and solar energy

Omniflow technology combines a vertical axis wind turbine with photovoltaic solar panels. This innovation was developed by a small Portuguese company which subsequently received financial support from the EU.



This technology has several innovative aspects: modular wing-shaped blades are integrated into a circular device which rests on a mast of varying size depending on the specific need. At its centre there is a mobile vertical axis which captures and accelerates wind coming from all directions, while the air above the turbine combines with the air coming directly from the turbine in an ascending cyclonic vortex. To complete the device, the surface is covered with solar cells. By combining these two energy sources, this hybrid technology increases total electricity generation and reduces storage needs thanks to the way solar and wind energy complement each other. As an energy source, the sun is usually more stable, but the turbine compensates for production losses in winter, as solar PV reaches peak production in summer while wind power experiences peak production in winter and can operate at night.

This start-up targets households as well as commercial buildings, and advises potential customers on the best solution for the site in question. It also offers a model that is suited to smart street lighting (Smart Street Lighting - Omnilight).

Source: Isento G. (10/11/2015) Omniflow é um gerador urbano com energia solar e eólica, publico.pt

TEXT BOX 1

• SOLAR PV TAKES OFF • The cost of solar PV has dropped significantly over the past few years, along with the price of storing electricity in batteries. In a sunny country such as Portugal, solar energy is a very appealing source of power to help balance the country's already impressive supply of hydraulic and wind energy. Portugal has invested in solar energy to take advantage of this potential, combining favourable conditions with technological progress and the government's stable regulatory framework. Recent investments have shown that Portugal can continue to play an active role in the deployment of renewable energies.

26 July 2018 marked the inauguration of a new solar facility in Ourique, Alentejo, in South-East Portugal. The *Ourika* plant has been operating since June, following 11 months of construction and 35 million euros of investment. **It is one of the largest solar power plants in Europe. Its 142,000 solar panels produce 80 GWh of energy per year, which is enough to power 23,000 households. In addition to its size, this power plant is the first on the Iberian Peninsula to be connected to the main power grid without a guaranteed tariff or other public subsidies.**

The Portuguese Minister of the Environment recently announced the planned instalment of 31 new

power stations in Portugal before 2021, which represents an additional production capacity of more than 1,000 MW. The total value of the projects has been estimated to be around 800 million euros. In 2021, the country will be able to triple its installed solar PV capacity from the current 572 MW to nearly 1,600 MW. The government even hopes to increase solar energy production sixfold before 2025.

A floating solar power plant in a hydroelectric dam

The company *EDP-Renovaveis*, which is associated with a French start-up, is testing a technology that is one of its kind in Europe: combining a hydroelectric dam and a floating solar power plant. The Alto *Rabagão* model, located in the north of the country, is small in size: 840 solar PV modules occupy a surface area half the size of a football pitch, submerged in a pool of water that is eight thousand times larger. With 220 kilowatts of power, they can only power around one hundred homes. But the test, which was launched in late 2016, at a cost of 450,000 euros, shows promise (Le Monde, 31/08/2018).

There are several advantages to installing panels in an aquatic environment: it cools the cells, which would increase their efficiency by 4 to 10%, and there is no need to use land or build additional power lines. Furthermore, the floating power station reduces evaporation from the reservoir and slows the growth of algae, according to those in charge of the EDPR projects.

If the test is successful, it will be followed by a project on a larger scale with 20 megawatts (MW). EDPR intends to develop the process on a larger Portuguese dam called Alqueva, which is located in Alentejo, in the south of the country, and to eventually export it to Brazil, where the energy company has a strong presence.

Photo: Rui Oliveira / Global Imagens

TEXT BOX 2

3 • THE CHALLENGES OF INTEGRATING A GROWING SHARE OF INTERMITTENT ENERGIES

The Iberian Peninsula is home to vast wind and solar resources, but it remains relatively isolated from the rest of Europe, which hinders the injection of renewable electricity into central European networks. Several projects are in progress with the aim of reversing this situation. At the same time, integrating intermittent energies creates new challenges for transport and distribution network operators. With this in mind, smart grids are being developed in several of the country's cities.

• THE PORTUGAL - SPAIN - FRANCE INTERCONNECTION • **In March 2018, Portugal produced more electricity from renewable energies than it actually needed. This marked the first time in the 21st century that the amount of electricity generated exceeded consumption.** However, the lack of energy connections with the rest of Europe remained a stumbling block. Without a properly connected electricity network or a well-developed storage system, some of this intermittent energy would be wasted. This is why interconnections are vital for EU energy union projects in order to create a

proper internal energy market, because they would enable surplus electricity to be transferred from one EU member state to another, depending on production and demand.

At the end of 2014, there were nine lines connecting Portugal and Spain: six were 400 kV and three were 220 kV, which meant there was a maximum exchange capacity of 2,800 MW from Portugal to Spain and 2,200 MW from Spain to Portugal. Despite this level of interconnection, sometimes there is still heavy traffic congestion between the two countries. Several investment projects are underway with the aim of remedying this issue, including two new 400 kV connections.

Furthermore, the EU has set the target of increasing the electricity interconnection capacity to 10% of the installed capacity in each country by 2020, and to 15% by 2030. In order to achieve this, special efforts need to be made to connect the Iberian Peninsula and integrate intermittent energies effectively. The completion of the planned interconnection projects between Portugal, Spain and France will help to increase electricity trading. Portugal and Spain will be in a position to export surplus renewable energy, particularly wind and hydraulic energy. Conversely, when wind energy generation is low or when hydroelectric resources are limited, more electricity from France could flow into the region.

In June 2015, the European Commission, France, Portugal and Spain signed a Memorandum of Understanding **for the creation of a High Level Group concerning interconnections for the South-Western region of Europe. Several projects are currently underway:**

• **Bay of Biscay line** Approved by the European Commission in January 2018, the project involves the installation of a 280 km long underwater line in the Capbreton Gulf (Landes). The French terrestrial portion will be entirely underground. This new line means that the interconnection capacity between the two countries will almost double from 2,800 to 5,000 MW. This will bring Spain closer to the interconnection target of 10% by 2025, the current level being 6%. This project received record EU funding of 578 million euros (Connecting Europe Facility-Energy).

-Santa Llogaia-Baixas Project (INELFE). The completion of the transformer in Arkale, Spain in June 2017 enabled full use of the Santa Llogaia-Baixas line between Spain and France, doubling the electricity interconnection capacity between the two countries, which rose from 1,400 to 2,800 MW. This line is 64.5 km long, with 33.5 km in France and 31 km in Spain. It connects the communes of Baixas in le Roussillon (France) and Santa Llogaia in Alt Empordà (Spain). The final route of the French portion was decided after 15 months of consultations with community representatives and local associations. One of the objectives of INELFE was to minimise the environmental impact of the interconnection, during both the design and implementation phases. The first step was to build the line underground and dig a utility tunnel to cross the Pyrenees. Although more costly, this solution helped to preserve, among other things, the forest tracks of the Albera mountain range[2].

• **Interconnection project between Spain and Portugal** (Ponte Lima - Vila Nova Famalicão - Recarei (Portugal) and Beariz - Fontefría (Spain)). This is a classic 400 kV aerial technology project which will connect Galicia with the Portuguese region of Minho, and will increase the exchange capacity between Spain and Portugal until it reaches the inter-governmental target of a 3.2 GW exchange capacity. The capacity will enable the full integration of the Iberian electricity market, as well as improving the management of renewable energy. The project is scheduled to be implemented in 2021. These projects, which are supported by the European Commission and the governments of Portugal, France and Spain, are an important step towards putting an end to the Iberian Peninsula's isolation from the rest of the European energy system.

• SMART GRIDS FOR SMART CITIES: EXAMPLE OF THE CITY OF ÉVORA • Évora is home to 56,596 inhabitants (2011), and is the capital of the Alentejo region, in south-central Portugal. It is the first city in the country to have tested certain smart grid technologies on a large scale through the *InovGrid* project. The *InovGrid project* has been developed by the energy company EDP in close

2 - *inelfe.eu/fr/projets/baixas-santa-llogaia*

collaboration with several organisations, including European research institutes and universities, industrial partners, local and national authorities, energy sector associations and regulators, the communities in question and other stakeholders. ***InovGrid* aims to transform the distribution network and provide a solution to a number of challenges in line with government policies: the need to increase energy efficiency, bring costs down, and to integrate intermittent energy producers as well as electric vehicles.**

An important component of *InovGrid* was the deployment of a smart grid infrastructure, which began in the municipality of Évora in 2011. The new infrastructure covers the whole of the city, reaching around 32,000 electricity consumers. Its main components are:

- smart boxes, installed in the homes of all low-voltage customers, which offer cutting-edge solutions such as real-time energy demand readings, load diagrams, voltage curves, etc.;
- distribution transformer controllers installed in each secondary substation, which act as data concentrators and as devices for local metering, supply quality monitoring and automation;
- a communication network based on powerline communication and radio service technologies, which connect computer housings and controllers to network headend systems;
- charging stations for electric vehicles;
- efficient street lighting systems, based on advanced control LED lighting.

Beyond implementing physical infrastructure, *InovCity* is seeking to improve communication between different stakeholders by offering various tools and services (displays, smartphone applications, etc.) and involving local authorities in a joint effort to improve energy efficiency.

The municipality of Évora has played an active role in this project, participating financially and allowing the first tests to be carried out in the city's public buildings. This project was guided by the city's 2012 action plan for sustainable energy[3], which aimed to reduce GHG emissions by 20% by 2020.

The Évora project highlighted several benefits of smart grids, including: an improvement in energy efficiency (3.9% reduction in electricity consumption); an increase in service quality (detection and handling of faults, monitoring supply quality); reduced energy losses, resulting from a drop in demand and better management of the network; reduced fraud, improved integration capacities of distributed energy resources and electric vehicles.

Currently, the project is expanding to other Portuguese towns, including Guimarães, Lamego, Batalha/Marinha Grande, Alcochete, Algarve and São João Madeira, reaching in excess of 150,000 consumers by the end of 2014. Furthermore, as of 2015, all new establishments use digital boxes, making this technology standard in Portugal[4].

Brain-e, a social network for better electricity consumption

The Brain-e platform helps users reduce their energy consumption in a simple and interactive way. "The energy market is booming, yet there is a real lack of consumer awareness." This was the idea that brought about Brain-e, a smart platform for managing energy consumption. "Not many consumers know how much they are consuming, what they are consuming, what prices are being charged by the market or how to make savings," explains Luis Guerreiro, one of the young people involved in the project (publico.pt/2015/09/22).

Brain-e collects energy consumption information in digital format and presents information to users in a simple way. The platform provides consumers with suggestions on how to save energy, information on market prices and forecasts for energy consumption and production potential. Users can also cooperate with their friends and neighbours to manage their consumption across communities.

Simple actions can help to save energy; for example, washing clothes one hour later than usual or switching off certain appliances at night. This social network wants to help people change their daily energy consumption patterns by

3 - cm-evora.pt/pt/site viver/Habitar/ambiente/PublishingImages/Paginas/Evoracarbonozero/PAES_Evora2012.pdf
4 - http://www.gridinnovation-on-line.eu/articles/library/inovgrid-project---edp-distribuicao-portugal.kl

providing consumers with information that will help them monitor their consumption. This project also seeks to forge energy management communities, which create incentives to jointly reduce the consumption of a certain location. Brain-e is free for users, who can save energy, save money and help to reduce CO_2 emissions. It is the result of work by a team of six entrepreneurs - four engineers, a social sciences researcher and a designer. The team has two important objectives at present: to launch a 1.0 version of the platform which can be tested by a limited number of users, and to find a commercial partner who is looking to break new ground in the services that they provide to their customers (publico.pt/2015/09/22).

"The biggest hurdle will be the limited number of digital devices that are capable of reading energy consumption in Portugal. This is why we are looking at other markets at international level, where these devices are more commonplace", explains Luis Guerreiro.

Source: www.publico.pt/2015/09/22/p3/noticia/uma-rede-social-de-poupanca-de-energia-1824238

TEXT BOX 3

CONCLUSION

Portugal has been experiencing steady growth in the use of renewable energies for electricity generation in recent years. This transition is guided by proactive policies - European and, above all, national - but also by the actions of various operators, be it a long-established energy company or new innovative enterprises. In addition, actions by some cities such as Évora demonstrate the importance of the role played by local authorities. Despite this progress, the country still has a long way to go before it achieves a completely decarbonised electricity mix.

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The United States: towards a bottom-up climate leadership?

The American power sector reveals the importance of non-state actors. In June 2017, the federal government announced the exit of the United States from the Paris Agreement, casting strong doubts about the country's ability to continue the newly started decarbonisation of its economy. However, governors, mayors and CEOs of American companies reacted immediately. A few hours after the announcement from Trump's government, an unprecedented coalition of now more than 2700 States, cities and companies joined behind the Paris Agreement under the slogan "We Are Still In". How do these initiatives translate into concrete action at the level of States, cities and companies? Will they be sufficient to ensure a deep decarbonisation pathway of the American power sector? In order to provide answers, we will conduct a three-part analysis of the recent evolution of CO_2 emissions in the United States' electrical sector and the role of different non-state actors.

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CONTENTS

1 • THE HUGE CHALLENGE OF DECARBONISING THE AMERICAN ELECTRICAL SYSTEM

• Emissions from the electricity sector continue to fall

• The decline of coal continues thanks to the rise of natural gas and renewable energy

2 • THE MOMENTUM OF CITIES AND STATES IS OPPOSED TO THE WITHDRAWAL OF THE FEDERAL GOVERNMENT

• The huge challenge of decarbonising the American electrical system

• Emissions from the electricity sector continue to fall

• The decline of coal continues thanks to the rise of natural gas and renewable energy

3 • THE ROLE OF BUSINESSES AND CITIZENS' INITIATIVES

• Companies integrate the climate dimension into their strategies

• The energy democracy movement

1 • THE HUGE CHALLENGE OF DECARBONISING THE AMERICAN ELECTRICAL SYSTEM

The United States' electrical system is a complex generation, transmission and distribution network providing nearly 4000 terawatt-hours of electrical power generated by approximately 7000 power plants (spread over more than a million kilometres of high-voltage transmission lines and more than 10 million kilometres of low-voltage distribution lines) with nearly 160 million residential, commercial and industrial customers.

In a system that has long been based on fossil fuels, a deep decarbonisation pathway leading to zero emissions by 2050 represents a daunting challenge for all stakeholders and requires proactive policies at various levels.

• EMISSIONS FROM THE ELECTRICITY SECTOR CONTINUE TO FALL • The United States remain among the ten most emitting countries per capita on the planet with 15.7tCO_2/person in 2016. Considering the total CO_2 emissions of the energy sector, it is the second largest emitter after China with 5073MtCO_2 in 2017. 34% of this total corresponds to the electrical sector.

After reaching a peak in 2007, CO_2 emissions from public heat and power generation are decreasing, and they are currently at the lowest level since 1990. They decreased by 3.7% in 2017, confirming their downward trend from previous years (Figure 1). This is mainly due to the gradual decline in carbon intensity of the American power mix (CO_2/kilowatt-hour). The partial substitution of coal for natural gas and the increase in the share of non-carbon sources have thus led to a decrease in the carbon intensity of electricity generation.

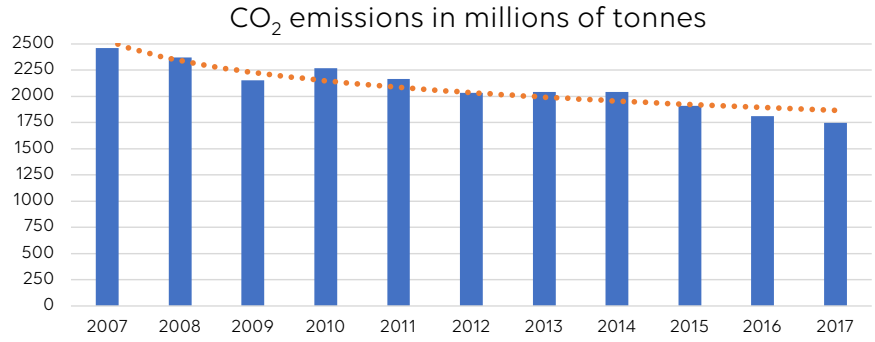

FIGURE 1. CO2 EMISSIONS FROM PUBLIC ELECTRICITY AND HEAT PRODUCTION

Source:: Compiled by the author using data from ENERDATA

Based on the 2018 analysis of the *Energy Information Administration (EIA) named "U.S. Energy-Related Carbon Dioxide Emissions"*, **two fundamental factors have contributed to reducing the carbon intensity of electricity generation since 2005: replacing coal-fired production with combined cycle natural gas production, which consumes less and is more efficient, and deploying renewable energy, in particular wind and solar energy.** According to EIA, the first factor explains 61% of the improvement in carbon intensity while the renewable energies account for the remaining 39%. As for the production of nuclear energy, it practically has not changed between 2005 and 2017.

Total electricity production decreased slightly between 2005 and 2017. Over this period, electricity generation from fossil fuels decreased by approximately 14% and non-carbon power generation increased by 33%.

The electricity consumption of the United States, which decreased by 2% in 2017, has remained relatively stable over the past decade with only minor variations due to climatic factors. Despite GDP growth of almost 22% between 2005 and 2017, electricity consumption has barely increased by 2.7%, showing the powerful effect of improving energy efficiency. Nevertheless, various forward-looking models (EIA, 2018) show that electricity demand is expected to rise again in the coming years, as the electrification of the economy – including transportation – continues.

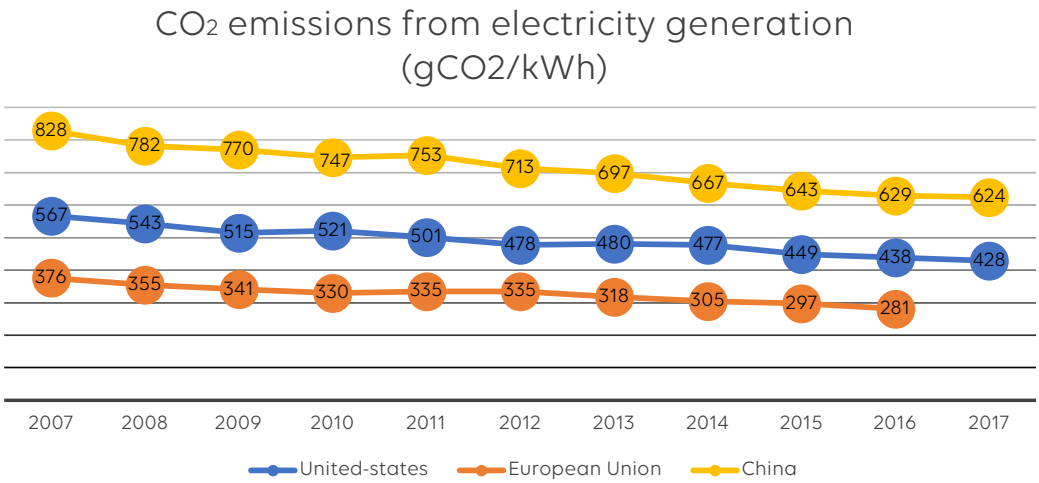

FIGURE 2. CARBON INTENSITY OF THE POWER MIX

Source: Compiled by the author using data from ENERDATA

This reinforces the need for further decarbonisation of electricity generation. Figure 2 above shows the decrease in carbon intensity of the American power mix that, however, still remains well above the average of other developed regions such as the EU and Canada. Will the current political and economic situation of the United States make it possible to continue or even accelerate the decarbonisation of the electrical sector? The change in energy policy proposed by the new conservative government threatens the continuation of decarbonisation; however, many coal plants were closed in the past year.

• THE DECLINE OF COAL CONTINUES THANKS TO THE RISE OF NATURAL GAS AND RENEWABLE ENERGY • Despite the US President's statement that he wants to end the "war on coal", industry experts are planning to continue plant closures. The number of US coal-fired power stations remains huge: according to EIA, a capacity of approximately 246GW was still active in July 2018, but it seems increasingly susceptible to decrease. The shutdowns announced for the 2018-2024 period – a total of 36.7GW – amount to approximately 15% of the current total (Feaster, 2018).
EIA forecasts that natural gas will account for 35% of electricity generation in 2018 and 2019, an increase from 28% five years ago. The share of renewable energy other than hydropower – mainly wind and solar – is also expected to increase to 10% in 2018 and nearly 11% in 2019. On the other hand, the share of coal is expected to fall to 27% in 2019 from 39% in 2014 (Feaster, 2018).

This trend seems to continue in this direction. On the one hand, the level of investment in renewable energy remains strong and costs continue to fall. On the other hand, the increase in domestic gas production is expected to keep a relatively low and stable price in the near future.

The age of the plants also becomes a significant factor for the US coal industry. Most of the country's coal-fired power plants were built in the 1960s, 1970s and 1980s, and many of these units are nearing the end of their "normal" end of life. S&P Global's data shows that in 2017, two-thirds of coal shipments went to power plants that were at least 38 years old and nearly 15% went to power plants that were at least 55 years old[1] .

1 - S&P Global, Coal's 'Aging-Out' Problem, Jan. 30, 2018 (coal deliveries from Nov. 1, 2016 to Oct. 31, 2017)

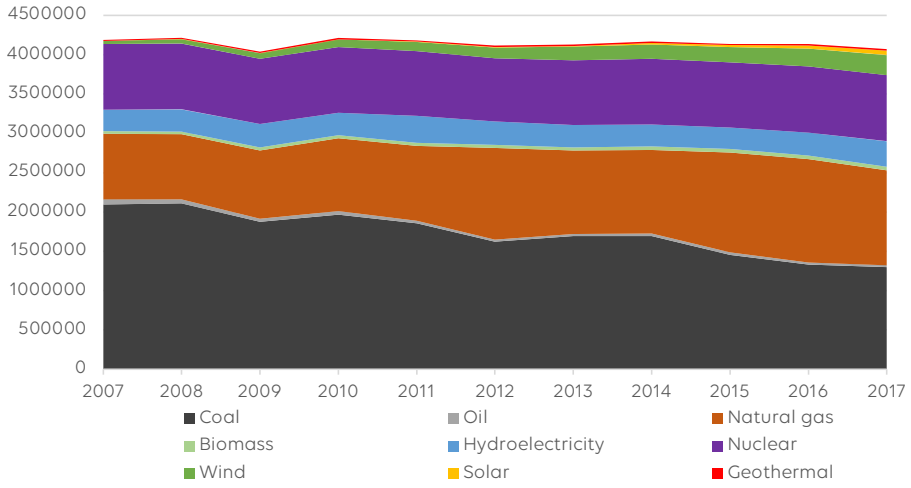

FIGURE 3. ELECTRICITY PRODUCTION PER SOURCE OF ENERGY (GWH/Y)

Source: Compiled by the author using data from ENERDATA

In contrast, much of the US natural gas capacity has been built since 2000, and most wind and solar facilities are less than ten years old[2]. A significant number of new gas, wind and solar power plants come into operation each year while few new coal-fired power plants have been commissioned in the last five years, and few (if any) are likely to be built in the future (Feaster, 2018).

Moreover, coal has serious competitive disadvantages compared to renewable energy and natural gas. In regions of the country where renewable energy and natural gas are abundant, even newer coal plants are closed. For example, power plant no. 5 of Sandow in Texas (600MW, commissioned in 2010) was retired in January 2018, just months after the announcement of its closure (Feaster, 2018).

Gas plants have a technical advantage over coal plants. They can generally respond quickly to fluctuations in demand and increase or decrease their production throughout the day. This allows them to integrate well with wind and solar power to meet the daily demand cycle while remaining economically competitive (Feaster, 2018). In contrast, coal-fired power plants are more efficient when operating continuously. Their operating and maintenance costs increase when they are cycled[3] and stopped for long periods.

In addition to this technical and economic disadvantage, coal-fired power plants are suffering the consequences of heavier regulations principally at the State level and the pressure of various environmental groups such as the Sierra Club.

In March 2018, the private electricity utility First Energy asked the Trump administration to intervene in order to keep coal and nuclear power stations under strain. So far, the government has taken no action to keep power stations open, but the administration was considering using executive power under the national security legislation to stop the wave of closures. However, no formal plan has been submitted.

The American Coalition for Clean Coal Electricity (ACCCE) also predicts that by 2020, at least 26,000MW of coal-fired power plants will be phased out. This association considers most of these closures to be driven by the policies of the Environmental Protection Agency (EPA) imposed under the Obama administration. The ACCCE supported the efforts of the Trump administration to lower EPA regulations and find ways to prevent the closure of coal-fired power plants.

Overall, these trends indicate that the power generation sector has entered a transition that is justified by economic and environmental principles. Coal infrastructure is aging and inflexible; the cost of renewable energy continues to decrease; private electricity utilities adopt decentralised power generation as they modernise their systems; and natural gas offers more flexibility by being less polluting than coal (Feaster, 2018).

At the same time, a fairly impressive number of innovations continue to emerge, particularly

2 - EIA, "Most coal plants in the United States were built before 1990," Today In Energy, April 17, 2017 3 - C'est-à-dire quand elles fonctionnent à différents niveaux de production tout au long de la journée, ou de façon saisonnière

in the field of electricity storage technology. In this context, some analyses show that if the costs of wind and solar energy and storage continue to fall, renewable energy will soon become more competitive not only in comparison to coal but also to natural gas. This has already been seen in some places such as Western Colorado (Cleantechnica, 2018)

2 • THE MOMENTUM OF CITIES AND STATES IS OPPOSED TO THE WITHDRAWAL OF THE FEDERAL GOVERNMENT

While the federal government is turning its back on climate policies, all the attention is focused on cities, States, businesses, universities and other relevant actors. A recent analysis suggests that if fully implemented, the objectives of registered and quantified non-state actors could approach the commitment made by the United States in the Paris Agreement, leading to a reduction in emissions of 17 to 24% in 2025 compared to 2005 levels. 22 States, 550 cities, and 900 companies in the United States have made climate change commitments, and the 50 States have adopted at least one policy likely to reduce emissions (Climate Action Tracker, 2018).

• A HIGHLY INADEQUATE FEDERAL CLIMATE POLICY • The American climate policy is currently considered highly insufficient to lead the country towards a deep decarbonisation pathway of its economy (Climate Action Tracker, 2018), as it was strongly shaken by the Trump administration in 2018. If the proposed actions become fully implemented, the projections of GHG emissions for the year 2030 could increase up to 400MtCO_2eq compared to the levels projected at the end of 2015. That is almost as much as the total of the emissions of the State of California in 2016. The federal government has proposed to replace the Clean Power Plan (CPP) to freeze vehicle efficiency standards after 2020 and not to apply standards to limit the extremely high emissions of hydrofluorocarbons (HFC). The administration also weakened standards for methane leakage from oil and gas production (Climate Action Tracker, 2018).

The *Clean Power Plan* issued by the Obama administration under the Clean Air Act was aimed at reducing emissions from the electricity sector by 32% by 2030 compared to 2005 levels by setting targets for each individual State. The successful implementation of the CPP would have been an important step in strengthening American climate action. However, in August 2018, the EPA proposed to replace the CPP with the Affordable Clean Energy (ACE) Rule (EIA, 2018) limiting the scope of the plan to reduce greenhouse gas emissions by setting more flexible rules for coal-fired power plants and allowing States to set their own standards (EPA, 2018). This is a significant departure from the CPP, which required all States to meet emission standards and is likely to result in emissions of up to 81MtCO_2eq/yr in 2025 and 212MtCO_2eq/yr in 2030 (Climate Action Tracker, 2018).

The federal government has played a fairly strong role in the diffusion of biofuels, but its role has been much weaker with respect to electric renewable energies. **Renewable electricity in the United States has been largely driven by State incentive policies, among other things, supported by federal tax incentives. In many respects, States as well as local governments and regional organisations have been more ambitious than the federal government.**

• STATES PAVE THE WAY TO RENEWABLE ENERGY AND ENERGY EFFICIENCY • At the sub-national level, 29 States have implemented Renewable Portfolio Standards (RPS) and nine have set voluntary targets (America's Pledge, 2017). Other incentives have also been put in place such as the net billing system or subsidised credits for renewable energy projects. The RPS are fairly flexible policy instruments that require electricity providers to obtain a minimum percentage of their energy from renewable energy sources by a certain date. Each State sets a quota (usually a percentage of renewable energy) and companies choose to fulfil their mandate using a combination of different sources (wind, solar, biomass, geothermal or other renewable sources). Some RPS specify the combination of technologies while others leave it to the market.

The first RPS was established in 1983; however, the majority of States adopted or strengthened their standards after 2000 (IEA/IRENA, 2018). The compulsory quota is usually accompanied by an element of economic flexibility: a system of tradable renewable certificates ("green certificates"). Electricity suppliers fulfil their obligation by producing renewable electricity themselves or by buying surplus certificates from other producers.

States have the power to individually dictate environmental protection policies, and this past year, many have strengthened some climate and energy standards. In recent months, State congresses have proposed hundreds of bills on clean energy production, reduction of GHG emissions, and regulations and measures for the protection of the environment. Many are also looking for ways to tax carbon emissions, encourage solar energy installations and demand general advancements in renewable energy technology (Green Gazette, 2017).

The scientific organisation Union of Concerned Scientists (UCS) recently proposed and applied a method that examines the evolution of clean energies across the country. By examining 12 parameters including the creation of clean energy jobs, the progress of renewable energy, and the reduction of power plant pollution, the report identifies the States that are making the most progress towards a sustainable future.

The UCS analysis clearly identifies leaders among the 50 US States:

• **California** paves the way for clean energy. The Golden State leads in the adoption of electric vehicles and is in the top five on six other indicators: residential solar capacity per household, energy savings, clean energy jobs, standard targets for renewable energy, the ability of companies to buy renewable energy and the targets for reducing carbon emissions (see Text box 1 below).

• **Vermont**, in second place, is the State that ranks first in terms of jobs in the clean energy sector and in its targets for reducing carbon emissions. It is also among the first in terms of energy savings, adopting electric vehicles and energy efficiency policies.

• **Massachusetts**, in third place, has the strongest energy efficiency regulation and ranks among the top five in terms of residential solar capacity per household, energy savings, clean energy jobs and emission reduction targets.

However, other bills oppose the transition to clean energy. Proposed legislation could put an end to the net billing system for "prosumers" (who produce and consume their own energy) of solar energy, which are gaining popularity in Indiana and Missouri. Wyoming lawmakers have considered penalising large-scale wind and solar producers. Most importantly, many States do not have laws to achieve their GHG reduction targets.

It also seems important to stress that some States that are less favourable to climate action and fossil fuel issues, such as Texas, are making remarkable progress in the field of renewable energies. If California is the champion of solar energy, then Texas in the champion of wind energy. This southern State has one of the most open and competitive electricity markets in the country and currently has the largest installed capacity of wind energy in the United States, with 22GW. Due to its low marginal cost, this type of energy has priority over the Texas electricity system, and in some months, it has already supplied a quarter of the electricity consumed in the State. For example, other more expensive sources of production such as coal are being pushed out of the market.

Despite a few exceptions, it is clear that it is the States more than the federal government that lead the decarbonisation of the electricity sector through two main principles: promoting renewable energy and improving energy efficiency.

The State of California: A sustainable energy policy.

California has adopted an aggressive programme to promote renewable energy. The centrepiece of the programme is the Renewable Portfolio Standard system introduced in 2002, which requires an increase in the percentage of State electricity sales from renewable sources each year (Ballotpedia, 2018). This percentage should reach 33% by 2020 and 50% by

2030. Other statutory tools to support this effort include a feed-in tariff for small-scale renewable electricity producers. In addition, the government introduced a net metering system in 1996 that allows customers who produce their own renewable electricity to sell a portion to the grid.

California also has the most ambitious legislation on climate change in the country. The 2006 Global Warming Solutions Act (known as AB 32) requires the State to reduce its GHG emissions to 1990 levels by 2020. AB 32 assigns the California Air Resources Board (CARB) the task of choosing the statutory and policy tools to achieve this target. CARB has chosen to implement a cap-and-trade programme. The programme caps all GHG emissions and then reduces the overall emissions limit annually until the 2020 target is achieved. In 2014, California tied its cap-and-trade system to Quebec's cap-and-trade system, creating a broader emissions trading market that should help reduce the costs (Dernbach, 2018).

In 2016, the California parliament passed a law setting a 40% GHG emissions reduction target relative to 1990 levels by 2030, leading to the need to adapt the cap-and-trade system to satisfy the new target.

The cap-and-trade programme is only part of California's overall plan to achieve the "technologically achievable" and "cost-effective" emission reductions that AB 32 requires. California also limits the carbon intensity of new long-term power supply contracts so that the supplier cannot produce more than a combined cycle natural gas power plant that emits approximately half of the emissions from a coal plan.

TEXT BOX 1

• INCREASINGLY COMMITTED CITIES • Many US cities have made a public commitment to reduce carbon emissions and combat climate change through initiatives such as the Covenant of Mayors, We Are Still In, or by developing their own climate action plans.

At least 80 US cities, under the coordination of the influential progressive NGO Sierra Club, have committed to achieving 100% renewable electricity production in the coming decades. In the United States, six cities – **Aspen, Burlington, Georgetown, Greensburg, Rock Port and Kodiak Island** – have already achieved their targets. These six cities now generate 100% of the energy used in their communities from clean, non-polluting and renewable sources.

As American cities join the quest for clean and sustainable energy, some are struggling against private electricity utilities that are sometimes resistant to change. Others have a municipal electricity utility or collaborate with their suppliers to move towards cleaner energy sources. As a result, some communities are separating themselves from these investor-owned businesses, joining forces to get their own energy sources through **Community Choice Aggregation (CCA)** programmes.

CCAs allow communities to bypass investor-owned electricity providers by joining together to buy their own wholesale energy and gain greater control over their energy options as a result. Thanks to CCA, decisions regarding electricity supply, tariffs and incentives are made at the local level. The 18 operational CCAs in California already represent many regions and cities in the State, and another nine are expected to be launched in the near future (Sierra Club, 2018). This is the case of **Santa Barbara** among others, which is in the process of creating a CCA in partnership with other neighbouring municipalities. This Californian city is committed to achieving at least 50% renewable electricity for the entire city by 2030. Further north, **San Francisco** and **San Jose** pioneered the creation of CCA, each with a target of 100% renewable energy over a decade ago.

In August 2017, the Orlando (Florida) city council unanimously passed a resolution to ensure the transition to 100% clean energy in municipal operations by 2030 and in the entire city by 2050. Led by Mayor Buddy Dyer – a strong supporter of the Sierra Club 100% clean energy movement – the Orlando resolution was supported by a broad and diverse coalition of local organisations including the League of Women Voters, IDEAS for Us and NAACP, as well as the Sierra Club. The coalition is currently working to secure the commitment to close the last two coal-fired power companies from the city's utility and replace them with renewable sources.

A 100% clean energy target is ambitious for all cities, but perhaps even more so for a long-standing coal industry capital like **St. Louis** (Missouri), home to two of the largest coal companies in the country. However, following the withdrawal of the Trump administration from the Paris Agreement, Lewis Reed – Chairman of the St. Louis council – urged his city to take charge of its future. In October 2017, the St. Louis council unanimously approved the commitment to switch to 100% clean and renewable energy by 2035. Its supporters have a long-term vision for the city focused on creating green jobs, clean air and a better quality of life for all residents. The city has set a deadline in December 2018 for developing its Clean Energy Transition Programme and has gathered a committee of stakeholders to this end.

These are a few examples of the many commitments made by US cities in 2017 and 2018. A follow-up of these commitments will make it possible to define their implementation and their real impact in the decarbonisation pathways of these cities.

3 • THE ROLE OF BUSINESSES AND CITIZENS' INITIATIVES

Just as in other countries, the electricity markets in the United States are in turmoil. Traditional businesses in the sector, whether private, public or mixed, face a dual threat. On the one hand, we see the arrival of new players from other economic sectors, often world giants. On the other hand, the large number of innovations in power generation and storage technologies enables increasingly decentralised production in which consumers and new forms of organisation play a more important role.

• COMPANIES INTEGRATE THE CLIMATE DIMENSION INTO THEIR STRATEGIES • As part of the **Global Climate Action Summit** held in September 2018 in San Francisco, 21 leading companies submitted the ***Step Up Declaration***. It is a new alliance dedicated to harnessing the power of emerging technologies and the fourth industrial revolution to help reduce GHG emissions in all economic sectors and ensure a positive climate change for 2020. Collectively, these organisations cover a wide range of sectors that can significantly reduce GHG emissions in buildings, data centres, the finance sector, telecommunications, transportation, etc. They include the following companies: Akamai Technologies, Arm, Autodesk, Bloomberg, BT, Cisco Systems, Ericsson, HP, Hewlett Packard Enterprise, Lyft, Nokia, Salesforce, Supermicro, Symantec, Tech Mahindra, Uber, Vigilent, VMware, WeWork, Workday and Zoox.

The Step Up Declaration was developed with the leadership of Salesforce, a leading California-based cloud computing company. The Declaration focuses on the transformative power of the fourth industrial revolution, which comprises artificial intelligence, cloud computing and the Internet of Things.

Are the oil giants joining the transition?

European oil companies have started to invest heavily in renewable energy – for example, solar energy at Total or off-shore wind at the Norwegian company Statoil, which has recently changed its name to Equinor. However, American oil companies are currently far less active. One of the provided reasons is the even lower profitability of renewable energy projects compared to oil and gas projects.

Nevertheless, American oil giants are taking a few steps towards non-carbon energies. ExxonMobil is interested in biofuels and is devoting a growing portion of its R&D budget to alternative energy sources[4]. This company invests approximately $1 billion per year into basic and applied research on low-carbon technologies. This oil supergiant is particularly focused on synthetic biology.

It hopes to prove the commercial feasibility of deploying genetically modified algae in large open-air operations capable of producing the equivalent of 10,000 barrels of renewable crude oil per day from sunlight and industrial CO_2. If the company's trial succeeds, this modular design could evolve to much higher levels. ExxonMobil is also developing genetically modified microbes together with the country's largest biodiesel producer Renewable Energy Group, which could produce biodiesel from residual biomass (i.e. without the use of food crops such as maize). Other projects include fuel cells that capture and consume CO_2 to produce electricity and new technologies for the manufacture of plastics emitting 50% less CO_2[5].

Chevron holds interests in solar, wind and geothermal generation facilities that can power approximately 113,000 US households each year. This seems modest, but it represents the first steps of a possible renewable energy development strategy for this company with a strong presence on the west coast of the United States. Chevron has also invested in next-generation renewable fuels with little success, but it still sees a bright future for renewable diesel. The company has tested various mixing ratios (with low-oil diesel) of 6 to 20% for some terminals in California.

TEXT BOX 2

With respect to electricity generation, private electric utilities provide 38.7% of the total production in the United States, other producers account for 39.9% of the total production, municipal utilities 10%, federal agencies 6.4% and electric cooperatives 5% (Klass, 2017).

Some of these companies are making progress in their decarbonisation efforts. This is the case of NRG Energy, an American company producing and distributing energy present in 11 States. Starting in 2009, NRG launched an initiative to become a green energy producer in the United States and began investing in clean energy projects. These include onshore and offshore wind energy, solar thermal energy, PV solar installations and the conversion of some of their traditional coal-fired power plants to biomass. At the end of 2010, NRG launched the "EVgo" network – one of the first networks of charging stations for electric cars. The company had set itself a target of halving its total emissions by 2030 compared to 2014 levels. It has already managed to reduce its emissions by almost 20 million tonnes, meaning that the target will be achieved well before 2030. **Climate action has helped NRG bring innovative solutions to the market, meet customers' current needs, and anticipate their future needs while making the company stronger and more efficient.** It also attracts and retains the best talent in the industry and provides excellent returns for shareholders, said one of the company's leaders (Greenbiz, 2018).

APPLE and TESLA enter the energy market

A number of established companies with a recognised brand in various sectors appear to be ready to compete in electric markets that have for long been dominated by traditional energy companies.

Among these new arrivals is Apple, who has quietly created a subsidiary called Apple Energy LLC and has applied to the Federal Energy Regulatory Commission (FERC) for a licence to sell electricity directly to retail consumers.

According to specialised press, Apple's strategy is due to several reasons (Sioshansi, 2017). First, Apple uses 93% of renewable energies in all its activities and its target is to quickly reach 100%. The company has contracts with solar

4 - tps://www.eniday.com/en/sparks_en/oil-majors-invest-renewable-energy/
5 - https://www.fool.com/investing/2018/06/04/big-oil-is-investing-billions-in-renewable-energy.aspx

developers around the world for a capacity of 521MW, making it one of the world's largest consumers of solar energy. In addition, it invests in net-zero energy buildings including its new headquarters in Cupertino, California.
Second, the company is in a position to generate surplus renewable energy most of the time, especially on cool, sunny days in the spring when there is no air conditioning. The surplus energy can be resold to the grid at wholesale prices, or even better, to other customers at current retail rates, which tend to be two to three times higher.
Third, some analysts speculate on the possibility of Apple resuming its plans for developing electric cars – an area in which it has been working quietly for some time. Having excess renewable energy to power electric vehicle batteries can open up new markets at a time when the mobile phone market appears to be saturated.
Finally, it counts on the value of its Apple brand. Its customers seem likely to buy any goods or services that boast the famous logo including electricity, especially if it is 100% renewable.
In mid-November 2016, Tesla shareholders at a special meeting approved the acquisition of SolarCity for $2.6 billion. This means that Tesla can move forward with the integrated solar roof and residential battery system announced in October 2016. The company predicted that the cost of solar electricity with storage via batteries will be lower than electricity retail rates in many places. If the company succeeds in combining the two products, it can use the same tools to shake the automotive and electrical industries by bringing together electric mobility, PV solar panels and storage. Affluent customers who can afford a high-end electric vehicle may wish to produce some of their electricity on their roof, and may want to store some of it in batteries for later use (Sioshansi, 2017).

TEXT BOX 3

• THE ENERGY DEMOCRACY MOVEMENT • Energy democracy is both a new concept and an emerging social movement that links the change in energy infrastructure to the possibilities of profound political, economic and social change. The term continues to spread in the context of climate justice struggles, driven by unions, academic communities and political parties. This concept is increasingly used in the United States to demand and justify the integration of policies linking social justice and economic equity to transitions to renewable energy (Burke & Stephens, 2017).
Energy democracy is born of citizen movements that fight against climate and economic crises, resist the expansion of fossil fuels, and seek a transition to renewable energies. Since 2012, various groups[6] and organisations in the United States and Europe have explicitly adopted the term "energy democracy" as the central theme of the energy and climate change discourse. In 2012 in the United States, the Cornell University's Global Labour Institute hosted an international round table of trade unionists who used energy democracy to discuss the struggle for the energy transition, which gave rise to a new organisation – the Trade Unions for Energy Democracy.

This transition path is characterised by a strong presence of actors who have lost confidence in existing governance systems, by the emergence of new guiding principles, beliefs and practices, the coexistence of multiple innovations and widespread experimentation, and a shift to more local or regional systems and decentralised technologies and management structures. These include energy co-ops, Community Choice Aggregation programmes (see 2.3 above), net metering systems and Community Benefit Agreements (Burke & Stephens, 2017).

6 - Community Power Network, Local Clean Energy Alliance, Trade Unions for Energy Democracy, Institute for Local Self Reliance, Center for Social Inclusion, Climate Justice Alliance, Rosa Luxemburg Foundation, Alternative Information and Development Centre, Public Services International, Emerald Cities Collaborative, Energy Democracy Alliance of New York, entre autres.

CONCLUSION

An analysis of the registered and quantified commitments of sub-national and non-state actors in the United States (America's Pledge, 2018; Climate Action Tracker, 2018) suggests that if implemented, these commitments could lead to a reduction in emissions of 17 to 24% in 2025 compared to 2005 levels.

While the federal government has significantly changed its climate policy – including the decision to leave the Paris Agreement –, the US climate leadership remains alive and well. It is a new kind of bottom-up leadership driven by the conviction of citizens, the leadership of cities and States as well as driven by the innovation capacity of its companies, making it possible not only to take concrete action now but also to lay the foundations for a future partnership with the federal government. In the coming years, the continuation of the decrease in CO_2 emissions from the American power sector will tell whether the dynamics of the Federated States will be stronger than the federal desire to revive coal contrary to recent economic developments.

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Fugitive emissions: a blind spot in the fight against climate change

The category of fugitive emissions covers a vast number of poorly controlled emissions: accidental, diffuse or unproductive. Fugitive emissions represent a significant proportion of anthropogenic greenhouse gas emissions and their assessment, let alone reduction, is still in its infancy. Often overlooked by climate policies and institutional mechanisms, actions in this area rely primarily on the emitters themselves, pushed by civil society and local stakeholders.

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CONTENTS

1 • FUGITIVE EMISSIONS: DEFINITION AND EVOLUTION

• Definition(s)

• Available data on fugitive emissions

• A presumption of increase

2 • IMPROVING MEASUREMENT AND REPORTING

• Issues and sources of uncertainty

• Academic, associative and industrial initiatives

3 • MAJOR SOURCES OF FUGITIVE EMISSIONS, SOLUTIONS AND INITIATIVES

• Flaring of natural gas

• Upstream gas and oil

• The coal sector

1 • FUGITIVE EMISSIONS: DEFINITION AND EVOLUTION

The nature of fugitive emissions makes them difficult to assess but their level is significant - around 5% of global emissions - and has probably increased in recent years.

• DEFINITION(S) • The IPCC defines fugitive emissions as "emissions [of greenhouse gases] that are not produced intentionally by a stack or vent" and stipulates that they may "include leaks from industrial plants and pipelines" (IPCC, 2006). A previous definition provides more detail on potential sources of fugitive emissions: "they may be caused by the production, processing, transmission, storage and use of fuels and include combustion emissions only if they do not meet production needs (e.g. natural gas flaring at gas and oil production facilities) "(IPCC, 1996).
This definition may vary from one sector to another. In the fossil fuel sector, fugitive emissions are sometimes broadly defined as any emissions unrelated to the end use of the fuel. In air pollution, a fugitive emission can be defined as the "release of pollutants into the free atmosphere after they have escaped an attempt to capture them with a hood, seal or any other means for ensuring the capture and retention of these pollutants". They therefore contrast with channelled emissions (CITEPA, 1999).

Accordingly, there is no stable and universal definition of fugitive emissions. In practice, they generally include accidental emissions (pipeline breakage, coal seam fire, etc.), leaks and diffuse escapes (defective valves or seals, migration of gas to the surface near wells or mines, emissions from abandoned wells, etc.) and unintentional but non-productive discharges (mine ventilation, flaring, degassing, etc.). Many phenomena are therefore involved in a category that is primarily negative: fugitive emissions are ultimately emissions related to human activities that do not fit into any other category.

• AVAILABLE DATA ON FUGITIVE EMISSIONS • Their very nature makes fugitive emissions difficult to quantify. There is no comprehensive global data, but it is possible to assess their significance and evolution by combining national inventories and secondary data.

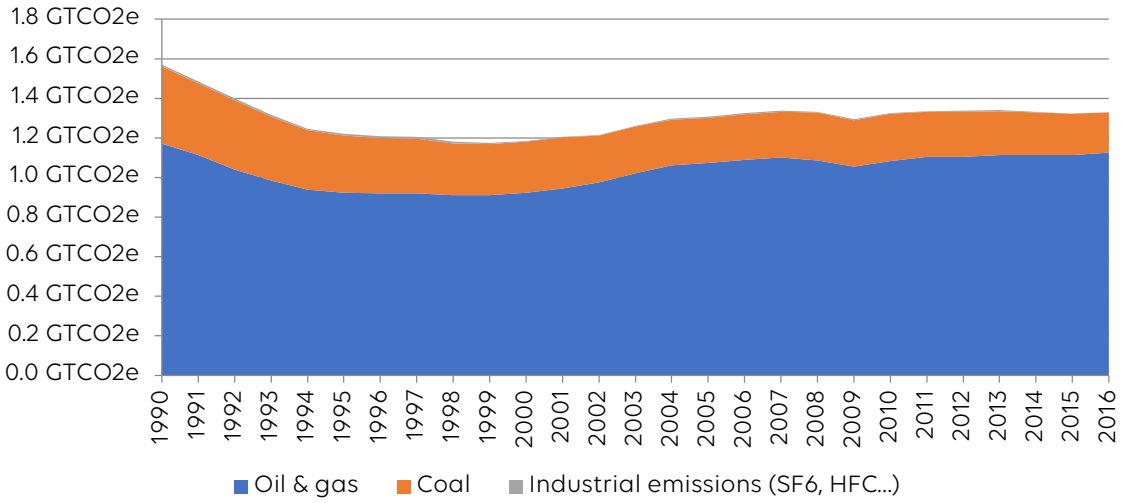

FIGURE 1. FUGITIVE EMISSIONS (ANNEX I COUNTRIES)

Under the United Nations Framework Convention on Climate Change, industrialised countries ("Annex I countries") regularly report fugitive emissions. These inventories show stable emissions since the mid-2000s after a decline in the early 1990s and a rebound around 2000. **In 2016, fugitive emissions reported by industrialised countries were 1.33 billion tonnes CO_2 equivalent compared to 1.57 in 1990, about 85% of which were from the hydrocarbons sector, 15% from coal and a fraction from industry (UNFCCC GHG data).**

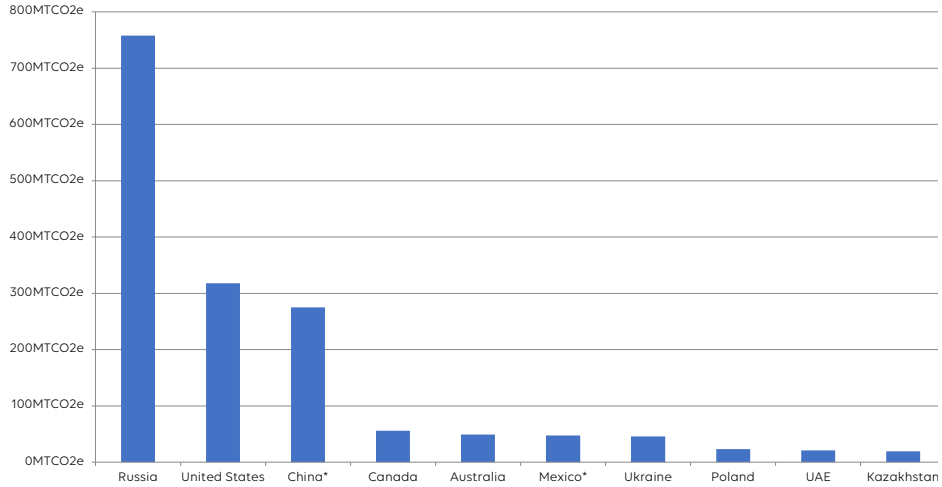

FIGURE 2. FUGITIVE EMISSIONS FOR SELECTED COUNTRIES UNFCCC GHG DATA EXCEPT *ENERDATA)

Outside Annex I countries, fugitive emission data are generally partial and dated: 276MTCO$_2$e for China (2005, CH4 only), 58MTCO$_2$e for Africa (2000, CH4 only), 47MTCO$_2$e for Mexico (2006, CH4 only), 21MTCO$_2$e for the UAE, etc. (Enerdata)

These data, although incomplete and partly obsolete, show that fugitive emissions account for a significant share of global greenhouse gas emissions: at least 2GTCO$_2$e i.e. 5% of the total. It also shows a correlation between countries with high emissions and those with a large oil, gas or coal industry.

While fugitive emissions can occur in any activities handling greenhouse gases - refrigeration (HFCs, CFCs), electricity (SF6), health (N2O), etc. - they occur mainly during the extraction, transport, storage and processing of fossil fuels and largely consist of CH4 (methane or "natural gas").

• A PRESUMPTION OF INCREASE • The orders of magnitude mentioned above must however be taken with caution. In fact, since the mid-2000s, there has been an unexplained increase in the concentration of methane in the atmosphere. This could indicate that fugitive emissions of this gas have been underestimated: the simultaneous increase of the ethane concentration seems to indicate that the oil and gas industry is responsible but the isotopic signature of the methane points to a natural origin (rice fields, swamps, livestock, degradation of natural or agricultural plant waste, etc.). Recent work has suggested a solution to this paradox and tends to confirm the responsibility of hydrocarbon production, which would be responsible for 50 to 75% of the observed increase (Worden, 2017).

Although this hypothesis remains controversial, it is corroborated by measurements carried out near the hydrocarbon production sites. These have found unusually high levels of methane (Zavala-Araiza, 2015): fugitive emissions reported by the US oil and gas sector could be under-estimated by 60% (Alvarez, 2018).

2 • IMPROVING MEASUREMENT AND REPORTING

The evaluation of fugitive emissions is an issue for the climate but also a political and economic one.

This is particularly the case for the gas industry. At equivalent energy, gas combustion produces about half as much carbon dioxide as coal and 30% less than petroleum products. However, at equivalent amounts, methane contributes much more to global warming than carbon dioxide, so this advantage can be rapidly offset by higher fugitive emissions. In the United States, for example, the shift from coal to gas in electricity production represents a gain for the climate only if the upstream leakage rate of plants is less than 3%. The conversion of liquid fuel to gas for commercial vehicles (trucks, buses, etc.) represents a gain if the leakage rate is less than 1% (WRI, 2013). Some studies suggest that fugitive emissions may exceed 4% (Pétron, 2014) or even 7.9% for unconventional gas

(Howarth, 2011). **These assessments cast doubt on the climate advantage attributed to gas compared to other fossil fuels, and therefore the investments made in this energy.**

• ISSUES AND SOURCES OF UNCERTAINTY • In addition to the lack of a clear definition, the evaluation of these emissions raises several practical and methodological problems. The first of them is detection. The emissions may actually be unintentional (leaks and losses from the gas network for example) or they may occur a long time after the end of an activity (emissions related to abandoned wells and mines, for example). Furthermore, the main gas involved is methane which, in its natural state, is invisible and odourless.

Independent producers in the United States

Since fugitive emissions are often diffuse, the collection of information is also problematic. This is particularly the case when the emitting activities are fragmented with many small players.

This is the situation in the oil and gas sector in the United States. Due to an original mining right that allows landowners to exploit the geological resources found on their land without authorisation or concession, oil and gas production in the United States is dominated by small and medium-sized enterprises. Accordingly, the United States has 9,000 independent producers (i.e. producing less than 5 million dollars of hydrocarbons a year or refining fewer than 75,000 barrels a day). These companies, with an average of 12 employees, drill 95% of wells and produce 54% of US oil and 85% of the gas.

This situation makes the estimation of fugitive emissions more complex and limits the means that companies can assign to measuring and reducing them.

Source : Independant petroléum association of America

TEXT BOX 1

A second problem is related to the conversion of these emissions into carbon equivalent. Fugitive emissions are largely composed of methane, a gas whose lifetime in the atmosphere and ability to intercept infrared radiation differs from that of carbon dioxide. To express the climate impact of these emissions in a single unit, their 100-year global warming potential (GWP) is calculated, i.e. the additional energy that they will send back to the Earth's surface in a century compared to that resent by a tonne of carbon dioxide. This equivalence makes it possible to estimate how many tonnes of CO_2 are "worth" one tonne of CH4. However, this figure has been revised steadily since the 1990s: The IPCC's second report puts it at 21, i.e. one tonne of methane would have the same effect on the climate as 21 tonnes of CO_2 - a figure that is still often referred to, while the fourth IPCC report puts it at 25 and the fifth at 28 (Greenhouse gas protocol, 2016). **All other things being equal, these revaluations mechanically increase the role of fugitive emissions.**

• ACADEMIC, ASSOCIATIVE AND INDUSTRIAL INITIATIVES • Significant work is still needed to arrive at a reliable evaluation of fugitive emissions both at the macro level and at the level of the facilities responsible for the emissions. Researchers, non-governmental organisations and manufacturers are mobilising to reduce these uncertainties and the resulting climate and economic risks.

Studies Initiated by the Environmental Defense Fund

The American NGO, the Environmental Defense Fund, has initiated a large-scale research programme to assess and locate fugitive emissions in the US

gas supply chain. This programme, covering 16 independent projects, involved 140 researchers and experts from 40 universities or research centres (NOAA Earth System Research Laboratory, Stanford, Harvard, University of Texas ...) and 50 companies.

It led to more than thirty scientific publications between 2013 and 2018. A summary of this work was published in Science (Alvarez, 2018). It evaluates leaks during the extraction, transmission, storage and processing of gas to be 2.3% of US production, or 60% more than the inventory produced by the EPA, the federal environmental protection agency, based on the declarations of the companies concerned. It also shows large disparities between different sites and suggests that faster detection of leaks would reduce them significantly and cheaply, with existing technologies.

Source : www.edf.org/climate/methane-studies

TEXT BOX 2

Research and development projects are also under way to bring solutions for faster detection of diffuse emissions to the market. This is the case, for example, of the GaSes optical imaging project, developed by the Spanish company SENSIA and supported by the European Union as part of the H2020 programme.

3 • MAJOR SOURCES OF FUGITIVE EMISSIONS, SOLUTIONS AND INITIATIVES

Even if the data are incomplete, it is possible to identify some activities that contribute significantly to fugitive emissions: gas flaring, the hydrocarbon logistics chain and the coal supply chain.

• FLARING OF NATURAL GAS • Gas flaring involves burning gas without using the heat produced. This operation makes it easy to get rid of combustible gases from oil extraction or refining but releases carbon dioxide. By convention, flaring-related emissions are considered fugitive emissions. Last year, 140.57 billion cubic metres of gas were flared, equivalent to 3% of worldwide natural gas production. **This practice decreased in 2017 for the first time since 2010: gas flaring volume dropped by around 5% despite an increase in world oil production of 0.5% (World Bank, 2018)**. Flaring, however, remains responsible for the emission of 300 million tonnes of CO_2 per year.

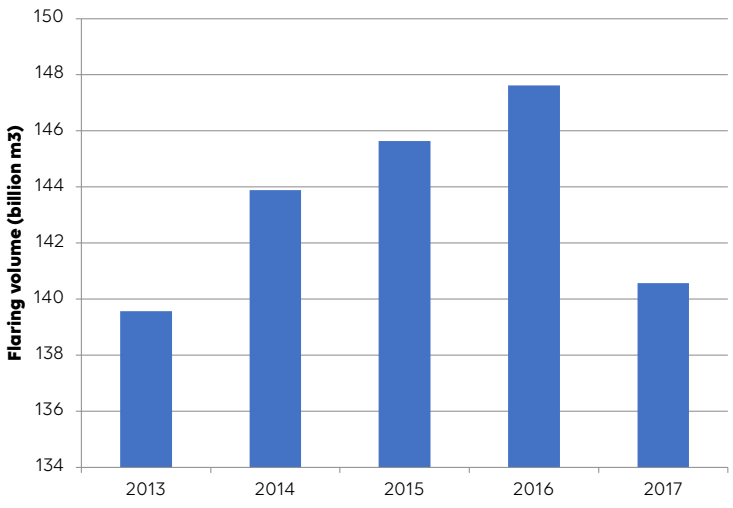

FIGURE 3. ANNUAL VOLUME OF GAS FLARED IN THE WORLD (WORLD BANK)

Source : Banque Mondiale

Origin of Flaring and Solutions

In general, oil deposits also contain methane. This "associated gas" must be separated from liquid hydrocarbons before they are processed. This gas has long been considered an embarrassing by-product of oil production that was rejected or burned. It was only in the second half of the 20th century that large-scale use of natural gas began, but even today it is sometimes cheaper to burn gas than to send it to a buyer, especially when the production site is distant from the consumption areas.

The range of solutions available for gas carriage has expanded. In addition to the construction of a gas pipeline, it is possible to compress the gas to reduce its volume, to liquefy it or to solidify it to make it easier to transport. Formerly marginal, this process has largely developed over the past 10 years, especially under the impulse of American companies - Chevron, Cheniere, Dominion, etc. - seeking new export markets. However, it requires particularly expensive infrastructure that takes a long time to implement.

There are other solutions for avoiding flaring even when gas cannot be transported cheaply, if at all. Note the following, in particular:

• The reinjection of gas in wells - this option can be used to increase the pressure in the tank and make it easier to recover the oil but also to conserve the gas so that it can be extracted again later, if required. Established in Kazakhstan in 2000, reinjection has prevented the discharge of 49 million tonnes of carbon dioxide and in Iran 31 million cubic metres per day are reinjected into tanks. This solution, however, is profitable only if the amount of gas involved is low.

• Generating electricity by burning the gas in a turbine rather than a flare.

• The production of methanol (which is used to produce other petrochemicals such as ethylene or propylene) or ammonia. This method is widespread in Persian Gulf countries.

Source : Soltanieh, 2016

TEXT BOX 3

Despite this progress, flaring remains common, especially in countries that do not have a market or infrastructure for the sale of gas. Its use is therefore often linked to the development and stability of the region: in Yemen, for example, the volume of gas flared per barrel of oil produced has increased four-fold between 2013 and 2017, while in Syria it has increased ten-fold (World Bank).

To limit this practice, the World Bank has launched a "Zero routine flaring" initiative that is mobilising oil tankers and governments to eliminate flaring in the normal operation of facilities by 2030.

Reduction of flaring at ENI

Some companies have committed to achieving this result more quickly: e.g. ENI. In 2007, the Italian company committed to gradually reducing flaring with a view to eliminating it completely in 2025. Two billion dollars were invested in this scheme, which has already reduced the volume of flaring gas by 75%. Additionally, since 2010, new projects developed by Eni no longer use flaring under normal operating conditions.

ENI has achieved this firstly by recovering the associated gas by coordination with the governments of the countries involved. This recovery in electricity generation or in local gas distribution is also used to improve the access of local populations to a modern energy. If recovery is not possible, Eni re-injects the gas into its wells.

The M'Boundi project (Republic of the Congo) is an example of this process: in March 2014, Eni

completed the installation of two compression plants to enable the majority of the associated gas to be transported to a 300MW power plant belonging to CEC (Congo Electric Power Plant), with the surplus gas reinjected into wells. This project required an investment of 300 million dollars and is recovering 3 million cubic metres of gas per day.

Source : ENI

TEXT BOX 4

Flaring also has consequences for the local environment (air pollution, noise, etc.), which is why communities are mobilising to end the practice, often with the support of NGOs. In 2015, for example, Nigerian representatives of the Egi communities participated in Total's general assembly to demand the cessation of flaring in the Niger Delta and to testify to the environmental and social problems caused by the exploitation of hydrocarbons. They were supported by the NGO Friends of the Earth (Novethic, 2015). In 2017, Total Exploration and Production Nigeria signed 2 agreements with the Egi community to improve the living conditions of those living near its facilities.

• UPSTREAM GAS AND OIL• In addition to flaring, the hydrocarbon sector is responsible for fugitive emissions of methane at all stages of its activity:

• Wells: methane is normally piped and recovered through the well casing but some can escape into the atmosphere through the soil in the area around the boreholes (Kang, 2014). These diffuse discharges can last a decade after the end of operations (Boothroyd, 2016),

• During gas transportation and storage: defective sealing of valves and fittings, breaks and leaks, intentional or uncontrolled degassing, etc.

• During the processing of petroleum products: a refinery has tens of thousands of valves that can leak small amounts of greenhouse gases or other pollutants.

The Aliso Canyon accident in 2015-2016

The Aliso Canyon gas storage facility, near to Porter Ranch, is operated by SoCalGas, the leading natural gas distributor in Southern California. It has 114 wells with capacity for 2.4 billion cubic metres of gas, equivalent to 15 million barrels of oil. This storage facility is the second largest in the United States and supplies gas to 11 million homes and 16 thermal power stations in the Los Angeles area.

On 23 October, 2015, site employees found a massive leak in the tank: every day about 1,000 tonnes of gas were escaping into the atmosphere. After many unsuccessful attempts, the leak was finally found and sealed on 13 February 2016.

During these four months, 97,100 tonnes of methane and 7,300 tonnes of ethane were discharged - the equivalent of the greenhouse gas emissions of 200,000 Americans for one year. The disaster resulted in the evacuation of 2,000 households located near the site. The estimated cost was $665 million. This accident drew attention to the vulnerability of US gas infrastructures to methane leaks. Most fugitive methane emissions are, however, much less spectacular - and therefore much more difficult to identify and remedy.

Source : Conley et Al, 2016

TEXT BOX 5

The solutions available for reducing these fugitive emissions depend on their source but in all cases require the mobilisation of companies involved in the hydrocarbon logistics chain. Apart from the major leaks and those that represent a risk to staff, it is not always economically profitable to reduce fugitive emissions: indeed, to detect leaks, to determine their source and correct them requires investments which may be much higher than the cost of the lost gas.

Local regulation and the actions of communities and NGOs can play an important role in encouraging businesses to respond to low-volume leaks. For example, BP has installed a leak detection and repair system on more than 80,000 valves at its refinery in Whiting, Indiana, but it needed the company to be bound by an agreement with the American justice system at the end of a procedure initiated by 3 American states (Indiana vs. BP, 2001). More recently, on 23 March, 2017, California adopted a new regulation on methane emissions in the hydrocarbon sector, to come into effect between 2018 and 2020, expected to reduce the state's emissions by 1.4 CO_2mteq per year, in particular by establishing quarterly monitoring of fugitive emissions and by imposing repair timescales when leaks occur.

The challenge of gas distribution networks

As operators of gas distribution networks enjoy a natural monopoly, they do not always have an economic incentive to reduce losses. In the absence of competition, tariffs are generally set by a regulator, often on the "Cost +" model: the remuneration received by the operator is based on the operating cost of the activity, valued based on previous years, plus a margin. In this system, gas lost during transmission and distribution is absorbed in the historical operating costs. As a result, the operator does not suffer losses from fugitive emissions and there is no incentive to invest to reduce them. Local authorities often play a role in the management of the distribution network: they can own it (as in France), set rates (this is generally the case at state level in the United States), be on boards of directors, etc. They can use this role to encourage network operators to combat leaks, thereby helping to reduce their fugitive emissions even when the gas industry is not directly present on their territory.

Source : Hausman, 2016

TEXT BOX 6

Cooperation between companies, researchers and public bodies at sub-national level is particularly necessary in the United States, where the election of Donald Trump in 2016 led to federal regulation being undermined and the commitments of the previous administration being abandoned. There are initiatives in this direction (Konschnik, 2018).

At world level, the objective of the Oil and Gas Methane Partnership, under the auspices of the Climate and Clean Air Coalition, is to encourage oil tankers to take voluntary action. Ten of the largest oil companies on the planet, including Royal Dutch Shell, Total and BP, as well as Mexico's PEMEX and Thailand's PPT, have ratified its guiding principles for reducing methane emissions in the gas industry.

• THE COAL SECTOR • After hydrocarbons, the next sector causing fugitive emissions is coal: like oil reservoirs, coal seams generally contain methane that can escape into the atmosphere when the resource is exploited.

Coal-related fugitive emissions mainly occur:

• During coal mining: the fracturing of the ore releases trapped methane. In an open cast mine, the gas occurs directly in the atmosphere. When the mine is underground, the methane spreads in the tunnels before being evacuated by the ventilation system. The concentration of methane in the ventilated air outside mines is usually a few tenths of a percent, while the risk of explosion ("firedamp") starts from a few percent.

• During the transportation and storage of coal: the gas still present in the ore is released into the atmosphere
• Following decommissioning: methane can continue to escape through cracks and wells created during operation. In the United States, for example, there are several thousand abandoned mines, including 400 identified as discharging significant quantities of methane (EPA, 2017).

According to the available inventories, most emissions occur during ore extraction: ventilated methane alone accounts for half of the sector's fugitive emissions (EPA).

The gas associated with coal can be recovered and used as natural gas for electricity generation, vehicle fuel or in petrochemical processes. It can also be used in mining: to dry ores, heat tunnels, etc. The reduction of fugitive emissions in the coal sector can thus be a profitable operation: in Europe, coal degassing would yield €1.8 - €2.2 per tonne of CO_2 equivalent avoided (Ecofys, 2009). However, these emissions are often neglected: in the ETS framework, the European carbon market, for example, they are not included in calculations of the carbon footprint of coal producers.

The Global Methane Initiative, a public-private partnership launched in 2004 to reduce methane emissions, identified nearly 200 projects in the coal sector in 2016 (Global Methane, 2016). Among the most recent are the installation of a 1MW gas turbine (with the option to extend to 6MW) in the Fuhong underground mine in China or gas recovery and use for the production of steam, heat and electricity at the Severnaya mine in Russia.

Degasification of the Khe Cham Coal Mine (Vietnam)

Located in the northeastern province of Quang Ninh, the Khe Cham coal mine is operated by a subsidiary of the public conglomerate Vinacomin (Vietnam National Coal and Mineral Industries Group) and produces 1.5 million tonnes of coal per year.

The Khe Cham coalfield is one of the richest in methane in the country. These fugitive emissions pose safety problems: in 2009, a firedamp fire killed 11 miners.

In 2012, a drainage system was put in place, which reduced the methane concentration in the mine atmosphere by 0.2 to 0.6 points. This meant that the mine was no longer forced to suspend operations due to the abnormal presence of methane (compared to an average of 20 hours per month of interruption before its installation). Ventilation costs have also been reduced by a third and output efficiency has improved. Finally, the collected methane can be used to supply a gas turbine and partly cover the electricity needs of the mine.

FIGURE 4. STATION DE DRAINAGE DE MÉTHANE À KHE CHAM

Source : Global Methane

TEXT BOX 7

As emissions continue beyond end of operations, site remediation and the attention of local authorities can also help to reduce emissions.

CONCLUSION

Despite a significant contribution, fugitive emissions are one of the blind spots in combating climate change. Much work remains to be done for better evaluation and reduction of fugitive emissions. The available information suggests that the extraction and, to a lesser extent the processing and transportation, of fossil fuels is the main source of fugitive emissions. Responsibility for their reduction therefore rests first and foremost in the oil, gas and coal companies, assisted - sometimes spurred - by other actors: researchers, local authorities and local communities, NGOs.

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Carbon capture and sequestration: a solution that is struggling to materialise

Carbon capture and sequestration (CCS) prevents the release of greenhouse gases into the atmosphere by recovering carbon dioxide at the emitting facilities and then storing it or using it, possibly after transport. CCS could quickly reduce greenhouse gas emissions from power generation and industry without the need to reduce fossil fuel consumption. The technical feasibility of this solution has been demonstrated by pilot projects including Petra Nova which started in 2017. However, CCS struggles to get deployed: only 5 projects are underway in the world. We ask what the possible reasons for this reluctance may be.

Main autor • **THIBAULT LACONDE** • *Consultant, Energie & Développement*

CONTENTS

1 • CCS: MIRACLE OR MIRAGE

• The functioning of CCS

• CCS today in the world

2 • COMPANIES: AN ENTHUSIASM WITHOUT A BUSINESS MODEL

• Insufficient carbon price to move beyond pilot projects

• The regulatory way

3 • A DIVIDED CIVIL SOCIETY

• NGOs and the academic world

• Local communities

4 • COMMUNITIES: UNDECIDED ARBITERS

1 • CCS: MIRACLE OR MIRAGE

Carbon capture and sequestration is a set of techniques for recovering carbon dioxide from large emitting plants (thermal power plants, steel plants, etc.) and storing it sustainably to prevent its release into the atmosphere.

Unlike most mitigation techniques, **CCS could reduce emissions without the need to reduce fossil fuel consumption and thus without disrupting our consumption patterns or the structure of our economies. It also has the advantage of potentially allowing it to be implemented a posteriori in an existing industrial tool.**

• THE FUNCTIONING OF CCS • CCS comprises three main steps:

• Capture: separating carbon dioxide from other gaseous effluents at the chimney outlet or modifying industrial processes to release pure CO_2

• Sequestration: sustainably storing the recovered carbon dioxide to stop it reaching the atmosphere

• Transport: transporting carbon dioxide from the capture point to the storage point

Each of these steps can involve multiple technologies – sometimes with varying levels of maturity, costs, and environmental impacts.

The first step of CCS is capturing carbon dioxide at the output of thermal power plants or industrial facilities. The difficulty of this step comes from the fact that the effluents are not composed of pure carbon dioxide: similarly to ambient air, they contain approximately 2/3 nitrogen and various impurities. It is therefore necessary to separate carbon dioxide from other gases or to modify industrial processes to produce only CO_2.

There are three types of technologies for this:

• Post-combustion: carbon dioxide is separated from other gases and recovered directly from the exhaust fumes – allowing use on existing equipment without major modification

• Oxy-combustion: the installation is modified so that the combustion of fossil fuels is carried out in pure oxygen and thus produces only water vapor (easy to precipitate) and carbon dioxide

• Pre-combustion: this process consists in extracting carbon before combustion This can be done by producing carbon monoxide from the fuel (for example by steam reforming or incomplete oxidation) which reacts with water vapor to form carbon dioxide and dihydrogen (this is referred to as "shift-conversion"). Then, hydrogen is burned, producing only water vapor.

Atmospheric capture and CCS

Atmospheric capture consists in removing CO_2 not at the output of emitting facilities but directly from the atmosphere. This emerging sector is different from CCS because it does not only reduce emissions, it creates "negative emissions". It is experiencing a growing interest that has been stimulated in particular by the objective of net zero emissions stipulated by the Paris Agreement.

Atmospheric capture often relies on all or some of the technologies developed for CCS. For example, biomass + CCS (or "Bioenergy + CCS", BECCS) consists in using photosynthesis to remove CO_2 from the atmosphere and then burning the biomass produced and recovering and sequestering the CO_2: this technique therefore uses the whole chain of CCS. Direct air capture uses a technological process to extract CO_2 from ambient air where it is much less concentrated than in factory fumes (approximately 0.04% vs. 30%) before sequestering it: in this case, only the transport and the sequestration are common with CCS..

Source : center for carbon removal

TEXT BOX 1

The captured carbon dioxide then must be stored safely and sustainably to prevent it from entering the atmosphere. The solution most often considered is geological sequestration: CO_2 is injected into depleted oil or gas reservoirs into unusable coal seams or deep saline aquifers. **In practice, however, the captured CO_2** is rather used than stored – it is sold, which improves the profitability of the process but can also decrease its positive impact on the climate. **The valuation may consist of:**

- Injecting CO_2 into a hydrocarbon reservoir during operation: as the petrol or gas is being extracted, the pressure in the reservoir drops, and the injection of CO_2 (or other gases) can make it possible to increase it and increase production – this is referred to as enhanced oil recovery or EOR
- Using CO_2 as a raw material in chemical, industrial or agricultural processes, for example as a solvent, refrigerant or dissolved in sparkling beverages
- Using energy to convert CO_2 into liquid or gaseous fuel through photosynthesis (e.g. by producing microalgae used for biomass production) or by methanation.

It is not always possible to use the dioxide at the place of capture and it is rarely possible to store it there. An intermediate step therefore consists in transporting the gas. This transport can be done by gas pipelines, but also by truck, train or boat.

• CCS TODAY IN THE WORLD • Carbon transport and sequestration – usually by EOR – has been carried out on a small scale for several decades. These first experiments have almost all taken place within petrochemical processes already producing concentrated CO_2 without the necessity to modify the emitting installation. For example, this is the case of the purification of natural gas (Terrell Natural in the United States in operation since 1972, Sleipner in Norway since 1996, etc.) or the production of nitrogen fertilisers (Enid Fertilizer in the United States since 1982).

Carbon capture from facilities that do not produce pure carbon dioxide is a more recent occurrence. For example, there are many demonstrators in electricity generation but only two large-scale projects are currently in operation: Boundary Dam in Canada (commissioned in 2014) and Petra Nova in the United States (commissioned in 2017).

Boundary Dam

Boundary Dam is a coal power plant operated by Sask Power in the Canadian state of Saskatchewan. Its unit 3 has been equipped to capture the emitted carbon dioxide: up to 90% of the CO_2 produced during combustion, i.e. approximately 50,000 tonnes per month, which is captured by absorption using a chemical solvent. The CO_2 is sold and transported via a pipeline to the Weyburn oil field where it is pumped into wells to increase production. At the beginning of 2018, Boundary Dam 3 exceeded the threshold of 2 million tonnes of captured CO_2.

The project cost $1.35 billion Canadian dollars (€945 million). It is approximately 5 times more than a coal power station without CCS which would have cost €150 to 200 million at equivalent power. An overconsumption of energy of 25% is also added to these investments. In addition to its net capacity of 110 MW, the plant produces 29 MW which only serve to fuel the energy-intensive process of carbon capture. Despite these costs, the project demonstrated the technical feasibility of post-combustion CCS on an industrial scale.

Source : www.saskpower.com

TEXT BOX 2

Excluding small demonstrators and pilots, 17 carbon capture and storage projects are currently in operation around the world, preventing the release of just over 31 million tonnes of CO_2 annually. Five additional projects are under construction and another fifteen are in various stages of development (Global CCS Institute, 2018).

There have also been several costly failures in carbon capture such as the FutureGen projects or the Kemper County project in the United States and ZeroGen in Australia.

The technical feasibility of capturing and sequestering carbon has therefore been established, but projects likely to significantly reduce emissions are rare and difficult to materialise. We may ask how to explain these difficulties and what role do non-state actors play in the development or instead in the resistances to CCS.

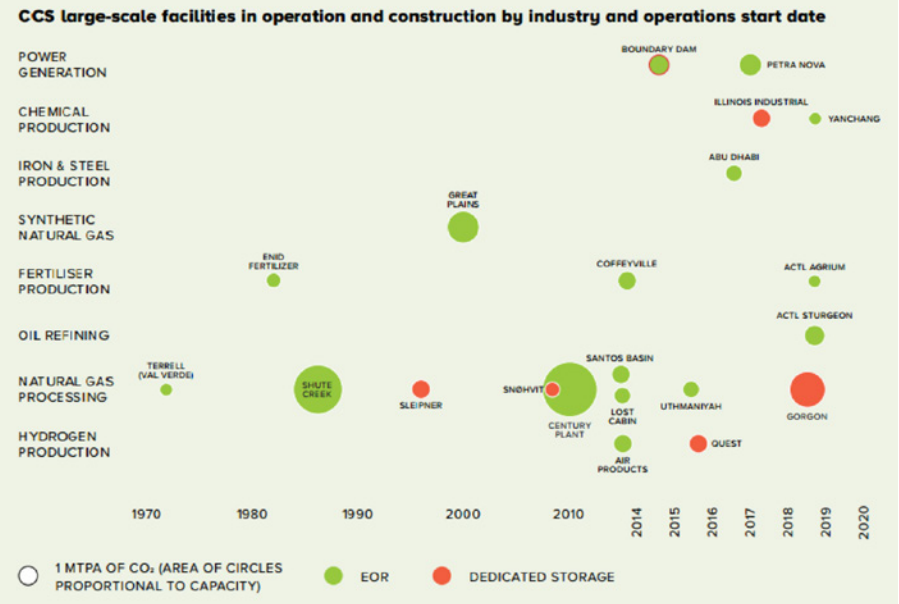

FIGURE 1. CCS PROJECTS ON AN INDUSTRIAL SCALE BY DATE OF COMMISSIONING, SECTOR AND THE QUANTITY SEQUESTERED (GLOBAL CCS INSTITUTE, 2018)

2 • COMPANIES: AN ENTHUSIASM WITHOUT A BUSINESS MODE

Carbon capture is attracting the interest of many economic players, especially those who depend on fossil fuels because its large-scale deployment would reduce emissions without jeopardising their activity. Coal industry, tankers, fossil electricity producers, heavy industries, etc. therefore support the development of this sector; however, like the Lacq pilot project (France) launched by Total, these experiments rarely lead to large-scale implementation.

One of the major causes of this reluctance is that carbon capture does not have economic rationality these days (Kapetaki, 2017).

• INSUFFICIENT CARBON PRICE TO MOVE BEYOND PILOT PROJECTS •

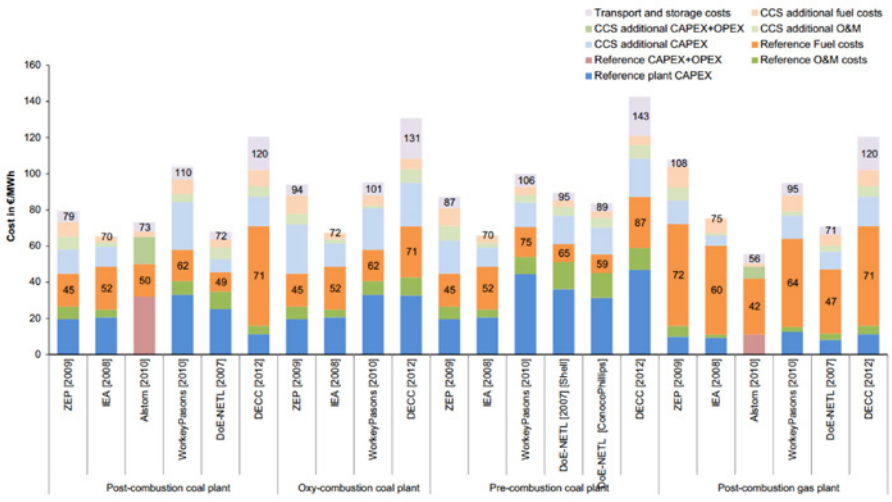

FIGURE 2. ADDITIONAL COST (LCOE) OF CARBON CAPTURE AND SEQUESTRATION PER MEGAWATT HOUR PRODUCED BY VARIOUS STUDIES

(Renner, 2014)

These projects are expensive and significantly decrease the performance of the facilities on which they are conducted. According to the considered studies and technologies, carbon capture and sequestration in a thermal power plant would increase the cost of electricity from €56 to €143 per megawatt. In Europe the price of electricity is around €40/MWh – it would therefore mean at least a doubling of the wholesale price.

Under these conditions, it would necessitate a price of carbon of €115 per tonne in Europe for thermal power plants with CCS to become the most profitable option. For comparison, the price of European carbon credits has been fluctuating between €4 and €20 per tonne of CO_2 since the creation of the European carbon market. In China, the tipping point is lower: a carbon price of €45 per tonne would be enough to make CCS profitable in the electricity sector. This threshold could be reached by 2030 (Renner, 2014), but the Chinese carbon market pilots currently place the price per tonne of CO_2 between €0.13 and €15.5.

Where it exists, **the price of carbon is therefore too low and often too volatile to justify the development of carbon capture and sequestration.** Companies have no incentive to go beyond pilot projects.

The new US carbon capture tax credit

In the United States, the 2018 budget has created a strong incentive for carbon sequestration: geological sequestration of one tonne of CO_2 gives the right to a tax credit of $50. The other uses of CO_2 are accompanied by a tax credit of $35 per tonne. This system applies both to CO_2 captured from energy or industrial installations and CO_2 removed directly from the atmosphere. It may not be sufficient to allow carbon capture and sequestration to become profitable, but this system should help many projects come closer to it.
This tax credit is also original by the variety of support that it gets, bringing together both climato-septic and environmental activists, Republicans and Democrats, coal producers, unions and NGOs.

Source : MIT Technology review

TEXT BOX 3

• THE REGULATORY WAY • In the absence of economic rationality, regulators may be tempted to impose carbon capture and sequestration on companies. The first example of this strategy can be found in Australia in the case of the Gorgon and Wheatstone gas projects: the Western Australian Government authorised the construction of these facilities by Chevron provided that 80% of the CO_2 removed from the gas is captured and sequestered.

This initiative replaces the carbon price: the Western Australia compulsory compensation scheme was abolished in 2011 when Australia created a carbon tax, but this tax was in turn abolished in 2014 by Tony Abbott's government. Chevron no longer has any financial incentive to reduce its emissions.

As part of the deal, Chevron invested $2.5 billion (out of a total investment of $88 billion) to capture 4 million tonnes of CO_2 per year. The sequestration will take place in a reservoir located 50 km from the coast and 2 km below the surface in the Isle of Barrow nature reserve.

However, the regulatory approach shows some limitations: the Gorgon site has been operating since March 2016, but carbon capture and sequestration is still not operational and it will ultimately only address 40% of emissions. This delay was not foreseen by the agreement whose application is therefore included. Two investigations were initiated by the local environmental protection agency.

The European Union has taken a more flexible approach: the 2009 CCS Directive does not require carbon capture and sequestration, but a feasibility study is required for new thermal power plants above 300 MW. When transposing this directive, some member states including France and Great

Britain decided to allow only CCS-ready projects, meaning projects fulfilling the conditions (space, access, etc.) allowing them to be retrofitted for carbon capture.

3 • A DIVIDED CIVIL SOCIETY

Another obstacle for carbon capture and sequestration projects is its image in civil society: this sector is little known and often leads to a rejection response.

• NGOS AND THE ACADEMIC WORLD• Some researchers see carbon capture as a "Faustian pact" (Spreng, 2007) that can lead to a technological impasse and hinder the development of low-carbon technologies such as renewable energy.

The Yanchang project – illustration of the CCS paradoxes

Yanchang in the coal-producing areas of northern China is to host the first industrial-scale carbon capture and sequestration system in Asia. The project is led by Yanshan Petroleum, a company owned by the provincial government of Shaanxi and the 4th largest petrol producer in China. It is to be opened in 2018 and avoid the discharge of 410,000 tonnes of CO_2 per year.

Yanchang illustrates the paradoxes of carbon capture: just like 4 out of 8 Chinese CCS projects, it is intended to capture emissions from coal liquefaction plants. The installation of these systems at the plant level does not eliminate emissions either upstream (for example fugitive emissions of methane during coal mining) or downstream (during fuel combustion). The process also consumes a large amount of water (6 to 13 tonnes of water per tonne of fuel). In addition, the catchment site and the storage site are separated by 140 km, and the transport is done by truck: more than 20,000 round trips will be needed each year. Finally, the captured CO_2 is sequestered in the Qiaojiawa oil field where it can stimulate the production of hydrocarbons.

The carbon capture and sequestration carbon is therefore part of a value chain emitting a lot of greenhouse gases which it helps to perpetuate.

Source : Financial times

TEXT BOX 4

This opposition was reinforced around the year 2010 when it became clear that CCS projects were facing many difficulties – delays, extra costs, abandonment, etc. (Markuson, 2012). This period also corresponds to a decrease in the resources allocated to research: in Europe, public and private investment in research into carbon capture and sequestration peaked in 2010 (Fiorini, 2016). In the United States, the Carbon Sequestration Initiative research programme into CCS at MIT closed in June 2016 after 16 years of existence.

In a similar fashion, some NGOs are radically opposed to carbon capture. Greenpeace believes that CCS is a dangerous waste of time, "Greenpeace opposes CCS as a dangerous distraction from the safe, secure 100 percent renewable energy future we all want." ***This position is however far from consensus: other organisations fight in favour of CCS (Bellona, ZERO, etc.), even WWF has sometimes cautiously supported this solution (WWF-UK in 2014: "Demonstrating carbon capture and storage is an urgent priority ... but the Government shouldn't plan significant investments in new fossil fuel plants today on the assumption that CCS technology will be available at an affordable cost in the future to capture emissions when we simply don't know that yet."***

• LOCAL COMMUNITIES • Carbon sequestration with its risk of leakage and induced earthquakes is worrying riverside communities. Their mobilisation has slowed or even prevented carbon capture and sequestration projects and pushed some governments to abandon on-shore sequestration in favour of more expensive off-shore sequestration.

This is what happened to the CCS project proposed by Shell in Barendrecht (The Netherlands). This project was to start in 2011 and provide storage for 10 million tonnes of CO_2 within 25 years. It was abandoned in 2010 due to opposition from the local population. Following this failure, the Dutch government decided that all CO_2 storage projects should be done at sea. Similar movements took place in Germany (Beeskow, Brandenburg) and in the United States (Greensville, Ohio and Long Beach, California).

The acceptance of carbon capture and sequestration projects by the local population is therefore a major challenge in the development of this sector. The topic has been the subject of numerous studies and scientific publications. As is often the case for emerging technologies, the first factor of acceptability is the perception of benefits, in this case the continued use of fossil fuels (L'Orange Seigo, 2014). As a result, populations heavily dependent on fossil fuels are more favourable to carbon capture and sequestration projects, even when they are otherwise hostile to emission reduction efforts. For example, in the coal state of Indiana, 80% of respondents support carbon capture and sequestration. However, this does not prevent the NIMBY effect ("not in my backyard"): 20% of respondents favourable to CCS change their minds if the project is close to their community (Krause, 2013).

The used technologies and especially the source of CO_2 are other factors likely to affect public opinion. A German study shows that CCS, which is on average perceived as relatively neutral, is supported more when it is conducted on biomass plants or industrial facilities than when it is conducted on coal plants. The mode of transport and storage also have an influence: using enhanced hydrocarbon recovery, for example, is better perceived than injecting into saline formations (Dütschke, 2016).

4 • COMMUNITIES: UNDECIDED ARBITERS

Carbon sequestration means storing a dangerous substance for an indefinite amount of time. This practice, and to a lesser extent carbon transport, has a significant territorial footprint, making communities crucial stakeholders.

For example, the 2009 European Directive on CCS provoked resistance in Germany, where the federal states challenged the sites selected for carbon sequestration. As a result of this move, the German CCS Act recognised the role of federal states by granting them a veto over carbon sequestration projects – **an unprecedented prerogative in German environmental law that does not generally give the right of scrutiny over infrastructure projects to local authorities.**

More generally, experience shows that the interest of communities can vary significantly depending on the selected technology and the equipment to be installed on their territory. In particular, they seem reluctant to accept the storage of carbon dioxide, especially when it is not associated with the construction of a new thermal power plant or with value-production (such as the production of hydrocarbons).

The implementation of the FutureGen project in the United States

FutureGen was announced in 2003, and it was conceived as the leading figure in Bush administration's "clean coal" agenda. The project was meant to demonstrate carbon dioxide capture and sequestration in a single location, bringing together the entire technology chain in a purpose-built state-of-the-art facility. This ambitious project had a budget of $1.5 billion, of which 74% was funded by the federal government.

Implementing the project was the subject of a two-year competitive process. Seven states applied for it and 12 sites were selected. The first selection round led to four finalists – two in Illinois and two in Texas. Both states have invested in the process including mobilising the general public to ensure project recognition and acceptability. In January 2008, Mattoon, Illinois was chosen as the site for FutureGen.

In mid-2009, the consortium in charge of FutureGen acquired the land in Mattoon. Laying the foundation stone of the new plant was planned for 2010. In August 2010, the project – now called FutureGen 2.0 – was restructured by cancelling the construction of the new power plant to instead retrofit an existing facility located 280 kilometres from Mattoon. In this way, Mattoon would have provided only the geological carbon storage site which led the community to withdraw support for the project. The search for a new site delayed the project for another year and was eventually abandoned in 2015.

Source : Markusson, 2011

TEXT BOX 5

CONCLUSION

Carbon capture and sequestration is an attractive option for reducing greenhouse gas emissions and could even help remove carbon dioxide from the atmosphere. A decisive advantage of CCS is that its technological feasibility has been proven and that it has been implemented on projects dating back several decades. Its main fault is that it is still too expensive and too uncertain to truly mobilise the economic actors. The reluctance of local authorities and the cautiousness of communities often complicate projects and obscure the prospects of a technology that, for the time being, remains an uncertain deus ex-machina.

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2018 GLOBAL OBSERVATORY
ON NON-STATE
CLIMATE ACTION

TRANSPORT

BOOK 1

Sector based action

**PUBLISHED BY CLIMATE CHANCE ASSOCIATION,
NOVEMBER 2018**

Citation
**CLIMATE CHANCE (2018)
« SECTOR-BASED ACTION »**

**BOOK 1 OF THE ANNUAL REPORT
OF THE GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION**

REVISED AND CORRECTED VERSION - DECEMBER 2018

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TRANSPORT

ROAD TRANSPORTATION 4

SECTOR PROFILE 4
The "Road" Towards Low Carbon Mobility

SWEDEN 26
Transport in Sweden, the automotive sector's transformation is taking shape

SOUTH AFRICA 40
Make road transport a solid pillar in combatting greenhouses gas emissions

INDIA 54
Policies for low carbon pathway and role of non-state actors in India

BRAZIL 64
Stabilization of road transport emissions in the country of ethanol

AIR SECTOR 74

SECTOR PROFILE 74
Air transport: efforts are still in the state of experimentation

RAILWAY SECTOR 90

SECTOR PROFILE 90
Greenhouse gas emissions: a decisive asset for rail?

MARINE SECTOR 102

SECTOR PROFILE 102
New initiatives in international maritime transport

The "Road" Towards Low Carbon Mobility

The Paris Agreement encourages raising mitigation ambition in Nationally Determined Contributions (NDCs) by reviewing and assessing the strength of their ambition and to formulate long-term low greenhouse gas emission development strategies. The current NDC's identify the transport sector as a significant mitigation source whose decarbonisation is critical in achieving economy-wide decarbonization.

This chapter is a synthesis report analysing the most recent data from the road sector and the factors behind its growth and development. The main ambition is to provide a status of global climate action related to the road transport sector, and the synergies between the State and non – state actors.

Head Editor • **SUDHIR GOTA** • *Consultant, Partnership on Sustainable Low Carbon Transport (SLoCaT))*

CONTENTS

1 • **STATUS OF ROAD TRANSPORT CARBON EMISSIONS**

2 • **WHY HAVE CARBON EMISSIONS INCREASED IN THE ROAD TRANSPORT SECTOR?**

High Growth in Road Transport Demand (Activity)

Mode Share (Shift in Transport Demand)

Changes in Energy Intensity and Low Carbon Fuel

1 • STATUS OF ROAD TRANSPORT CARBON EMISSIONS

In 2016, the transport sector constituted about 23% share in total fuel combustion carbon emissions[1]. **Most of the Carbon emissions within the transport sector are from the road transport sector, which constitutes about three-quarters of transport carbon emissions[2]** i.e. about 6GT of direct Carbon emissions in 2017. Since 2000, road transport carbon emissions have increased at an annual rate of 2% becoming one of the fastest growing sub-sectors of fuel combustion emissions[3] over the past half-century. **However, since 2015, road transport carbon emissions growth has grown at a slower annual rate of 1.4% when compared with historic annual growth of 2%.** However, this slowing down of emission growth is not yet compatible with the findings of the IPCC Special Report on Global Warming of 1.5°C[4] i.e. ***limiting climate change to 1.5-degree Celsius means nothing short of de-carbonizing road transport sector around mid-century or soon afterwards and thus necessitates transformational changes in thinking, behaviour, and the combined actions of all stakeholders.***

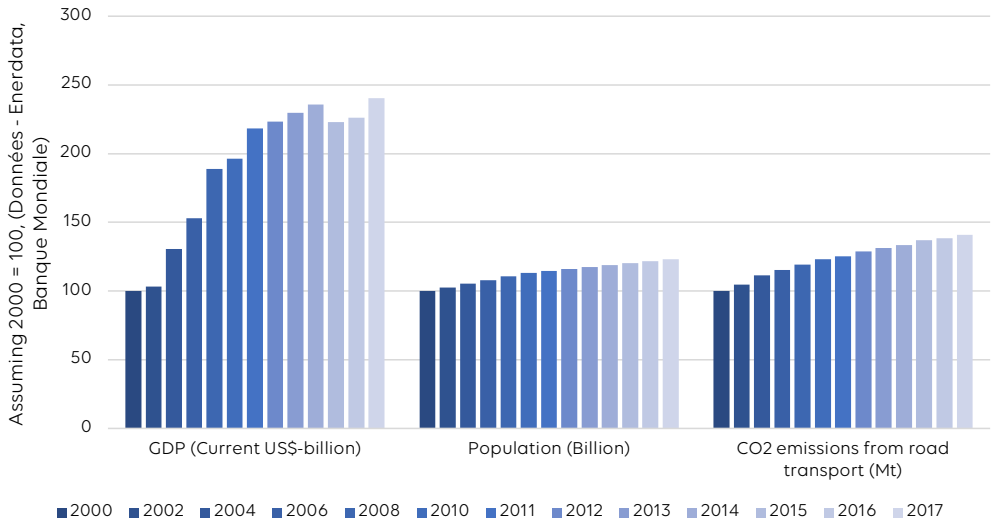


FIGURE 1. GROWTH IN ROAD TRANSPORT EMISSIONS

The entire growth in the road transport carbon emissions post-2000 has come from non-OECD countries (Table 1). The non-OECD countries share increased from 31% in 2000 to 47% in 2015[5] and most of the growth concentrated in Asian and African countries where road transport carbon emissions have doubled (Enerdata et Edgar). **However, in the last couple of years i.e. from 2014 to 2016, road transport emissions annual growth in the non-OECD countries have slowed down with an annual growth of 2%[6] mainly due to slowing down of growth in emissions in countries like Brazil, China, India, Indonesia, Malaysia and Saudi Arabia (Global Energy Statistical Yearbook, Enerdata).** The decline in Brazilian emissions underlined in this report, is an example of this link between growth and CO_2 emissions from road transport (Country profil Brazil – Road Transport section, Book 1), while the increase in Indian emissions underlines the strong impact on CO_2 from the increase in the car fleet (Country profil India – Road Transport section, Book 1).

	2005	2010	2016	2017
World	4,809.3777	5,237.1766	5,883.8007	5,983.9182
Italy	116.9636	103.7557	98.3021	96.5156
Netherlands	33.4361	32.7982	28.7313	29.2687
France	126.1286	118.9547	117.9526	118.646
United Kingdom	118.7426	110.2636	114.0851	114.2115
Sweden	21.2929	20.6226	18.3109	17.8555
Poland	33.4424	46.2345	51.1971	57.8695
Germany	150.1151	143.9549	157.2153	161.1553
Russia	114.881	143.3387	157.11	153.9852
Canada	126.0199	141.9901	142.0916	145.9141
United States	1 561.1449	1 469.1629	1 509.7615	1 516.4608
Australia	71.2071	74.8835	81.0902	84.3928
Japan	208.0171	193.8698	187.7446	186.2568
China	314.5042	467.6695	693.5187	717.2486
India	103.2084	176.0312	243.0412	260.7791
Indonesia	62.1026	88.2062	112.2836	116.3845
Mexico	125.7182	146.5216	151.9731	145.7665
Brazil	123.7752	149.6977	179.9659	184.7932
Colombia	19.9236	20.9936	29.9612	30.9587
Saudi Arabia	73.9228	103.3289	133.0469	130.3684
Algeria	19.3229	29.2905	41.4319	40.7904
Ivory Coast	1.0552	1.3077	2.8659	n.a.
Nigeria	28.5036	27.4846	23.7578	25.3636
South Africa	40.1567	45.0207	47.5597	49.7997

TABLE 1. GREENHOUSE GAS EMISSIONS ($MTCO_2$) BY COUNTRIES

(Source: Enerdata)

Within the road transport segment, the light-duty vehicles (cars) constitute about 60% of road transport emissions[6]. The road-based public transport services such as bus (including minibus) and two-and-three-wheelers constitute about 6% each respectively. However, there are significant variations in the magnitude of carbon emissions among different sub-modes across different countries. For example, the two-and-three-wheelers constitute about 2% and 11% of total road transport carbon emissions in OECD and non-OECD countries[7]. The two-wheelers are a significant source of emissions in the ASEAN, China, India and Africa[8].

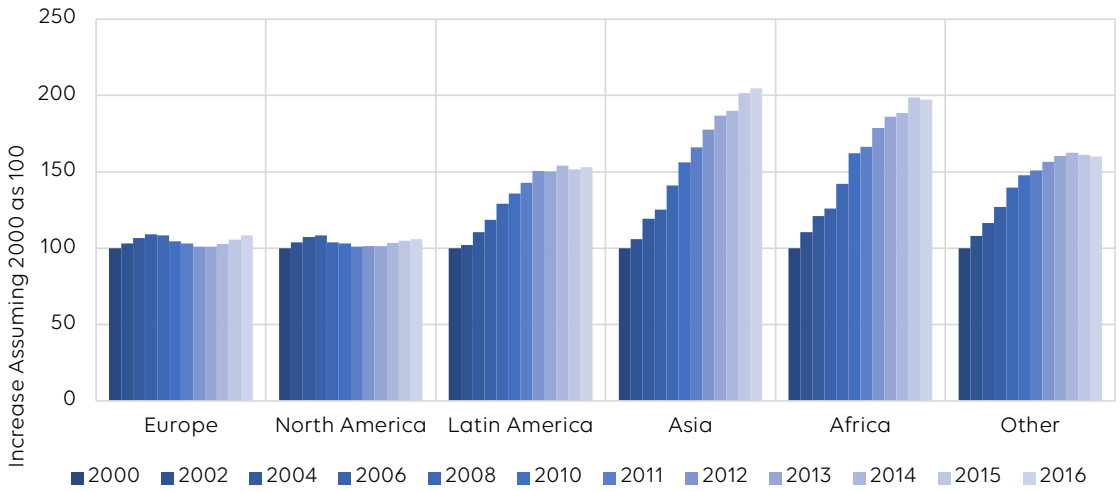


FIGURE 2. REGIONAL GROWTH IN ROAD TRANSPORT CARBON EMISSIONS (COMPARED TO A BASE 100)

An increasing share of CO_2 emissions is associated with road transport in and around cities. In 2013, the International Energy Agency estimated that urban road transport constitutes about half of road transport carbon emissions. In heavily urbanised countries like the US, urban transport constitutes about 60% of road transport carbon emissions while developing countries like India and South Africa, this share is about 41% and 44% respectively[9].

By 2050, the continuation of existing business-as-usual growth in road transport carbon emissions will result in global road transport carbon emissions increasing to about 10 Gt[10] to 17 Gt[11]. However, there is a large differentiation among road transport emissions trends between individual modes and countries. The road transport carbon emissions in the OECD countries could decrease by close to 30%, while it could increase by 100% in the non-OECD countries[12]. However, the scale of the transformation ahead in the road transport sector on the path toward a decarbonized transport system is well illustrated by recent studies on transport sector decarbonisation which illustrate a need to decarbonise to 2 to 3 Gt by 2050[13].

2 • WHY HAVE CARBON EMISSIONS INCREASED IN THE ROAD TRANSPORT SECTOR?

An understanding of CO_2 emissions from road transport globally requires a clear picture of several interlinked factors, i.e. transportation demand (activity), mode of travel, modal energy efficiency and carbon intensity (ASIF Framework[1]).

• HIGH GROWTH IN ROAD TRANSPORT DEMAND (ACTIVITY) • Globally, road transport accommodates nearly about 90% and 70% of passenger and surface freight demand[14]. Historically, growth in the demand for both passenger and freight road transport has been closely correlated with growth in economic activities. The global motorised road passenger mobility measured in motorised passenger-kilometres (pkm) increased from 27 trillion passenger kilometre in 2000 to about 41 trillion passenger kilometres in 2015 i.e. an increase from about 4400 passenger-kilometres to about 5600 passenger-kilometres per capita[15]. **The global road passenger transport demand experienced a sustained period of robust growth until the economic crisis of 2008. Since 2008, the OECD and non-OECD countries show diverse trends.** For example, in Europe[16], road passenger transport demand increased from about 10,180 km/capita in 2000 to about 10,570 km/capita in 2008. Since its peak in 2008, it had remained broadly stable, with only a slight overall reduction being a result of the economic recession from 2009 to 2012. In 2015, total passenger per-capita transport demand was the same as in 2000. The OECD passenger road passenger transport demand decreased from 13000 to about 10000 kilometres per capita. The non-OECD countries passenger transport demand measured in pkm increased from 2400 to 4600 kilometres per capita.

Passenger Transport Demand

In OECD countries, since 2008 financial crisis, the volume of passenger transport relative to GDP has reduced by 35 percent in Lithuania, 20 percent in Ireland, 9 percent in Switzerland and 8 percent in United Kingdom. In cities, implementation of demand management policies has resulted in reduction of vehicle travel. For example, implementation of the congestion charge scheme has reduced vehicle travel by more than 15 percent and reduced congestion by 30 percent and in the Stockholm congestion charge implemented in 2007 reduced kilometres driven in the inner city by 16 percent, and outside the city by 5 percent despite economic and population growth.

In non-OECD countries, the passenger mobility has been growing faster than the GDP. In countries like Burundi, China, Nigeria, Zambia, Vietnam, India, Georgia and Panama, the Car ownership has been growing with an annual rate of more than 10% since 2000. To reduce passenger transport demand, cities have been implementing several transport demand management strategies. For example, Singapore in 2018 has implemented zero growth strategy for vehicle ownership to move towards car-free society.

TEXT BOX 1

The global road freight transport demand increased from about 8 trillion tonne-kilometre in 2000 to about 24 trillion tonne-kilometres in 2015 i.e. an increase from about 1300 tonne-kilometres to about 4000 tonne-kilometres per capita. **Historically, the global road freight transport demand in terms of tonne-km bore an extremely stable relationship with economic growth, i.e. GDP with the road freight volumes showing very strong correlation to the economic environment, i.e. for every 1% increase in GDP per capita, road freight movement i.e. tonne-km per capita increases by 1.07% on average[17].** However, the intensity of freight demand and its growth could vary significantly among countries. For example, the OECD road freight transport demand increased from 4500 to about 9500 tonne-kilometres per capita and the non-OECD countries demand increased from about 500 to 2800 tonne-km per capita.

Freight Transport Demand

Since 2000, the freight vehicle ownership has grown by an annual rate of more than 10% in low- and middle-income countries like Lao PDR, Indonesia, Panama, Barbados, Vietnam, Morocco and Chile. In EU-28, the freight transport demand increased considerably between 2000 and 2007 with a reduction due to economic downturn in 2008 and, after a limited recovery, freight volumes have since remained largely stable. The total road freight transport demand (in tonne-km) in 2015 is about 14% higher than in 2000.

TEXT BOX 2

Increase in passenger and freight mobility has resulted in rapid expansion of vehicles on roads and thereby generating high motorised trips. From 2000 to 2015, the vehicle kilometre travel has increased by about 66% in global, 24% and 166% in OECD and the non-OECD countries[18]. If population and incomes grow in accordance with the expectations, and if there is no paradigm shift in the relationship between income and the demand for mobility as illustrated in *Figure 3*, then mobility will grow strongly in future with entire growth outside of the OECD region. The International energy agency estimates that by 2050, the road passenger and freight transport demand could increase to about 72 trillion passenger kilometres and 85 trillion tonne-kilometres[19].

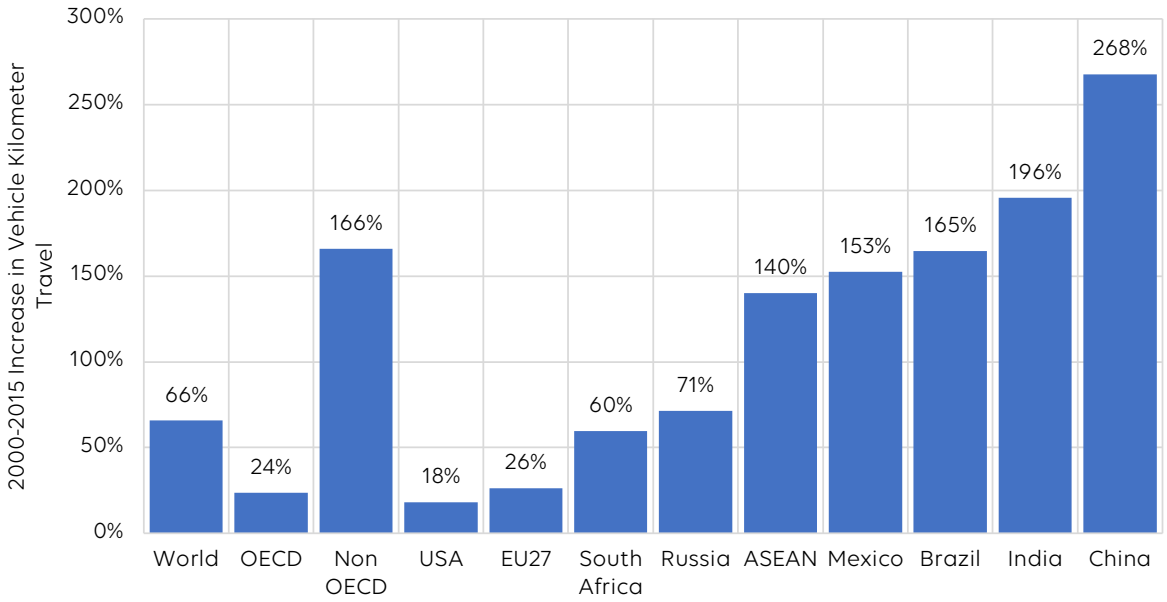


FIGURE 3. INCREASE IN VEHICLE KILOMETER TRAVEL

The policy response to reduce transport demand involves the use of "Avoid" strategies to change travel behaviour. These strategies reduce unnecessary travel through e.g. urban planning, logistics redesign and by behavioural changes. Reducing transport demand is perhaps the most difficult of the transitions as it has historically received less attention from stakeholders[20]. However, there exist several best practice examples from countries, cities and companies which have initiated transportation demand management strategies to reduce transport demand (in vehicle kilometres or in passenger/ tonne-kilometres travel) and have resulted in very high positive co-benefits. These strategies often consist of a mix of push and pull strategies to change travel behaviour using disincentives and incentives (few examples below).

Example	Description
Singapore	In October 2017, the Land Transport Authority (LTA) of Singapore announced that its vehicle growth rate would be reduced to zero (from 0.25%), effective February 2018. The main policies to reduce urban transport demand include urban planning (smart growth), electronic road pricing (ERP), vehicle quota system, public transit policies and improving walking and cycling facilities. The ERP scheme tackles traffic congestion by individual charging point, the direction of travel, time of day and vehicle type (based on road space occupancy).
London	London charge scheme (Introduced on Feb 2002) considers charging not only for crossing a cordon but also for movements within the cordon. The new transport strategy (2018) targets 80% of trips by foot, by cycle or by public transport by 2041 and full network road pricing. The London's congestion charge scheme has reduced vehicle travel by more than 15 percent and reduced congestion by 30 percent (immediate impact) and created an additional funding source for public transport and non-motorised transport improvements.
Mexico	In 2017, Mayor of Mexico City announced the "limitation of parking spaces in the city construction code". This new norm changes minimum parking requirements to maximum depending on the land use of the construction.
China	Several Chinese major cities are limiting the number of annual vehicle registrations with auctions (or lotteries). In recent years (2016 and 2017), the Beijing municipal government has proposed the implementation of dynamic tolls, dynamic parking fees according to the parking location, length of stay and arrival/departure time of parking, and consideration of congestion charging and dynamic fees for public transport and taxis to reduce road transport demand.
Unilever	'Big Bang' project in Europe focuses on using trucks and pallets efficiently. In 2017, the project increased truckload fill rates by 2% thus reducing truck trips. In China, Unilever made changes to the pallet size – adding one extra layer to increase load fill by 11%, creating savings of €500,000 as well as reducing CO_2 emissions.

TABLE 2. EXAMPLES OF AVOID STRATEGIES

State and non – state actors are implementing several initiatives to reduce transport activity. For example:

• The Paris Process on Mobility and Climate (PPMC) has developed a Global Macro-Roadmap (GMR)[21] for complete decarbonisation of the transport sector. The Roadmap is relevant for all continents and comprises eight components that are phased and articulated in synergy with each other. The avoid related components include urban transformation, optimizing supply chains to manage freight transport emissions, avoiding vehicle kilometres through greater intermodality and shared transport for commuting, shopping and accessing services. Some of the targets (2040/2060) include

- urban passenger trips are reduced to 20%, while, the combined share of trips by walking, cycling, and shared transport trips rises to 80% of all trips. A 50% reduction in private passenger vehicle kilometres travelled.

• The Shared Mobility Principles[22] for Livable Cities were launched at the 2017 Ecomobility World Festival in Kaohsiung, Taiwan. The shared mobility principles are designed to guide urban decision-makers and stakeholders toward the best integration of shared modes with the city land-use and transport networks.

• C40's TOD Network[23] and ITDP's TOD Standard[24] promotes integrated urban places designed to bring people, activities, buildings, and public space together, with easy walking and cycling connection between them and near-excellent transit service to the rest of the city.

• MODE SHARE (SHIFT IN TRANSPORT DEMAND) • Global motorised road transport demand comprises several modes and segments. **Globally, passenger cars contribute to about 52% of the global passenger mobility, bus-based public transport about 34%, and two-and-three wheelers about 14% of total passenger transport demand (in passenger-kilometres)**. However, there exists great diversity in the mobility pattern among different geographical regions and income levels. The passenger cars (LDV's) constitute about 84% (OECD) and 37% (non-OECD) of road passenger transport demand. The two-and-three-wheelers share in road passenger transport demand varies from 3% in OECD countries to 19% in non-OECD countries.

Since 2000, global motorised passenger transport volumes (in pkm) across the different modes have changed as follows:

• Passenger cars: -5%;

• Powered two-and-three-wheelers: +5%;

• Buses and mini-buses: 0%;

However, in the non-OECD countries, there has been tremendous mode shift from the buses and mini-buses to Cars and two-and-three-wheelers. The bus road passenger mode share has reduced from 58% (2000) to 43% (2015). About 60% of the global road passenger-kilometres travel occurs in the urban area. In the OECD countries, the urban share of passenger activity is about 66%, while in the low-and-middle income countries like India it is about 59%.

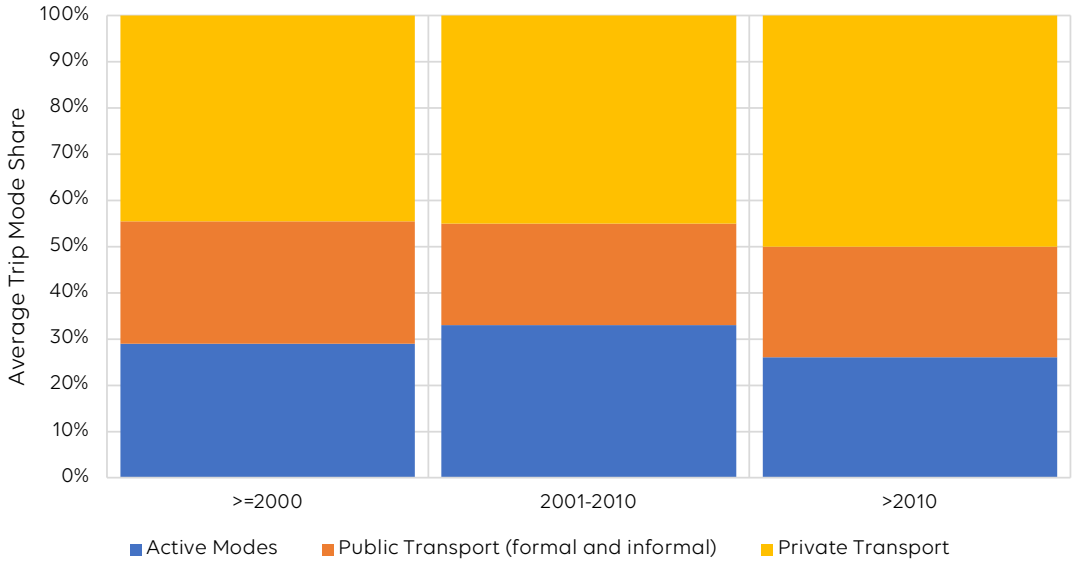


FIGURE 4. GLOBAL TRIP MODE SHARE (URBAN)

Urban freight constitutes only about 12% of the road freight activity (tonne-kilometres) but generates about 50% of freight road vehicle kilometre travel[25] as final products get delivered in low volumes, and at high frequencies in congested traffic conditions. The road transport plays a leading part in carrying surface freight in all countries. Since 2000, there is tremendous mode-shift towards road freight with its mode share (in total freight) increasing from 12% (2000) to 22% (2015)[26].

The policy response to change transport structure involves the use of the "Shift" strategies to improve trip efficiency. **These strategies induce a modal shift from the most energy and emission intensive mode (i.e. cars, road freight) towards more environmentally friendly modes (walking, cycling, public transit, railways, waterways).** The New Urban Agenda (NUA) adopted in 2016 with an overall emphasis on human-scale and people-centered planning, makes explicit references to improvement in walking, cycling and public transit infrastructure i.e. "*A significant increase in accessible, safe, efficient, affordable and sustainable infrastructure for public transport, as well as non-motorized options such as walking and cycling, prioritizing them over private motorized transportation*".

There exist several best practice examples from countries, cities and companies which have initiated modal shift strategies. For example, the EU's 2011 whitepaper[26] – "Roadmap to a Single European Transport Area" targets "thirty percent of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed". The EU's Trans-European Transport Network (TEN-T) policy[28] daims at the development of multimodal core-network corridors, promoting modal shift and sustainable infrastructure and equipment.

In recent years, many cities have increased investments in public transport, walking and cycling infrastructure. **Globally, since 2000, the bus rapid transit system, light rail transit and metro rail infrastructure expanded by 835%, 88%, and 67%, respectively. By 2018, there are more than 1700 bike sharing systems globally[29].**

The State and non – state actors are also implementing several initiatives for modal shift. For example:

• The Global Sidewalk Challenge[30] raises the voice and profile for walking internationally and sets a challenge to governments, private businesses and NGO's to collaborate and invest in walking infrastructure, especially dedicated, safe and barrier-free sidewalks at transport hubs, to benefit the people who walk most by focusing on the places most walked in order to reduce traffic externalities.

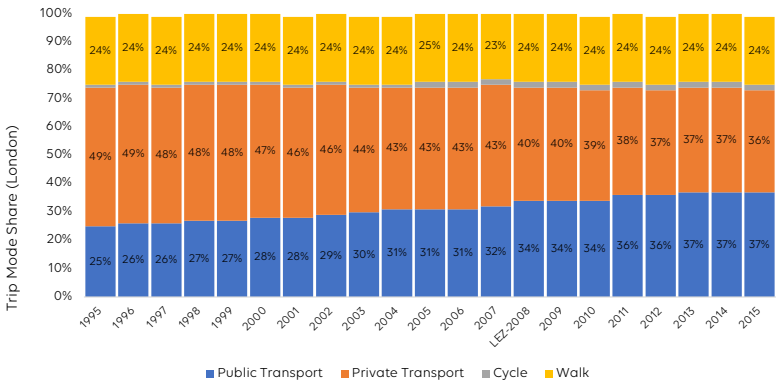
• In 2012, the European Commission launched the Sustainable Urban Mobility campaign "Do the Right Mix[31]" aiming to support sustainable urban mobility campaigners in 31 countries. The main objective of this initiative is to promote the advantages of combining different modes of transport. The campaign works with diverse stakeholders to take steps towards changing mobility behaviour in their neighbourhoods and cities by running their own 'actions'.

• Public Transport - UITP's Declaration on Climate Leadership targets doubling the market share of public transport by 2025 and pledged over 350 projects to climate action in over 80 cities around the world. The UIC Low Carbon Sustainable Rail Transport Challenge proposes 50% increase in rail's share of passenger transportation by 2030 and doubling by 2050 (2010 baseline), rail freight activity equal to that of road freight by 2030, and exceeding road freight volumes by 50% by 2050.

• In 2015 the UN Environment Share the Road Programme - with the support of the FIA Foundation - helped the Nairobi City County Government launch an NMT Policy for Nairobi which included a first of its kind commitment in Africa - earmarking 20% of their road construction budget to NMT investment[32].

Trip Mode Share

In London, the private transport trip mode share has declined from 49% in 1995 to about 36% in 2015, whereas those made by public transport have increased from 25% to 37% during the same period. Central London has seen the largest reduction in motor vehicle kilometres since 2000. The mode shift is mainly due to improvement in bus services, metro systems, walking, cycling and due to implementation of congestion charges. The 2018 London Mayor's Transport Strategy has the bold ambition to achieve about 80 percent of all trips in London by walking, cycling and by using public transport by 2041.



TEXT BOX 3

City	Mode Shift targets
Adelaide	Double the number of people cycling in the City (baseline 2011), Increase the number of car share vehicles available in the City to 100 vehicles.
Chengdu	65% Public Transit share by 2020 (of which metro to have a 35% share)
Chongqing	47% Public Transit trip share by 2020 (Metro to take 21% of total daily trips by 2020)
Copenhagen	By 2025, the city wants 75% of trips to be made by foot, bike, or public transit
Gothenburg	By 2035, A doubling of the number of journeys on foot or by bicycle. A doubling of the number of public transport journeys. A reduction by a quarter of the number of car journeys (compared to 2011)
Greater Kuala Lumpur/Klang Valley	Target 40% modal share for public transport in the urban areas by 2030 during AM peak periods
Hô Chi Minh	Public transport mode share of 47-50% by 2020
London	80 per cent of all trips in London to be made on foot, by cycle or using public transport by 2041
Nairobi	By 2025, Public Transit mode share to be 35%, Cycling to be 10% and walking to be 50% of trip mode share (for up to 5km trip length)
Phnom Penh	Public Transit mode share to be 30% of trip mode share by 2035
Shanghaï	Metro to take 60% of Public transport trips by 2020
Shenzhen	Public Transit and non-motorised vehicles to take 65% of overall trips by 2020
Singapore	A 75% public transport modal share during both the morning and evening peak hours by 2030, up from today's 64%.
Stockholm	The proportion of all journeys at peak hours performed by bicycle must be not less than 15 per cent by 2030. The proportion of local journeys made on foot will be at least 60 per cent in the inner city and 50 per cent in the suburbs by 2030
Taipei	12 per cent modal share for bicycles by 2020
Vancouver	By 2040, at least two-thirds of all trips will be made by foot, bike, and transit.

TABLE 3. CITIES WITH MODAL SHIFT STRATEGIES

• CHANGES IN ENERGY INTENSITY AND LOW CARBON FUEL • The transport energy intensity (defined as the ratio of energy consumption with passenger or freight activity) of the road transport sector varies significantly among modes and regions as illustrated in the figures below. All modes of passenger transport show improvement in transport energy intensity with light-duty vehicles showing the least progress. For individual modes, the energy intensity is much higher in OECD

countries when compared with the non-OECD countries, mainly due to factors such as occupancy or loading, fuel efficiency, fleet composition, vehicle size i.e. bigger SUVs and mode split.
International Energy Agency analysis of fuel economy for the past decade for new light-duty vehicles (LDVs) reveals about 1.5% annual improvement globally between 2005 and 2015[33]. Overall, globally, from 2005 to 2015, the energy intensity of passenger and freight road transport has improved by about 22% and 6% respect.[34]

Road Transport remains very dependent on oil, with the transport sector accounted for about two-thirds of global oil consumption in 2015 with the road sector alone accounting for half[35]. **At present, the transport sector is the least diversified energy end-use sector due to the high emphasis on energy density. About 93% to 98% of road transport modes are powered by petroleum products with limited penetration of biofuels and electricity. Liquid biofuels (ethanol and biodiesel) share in global road transport fuel is about 4%[36].**

Electricity share in road transport energy consumption has only increased marginally over the past 15 years in different modes. However, two-and-three wheelers are an exception and currently, they constitute about 20% of the fleet. In 2015, close to 38 million electric bikes were sold globally and out of which more than 90% was in China alone[37]**. For electric vehicles, it is important to consider how electricity is generated and its exposure to people/proximity of emissions to people. In 2016, globally, 26% of the electricity consumed by electric vehicles were renewable[38].** However, the transport sector could benefit from decarbonizing efforts in the electricity sector. By 2030, renewables could become the leading source of electricity by 2030 and the carbon intensity of the power sector is projected to improve by 30%[39].

The policy response to improve modal efficiency involves the use of "Improve" strategies to improve vehicle and fuel technologies and by optimising transport infrastructure. There exist several best practice examples from countries, cities and companies which have initiated such improvement strategies.

For example:

• The number of countries that have adopted a biofuel obligation/ mandate increased from 36 in 2011 to 68 in 2017 [41].

• In 2016, Brunei, Ethiopia, India, Morocco, Nigeria, United Arab Emirates & Viet Nam proposed reducing fossil fuel subsidies[42].

• In 2016, about 34 countries proposed energy efficiency improvement strategies for implementation in the Nationally determined contributions[43].

• About 83% of new LDV sales are in countries which have proposed fuel economy standards for LDVs[44]. For example, countries and regions like China, EU, Japan, Canada, US, Mexico, South Korea and India have established LDV fuel economy standards.

• About 48% of the new heavy-duty vehicle (HDV) sales are in countries which have proposed fuel economy standards for HDVs. For example, countries and regions such as China, EU, Japan have established HDV fuel economy standards.

• Countries and cities like Norway, Ireland, Netherlands, Slovenia, Paris, Scotland, Reykjavik, United Kingdom, France, etc. have announced target deadlines for a ban of new vehicles with gasoline and diesel engines.[45]

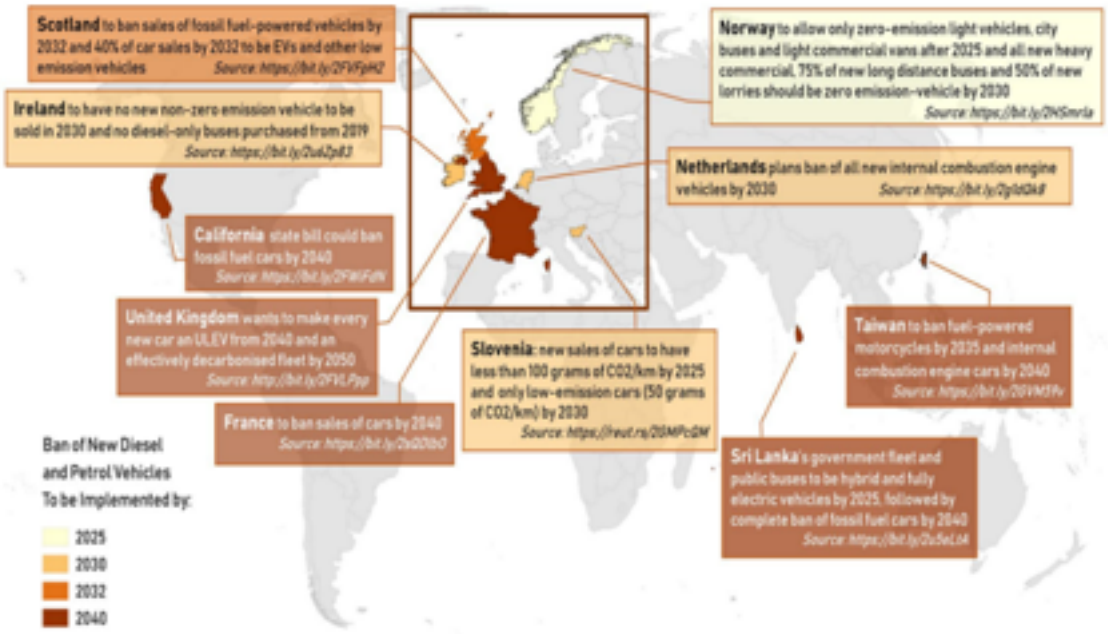


FIGURE 7. BAN ON NEW DIESEL AND GASOLINE VEHICLES (TARGETS)

The collapse of the diesel fleet and growth in the share of SUVs lead to an increase of emissions in Europe

Target because of its impact on human health, and progressively hunted in European cities (Hamburg, Paris ...), diesel is progressively losing its privilege and favour.

In France, the alignment of taxes on gasoline and diesel have led to rapid changes in behavior. In 2017, the market share of diesel vehicle sales decreased by 5% compared to the previous year. For number of companies, where this type of motorization has been almost hegemonic since the 1970s, the lastest results are spectacular; sales fallen by 34% in one year (September 2017 - September 2018).

But this rapid change has had a reverse effect on CO_2 emissions. In its annual report on new vehicle sales, the agency AAA Data notes that the average CO_2 emissions of new vehicles sold in 2017 were 111 grams per km, compared to 110 grams in the previous year. This is the first increase since 1995. Diesel production is one of the reasons for these changes. Diesel vehicles can emit up to 20% less CO_2 per km, and this mutation is one of the reasons for this increase.

The analysis of new vehicle emissions in Europe carried out by the Jato Dynamics institute reveals no other conclusion: 118.1 grams of CO_2 per km in 2017, against 117.8 g / km in 2016. This is a very disturbing trend that is moving Europe further and further away from the European Commission's target of 95 g / km on average by 2021 for new vehicles. But the return of the gasoline engines is not the only reason for this increase. The explosion in sales of SUVs, which are more powerful and heavier, is another key reason. SUV vehicles represent 30% of total vehicle sales in Europe in 2017, contributing significantly to this increase.

The improvement of technologies and motors, particularly electric motors, is necessary to achieve this goal 2021. However, sales of SUVs are struggling to take off, despite its advertisement campaigns: Renault Zoe, the best-selling

electric vehicle in Europe, has reached sales level of only 30,000 units in 2017. Manufacturers' emissions (see figure 8) give some idea of the efforts required, although the good sales of Toyota due to success of its hybrid vehicles (300 000 units sold) is an interesting benchmark of a possible change of trend.

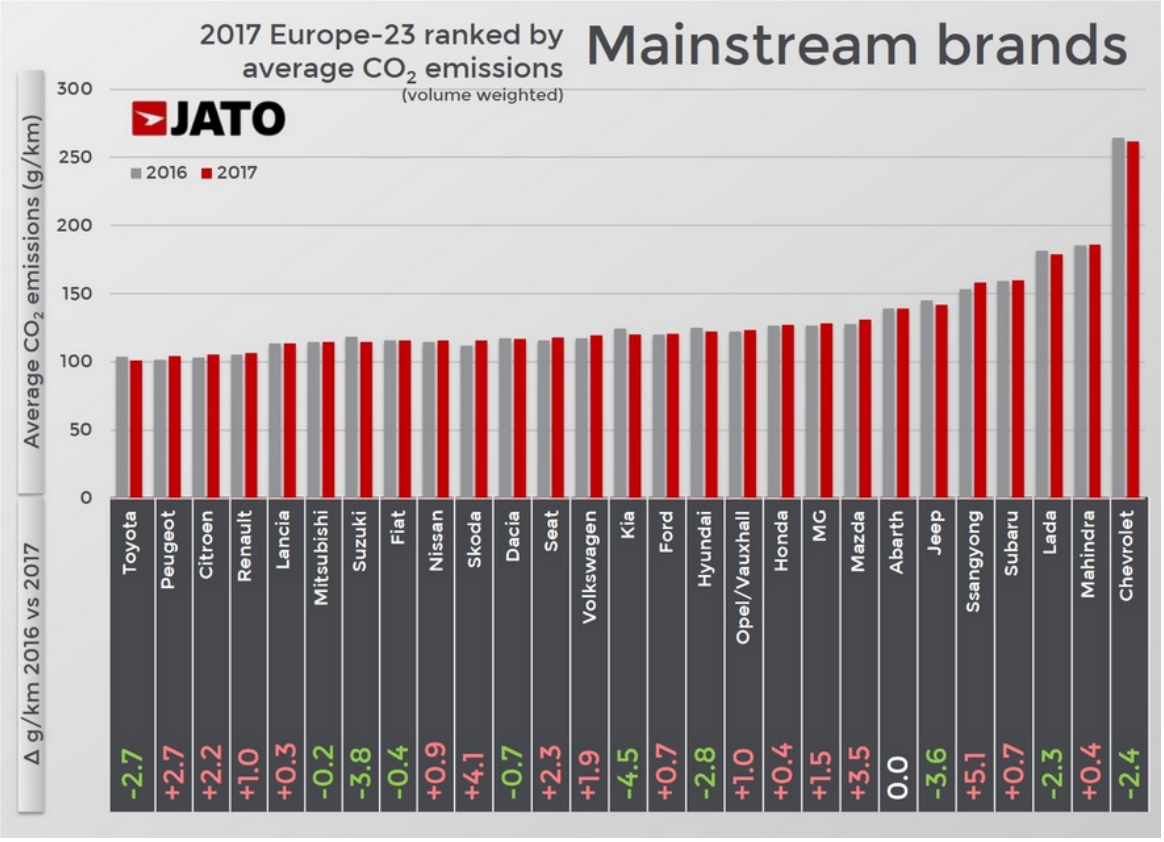


FIGURE 8. EMISSIONS OF CAR MANUFACTURERS IN EUROPE, IN 2016 AND 2017

Source: Jato Dynamics, 2018 - https://www.jato.com/brands-average-co2-emissions-110-130-g-km-counted-73-european-car-regs-2017/

TEXT BOX 4

State and non – state actors are implementing several initiatives for supporting government policies and actions on energy efficiency and decarbonising fuel.

For example:

• The Global Fuel Economy Initiative (GFEI) is supporting countries to put in place fuel economy strategies. The main ambition is to achieve an average improvement across all vehicles by 50% by 2050 (30% improvement of new car fuel economy, worldwide, by 2020 and 50% by 2030). The GFEI's campaign – '100 for 50by50' – was developed to gather new country commitments to the improvement in fuel economy. Currently, GFEI is supporting over 70 countries and the target is to get commitments on "50 by 50" mission from 100 countries.

• Global Macro-Roadmap (GMR) has proposed milestones as shown below to be considered as fleet averages for the concerned vehicle sector. For cities, the proposal suggests Zero Emission Zones (ZEZs), followed by Zero Emission Cities (ZECs), for both air pollutants and GHGs. Front-runners (leading cities) will aim for 2025 or 2030 as can be seen from the examples of Copenhagen and Oslo who have already committed to zero carbon by 2025. The recent announcements by France and the United Kingdom to ban the sales of petrol and diesel cars by 2040 also set important precedents for the transition to ZECs.

• The C40 Clean Bus Declaration of Intent was officially announced in March 2015. The main goal of

this initiative is to incentivize and help manufacturers and other stakeholders, such as multilateral banks, develop strategies to make clean bus technologies more affordable for cities. Currently, the 23 C40 signatory cities have committed to having over 40,000 buses (out of a total fleet of 166876) operating via clean technologies by 2020. Estimates suggest that, if these cities reach their 2020 clean bus targets, it would result in a cumulative 880,500 tons per year in GHG savings.

• The Electric Vehicles Initiative (EVI) announced a new campaign in 2017 called EV 30@30 to speed up the deployment of electric vehicles and target at least 30 percent new electric vehicle sales by 2030.

• The International Zero-Emission Vehicle Alliance (ZEV Alliance) is a partnership of governments acting together to accelerate the adoption of zero-emission vehicles (electric, plug-in hybrid, and fuel cell vehicles). The main objective is to accelerate the adoption of zero-emission vehicles. The target is to ensure that all passenger vehicle sales in their jurisdictions ZEVs by no later than 2050.

• US Smartway Initiative which is launched by the United States Environmental Protection Agency (EPA) has about 3,600 North American companies in the partnership. It helps companies identify and select more efficient partners i.e. freight carriers, transport modes, equipment, and operational strategies to reduce operational costs and improve supply chain sustainability. Since 2004, SmartWay has helped its partners save 215.4 million barrels of oil- equivalent and about $29.7 billion on fuel costs.

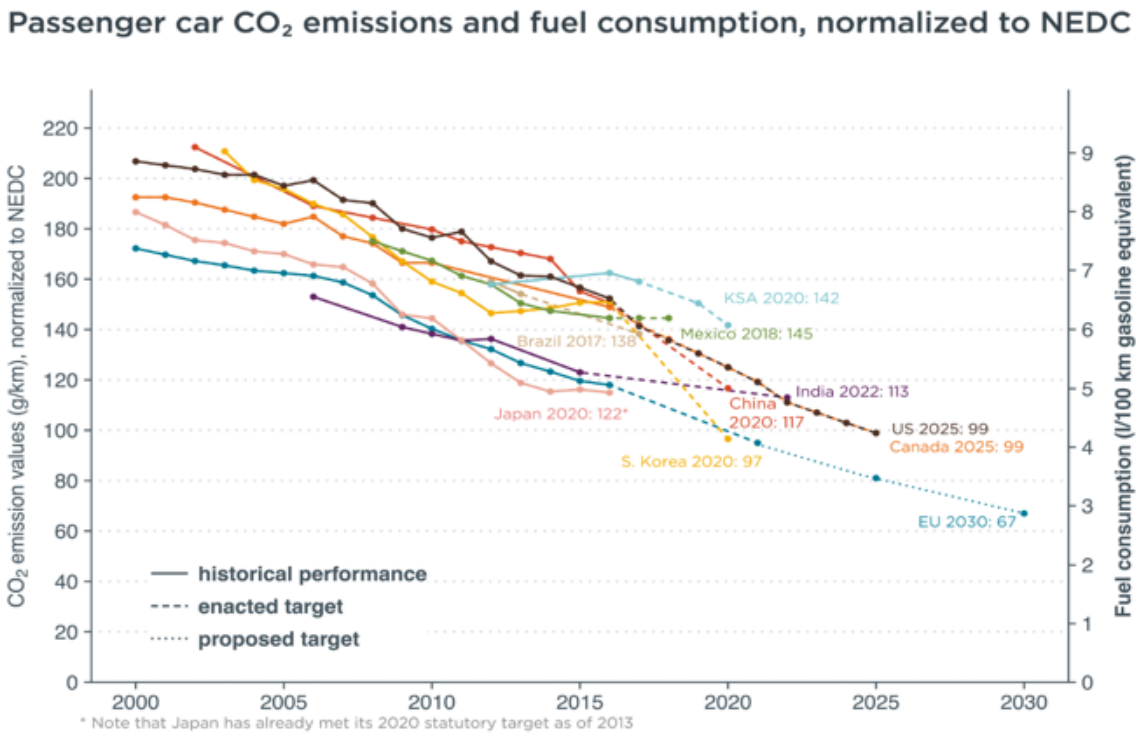


FIGURE 9. PASSENGER CAR CO_2 EMISSIONS (FUEL ECONOMY)

• L'initiative étasunienne Smartway, lancée par l'Environmental Protection Agency (EPA) des États-Unis, regroupe environ 3 600 entreprises nord-américaines. Il aide les entreprises à identifier et à sélectionner des partenaires plus efficaces, comme les transporteurs de fret, les modes de transport, les équipements et les stratégies opérationnelles, afin de réduire les coûts opérationnels et d'améliorer la durabilité de la chaîne d'approvisionnement. Depuis 2004, SmartWay a aidé ses partenaires à économiser 215,4 millions de barils d'équivalent pétrole et environ 29,7 milliards de dollars en coûts de carburant.

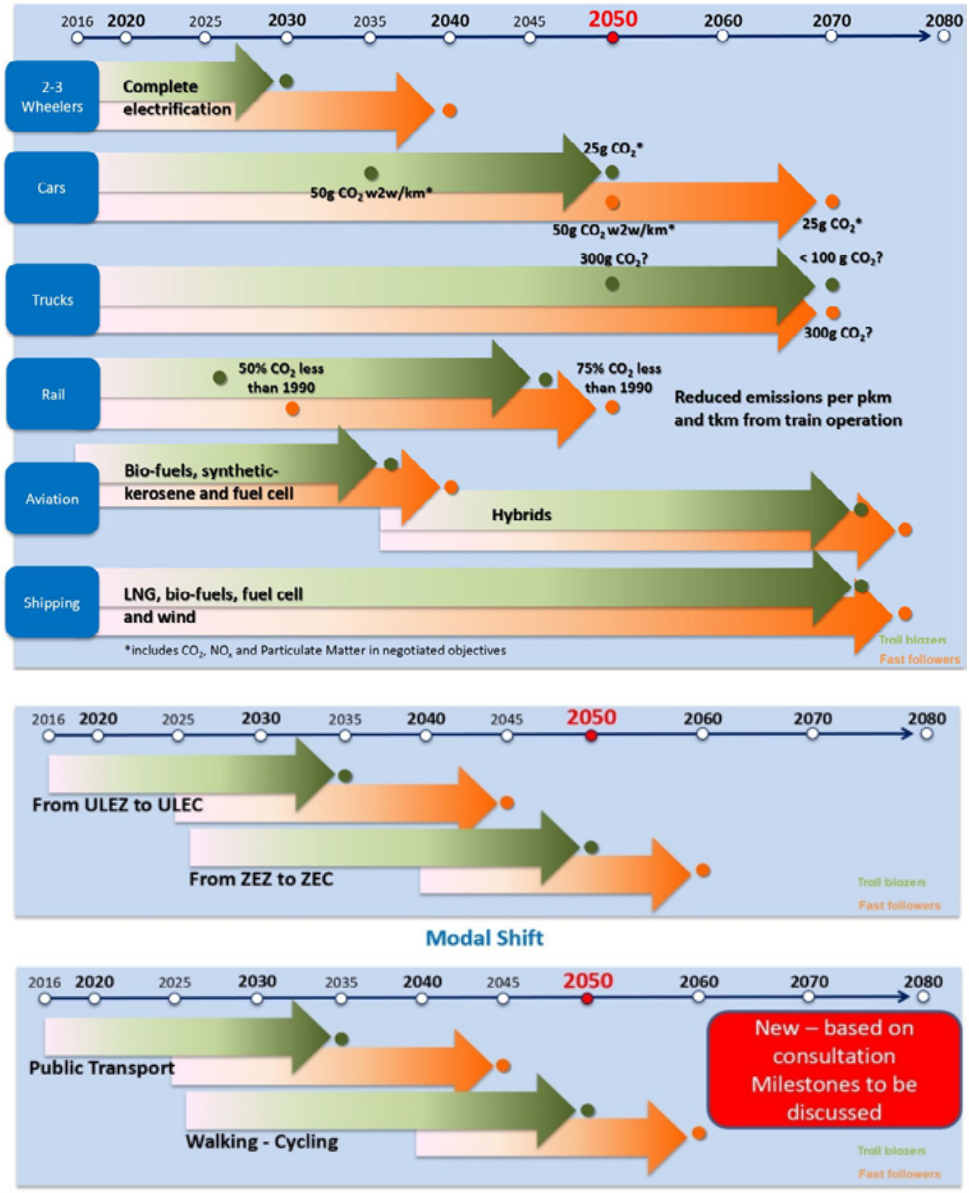


FIGURE 10. GLOBAL MACRO ROADMAP CONSULTATION TARGETS

CONCLUSION

Road transport carbon emissions are the result of a complex mix of human behaviour, economic growth, public policy and transport regulations. Overall, the global road transport carbon emissions have increased when compared with 2000 levels. The rapid increase in the travel demand (growing in non-OECD countries), modal-structure (shift towards energy-intensive modes, especially in non-OECD countries), energy intensity (minor improvement due to new technologies) and high carbon content of fuels (lack of penetration of low carbon fuels) interacted to determine overall increase in global road transport carbon emissions.

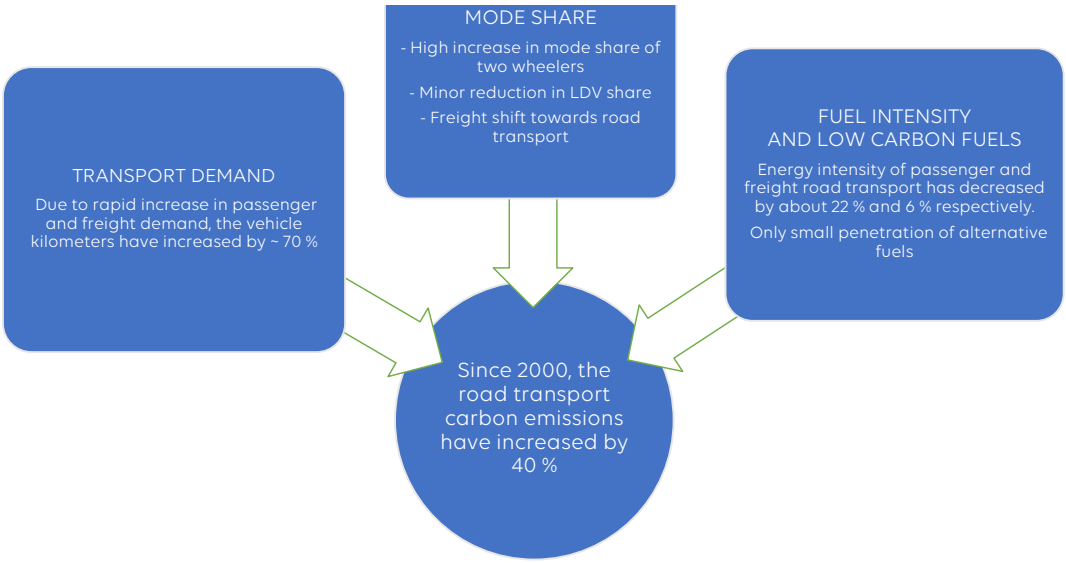


FIGURE 11. TREND IN ROAD TRANSPORT (2000 TO 2015)

The large differentiation among road transport emissions trends between individual modes and countries underscores the necessity of a heterogeneous approach to tackling current and future road transport sector emissions worldwide. Policy responses have been successfully implemented in OECD and non-OECD countries, demonstrating the potential of the road transport sector to contribute to rapid steps toward decarbonization on a global scale. However, there is no silver bullet to decarbonize road transport sector, instead, it is a range of strategies and initiatives that must be embraced in a comprehensive manner covering all modes of transport. A typical road transport low-carbon policy response includes a combination of 'Avoid' strategies, which reduce the need to travel (e.g. transport demand management); 'Shift' strategies, which move transport trips to more efficient modes (e.g. public transport improvements); and 'Improve' strategies, which increase the efficiency of existing trips (e.g. fuel economy standards).

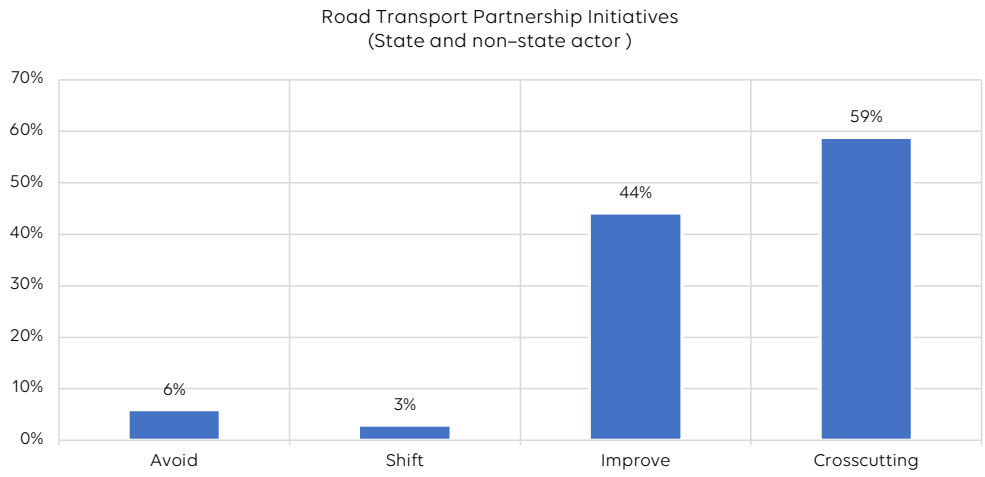


FIGURE 12. AVOID-SHIFT-IMPROVE INITIATIVES

Currently, road transport is one of the fastest growing sub-sectors in the economy-wide emissions indicating that the policies, measures and non-state actor initiatives over the past decade h**ave only been marginally effective**. An immediate lack of emission performance does not in itself suggests failure. However, as the best practice examples illustrate - policies, measures and non-state actor initiative's **effectiveness are increasing over time due to better awareness and capacity.** The role of the non-state actors in this transformation (especially in setting agenda) has been critical.

• To date, transport sector mitigation efforts have relied heavily on the technological transformation (i.e. 'Improve' measures)[36] . However, the non-state actor initiatives were more balanced (since not subject to the same political constraints as state-actors), promoting all three instruments of low carbon road transport thereby filling a critical gap.

• Non-state actors have financed the development of nearly one-quarter[37] of total transport sector carbon emissions quantification methodologies and tools to ensure that the action on transport and climate change is not held back by the absence of tools to analyse transport interventions for their climate impact.

• Recently, several countries and companies have set ambitious targets for the reduction of the carbon emissions from the transport sector, however, globally, there is a complete lack of transparency on the progress towards transport sector targets. Non-state actors play an essential role in reviewing voluntary pledges, measuring, verifying and communicating transport sector emission impacts outside the UNFCCC (sometimes even in enforcement as in Dieselgate).

• Many transport interventions (especially avoid and shift related) take longer to deliver first results due to slow turnover of stock and infrastructure and the huge sunk costs in the present transport system. By limiting future infrastructure deployment for carbon-intensive modes and by prioritising infrastructure for low carbon modes, the carbon trajectory can be lowered while at the same time enhancing the co-benefits and lowering the overall cost of the infrastructure. There is an increasing recognition that low carbon measures within the transport sector could be successful if widely supported by state and non-state actors, with strong political leadership and private sector commitments and if implemented at scale.

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ANNEXURE - GLOBAL AND REGIONAL INITIATIVES

	AVOID	SHIFT	Improve	CROSS CUTTING	CROSS-SECTORAL
"30 BY 30" RESOLUTION	Y		Y		
21ST CENTURY TRUCK PARTNERSHIP			Y		
BELOW 50			Y		
C40 CITIES CLIMATE LEADERSHIP GROUP (C40)				Y	Y
C40 CLEAN BUS DECLARATION			Y		
CARBON NEUTRAL CITIES ALLIANCE				Y	Y
CARING FOR CLIMATE					
CCAC: DIESEL INITIATIVE			Y		Y
CIVITAS				Y	
CLEAN AIR ASIA				Y	Y
COMPACT OF MAYORS				Y	Y
COVENANT OF MAYORS				Y	Y
"DO THE RIGHT MIX"-SUSTAINABLE URBAN MOBILITY CAMPAIGN	Y	Y			
DECARBONISING TRANSPORT INITIATIVE				Y	
EST INITIATIVE				Y	
ECOMOBILITY ALLIANCE				Y	
EUROCITIES				Y	Y
ELTIS, THE URBAN MOBILITY OBSERVATORY				Y	
EV100			Y		
GLOBAL FUEL ECONOMY INITIATIVE (GFEI)			Y		
GLOBAL GREEN FREIGHT ACTION PLAN				Y	
GLOBAL STRATEGY TO INTRODUCE LOW-SULFUR FUELS AND CLEANER DIESEL VEHICLES (THE "GLOBAL STRATEGY")			Y		
GREEN FREIGHT ASIA NETWORK (GFAN)				Y	

	AVOID	SHIFT	Improve	CROSS CUTTING	CROSS-SECTORAL
GLOBAL MACRO ROADMAP				Y	
ICLEI - LOCAL GOVERNMENTS FOR SUSTAINABILITY				Y	Y
INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION (ICCT)			Y		
INTERNATIONAL ZERO-EMISSION VEHICLE ALLIANCE (ZEV ALLIANCE)			Y		
INITIATIVE FOR CLIMATE ACTION TRANSPARENCY				Y	Y
IPIECA			Y		Y
ITS FOR CLIMATE				Y	
KYOTO DECLARATION FOR THE PRO-MOTION OF ESTS IN CITIES				Y	
LCTPI LOW CARBON TRANSPORT FUELS			Y		
LCTPI: LOW CARBON FREIGHT				Y	
LEAN AND GREEN				Y	
LOGISTICS CARBON REDUCTION SCHEME (LCRS)			Y		
LOW CARBON ROAD AND ROAD TRANSPORT INITIATIVE (LC2RTI)			Y		
LOW CARBON VEHICLE PARTNERSHIP (LOWCVP)			Y		
LOW EMISSIONS DEVELOPMENT STRATEGIES (LEDS) GLOBAL PARTNERSHIP				Y	Y
MOBILISEYOURCITY				Y	
MARKET PLACE OF THE EUROPEAN INNOVATION PARTNERSHIP ON SMART CITIES AND COMMUNITIES				Y	Y
PARIS DECLARATION ON ELECTRO-MOBILITY ON CLIMATE CHANGE			Y		
PARTNERSHIP ON SUSTAINABLE, LOW CARBON TRANSPORT (SLOCAT)				Y	
PARIS PROCESS ON MOBILITY AND CLIMATE (PPMC)				Y	
PARTNERSHIP ON TRANSPARENCY IN THE PARIS AGREEMENT				Y	Y
PRIVATE FINANCING ADVISORY NETWORK (PFAN)			Y		
PUBLIC TRANSPORT DECLARATION ON CLIMATE LEADERSHIP (UITP)		Y			

	AVOID	SHIFT	Improve	CROSS CUTTING	CROSS-SECTORAL
REN21 (RENEWABLE ENERGY POLICY NETWORK FOR THE 21ST CENTURY)			Y		
SIDEWALK CHALLENGE	Y	Y			
SMARTWAY				Y	
SCIENCE BASED TARGETS				Y	Y
SUSTAINABLE MOBILITY FOR ALL (SUM4ALL)				Y	
TAXI4SMARTCITIES			Y		
TRANSPORT DECARBONISATION ALLIANCE (TDA)				Y	
THE CLIMATE REGISTRY				Y	Y
THE PRINCE OF WALES'S CORPORATE LEADERS GROUP (CLG)				Y	Y
TRANSFORMATIVE URBAN MOBILITY INITIATIVE (TUMI)				Y	
UITP DECLARATION ON CLIMATE CHANGE LEADERSHIP				Y	
UNDER2 COALITION				Y	Y
UNEP PARTNERSHIP FOR CLEAN FUELS AND VEHICLES (PCFV)			Y		
URBAN ELECTRIC MOBILITY INITIATIVE			Y		
URBAN ELECTRIC MOBILITY INITIATIVE (UEMI)			Y		
URBAN-LEDS PROJECT				Y	Y
VERRA (FORMERLY VERIFIED CARBON STANDARD)				Y	Y
WBCSD URBAN INFRASTRUCTURE INITIATIVE (UII)				Y	Y
WE MEAN BUSINESS COALITION				Y	Y
WORLD CYCLING ALLIANCE (WCA) AND EUROPEAN CYCLISTS' FEDERATION (ECF) COMMITMENT	Y				
WWF CLIMATE SAVERS				Y	Y
ZEV ALLIANCE			Y		

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Transport in Sweden, the automotive sector's transformation is taking shape

In a European context marked by an almost universal increase in CO_2 emissions from motor transport, Scandinavia, and especially Sweden, is demonstrating that this evolution is not inevitable by showing a significant and regular decrease in emissions. In this chapter we have tried to analyse the factors related to this evolution, and in particular the links between the Swedish government's long-standing and very proactive policy on carbon taxation, and the strategy of the economic players. This case study ultimately attempts to answer this important question: to what extent are the elements of success of the Swedish stakeholders' strategy sustainable and reproducible?

Head editor • *Climate Chance Observatory*

CONTENTS

1 • ACCELERATED DECLINE IN DOMESTIC TRANSPORT EMISSIONS

2 • THE SWEDISH STATE'S PROACTIVE POLICY IN THE TRANSPORT SECTORT

3 • A REDUCTION OF EMISSIONS BACKED BY THE DEVELOPMENT OF THE BIOFUELS SECTOR

The rise of the Swedish biofuels sector

HVO biodiesel enabling European targets to be exceeded

4 • AN ENVIRONMENTAL ASSESSMENT OF SWEDISH BIOFUELS: TO BE EVALUATED

5 • THE EVOLUTION OF THE SWEDISH CAR FLEET

An increase in the fleet does not lead to an increase in emissions

Super "green cars" and the proactive industrial policy of the manufacturers

SUVs contrasting with the positive trajectory of the Swedish car fleet

1 • ACCELERATED DECLINE IN DOMESTIC TRANSPORT EMISSIONS

Since 2007, Sweden has seen its carbon emissions decline continuously. Statistics from the Swedish Environmental Protection Agency, as part of its 2017 annual inventory of greenhouse gas emissions, in accordance with the UNFCCC guidelines, show that this trend continued in 2016 with a 1.99% decrease in emissions compared to 2015 (see Figure 1).

Carbon Dioxide (CO_2) (kt)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
NATIONAL TOTAL (excluding LULUCF, excluding international transports)	52,816.5	50,723.1	47,153.2	52,927.3	48,970.0	46,403.6	44,769.0	43,225.7	43,385.6	42,568.0
Domestic transport, total	20,970.1	20,350.7	20,037.2	20,090.1	19,643.6	18,418.9	17,910.6	17,703.8	17,661.7	16,686.1

FIGURE 1. EVOLUTION OF OVERALL CO_2 EMISSIONS AND THOSE FROM TRANSPORT BETWEEN 2007 AND 2016 IN SWEDEN

Source : Statistical database sweden, SMED on behalf of the swedish environmental protection agency, 2017

This decrease was as a result of the domestic transport sector in particular, which recorded a significant decrease of 5.6% in CO_2 emissions between 2015 and 2016. This drop in overall emissions from motor transport comes after a decrease of 11.76% between 2010 and 2016 (see Figure 2). This sustainable trend and its remarkable acceleration over the last year is nevertheless occurring against a background of stable, or even increasing, transport emissions in Europe, reaching 1029 $MtCO_2eq$ in 2014 and 1048 $MtCO_2$ in 2015.

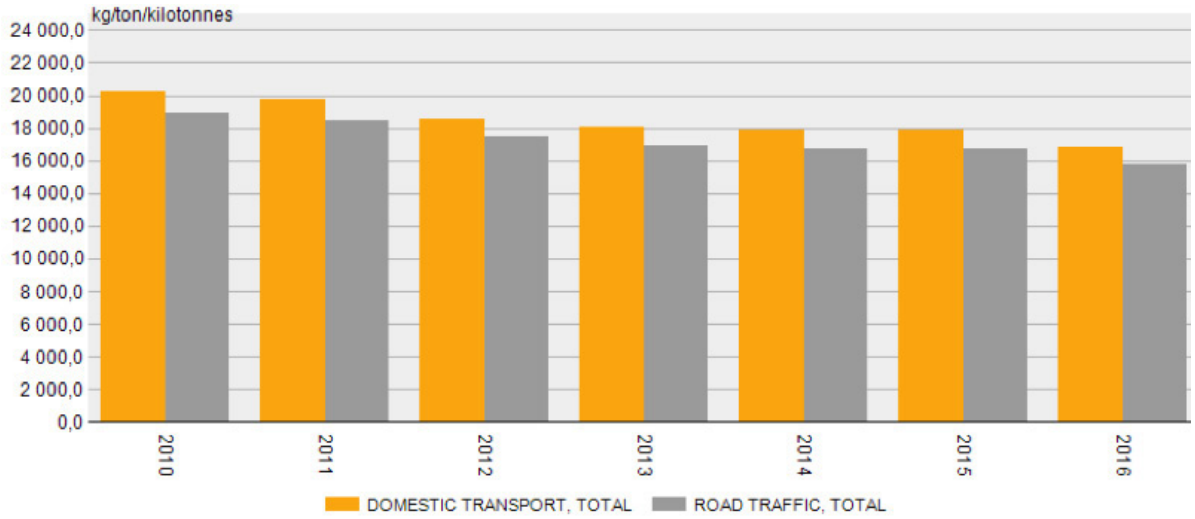

FIGURE 2. GREENHOUSE GAS EMISSIONS FROM TRANSPORT IN SWEDEN, 2010-2016

Source : Swedish Environmental protection agency, 2017

Sweden's distinctiveness comes first and foremost from the State's proactive policy to abandon fossil fuel energy, from ecological taxation and from the overall transformation of the transport sector, a coherent action which was analysed in particular in 2017 in the report "CO_2 emissions and economic incentives" for the Nordic Council of Ministers (Jordal-Jorgenssen et al., 2017). It would not make much sense to analyse the actions developed by non-state stakeholders, if we did not first focus on the policies being pursued by the Swedish state.

2 • THE SWEDISH STATE'S PROACTIVE POLICY IN THE FIELD OF TRANSPORT

Le gouvernement suédois est l'un des premiers pays au monde à utiliser la fiscalité écologique co The Swedish government is one of the first countries in the world to use ecological taxation as a cornerstone of its environmental policy (Millock, 2010). **Thus, Sweden was the first country to introduce a carbon tax in 1991 at EUR 27 per tonne of CO_2 (Akerfeld & Hammar, 2015). This tax is now 96€/tCO_2, making Sweden the country with the highest carbon tax (I4CE, 2017).**

This significant taxation is combined with ambitious objectives to reduce its greenhouse gas emissions. The Swedish government announced the "Fossil Free" initiative within the framework of COP21 in 2015, in order to highlight the drive of national companies, institutions and organisations to contribute to the climate effort. The ambition is to make Sweden the first country without fossil energy. **The Free Fossil Declaration states that the stakeholders signing up to it must carry out concrete and coordinated actions with a view to reducing their national greenhouse gas emissions:**

"The ambition is to make Sweden one of the first fossil free welfare countries in the world. Not only because it is our responsibility to future generations, but because it makes economic sense. To achieve this, all actors in society must work actively to reduce emissions. Fossil Free Sweden is open to all actors who support the declaration drawn up for the initiative."

Source : Free fossil declaration, government officies of sweden, 2015

In its third biennial report to the UNFCCC, the Swedish government sets a goal of a 70% reduction in GHG emissions in 2030 compared to 2010, excluding domestic air traffic (Ministry of the Environment & Energy, 2017).

In the transport sector, **in 2016, the Swedish government set out an infrastructure investment plan for the 2018-2029 period** totaling SEK 622.5 billion (EUR 60.9 billion) for the entire plan (Swedish Transport Agency, 2017). While the investments are mainly aimed at maintaining existing rail and road infrastructure, the Swedish government has six main objectives: accessibility, environmentally-friendly mobility, development of regional networks, security, entry of the Swedish transport network into the EU market and, the sixth objective that must be highlighted, reducing the environmental and climatic impact of the transport sector:

"Consequently the Government proposes several policies and measures aimed at the transport sector in the budget proposal for 2018. Lately the local climate investment program has granted support for infrastructure for the introduction of electrical vehicles [...] a bonus/malus-system for new light vehicles and an emission reduction obligation for petrol and diesel to further spur emission reductions in the transport sector. Moreover, the Government proposes that a tax on air travel will be introduced with the aim to reduce the climate impact of aviation."

Source : Sweden's third biennial report under the UNFCCC, Government officies of sweden, 2015

In addition to this infrastructure investment plan, Sweden is pursuing its policy of developing mobility backed by biofuels, including air transport with the first test flight of an ATR plane using biodiesel in 2017. According to EurObserv'ER's analysis, "Sweden is not exactly aiming to totally eliminate fossil fuels in transport. The definition given by the commission of experts in charge of implementing this plan is "establishing a fleet of vehicles independent of petroleum fuel mainly fueled by biofuels and electricity" (EurObserv'ER, 2017).

3 • A REDUCTION OF EMISSIONS BACKED BY THE DEVELOPMENT OF THE BIOFUELS SECTOR

• THE RISE OF THE SWEDISH BIOFUELS SECTOR •

Definition and categorisation of biofuels

The first generation of biofuels refers to those derived from food products (more precisely the storage organs of crops: seeds, beet roots, oil palm fruits). They are therefore in competition with agricultural products dedicated to human and animal nutrition. There is a difference between the petrol (bioethanol) sector based on the industrial fermentation of sugar contained in sugary and starchy plants (wheat, maize), and the diesel (biodiesel) sector obtained from vegetable oils or animal fats converted into fatty acid esters (fatty acid methyl esters - FAME). Within the "oil" sector, it is important to note the increasing share of biodiesel obtained by hydrotreating oils (HVO), which, despite its superior properties and increasing use of waste oils and residues and agro-industrial waste, remains a first generation biofuel.

Second generation fuels are derived from the transformation of lignocellulose from agricultural residues (straw), forest residues (woods, leaves, and so on) or from dedicated energy crops with high biomass productivity (short-rotation coppice). This transformation is thermochemical to obtain a synthetic biodiesel (the Biomass to Liquid or BtL industry), or biochemical to produce ethanol. These biofuels are still in the development phase and their commercialisation should be confirmed by 2020.

Source : Ministère Français de la transition écologique et solidaire

TEXT BOX 1

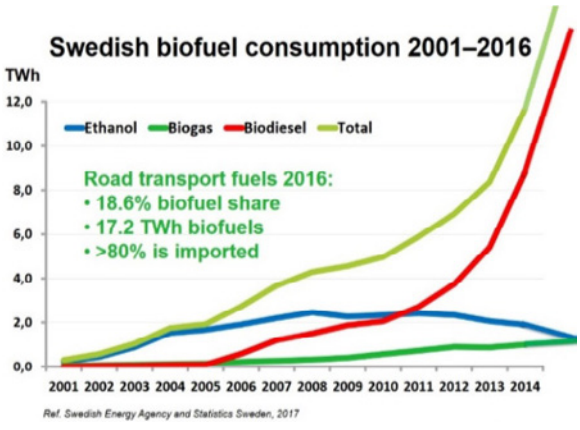

FIGURE 3. BIOFUEL CONSUMPTION IN SWEDEN, 2001-2016

Sources figures 3 et 4 : SVEBIO, 2017

The consumption of biofuels in Sweden has increased significantly in recent years (see Figure 3). While ethanol and biogas consumption has been slowly developing, biodiesel consumption has increased exponentially. Comparison of the fuels used (see Figure 4) confirms the growing trends of Swedish consumption of biofuels in 2016 (1.32Mtoe, +23.77% compared to 2015), with, notably, an increase in biodiesel consumption (1.096 Mtoe, +34.36%), far ahead of the declining consumption of ethanol (0.11Mtoe, -21.68%) and biogas fuels (0.11Mtoe, -1.83%) (EurObserv'ER, 2017).

In 2016, this impressive increase in the consumption of biofuels, especially biodiesels, largely accounts for the observed reduction in CO_2 emissions from motor transport, as the evolution of the car fleet and changes in behaviour do not appear to have had a significant impact on emissions at this stage.

According to the Swedish Energy Agency, the representation of biofuels in the sector reached 19% in 2016 compared to 15% in 2015 and should continue to increase in the coming years to reach a volume of nearly 2 million tonnes in 2020, 80% of which being biodiesel. The biofuels sector benefits from the strong responsiveness of Swedish economic players, with massive investments in advanced biofuel production units, including biodiesel (see Figure 6). Their organisation within a very active professional association, the Swedish Association of Bioenergies (Svebio), bears witness to this.

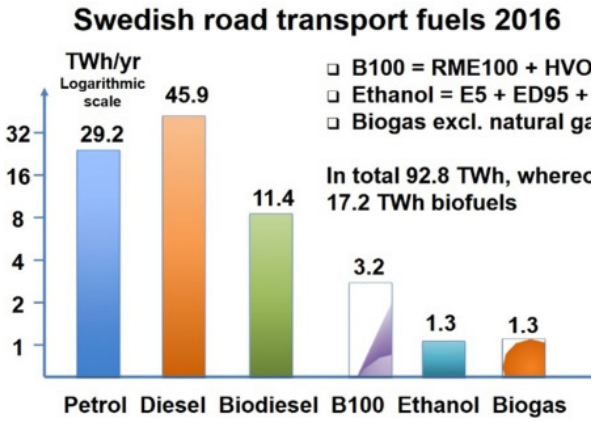

FIGURE 4. COMPARISON OF THE FUELS USED IN SWEDISH ROAD TRANSPORT IN 2016.

In 2017, Svebio noted a certain stagnation in the development of traditional biofuel production units, with only three new ethanol production centres by St1, Agroetanol and SEKAB, two new FAME biodiesel units by Perstorp, and a few additional Biogas centres by E.ON, Swedish Biogas, Strängnäs, and so on. Conversely, the organisation recorded a significant wave of new pilot and commercial projects for HVO biodiesel (hydrotreated vegetable oils) for which, the Swedish oil company Preem, for example, has planned a 600% increase in its production capacity to reach 1.3 million m^3 in 2023. This increase in projects shows the extension of the HVO market, and the erosion of the quasi-monopoly of the Finnish company Neste which currently represents more than 50% of world capacity with 2.5 million tonnes (Greenea, 2017).

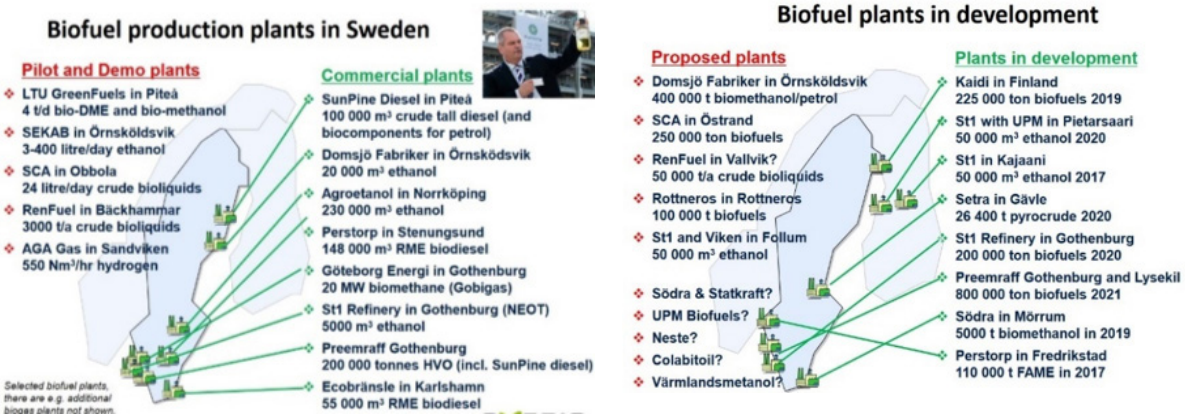

FIGURE 5. DEVELOPMENT OF BIOMASS PRODUCTION PROJECTS IN SWEDEN.

Source : SVEBIO, 2017

HVO biodiesel from Neste

The Finnish company Neste has developed and patented a process for the hydrogenation of vegetable oils for the production of biodiesel. As in the traditional process, it is a catalytic reaction. The difference is that, this time, the oil is brought into the presence of hydrogen, instead of methanol which is used for other types of biodiesel and in particular for FAME biodiesel. The product obtained is a synthetic diesel fuel that, technically, can be used at almost 100% in a conventional engine. This technology also makes the final product more stable with a higher combustion index. It also avoids the co-production of glycerin, for which there are not always local outlets.

Source : Eurobserv'er, 2017

TEXT BOX 2

• HVO BIODIESEL ENABLING EUROPEAN TARGETS TO BE EXCEEDED • The rapidly expanding sector enabled the country to achieve the 30% renewable energy threshold for final transport energy consumption in 2016, an increase of 6 points compared to 2015 (Eurostat), and more than three times the European target of 10% renewable energy in the transport sector by 2020.

This performance by Sweden is linked to the specific accounting procedure that HVO partly benefits from as an advanced fuel. The raw materials used are still mainly of an agricultural nature and similar to those used for first generation FAME-type biodiesel. However, it allows for the more attractive use of agricultural residues and waste, especially those mentioned in Directive 2009/28/EC (Annex IX). HVO biodiesel operators using these raw materials are considered to be using advanced biofuels by the European Union, so they can claim double accounting of their real energy value and contribute doubly to the achievement of European objectives.

The consumption of biofuels in Sweden complies with EU directives

The development of the European Union's market for biofuels for transport is currently, and will be until 2020, governed by Directive 2015/1513 of 9 September 2015, the so-called CASI Directive, which amends Directive 98/70/EC on the quality of petrol and diesel fuels; and Directive 2009/28/EC on the promotion of the use of energy from renewable sources. These two guidelines have been revised to recognise and mitigate the detrimental impact that first generation biofuel production can have on the environment, due to greenhouse gas emissions associated with cases of indirect land-use change (ILUC), that is, the conversion of farmland to crops for biofuel production. Thus, the share of agrofuels from these dedicated crops (cereals, starch-rich plants, sugary plants and oilseeds) has been capped at 7% of total energy consumption in transport. The EU, however, is aiming for a 10% renewable energy target in the transport sector by 2020. The remaining 3% can therefore be obtained through electric transport, or through the use of so-called "advanced" biofuels produced from specific raw materials that can claim double accounting (Annex IX).

Respect of European criteria is a requirement to be able to count biofuels in the share of renewables in total energy consumption and to be able to benefit from public support schemes. It results in the issuing of "certificates". They stipulate, on the one hand, a reduction of at least 50% of GHG emissions from biofuels compared to fossil fuels, and 60% for installations after 5 October 2015. On the other hand, they render ineligible biofuels derived from raw materials coming from land of high value in terms of biodiversity or with a large carbon stock (primary forests, wetlands, peatlands, and so on). Finally, Member Countries have an obligation to carry forward GHG emissions related to indirect changes in land use according to the type of plants used. On the other hand, it considers those from "advanced" biofuels, derived from the raw materials mentioned in Annex IX, as nil due to the current lack of data for their estimation.

Source : 2017 Biofuel barometer, european directives

TEXT BOX 3

This high-quality biodiesel has the other advantage of being able to be used in a high concentration in diesel engines, or even in pure form since the marketing of HVO100 in 2015. To promote their consumption, Sweden applies different tax exemption rates according to the type of biofuel (ethanol, FAME or HVO), and according to the content of the mixture in biofuels. HVO 100 is thus 100% exempt from both the carbon tax and the energy tax, and its price remains competitive with that of fossil diesel. The total consumption of HVO doubled between 2015 and 2017 to reach 73% of liquid biofuel shipments (see Figure 5), making it the third most consumed fuel in Sweden, behind petrol and diesel.

Year	FAME (m^3)	HVO (m^3)	Ethanol (m^3)
2011	250,563	44,943	619,161
2012	294,009	131,085	607,208
2013	292,895	289,095	354,569
2014	431,015	438,813	326,560
2015	422,590	704,687	263,446
2016	341,203	1,203,680	213,446
2017	330,847	1,441,780	205,367

FIGURE 6.
DELIVERED VOLUME OF RENEWABLE FUELS IN SWEDEN (M^3), 2011-2017

Source : Swedish Institute of petroleum and biofuels, 2017

Conversely, FAME biodiesel and bioethanol production are gradually decreasing and only accounted for 17% and 10% respectively in 2017. This industrial strategy is consistent with the reduction of biofuels from dedicated agricultural production encouraged by the European Union.

4 • AN ENVIRONMENTAL ASSESSMENT OF SWEDISH BIOFUELS: STILL TO BE CLARIFIED

The Swedish strategy, however, raises questions in relation to the foreseeable evolution of the world market for biofuels intended in particular for transport in the European Union. A study commissioned by the European Commission in 2015 shows that biodiesels from vegetable oils (rapeseed, palm, soybean, sunflower) may ultimately be more emitting than conventional diesel, by including the "*ILUC emission*" factors due to land use changes caused by their production - up to three times more in the case of palm oil. 70% of these emissions are attributed to peatland degradation in Malaysia and Indonesia caused by palm plantations.

Faced with the environmental problems caused by the massive production of biofuels, the European Union wants to support "*advanced*" and second generation biofuels, by gradually reducing the authorised ceiling for the inclusion of biofuels from agricultural products (see Text box 3), which is currently under discussion in the context of the revision of the 2030 energy package.

To reduce the impact of its production, **the Swedish biofuel industry is relying on the definition given to a number of materials considered by Swedish national authorities to be residues that theoretically do not compete with food production.** It falls within the scope of "*advanced*" biofuels and is therefore not subject to the same traceability requirements. This is the case, for example, with Palm Fatty Acid Distillate (PFAD), a processing residue derived from the refining of crude palm oil. The bulk of biofuel production destined for the Swedish market remains linked to European production. However, there was a significant increase in imports of raw materials for HVO biodiesel from Indonesia and Malaysia between 2015 and 2016 (see Figure 8), which corresponds to the imports of PFAD.

	Sweden	Europe excluding Sweden	Indonesia	Malaysia	USA	Other	Total
2011	32,452	2,489					**34,941**
2012	59,021	55,946	8,502	6,734	9,399		**139,602**
2013	101,836	189,354	49,239	24,892	25,876		**391,196**
2014	93,405	286,729	56,110	17,874	28,994		**483,111**
2015	99,664	429,792	86,107	20,310	96,031		**731,904**
2016	46,269	573,770	182,596	73,104	142,134	344,999	**1,220,738**

FIGURE 7. HVO USED IN SWEDEN, BY COUNTRY OF ORIGIN, SINCE 2011, VOLUME (M3)

Source : Swedish energy agency, 2017

In 2016, for the first time since 2011, no palm oil as such was used for the production of HVO biodiesel. PFAD, in contrast, represented 22% of the raw materials in 2016, whereas it was absent in 2015.

	Tall oil	Vegetable or animal oils	Slaughter-house waste	Palm oil	Animal fat	Rapeseed	PFAD	Corn	Other	Total
2011	32,452	2,489	0	0	0	0				**34,941**
2012	64,589	30,034	29,743	15,236	0	0				**139,602**
2013	100,113	5	201,409	74,131	15,540	0				**391,196**
2014	106,419	108,447	168,708	73,984	25,554	0				**483,111**
2015	112,114	227,009	220,713	106,418	0	65,651				**731,904**
2016	84,283	459,473	234,807	0	0	101,416	276,593	43,240	20,926	**1,220,738**

FIGURE 8. RAW MATERIALS FOR THE MANUFACTURE OF HVO USED IN SWEDEN, SINCE 2011, BY VOLUME (M^3)

Source : Swedish energy agency, 2017

Substituting PFAD for palm oil allows Sweden to reduce the emissions ascribed to indirect changes in land use, since suppliers are not subject to the obligation to carry forward the emissions due to the production of agricultural residues and waste, nor are they subject to the same traceability requirements.

Le Palm Fatty Acid Distillate (PFAD)

Considered a residue, Directive 2015/1513 considers it to have "estimated indirect land-use change emissions of zero". This is in line with Neste, which believes that the demand for PFAD will not put additional pressure on arable land in favour of palm oil, but rather will incentivise improvements in processes to reduce its quantity. This position relies on its low concentration in crude palm oil of around 4 to 5%, and on its market price, which is 15% lower than that of a tonne of refined palm oil (Zero and Rainforest Foundation Norway, 2016). Neste has nevertheless announced that it will implement the same level of traceability for PFAD as for palm oil by 2020.

TEXT BOX 4

However, the evolution of the PFAD market shows that the increasing exploitation of agricultural residues gradually gives them a similar impact on land use. **Added to the opportunities that PFAD also finds in the food and cosmetics industry, its use in the transport sector could increase economic pressure on land, making its use a temporary solution.** With 57 million tonnes of palm oil produced by Malaysia and Indonesia in 2017 (USDA), their potential for producing PFAD can be estimated at nearly 2 million tonnes. This is just 8 times the current Swedish demand for PFAD in 2016, which could develop very quickly. **It is therefore very clear that use of this resource is not reproducible on a large scale.**

The Norwegian government, reconsidering its emissions related to palm oil production, has moreover re-designated PFAD as a "co-product" in 2017, and Sweden should do the same from 2019. It will thus fall within the scope of the sustainability criteria of the directive, which impose stricter reporting of emissions and traceability on operators, and it will lose the benefit of double accounting. The debate over redefining the status of PFAD could lead to the reclassification of other derived products such as technical corn oil (TCO), which is considered to be a residue from the production of ethanol used for the production of biodiesel, or Tall Oil Fatty Acid (TOFA), a residue from paper production.

The special attention given by Sweden to biodiesel, especially HVO, therefore allows it to comply, for the time being, with European requirements and to have a leading role in reducing emissions and in energy transition in the transport sector. **The environmental impact of the Swedish strategy nevertheless remains to be clarified and will depend heavily on future developments in the local production share of second-generation biofuels.** In the long term, the evolution of the Swedish car fleet could play a bigger role in Sweden meeting its emission reduction targets.

Relocating the production of raw materials in the long term

Sweden currently occupies 0.39 hectare per capita of the available arable land in the world, which should be compared to the available arable land per capita on a world scale, which was estimated at only 0.194 ha in 2016 by the Food and Agriculture Organization. Of these 0.39 ha, approximately 0.05 ha represent land dedicated to Swedish biofuel production, of which almost 80% (or about 0.04 ha) of this land is located abroad (see Figure 7). To meet these challenges in part, the Swedish Knowledge Center for Renewable Transportation Fuel, a research institute funded by the Västra Götaland region and by industrialists and universities active in the biofuels sector, believes that the country is in a position to relocate, by 2030, the production chain of around 20 TWh, that is the total current biofuel consumption in Sweden. They believe that this can be done without indirect land-use changes, but rather through the increased use of residues from agriculture, forestry, industry and so on, and also (a point on which the report is very proactive) by reconverting land currently used for alcohol and meat production, which represent the majority of land use in Sweden. Sweden could thus triple its timber harvest and continue to sustainably manage its resources (De Jong-Akselsson et al, 2017).

In order for Sweden to be a pioneer country in the transition to a fossil fuel free transport sector, we need to include a high realisation of domestic biofuel production. We should not shift a dependency on imported fossil fuels, for a dependency on imported biofuels.

Source : Biofuels from agricultural biomass - Land use change in swedish perspective, the swedish knowledge centre for renewable transportation fuels, sweden, 2017

TEXT BOX 5

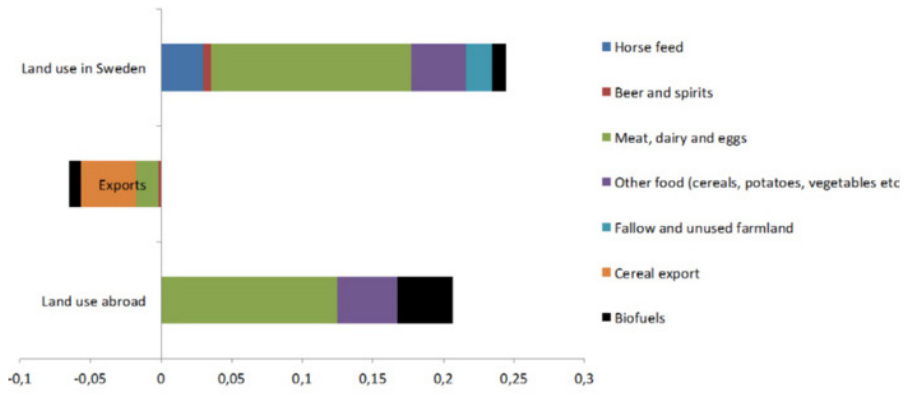

FIGURE 9. ARABLE LAND USED BY THE AVERAGE SWEDE, IN SWEDEN AND ABROAD (IN HECTARE PER PERSON)

Source :Swedish knowledge centre for renewable transportation fuels, 2017

5 • THE EVOLUTION OF THE SWEDISH CAR FLEET

• AN INCREASE IN THE FLEET DOES NOT LEAD TO AN INCREASE IN EMISSIONS •

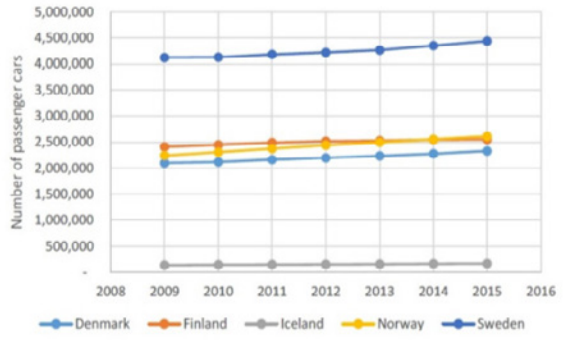

FIGURE 10. EVOLUTION OF THE CAR FLEET IN THE NORDIC COUNTRIES FROM 2009 TO 2015

The trajectory of carbon emissions by Sweden's transport sector shows a steady decline since 2007. However, as stated in the report "CO_2 emissions and economic incentives" for the Nordic Council Minister (Jordal-Jorgensen et al., 2017) on motor transport, the Swedish car fleet has increased since 2009 from 4.30 million cars in 2009 to 4.67 million in 2015, an increase of 9.11% (see Figure 10). This increase, which is greater than in the rest of Scandinavia, can be partly explained by the lack of registration taxes linked to the size and power of vehicles, unlike its Nordic neighbours (Swedish Transport Agency, 2017).

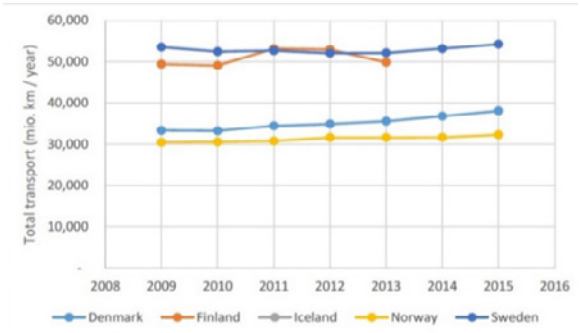

FIGURE 11. EVOLUTION OF DISTANCES TRAVELLED BY CAR IN THE NORDIC COUNTRIES BETWEEN 2009 AND 2015

Added to this is the significant increase in car travel in Sweden (see Figure 11), from 63.28 million km in 2008 to 65.82 million km in 2015 (TRAFA, 2017). This occurred despite the initiatives of several Swedish communities, such as Stockholm and Gothenburg, to introduce a "congestion" tax to reduce urban traffic.

The reduction of CO_2 emissions in Sweden can therefore be explained primarily by the improvement of vehicles, new types of engine and the use of biofuels, rather than by changes in behaviour. This improvement in vehicle quality is particularly striking in Sweden, according to the European Environment Agency and the European Commission services (see Figure 12), which shows the considerable progress made since 2000 in reducing CO_2 emissions per kilometre.

The figures provided by Bil Sweden, the Swedish trade association for manufacturers and importers of cars, trucks and buses, show a significant evolution of the car fleet between 2016 and 2017 with 379,393 new cars in 2017, an increase of 1.9% compared to 2016, the highest figure ever recorded (Bil Sweden, 2018).

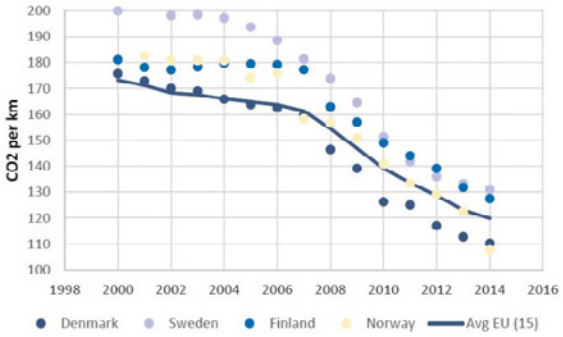

FIGURE 12. CO_2 EMISSIONS PER KILOMETRE OF NEW CARS IN THE NORDIC COUNTRIES BETWEEN 2000 AND 2014

Sources Figures 10 à 12 : Nordic Council of ministers, 2007, P39 et 43

As in the rest of Europe, there has been a significant decrease in the share of newly registered diesel cars with a decrease of 4.3% in 2017. This type of car thus represents only 49.1% of the new car fleet compared to 52.3% in 2016 (Bil Sweden, 2018). However, the decline in the diesel fleet did not lead to an increase in CO_2 emissions in 2016 (diesel vehicles are less CO_2 emitting than petrol vehicles), as was announced on the European scale by the Jato Dynamics Institute. This institute attributed the increase in average CO_2 emissions of new cars from 117.8 g/km in 2016 to 118.1g/km in 2017 to the drop in diesel car numbers (and the increase in SUV vehicles) (study presented at the Geneva Motor Show in March 2018).

• SUPER "GREEN CARS" AND THE PROACTIVE INDUSTRIAL POLICY OF THE MANUFACTURERS •

The distinctive position of Sweden regarding diesel biofuels, as well as the use of a significant proportion of ethanol in petrol vehicles, help explain this result, but the rapid development of the sale of "super green cars", a label given to vehicles that emit less than 50gCO_2/km, should also be taken into consideration.

In 2017, a record year of new vehicle sales, super green cars accounted for 5.1% (19,000 cars) of new cars registered, an increase of 1.6 percentage points over 2016 (3.5%). Bil Sweden's 2018 forecast, confirmed so far by the first quarter sales results, provides for 34,000 "super-clean" cars to be newly registered in 2018, representing 9.4% of the total expected market of 360,000 new cars. **This change in the Swedish car fleet through the rapid deployment of "super-green cars" is a major hope factor for the reduction of CO_2 emissions, which shows the importance of a synergy between government financial incentives and the dynamism of manufacturers.**

Super-Green Cars and the Ecological Taxation of Vehicles in Sweden

The 2011-2018 Super-Green Car Premium Ordinance, which came into force in January 2012, aimed to promote the sale of energy-efficient and low-emission cars, which refers to cars that emit less than 50g of CO_2 per kilometre (2016 threshold). The "super-green car premium" consisted of a purchase bonus of SEK 20,000 (EUR 1,960) for a hybrid vehicle and SEK 40,000 (EUR 3,920) for electric vehicles. The Swedish government has decided to replace this premium from 1 July 2018 by a bonus/malus system for passenger cars, which extends to low-emission buses and trucks.

The malus applies to both diesel and petrol vehicles and continues for the first three years on the road. It is 82 SEK/gCO_2/km (8 €/gCO_2/km) between 95 gCO_2/km and 140gCO_2/km, then rises to 107 SEK/gCO2/km (10.50 €/gCO_2/km). The bonus for zero emission vehicles is progressive up to 60 gCO_2/km to reach SEK 10,000 (EUR 977), within a limit of 25% of the purchase price of

the vehicle. The aim is to reach an average of 95 gCO_2/km for all vehicles on the road by 2022, which corresponds to the threshold to be reached by 2021 set by the European Union.

TEXT BOX 6

At this stage, super green cars do not yet represent a significant share in the Swedish car fleet, and the weak development of the electric car (only 0.8% of the Swedish car fleet in 2015) raises questions about the adequate development of the electrical charging infrastructure throughout Sweden. Gas-powered vehicles are falling (1.4% in 2015), while hybrid power still accounted for only 2% in 2015. According to the report "CO_2 emissions and economic incentives", if the average age of the car fleet in Sweden was 10.2 years in 2014, lower sales prices for electric vehicles (EUR 30k on average), simple hybrids (EUR 25k on average) and hybrid plug-in vehicles (EUR 38k on average) would actually make it possible to envisage the rapid renewal of the fleet with less emissive vehicles, even though the average prices of petrol cars (EUR 12k) and diesel cars (EUR 23k) would remain stable (Jordal-Jorgensen et al., 2017, p.47-50).

Volvo's commitment to the end of internal combustion engines

Swedish vehicle manufacturer Volvo announced in early July 2017 that all new models it would release from 2019 would be fully electric or hybrid. Models launched before this date will still have combustion engines. It will gradually introduce models ranging from all-electric to hybrids with rechargeable batteries into its range. Volvo's strategy must be related to that of its owner, the Chinese manufacturer Geely, which aims to develop an offer of electric vehicles in China, and to open an innovation centre for their development in Gothenburg, Sweden.

TEXT BOX 7

Other research initiatives to be closely monitored have also been launched, such as "electric light trucks" by the truck manufacturer Scania, in partnership with Siemens, Volvo and Alstom (ICCT, 2017) to move towards zero-emission freight transport. The November 2017 Global Electric Trucks Market Research Report states that while the global electric truck industry suffered a slowdown in 2016, the overall trend over the past four years is positive (+55% between 2013 and 2016,+ USD 41 million) and it should maintain its momentum in the coming years to reach USD 159 million in 2021. A technologically complementary infrastructure is important for these plans to convert to electric power. For example, Scania, in partnership with Siemens, is developing "e-highway" highway electrification projects (Siemens, 2015) based on the omnibus model. The University of Lund has initiated the "Elonroad" project (ICCT, 2017) on the basis of a conductor rail that allows electric cars and trucks to recharge while driving.

• SUV'S CONTRASTING WITH THE POSITIVE TRAJECTORY OF THE SWEDISH CAR FLEE • The massive development of the market for sport utility vehicles (SUVs), which mainly have diesel engines, is a worrying signal that increases the risks of increased CO_2 emissions and microparticles cancelling out the positive effects of "super-green cars". The Volvo XC60 SUV was the best-selling car in Sweden in 2017, with 21,419 models sold (Statistica, 2018). Foreign manufacturers have also established themselves on the Swedish market with, for example, the Volkswagen Tiguan SUV, which is the 7th best-selling car in the country.

The growing SUV market in Europe

Between 2006 and 2016, sales of SUVs in Europe grew by 300% (from 1.12 million vehicles in 2006 to 3.88 million in 2016). This trend seems to be confirmed in the coming years as Jato Dynamics' forecasts predict 6 million SUVs will be registered in 2020 (Jao Dynamics, 2017, p. 4). With only 3.9% of SUVs benefitting from electric engines in 2017, the increase in SUV sales contributed to the recorded increase in European CO_2 emissions of at least 0.1% over the 2016-2017 period.

TEXT BOX 8

CONCLUSION

In conclusion, Swedish national policy has given stakeholders in the various road transport sectors a strong incentive base for their investments in technological innovation in both vehicle and biofuel performance. However, the Swedish situation presents contradictory trends, as evidenced by the development of the diesel SUV market and the increase in car journeys, despite traffic limitations in urban areas. The issue of accounting for CO_2 emissions related to biofuel consumption in Sweden will be central in the coming years. Changes to supply (especially for palm oil) and relocation of production will be essential choices if Sweden is to demonstrate the sustainability of its biofuel-based strategy for reduction of emissions, which for now appears to be a temporary solution and one which is not reproducible on a global scale. How these contradictory trends develop will determine whether Sweden will be tomorrow's showcase for climate-compatible road transport.

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Make road transport a solid pillar in combatting greenhouses gas emissions

Following the example of the international community in response to the climate challenge, the South African government aims to reduce national carbon dioxide (CO_2) emissions by 34% in 2020 and 42% by 2030. The transport sector, one of the main contributors to atmospheric pollution and the 2nd emitter of CO_2, is one of the key sectors of this fight. In road transport in particular, which includes freight and passenger transportation, the technologies currently used and the modes of operation are not in line with these objectives and must be reconsidered.
In this regard, the state and municipal authorities have taken various initiatives to meet the targets set. The materials used and the modes of operation are constantly being re-examined. Indeed, support for the renewable energy sector through investment programmes and substantial subsidies is expected to make compelling contributions to reducing greenhouse gas (GHG) emissions in the South African road transport sector. This paper presents the evolution of emissions in the road transport sub-sector in South Africa, the explanatory factors for the trends observed and the mitigation actions being carried out.

Head editor • **ALIOUNE THIAM** • *Transport and Urban Mobility Expert, Eco-Access*

CONTENTS

1 • THE ROAD TRANSPORT SUB-SECTOR IS A KEY CONTRIBUTOR OF EMISSIONS IN THE SECTOR

- The emissions of the road transport sub-sector are strongly correlated with diesel consumption
- The reason: urban forms and modes of travel

2 • THE STATE'S INTENTIONS ARE STILL RATHER TIMID

- Adherence to international agreements and a focus on the most polluting sectors
- Particular attention paid to the transport sector, especially road transport, through innovative mechanisms

3 • REMARKABLE CONTRIBUTIONS FROM PRIVATE ACTORS

- High participation of non-state actors

4 • STRATEGIES OF LOCAL PUBLIC ACTORS

- Coordinating the town planning and transport policies to reduce the number of journeys
- Paradigm change following the urban public transport crisis: towards sustainable mobility
- Innovations in the public transport sector
- A growing awareness in civil society and in the general public in favour of hybrid and electric vehicles
- Local initiatives with strong support from NGO

1 • THE ROAD TRANSPORT SUB-SECTOR IS A KEY CONTRIBUTOR OF EMISSIONS IN THE SECTOR

• THE EMISSIONS OF THE ROAD TRANSPORT SUB-SECTOR ARE STRONGLY CORRELATED WITH DIESEL CONSUMPTION • The changing trend in emissions from the road sub-sector is relatively similar to that of the transport sector taken overall. This is hardly surprising since it represents over 99% of the emissions of the sector. Their respective evolutions over the 2002-2017 period are very close: 3.02% for road transport compared to 3.21% for the transport sector.

From year to year, a slight progression can be observed, except in 2016 when reductions were recorded for both the transport sector in its entirety (-4.43% in comparison to 2015) and the road transport sub-sector (-5.11% relative to 2015).

The evolution of road transport emissions follows the same rhythm as emissions from fossil fuels, notably diesel. This is the case for the 2002-2017 period where an increase of over 6.59% in diesel emissions was observed. The recent reductions recorded were made possible by a steep reduction of $_2$ from the combustion of diesel, i.e., a fall of 2.59% between 2014 and 2015, and 10.66% between 2015 and 2016 (Enerdata, 2018).

		2002	2006	2010	2012	2014	2015	2016	2017
Transport (fuel consumption)	Quantity (in Mt)	36.97	44.45	48.14	51.20	52.93	53.73	51.36	54.80
	Evolution average/ year	-	5.06%	2.08%	3.17%	1.69%	1.53%	-4.43%	6.70%
	Evolution 2002-2017	3.21%							
Road transport	Quantity (in Mt)	34.29	41.28	45.02	47.69	49.43	50.12	47.56	49.80
	Evolution average/ year	-	5.10%	2.26%	2.96%	1.82%	1.40%	-5.11%	4.71%
	Evolution 2002-2017	3.02%							
Petrol consumption	Quantity (in Mt)	22.51	24.54	24.85	26.02	24.15	25.50	25.47	26.25
	Evolution average/ year	-	2.27%	0.31%	2.35%	-3.58%	5.57%	-0.12%	3.06%
	Evolution 2002-2017	1.11%							
Diesel Consumption	Quantity (in Mt)	11.76	16.71	20.16	21.66	25.25	24.60	21.97	23.38
	Evolution average/ year	-	10.52%	5.17%	3.72%	8.28%	-2.59%	-10.66%	6,41%
	Evolution 2002-2017	6.59%							
GPL Consumption	Quantity (in Mt)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gas consumption	Quantity (in Mt)	0.0000	0.0000	0.0000	0,0004	0.0004	0.0004	0.0004	0.0004

FIGURE 1. EVOLUTION OF CO_2 EMISSIONS FOR TRANSPORT, 2002-2017

Source: ENERDATA

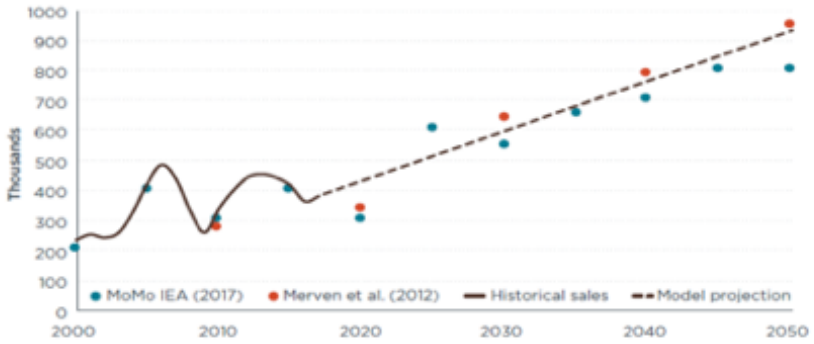
Fossil fuel emissions from the road sector represent on average 99.89%, with a contribution of 44.79% for gasoline and 55.11% for diesel. Thus, the near-constant, slight and progressive rise noted over the 2012-2017 period is primarily the result of a variation in emissions of these two sources of transport energy (diesel and gasoline) at a time when alternative energies (electric, biofuels and compressed natural gas) have made only a very timid market appearance since 2012 (Enerdata, 2018).

• THE REASON: URBAN FORMS AND MODES OF TRAVEL • Economic success naturally leads to perceptible social changes in ways of life, behaviour and actions. South Africa, the biggest economy on the continent, is no exception to this rule. **A high rate of motorization has hit the country not only because population income levels are rising, but also due to the strong presence of the automobile industry (Volkswagen, Toyota, etc.)**. Competition in the domestic automobile market has made cars easily accessible to individuals.

Evolution of the car fleet

In 2015, manufacturers sold over 400,000 cars on the South African market and exported over 300,000 units. One of the two largest industries on the market, Toyota, is well positioned in the production of small and medium-sized cars as well as sports utility vehicles (SUV). These types of vehicles, preferred by South Africans, produce 43% of the CO_2 emissions of the fleet. The high emissions for SUVs is explained by the fact that 62% of these vehicles run on diesel (Posada, 2018). In 2015, the share of petrol/diesel consumed by the transport sector was 43.8% (GIZ, 2017).

In line with the International Energy Agency's Mobility Model (MoMo), the projections for 2050 predict a rise in sales of new vehicles of 600,000 to 800,000 units. Equally, estimations by the University of Cape Town show a rise in sales of between 640,000 and 950,000 units from 2030 to 2050. Based on these two projections, the fleet is set to rise by 4% in 2020 then fall by 2.1% until 2050 (Posada, 2018).



MODÈLE ICCT: PROJECTION DE CROISSANCE DU PARC AUTOMOBILE PARTICULIER

TEXT BOX 1

Moreover, the urban form of South African cities characterised by non-dense residential zones and urban sprawl is also an explanatory factor of the rise in motorization rates. The apartheid had very negative effects, especially on the transport sector. **Indeed, public transport development was constrained by the problem of population cohabitation, meaning that the services provided were aimed at a fixed group of customers**. This meant that individual modes of transport became preferable and their growth has made a large impact on environmental pollution levels through the amount of greenhouse gases produced.

2 • THE STATE'S INTENTIONS ARE STILL RATHER TIMID

The South African authorities have long claimed to have real ambitions to combat climate change through programmes and policies to reduce greenhouse gas (GHG) emissions at a national level. However, beyond the few legislative and regulatory measures, meaningful actions are late arriving.

• ADHERENCE TO INTERNATIONAL AGREEMENTS AND A FOCUS ON THE MOST POLLUTING SECTORS • In its Defined National Contribution (DNC), the State claims to be pressing hard on the "Transport" lever to contribute effectively to the global effort to reduce GHG emissions across the world. It is now committed to **mobilizing financial means to invest in the promotion of sustainable transport systems that respect the environment.**

Since the Copenhagen negotiations in 2009, the option of **a reduction in domestic emission of greenhouse gases of 34% in 2020 and 42% by 2025** (GIZ, 2017) was adopted by the South African government, through its DNC.

• PARTICULAR ATTENTION PAID TO THE TRANSPORT SECTOR, ESPECIALLY ROAD TRANSPORT, THROUGH INNOVATIVE MECHANISMS • Through the "National Climate Change Response Paper (NCCR)", South Africa intends to **improve the energy efficiency of its vehicle fleet, thus encouraging green technologies such as electric and hybrid vehicles.** The goal set by the state authorities is to put **3 million electric cars into circulation by 2050 and make an investment programme worth 6.5 million Rands available to green technology industries** (GTS, 2016-2021).

One of the key battles planned by South Africa is **the introduction of environmental taxation which will make it one of the first countries in Africa to implement such a reform.** This taxation system aims, among other things, to reduce the use of fossil fuels such as petrol, diesel and gasoline in the energy production and transport sectors (Letter on Environmental Taxation Reform Policy, in 2006). **The law is currently being considered by the National Assembly, and the Government plans to implement this reform at the beginning of 2019.** These fiscal measures promote the development of renewable energy sources (electric, biofuel, biogas, ethanol, etc.) which could be used in the road transport sub-sector with the view to achieving an energy transition.

Beyond the legislative and regulatory measures, the public authorities have put in place **programmes aimed at developing renewable energy sources for use in the road transport sector.**

For example, the decarbonisation initiatives in the goods transport domain. **The introduction of a system of road tolls** by the South African government is another example. Across the whole network, **16% of roads are equipped with toll booths**. The reduction of traffic on these roads resulting from the cost of the toll would result in a gain for the country in terms of reducing CO_2 emissions in the road sub-sector (SANRAL, 2013).

3 • REMARKABLE CONTRIBUTIONS FROM PRIVATE ACTORS

Although road transport emissions continue to dominate the transport sector overall, we should note that the quantity of CO_2 it generates has remained stable in the last few years with slight, and occasionally negative, variations. This situation is in many ways down to private initiatives.

• HIGH PARTICIPATION OF NON-STATE ACTORS • This stability is mainly the result of a **high participation by non-governmental organizations, local authorities and private firms in supporting the South African government in meeting its environmental objectives.**
In this sense, the actions of **transport and logistics companies** can be cited as an example, notably **their participation in the process of decarbonizing freight road transport**. Many of the South African leaders in transport logistics have invested in the country's environmental policy. **The TIMBER programme (Technology, Infrastructure, Market Changes, Behaviour, Energy and Regulation),** launched in 2011 with the aim of reducing carbon emissions in goods transportation, benefits from the participation of many private sector firms**.**

Some initiatives by private companies

In 2014, Barloworld introduced the "Green Trailer" in its fleet. This technology operates at a constant speed of 70 to 80km/h, thus saving 11% in fuel for the firm and reducing CO_2 emissions by 66.8 tonnes over a period of 10 months (Henderson, 2014).

In the forestry and wood industry, the use of "Smart Trucks" is growing. These trucks are generally long and have more capacity to transport heavy loads than any other vehicle. The use of this type of equipment will reduce the amount of freight traffic and, at the same time, increase the productivity of the sub-sector. In environmental terms, South Africa will benefit from a significant reduction in its carbon emissions and avoid wear on its roads.

With a futuristic design, they possess in particular improved safety systems and simulation and assessment tools (analysis of the impact on road wear; GeoTrack to simulate the manoeuvrability of vehicles at low speeds, etc.).

The transportation and logistics operators (Unitrans, Barloworld, Buhle Betfu and AB InBev) have noted a reduction of 39% in accidents and an average decrease of 12% in fuel consumption thanks to increased payload efficacy enabling a reduction of over 84,000 trips per year (Infrastructure Naws, September 2018). South Africa today has over 300,000 registered heavy goods vehicles, of which 270 are intelligent.

Since 2014, Imperial Logistics has been running the "Extra Distance" campaign: the title refers to the difference between the number of kilometres driven by the vehicles and the number of kilometres required in optimal planning conditions. "The first indications are that eliminating the extra distance in their Gauteng and Cape Town fleet could lead to a reduction in costs of 29 million rands" (De Swardt, 2014).

ECO_2Fleet is a data collection and reporting service on the management of vehicle fleets based on the internet. Its purpose is to measure carbon emissions and provide emissions declaration data in conformity with the international norms. Nearly 500 companies (40,000 vehicles) are currently subscribing to this product. "A client reports that by using this data, the average fuel consumption per vehicle for the 900 vehicles of the firm has fallen below an average of 10 litres/100km for the first time, an improvement that could reach 30% for some vehicle categories" (De Swardt, 2014).

TEXT BOX 2

The congestion of the main traffic arteries in the large South African cities is the result of a sharp rise in vehicle numbers. Truck commercial speeds have fallen as a consequence, resulting in an excessive fuel consumption, and in parallel, an accumulation of greenhouse effects in the atmosphere. An estimation of the costs induced by this situation shows an extra 4 billion rands (or 10%) are added to the total costs of domestic externalities (Tom Tom, 2014).

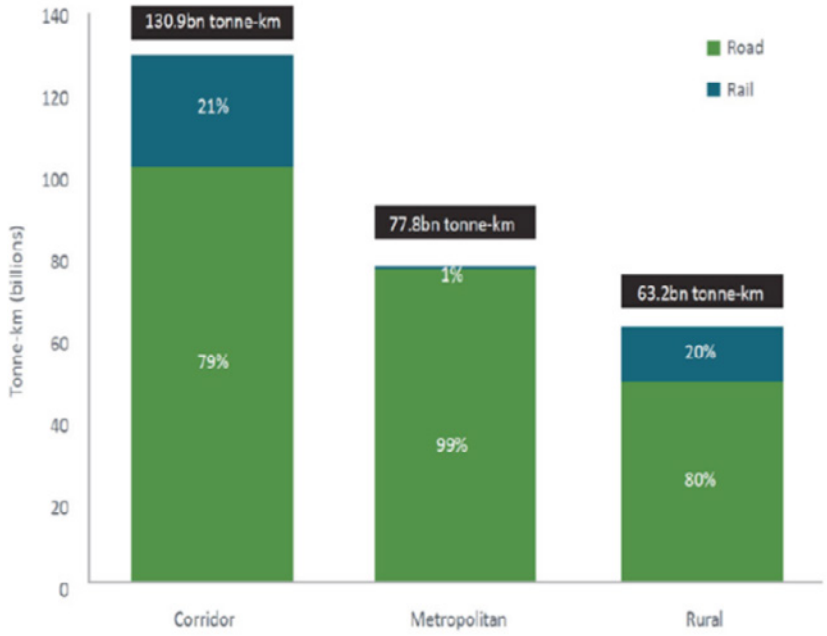


FIGURE 2. DISTRIBUTION OF THE GENERAL DEMAND FOR FREIGHT IN SOUTH AFRICA IN 2014

Source: Havenga, JH, et al. (2016), Logistics Barometer South Africa 2016, Stellenbosch University

In 2013, according to WWF, 45% of national freight emissions came from the use of two key corridors (Johannesburg-Durban and Johannesburg-Cape Town).

An intermodal terminal project in the cities with high freight activity was then implemented for a better interconnection of logistics hubs through strong incentives to shift part of the road freight over to rail. Road traffic benefits in this case from improved fluidity and the decarbonisation initiatives in goods transportation in the country are thus advanced.

As such, in 2012 **Transnet** introduced a new generation of locomotives in the rail freight sub-sector ("**Rail freight**"). The deployment of this new technology across the **Transnet** network demonstrates the firm's ambitions to be more respectful of the environment in its operations. With this initiative, the rail sector will be well equipped with modern technologies to fulfil its role in the context of a modal shift from road freight to rail.

A desire to promote intermodality

"The construction of three intermodal terminals to connect the three main industry centres - Gauteng, Durban and Cape Town - through an intermodal solution could reduce the transport costs of the 22.9 million tonnes of intermodal freight identified on the two key corridors generating externalities, leading to savings of 1.2 million tonnes of CO_2". Havenga et al. (2015)

TEXT BOX 3

Today, the actors **in transport logistics, particularly private firms, are particularly invested in the idea of intermodality**. This vision was taken into consideration in the **Annual Shareholders Agreement between the National Department of Public Firms (the shareholders) and the national railroad operators. Moreover, the signing in 2013 of a protocol agreement between the largest South African logistics service providers (Imperial Logistics, Barloworld Logistics and Transnet)** further promotes this desire to integrate the different modes.

Finally, the actions outlined above demonstrate an emerging awareness among non-state actors in South Africa for the need to combat climate change. **In the road transport sector, the involvement of several transport and logistics operators has led to an increased coherence between their programmes and those enacted by the government. However, so far we are seeing more intention than action for the latter, the measures aimed at the private sector provide little incentive to participate fully in the challenge to reduce national greenhouse gas emissions.**

However, the actions of these private firms are strengthened by the initiatives of local authorities involved in implementing sustainable urban mobility policies.

4 • STRATEGIES OF LOCAL PUBLIC ACTORS

In 2015, South Africa had 55 million inhabitants, or 0.8% of the global population. The country is the most urbanised in Africa, with 64.8% of its inhabitants living in urban zones in 2015, and over 2/3 in 2017 (GIZ, 2017). The urban structure is characterised by low population densities in the cities (Johannesburg: 2,894 habitants/km²; Cape Town: 1,560 habitants/km², in 2016) and a sprawling urban growth over large distances making urban mobility an important issue for individuals.

• COORDINATING THE TOWN PLANNING AND TRANSPORT POLICIES TO REDUCE THE NUMBER OF JOURNEYS • The urban sprawl is a legacy of the Apartheid regime, which encourages residents to use private cars. In the large agglomerations both in the north and south of the country, an effort to develop inland connections and mobility followed by a harmonious expansion of the peripheries and the creation of more or less complete centralities, has had the effect of bringing economic activities and households geographically closer. Thus, the urban morphology has undergone significant transformations in which transport and mobility have played a major role (Vermeulin and Kahn, 2010).

Overview of CO_2 emissions by transport mode: a great potential for reduction remains untapped

The contribution of cars to carbon dioxide emissions in urban passenger transport is very high in South Africa. In 2014, Gauteng recorded 68.8% of CO_2 emissions from the use of private cars (PCs), 22.8% of emissions by taxis, 3.2% of emissions by buses and 0.1% by BRT (Bus Rapid Transit). For Cape Town, 86% of emissions came from PCs, 7% from minibus taxis, 4% from buses and 1% from motorcycles (WWF, 2016).

In 2014, the number of passenger kms by mode was distributed at 45% for private cars (PCs), 50% for buses and 5% for rail (GIZ, 2017). In view of this modal distribution and the contribution potential of each mode (Cf. figure 3), it is evident that the GHG reduction potential remains significant.

TEXT BOX 4

3 - https://www.acare4europe.org/sites/acare4europe.org/files/document/volume1.pdf
4 - https://www.acare4europe.org/documents/delivering-europe%E2%80%99s-vision-aviation-sria-2017-update
5 - L'ICSA est composée de l'Aviation Environment Federation (AEF), Carbon Market Watch, EDF Environmental Defense Fund, the International Council on Clean Transportation (ICCT), Transport & Environment, et le WWF.

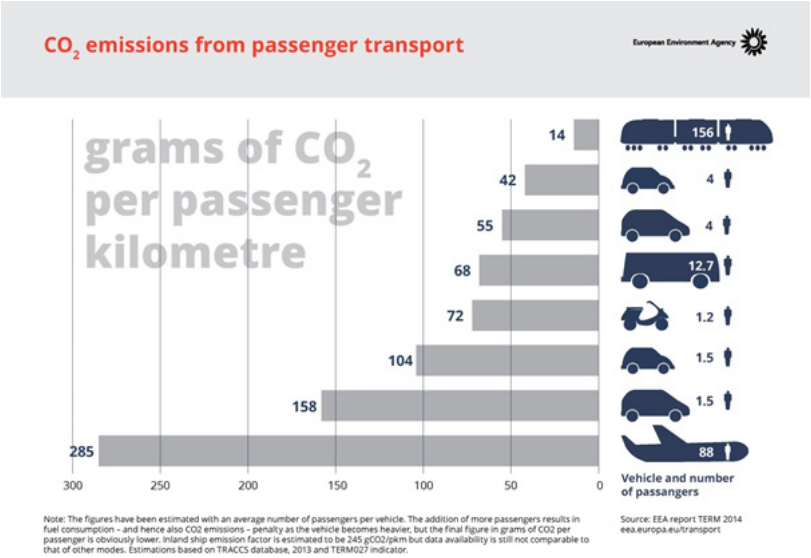


FIGURE 3. COMPARISON OF EMISSIONS PER MODE

Source: European Environment Agency (http://www.consumovehicular.cl/)

• PARADIGM CHANGE FOLLOWING THE URBAN PUBLIC TRANSPORT CRISIS: TOWARDS SUSTAINABLE MOBILITY • The issue of sustainable development is a national priority and should be addressed at all levels of the territory. **At a local level, the municipalities, whose powers were expanded in 1995, integrate sustainability in all of their urban planning and development actions.**

However, this has not always been the case. During the Apartheid era, high levels of discrimination in favour of the "whites" and to the detriment of the "non-whites" was a feature of public transport on the central and pericentral routes. Indeed, black, mixed-raced and Indian workers would travel on networks often managed by illegitimate authorities with few resources, such as the Bantustans. Following this, to fill the gap left by these companies, small private operators of buses and taxis-minibuses began to appear in the townships. Their number grew rapidly and their network spread in the neighbourhoods.

This artisanal, informal and sometimes very turbulent sector spread across all the South African cities when the Apartheid regime fell. The African National Congress (ANC), who came to power in 1994, had no choice but to accept the major role this informal sector played in urban passenger transport, and was forced to delay addressing the sensitive issue of regulating the sector (Vermeulin and Kahn, 2010). In this atmosphere of public transport deregulation and disorganization, the use of non-sustainable transport modes grew, as did their negative impacts on people's lives.

Today, urban mobility governance is a pressing topic in South African towns. Many municipalities have opted to create a local regulating authority for urban transport. (Vermeulin and Kahn, 2010)

As such, in 2003, **the municipality of Thekwini in Durban was the first to introduce an Urban Transport Organizing Authority (UTOA)**, an independent body under local government supervision where local elected representatives make up the governing board. The municipality then became an "arbitrator" of the urban transport sector and was thus obliged to let go of its own bus company (Bellangère et al., 2004).

This phase of introducing the UTOA was followed by the privatization and externalization of public transport services. However, apart from the transport authorities, the municipalities benefit from a relative control over use of lines since they can attribute national subsidies to operators of their choosing. **Today, with their agendas integrating the environmental aspect, the municipalities are all involved in setting up a sustainable transport system.**

The football World Cup held in South Africa in 2010 helped to accelerate the development of sustainable transport infrastructures in South African cities. The increase in the number of Bus Rapid Transit (BRT) lines and the exploitation of Metrorail and Gautrain buses has provided the

municipalities with a modern image of urban transport. Since then, local authorities have been taking ever more interest in sharing infrastructures and in economic modes that are more respectful of the environment. **In line with this, the town halls have often relied on the support of non-governmental organizations (NGOs) acting to raise awareness, provide advice and strengthen capacity, alongside their financial support.**

• INNOVATIONS IN THE PUBLIC TRANSPORT SECTOR • In all South African cities, taxi-minibuses are the most widely used mode of public transport, while buses and trains are gaining low market shares. **Sustainable urban transport theory stands in opposition to systems dominated by ad-hoc small businesses, which perform badly in terms of accessibility, comfort, reliability, regularity, punctuality and safety. Additionally, the prices charged are not attractive for poor people. Moreover, their vehicle fleets do not conform to new environmental norms that require more energy-saving and less polluting modes of transport.** The age of their fleet increases road danger and atmospheric pollution is harmful to the health of populations living in urban spaces.

South African cities are showing their commitment to "greening" their municipal vehicle fleets. In Gauteng, for example, the use of compressed natural gas (CNG) as a fuel for buses and minibus taxis is already on the rise. This ambition of the South African municipalities thus appears feasible as long as the projected municipal demand for new buses is sufficient to sustain the local manufacture of green buses. Also, the cities are currently engaged in introducing a centralised supply mechanism that could provide bus manufacturers with the necessary guarantees to justify such an investment. One of their concerns is the need to adapt to the different technical requirements in each city as well as to each local political authority (SACN, 2015).

In Johannesburg, Metrobus, as a public urban transport supplier owned by the municipality, committed in 2015 to transforming some of its diesel buses by equipping them with bi-modal fuel tanks, fuel - duel-fuel (DDF), in addition to new acquisitions. It also acquired Euro-5 DDF buses, which are better for the environment in terms of carbon emissions. In all, 150 buses running on compressed natural gas (CNG) are available (50 transformed; 100 new acquisitions). This project required an investment of over 355 million USD for the buses. The supply contract was awarded to Sandown Motor Holdings (Pty) Ltd, a dealer in Mercedes-Benz utility vehicles in South Africa. Moreover, a sum of around 1.67 million USD has been set aside to supply and deliver a compressed natural gas (CNG) service station; this bid was won by NGV Gas (Pty) Ltd.

Compressed biogas and other sources of energy such as electric energy and biofuels should also be adopted to make a significant impact on city pollution. **Many South African municipalities are promoting these types of energy. They are not only better for the environment than gasoline and diesel but also allow for the recycling of household and industrial waste in cities. (SACN, 2015).**

Compressed natural gas (CNG) and biofuels, an important step towards sustainable urban transport

• Compressed natural gas (CNG) channels

Compressed natural gas (CNG) has been used as a vehicle fuel since at least the 1930s. It has recently become profitable on a large scale and it is widely used today. A mix of gas (mainly methane) is extracted, either from dedicated gas wells or alongside petroleum, and is then treated, compressed and consumed in a specially designed engine.

CNG could potentially reduce public transport emissions in South Africa, which would be an important step towards sustainability. **In Gauteng, CNG is already being used as a fuel for buses and public transport (TMS).**

In March 2014, the first public CNG service station in South Africa was ope-

ned in Langlaagte Johannesburg, and other service stations are planned for the near future. Like other substitution fuels, CNG requires a substantial infrastructure: depots must be converted and staff retrained to man and maintain the CNG buses (SACN, 2015).

• Biofuel Channels

Biofuels come in various types such as biogas, listed below, bioethanol and biodiesel. These energies are biological combustibles that have no major impact on the environment. They are part of a class of renewable energy sources that are cleaner than classic fuels. However, although biofuels can be produced through waste treatment, they are generally made from crops with high carbohydrate levels such as sugar cane, sugar beet and starches. This production leads to a reduction in land used for food production and thus leads to food insecurity and sovereignty issues (SACN, 2015)

Recently, South Africa put in place an industrial strategy for biofuels seeking to attenuate the potential impacts on food security by excluding some biofuel crops. It aims to reach a penetration of 2% of biofuels in the national supply of liquid combustibles in the short term. This could be accomplished by using around 1.4% of the arable land of South Africa, of which approximately 14% is currently under-used - mainly in the former homelands (DME, 2007). In practice, this objective has been shown to be hard to attain. (SACN, 2015).

• Biogas Industries

To produce biogas, organic waste is placed in an anaerobic digester containing a specific mix of bacteria (rather than taken to landfill). Over a period of around two weeks and with a minimum of additional inputs, these bacteria decompose the waste into methane and CO_2 in a process similar to that of a landfill site. However, in an anaerobic digester, the process is controlled, faster and allows the gas to be captured, purified, compressed and used. The same process can be used to treat both agricultural and sewer waste. This process used to be standard in many waste treatment plants in South Africa, but many of the digesters used are now in a state of disrepair. A recent study suggested that South Africa could produce around three million cubic metres of raw biogas per day near to urban centres, with municipal solid waste making the largest contributions (EcoMetrix, 2015; SACN, 2015).

The municipality of Thekwini has several projects underway to identify clean development mechanisms that produce biogas from landfill sites, waste water and agricultural effluents. Long term viability is even more important than short term gains and these biogas infrastructures will remain important in the treatment of waste and production of energy. In contrast to all other sources of energy, biogas increases with the population, which is important since not only will population and economic growth lead to a rise in energy demand, but it will also contribute to producing waste and to the pressure on waste water (Greben et al. 2009: 1).

South Africa will benefit from international and national support for biogas. Finland, Austria and the United Kingdom have been the main donors to biogas projects in South Africa, while the World Bank and the Development Bank of Southern Africa (DBSA) have also been closely involved in biogas initiatives. The DBSA wishes to provide financial support to pertinent biogas propositions that will take independent power producers (IPP) in South Africa to a bankable stage. The Energy Department possesses the necessary information on the potential of biogas, the legislative landscape and the intentions of

the decisions-makers. Through SANEDI, it carried out research that suggests there are sufficient numbers of potential biomass sources for the production of biogas at a level required for transport. (SACN, 2015.)

TEXT BOX 5

• A GROWING AWARENESS IN CIVIL SOCIETY AND IN THE GENERAL PUBLIC IN FAVOUR OF HYBRID AND ELECTRIC VEHICLES • The use of hybrid and electric vehicles in South Africa, despite the newness of the fleet, demonstrates a rising awareness in civil society and, more generally, of populations experiencing the inconveniences of non-economic and non-environmentally friendly modes of transport such as private vehicles running on petrol or diesel which are still very common.

In 2018, the analysis group Lightstone revealed that only 375 electric vehicles have been sold in South Africa since 2013 (the year electric vehicles were introduced in the national fleet) which represents 0.2% of new registrations over this period. It thus appears that "South Africa is not an early adopter of electric vehicles", compared to Norway, the current world leader with 6.6% of electric vehicles, or 135,000 (Business Tech, 2018).

• LOCAL INITIATIVES WITH STRONG SUPPORT FROM NGOS • The actions of NGOs such as S**ustainable Energy Africa - SEA, World Wildlife Fund - WWF, South Africa Cities Networks – SACN, Greencities, African Association of Public Transport – UATP** and its parent company, **the International Association of Public Transport - UITP, are remarkable in South Africa.** These organizations often take the **role of catalysts in the implementation of sustainable mobility strategies in South African cities.** "*There also exists an emerging non-governmental sector focusing on transport, climate change and the related problems linked to urban design and accessibility, as proven by the* ***Low Carbon Programme on Transport by WWF and the Africa Sustainable Energy Project adopted in many African municipalities all characterised by their desire to promote lower carbon transport systems***" (Cape Town Briefing Paper).

Overview of co-operations between local authorities and NGOs

World Wildlife Fund (WWF) aims to help South Africa transition to a low carbon economy through innovations and transformations. By educating and supporting the South African government, the organization has set an objective to transform the country and ensure that renewable energies are used at 100% by 2050. In its last report published in 2016, an analysis based on two studies ("Attenuation in the Long Term" and "Analysis of Attenuation Potential") allowed the WWF to make the following recommendations to reduce GHG emission in South Africa: (1) increase the use of rail transportation for goods, (2) transfer private car passengers to public transport, (3) increase the occupation rate of vehicles, (4) increase the number of hybrid vehicles on the roads, (5) introduce electric vehicles, (6) improve the efficiency of tourist vehicles, (7) increase the number of private diesel vehicles (which produce less CO_2 than petrol vehicles), (8) progressively substitute petrol and diesel for biofuels.

Sustainable Energy Africa (SEA) is also very active in South Africa. Through various studies, the organization provides guidance to the South African state to support the goal of sustainably reducing GHG emissions. Based on the observation that 18 metropolitan areas and secondary towns in South Africa consume 37% of the country's energy, it recommends introducing concrete actions at a local level to promote reductions in national emissions, especially in the transport sector which is characterised by inefficiency, road congestion and a high reliance on private cars (SEA, 2015).

The African Association of Public Transport (UATP): in Africa, and particularly in South Africa, the UATP is currently playing an important role in promoting public transport. Through forums, conferences and meetings of

decision-makers in the urban transport domain, the UATP makes pertinent recommendations for the introduction of effective urban public transport networks. As an example, we can cite the third congress and exhibition on African public transport held in South Africa in 2014 in collaboration with the road and transport department of Gauteng and the Management Agency of Gautrain. On the theme of "The growth of Africa through an efficient public transport system", over 300 local and international participants, delegates and exhibitors shared their diverse experiences on this subject. In 2015, the 7th AFRICITES summit in Johannesburg allowed the **UATP and African Water Association - AFWA** to produce guidance on the challenges and sustainable solutions for transport, energy, water and sanitation for emerging African cities.

TEXT BOX 6

CONCLUSION

The stabilization of CO_2 emissions from the road transport sub-sector in Africa in the last few years is the result of rising environmental awareness in the central State and local authorities, with the strong support of non-state actors.

However, for all the encouragement it provides, this drive from the state requires more commitments and concrete actions on the challenges faced in terms of reducing greenhouse gases generated by road transport, which is the greatest polluter in the transport sector.

Indeed, the emissions levels of the road transport sub-sector remain high and the potential for reduction is significant.

Also, the question should be raised as to whether, at the current rate of energy transition in the road transport sector and also in terms of individual and collective awareness of the issue, the objective of using 100% renewable energy in the transport sub-sector at the 2050 horizon is in fact feasible.

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Policies for low carbon pathway and role of non-state actors in India

An efficient transport system is crucial for India as it witnesses rising demand for transport services and related infrastructure. As mobility needs of the country are increasing, the subsequent impacts are also intensifying. With road transport sector becoming one of the major contributors towards GHG emissions, air pollution, congestion and several other negative externalities, various policy measures are being implemented to make the sector more efficient. Coordination and collaboration between government policies and actions of non-state actors in the form of awareness campaigns, capacity building initiatives and policy research can strengthen the implementation of these policy measures. To this end, the focus of this study lies on how efforts of non-state actors are aligned towards promoting low-carbon road transport sector in India. We will focus here only on normative and technical developments in road transport, bearing in mind that urban development and the development of public transport remain essential for the stabilization of emissions from the sector.

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CONTENTS

1 • **ROAD TRANSPORT SECTOR : AN OVERVIEW**

2 • **TRANSPORT DEMAND : IMPLICATION ON ENERGY AND EMISSIONS**

3 • **POLICY INITIATIVES TO DECARBONIZE ROAD TRANSPORT SECTOR**

- Electric Mobility
- Improved Fuel Technology Standards
- Move towards Alternative Fuels : Biofuel Policy

1 • ROAD TRANSPORT SECTOR : AN OVERVIEW

Transport plays a vital role in the path of economic development; by moving passenger and goods, it fosters personal & economic growth (United Nations, 2016). Hence, the provision of a safe, sustainable and efficient transport system becomes crucial for a growing economy like India. The transport system in India consists of diverse modes such as rail, road, shipping, civil aviation, inland water transport and pipelines. India has one of the largest and densest roads and rail network in the world and transport in the country is dominated by rail and roads (World Bank, 2011) Transport demand in India is primarily driven by population growth and increase in economic activity. As India's population is expected to exceed that of China by 2024 (UNDESA, 2017), this coupled with increasing industrial and commercial activities will bring about a rapid transition in the way people and goods move.

Over the past few decades, better installed infrastructural capacity, focussed policy and investments have led to rapid expansion of road transport in India (NTDPC, 2014). Road network in India consists of National Highways, State Highways, District Roads, Rural Roads, Urban Roads and Project Roads. National Highway (NH), the principal network connecting metropolitans and major cities has played a pivotal role in the development of road transport sector in the country. **NH constitutes less than 2% of the road network but carries more than 40% of the total traffic volume** (NHAI, 2017).

Road transport sector has always held a dominant share of total traffic flows in the country with the sector currently accounting for 90% of the passenger movement and 67% of the freight movement (MoRTH, 2016). Statistics from the Road Transport Year Book (2016) reveals that between 2005-06 and 2015-16, the total tonne kilometres by road increased at a CAGR of 11% while total passenger kilometres increased at a CAGR of 14% (Figure 1).

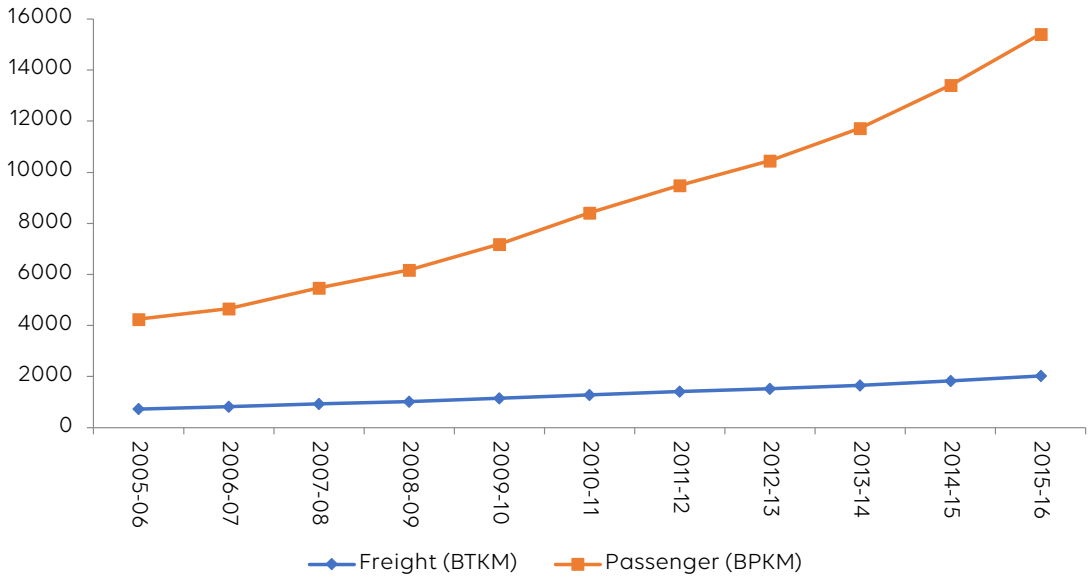

FIGURE 1. FREIGHT AND PASSENGER MOVEMENT BY ROADS

(Source : MoRTH)

Urbanisation is also a key factor that has contributed to rapid motorisation (IUT, CSTEP, 2014). As more and more people have moved to urban areas in search of economic opportunities, the demand for motorised transport has increased. As per the Census data 2011, Indian urban population increased at a rate of 31.8% over the decade and accounted for a share of 31.6% in the total population of the country. Reaching a figure of 230 million in 2016, motor vehicles in India grew at a CAGR of 9.9% between 2006 and 2016 (Figure 2) (MoRTH, 2016). An increase of urban

agglomerations/million plus cities in the country from 35 in 2001 to 51 in 2011 has led to higher proliferation of motorised vehicles in these cities with them comprising 31% of the total registered motorised vehicles in the country. Growth of cities and changing land use pattern has resulted in urban sprawl which has led to increased travel demand. A large share of this travel demand has been met by high ownership of two wheelers and cars which at present account for 86.6% of the total registered vehicles in the country.

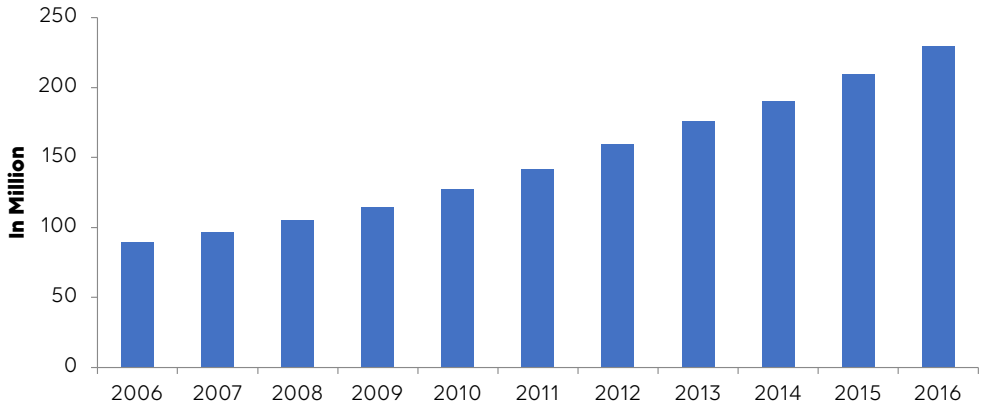

FIGURE 2. TOTAL NUMBER OF REGISTERED MOTOR VEHICLES

(Source : MoRTH)

2 • TRANSPORT DEMAND : IMPLICATION ON ENERGY AND EMISSIONS

Increase in transport demand has made the transport sector as one of the most energy intensive sector in the country. **Presently, the transport sector accounts for 24% of the total energy consumption in the country (TERI, 2018) and 98.5% of which is met by petroleum products (TERI, 2016). India's transport sector accounts for 99.6% of the total petrol and 70% of the total diesel consumption in the country (Nielsen, 2013). As per estimates by the International Energy Agency (IEA), India's transport sector accounts for almost 3% of the total transport sector fuel consumption in the world.** Between 2005 and 2015, India's transport sector fuel consumption grew at a CAGR of 8.3% from 38.8 million tonnes of oil equivalent (MTOE) in 2005 to 86 MTOE in 2015 (Figure 3). While over the same period, the world transport fuel consumption grew at a CAGR of 2% from 2212 MTOE to 2704 MTOE.

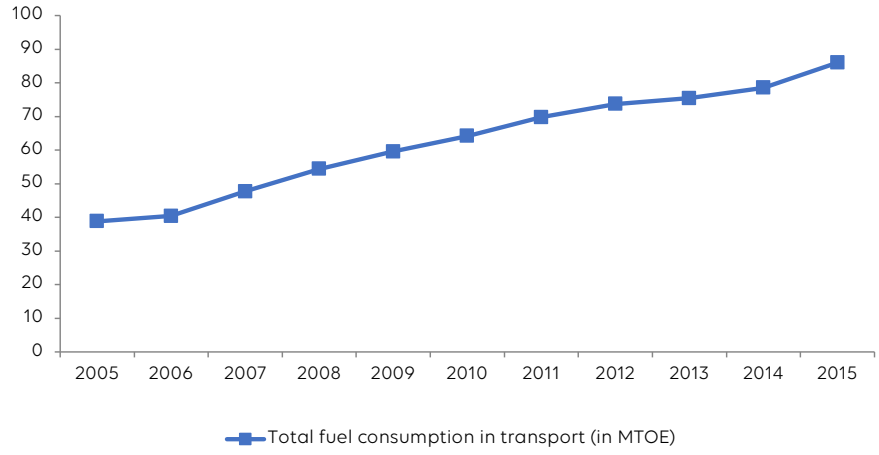

FIGURE 3. FUEL CONSUMPTION BY TRANSPORT SECTOR IN INDIA

(Source : IEA)

In India, transport sector accounts for 10% of the total Green House Gas (GHG) emissions [1] (MoEF,

GoI, 2015). Since, a predominant share of the transport sector's energy requirements are met through conventional fossil fuels like petroleum and diesel, the emission intensity of fuel combustion in the sector has increased from 10.5% in 2000 to 11.5% in 2014 (World Bank, 2018)[2] . **Transport sector in India accounts for 13.2% of the total CO_2 emissions from fuel combustion across sectors in the country, of which road transport accounts for the highest share of 87% (UIC/IEA, 2016).**

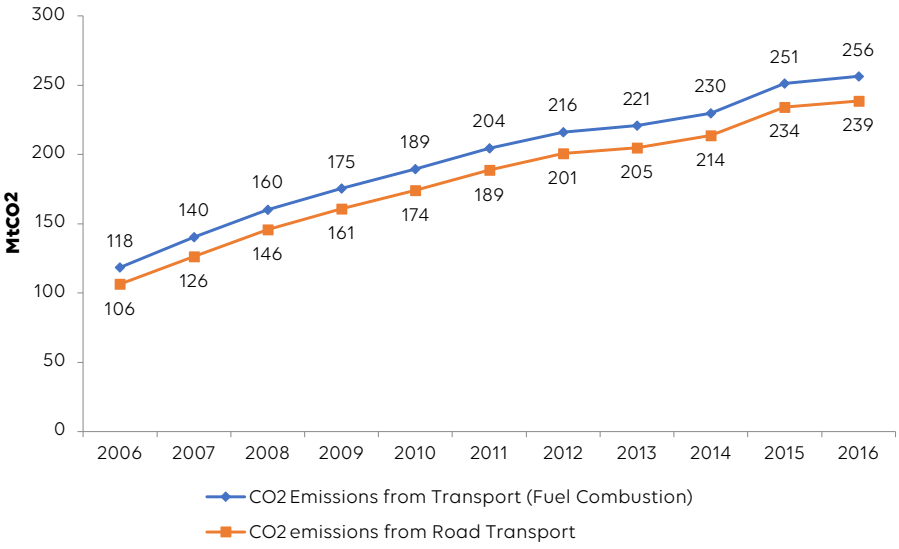

FIGURE 4. CO_2 EMISSIONS FROM FUEL COMBUSTION IN TRANSPORT SECTOR IN INDIA

Source : Enerdata

At the current rate of growth, this manifold increase in road transport demand can have huge implications on the overall energy demand of the sector and the concomitant emissions. India's CO_2 emissions are projected to triple by 2040 from 2013 levels if sectoral policies to manage energy demand are not put in place (Busby & Shidore, 2017). Considering the high reliance of the sector on fuel consumption coupled with India's high import dependence of crude oil (83% of total oil consumption) it is imperative to plan for sectoral policies that can manage fuel and energy demand from the sector in the coming decades and can influence the future carbon emissions (Pal, Singh, Wilson, & Joshi, 2015).

In this context, mitigation and adaptation strategies in the transport sector will play a significant role in achieving the Nationally Determined Contributions (NDCs) targets, which represent a unique opportunity for India to scale down its emissions and energy consumption. Under the NDCs a set of strategies to reduce the emissions intensity of its GDP by 33%–35% below 2005 levels by 2030 has been developed (UNFCCC, 2015). To this end, India is focusing on several mitigation initiatives to develop energy efficient and low carbon transport systems to reduce emissions from the transport sector.

With an objective of promoting energy efficient low carbon growth of the road transport sector, government has introduced several policies and programmes across passenger and freight segments. In terms of fuel quality and vehicle emission standards, India lags behind the international standards (NTDPC, 2014). Hence, the major focus of the policies in the road transport segment is towards improving vehicular technology through the implementation of progressive fuel efficiency norms, emission standards, electrification and bio-fuel blending. Adoption of these policies will lead to significant fuel savings and emission reduction, thereby promoting a low carbon and sustainable future for the road transport sector.

However, in order to realise the vision of a sustainable and low carbon road transport sector an effective engagement of concerned stakeholders is necessary. In this regard, initiatives by

1 - In terms of CO_2 equivalent
2 - Global emission intensity from transport sector decreased from 22% to 20.4% between 2000 and 2014

non-state actors such as Central Road Research Institute (CRRI) a premier national laboratory, and also a constituent of Council of Scientific and Industrial Research (CSIR), engaged in carrying out research and development projects for transport , Automotive Research Association of India (ARAI) a co-operative industrial research association by the automotive industry under the Ministry of Industries, Government Of India, Society of Indian Automobile Manufacturers (SIAM), the apex industry body representing automobile manufacturers in India, other industrial & technological research organisations, corporates and policy think-tanks to cut down emissions are becoming increasingly significant. **While the Government of India has planned a policy roadmap for the sustainable movement of passenger and freight, the successful implementation and adoption of these policies will be significantly determined by the actions and contributions of the non-state actors.** To assess the role of non-state actors in achieving a low carbon pathway for the road transport sector, it is first important to understand the current policies aligned towards achieving it.

3 • INITIATIVES TO DECARBONIZE ROAD TRANSPORT SECTOR

• ELECTRIC MOBILITY • Globally, electric mobility has emerged as one of the most aspiring solution towards the development of sustainable transport solutions. This is primarily due to increasing costs of energy, depletion of fossil fuels and rising emissions (DHI, 2012). Regulatory interventions by governments to promote zero-emission vehicles have also led to the shift towards Electric Vehicles (EVs); with zero tail-pipe emissions and long term economic viability, worldwide EVs are proving to be a favourable alternative technology solution (ASSOCHAM, EY, 2018).

India being a fast growing economy is also experiencing a rapid increase in transport demand for moving people and freight over distances. This increase in transport demand is largely being met by road transport which is highly energy intensive. High demand for petroleum products by road transport sector has subsequent economic, environment and social implications in the form of rising oil import bill, energy costs, depletion of fossil fuels and rising emissions. Hence, faster adoption of EVs is one of the policy interventions that Government of India (GoI) has taken to increase the efficiency of transport sector and to mitigate the adverse economic and environmental impact from the sector.

The history of electric vehicles in India dates back to 1996, when 400 EVs were made and sold by Scooters India Ltd. Bharat Heavy Electricals (BHEL) also developed an electric bus in 2000 and with support from government 200 electric vans were built in Delhi. However, the major leap came in 2001, with the introduction of REVA, an electric car which was more efficient and consistent than the earlier vehicles. The major concerns with respect to mass adoption of electric vehicles were high cost of charging, charging infrastructure, low battery life, etc. (DHI, 2012). Hence, in order to promote the mass and faster adoption of EVs in India, GoI launched the National Electric Mobility Mission Plan (NEMMP) 2020 in 2013 and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME India) scheme under it. As part of the scheme, subsidies were introduced to promote the sales of electric and hybrid vehicles. Till date, the implementation of the scheme has led to 77000 tonnes of CO_2 emission reduction and 31 million litres of fuel savings (DHI, 2018).

Initiatives by Start-ups :

In 2015, in a move to make Bangalore's air cleaner, Lithium Urban Technologies, entered the EV domain. Lithium is a B2B organisation and is India's first electric cab service. With a fleet of 200 vehicles, it saves nearly 11 tonnes of carbon emissions everyday by covering a total distance of 60,000 kilometres. In order to run these pollution free vehicles, the company has also setup 200 high-speed charging stations around the city (The Better India, 2017).

TEXT BOX 1

In order to spearhead the adoption of electric vehicles in India, an investment outlay of INR 795 crore was approved under FAME-I for technology development, infrastructure creation, boosting demand through subsidies and pilot projects (ASSOCHAM, EY, 2018). Government has also selected 11 cities to ensure the penetration of EVs in public transport (Buses, three-wheelers and taxis) for several pilots (PIB, 2015). **The implementation of electric mobility in India is further being expanded by collaborative and coordinated actions of the governments, non-state actors and private sector players. Automobile manufacturers such as Mahindra and TATA through their partnerships with the central and state governments' are facilitating the implementation of policy frameworks**. To support the eMobility awareness campaign of the State of Karnataka, Mahindra Electric (pioneer of electric vehicles in India) along with Baghirathi Group (shared mobility service provider) deployed a fleet of 50 electric cars with an additional investment announcement of INR 400 crore over five years. With an aim to promote low carbon, zero emission and sustainable mobility solution, the Baghirathi Group also plans to deploy 1000 Mahindra electric cars for corporate mobility (Mahindra & Mahindra Ltd., 2018). In a similar move towards reducing the country's carbon footprint, Tata Motors signed a MoU with the state of Maharashtra in India to support the state's EV Policy. As a part of the collaboration, Tata will deploy 1000 EVs across passenger and commercial segment and will also setup 100 EV charging stations in the state (Tata Motors, 2018) (ET, 2018).

Apart from the private vehicle segment, government is also introducing EVs in multi-modal public transport. **In 2017, Nagpur became the first city in India to launch the electric mass transport project in India. The pilot was launched in collaboration with Mahindra Electric, Kinetic Green Energy and Power Solutions and Ola.** A fleet of 200 electric vehicles was procured, out of which Mahindra Electric manufactured the 100 'e20' electric taxis and Kinetic Green Energy and Power Solutions supplied 100 e-rickshaws and Ola, a cab aggregator provided the service platform for running the vehicles. Ola also built four charging stations having 53 charging points to power the fleet of 200 e-vehicles (live mint, 2017).

In 2018, Centre for Study of Science, Technology and Policy (CSTEP) which is a private policy think tank along with support from Shakti Sustainable Energy Foundation (SSEF) developed an e-bus fleet implementation plan for Bengaluru. As a part of the study, a detailed route analysis was conducted to identify suitable routes for installing Electric Vehicle Supply Equipment (EVSE) and charging infrastructure. An analysis of transport and electricity distribution was also carried out along with Bangalore Metropolitan Transport Corporation (BMTC) and Bangalore Electricity Supply Company (BESCOM) (CSTEP-SSEF , 2018).

Eco-friendly Intermediate Public Transport (IPT)

In a move to bridge the gap of first and last mile connectivity e-rickshaws were launched by the Delhi Government in the year 2010. Since then, e-rickshaws have gained tremendous popularity in the city and have increased from 4000 units in 2011 to 0.1 million units in 2015 (CEED, 2017). In order to further promote the uptake of these battery-operated vehicles, Delhi Government has also initiated the process of providing subsidies of INR 30,000 to drivers for retrofitting the old vehicles and registration of vehicles (ET, 2016).

TEXT BOX 2

• IMPROVED FUEL TECHNOLOGY STANDARDS • Globally, one third of the oil demand and around 50 per cent of all the transport related GHG emissions are accounted by passenger cars, two-wheelers, three-wheelers and light commercial vehicles (ICCT, 2018). Growth in road-based transport makes energy management in the transport sector a challenging task (AITD, 2000). Hence, adoption of vehicle based norms can play a crucial role in determining the future energy demand of

any country. Considering the fact that demand for automobiles in India will remain strong and will subsequently impact country's energy security and climate mitigation strategy, the Government of India through its Auto Fuel Policy has recognised the importance of regulatory measures such as fuel economy norms and progressive emission standards (Ministry of Heavy Industries & Public Enterprises, 2018).

• Fuel Efficiency Norms

In April 2017, Ministry of Road Transport and Highways (MoRTH) came up with first set of fuel economy norms for Light Duty Vehicles (LDVs) in passenger segment. These standards are based on Corporate Average Fuel Economy (CAFE) norms and define the targets in terms of fuel consumption in litre/100 km. In order to ensure compliance, these standards are converted into CO_2g/km for petrol, diesel, Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) passenger vehicles with Gross Vehicle Weight (GVW) under 3.5 tons. The policy will lead to continuous reduction in CO_2 emissions through setting the efficiency standards for new vehicles at 130g/km in 2017 and 113g/km in 2022 for every automaker (TransportPolicy.net). **As India is expected to have highest number of cars on road in the world by 2050 (SSEF) and with rapidly increasing sales, India is presently the fourth largest automobile market in the world (ET, 2018)**. In view of the fact that India's future transport demand will be largely driven by cars, the efficiency standards for LDVs are expected to reduce CO_2 emissions by 50 million tons by 2030 (UNFCCC, 2015) and will achieve energy savings of 22.97 MTOE by 2025 (BEE, 2017). However, to achieve significant impacts, energy demand management of the remaining modes of passenger and freight segment also need to be addressed simultaneously, (AITD, 2000). Apart from this, it is also expected that India's demand for High-Speed Diesel (HSD) will increase from 76 million metric tonnes (MMT) in 2016-17 to 110.8 MMT in 2021-22. Since 38% of this demand is accounted by commercial vehicles, an absence of regulatory measures in this segment of vehicles can have serious implications on India's energy security (Nielsen, 2013).

Considering that Heavy Commercial Vehicles (HCVs) account for more than 50% of the CO_2 emissions from road transport in India, several research entities are focussing on the regulatory framework for fuel efficiency norms for HCVs. The Energy and Resources Institute (TERI) undertook a study to develop pathways for the adoption of fuel efficiency in HCV sector in India. The study exhibits several methodologies to formulate fuel efficiency standards and also identifies various technologies available for improving the fuel efficiency. The aforementioned study was carried out with support from SSEF which works collaboratively with policy makers, think tanks, civil society and industry and aids in designing and implementation of energy efficient and cleaner transport policies.

• Emission Standards

On- Road vehicles are a key contributor to air pollution in the country. Pollutants like Carbon Monoxide (CO), Hydrocarbons (HC), Oxides of Nitrogen (NOX) and Particulate Matter (PM) emitted by vehicles not only increase the local air pollution but also significantly impact the health of the people. In order to reduce the vehicular air pollution, emission standards were instituted in India by the Government of India.

The first set of mass emission limits were implemented in 1991 for petrol vehicles and in 1992 for diesel vehicles, which were gradually made stringent during 1990s. In the year 2000, India 2000 norms were implemented for passenger cars and commercial vehicles which were equivalent to Euro I norms (DieselNet). In 2001, Bharat Stage II (Equivalent to Euro II) norms were implemented for all the vehicles in cities of Delhi, Mumbai, Chennai and Kolkata (SIAM). The National Auto Fuel Policy (2003) laid out the roadmap for nationwide implementation of Bharat Stage II (BS II) norms by 2005 and of BS III (equivalent to Euro III) along with implementation of BS IV norms in 13 cities by 2010 (PIB, 2015). In 2015, the draft Auto Fuel Policy and Vision 2025 recommended the roadmap for implementation of BS IV norms across the country in a phased manner and it further envisaged

advancing the introduction of BS VI norms by 2020 by leapfrogging the BS V norms (SIAM). The implementation of BS IV was a major step towards addressing the issue of extremely high levels of pollution across Indian cities. The implementation reduced the limit on sulphur content in petrol and diesel to 50 ppm from 150 and 350 ppm respectively. With the implementation of BS VI norms by 2020, it is expected to further reduce sulphur content up to 10 ppm for both diesel and petrol vehicles (TransportPolicy.net).

Emission from vehicles is majorly determined by factors like vehicular technology, fuel quality, inspection & maintenance of in-use vehicles and road & traffic management. In order to control and regulate these factors a multi-agency approach is necessary. While the task of setting up the emission standards is carried out by the Ministry of Road Transport and Highways (MoRTH) in India; the enforcement happens through industrial stakeholders like Society of Indian Automobile Manufacturers (SIAM), the apex industry body in the country which represents the leading vehicle and vehicular engine manufacturers in India and several industrial research associations.

• MOVE TOWARDS ALTERNATIVE FUELS : BIOFUEL POLICY • As India is going through demographic dividend its energy demand is also increasing. The existence of strong correlation between energy consumption and economic growth is highly reinforced by the critical role that energy plays in the socio-economic development of the country. Given the fact that a significant share of India's energy demand is met by fossil fuels which are highly polluting and non-renewable it is important to give impetus to renewable resources which are indigenous, non-polluting and inexhaustible (National Policy on Biofuels, 2018).

Due to India's high dependency on fossil fuel based energy sources, energy security is also a key area of concern. Road transport sector which contributes 6.7% to India's total GDP accounts for the highest share of this energy consumption. The limited domestic production of crude oil in India has led to a rising import dependency with India currently importing 82% of the crude oil (National Policy on Biofuels, 2018). In order to address these concerns Government of India announced the National Biofuel Policy in 2009 and was further amended in 2017 to increase the targets and has been named as National Policy on Biofuels-2018.

The policy aims to increase the penetration of biofuels (derived from renewable biomass resources) in the energy and transportation sector of the country. As the production of biofuel will mainly rely on domestic feedstock, this substitution for fossil fuels will subsequently promote energy security, climate change mitigation and will create additional employment opportunities for farmers and cultivators in a sustainable manner. **At present, ethanol blending in petrol is around 2% and biodiesel blending in diesel is less than 0.1%.** The policy proposes to achieve the target of 20% ethanol blending in petrol and 5% biodiesel blending in diesel by 2030. As the major thrust area of this policy is to ensure generation of biofuels from indigenous feedstock, Government plans to create a National Biomass Repository by conducting assessment of biomass and feedstock samples across the country. (National Policy on Biofuels, 2018)

Effective implementation of the biofuel programme is largely dependent upon active participation from the central and state governments, farmers, industry and professionals. **With an assured policy support from the central government, several public and private sector industries are generating biofuels. Pune based Praj Industries Limited has developed technology to produce ethanol by utilising agri-waste like sugarcane trash, rice and wheat straw, etc. The process is based on techno-socio-commercial model as farmers are getting better prices for their produce and the agri-waste which was traditionally burnt for household cooking is being utilised sustainably.**
In Assam, a joint venture between Numaligarh Refinery Limited, a public sector enterprise and Chempolis Oy, a Finnish technology firm plans to produce 60 million litres of ethanol every year by using bamboo. In addition to this, several of the Indian oil companies are investing in biofuel refineries to increase the production of ethanol from non-molasses sources and to promote the green-fuel use.

Cultivator's and Farmer's Perception of Biodiesel

Sugarcane molasses is the main source for ethanol production and oil from jatropha & other oilseeds is used for biodiesel production. It has been observed that promotion of biofuels is dependent on various factors among which feedstock supply and management is the key issue at local level. To understand the feasibility scenario of Jatropha cultivation, Integrated Research and Action for Development (IRADe) and IT Power India Pvt Ltd undertook an analysis based on surveys conducted in 41 villages of Rajasthan and Orissa.

In Rajasthan, enthusiastic participation was observed from farmers for Jatropha cultivation. The State has initiated several programmes for supporting the plantation. Additionally, many private sector companies are also promoting farming through contracting farmers.

In Orissa, farmers have taken up cultivation of Jatropha on their waste lands without compromising on the growth of the plantations. Several Self Help Groups (SHGs) have also been established in the process. It was observed that in both the states the additional economic benefits from the use of waste land have been the driving force for the cultivation. Please give reference to the below table somewhere in the text.

	Analysis of Survey Data : Farmer's Perception for Choosing to Plant Jatropha	
Reasons for Planting Jatropha	Rajasthan	Orissa
Economic Benefit	92%	96%
Best Use of Wasteland	54%	77%
Low Inputs Requirement	77%	-
Support from local organisations	-	32%
Protection from cattle not required	46%	-

Source : (IRADe, IT Power India Pvt Ltd., 2011)

TEXT BOX 3

CONCLUSION

To counter the trend of increasing fuel consumption and rising emissions along with meeting the national commitments, a set of policy measures is being implemented by the Indian government in the transport sector. However, in order to ensure that these policy measures are effective in decarbonizing the road transport sector, it is important to build a holistic approach for confirming strong implementation and compliance of various policy goals. To this end, a multi-stakeholder approach which includes contribution and actions from civil society, corporates, think tanks and other public and private actors through decentralised action can play a crucial role in bringing down emissions from road transport sector.

PLEASE DO NOT HESITATE TO REACT TO THIS STUDY, AND NOTIFY US COMPLEMENTARY REPORTS AND DATA VIA THIS ADDRESS : CONTRIBUTION@CLIMATE-CHANCE.ORG

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Stabilization of road transport emissions in the country of ethanol

Brazil's attenuation target is a 37% reduction in national GHG emissions by 2025 and 43% by 2030 compared to the 2005 baseline. While the country's main efforts are focused on increasing the share of renewable energies in the energy matrix, achieving zero deforestation and recovering 12 million hectares of forests in the Amazon, the challenge is also important in the transport sector: diesel and petrol account for 75% of the energy consumption of the sector and forecasts predict that transport-related GHG emissions will be 45% of the national total in 2025 (Waycarbon, 2018). This chapter analyses the factors explaining the evolution of emissions in the transport sector and the various actions in progress.

Head editor • **GHISLAIN FAVÉ** • *Consultant*

CONTENTS

1 • **RECENT STABILISATION OF EMISSIONS**

2 • **URBAN MOBILITY UNDERGOING TRANSFORMATION**

The crisis of public transport

Urban mobility plans, instruments of low-carbon mobility

3 • **FUELS: BETWEEN SUCCESSES AND CHALLENGES**

Ethanol fuel: the brazilian model

Dependence on the road freight and on diesel

Emergence of biodiesel

1 • RECENT STABILISATION OF EMISSIONS

Driven by the reduction in illegal deforestation, Brazil has seen a 28% reduction in its emissions over the 2008-2014 period (see Figure 1). However, in 2015 and 2016, GHG emissions increased by 12.3%, driven by the resumption of illegal deforestation. **Transport sector emissions increased by 40% over the 2008-2014 period and stabilised in 2015 and 2016 at around 190 million tonnes of CO_2eq, i.e. the same level as in 2012.**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Transport domestique (hors aérien)	144	150	147	164	179	196	203	209	193	194
Total national	2,682	2,807	2,003	1,925	1,927	1,947	2,107	2,022	2,091	2,278

FIGURE 1. EVOLUTION OF CO_2EQ EMISSIONS IN TOTAL AND IN THE TRANSPORT SECTOR IN BRAZIL (MILLIONS OF TONNES).

Source : From the databases of the SEEG (System for Estimates of Emissions and Removal of Greenhouse Gases), 2018

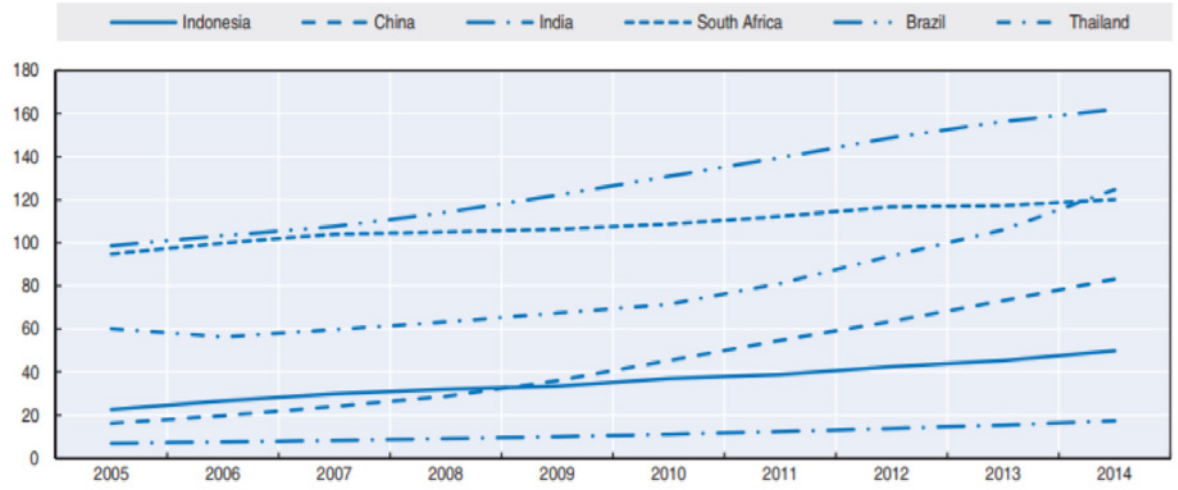

FIGURE 2. EVOLUTION OF THE RATE OF MOTORISATION IN SELECTED DEVELOPING COUNTRIES

Source : ITF Transport Outlook, 2017

Strong economic growth rates in emerging economies have led to a rapid rise in motorisation rates, and it is no different in Brazil, with growth of 60% between 2005 and 2014 (see Figure 2). This has been particularly significant in Brazil where economic growth between 2001 and 2015 led to a large part of the population on low incomes moving up into the middle class. In addition, this dynamic has been reinforced by the encouragement of the Brazilian government for the motorisation of households to support the automotive industry, which is important for the country's economy. Thus, in 2008, during the global financial crisis, the state reduced taxes on industrialised products (IPI); this measure was renewed in 2012. Other factors, such as easier access for households to credit and financing for new cars, also contributed to this growth in individual motorisation. According to the production and sales statistics released by the ANFAVEA (National Association of Motor Vehicle Manufacturers), the total volume of sales of new vehicles in Brazil increased from 1.4 million vehicles in 2002 to 3.8 million in 2012, a growth rate of 11.5% per year (ANFAVEA, 2015). These elements make it possible to understand the major increase in GHG emissions from the transport sector between 2008 and 2014, from 150 to 209 million tonnes of CO_2eq (see Figure 1).

The economic crisis that Brazil has been experiencing since 2015 largely explains the recent stabilisation of emissions in the transport sector. Thus, GDP fell by 3.8% in 2015 and 3.6% in 2016,

which is reflected in the GHG emissions of the Brazilian energy sector: over this 2015-2016 period, emissions in the energy sector fell 7.3% (SEEG, 2016). Further proof of the effect of the current crisis on transport sector emissions is the 30% drop in new car sales between 2012 and 2015 (PwC, 2016).

If the recent stabilisation of transport sector emissions appears above all cyclical, we should try to analyse the main drivers of these and identify the strengths and weaknesses of the sector in Brazil.

2 • URBAN MOBILITY UNDERGOING TRANSFORMATION

• THE CRISIS OF PUBLIC TRANSPORT • Brazil's economic growth since the 1950s has been accompanied by rapid urbanisation: while only 45% of Brazil's population was urban in 1960, more than 80% of Brazilians were living in cities in 2010 (IBGE, 2010). This rapid urban growth has been shaped by automobiles and structured along major highways. The ex-nihilo creation of the federal capital Brasilia in 1960 is the perfect example: its ambitious urban plan was conceived based on the car, as a symbol of this era when the car was presented as the only solution to urban travel.

This powerful urbanisation was accompanied by a rise in property prices and property speculation, which pushed the poorest populations in marginal areas further and further away, all the more so as informal housing was increasing. Transport infrastructures struggled to keep pace with this urban sprawl and transport times became considerably delayed, prompting people to turn increasingly to individual methods of motorisation to cope with their travel needs.

The response from municipal, regional and federal governments is, in most cases, investment in infrastructure, which may include an ever-growing car fleet, to the detriment of public transport, which is confirmed by analysis of the evolution of the index of passengers per kilometre on the urban bus network. **The figures provided by the Associação Nacional das Empresas de Transporte Urbano on the cities of Belo Horizonte, Curitiba, Fortaleza, Goiânia, Porto Alegre, Recife, Rio de Janeiro, Salvador and São Paulo, show a 38% drop in this index between 1994 and 2015, a reflection of a public transport system that can no longer attract Brazilians.**

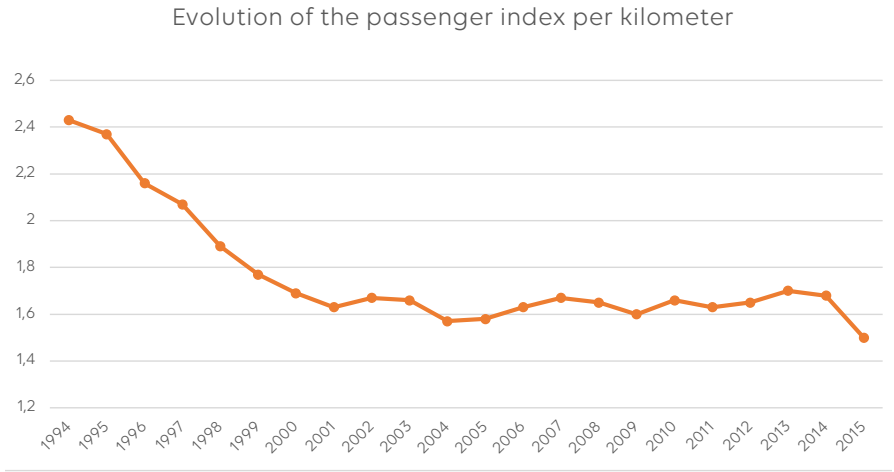

FIGURE 3. EVOLUTION OF PASSENGER INDEX PER KILOMETRE BETWEEN 1994 AND 2015 IN THE CITIES OF BELO HORIZONTE, CURITIBA, FORTALEZA, GOIÂNIA, PORTO ALEGRE, RECIFE, RIO DE JANEIRO, SALVADOR AND SÃO PAULO.

SOURCE: Based on data from the Associação Nacional das Empresas de Transporte Urbano (NTU)

Alternate traffic in São Paulo

São Paulo, a megalopolis of more than 12 million inhabitants and the economic heart of Brazil, is frequently plagued by traffic jams. According to a study by the specialised firm INRIX, the inhabitants of São Paulo spent an average of 86 hours per year in traffic jams in 2017, i.e. the 4th city in this study, which covers 1360 cities. On average, traffic congestion totals 300km per day in this metropolis, at an estimated cost of 69.4 billion reais or 7.8% of local GDP, according to a technical study published in July 2014 by Firjan.

In order to improve the situation and especially to reduce air pollution, from 1997 the city introduced restrictions on traffic in the extensive centre of the city: the rodizio. Every working day, based on the last number on their number plate, traffic is prohibited between 7am and 10am and between 5pm and 8pm in the city centre. The rodizio, by removing 20% of the vehicles from traffic, initially led to lower congestion and atmospheric pollution. The results are now more mixed: the vehicle fleet has grown by 40% since the establishment of this measure, especially because many people have acquired a second car with a different registration, to escape the rodizio.

TEXT BOX 1

One of the consequences of this crisis in the demand for urban public transport and the increase in the motorisation rate is the deterioration of urban air quality, and high GHG emissions linked to the transport sector in Brazilian cities. Thus, urban transport represents 68.2% of the emissions of the city of São Paulo (municipal inventory 2011), 57.6% in Belo Horizonte (municipal inventory 2015) and 54.5% in Recife (2015). By comparison, the transport sector accounts for around 26% of GHG emissions in European cities (Covenant of Mayors in Figures: 8-year assessment, 2017). This greater share in Brazilian cities is also linked to the low carbon intensity of the electrical energy consumed in Brazil and, consequently, to the lower share of the energy sector in municipal emissions. Even though the car ownership rate is still growing strongly and is much lower than in other countries, the trend is towards growth of urban transport in GHG emissions, which represents the biggest challenge in terms of mitigation for Brazilian cities: the city of Recife predicts that emissions associated with transport will account for 75% of the city's emissions in 2040, if the current trend continues.

Mobilisation of civil society

At the beginning of 2013, following the announcement of an increase in bus fares, demonstrations broke out at the call of the Movimento Passe Livre, a movement calling for free public transport. Soon, these events spread to the whole of Brazil, mobilising up to one million people and the demands extended to education and health, along with criticism of the expenses related to the organisation of the 2014 World Cup. Following this unprecedented mobilisation, urban mobility became the symbol of these public policies that struggle to meet the expectations of the population.

TEXT BOX 2

• URBAN MOBILITY PLANS, INSTRUMENTS OF LOW-CARBON MOBILITY • In April 2012, the law establishing the Política Nacional de Mobilidade Urbana (National Urban Mobility Policy - PNMU) came into force. It stipulates that towns with more than 20,000 inhabitants must produce their Urban Mobility Plan (UMP), in way that is integrated with their master plan, within three years. Previously, only cities with more than 500,000 inhabitants were under this obligation; with this new law, there are now 1663 municipalities that must submit a UMP, otherwise they will no longer be able to receive federal funds intended for urban mobility (CODATU, 2015).

The PNMU defines public transport and active modes as priorities for cities, instead of individual motorised transport. It provides guidelines for sustainable urban development: the development of cycle lane networks and bus lanes, restriction of vehicle traffic at certain times, pricing of public parking, etc. To fight against air pollution and against GHG emissions, the law also provides for the control of the level of emissions, the introduction of pollutant emission limits, and traffic restrictions if thresholds are exceeded. This law, contrary to the reduction in vehicle taxes renewed in 2012 by the federal government, stimulated the transformation of urban mobility in Brazil.

Fortaleza, the latest Brazilian example of sustainable mobility

Fortaleza, the 5th largest city in Brazil with a population of almost 3 million, has been transforming urban mobility since 2014: prioritising active modes and public transport (development of 108km of bus lanes, modernisation of bus terminals, refurbishment of the fleet with air conditioning and wifi), 225km of cycle paths (240% growth in the last 5 years), a shared bike programme integrated with the public transport system, the launch of a pilot programme of shared electric cars and traffic calming initiatives. **The results are already measurable: road mortality has been reduced from 14.66 per 100,000 in 2014 to 9.71 in 2017, the shared bike system is now the most used in Brazil, and on some bus routes, journey times have been halved.** With these actions, the city aims to reduce its emissions by 20% in 2030 compared to developments if current trends continue. These achievements have brought international recognition to Fortaleza, with the "Sustainable Transport Award" being awarded to the city in 2018 by the ITDP.

TEXT BOX 3

TransCarioca, the heritage of the Rio de Janeiro Olympics

As a result of Rio's commitment to hosting the FIFA World Cup and the Olympic Games (2014 and 2016 respectively), the city has been the focus of major investments in transport infrastructure, including the development of a network of 150km of BRT (Bus Rapid Transit) lines. The TransCarioca, a 39km line inaugurated shortly before the World Cup, is the main legacy of these events. With a cost of about $550 million and 75% funding from the BNDES, the national development bank, the TransCarioca connects Barra da Tijuca district, where most of the sports facilities of the Olympics were concentrated, in the southern districts of the city, with Rio International Airport.

FIGURE 4. MAP OF THE BRT TRANSCARIOCA

SOURCE: Rio de Janeiro City Councilo

Today, approximately 320,000 passengers use the line every day and nearly 500 buses have been removed from traffic, reducing travel times, congestion and GHG emissions. This line crosses many more disadvantaged neighborhoods of the northern area of the city and provides a major development opportunity for this region.

TEXT BOX 4

3 • FUELS: BETWEEN SUCCESSES AND CHALLENGES

• ETHANOL FUEL: THE BRAZILIAN MODEL • The production of ethanol, from the fermentation of sugar contained in sugar plants such as sugar cane, has been developed in Brazil for many years, but it is since the oil shocks of the 1970s that its use as a substitute to gasoline has intensified. In response to the rise in oil prices, Brazil, then increasingly dependent on oil imports, implemented in 1975 the Programa Nacional do Álcool (National Alcohol Programme) - PROALCOOL. Support measures for the production of fuel ethanol were taken: enhanced credit for investments and price setting. **The sector benefited from the very strong responsiveness of economic actors with massive investments in fuel ethanol production units and the launch of hydrated alcohol vehicles**

(operating only with ethanol) by all car manufacturers. The programme was very successful with the production of 5.6 million ethanol vehicles between 1975 and 2000. It is estimated that this programme prevented the emission of 110 million tonnes of carbon equivalent over the same period (EPE, PNE 2030).

The early 2000s saw the emergence of productivity gains in both the agricultural and industrial sectors, as well as the emergence of flex-fuel engines that work equally well with gasoline, ethanol, or a mixture of both (in 2003, the first flex-fuel model, the Volkswagen Gol flex-fuel). Today, all car manufacturers offer flex fuel models, which accounted for almost 90% of light vehicle sales in 2015 (EPE, 2015). These factors led to a sharp increase in fuel ethanol consumption between 2003 and 2009, reaching a peak in 2009 of more than 100 million tonnes of oil equivalent (MMA, 2014). Over the 2009-2012 period, ethanol fuel lost market shares: it was more profitable to produce sugar than ethanol, investments in the means of production were reduced, and the price of petrol fell and became more competitive. In fact, over these three years, the share of fuel ethanol in the energy matrix of passenger transport declined from 33% to 22% (SEEG, 2018). The increase in the compulsory fraction of anhydrous alcohol in petrol (now 26%) has helped recover consumption growth and in 2016, ethanol accounted for 29% of energy consumption in the passenger transport sector (SEEG, 2018).

With this success, is Brazil continuing to develop its fuel ethanol sector and is now resisting the electrification of its car fleet: **despite the enormous potential for reducing emissions that this technology represents, especially since the electrical matrix in Brazil is clean with more than 68% hydropower (EPE, 2018), ethanol is defended by the entire productive chain and the federal government.** The Transport and Urban Mobility Sector Plan for climate change mitigation plans for a penetration of only 3% of hybrid gasoline vehicles in 2021, while the consumption of fuel ethanol would reach 52 billion litres in the same year.

Biofuels are often criticised for their environmental impacts, mainly due to land use changes induced by their production. In some regions, for example, growing production accelerates deforestation and increases the price of food. Attentive to maintaining the forest-fuel-food balance, the Brazilian government established the zoning of sugar cane in 2009, delineating 70 million hectares for its cultivation. The northern region of Brazil is excluded from this zoning as the planting of sugar cane in the Amazon basin is prohibited. Brazil does not lack space to develop a sustainable ethanol sector, the demarcated area being 10 times larger than the area needed for production in 2020. The largest production areas are concentrated in the Centre-South region and their growth does not threaten the Amazon rainforest. In these areas, expansion of sugar cane cultivation is

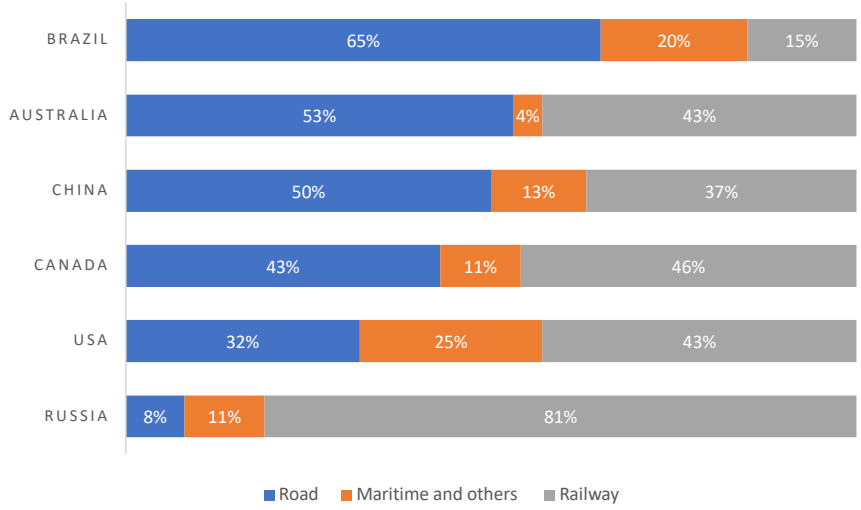

FIGURE 5. MODAL DIVISION OF FREIGHT TRANSPORT IN CONTINENTAL-SIZED COUNTRIES IN 2015.

Source : SEEG, 2018.

mainly on degraded or abandoned pastures and does not compete with food production. On the other hand, the remarkable Cerrado and Mata Atlântica biomes could be subject to strong agricultural pressure (Feres et al., 2011).

• DEPENDENCE ON THE ROAD FREIGHT AND ON DIESEL • While the rail network was developed at the beginning of the 20th century, it was gradually replaced by a road network during the post-war period, partly to promote the growth of the car industry. **The transport of goods is today heavily dependent on road transport, which accounted for 65% of freight in 2015, much more than in other continental-sized countries like Brazil (see Figure 5).**

Trucks are essential for regional freight transport in Brazil and diesel is the most consumed fossil fuel, accounting for 53% of transport sector consumption in 2005 (PNE 2030, 2007). As a result, freight transportation is a major source of GHG emissions, not only in the transportation sector but throughout the energy sector. According to SEEG's analysis, in 2016, road transport emitted 101.9 $MtCO_2eq$, i.e. half of the emissions from the transportation sector and one-fifth of the emissions associated with the energy sector, more than the total emitted by power plants in the same year (54.2 $MtCO_2eq$).

In addition to this environmental cost, this predominance of road transport represents a high economic cost for the Brazilian production chain. The National Logistics Plan (2007) thus designates the transport of goods as one of the main factors limiting the country's competitiveness, as the current matrix prioritises the highest cost modes. A better balance of freight transport modes is therefore needed.

The Plano Nacional de Mudança do Clima (National Climate Change Plan or PNMC) emphasises the importance of reducing the volume of transport by HGV and of a shift towards less carbon-intensive modes such as rail and river transport. Despite this understanding, this modal shift requires major investments and the migration will be slow: roads in Brazil will remain the dominant mode in the transportation of goods. Between 1999 and 2008, the truck fleet increased three-fold (ANFAVEA, 2009) and the National Energy Plan 2030 forecasts a growth of 3.5% per year of diesel consumption over the 2005-2030 period.

Mobilisation of truck drivers and the diesel crisis

From 2011 to 2015, the Brazilian government artificially controlled the price of petrol and diesel fuel at the pump, with the main aim of controlling inflation and avoiding consumer price instability caused by high volatility of international tariffs. This policy heavily indebted Petrobras, the national oil company, and therefore ceased in 2016. Petrobras began to index its prices on those of oil and the dollar. Following the rise in the price of a barrel and the rise of the dollar against the Brazilian real, the price of diesel at the pump increased significantly in 2018, provoking the anger of truck drivers who went on strike in May 2018. The country, which is highly dependent on road transport, was paralysed as many cities faced shortages of food and fuel. Faced with the difficulty of transporting goods, some international airports were affected, and cancelled flights due to a lack of kerosene. A state of emergency was declared in many cities and the army received the order to free up the highways. After 11 days of strike action – the biggest strike in the sector in the history of Brazil – the Temer government yielded, announcing an immediate reduction of 0.46 reais in the price of a litre of diesel, based on a reduction in taxes on diesel at 0.10 reais per litre as well as direct subsidies in the amount of 0.30 reais per litre. The government estimates that these two measures will respectively represent a shortfall of 4.01 billion reais in 2018 and a cost of 9.5 billion reais.

TEXT BOX 5

• EMERGENCE OF BIODIESEL • Si l'éthanol biocarburant est fortement implanté au Brésil, les débuts du biodiesel sont plus timides. La compagnie nationale Petrobras, après avoir investi dans des usines biodiesel, n'a jamais atteint le seuil de rentabilité et a même enregistré des pertes record entre mai et juin 2015, totalisant 304 millions de réais. En 2016, elle a annoncé son retrait progressif de l'activité, fermant l'une de ses principales unités de production.

L'augmentation de la part de biodiesel dans le diesel a un potentiel de réduction des émissions considérable et est l'une des stratégies du Brésil pour atteindre ses objectifs d'atténuation. Dans le document *"Fundamentos para a elaboração da Pretendida Contribuição Nacionalmente Determinada (iNDC) do Brasil no contexto do Acordo de Paris sob a UNFCCC"*, le Ministère de l'environnement définit l'objectif d'une fraction de 10 % de biodiesel dans le diesel (diesel B10) d'ici 2030.

Cities invest in low-emission buses

Beyond this government objective, cities and manufacturers are already undertaking a more ambitious transformation, starting notably with low-GHG urban bus programmes. In 2012, the city of Rio launched a pilot programme of urban buses running on 30% biodiesel. São Paulo has also initiated a B20 bus project called "Ecofrota" (a mixture of 20% biodiesel). The most ambitious programme comes from the city of Curitiba which, in partnership with Volvo and the Swedish government, is being equipped with hybrid buses with biodiesel engines.

TEXT BOX 6

CONCLUSION

The recent stabilisation of transport sector emissions at the 2012 level is more the result of the current economic crisis in Brazil than of pro-climate actions. It will be interesting to observe the evolution of the sector's GHG emissions as the country recovers economic growth. Many initiatives are under way to decarbonise transport, at the federal level in terms of biofuel, but also at the municipal and civil society level; will these actions reverse the emissions curve?

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Air transport: efforts are still in the state of experimentation

With regard to climate change, air transport has two major characteristics. First, a strong growth in emissions that the technological and organisational progress is currently unable to contain. Second, international air transport has been excluded from the climate negotiations and the sectors covered by the United Nations Framework Convention on Climate Change (UNFCCC). The file was entrusted to the International Civil Aviation Organization (ICAO) that brings together the dominant players in the sector (manufacturers, airlines). This resulted in a proposal for the long-term management of air transport emissions: the CORSIA scheme for "*Carbon Offsetting and Reduction Scheme for International Aviation*".

Head editor • **JEAN PAUL CERON** • *Associate expert on climate and energy policies of TEC – Member of the IPCC*

SUMMARY

1 • AIR TRANSPORT EMISSIONS ARE STEADILY INCREASING

2 • INSTITUTIONAL AND POLITICAL RESPONSIBILITY FOR AVIATION EMISSIONS: THE ICAO PROPOSAL

- The scheme
- CORSIA
- The position of the players when facing large offset systems
- Sweden, the pioneer in taxation on flightss

3 • VOLUNTARY OFFSET SYSTEMS

- Voluntary offset put in place by airlines in support of labelling
- Tour operators also rely on voluntary offset labelling

4 • TECHNOLOGICAL CHOICES

- Engines
- Biofuels
- Airports

1 • AIR TRANSPORT EMISSIONS ARE STEADILY INCREASING

When calculating emissions from the air transport sector, international transport emissions (530 million tonnes of CO_2 equivalent in 2015, i.e. approximately 60% of the total) and those from domestic transport (345 million tonnes of CO_2 equivalent or 40%) are always differentiated. The temporal dynamics of these emissions are the result of the growth of air transport and the improvement of its energy efficiency.

	2015
international aviation	
World	529.69
Europe	136.08
France	17.78
National aviation	
World	345.44
Europe	18.98
France	3.64

TABLE 1. DOMESTIC AND INTERNATIONAL AVIATION EMISSIONS IN 2015 (MTCO2E)

Source: International Energy Agency (IEA), Enerdata

International aviation is a driver of emission growth. Between 1990 and 2015, its emissions increased by 104.6% worldwide, 88.1% in the European Union and 88.8% in France (AIE, 2017, p.109). **At the global level, emissions from domestic aviation are growing three times slower than international aviation emissions (+ 15% between 2000–2017) (Enerdata)**

In Europe, these emissions remained stagnant and even decreased in France by 13% between 2000 and 2016 (source Enerdata), probably because of the increased use of the high-speed rail. The European Union accounts for 26% of international aviation emissions and 5.5% of domestic aviation emissions, which is easily explained by the small size of the member countries. France accounts for 13% of European emissions from international aviation and 19% from domestic aviation, which reflects both the lower propensity to travel abroad (tourist trips) compared to the countries of Northern Europe and the size of the country (1,000 km of diagonal distances across the "Hexagone"), favouring certain domestic links by plane.

	Unit	2015	2016	2017
European Union		**$MtCO_2$**	**18,9757**	**19,8323**
North America	$MtCO_2$	172.8483	179.9023	188.1661
Latin America	$MtCO_2$	15.5112	14.6124	14.5108
Asia	$MtCO_2$	94.0161	101.2096	103.9358
Pacific		**$MtCO_2$**	**10.1798**	**10.9321**
Africa	$MtCO_2$	8.4273	8.1547	8.3436
Middle-East	$MtCO_2$	4.0618	4.117	4.0657
World	$MtCO_2$	345.4379	359.9141	371.7467

TABLE 2. DOMESTIC AVIATION GREENHOUSE GAS EMISSIONS BY REGION

(Source: Enerdata)

The radiative forcing of aviation

The figure of aviation's contribution to anthropogenic CO_2 emissions of around 2% is frequently put forward; it can be discussed for two reasons:

- An alternative calculation results in less optimistic figures. According to the International Energy Agency, in 2015 aviation accounted for 7.5% of world oil consumption, or 288 Mtoe (excluding ground fuel use). By multiplying it by the Base Carbone ® coefficient of Ademe (3,642 tCO_2/toe) which includes emissions from extraction, transport and refining, we obtain a figure of 1,049 million tonnes of CO_2, i.e. 3.2% of global fuel emissions (32,294 million tonnes in 2015). In addition to CO_2, aviation produces in-flight nitrogen oxides that are not greenhouse gases but are the precursors of ozone, which is a potent greenhouse gas with a short life span on the one hand, and on the other hand, it contributes to the destruction of methane, which has the opposite effect of cooling. The net result is a warming effect.

Especially, at very high altitudes, planes produce contrails that can turn into cirrus clouds. These clouds are formed at very cold temperatures (-40°) in very high humidity and are also dependent on the dust emitted by the combustion of kerosene(Kärcher, 2018). The issue of their contribution to global warming has long been known (Penner, Lister D.H., Griggs D.J, Dokken D.J, & M., 1999); existing evaluations show that this contribution is important, but they present a very high margin of uncertainty. This was the pretext for excluding this issue from the discussions on aviation's contribution to climate change, thereby minimising its impact.

However, it should be noted that cirrus clouds have a short life span: if the flights stop, the effect disappears within 24 hours unlike CO_2 whose life span is one hundred years or more. There are ways of reducing cirrus clouds, the main one being the reduction of combustion dust (the use of biofuels could be useful in this respect), which could decrease the formation of these clouds ten-fold (Kärcher, 2018).

The estimate by a group of researchers (Lee et al., 2009) shows an aviation contribution to global warming of 4.9% in 2005 (with a 90% probability of being placed between 2% and 14%).

TEXT BOX 1

2 • INSTITUTIONAL AND POLITICAL RESPONSIBILITY FOR AVIATION EMISSIONS: THE ICAO PROPOSAL

• THE SCHEME • The UNFCCC has excluded international air transport emissions from targets set for the countries because of the difficulty in allocating them. National emissions may be included in the voluntary national contribution (Art. 31)[1] . Already in 1992, the Kyoto Protocol specified that Annex I countries should continue to limit emissions of gases not covered by the Montreal Protocol. The International Civil Aviation Organization (ICAO) has been in charge of the file since 1998 in addition to its usual tasks (management of conventions between countries, security, etc.) However, there is a clear gap between the UNFCCC's mission to reduce greenhouse gas emissions and ICAO's mission to protect and promote international aviation (Lyle, 2018).

By the end of the Kyoto Protocol period (2012), ICAO had made little progress in establishing mechanisms for managing international aviation emissions. It set targets: a voluntary energy efficiency improvement of 2% per annum and carbon-neutral aviation growth from 2020 consisting in the use of economic tools, technological and organisational progress and the use of alternative fuels. In parallel with ICAO, the International Air Transport Association (IATA) had a fairly similar outlook with an emission reduction target of 50% in 2050 compared to 2005 levels (Bows-Larkin, 2015). **Starting in 2013, ICAO began to clarify its intentions: to use a market mechanism and tradable emission permits, biofuels and to set new technical standards for aircraft starting in 2016.**

During this period, the European Union advocated for territorialised measures and eventually included aviation in its emission trading system (EU-ETS).

Failure of the European ETS against the opposition from China and the United States

The inclusion of aviation in the European emission trading system (EU-ETS) entered into force in 2009. The global allocation for European Union internal and external air transport was then set at 95% of the average emissions for the 2004–2006 period. All flights departing and arriving within the European Union were taken into account.

In 2009, airlines and airline associations based in the United States and Canada brought forward an action for the annulment of the United Kingdom's transposition of the EU Directive. The English court referred this to the Court of Justice of the European Union (CJEU), and the Advocate General of the CJEU gave unfavourable conclusions to the airlines in early October 2011. Far from easing tensions, these conclusions foreshadowing a defeat for the airlines have raised the tension even more: two weeks later, the House of Representatives passed a bill prohibiting US airlines from complying with European regulations. In early November 2011, the International Civil Aviation Organization (ICAO) Council adopted a position urging the EU and its member states to refrain from including airlines based outside the EU in the EU-ETS. This was a move that triggered a strong reaction from Connie Hedegaard, the European Commissioner for Climate, and the Association of European Airlines (AEA) who lamented a disappointing political position. China and India have also vigorously opposed the inclusion of aviation in the European carbon market, denouncing the political and economic decision against them. However, the Chinese Academy of Social Sciences, while recommending Chinese airlines to take legal action against the EU, also urged them to limit their CO_2 emissions by using biofuels, improving the efficiency of engines and optimising airlines. As a result of these pressures, the field of application of the EU-ETS was restricted to flights within the European airspace and the allocation was reduced accordingly. 82% of emission permits were distributed free of charge, 15% auctioned and 3% allocated to a reserve for new operators on the market. For the reasons

1 - At COP 21 in Paris, the part of the text relating to air and maritime emissions was withdrawn during the negotiations. This issue therefore continues to be managed by ICAO. However, the climate negotiations have taken a bottom-up approach, with the countries setting their contribution via the "INDC", quite in opposition to the top-down approach of ICAO consisting in developing standards to be applied by all parties.

of compatibility, the European Community has proposed the indefinite retention of flights from or to the European Economic Area outside of the EU-ETS, which results in a shortfall in reducing emissions of approximately 1/3. In addition, for intra-European flights, the Community proposed to align the requirements for aviation with those of other sectors, which amounts to a reduction in permits of 2.1% per year from 2021.

TEXT BOX 2

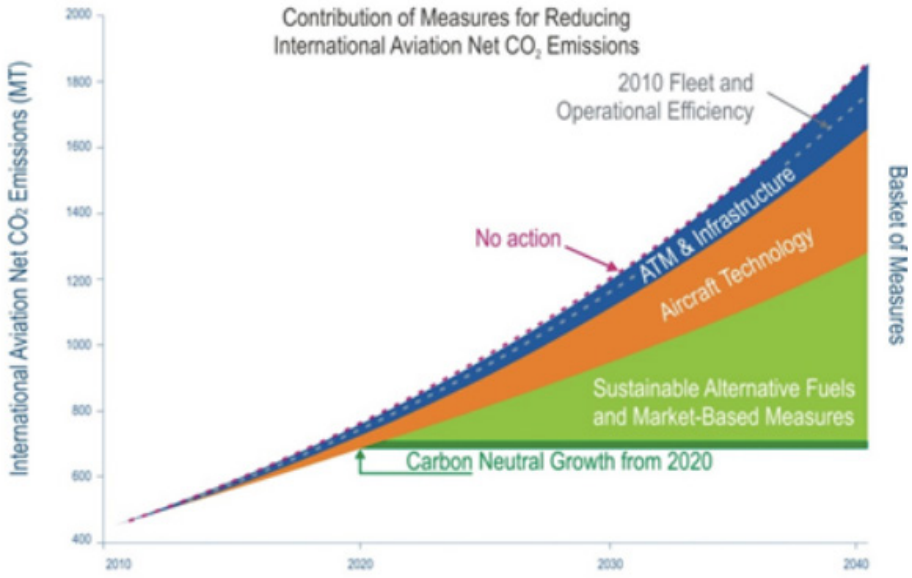

FIGURE 1. AO'S VISION FOR REDUCING EMISSIONS

Source: ICAO, 2013

The emissions estimated by ICAO in its forecast of the distribution of measures for the reduction of net CO_2 emissions due to international aviation are those of the airlines for each journey they make. In particular, this principle results in circumventing the principle of "common but differentiated responsibilities" between countries fundamental in international climate negotiations but contradictory to the equal treatment by ICAO. The responsibility for monitoring, reporting and verification (MRV) of the international airlines rests with the individual countries. Beyond MRV, an important carbon offsetting and reduction scheme (CORSIA) is being carried out by ICAO which plans to keep a consolidated register.

• CORSIA • In October 2016 after several years of discussions, the air transport sector signed a future emissions management plan called CORSIA (Carbon Offset and Reduction Scheme for International Aviation) developed by the Committee on Aviation Environmental Protection (CAEP) composed of country representatives and private sector experts who play a leading role (Lyle, 2018). CORSIA is a global scheme of market-based measures designed to offset CO_2 emissions from international aviation in order to stabilise their levels starting in 2020 (CNG2020). The draft standards and recommended practices (SARP) and related guidance material form the "CORSIA Package" to help offset CO_2 emissions through aircraft operators acquiring and cancelling emission units from the global carbon market.

For this, every three years, ICAO member countries participating in CORSIA must verify that their aircraft operators comply with the CORSIA offsetting requirements in addition to the MRV of annual CO_2 emissions. The plan includes a pilot phase starting in 2021 until 2023 and a first operational phase from 2024 until 2026. These two phases rely on the voluntary participation of the countries. Finally, there is a phase of full application from 2027 until 2035 including all countries whose individual share of international aviation activities in 2018 is greater than 0.5% of the world

total or whose cumulative share accounts for 90% of the world total. **The least developed countries, small insular developing countries and landlocked developing countries are exempted from this scheme unless they voluntarily join it. These numerous ICAO exemptions mean that this agreement to reduce emissions from the international aviation sector ultimately cover only approximately 75% of emissions(Lyle, 2018, p.110).**

Calculation procedure for emission offsets required from operators under the CORSIA system

The quantities of CO_2 to offset is calculated according to the following formula:
Annual emissions of operator x, growth factor = amounts of CO_2 to be offset
The growth factor in this equation changes each year according to the growth of emissions of each sector and each operator. The growth factor is calculated by ICAO based on the percentage increase in the quantity of emissions from the base year to a given future year. This calculation of the offsetting requirements to be allocated to the different airlines will go through different phases. Over the 2021–2029 period, this factor will be indexed only on the growth factor of the emissions from the sector. The objective is to gradually move to a factor calculation based solely on the evolution of emissions of the operators.
After this calculation, the operator reports on the use of sustainable airplane fuels during the compliance period. The government therefore deduces the benefits of using sustainable aviation fuels and informs the operator of its final offset requirements for the compliance period. Finally, the operator submits a validated emission unit cancellation report to the government that it verifies by informing ICAO.

Source: ICAO, Presentation of the CORSIA scheme, 2018

TEXT BOX 3

The position of the European Union concerning the ETS system was first to wait for the implementation of the international CORSIA management plan and to take timely measures to adapt to it. An assessment of the effects of CORSIA for the European Economic Area accompanied the study of the implementation of the EU-ETS. The following table shows the main features of CORSIA and EU-ETS; it highlights the gap in ambition and the problems of compatibility between the two systems.

CORSIA	EU ETS
Unlimited growth	Scalable ceiling
Nothing on emissions below the 2020 level	Total coverage of emissions, with a "temporary" exclusion of aviation to or from locations outside Europe
Partial coverage of emissions (exceptions)	
Completely based on offsetting	Excludes offsetting starting in 2020
Offsetting criteria currently unknown	List of what cannot be retained as offsetting
Voluntary until 2027	Binding
Absence of sanctions	Financial penalties

TABLE 3. DIFFERENCES BETWEEN CORSIA APPROACH AND EU EMISSION TRADING SCHEME

Source: Adapted from Carbon Market Watch, 2017

Similar to the EU-ETS, the establishment of the CORSIA system is questionable. There are many differences of opinion between ICAO and other non-state actors on the subject of reducing emissions from the international aviation sector, which shows the complexity of the positions of each of the actors with regard to the possible actions

• THE POSITION OF THE PLAYERS WHEN FACING LARGE OFFSET SYSTEMS • Manufacturers and airlines intervene through various associations whose aim is to provide expertise in the debate on methods to reduce CO_2 emissions in the aviation sector. The main associations are ATAG and ACARE[3] on the manufacturers side and IATA for airlines. These actors have certainly played a decisive role in the rather opaque development process of the ICAO proposals, and they absolutely adhere to a strategy of using biofuels and an offsetting system for the remaining emissions. Their communication highlights expected technological and organisational changes. For example, they state a 75% reduction in passenger CO_2 emissions by 2050 compared to 2005 levels (source ACARE)[4]. An objective to be adhered to in the context of increased development of global air traffic. In fact, in October 2018 IATA planned a doubling of global air traffic by 2037.

However, according to the 2016 Carbon Market Watch annual report, CORSIA's maximum contribution to the reduction of aviation emissions is estimated to be 0.3 GT of CO_2 equivalent per year, while the extra emissions from the sector should be around 0.6 GT in 2030 compared to 2017 levels. The International Coalition for Sustainable Aviation (ICSA)[5] published a report in February 2018 entitled "*Understanding the CORSIA scheme: a critical guide to the key provisions of the draft standards and recommended practices and related guidance material for the carbon offsetting and reduction scheme for international aviation (CORSIA)*", in which it gives a critical opinion on the implementation of this system and on several elements of its functioning.

First, it considers that CORSIA's monitoring, reporting and verification (MRV) system as proposed in the CORSIA Package is not transparent enough. For ICSA, allowing third parties to access reports on emissions submitted by airlines would help to ensure the environmental integrity of CORSIA and avoid market distortion by deterring any preferential treatment of transport companies. In addition, the coalition suggests that ICAO refrain from awarding credits to alternative aviation fuels under CORSIA as long as the provisions on sustainable aviation fuels including sustainability criteria have not been strengthened. According to ICSA, these strict and comprehensive sustainability criteria should be included in the final implementation elements of CORSIA before the launch of the 2021 pilot phase.

• SWEDEN, THE PIONEER IN TAXING FLIGHTS • In Sweden, a law passed on 30 November 2017 introduced an aeronautical tax starting on 1 April 2018. The Swedish government requires airlines to declare and pay tax on all commercial flights departing from Sweden, chartering aircraft with more than 10 seats. The tax rate depends on the final destination of the passenger: €6 to continental Europe, €25 to countries outside Europe (Middle East, Africa, USA, Central Asia), and €40 to other countries. The law provides for exemptions for children under 2 years of age, crew members on duty, flights following a technical stop, flights returning to the airport for weather reasons or following a mechanical failure.

The consequences of introducing this tax were very quickly felt. **On 1 October 2018, the Swedish transport agency lowered its air traffic forecasts for 2018 and 2019 by 500,000 passengers compared to the forecasts published in the spring of 2018. The number of passengers departing from Swedish airports should therefore only increase by 1.3% in 2018, totalling 23.7 million passengers, and 2.3% in 2019 (totalling 23.9 million passengers)**. External traffic is expected to increase, while domestic traffic is expected to decrease. The Swedish transport agency has attributed the relatively small

3 - https://www.acare4europe.org/sites/acare4europe.org/files/document/volume1.pdf
4 - https://www.acare4europe.org/documents/delivering-europe%E2%80%99s-vision-aviation-sria-2017-update
5 - The ICSA is comprised of the Aviation Environment Federation (AEF), Carbon Market Watch, Environmental Defense Fund (EDF), the International Council on Clean Transportation (ICCT), Transport & Environment, and WWF.

increase in the number of passengers to the Swedish air transport tax, which came into force in April 2018, and the bankruptcy of Nextjet, the main regional airline, which has led to a reduction in supply, particularly in the domestic aviation market. Moreover, following the implementation, the airlines reacted strongly via IATA, warning that in the short term, this tax would cause the loss of 7,500 jobs in Sweden and would have a negative impact on Sweden's economic competitiveness, with the sector currently accounting for 4% of the GDP and 240,000 jobs in the country. It should be noted that IATA did not refer to the 1944 Chicago Convention, the reference document for the regulation of international air traffic which gave rise to the creation of ICAO, stating that the fuel contained in the tank of an airplane cannot be taxed upon arrival in a country. This agreement is regularly used to prevent any taxation of kerosene.

3 • VOLUNTARY OFFSET SYSTEMS

Environmental protection NGOs and small companies specialising in sustainable development consulting are seeking to produce and sell "carbon credits" to companies not covered by the Kyoto Protocol. **This market mechanism is called a voluntary carbon offset market. These promoters are therefore seeking companies in various sectors that do not have a legal obligation to invest in offset services for their GHG emissions (Valiergue, 2018).** Some of them even extend their proposals by promoting categories of projects not listed by the UN as potentially producing carbon credits, for example selling improved ovens or distributing water filters. Establishing this voluntary offset market is based on the implementation of various systems and practices that monetise these carbon offsetting services. As such, many economic players implement support services for voluntary carbon offsetting by customers during their purchases, particularly in the tourism and aviation sector.

• VOLUNTARY OFFSET PUT IN PLACE BY AIRLINES IN SUPPORT OF LABELLING • Ryanair offers customers the option to check an option when buying their ticket to *"donate to offset the carbon footprint of my flight and contribute to other environmental initiatives"*. Meanwhile, Air France sends an email to customers after a flight to promote its "*Trip and Tree*" initiative. Consumers can also choose to go directly through private organisations or specialised NGOs to monetarily offset the carbon emissions of their travels. The principle is always the same: after calculating the carbon equivalent of the trip, the total is converted into a sum of money which the passengers can pay to an association of their choice who will use it to plant trees, for example. Labelling becomes an essential tool so that the consumers can find their way around the multitude of offsetting offers.

Evaluation differences in calculating the offsetting needs when buying a plane ticket

As part of a news story, in October 2018 the French newspaper Libération tried a test ticket purchase for a direct ticket between Paris and Cape Town, South Africa, on several platforms integrating calculators. It is deduced that a passenger in economy class consumes:

- The equivalent of 932 kg of carbon if we trust the Air France calculator;
- 1.735 tonnes according to the German atmosfair.de, which also considers the aircraft model;
- 1.8 tonnes of CO_2 according to myclimate.org;
- 1.98 tonnes according to CO_2solidaire.org, climatmundi.fr and greentripper.org;
- 2.05 tonnes on GoodPlanet.org (the Yann Arthus-Bertrand foundation);
- 2.31 tonnes based on CO_2balance.com;
- On the website of the French Ministry of the Environment (MTES) (Directorate General of Civil Aviation), Cape Town is not listed as a destination. However, a consumption of 891 kilograms of CO_2 equivalent is indicated for a flight between Paris and Johannesburg (South Africa).

In conclusion, the various calculators differ by a multiple of 2.5 in their consumption estimate for the same flight, which adds to the uncertainty as to the effectiveness of the voluntary offsetting actions, and it causes a loss of readability for consumers.

Source: Libération, 20/10/2018

TEXT BOX 4

An operator's membership in an international label therefore appears as more beneficial. Commonly recognised as the most successful, the Gold Standard was created in 2003 at the initiative of international NGOs WWF, SouthSouthNorth and Helio International. It is considered to currently guarantee the best traceability of offsetting projects. Other labels also position themselves as references, such as the "VCS" created in 2006 and adopted by Caisse des Dépôts for the creation of its carbon credit registry in March 2009.

In addition to the labels, project selection remains paramount. For example, reforestation projects are highly controversial, to the extent that Climat Mundi (a consulting firm specialising in supporting economic and institutional players in integrating climate issues and emission reduction into their development policies) is refusing to finance it. Currently, the two main problems are the difficulty of evaluating the amount of carbon stored in a forest and the diachrony between CO_2 emitted by humans and effective offsetting by a forest of at least thirty years.

• TOUR OPERATORS ALSO RELY ON VOLUNTARY OFFSET LABELLING • Tour operators are also mobilising to promote voluntary offsetting to their customers. The ATR (Acting for Responsible Tourism) label, entirely renewed in 2015, wanted to open up to major operators demonstrating that sustainable tourism should not be confined to a niche. Until now, the airlines were invited to determine their annual carbon footprint based on the choice of offers offered to their customers. To go further, the management of the ATR label has announced a proposition that starting in the second half of 2018, 100% of the emissions from airlines shall be offset. The argument put forward by the label is that it seems indispensable that instead of asking for voluntary offsetting from their customers, the airlines themselves must be proactive on the issue. Some companies already operate with this change such as the travel agency Les Ateliers du Voyages (Travel Lab group), which has the ATR label, which for example, on the occasion of the World Responsible Tourism Day on 2

June offset the carbon of all the trips sold that week. This approach was based on a partnership with the CO_2 Solidaire platform of GERES that was launched in 2004 and is currently serving four project leaders (GERES, Initiative Développement, Microsol and Bleu-Blanc-Cœur) with the aim of offering carbon credits with high social quality and direct distribution.

Impact of the development of global tourism on the aviation sector

A study published in May 2018 in Nature Climate Change (Lenzen & al., 2018) states that tourism is responsible for approximately 8% of global GHG emissions. Between 2009 and 2013, the carbon footprint of the sector at the global level increased from 3.9 to 4.5 billion tonnes of CO_2 equivalent considering transport-related emissions and also those resulting from the consumption of goods and services by tourists and business passengers. Given the estimated strong growth of the world tourism sector corresponding to +7% over 2017, the authors of this study conclude that tourism will continue to constitute a growing share of global GHG emissions in the coming years and therefore will increase travel needs, especially air travel. Most of these emissions come from high-income countries because of domestic travel (supported by the development of low-cost domestic flights) but also because of their nationals traveling abroad.

TEXT BOX 5

Other tour operators were also interested in the subject in the early days, such as the Voyageurs du Monde company. Since 2007, the tour operator has offset 100% of its employees' emissions and up to 20% of those of its customers with reforestation programmes through the "*Insolite Bâtisseur Philippe Romero*" foundation. Since 1 January 2018, the group has gone even further by covering 100% of the CO_2 emissions generated by air and ground transport for each trip made by Voyageurs du Monde and Terres d'Aventure. In total, this measure costs approximately €500,000 per year for Voyageurs du Monde and €200,000 for Terres d'Aventure. This is an important choice for the two companies which will replace voluntary offsetting on the part of their customers, which they consider to be inefficient. Others have developed hybrid offsetting systems: 50% of the amount of the carbon offset is provided by customers, and the tour operator pays the remainder to finance energy-efficient tools and equipment in developing countries in partnership with NGOs and local associations. The tour operator Double Sens has implemented this system of traveller commitments in its projects from 2017 and gained interesting results with 30% of travellers participating in the voluntary offsetting process.

4 • TECHNOLOGICAL CHOICES

As part of the preparations for the COP 21 in Paris in 2015, aircraft manufacturers made commitments alongside the world's major airlines to significantly reduce the CO_2 emissions due to the engines from their production lines. **In a letter of commitment issued by the Air Transport Action Group (ATAG), 28 leaders of the main commercial aviation manufacturers, engine manufacturers and airline trade groups and airports have pledged an annual 1.5% improvement in global fleet energy efficiency, carbon-neutral growth from 2020 and a 50% reduction in CO_2 emissions by 2050 compared to 2005 levels.** To comply with this roadmap, manufacturers and companies are working on three major axes: reducing the weight of planes, new engine technologies and alternative fuels instead of kerosene. Developments in airport infrastructure and companies' directives for ground crews also make it possible to participate in the effort of the sector.

• **ENGINES** • Aircraft construction companies, particularly the two largest companies worldwide – Airbus and Boeing – rely on a series of engine manufacturers. Two major competing companies

– one French-American (CFM International) and the other American (Pratt & Whitney) – compete for the world market. Their numerous collaborations, notably with Airbus, resulted in 2016 in the delivery of 68 A320neo aircraft including the first model with LEAP-1A engines delivered to the Turkish company Pegasus Airlines.

With the A320neo, Airbus gained a 15% reduction in fuel consumption per seat as soon as it was commissioned and 20% by 2020 compared to the current A320 model. As a result, CFM International's engine gives the operators a two-digit improvement in fuel consumption and CO_2 emissions compared to the best CFM engines in service, as well as a reduction in nitrogen oxide emissions and noise pollution. CFM International, the 50–50 joint venture between General Electric (GE) and Safran, has planned to deliver approximately a hundred LEAP engines in 2016, then 500 in 2017 and 1,200 in 2018.

There were more than 11,100 orders and purchase intentions for the LEAP engine at the end of July 2016 (compared to 8,400 GTF from P&W in mid-December). According to the manufacturers, the set of used technologies will lead to an optimisation of the operating conditions combined with the reliability and low maintenance costs of the CFM engines. According to Safran, they will allow greater fleet availability, increased longevity and will help reduce costs and maintenance operations.

The era of hybrid electric engines opens for the aeronautical sector

A hybrid electric propulsion aircraft will fly in 2020. This commitment was made in December 2017 in a tripartite agreement between Airbus, the engine manufacturer Rolls-Royce and German company Siemens. This cooperation completes the agreement planned in April 2016 between Airbus and Siemens to develop hybrid electric engines for airplanes, helicopters and drones by 2020. Industrialists are relying on a project called E-Fan X to design a plane that is less dependent on fossil fuels in order to meet the global objectives of reducing CO_2 emissions. This programme replaces the E-Fan, a two-seat aircraft equipped with a 100% electric engine which Airbus had abandoned in March 2017.

Within this project, along with Airbus responsible for the global integration of the hybrid propulsion system and batteries, Rolls-Royce will develop the turbine engine, the two-megawatt generator and the power electronics. Siemens will supply the electric motors and their electronic power control unit as well as the inverter, the DC/DC converter and the power distribution system.

The E-Fan X aircraft is scheduled to fly in 2020 after a full set of tests on the ground. It will be a BAe 146 test aircraft with one of the four reactors replaced by a two-megawatt electric engine. Subsequently, arrangements will be made to replace a second turbine with an electric engine once the maturity of the system has been demonstrated, as specified by the three manufacturers involved.

Source: Airbus Newsroom, 2017

TEXT BOX 6

• **BIOFUELS** • During the preparations for the Paris climate agreement, aircraft manufacturers have highlighted the importance they attach to biofuels, potentially reducing CO_2 emissions by 50 to 80% compared to fossil fuels, with the establishment of "*sustainable aeronautical biofuels*"

sectors. **In the context of mass utilisation of biofuels, industry players and ICAO member countries have identified a set of measures for the deployment of sustainable alternative fuels of the "drop-in" type** (fuels with a chemical structure analogous to fossil fuels facilitating their incorporation in large quantities). The integration of alternative fuels in the pilot phase of the CORSIA carbon offset system in 2021 is already planned. Moreover, in the next version of the Renewable Energy Directive expected in 2018, Europe plans to integrate the aviation sector into the ENR8 objectives of the transport sector. Meanwhile at the end of 2017, the French government signed a public/private partnership in the form of a commitment for green growth (ECV) about establishing a sustainable aerospace biofuels sector in France from waste biomass.

Based on the first test of an airplane that flew on biofuel in 2008, IATA launched its Sustainable Aviation Fuel (SAF) programme in 2011 expecting that 100,000 flights would be flown using biofuel by 2017 and that approximately one million flights would be affected in 2020. Eventually, the projection leads to 1 billion passengers potentially travelling on biofuel flights in 2025. Achieving this goal assumes the creation of many bilateral commitments between producers and airlines and sometimes also manufacturers in the coming years. **Since the first partnership was declared in 2009, these commitments have multiplied and counted 28 in total between 2010 and 2015 involving regional stakeholders** (IATA, 2015). The flight of Hainan Airlines on 21 November 2017 was made using biofuel manufactured by the local unit of Sinopec Group, a Chinese petrochemical company. China made its first transoceanic flight from Beijing to Chicago using green fuel and carrying 186 passengers and 15 crew members. The Boeing 787 aircraft flew on biofuel produced from used cooking oil supplied by China Petroleum and Chemical Corp., a subsidiary of Sinopec Group based in Ningbo, Zhejiang Province. The manufacturer and the company welcomed this success; however, the biofuel used in this case was composed of only 15% cooking oil and 85% conventional aviation fuel.

Although a number of airlines have signed biofuel purchase agreements, the results do not match the ambitions envisioned by IATA. Based on $51 to $55 per barrel of fossil fuel, the use of biofuel accounted for an additional cost of approximately 27% for airlines in 2017 (US Department of Energy, 2017).

The SAS and Preem agreement for the use of biofuel

In Sweden, SAS, an airline, and Preem, an oil company, have signed a letter of intent for an agreement to produce and use renewable aviation fuel. SAS aims to replace the current domestic aviation fuel volume with biofuels by 2030. This letter of intent notifies that SAS and Preem intend to collaborate to jointly produce biojet (renewable aviation fuel or biofuel) as part of the planned expansion of Preem's capacity at the Göteborg refinery. The preliminary start of production will begin in 2022, and the total capacity of biofuels is estimated at over one million cubic metres of which a subset can be biojeted on the plane.

TEXT BOX 7

In order to boost the development of the initiatives, the ICAO secretariat published a very large-scale proposal for the use of biofuels ahead of its top-level conference on alternative fuels in Mexico from 11 to 13 October 2017. **The proposal involves 5 million tonnes of biofuels per year used by airplanes by 2025 corresponding to 2% of projected aviation fuel use; 128 million tonnes per year used by 2040 representing 32% of projected aviation fuel use; 285 million tonnes per year used by 2050 corresponding to 50% of projected aviation fuel use. However, beyond the quantities of production and consumption, the quality of the biofuels used is an important issue not only in terms of fuel efficiency but also in terms of environmental impact and reduction in the use of conventional fossil fuels**. Six aeronautical biofuels are already certified by ASTM (*American Society for Testing and Materials*) for use in combination with fossil kerosene, and several new technologies are being

certified.

Les technologies biocarburants aéronautiques certifiées ASTM en juin 2018. Source : ANCRE

Technologies certifiées	Ressources biomasses	Taux de mélange certifié	Maturité technologique	Principaux acteurs impliqués sur l'ensemble de la chaîne (dont industriels et acteurs R&D français)
HEFA (1) Hydrotraitement d'huiles	Huiles végétales, huiles usagées, graisses animales, huiles microbiennes	50 % vol.	**TRL9** : Technologie mature dont usine Total en cours d'ouverture à la Mède (France)	**Axens, Total,** IFPEN Neste (Finlande, Pays-Bas, Singapour), UOP-ENI (Italie, USA)
HEFA (1-bis) Hydrotraitement d'huiles	Idem HEFA (1) en coprocessing avec des résidus du raffinage	5 % vol.	**TRL9** : Technologie mature	Idem HEFA (1)
FT-SPK (2) Gazéification & Fischer-Tropsch	Biomasse lignocellulosique	50 % vol.	**TRL8** : Fin du programme R&D BioTfueL en France en 2019	**Bionext (BioTfueL),** IFPEN, CEA, **AVRIL** BELT (Canada), Fulcrum (USA), RedRock (USA), Velocys (USA)
FT-SPK (2-bis) + aromatiques	Biomasse lignocellulosique	50 % vol.	Démontré sur ressources fossiles **TRL7** à partir de biomasse	Idem FT-SPK (2)
SIP (3) Farnesane par voie biologique	Sucres issus de plantes sucrières, Sucres lignocellulosiques	10 % vol.	**TRL9** :Technologie mature à partir de canne à sucre au Brésil, **TRL4** : R&D sur voie lignocellulosique	Amyris (Brésil) en partenariat avec **Total et Airbus** pour l'importation
ATJ (4) iso-butanol ou éthanol	Sucres issus de plantes sucrières, Sucres lignocellulosiques	50 % vol.	Technologie mature pour la production d'alcool, **TRL7** sur la chaîne complète, **TRL4** à démontrer sur biomasse lignocellulosique	GEVO, Lanzatech, Byogy (USA) Ethanol lignocellulosique : **Procethol2G (Futurol),** INRA, IFPEN, **ARD, Lesaffre**, Biochemtex (Italie), Clariant, Poet-DSM (USA), Praj (Inde)

(1) Hydrotreated Esters And Fatty Acids ; (2) Fischer-Tropsch - Synthetic Paraffinic Kerosene ; (3) Synthesized Iso-Paraffins ; (4) Alcohol To Jet.

FIGURE 2. ASTM CERTIFIED BIOFUEL TECHNOLOGIES AS OF JUNE 2018

Source: ANCRE, June 2018

In its report from October 2017, the NGO Biofuelwatch warned about the economic and environmental sustainability of the massive use of ASTM-approved biofuels (Biofuelwatch, 2017). Among these, HEFA is an aviation fuel derived from refined hydrotreated vegetable oil, involving the use of hydrogen (HVO process). It is a special type of HVO for aviation that is slightly different from HVO diesel used as fuel for the road sector. In its report, Biofuelwatch pointed out that HVO fuels, and specifically HVO diesel fuels, experience a huge increase in production. The NGO fears that this new market will create a growing demand for vegetable oils and especially palm oil. **Exponential increate in the use of HVOs in aviation under the pretext of reducing carbon emissions from the sector could thus provoke an additional massification of oil palm cultivation, leading to further deforestation – current surfaces cannot suffice to satisfy all demands for food and fuel**.

• AIRPORTS • Faced with the challenges of reducing the carbon emissions of the sector, airports also make commitments to support the necessary transition. According to the UNFCCC, there were 250 airports in 68 countries in October 2018 (out of 3,864 commercial airports worldwide) with climate change commitments and 44 of them already achieved climate neutrality as part of the Airport Carbon Accreditation programme run by the Airports Council International (ACI). 48 airports joined the programme in the 12 months leading to May 2018 – an increase of 25% from the previous year. In total, this covered 3.3 billion passengers last year, which represents 44.2% of global passenger traffic according to Airport Carbon Accreditation (ACA). ACI World is currently examining various options to ensure that airports around the world officially join the programme.

ACI identifies different sources of emissions by field of application for which airports must take action (ACI, 2009):

- Field of application 1: Sources owned or controlled by the airport. Power plants (heating, air conditioning and electricity production), vehicle fleet (passenger transport, service vehicles, machines used airside and landside), airport maintenance (cleaning, repairs, green spaces, etc.), handling and maintenance of aircraft on the ground, emergency energy, training in firefighting, waste treated on site.
- Field of application 2: Off-airport electricity production purchased by the airport operator.
- Field of application 3: Other activities and sources linked to the airport

Between July 2016 and July 2017, the airports that reported their emissions to the Airport Carbon

Accreditation platform reduced their CO_2 emissions by 202.8 $MtCO_2$, which is a lower result than in previous years (206 $MtCO_2$ in 2015–2016 and 212.4 $MtCO_2$ in 2014–2015).

Airport Carbon Accreditation programme of ACI

The Airport Carbon Accreditation programme run by the Airport Council International is managed independently, approved by the institutions and given support by UN Climate Change, UN Environment, the International Civil Aviation Organization, the US Federal Aviation Administration and the European Commission. To date, airport commitments being voluntary, 39 airports in North America, 17 in South America, 136 in Europe, 47 in the Asia-Pacific region and 10 in Africa carry this certification.

ACI issues four levels of accreditation covering all stages of carbon management:

• Level 1, Inventory: an inventory of sources and annual quantities of CO_2 emissions over which the airport operator has direct control (sources from scopes 1 and 2), with the possibility of including certain scope 3 sources and other greenhouse gases than CO_2. A list of other sources of emissions (scope 3) is also required.

• Level 2, Reduction: same as the inventory for level 1, and a management plan for carbon emissions produced by scope 1 and 2 sources must be developed and implemented. Evidence to support ongoing measures, reporting and emission reductions must also be provided.

• Level 3, Optimisation: the inventory needs to be expanded to include some scope 3 sources, (at least) taking into account the aircraft LTO cycle, the GAP, surface access and business trips. The carbon emission management plan must be expanded to involve other stakeholders and ongoing emission reductions must be demonstrated.

• Level 3+, Neutrality: same as the requirements for level 3, and the airport operator must demonstrate that they have offset their residual emissions from scopes 1 and 2 and have therefore reached "*carbon neutrality*".

Only the management of CO_2 emissions is mandatory under the ACA programme. The inclusion of other GHG emissions is optional.

TEXT BOX 8

Many airport initiatives are therefore to be highlighted with a view to reducing their emissions. **In October 2018, Côte d'Ivoire's busiest international airport, the Félix Houphouët-Boigny Airport serving Abidjan, renewed its Airport Carbon Accreditation at the highest level (3+ Neutrality). To date, this airport is the only one on the African continent to have reached this level of maturity in carbon management.** In September 2018, the partnership between Brisbane Airport headed by Brisbane Airport Corporation (BAC), Virgin Australia and Australia's leading supplier of transport fuels Caltex resulted in a series of conclusive tests regarding the use of biofuel for flights of the company. Successful testing is an important first step for stakeholders and the Queensland government is ensuring that Australian airports and the fuel supply chain are ready to provide biofuels on a regular basis while developing a genuine local sector. Flight path optimisation and tarmac taxiing on landing and take-off are also part of the solutions to reduce fuel consumption in airports. Air France – KLM, for example, encourages its pilots to use eco-friendly practices by optimising the transport of fuel or by cutting one of the two engines during taxiing.

On the ground, the airline is also using electric track vehicles (50% of the fleet). Objective for the Franco-Dutch group: improve its energy efficiency by 20% by 2020 compared to 2011 levels.

ur le groupe franco-néerlandais: améliorer son efficacité énergétique de 20% d'ici 2020 versus 2011.

CONCLUSION

The extremely fast growth of air transport as envisaged for the coming decades (increase in mass tourism, in particular) places all the players involved (manufacturers, airlines, airports) in the face of a major challenge of controlling carbon emissions. As an exception to the agreements between countries under the umbrella of the Climate Convention, air and maritime transport regulation was left to the responsibility of the players themselves through the intermediary of international organisations (ICAO, IATA), although national governments obviously continue to watch over their interests as we have seen with the European ETS. This system of regulation is also based on a refusal to limit the growth of the sector; it has not yet demonstrated its feasibility, and it raises a lot of scepticism about the two preferred tools – offsetting and the call for biofuels.

However, it should be noted that the players are truly investing in technological developments (engines and fuels) and forming industrial partnerships, both for flights and ground infrastructure. The impact of these new technologies in terms of raw carbon emissions and environmental sustainability (including biofuels consumed) will be a key issue in the coming years.

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Greenhouse gas emissions: a decisive asset for rail?

Globally, rail is a mode of transport that does not emit much in the way of greenhouse gases. It also has much opportunity for improving its energy efficiency and reducing emissions (electrification). That's why it is tempting to predict a bright future for it, but as this sheet shows, the reality is a little different...

Head Editor • **THE CLIMATE CHANCE OBSERVATORY TEAM** •

CONTENTS

1 • **STATE OF PLAY**

2 • **EVOLUTION OF CARBON EMISSIONS IN THE RAIL SECTOR**

Low-emission rail transport in terms of load capacity

Rail transport prospects are fuelling national targets for lowering carbon emissions

3 • **LOW-CARBON VISIONS AND STRATEGIES ARE AMONG THE KEY PLAYERS IN THE RAIL SECTOR**

Commitments of the representative institutions in the rail sector

Private economic actors are increasing their use of rail services

Rail companies initiatives

4 • **THE DECARBONISING POTENTIAL AND TECHNOLOGICAL COMMITMENT OF MANUFACTURERS**

Infrastructure, installations and rolling stock

The potential of decarbonising traction energy

The improvement of auxiliary services

Energy management by intelligent systems

1 • STATE OF PLAY

Rail transport is a sector encompassing multiple modes of urban travel (electrified or non-electrified trains, trams, underground rail, etc.), medium and long-distance journeys (regional or high-speed trains), as well as goods transport (freight). Since the first steam locomotive test in Wales in 1804, the development of rail infrastructure around the world has been very uneven not only across countries, but also over time.

In the current climate of concern surrounding climate change, the benefits of rail are mainly fourfold. Firstly, its ability to provide mass transport provides economies of scale that reduce energy consumption and emissions per unit transported. The possibility of using electrical energy then gives carbon-free and renewable energies an important place for the future of the sector. In addition, a permanent connection to the electricity network makes it possible, on the one hand, to recover braking energy, and on the other hand to optimise the use of the network's energy, or even to contribute to the resilience of this network. Finally, high speed access makes it possible to take a market share over less energy efficient and more polluting means of transport such as air transport, for example.

However, the rail sector's major handicaps still lie in the scale of investments required, especially for infrastructure, and the inability of this mode of transport to completely move goods and people in sparsely populated areas: it can't go that extra mile and lacks flexibility when it comes to travel adjustments. These handicaps have become more significant over time, with rural areas seeing their population decrease, even as the costs of infrastructure and investments have increased due to urban expansion or technical developments (the advent of high-speed rail for example). **This means that rail has lost ground in most countries around the world.**

Among the formerly industrialised countries, some have retained and developed intra- and inter-urban passenger transport, even though all have adopted the car en masse; as the case may be, rail freight has more or less held its own against road transport. Some large emerging countries (China, India, etc.) have a considerable rail network, possibly inherited from the colonial era, and others do not (Brazil). In many developing countries, the rail network left by colonisation has long been dormant (Ethiopia), and in some cases formerly precursor colonised countries, such as Mexico, have also completely abandoned their infrastructure in favour of road transport. In some other emerging countries, lines dedicated to private transport have been created (Mauritania) and new investments are now helping to renovate some lines (Addis Ababa, Djibouti, Nairobi).

This fact sheet attempts to factor in this extreme diversity and focuses on the spatial dimensions and promising developments in terms of decarbonisation.

2 • EVOLUTION OF CARBON EMISSIONS IN THE RAIL SECTOR

• LOW-EMISSION RAIL TRANSPORT IN TERMS OF LOAD CAPACITY • While in 2015 transport accounted for 24.7% of global CO_2 emissions and 28.8% of the final energy consumed, rail transport accounted for 4.2% of global CO_2 emissions from transport and 1.9% of its final energy demand. In the same year, it accounted for 6.7% of passenger kilometres and 6.9% of world freight (tonne kilometres). **From 2005 to 2015 CO_2 emissions from rail transport per passenger kilometre decreased by 21.7% and emissions per tonne kilometre for freight by 19%(IEA & UIC, 2017, p.18)**. In 2015, the top four emitters were China (43.8%), Russia (10.4%), the European Union (8%), and India (7.7%) (see Figure 1).

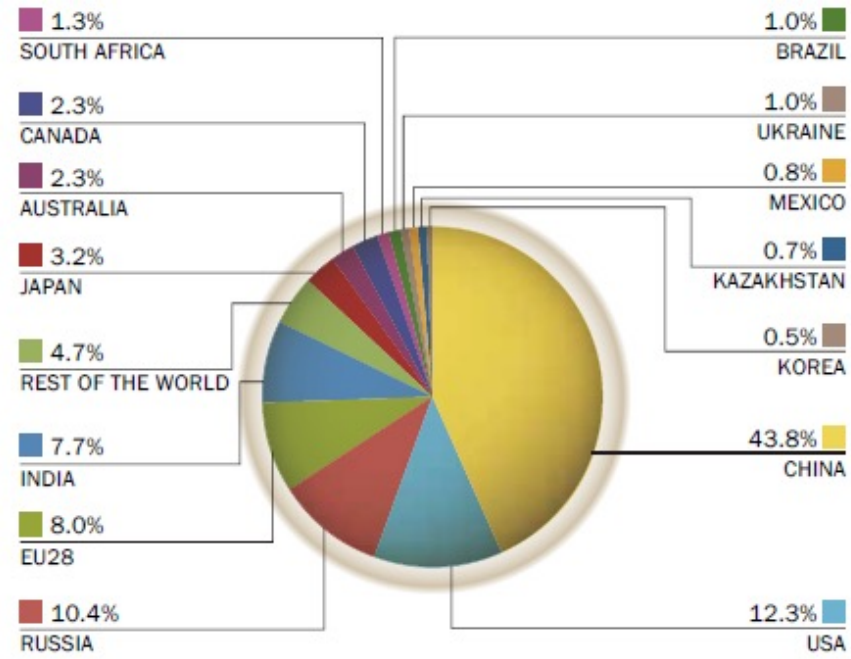

FIGURE 1. CO_2 EMISSIONS FROM RAIL TRANSPORT BY COUNTRY IN 2015

Source: Railway Handbook. Energy consumption and CO_2 emissions, IEA & UIC, 2017, p22.

Over the last two years (2015-2017), the share of rail transport in global emissions is trending downwards for China (-3%), upwards for India (+ 7%) and remains comparatively stable for the USA and Europe (Source: Enerdata).

Rail transport emits little greenhouse gas in terms of its contribution in volume to the transport of passengers or goods. In Europe, the sector's contribution is less than 1.5% of total transport emissions, while its modal share is 8.5% (CER & UIC, 2015, p.3). Comparison with other modes of transport appears favourable for rail, both for passenger and freight transport, as shown in the following graphs.

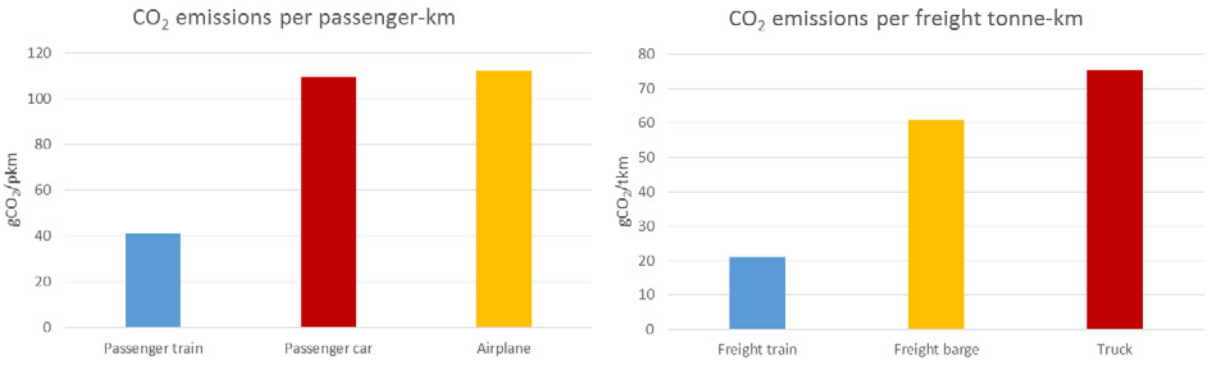

FIGURE 2. CO_2 EMISSIONS, IN PASSENGER/KM AND IN TONNE/KM, BY MODE OF TRANSPORT IN 2011

Source: (UNIFE & CER, 2016, p.4), based on data from the European Environment Agency (2013)..

Crude analysis of the evolution of CO_2 emissions related to rail transport is therefore complex. **Their increase may paradoxically appear as good news, if it reflects an increase in modal shift between road and rail. Conversely, the decline in emissions is not necessarily positive if it reflects a collapse of rail freight.** The emission reductions to be highlighted are therefore related to equipment and motorisation, for example the replacement of diesel with electricity produced by renewable sources.

• RAIL TRANSPORT PROSPECTS FUEL NATIONAL TARGETS FOR LOWERING CARBON EMISSIONS•

In view of the performance of rail transport in terms of load/emissions ratios, many governments and national bodies are betting on rail to try to meet the general objectives of reducing carbon emissions in their territory. So much so that the future of rail seems to be fed by the perspectives indicated by the political positions taken by Governments regarding the sector's development.
In India, a study on rail decarbonisation by 2030 examines the consequences of strong electrification, using solar and wind energy to power the grid. Scenarios produced by the Indian authorities conclude that decarbonisation saves 17% in the sector in terms of traction energy compared with a non-decarbonised scenario and 33% on all other rail energy needs.

In France, several scenarios deal with the place of rail transport and its emissions in 2050: the national low carbon strategy (SNBC) of the Commissariat général au développement durable (Office of the Commissioner General for Sustainable Development) (2016), the "visions" of the Ademe updated in 2017, the scenarios of the Institute for Sustainable Development of International Relations (IDDRI) 2017, the Negawatt scenario of 2017. The four scenarios predict a growth in railway development from 23% to 102% for passengers and from 68% to 203% for freight, due to an increase in demand and/or the increase in rail's modal share. Scenarios based on an increase in modal shares (from 10 to 25% for Ademe and 40% for Negawatt) imply a tight mesh around the supported territory, including the regional lines, with a diesel output. Other scenarios rely on energy substitution and improved energy efficiency to reduce emissions. This is the case in the SNBC scenario, and the TECH-first scenario of IDDRI. Depending on the ambition of this modal shift and other changes in transport demand, the potential emissions reductions in the transport sector by 2050 are more or less significant: -100% for negawatt, -91% for ADEME, -79% for TECH-first and -62% for the national low carbon strategy (Bigo, 2018).

Germany, too, supports the idea of using the railways to achieve climate change goals. The infrastructure plan for 2030, unveiled by the Federal Minister for Transport, provides for an investment of €270 billion, of which about 40% will be for rail. This will allow Germany to make a strong commitment in terms of European targets and increase the capacity of the German rail network by 20%, without the need for new infrastructure, and 70% of the national grid will be electrified.

In the light of these hopes, based on improvements in rail transport, industry players have made commitments to reducing their carbon emissions.

2 • LOW-CARBON VISIONS AND STRATEGIES ARE AMONG THE KEY PLAYERS IN THE RAIL SECTOR

In structuring the industrial strategies in the rail sector, the close relationship between the positions and initiatives of organisations representing the sector (e.g. the International Union of Railways (UIC) on a global level, Community of European Railway and Infrastructure Companies (CER) and Union of European Railway Industries (UNIFE) in Europe etc.) and the emission reduction targets of the political entities, is the factor that we are proposing to study more closely here. **Indeed, it appears that on many initiatives, some of which are detailed below, rail sector organisations are appropriating the political ambitions of states to develop their own goals and strategies.**

• COMMITMENTS OF THE REPRESENTATIVE INSTITUTIONS OF THE RAIL SECTOR • The interests of rail transport stakeholders are defended by several supranational entities such as the International Union of Railways (UIC), which was founded in 1922 and has 240 members on five continents: railway companies, infrastructure managers, research institutes and so on. Its mission is to promote rail on a global scale. The Community of European Railway and Infrastructure Companies (CER) brings together more than 70 railway companies, their national associations, infrastructure managers and rolling stock leasing companies. In the European Commission in particular, the CER advocates the idea of rail transport as the backbone of sustainable transport in Europe. UNIFE has represented the rail industry in Brussels since 1992. The organisation brings together 80 firms specialising in the design, manufacture and maintenance of rail.

In 2014 the UIC (UIC, 2014) proposed a strategy compatible with the + 2°C target, based on two pillars:

• Energy consumption and carbon intensity:

- reduction of final energy by 50% in 2030 (baseline 1990), and by 60% in 2050.
- reduction of CO_2 emissions by 50% in 2030 and by 75% in 2050 (baseline 1990).

• The modal division:

- rail share in passenger transport (p/km): +50% in 2030 compared with 2010, and +100% in 2050.
- rail share in land freight (t/km): equal to road freight in 2030, 50% higher than road in 2050.

In order to meet these objectives, the UIC is relying on private partners to support innovation and improved energy efficiency, as well as on public partners, governments and international institutions to promote modal shift in favour of rail: investment in new projects, in particular urban rail and freight corridors, internalisation of external costs, creation of a favourable context for private investment, urban planning and land use, investment aid for rolling stock and so on.

The CER acknowledges the European Union's desire to reduce its emissions from 80 to 95% in 2050 compared with 1990, with an intermediate target of a 40% reduction in 2030 (CER & UIC, 2015). In 2010 members of the CER (also members of the UIC) committed to reducing their specific CO_2 emissions by 50% in 2030 compared with 1990, and beyond then to be completely decarbonised by 2050(CER & UIC, 2015, p.8). To achieve this, the CER is betting on the continuation of the European rail network electrification (today only 60% of the lines are electrified), the development of intermodal facilities in the vicinity of railway infrastructures, the installation of electric charging points for individual vehicles near railway stations, all supported by the "Smart Grid" for optimised energy sharing. In addition, the CER, in partnership with UNIFE, the European Association of Train Manufacturers, strongly promotes the development of research and innovation in support of European credits, with, for example, the Shift2rail project, a major €920 million public-private partnership for the 2014-2020 period to innovate on the energy efficiency of rolling stock (UNIFE & CER, 2016). Private economic actors are therefore not only stakeholders in the rail sector's innovation process but also rely on it to regulate their own carbon emissions.

• PRIVATE ECONOMIC ACTORS ARE INCREASING THEIR USE OF RAIL SERVICES • The Carbon Disclosure Project (CDP) focuses part of its reporting and analysis on the impact of supply chains in the fight against GHG emissions According to this organisation, "these must be at the centre of the concerns of global organisations seeking to avoid risks and to take advantage of the opportunities offered by building a sustainable future" (CDP, 2017). As such, the CDP recalls that in 2016, the value of the combined purchasing power of the 89 organisations registered on its platform and requesting information for their suppliers on controlling their emissions (BMW, Johnson & Johnson, Microsoft or Walmart, for example), a 20% increase in the number of registrants in 2016, was $89 billion.

The Carbon Disclosure Project – CDP – is publishing its first ranking of companies that encourage their suppliers to engage in climate action the most

Greenhouse gas emissions in the business supply chain are four times larger, on average, than their own direct emissions. This is why the supply chain is increasingly considered as one of the most promising sources of emissions reduction in the private players' ecosystem. For the first time, in 2016 the CDP evaluated the work done by companies with their suppliers to encourage them to reduce their emissions and adopt climate strategies. These players, who thanks to their purchasing budget have a significant margin of negotiation, have particularly focused their efforts on raising awareness of sustainable development issues and on taking into account indicators inspired by the CDP from their suppliers, such as transparency or the amount of emissions reported.

According to the CDP report, the efforts made by 4,366 companies to reduce their emissions in their supply chain have prevented some 434 million tons of CO_2 in 2016 at their suppliers, a saving of $12.4 billion. In addition, the 4,818 projects provided significant quantifiable savings: 36% saved at least $100,000 USD, 12% saved $1 million or more, and less than 1% saved at least $100 million USD. In addition to savings from emission reduction projects, suppliers also report benefits upstream by engaging their supply chains, or downstream through innovations related to the commercialisation of low-carbon products or services. About 25% of the companies with projects would directly address climate issues by allowing their own suppliers to reduce their emissions, or by increasing their revenues through the sale of low-carbon products or services (energy efficient, more sustainable materials for products and packaging, process innovations for minimising water use and carbon emissions).

Source: CDP, 2017.

TEXT BOX 1

Many of these companies encourage their partners to choose rail transport for developing their activities. The Nestlé Group, aiming to reduce half of its CO_2 emissions in Switzerland between 2010 and 2020, has made a commitment, in cooperation with its distributor Migros, to reduce the number of lorries used to transport Evian water in Switzerland by one thousand. **The number of carriages used has thus increased from 170 to 700**. A collaboration with Swiss railways is also underway to organise this transport without disrupting the network's schedules[3]. Other companies outside of the CDP partnership have made commitments, such as Panasonic, which in 2016 modified the distribution logistics of its products in collaboration with its carriers, including Mitsui-Soko Logistics Co. Ltd., Japan Freight Railway Company and Nippon Express Co. Ltd. **In 2017, this resulted in the use of rail infrastructure for nearly ten thousand 5-tonne containers, reducing CO_2 emissions by almost 5,000 tonnes[4].**

•RAIL COMPANIES INITIATIVES • In February 2018, Eurostar presented a plan[5] considered to be a contribution to the Paris Agreement: reducing train energy consumption by 5% by 2020, eco-driving programs, eliminating all fossil energy used between now and 2030, and investments in renewable

3 https://www.nestle-waters.com/media/featuredstories/reducing-environmental-impact-by-moving-from-road-to-rail-transport
4 https://www.panasonic.com/global/corporate/sustainability/eco/co2/logistics.html
5 Cheul-Kyu Lee, et al. (2009). Global warming effect Comparison of each material for railway vehicle. Korea.

energies (solar panels). In addition, going beyond the mechanical operation of the trains, the company is committed to reducing indirect emissions from its operations by commissioning a company fleet entirely composed of electric vehicles between now and 2020, reducing the use of plastics and waste, and even the distribution of certified food products on board trains.

Still in Europe, the German company Deutsche Bahn plans to invest a "record amount" of €9.3 billion for the modernisation, repair and extension of railways, stations, bridges and tunnels in 2018, according to the chief of infrastructure, Ronald Pofalla. That is an increase of 9.4% compared with the previous year. Flagship projects include upgrading major roads, such as links between the northern ports of Bremen and Hamburg and cities further south, as well as two lines crossing the south-eastern border of Germany with Austria. Some 700 stations, including hubs such as Frankfurt, the Western financial capital, and East Germany, will also benefit from interventions worth a total of €1.2 billion.

SNCF's commitment to Global Climate Action on the NAZCA portal led by the UNFCCC (Global Climate Action)

In 2015, SNCF made a public commitment to reduce its CO_2 emissions by 20% by 2025 (2014 reference year). In 2017, SNCF set itself the new ambition of improving the carbon performance of 25% per passenger per kilometre and per tonne of goods per kilometre by 2025, and in particular, the end of thermal traffic by this time at the latest. In accordance with this, in 2018, SNCF partnered with Alstom to conduct the first TER Hybride experiments in France, in partnership with the Greater East, New Aquitaine and Occitaine Regions.

SNCF Réseau is committed to reducing its energy consumption and greenhouse gas emissions by 25% between 2015 and 2025. To achieve this, several actions have been implemented, including the use of environmental green bonds.

SNCF Réseau finances part of its infrastructure works by issuing Green Bonds to help combat climate change and protect biodiversity. The projects financed by the Green Bonds in 2017 will prevent the equivalent of nearly 5.9 million tonnes of CO_2 over 40 years, which equals the carbon footprint of 12,000 French people over the same period. SNCF Réseau's strategic priorities have directed investments in the amount of €1.75 billion from its bonds issued in 2017 to network renewal and modernisation operations. In line with its commitment to become a benchmark in the Green Bonds market, SNCF Réseau has made a total of three Green Bond issues since 2016, for a total amount of €2.65 billion, becoming one of 15 largest issuers of Green Bonds (excluding China onshore) in the world.

Source: SNCF Réseau, 2018.

TEXT BOX 2

In 2018 the Canadian National Railway Company made a commitment to reduce its emissions per tonne-kilometre by 29% by 2030, compared with 2015. To this end it is proposing a $13.5 billion initiative, GO Regional Express Rail (RER), to transform the rail network by offering faster and more frequent services, with the electrification of key segments of the network, including the Union Pearson (UP) Express. This will result in a doubling of rush hour services and a four-fold increase in off-peak services from the 2015 level, with the number of GO Transit trips expected to increase from approximately 1,500 per week to nearly 6,000. Metrolinx, the transport authority for the Greater Toronto and Hamilton area and the MTO (Ontario Ministry of Transportation) are planning major improvements to the GO Transit rail system, including additional modifications to railway tracks and bridges, new stations and modernised rail/road and rail/rail level separations, new improved train control systems and new electric train systems (MTO, 2017).

3 • THE DECARBONISING POTENTIAL AND TECHNOLOGICAL COMMITMENT OF DEVELOPERS

Although rail transport is one of the lesser emitters of CO_2, the sector's decarbonisation potential remains significant. Efforts can be focused on infrastructure, facilities and rolling stock, traction energy, ancillary systems, or the use of artificial intelligence for energy management.

• INFRASTRUCTURE, FACILITIES AND ROLLING STOCK • Train aerodynamics also have an interesting potential for reducing energy consumption and associated emissions: a 25% improvement in the drag coefficient results in savings of 15% in traction energy for the Alstom high-speed railcar (AGV), commissioned for 2022, compared with a conventional TGV. There have been similar achievements at Bombardier (Zefiro) or in Japan with the Tokaido Shinkansen (700 series) (UIC, 2016, p.33). The use of new materials also reduces the weight of vehicles. Here, the development of composite materials for the construction of a passenger carriage can reduce its weight by about 20 to 30%; the corresponding potential for reducing traction energy and emissions is in the region of 5% (Lucintel, 2017). According to a report published in February 2017 by market research firm Lucintel, the market for composite applications in the global rail industry is expected to reach $821 million by 2021, with an annual growth rate of 3.6%. Research and trials are being conducted in this area, notably by Alstom, New Rail (UK), Indian Railways and in Korea for the Pendulum Express (UIC, 2016, p.37). CRRC's Next Generation metro train, Cetrovo, a joint venture project with CG Rail in Germany, was unveiled at the InnoTrans congress in September 2018 in Berlin. The carriage is composed of about 70% carbon fibre structures, which represents a weight reduction of 13 to 14% compared with a conventional metro vehicle.

A number of experiments using renewable energies (solar, wind turbines) in fixed installations, and even on rolling stock, have also been put in place. In July 2018, Ravindra Gupta, a member of the board of directors of Indian Railways, inaugurated carriages incorporating solar panels to operate the fans, lighting and mobile charging points inside passenger trains on the Rewari-Sitapur lines, and soon on the Taj Express and Shane-Punjab Express. In 2017 the Indian Railways Organization for Alternate Fuels (IROAF) also installed solar panels on diesel multi-unit (DMU) trains.

• THE POTENTIAL OF DECARBONISING TRACTION ENERGY • Traction energy represents about 85% of the total energy consumed by a moving train (CER & UIC, 2015, p.15). With a view to reducing carbon emissions from rail transport, the main challenge is to develop electrification, which represents a reduction in emissions from 19 to 33%[7] compared with the use of diesel engines on locomotives. Half of the European rail lines are electrified. Great Britain is the least equipped country in electric rail infrastructure with only 32% of its lines connected. However, a line electrification program has been underway in Scotland since 2009, with the aim of completely eliminating trains running on diesel alone by 2040. Sweden is the most electrified European country with 84% of the train lines covered. In Asia, 43% of the network is electrified, 18% in Africa and 0.5% in North America (CER & UIC, 2015, p.59).

Overall, it is estimated that by improving traction energy efficiency, the sector can potentially reduce emissions by around 15%. "Resibloc Rail", developed by ABB, is an oil-free traction transformer with 97% energy efficiency, the implementation tests of which were completed in Austria in 2018. The transformer reduces energy costs by 10% compared to conventional transformers and can reduce carbon dioxide emissions by 38 tonnes per year.

In order to ensure train traction in the non-electrified sections, the manufacturers put hybrid trains on the market, equipped with new engines using alternative energies, such as gas or hydrogen. European Lok Pool (ELP), a new European locomotive rental company specialising in hybrid traction,

6 Network Rail (2009) Network RUS electrification (UK). October 2009. London (UK). http://www.networkrail.co.uk/browse%20documents/rus%20documents/route%20 utilisation%20strategies/network/working%20group%204%20-%20electrification%20strategy/networkrus_electrification.pdf
7 Schaffler. Air conditioner power systems for rail. http://www.schaffler.com

announced in September 2018 that it had received the first order for 10 Stadler EuroDual locomotives, with a first delivery expected in the second half of 2019. The company is also considering adding four-axle bimodal locomotives to its portfolio. Gmeinder, a German locomotive manufacturer, also offers a hybrid model equipped with a Caterpillar engine and a lithium-ion traction battery, which can use electrification on a third rail or per 750 Vdc head. Steel producer ArcelorMittal ordered six units of this model in 2018. STADLER, a Swiss manufacturer, and Havellian Railway (HVLE), a regional rail authority in Pakistan, unveiled a new generation of six-axle Eurodual bimodal locomotives that can be powered by a 2.8 MW diesel engine or by electrical power up to 7 MW. HVLE ordered 10 Eurodual locomotives in 2017, thus becoming the customer to launch the new platform.

However, diesel seems to have a bright future ahead of it. General Electric Transportation announced the signing of a contract in 2018 for the supply of five of its PowerHaul (PH) diesel locomotives to Turkish private operator Korfez Ulastirma, the rail freight subsidiary of Tüpras, Turkey's largest oil refinery company, responsible for transporting petroleum products between its refineries. GE Transportation has also unveiled a new high-speed light diesel engine, which will debut on a new fleet of 300 shunting locomotives to be delivered to a Kazakh railway company in 2019. The engine is expected to offer a 5% reduction in life cycle costs, a 5% improvement in energy efficiency and a 10% reduction in maintenance costs. Finally, in September 2018, Gmeinder introduced the two-engine diesel variant of its modular DE75 BB locomotive, designed to allow the use of various traction configurations. The four-axle locomotive can be supplied by two Caterpillar 354 kW diesel engines.

Another non-carbon-free source is natural gas, which nevertheless reduces CO_2 emissions by 30% compared with diesel fuel; this option is of particular interest to Renfe, Union Pacific Railroad and Russian Railways (RZD), which are in the prototype development stage (UIC, 2016, p.79).

Hydrogen, the energy of the future for rail transport?

Presented as a powerful alternative to the use of fossil fuels, the use of hydrogen for rail transport has been the subject of important research in various countries for several years.

Some fifteen engineers are working on a train project in France, called "Space Train", running on hydrogen and moving two millimetres from the ground thanks to a propulsion on monorail, with induction motors creating a magnetic field. The engineers are aiming to reach top speeds of 720 km/h which would make this train the fastest in the world, compared to the TGV, whose optimal average speed (when it is not in operation) reaches 500 km/h and 574 km/h maximum, and the Japanese Maglev, the current world record holder, reaching the maximum of 603 km/h. Targeting inter-urban lines up to 300 km long, the first tests of the Space Train are scheduled for late 2019 or early 2020 for commercialisation in 2025.

In addition to ongoing research to improve the combustion system and reduce the environmental impact, hydrogen trains have already been put into service in recent years. In October 2017, China commissioned the world's first hydrogen tram, designed by China Railway Rolling Corporation (CRRC) Tangshan Co. Ltd. The tram can be refilled with hydrogen in 15 minutes and travel 40 km with a maximum speed of 70 km/h. It serves a railway line built 136 years ago in Tangshan, one of the country's leading industrial cities, and links several industrial heritage sites.

On September 16, 2018, the French manufacturer Alstom formalised the commissioning of two trains named Coradia iLint, the first trains in the world put into service and running on 100% hydrogen. These trains connect the cities of

Cuxhaven, Bremerhaven, Bremervörde and Buxtehude, located in the north of Germany. Reaching 140 km/h and with the capacity to cover 1,000 kilometres on one fuelling, this model has attracted the German regional companies and by 2021, 14 other trains are expected to be delivered to Lower Saxony. In March 2018, the Government of Sarawak State in Malaysia proposed that the Kuching light rail system be fuelled by hydrogen fuel cells, to be completed by 2024.

TEXT BOX 3

• THE IMPROVEMENT OF AUXILIARY SERVICES • While traction energy accounts for 85% of the trains' final energy consumption, a significant part of it is used in the auxiliary systems on board (heating, cooling, lighting) or outside the trains. **Refrigeration and heating account for most of the auxiliary energy consumption on board a train (up to 80%). Decarbonisation can come mainly from the use of new, more efficient refrigerants, and in the intelligent management of heating/cooling systems**[8]. For example, in Berlin, Liebherr-Transportation Systems will equip one of the city's tram lines with CO_2 sensors that will estimate the number of passengers and adjust the outside air intakes accordingly; this should reduce energy consumption by 13% (UIC, 2016, p.101). In 2018 the international supplier Thermo-King introduced its new system using the refrigerant R134A, a refrigerant whose global warming potential (GWP) has been reduced by more than 50%, but which maintains the same performance, reliability and comfort of passengers as current refrigerants. More generally, the introduction of energy recovery systems, which can also store it (flywheel, battery, etc.), could reduce the energy consumption of a train by around 10 to 30%, and eventually lead to a sharp decline in peak energy demand (-50%). **Several manufacturers have developed systems using flywheels and saving up to 20% of the energy used during a journey (UIC, 2016, p.144): Piller-Powerbridge (Germany)[9] , Kinetic Traction (USA), Adif (Spain)[10].**

Railway stations are also sensitive areas, with the Asian Development Bank (ADB) pointing out inefficiencies in the management of heating, cooling and ventilation. Indeed, it believes that stations consume about 214 kWh/m²/year of electricity when the rest of the public buildings have an average consumption of 114 kWh/m²/year[11]. **That's why India has extended its program of installing solar panels on the roofs of railway stations and level crossings, aiming to gain 1,000 MW of solar energy to use. Guwahati Station, one of the largest in the State of Assam, has been running entirely on solar energy since mid-2018. Some 20,000 travellers pass through it every day.** All of its roofs have been equipped with photovoltaic panels with a capacity of 700 kilowatts, enough to supply the rail network as well as the structure's various services, which saves about 21,000 litres of diesel per train and 67.7 million Rupees each year (around €85,000), according to the Northeast Frontier Railway.

• ENERGY MANAGEMENT BY INTELLIGENT SYSTEMS • The potential now offered by IT makes it possible to adjust the use of energy to the actual needs of railway equipment[12] and to reduce greenhouse gas emissions by the same amount. For example, improving the filling rate of vehicles (reservation system) can provide energy savings of around 15 to 17%. Improved driving modes, whether computer assisted or not, would mean that braking and acceleration can be minimised, saving up to 20% on traction energy. Computerised assistance would thus reduce braking needs by 30%, which would result in a 10% improvement in punctuality (UIC, 2016, p.134). Finally, the use of

8 Schaffler. Air conditioner power systems for rail. http://www.schaffler.com
9 Witthuhn, M. et al. (2001): Applications for energy storage flywheels in vehicles of Deutsche Bahn AG. Proceedings of the World Congress of Railway Research WCRR 2001, Cologne (Germany).
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smart grids can better control the power demands of the trains in circulation or reduce them on a route segment. This is the case, for example, in Japan (East Japan Railway Co.). The Merlin Project (2012-2015)[13] ,carried out within the framework of projects financed by the European Union, made it possible to examine the feasibility of integrated electricity management systems in railways.

CONCLUSION

This comprehensive overview of the innovations initiated by players in the rail sector underlines the dynamism of a sector convinced about holding a part of the answer to reducing mobility-related CO_2 emissions. The significance of its contribution and speed of its deployment will depend on several economic factors: its ability to mobilise sufficient investment, particularly in developing countries, and its price competitiveness when compared with the road sector for freight; and compared with the car, bus and airline sectors for passenger transportation.

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13 http://www.merlin-rail.eu

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New initiatives in international maritime transport

Rapidly evolving over the past decade, international maritime transport contributes significantly to global anthropogenic greenhouse gas (GHG) emissions, exceeding those of the civil aviation sector. The establishment of the European Union MRV Regulation and the agreement adopted within the International Maritime Organization (IMO) can be a indicator of the beginning of a transition, provided that they lead to quantitative results. The past year has seen some interesting technological initiatives, driven by key industry stakeholders in the sector.

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CONTENTS

1 • GHG EMISSIONS CONCENTRATED ON SHIPPING ROUTES

• A recent increase

• Emissions profile of the maritime sector

• GHG evolution correlated with vessel tonnage, size and speed

2 • THE ONSET OF AWARENESS

• Actions of the IMO

• Regulatory tools in place

• An interesting recent agreement

3 • THE MOMENTUM OF SHIPPING COMPANIES

• Stakeholder partnership solutions

• The industry in Sweden leading the sector

• Support needed to stimulate the market

4 • TOWARDS RESPONSIBLE MARITIME TRANSPORT

• Electrification of the sector

• Other trending solutions

1 • GHG EMISSIONS CONCENTRATED ON SHIPPING ROUTES

• A RECENT INCREASE • Global CO_2 emissions from maritime shipping have been steadily decreasing since 2007, decreasing from 1.1 $GtCO_2$ to 932 $MtCO_2$ in 2015, representing 2.6% of total CO_2 emissions for the same year (compared to 3.5% in 2007). In 2015, emissions from international maritime transport alone accounted for 87% of total CO_2 emissions from maritime shipping, with 812 $MtCO_2$ emitted, a decrease of 8% compared to 2007 (881 $MtCO_2$). Nevertheless, the increase observed since 2013 (+1.4%) and according to unpublished estimates, **international maritime transport emissions should be 847 $MtCO_2$ in 2016 and 859 $MtCO_2$ in 2017, an increase of 5.8% compared to 2015** (Table 1). Regarding fishing vessels, their emissions have halved since 2007, from 86 $MtCO_2$ to 42 $MtCO_2$ in 2015 and stabilised in 2017. Emissions from domestic maritime transport decreased by 41% over the same period, from 133 $MtCO_2$ in 2007 to 78 $MtCO_2$ in 2015, and are also estimated to have stabilised in 2017. Finally, cruise ships emitted 38 $MtCO_2$ in 2015, or about 4% of emissions from the maritime sector (ICCT, 2017).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*	2017*
International transport	881	916	858	773	853	805	801	813	812	847*	859*
Domestic maritime transport	133	139	75	83	110	87	73	78	78	78*	78*
Fishing vessels	86	80	44	58	58	51	36	39	42	42*	42*
Total maritime shipping	1100	1135	977	914	1021	942	910	930	932	967*	979*
% global CO_2 emissions	3.5%	3.5%	3.1%	2.7%	2.9%	2.6%	2.5%	2.6%	2.6%		

TABLE 1. CO_2 EMISSIONS FROM GLOBAL MARITIME SHIPPING (SOURCE: ICCT, 2017).

* 2016 and 2017 data are estimates from an internal source of the ICCT (2018).

• EMISSIONS PROFILE OF THE MARITIME SECTOR • Between 2013 and 2015, three classes of vessels accounted for 55% of total GHG emissions from international maritime transport: container ships (23%), bulk carriers (19%) and oil tankers (13%) (Figure 1).

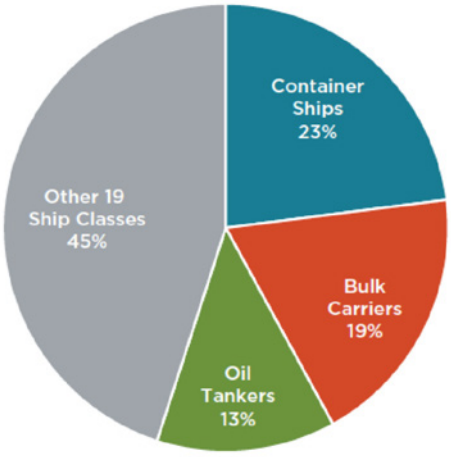


FIGURE 1. SHARE OF CO_2 EMITTED BY CLASS OF VESSEL BETWEEN 2013 AND 2015.

Source: ICCT, 2017

These emissions are defined by the International Maritime Organization (IMO) into four categories. Firstly, there are exhaust emissions, which are the largest volume of GHGs and come from main and auxiliary engines, boilers, and incinerators. Then there are refrigerant emissions, which are essential for refrigeration systems and air conditioners, but which also escape during maintenance operations and dismantling processes (emissions are allocated to the countries carrying out the operations). Then there are various emissions produced during transportation periods, including leaks and releases. In the final category are GHG emissions from testing and maintenance phases (Shi & Gullett, 2018). At the operational level, shipping routes were responsible for the majority of GHG emissions from major vessels in 2015. However, for some vessels (oil and methane

tankers), berthing still represents a significant energy expenditure (respectively 17% and 14% of their total GHG emissions). Anchoring represents about 5 to 9% of GHG emissions for each class of vessel.

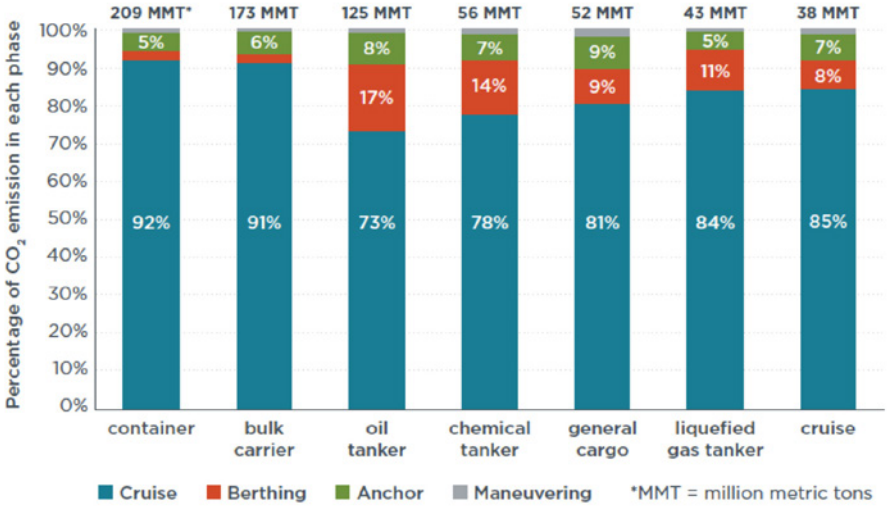


FIGURE 2. CO_2 EMISSIONS DURING THE OPERATIONAL PHASES OF THE MAIN EMITTING VESSELS, 2015.

Source: ICCT, 2017..

Of the 223 countries represented in maritime transport, **52% of emissions in 2015 were attributable to vessels operating under six flags:** Panama (15%), China (11%), Liberia (9%), the Marshall Islands (7%), Singapore (6%) and Malta (5%) (Figure 2). Global CO_2 emissions from the maritime shipping sector are concentrated on well-defined shipping routes around the globe (Figure 3).

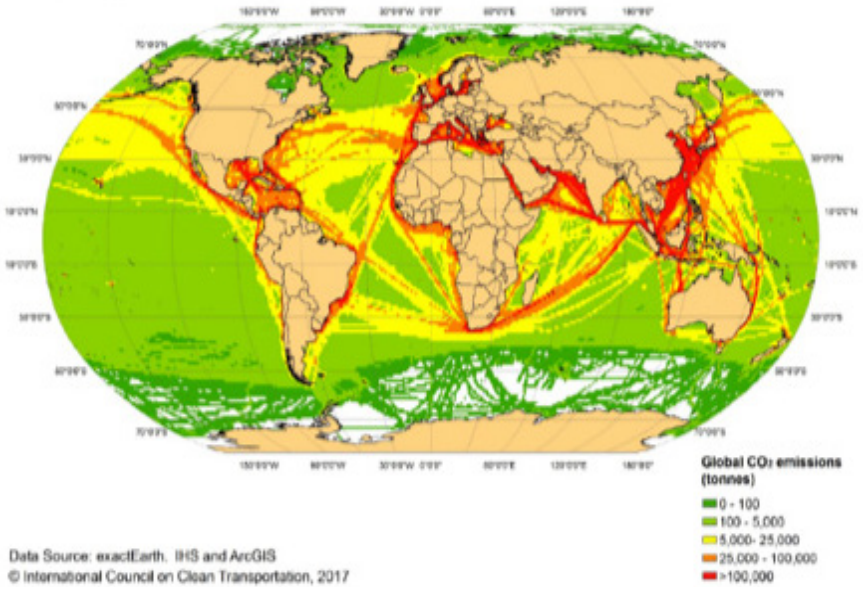


FIGURE 3. GLOBAL DISTRIBUTION OF CO_2 EMISSIONS FROM MARITIME TRANSPORT, 2015.

Source : ICCT, 2017.

• GHG EVOLUTION CORRELATED WITH VESSEL TONNAGE, SIZE AND SPEED • While the decline of CO_2 emissions from maritime shipping during the Kyoto period (2007-2012) is largely attributed to the global financial crisis of the time, an increase is to be expected over the coming years due to the growth of international maritime trade (Shi & Gullett, 2018). Smith et al. (2015) estimated that, as it stands, CO_2 emissions from the maritime sector could increase by anywhere from 50% to 250% by 2050. In the absence of measures, the sector's share could reach 17% of global GHG emissions by that date (Cames et al., 2015). In addition, the recent increase in GHG emissions from the sector comes as the CO_2 intensity of the majority of vessel categories improves, cancelling out these efforts (ICCT, 2017). One reason is the increase in cruising speeds. Indeed, between 2013 and 2015, container ships increased their average speed by 11% and oil tankers by 4% compared to the total average of international

transport, leading to an increase in CO_2 emissions per tonnage transported.

With a volume approaching 9 billion tonnes of freight transported per year, the seaway is the primary mode of transport for commercial activities. Its share in global commercial transport has reached 80% in terms of volume and 70% in terms of value. **In terms of goods, the main resource transported in 2012 was still crude oil, at 1.863 billion tonnes (see Figure 4).** In terms of evolution, the world fleet of commercial vessels has been on an exponential curve since the 1970s, after a decline in the late 1990s. Representing 289,926 gross tonnes sailing the world seas in 1973, in 2016, it accounted for 6 times more at 1,862,000 gross tonnes. In 2017, it was estimated that 93,000 vessels make up this commercial shipping fleet (Cargill, 2017). The largest are cargo vessels used to transport goods such as bulk carriers (41%), which carry bulk solids (sand, aggregates, cereals), tankers (38%), such as oil tankers, methane tankers or refrigerated cargo vessels carrying liquid foodstuffs and container ships (14%), which, since February 2018, can carry more than 20,000 containers (compared to 1700 in 1970) and the inauguration of CMA CGM Antoine de Saint-Exupéry, the largest vessel of its kind. These three classes account for 84% of the total merchandise supply by seaway. In addition to goods, the world's maritime fleet consists of multipurpose vessels (6%), including all kinds of fishing vessels and large cruise ships belonging to a thriving cruise industry (1%) which carry millions of passengers to tourist destinations (Info Arte, 2016).

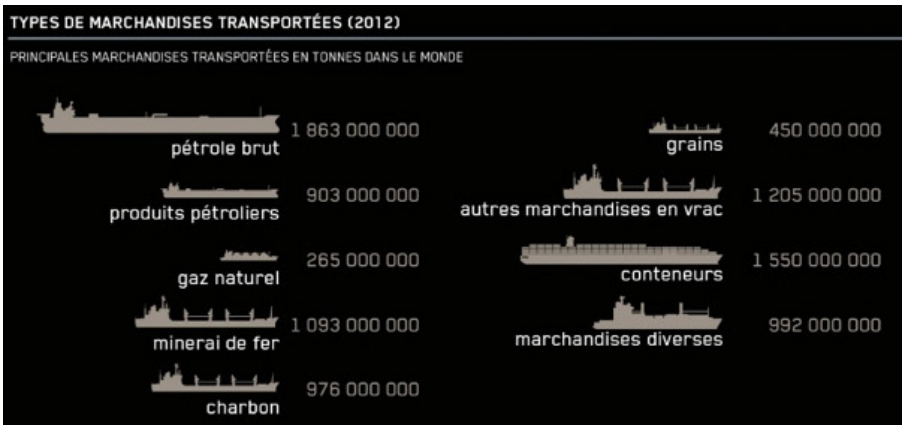


FIGURE 4. MAIN GOODS CARRIED IN TONS WORLDWIDE (2012)

Source: ARTE

Thus, the regulation of GHG emissions from international maritime shipping is based on a wide variety of vessels and activities. Nevertheless, cargo ships emit far more than other types of boats due to their size and tonnage, while being easier to regulate internationally as a result of their design and the international nature of their journey (Shi & Gullett, 2018). Therefore, reducing emissions can only come from concerted action by stakeholders to improve energy efficiency and develop alternative means of propulsion (ICCT, 2017).

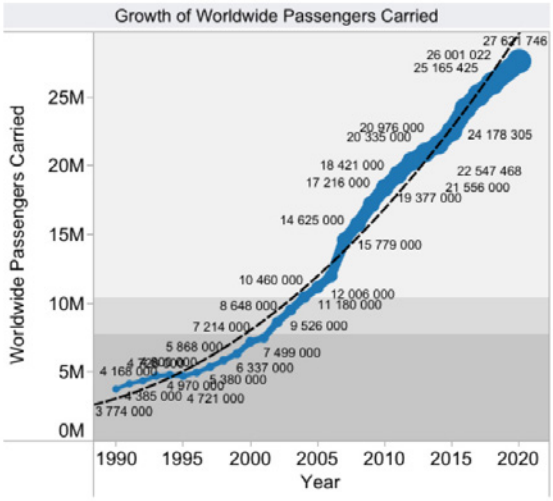
2 • THE ONSET OF AWARENESS

• THE ACTION OF THE INTERNATIONAL MARITIME ORGANIZATION (IMO) • The International Maritime Organization (IMO) is the international authority that regulates international maritime transport. The IMO defines international maritime transport as the maritime transport between ports of different countries, as opposed to domestic maritime transport, and excludes military and fishing vessels (IMO, 2014). **Maritime transport is the only sector (together with air transport) whose contribution to climate change mitigation is directly negotiated at the international level, and is not included or mentioned in the Kyoto Protocol or the Paris Agreement** (Wan et al., 2017). Discussions related to this sector, often blocked by several influential countries (China, the country that operates the most vessels), have been left to the IMO, which is expected to promote trade, set emission reduction efforts, and develop strategies to be put in place as a regulator of international maritime transport (Wan et al., 2017).

The future impact of the cruise industry

Although it only represented 4% of the maritime sector's total emissions with 38 $MtCO_2$ in 2015, the growth of international passenger transport has been exponential, and the cruise industry is evolving more strongly than other forms of tourism. Over the past 20 years, the average annual passenger growth has been 7% (Florida-Caribbean Cruise Association, 2015). In 2016, 23 million passengers worldwide were welcomed on cruise ships, most of them from North America. Cruise ships require a lot of energy, both for navigation and for the many services offered on board. For example, the Freedom of the Seas, one of the largest ocean liners in the world, burns 4200 litres of fuel per hour during the navigation period. As a matter of logic, the size, services offered, and cruising speed of the ships affect the GHG emissions. However, the construction of new passenger ships tends to increase their capacity, the diversity of the services offered, and their cruising speed, which cancels out the improvements generated by the new propulsion processes and the installation of electrical systems at the docking ports to encourage them to stop using their generators once at the dock.

TEXT BOX 1



Source Region of Passengers

Year	North America	Europe	Other	Worldwide Passengers Carried
2017	14 130 410	6 417 159	4 617 856	25 165 425
2018	14 167 168	6 764 273	5 069 580	26 001 022
2019	14 526 363	6 933 353	5 397 702	26 857 418
2020	14 829 278	7 075 424	5 717 044	27 621 746

FIGURE 5. GROWTH AND FORECAST OF THE CRUISE INDUSTRY BY EVOLUTION OF PASSENGERS TRANSPORTED BETWEEN 1990 AND 2020

(Cruise Market Watch, 2017)

• REGULATORY TOOLS IN PLACE • To date, there is only one regulation that focuses on the energy efficiency of vessels on a global scale, the Energy Efficiency Design Index (EEDI). Promulgated by the IMO in 2013, the EEDI subjects new vessel designs to requirements for the use of equipment and engines that pollute less (less CO_2 per nautical mile travelled) and more energy-efficient. It is expected that these requirements will be gradually increased every five years to encourage the integration of innovations and the development of new techniques, from the design phase of the vessel to the fuel consumption required for its operation. Vessels built between 2015 and 2019 must be 10% more efficient in terms of grams of CO_2 per tonne per nautical mile than those built over the 1999-2009 period and for those built between 2020 and 2024, the target is 20%, before reaching 30% beyond 2025. However, the EEDI is a non-normative, voluntary performance-based mechanism that leaves the choice of technologies to be used in vessel designs to the industry (ICCT, 2017).

The Ship Energy Efficiency Management Plan (SEEMP) is an IMO operational mechanism aimed at optimising the energy consumed by maritime shipping during the operation of ships. Developed with the World Maritime University, the SEEMP aims to promote energy-efficient technologies for new and existing vessels and to get them to use the Energy Efficiency Operational Indicator (EEOI), which allows for continuous monitoring of the energy consumed during the operation of a vessel. This tool provides an overview of the global fleet in terms of performance while allowing on-board engineers and mechanics to have continuous control of the energy efficiency of vessels during their operation, to report observations, better plan trips, estimate the propeller cleaning frequency, or even evaluate the efficiency of introducing new forms of propulsion (IMO, 2018).

The impetus of the European Union on the maritime sector

The European Union is keen to integrate the air and maritime sectors into international climate negotiations. Given the reluctance of many countries on the maritime issue, the EU has developed an MRV (Monitoring, Reporting, Verification) regulation for vessels visiting its ports. As such, the EU MRV entered into force on 1 July 2015 and requires shipowners and operators to monitor, report, and verify the CO_2 emissions on an annual basis of vessels of more than 5000 gross tonnage, in any port of the European Union and the European Free Trade Association. Data collection takes place per trip and started on 1 January 2018. The reported CO_2 emissions, as well as additional data, must be verified by independent certified bodies such as DNV GL, a Norwegian certification body, and sent to a central database managed by the European Maritime Safety Agency (EMSA). Aggregated emissions and vessel efficiency data will be published by the European Commission no later than 30 June 2019, then annually thereafter. Regarding the new agreement announced by the IMO, the objective of reducing maritime sector emissions by 50% by 2030 is less ambitious than the European Union wanted, but this timeframe makes it possible to include the maritime framework in line with the objectives of the Paris Agreement. During the discussions prior to this agreement, the European Union was able to play its full weight, using the 41% of the world fleet that it represents through its member countries, but also by relying on its new MRV regulation to encourage it to be applied in the future on a global scale.

TEXT BOX 2

• A RECENT AGREEMENT • At the 72nd meeting of the Marine Environment Protection Committee (MEPC 72) in April 2018, the 170 member countries of the IMO agreed to adopt a resolution codifying a GHG reduction strategy for international maritime transport. The agreement was found despite the reservations expressed by several countries (Saudi Arabia, United States, China) and the disproportionate influence of the five countries under which the majority of commercial vessels are registered (Bahamas, Marshall Islands, Liberia, Malta, Panama), which account for 43% of the total IMO funding. This strategy, which represents the first global climate framework for maritime transport, sets targets for reductions up to 2050 and sets 2023 as the deadline for its revision.

The strategy involves implementing policies to significantly increase the energy efficiency of the global fleet and to promote the deployment of innovative propulsion and alternative fuels in order to achieve:

- The reduction of GHG emissions (per tonne per kilometre) by at least 40% for vessels by 2030, while continuing to reach a 70% reduction by 2050,
- The reduction of emissions by at least 50% in 2050 compared to 2008, while continuing the action towards the total decarbonisation of maritime transport.

A list of short-, medium- and long-term measures to help achieve the objectives was developed by the ICCT (2018). Nevertheless, these measures must be made mandatory by an IMO convention before they become legally binding.

Type	Period	Measure	Target	Current status
Short term	2018-2023	New phases of the EDDI	New vessels	-10 % en 2015
				-20 % en 2020
				-30 % en 2025
		Operational efficiency measures (SEEMP, standards)	Vessels in service	SEEMP planning required
		Existing fleet improvement programme	Vessels in service	-
		Speed reduction	Vessels in service	-
		Measures to combat methane and VOCs	Fugitive emissions and engines	-
Medium term	2023-2030	Alternative low carbon or zero carbon fuel programmes	Fuels - new vessels / vessels in service	-
		Additional operational efficiency measures (SEEMP, standards)	Vessels in service	SEEMP planning required
		Market-based measures [2]	Vessels in service - fuels	-
Long term	2030 +	Development and provision of zero-carbon or non-fossil fuels	Fuels - new vessels / vessels in service	-

TABLE 2. MEASURES WHICH COULD BE INCLUDED IN THE IMO'S INITIAL STRATEGY TO REDUCE GHGS (SOURCE: ICCT, 2018).

(Source : ICCT, 2018).

Beyond these measures, the ICCT (2018) has identified other measures that could indirectly support efforts to reduce GHGs, such as:

- Encouraging the development and updating of national action plans;
- Encouraging ports to facilitate reductions in GHGs from vessels;
- Initiating and coordinating Research and Development activities by setting up an International Maritime Research Board (IMRB);
- Promoting the search for zero-carbon or non-fossil fuels for the maritime sector, and developing robust guidelines on GHG lifecycles for replacement fuel;
- Carrying out additional studies on GHG emissions to inform political decisions and calculate the marginal cost curves of reduction for each measure;
- Encouraging technical cooperation and reinforcing capacity.

These ambitions should encourage ships to use alternative fuels to fuel oil, as the latter releases more than 3500 times more sulphur than the diesel used by road vehicles. On this subject, the OECD suggests a move towards biofuels, hydrogen, ammonia and a growth in the use of sails, with liquefied natural gas remaining a short-term alternative (OCDE, 2018).

3 • THE MOMENTUM OF SHIPPING COMPANIES

• STAKEHOLDER PARTNERSHIP SOLUTIONS • Several initiatives backed by non-state actors have sought to make the maritime sector sounder in terms of GHG emissions. Of these, **the Sustainable Shipping Initiative (SSI) it is backed by an independent body, which brings together shipping**

2- Market-based measures seek to address the market failure of "environmental externalities" by incorporating the external cost of production or consumption activities through taxes or royalties on processes or products, or by creating property rights and facilitating the establishment of an environmental services market. According to this definition, these measures aim to provide polluters (shipowners and economic operators) with an economic incentive to reduce their GHG emissions in line with the "polluter pays" principle (Shi & Gullett, 2018).

companies (shippers, shipyards, equipment) and other stakeholders (banks, technology companies, NGOs) with the aim of creating a more environmentally friendly, socially responsible, safer, and more economically profitable maritime industry by 2040. Members of this network include Maersk Line, Oldendorff and China Navigation, as well as environmental non-governmental organisations (NGOs): WWF and Forum for the Future. The roadmap to 2040 includes six main actions including action 6, which seeks to "Adopt a diverse range of energy resources, using resources more efficiently and responsibly, and dramatically reducing greenhouse gases". The measures put forward to achieve this include the introduction of significant improvements to the energy efficiency of vessel design; rehabilitation and navigation; a search for and use of renewable sources of energy in propulsion systems to improve energy intensity; and the involvement of partners in achieving energy gains in the supply chains.

Four other non-governmental organisations (The Global Maritime Forum, The North American Marine Environment Protection Association (NAMEPA), The Maritime Anti-Corruption Network, and The Women's International Shipping and Trading Association (WISTA)) are involved in an initiative backed by Cargill, a United States company specialising in supplying foodstuffs and trading in raw materials. With the help of these NGOs, Cargill seeks to boost sounder shipping by aiming to reduce GHG emissions from its 650 vessels by 15% in 2020 compared with 2016. **Furthermore, Cargill has announced that it improved the energy efficiency of its fleet in 2017 and reduced CO_2 emissions by 5.7% compared with 2016 on the basis of tonnage of cargo carried per mile (Cargill, 2017).**

• THE INDUSTRY IN SWEDEN LEADING THE SECTOR • The Swedish maritime transport industry is also extremely active in decarbonising its business. Its representative association has announced a zero-emission target by 2050 and several companies are pioneering low-emission maritime transport. Sweden boasts a growing number of initiatives: **Stena Line operates a ferry fuelled by methanol, Sirius Shipping has developed a boat fuelled by LNG, several companies (Terntank, Erik Thun, Rederi Gotland) also have vessels that run on LNG, and HH Ferries and Green City Ferries have launched electric ferries (OCDE, 2018).** This proactive approach is the result of cooperation between decision-makers, financial support from the Swedish government, the European Union, or the Norwegian NOx Fund, depending on the particular project, and support in terms of regulation. This convergence of interests between Swedish shipowners and maritime companies has encouraged other industries, such as energy companies, to embark on long-term partnerships; a factor which is critical to the success of this type of initiative. The best example can be seen in the **"Zero Vision Tool", a collaborative platform, which brings together the maritime transport industry, the government, and the research community with a view to solving the technical issues affecting pilot projects on LNG refuelling or fuelling vessels with LNG or methanol.** Finally, the introduction of sulphur-emission standards has also stimulated requests to convert to propulsion systems with lower GHG (OCDE, 2018).

• SUPPORT NEEDED TO STIMULATE THE MARKET • In France, it is important to note the involvement of the Agency for Environment and Energy Management (ADEME). In the area of Transport and Mobility in the Investments for the Future Programme (PIA), "Vessels of the Future" is a topic that includes some 49 projects to which ADEME makes a financial contribution. In 2017, ADEME launched a call for proposals seeking to fund R&D projects in the naval industry, which could lead to industrialisable products. The call related to boats, vessels and mobile floating platforms used for commercial transport (people, goods), work (fishing, marine energy, surveillance, research, dredging, resource development), or leisure (boating). Of the four thematic areas, Area 1 "Economical Vessels" aims to achieve energy efficiency through reducing resistance to forward motion (shape, materials, structures, hydrodynamics), improving propulsion and energy use (performance, systems), and developing innovative solutions based on renewable energy or through optimisation of the total energy balance by managing on-board needs (water, ventilation, air conditioning, etc.). This

area also seeks to improve operational efficiency through optimising navigation operations, port manoeuvres and commercial operations (loading/unloading), optimising the preservation and recovery of cargoes, and enforcing interoperability with other modes of transport and onshore infrastructure.

The Honfleur project, winner of the ADEME prize

The aim of the HONFLEUR project, which was launched in March 2017 for a period of two years, is to achieve the replacement of the Normandie liner (1992) currently in service between the ports of Caen-Ouistreham (FR) and Portsmouth (UK). Over the next three decades, technological decisions affecting the design of the hull and its appendages, its diesel-electric motors, and devices used to manage and recover energy consumed should allow the HONFLEUR to consume 20% less energy compared with conventional vessels of its kind, and to be less polluting through its use of liquefied natural gas (LNG) as an alternative to oil fuel. This vessel will be the first LNG ferry to operate in the Channel-North Sea sector. The use of LNG allows for a drastic reduction in emissions of sulphur (-99%), fine particles (-90%), and nitrogen oxide (-87%) compared with the same amount of energy provided by marine diesel oil (MDO). It will also lead to a significant reduction in the carbon emissions of the vessel, which is also equipped with devices to manage electrical energy and energy recovery, and has diesel-electric motors. This all adds up to an average of 12,000 tonnes of CO_2 avoided per year compared with a conventional ferry. These environmental gains are important for air quality in port areas, which are generally close to areas with high population density (ADEME, 2018).

TEXT BOX 3

4 • TOWARDS RESPONSIBLE MARITIME TRANSPORT?

• ELECTRIFICATION OF THE SECTOR • Over the last ten years, there have been several initiatives in the engineering and naval construction sector to develop electric means of propulsion. These initiatives cover domestic transport vessels (Port-Liner), electrical cargo vessels (Hangzhou Modern Ship Design & Research Co.) and passenger transport (E-Ferry). These vessels, particularly passenger ships and ferries, are easier than any other type to equip with electrical propulsion due to their short journeys between the same ports. However, these initiatives do not specify the sources of energy used to recharge this new fleet's batteries, so it is difficult to estimate the reduction in GHG emissions attributable to shipping.

In addition to the electrification of vessels, ports have also embarked on electrifying their operations. In 2018, Nidec Industrial Solutions announced an advanced electrical supply system for the Port of Genoa in conjunction with the Western Ligurian Sea Port Authority. This project will enable berthed vessels to connect to a power supply once they have docked, eliminating the need to use their engines. This solution will reduce GHG emissions and limit the exposure of neighbouring residents to the atmospheric pollution and sound pollution produced by the generators normally used. This project follows numerous similar projects implemented in the ports of Livorno (Italy), Los Angeles and San Francisco (California), Juneau (Alaska), Gothenburg (Sweden) and Lübeck (Germany). In France, in 2017, the Port of Marseille Fos and La Méridionale introduced electrification of the quays to allow ferries to connect to an electricity supply from 30 minutes after passenger disembarkation until 2 hours before departure. It is now no longer necessary to use motors running on oil fuel

during this period at dock. In 2018, Corsica Linea, a company that provides a regular ferry service between Marseille and Corsica, announced that it planned to equip three of its vessels so that they too could connect to the electricity network when berthed. The introduction of the equipment for this new electrical connection device required an investment of between 3 and 5 million euros per vessel, to which ADEME and the PACA (Provence-Alpes-Côte d'Azur) Region were to contribute.

Burgeoning electrical maritime transport projects

CONTAINER BARGE • Port-Liner, a Dutch shipping company, is due to launch its first electric container barge shortly. Dubbed the "Tesla Ship", this vessel will operate by electric propulsion powered by independent batteries, giving it 15 hours of power in the case of the first model (52 m long and 6.7 m wide with a transport capacity of 24 containers), and 35 hours of power for the second model (110 m long and 11.40 m wide with a capacity of 270 containers.

CARGO SHIP • China launched the first electric cargo ship at the end of 2017. The ship, 70 m long by 14 m wide and weighing 2000 tonnes, was designed by Hangzhou Modern Ship Design & Research Co. The cargo ship can reach a cruising speed of 12.8 km/h and is powered by a series of batteries that generate 2400 kWh and which can be recharged in two hours, which enable it to travel 80 kilometres. In dock, the cargo ship has just the time to fully recharge while its cargo is being loaded and unloaded. The company hopes that this technology will soon be used by passenger vessels.

FERRIES • In 2018, the Havyard shipyard (Norway) announced that it had won a contract to build seven battery-powered ferries for the Norwegian transport company Fjord1. This news comes at a time when the operators of the first electric ferry in Norway, Ampere, announced their statistics with savings of up to 80% of energy and a 95% reduction in GHG emissions after two years in service. This vessel, which was brought into operation in 2015 as a result of a partnership between Norled AS (shipping company and ferry operator), Fjellstrand (shipyard), Siemens AS and Corvus Energy, is equipped with a battery with a capacity of 1 MWh. These economies of scale have triggered a series of orders to build new electric ferries or to convert ferries currently running on diesel. This announcement also comes at a time when Fjord1 is in the process of modernising its fleet following a request from the Norwegian authorities to achieve a zero-emission fleet. In parallel, Stena Line (a Swedish company) announced that it would convert Stena Jutlandica, a 185 m-long vessel which operates between Frederikshavn (Denmark) and Gothenburg (Sweden), to be powered by electricity, which would make it the largest electric boat in the world.

THE E-FERRY PROJECT • The E-ferry project (E-ferry – prototype and full-scale demonstration of next generation 100% electrically powered ferry for passengers and vehicles), funded by the EU, it is about to launch a fully electric, medium-sized ferry designed to transport passengers, cars, lorries and goods. Targeting medium-haul vessels, it should be able to travel distances of more than 20 NM between each charge with a large battery pack of 4 MWh. It is to be brought into service on lines between the Danish towns of Soeby and Fynshav (10.7 NM), and between Soeby and Faaborg (9.6 NM). The current E-ferry project was developed so that a recent design concept for high-energy performance could be applied. There were also plans to develop a case study and a commercial model, and prepare the concept before its forthcoming market launch, after a demonstration period. The aim, beyond the immediate duration of the project, is to bring into service each year around ten additional E-ferries in Europe and in the world to reach a total of ten or more by 2020, 100 or more by 2030, and thereby avoid emitting 10 to 30,000 tonnes of CO2 per year by 2020 and 100 to 300,000 tonnes of CO2 per year by 2030.

TEXT BOX 4

• OTHER TRENDING SOLUTIONS • In addition to electrification projects, there are also other types of solutions, such as incentives for better navigation. Consequently, the slowing down of vessels at the entrance to ports (or slow steaming) is one solution advocated in Long Beach and Los Angeles Port, which offers a reduction of 25% in demurrage charges in exchange for reduced speed when berthing. More effective and fuel-efficient navigation, and a reduction of speed at sea are therefore encouraged. There are further measures for managing vessels to reduce GHG emissions during navigation, such as reducing speed over journeys, reviewing the cladding of the hull, developing systems to recover lost heat, working on optimising the envelope and the ballast, regularly reviewing propeller polishing, reviewing the setting of the main motor on each new trip and updating autopilot upgrades (ActuEnvironnement, 2018).

The SeaWing project

The SeaWing project, which was launched in June 2016 for a period of 3.5 years with support from ADEME, consists of developing and marketing an auxiliary vessel towing system using an automated kite. The project was developed by the Toulouse AirSeas start-up comprising former Airbus employees and brought together marine architects, LMG Marin, the French Maritime College and MaxSea, the world leaders in marine navigation software. Technically, the idea was to assist the propulsion of a vessel by towing it using an immense wing. Inspired by kite surfing, this 1000 m2 wing attached to the end of a 400 m cable should be able to reduce a vessel's consumption by 20%. Another advantage of the procedure is that it is automated; the wing, folded on the deck of the ship, can be hoisted on a collapsible mast and deployed to the end of its cable by a single automated command, which includes the reverse procedure of folding it again. In addition to this wing, AirSeas is working on a project for decision-making software to help captains find the optimal route for their vessel depending on wind and ocean conditions, alert them to the opportunity to use the wing, and help them find the most effective position for it (La Croix, 2017).

TEXT BOX 5

CONCLUSION

Actors in international merchant shipping have, with the new IMO resolution on the GHG emissions-reduction strategy, at least demonstrated their desire to meet the challenge posed by the GHG emissions caused by shipping. Given these innovations, particularly in the area of electricity, maritime companies and shipyards will, in the coming years, have at their disposal a wide range of technological options to modify the means of propulsion of their vessels. The IMO is an important coordinator on a global scale in ensuring the deployment of partnerships between state and non-state actors needed to achieve the ambitious objectives of an international maritime transport industry that is in step with the Paris Agreement. The increase in the size of vessels and their cruising speed are also challenges that must be part of the IMO's new GHG reduction strategy if it is to achieve a successful energy transition for the international maritime sector, a sector that constantly faces major issues in international commerce; its strategic importance for major exporting countries, first and foremost China, makes defining a binding regulatory framework a complex task.

PLEASE DO NOT HESITATE TO REACT TO THIS STUDY, AND NOTIFY US COMPLEMENTARY REPORTS AND DATA VIA THIS ADDRESS : CONTRIBUTION@CLIMATE-CHANCE.ORG

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2018 GLOBAL OBSERVATORY
ON NON-STATE
CLIMATE ACTION

INDUSTRIES

BOOK 1

Sector based action

CLIMATE CHANCE

**PUBLISHED BY CLIMATE CHANCE ASSOCIATION,
NOVEMBER 2018**

Citation
**CLIMATE CHANCE (2018)
« SECTOR-BASED ACTION »**

**BOOK 1 OF THE ANNUAL REPORT
OF THE GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION**

REVISED AND CORRECTED VERSION - DECEMBER 2018

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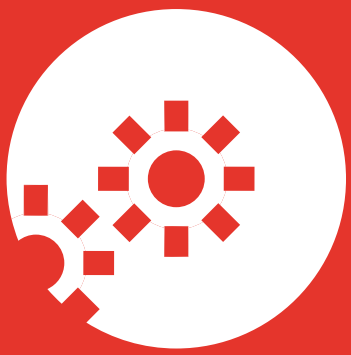

INDUSTRIES

INDUSTRIES..... 4

SECTOR PROFILE.....4
Reducing industrial emissions: a strategic and complex objective

Reducing industrial emissions: a strategic and complex objective

The industry is a very heterogeneous sector comprising many sub-sectors such as plastics, metallurgy, textiles and leather, agri-food, electronics, electrical equipment and machinery, wood and paper, chemistry and pharmacy, etc. Despite their diversity, these activities have in common the transformation of raw materials and energy – whose carbon footprint is relatively easy to evaluate – into much more complex finished or semi-finished products. They therefore have an important role to play, both in limiting their own emissions and in helping to decarbonise world consumption.

Head editor • **THIBAULT LACONDE** • *Consultant, Energy & Development*

CONTENTS

1 • EMISSIONS TRENDS FOR THE SECTORR

• Emissions in stabilisation

• Contrasted trends by sector and by country

2 • POLITICAL ACTION

• Carbon pricing

• Regulatory tools

• Voluntary approaches

3 • THREE VERY DISTINCT ISSUES

• Emissions related to energy and electricity consumption

• The industrial process issue

• Downstream and upstream emissions

4 • TRANSVERSE APPROACHES

• Transparency and voluntary commitments

• Cooperation

• Internal or local carbon prices

1 • EMISSIONS TRENDS FOR THE SECTOR

There is not a lot of updated information available to estimate emissions for all of industry. According to some sources, industrial activity is responsible for 24% of the 37 billion tonnes of CO_2 emitted in 2017 (SITRA, 2018). The available data show that these emissions experienced a period of strong growth during the 2000s and then stabilised before starting to rise again in 2017.

• EMISSIONS IN STABILISATION • Industrial combustion, excluding the energy industries, led to emissions of 6.54 billion tonnes of CO_2 ($GTCO_2eq$) in 2017 (Enerdata). **These emissions were virtually stable before the year 2000; they then displayed growth averaging 4% per year between 2001 and 2011, which took them from about 5$GTCO_2eq$ per year to 7.5$GTCO_2eq$ in one decade.** They then stabilised between 2011 and 2016, growing on average by 0.2% per year (Janssens-Maenhout, 2017). Still partial data for 2017 show much stronger growth last year, in the range of 2.5 to 3% (Enerdata).

Industrial emissions of other greenhouse gases have developed in diverging ways. The latest available data are from 2015; they show a downward trend for nitrous oxide (-18% between 2010 and 2015), perfluorocarbons or PFC (-9%) and sodium hexafluoride or SF6 (-14%). These positive developments are, however, counterbalanced by the increase in methane or CH4 emissions (+5% between 2010 and 2015) and, above all, hydrofluorocarbons or HFCs (+18%). In total, industrial emissions excluding CO_2 increased by 10% between 2010 and 2015, almost regaining 2000 levels (Enerdata, 2018). **It should be noted that these data are fragmentary and are generally only available for industrialised countries: China and India, for example, are absent.**

	2010	2011	2012	2013	2014	2015	2016	2017
CO_2	5,985.7	6,232.4	6,224.0	6,310.4	6,431.2	6,410.1	6,364.5	6,541.6
CH_4	2.1	2.1	2.1	2.1	2.2	2.2		
N_2O	50.9	51.0	44.0	41.2	43.0	41.7		
HFC	290.4	299.1	313.8	325.5	341.7	343.2		
PFC	18.7	20.5	18.8	18.5	17.3	17.0		
SF_6	18.6	18.9	21.4	20.4	16.4	16.0		

TABLE 1. TRENDS IN INDUSTRIAL EMISSIONS IN MILLIONS OF TONNES OF CO_2 EQUIVALENT

Source: Enerdata

These data, although incomplete, suggest that total industrial emissions grew strongly until the beginning of the decade and then remained stable before bouncing back in 2017.

• CONTRASTED TRENDS BY SECTOR AND BY COUNTRY • As can be expected in a sector as large and varied as industry, this global progression hides many differences. Emissions from the agri-food and chemical industries, for example, are heading downwards or stable (-15% and +1% between 2010 and 2015 respectively) while those of car manufacturers are growing rapidly (+23% between 2010 and 2015).

The two industrial sectors that emit the most are steel and non-metallic ores (sand, potash, phosphate, clay, etc.). They are also the ones that have risen the most over the long-term; their emissions have doubled since 2000. The pace of growth slowed down at the beginning of the decade but has been sustained: emissions from these sectors increased by 16% for steel and 7% for non-metallic ores between 2010 and 2015

	2010	2011	2012	2013	2014	2015	2016
Automotive	788.3	837.2	859.9	884.1	956.9	972.0	989.9
Steel	1,037.4	1,128.8	1,164.4	1,196.8	1,231.4	1 200.2	
Non-ferrous metals	132.1	132.8	128.1	136.0	140.5	139.3	
Non-metallic ores	1,035.4	1,124.0	1,106.9	1,111.1	1,148.8	1,106.5	
Chemicals	728.7	764.6	715.0	716.2	709.8	738.0	
Agri-food	273.6	270.3	260.7	257.7	239.3	233.6	

TABLEAU 2. TRENDS FOR CO_2 EMISSIONS IN CERTAIN INDUSTRIAL SECTORS IN MILLIONS OF TONNES

Source: Enerdata

Similarly, country-specific trends show a clear divergence between major emerging countries and the rest of the world: the sharp rise in industrial emissions recorded during the 2000s almost entirely occurred in China. Chinese industrial combustion emissions increased by 2GTCO_2eq between 2001 and 2011, while those in the rest of the world only increased by 0.4GTCO_2eq. The slowdown in Chinese growth and the evolution toward an economy that is less dependent on heavy industry and construction are therefore a major factor in stabilising industrial emissions.

In 2015 and 2016, Chinese industrial emissions fell slightly. This favourable development, however, was interrupted in 2017 by an expansionary economic policy, especially in the area of infrastructure, which has stimulated sectors such as cement or steel (Chinadialogue, 2017). Chinese industrial emissions are therefore up again in 2017 (+117MTCO_2eq), explaining the main bulk of the global upturn (an additional 180MTCO_2eq, approximately).

India became the 2nd largest industrial emitter in the world, surpassing Russia and Japan in the mid-2000s and the United States in 2012. **Even though it remains far behind China for total emissions, the role that India is playing is increasing: both countries have contributed almost as much to the growth of industrial emissions since 2010, and in 2017, Indian emissions increased by 24MTCO_2eq.**

The opposite trend is observed in Europe, the United States and Japan: there has been a drop in industrial emissions since 2010. Emissions from the three groups, however, are up again in 2017.

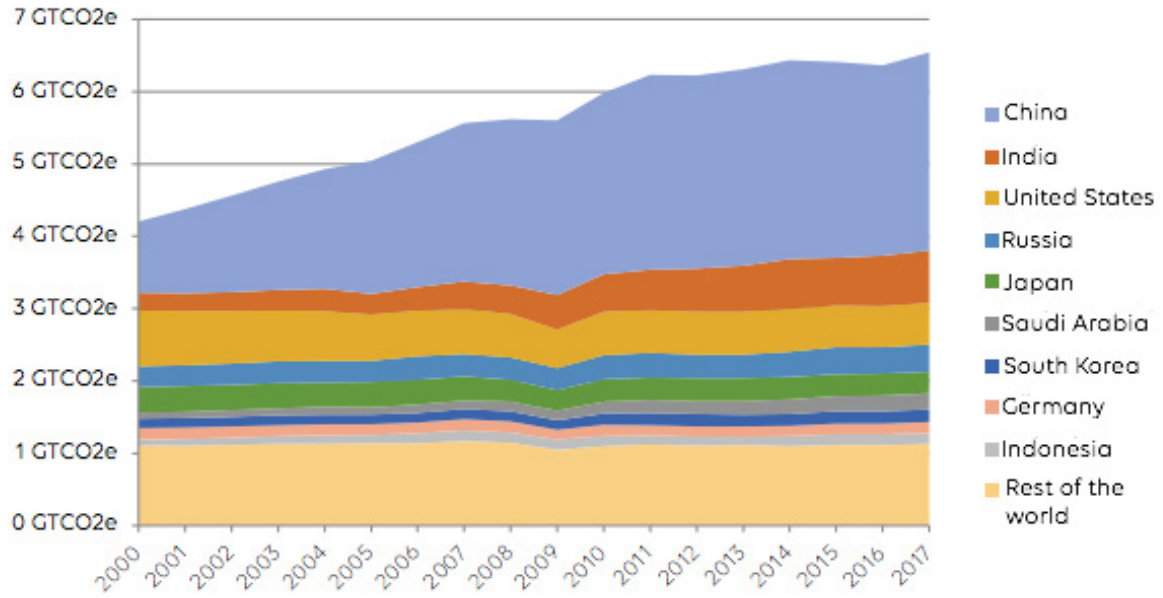

FIGURE 1. CHANGES IN INDUSTRIAL COMBUSTION EMISSIONS BY COUNTRY

Source: Enerdata

The strong growth of emissions in emerging countries can be partly explained by changes in their domestic demand, particularly in the materials and construction sectors. The increase in emissions, particularly in the manufacturing industry, is also linked to the shift in world trade towards Asia: about a quarter of global emissions are attributable to exported products or services, mostly from emerging countries to developed countries (Davis, 2010).

2 • POLITICAL ACTION

Due to its diversity and international competition, industrial activities are less easy for public emission reduction policies to reach than other sectors such as electricity generation, transportation or housing. However, some policy instruments regularly used to try to limit industrial greenhouse gas emissions can be identified.

• CARBON PRICING • Carbon pricing, by means of a tax or a market, is emerging as a central policy tool to incite manufacturers to reduce their emissions. **In 2018, 46 countries have implemented a carbon price, to which 26 provinces must be added (I4CE, 2018).**

In 2017, carbon taxes were implemented in Chile and Colombia, and carbon markets have been inaugurated in Alberta and Ontario. The Paris Declaration on the carbon price in the Americas, signed by 12 national and sub-national governments in December 2017, seems to herald that these systems are spreading further afield. These initiatives often call for other policies (taxation, planning, etc.) that may otherwise limit the effectiveness of the carbon price becoming more consistent (World Bank, 2018).

The largest carbon market currently in service is in the European Union. It was set up in 2005 and covers nearly 11,000 facilities including large industrial sites in the fields of steel, cement, glass, paper, etc. It has been extended to new facilities, particularly for chemicals, from 2013. Since manufacturing industries are exposed to international competition, they benefit – unlike the electricity sector – from free emissions allowances, which may have limited the efficiency of this provision. Since the price of emissions quotas has remained at a very low level until recently, the pressure exerted by this mechanism on industries to adopt low-carbon solutions has remained limited for the moment. In particular, there does not seem to be any correlation between the carbon price trends and research and development efforts, as measured by the number of patents filed (Marcu, 2017).

In China, the carbon market announced at the end of 2017 should initially only cover emissions from electrical power plants. However, this is not always the case for the markets that have prefigured it at the local level: in Hubei province, for example, the scope of the carbon market was extended in 2017 to cover all industrial facilities whose annual consumption exceeded 10,000 tonnes of coal equivalent at least once between 2014 and 2017.

• REGULATORY TOOLS • Various regulatory measures may also affect industrial greenhouse gas emissions. It is difficult to draw a systematic picture of these measures given the diversity of the activities involved. By way of illustration, we can mention:

• The progressive ban on hydrofluorocarbons (HFCs) following the Kigali amendment to the Montreal Protocol on the protection of the ozone layer.

• Emissions standards for both direct emissions from industries and the use phase of their products (e.g. automotive emissions standards).

• Various energy efficiency standards in the industrial sector. For example, the European Directive 2008/1/EC on industrial emissions, which submits the authorisation of more than 50,000 installations to the application of the best available techniques (BAT) and the emission limit values associated with them.

• VOLUNTARY APPROACHES • Finally, States can play a facilitating role by encouraging industries to self-regulate. This voluntary approach dominated in the 1990s and 2000s (OECD, 2003). It can rely on numerous instruments such as non-binding agreements, emissions reporting and benchmarking, self-assigned objectives, but also negotiated but binding agreements accompanied by penalties for non-compliance.

There is an example of this in Japan. After the adoption of the Kyoto Protocol, the country adopted a law on the reduction of emissions in 1998. With the help of MITI, the powerful Ministry of Trade and Industry, the economic players obtained its suspension on condition that each sector adopts its own action plan. In this way, 38 professional associations have made unilateral commitments since 1998. The steel industry, for example, has committed to reducing its emissions by 10% (compared to 6% for the economy as a whole), notably through the use of recovered fuel and energy.

3 • THREE VERY DISTINCT ISSUES

Direct emissions from industry, excluding the energy industry, have two major origins: fossil fuel combustion on the one hand, to which can be added indirect emissions related to electricity consumption, and other emissions from industrial processes (OECD, 2003).

Indirect upstream and downstream emissions must be added to these two categories, including production of the materials and equipment used, logistics, use of products, disposal, etc.

• EMISSIONS RELATED TO ENERGY AND ELECTRICITY CONSUMPTION • The reduction of direct emissions begins with more efficient energy use, whether it is produced on-site or purchased from a third party.

Reducing energy consumption generally requires modernisation of the industrial base and the adoption of more efficient technologies. In China, for example, the potential for reducing consumption in the cement industry could prevent the emission of 360MTCO_2eq, i.e. about a quarter of the emissions projected for the sector in 2020 (Wen, 2015). Significant energy saving potential also exists in developed countries: in Germany, for example, the chemical industry accounted for about one-fifth of the end-use energy consumption for industry in 2014, which represented 48.2MTCO_2eq. The energy saving potential in this sector is estimated at 6.8TWh per year, with 6.4TWh having a negative cost over the entire life cycle (Bühler, 2018).

Energy saving initiatives are often facilitated by cooperation between industrialists in the same

sector and with public authorities and research institutes. This is the case, for example, for glass production in Great Britain.

The energy efficiency and climate roadmap for the British glass industry

The manufacture of glass uses ovens, generally heated with gas, which alone account for 80% of the fossil energy consumption of the sector. In Great Britain, the efficiency of ovens has already been improved by 50% over 40 years and the sector adopted a roadmap in 2017, supported by the British government, to continue this progress.

This roadmap foresees the creation of a high-level group bringing together industry and professional organisations to lead the process, facilitate exchanges and develop collaboration with the authorities, particularly the BEIS, the ministry responsible for energy and industry. The industry is committed to accelerating the adoption of energy saving technologies and best practices, and exploring the use of lower carbon energies. It also wants to collaborate more closely with its suppliers and promote the use of products that emit less greenhouse gases with its customers. Efforts in the areas of training and research are also planned. Furthermore, the roadmap also envisages increasing glass recycling, which consumes much less energy than its manufacture.

For each of these actions, those responsible and a schedule were defined.

Source: British Glass, 2017

TEXT BOX 1

• THE INDUSTRIAL PROCESS ISSUE • Emissions from industrial processes are emissions related to the chemical reactions needed to manufacture certain products, cement and steel for example. Leaks of refrigerants (HFCs and PFCs) are also a part of it.

These emissions are generally difficult to reduce as they are fundamentally linked with the production processes. Around two-thirds of the emissions from cement production, for example, come from the high-temperature decarbonisation of limestone and clay to form clinker, a substance that is the raw material of cement. It is possible to reduce the carbon intensity of the energy required for its cooking, but the decarbonisation will always produce the same amount of CO_2.

Since it seems difficult to go without products as ubiquitous as steel or cement, the elimination of these emissions can be done either by their capture and sequestration (discussed in another sheet of Book 1 – Energy Section), or through the development of alternative manufacturing processes. In the second case, a particularly important technological innovation effort is necessary, followed by an upgrade of the industrial facilities.

Towards a steel without CO_2 emissions?

The steel industry is one of the most polluting industries. It is responsible, according to some sources, for 7% of the planet's carbon dioxide emissions. The use of coke, a derivative of coal, is responsible for 85 to 90% of the emissions from steel production. Coke is currently essential both for reducing iron oxides, which produces metallic iron and carbon oxides, and for heating blast furnaces.

In 2016, Swedish companies Vattenfall, SSAB and LKAB (the leading European iron ore producer) joined forces to try to perfect a process for making steel without fossil fuels or greenhouse gas emissions. The project, named HYBRIT, successfully passed its pre-feasibility study, and planning for the creation of a pilot was able to start. This pilot, 50% funded by the Swedish energy agency, is expected to enter the test phase between 2021 and 2024.

The goal is to replace coke with dihydrogen (H2) for the reduction of the iron oxides, on the one hand, and with electricity for heating blast furnaces on the other hand. The reduction of iron oxides by hydrogen only produces water vapour. The electricity needed for hydrogen production and heating will be completely carbon-free, which is already the case today in Sweden.

Given the current price of electricity, coal and CO_2, the steel produced by the HYBRIT project is expected to be 20 to 30% more expensive than conventional steel.

In 2016, the CDP estimated that over the last seven years and among the companies reporting on its platform, progress has been limited and that most have seen their energy emissions or intensity increase (CDP, 2016). The organisation, however, highlights the efforts of POSCO, which has commercialised a technology called FINEX to reduce emissions from steelmaking by eliminating scrubbing; SSAB, whose factories are considered the least energy intensive thanks to the use of electric stoves; and ThyssenKrupp, whose carbon intensity is low and who focuses on the manufacture of chemicals from its production waste. Conversely, US Steel, Tata Steel, Evraz or CSN stand out for the high carbon and energy intensity of their products, or for their lack of commitments or transparency.

Source: www.hybritdevelopment.com

TEXT BOX 2

• DOWNSTREAM AND UPSTREAM EMISSIONS • These emissions take place in the producer's value chain before their involvement (production of raw materials and equipment for example) or after (transport, use and end of life of products). They are not directly dependent on the responsibility of manufacturers but depend largely on their decisions, for example in the choice of supply chains, product design or site installations.

Supply-related emissions are on average four times higher than direct emissions, so they represent a significant potential for reduction. This energy supply is still relatively unexploited: according to the CDP, 52% of the suppliers who responded to its survey declare that the climate is integrated in their strategies, but only 23% work with their own suppliers on the reduction of their emissions (CDP, 2018).

Emissions during the downstream phases (use and end of life) vary greatly according to the product under consideration: they are of the order of 10% for electronic products (The Shift Project, 2018), but more than 50% for an electric vehicle and of the order of 80% for a thermal vehicle (Hawkins, 2012) or a building (Cho, 2016).

Technology choices and product design can therefore have a significant impact on long-term emissions. Such developments require an expensive innovation process and are often the subject of partnerships between industry, public authorities and research institutes. By way of illustration, the reduction of the weight of cars, for example by replacing steel with aluminium, would make it possible to avoid more emissions from here to 2050, than the switch to electric motors (Serrenho, 2017). This is the subject of an "Affordable Lightweight Automobiles Alliance" research programme as part of the "European Green Vehicles Initiative" public-private partnership. The goal is to design and test 25% lighter vehicles. The project involves some 20 industrial and university partners including Opel, Volvo, Thyssenkrupp, the Fraunhoffer Institute and the University of Florence.

One of the solutions to reduce these indirect emissions is the development of the circular economy, that is to say, to reintroduce all waste and by-products into the production cycle, for example heat or CO_2, which it itself produces. In Europe, the potential of the circular economy for the four main industrial materials (steel, plastics, aluminium and cement) in two major sectors (automotive and construction) would enable a reduction of the industry's emissions by 56% by 2050 (300MTCO_2eq per year) i.e. more than half of the total reduction needed to achieve carbon neutrality. At the global level, the potential for reducing industrial emissions is estimated at 3.6 billion tonnes per year in 2050 (Material Economics, 2018).

The circular economy is generally a territorial one, which explains why local authorities play an important role. The European Circular Economy Stakeholder Platform includes many local authorities among its contributors, including for example Amsterdam, Grenada or the French department of Lozère. A concrete example of this type of collaboration is provided by the port of Antwerp: in its strategic plan for the 2018-2020 period, it plans to develop exchanges of materials and energy between the petrochemical industry and companies developing renewable chemistry, and 90 hectares have been put aside for these activities.

4 • TRANSVERSE APPROACHES

Although existing differences between industry sectors do not provide universal solutions, some approaches appear to be widespread.

• TRANSPARENCY AND VOLUNTARY COMMITMENTS • A first level of commitment for manufacturers is to quantify and make public their emissions. These publications have become mandatory in some countries, for example in France for companies employing more than 500 employees or in the United States for facilities emitting more than 25,000 tonnes of CO_2, but they can also be voluntary or cover a wider scope than the one imposed. Doing this of their own free will seems to have multiple benefits for companies: there is a correlation between the level of transparency and financial performance, they also improve the company image and sometimes achieve gains in terms of energy consumption (Hahn, 2015).

International standards have been put in place to make these emissions results comparable. This is notably the case of the Greenhouse Gases Protocol, an accounting and emissions reporting standard intended for businesses and created on the initiative of the World Business Council for Sustainable Development and the World Resources Institute in association with numerous companies and NGOs. The Carbon Disclosure Project, a British NGO, is also helping companies to voluntarily evaluate and make public their emissions.

An additional step is to make reduction commitments. **In particular, the Science Based Targets initiative, a partnership between the CDP, Global Compact, WRI and WWF, helps companies determine a level of commitment consistent with the goal of limiting global warming to 2°C. About 400 companies are involved in this process including many industrialists in fields as diverse as automotive (Daimler, Honda, PSA, Michelin, etc.), materials (Saint Gobain, China Steel, etc.), consumer products (Kimberly-Clark, SEB, etc.), and so forth.**

• COOPERATION • Cooperation between manufacturers and with their stakeholders can enable the exchange of best practices and collaboration in finding a solution. This cooperation may be local, for example at the scale of an industrial zone, where it will enable the joint implementation of actions that complement individual commitments. Experimentation with these approaches in Canada (Côté, 2016) and in Germany (Bühner, 2013) has shown that they can reduce emissions by more than a third with limited costs.

Cooperation between manufacturers can also be sectoral with commitments and research programmes brought about by professional associations at the national or international level. Finally, it is notable that among 59 major global banks, 97% are involved at one level or another in such groups (World Bank, 2018).

The World Cement Association Climate Plan and CDP Data

Cement occupies a central place in the contemporary economy: it is the key component of concrete, which is the product most consumed by humanity after water. Cement production is based on a chemical reaction – the decarbonisation of limestone – which requires a large amount of energy and releases carbon dioxide. These two sources of emissions make the cement industry the second most emitting sector of greenhouse gases after the energy sector. Its emissions are estimated at 1.45 billion tonnes of CO_2 in 2016 and almost 40 billion tonnes accumulated since 1928 (Andrew, 2018). At the beginning of 2018, the CDP estimated that the companies reporting their data on their platforms and representing 15% of global production, showed only a 1% drop per year in the carbon intensity of their production over the last four years. Cement manufacturers must more than double their efforts to reduce emissions to achieve a trajectory consistent with the objectives of the Paris Agreement (CDP, 2018). Only Indian companies stand out with a lower proportion of clinker in their cement, a highly carbon-intensive component, thanks to better access to waste from other industries, such as slag or fly ash. Finally, it should be noted that the share of revenue given over to R&D among cement manufacturers is lower than in other industries, with an average investment of 6%.

In July 2018, the World Cement Association, which brings together some 50 cement companies from 30 countries, organised its first climate change forum. This work concluded that currently available technologies can indeed enable the achievement of the 50% reduction in their emissions needed for compliance with the Paris Agreement, but are still spreading too slowly.

In October 2018, the association published an action plan that is yet to be detailed at its annual summit at the end of the year. This plan defines five areas of collective action:

- The evaluation and publication of greenhouse gas emissions with the development of protocols adapted to the sector and the introduction of training;
- The efficient use of the cement produced and the reduction of emissions from the building sector over the entire life cycle;
- The use of waste energy for cement firing with the creation of an exchange platform intended to share knowledge and best practices in this field;
- Technological innovation, particularly around carbon capture, information systems and new types of cement and binders;
- The implementation of a process designed to distinguish innovative business models and products.

Source: www.worldcementassociation.org

TEXT BOX 3

4 - tps://www.eniday.com/en/sparks_en/oil-majors-invest-renewable-energy/
5 - https://www.fool.com/investing/2018/06/04/big-oil-is-investing-billions-in-renewable-energy.aspx

• INTERNAL OR LOCAL CARBON PRICES • In the absence of a carbon price, or if it is insufficient, the improvement of the carbon footprint can be achieved by creating an internal or local carbon price.

Internal carbon price

An internal carbon price is a value that a company voluntarily gives to its greenhouse gas emissions. It can be used to encourage decarbonisation and to recognise the financial risks associated with emissions.

Several methods exist: an implicit carbon price consists of retroactively calculating the price of emission reductions made by the company. A shadow price is calculated and taken into account in investment decisions. Finally, an internal carbon tax is a contribution that is made within the company on greenhouse gas emissions in order to quickly reduce emissions and generate revenues for the organisation's compensation or climate transition.

Microsoft, for example, uses an internal carbon tax to finance its investments in renewable energy and energy efficiency, as well as research and awareness activities for its employees. This price is calculated to cover a predefined investment programme applied to direct emissions and some indirect emissions (purchase of energy, air travel of employees, etc.). In recent years, it has been in the range of $5 to $10 per tonne.

Royal DSM, a Dutch manufacturer active in the field of nutrition and health, uses a virtual price of $55.84 per tonne, much higher than that of the European carbon market, to guide its investment decisions. The transition to renewable energy conducted by Unilever has resulted in an implicit carbon price of $10 per tonne.

Source: C2ES, 2017

TEXT BOX 4

We Mean Business, a coalition of NGOs working with businesses to tackle climate change, and the Carbon Disclosure Project launched the Carbon Pricing Corridors initiative in 2017. Its purpose is to encourage companies to set internal carbon prices consistent with the objectives of the Paris Agreement.

Finally, some 20 regions and cities have also set up a carbon price system over their territory. For example, a carbon tax is provided for in the Climate Change Act passed in 2017 by the Catalan Parliament. From an initial amount of €10/TCO_2eq gradually increasing to €30 in 2025, it notably concerns large industrial facilities. The tax must feed into a climate fund to finance emissions reduction and climate change adaptation policies. The future of this project is however uncertain because of the crisis between Barcelona and Madrid (World Bank, 2018). Other carbon tax and carbon trading schemes have been implemented in the territories, some of which are covered in section 2 of the 2018 Territorial Mobilisation Book 2.

CONCLUSION

Characterised by the diversity of products, processes and locations of installations, industry is not very accessible to general solutions to reduce its greenhouse gas emissions. The fight against climate change most often involves an approach using innovation at the scale of the site or activity. This specificity makes it essential to mobilise industrial players themselves and their stakeholders.

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2018 GLOBAL OBSERVATORY
ON NON-STATE
CLIMATE ACTION

LULUCF

BOOK 1

Sector based action

CLIMATE CHANCE

**PUBLISHED BY CLIMATE CHANCE ASSOCIATION,
NOVEMBER 2018**

Citation
**CLIMATE CHANCE (2018)
« SECTOR-BASED ACTION »**

**BOOK 1 OF THE ANNUAL REPORT
OF THE GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION**

REVISED AND CORRECTED VERSION - DECEMBER 2018

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LAND USE, LAND-USE CHANGE AND FORESTRY (LULUCF)

LULUCF 4

SECTOR PROFILE 4
LULUCF emissions and the disappearance of the forests: a situation as dramatic as ever

PERU 20
Preserving Peruvian Amazon rainforest : a societal challenge

IVORY COAST 32
Ivory Coast winning back its forests

FRANCE 46
The indispensable role of biomass and soils in France, concrete actions still being discussed

LULUCF emissions and the disappearance of the forests: A situation as dramatic as ever

In its overall assessment of greenhouse gas emissions (GHG), the IPCC estimates in its 5th report that the land use and land-use change and forestry sector (LULUCF) is an important sector, responsible for 20 to 25% of global greenhouse gas emissions. Soil contains between 1500 and 2400 gigatonnes of CO_2, about two to three times the amount of carbon in the atmosphere. The balance between release and storage of carbon in soil is crucial to maintain the climate balance, and the different scenarios envisaging carbon neutrality by the middle of the 21st century all rely on the capacity of forests, grasslands and wetlands to store a portion of the CO_2 emitted. Maintaining forests is also a challenge in terms of biodiversity, rain regulation and local communities.
«*There is no need to cut down forests to produce more food*» is the message hammered out by FAO in its 2016 report entitled «*Forests and agriculture: challenges and opportunities for land use*». According to the FAO, deforestation in the tropics and subtropics is mainly due to large-scale commercial agriculture (40%) followed by local subsistence agriculture (33%), infrastructure (10%), urban expansion (10%) and mining (10%), «with, however, significant regional variations».

Head Editor • *The Climate Chance Observatory team*

CONTENTS

1 • THE LULUCF SECTOR: EVER-DIFFICULT ESTIMATIONS

2 • THE RESUMPTION OF TROPICAL DEFORESTATION

- Brazil: See-saw deforestation
- Other Amazon basin countries
- Accelerating deforestation in Africa
- Trends for the timber industry in Africa
- Malaysia and Indonesia

3 • REFORESTATION

- The race for trees in India and China
- The complexity of European accounts in the LULUCF sector
- Reforestation in Africa

1 • THE LULUCF SECTOR: EVER-DIFFICULT ESTIMATIONS

More complex to calculate than the CO_2 emissions linked to fossil fuel combustion, their aggregations are highly uncertain as underlined for example by the Global Carbon Project in its "Global Carbon Budget" and which propose two figures separating LULUCF from the rest of the other sources of emissions. This margin of error can reach 30%, as shown by the Carbon Budget Global Carbon Project chart, which estimates 2016 land use emissions at 4.6GtCO_2eq (see Figure 1).

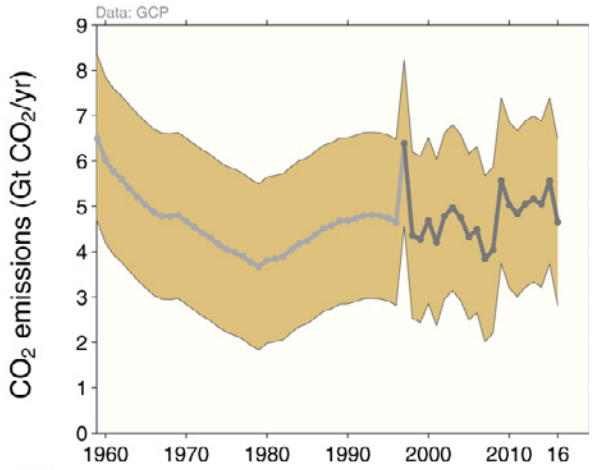

FIGURE 1: ESTIMATES FROM TWO BOOKKEEPING MODELS, USING FIRE-BASED VARIABILITY FROM 1997

Lecture: "Land-use change emissions are highly uncertain. Higher emissions in 2016 are linked to increased fires during dry El Niño conditions in tropical Asia"

Sources: Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Le Quéré et al 2017; Global Carbon Budget 2017

In its annual report on trends for GHG emissions «*Emission Gap Report 2017*», the United Nations Environment Programme (UNEP) highlights the doubts existing on the data provided by the States, quantifying at 3GtCO_2eq the differences between scientific estimates and the aggregation of the data from the national reports. The role of soils in emissions offsetting policies of other sectors, with the associated financial flows, also leads States to overestimate their carbon sinks potential, including in Europe. **According to a recent study (Luftalla et al., 2018), the conversion of forests and grasslands to soils rich in organic carbon generates a CO_2 flux from soils to the atmosphere corresponding to 10% of anthropogenic greenhouse gases. The fight against deforestation is therefore one of the major challenges of climate stabilisation.**

Since few countries provide annual figures for their land use-related emissions, and forests are often the main contributors to CO_2 fluxes (CITEPA), we have chosen to focus mainly on trends for forest cover, well documented worldwide. Trends for other categories of land use, such as the disappearance of grasslands and wetlands, the growth of artificial areas or cultivated land, would however require a dedicated analysis of their respective factors.

The causes of deforestation are particularly diverse and heterogeneous depending on the country and the continent: from urban sprawl to the development of intensive agriculture, from the firewood needs of the local populations to drilling for oil, or again from cutting down trees for precious woods to mining activity. In the particularly significant losses recorded in 2016, up 51% compared to 2015, forest fires also played a significant role: Brazil lost 3.7 million hectares, more than triple that in 2015. Portugal lost 4% of its forest area, and in Canada, the high-profile Fort Murray fire resulted in the loss of 600,000 hectares (Global Forest Watch estimates). Given such diversity of causes, we have chosen to scan the situation by continent, without seeking to be exhaustive, but by going over some major facts of recent years. This panoramic sweep, hardly optimistic in view of the figures, will cross-reference different tools used for the maintenance of forests, certifications, compensation mechanisms and so on, in a field where debates between players on the impact of these mechanisms are sharp.

United Nations strategic plan for forests

The seriousness of the situation, with an estimated loss of 13 million hectares of forest per year (UN figure), has led the United Nations to adopt a strategic plan for forests. This Strategic Plan was adopted by the Economic and Social Council (ECOSOC) on 20 January 2017 on the recommendation of the United Nations Forum on Forests, before being approved by the General Assembly on 27 April. It is based on six objectives and 26 targets, which are, as recalled by the President of the General Assembly Mr Peter Thomson, directly related to those of the 2030 Agenda for Sustainable Development.

The objectives are to end the reduction of forest cover by sustainable forest management; to enhance the economic, social and ecological benefits derived from forests; to significantly increase the surface area of protected forests and sustainably managed forests; to mobilise substantially larger financial resources; to promote governance frameworks for sustainable forest management; and to strengthen cooperation, coordination, coherence and synergies as far as the questions of forests are concerned.

Source: Economic and Social Council (ECOSOC)

TEXT BOX 1

2 • THE RESUMPTION OF TROPICAL DEFORESTATION

After a lull in the early 2010s, deforestation accelerated again in 2017, the second most devastating year in contemporary history after 2016. According to the report published by the Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM), Brazil, the Democratic Republic of Congo, Indonesia, Madagascar, and Malaysia have suffered the biggest losses in 2017.

• BRAZIL: SEE-SAW DEFORESTATION • Brazil lost more than 6000km2 of forest cover in 2017, albeit a bit less than in previous months (7989km2 between August 2015 and July 2016), but much more than the encouraging results of previous years (the Brazilian Ministry for the Environment). According to the estimate of the National Institute for Space Research (INPE), deforestation had reached its lowest level in 2012, with 4571km2 of forest cut down, compared with the peak of 27,700km2 in 2004. This deceleration in one year was however welcomed by President Michel Temer, in power since 2016, who was pleased that the deforestation curve had reversed after three years of increases. The intervention of the Brazilian President was also an attempt to respond to the threat from the Norwegian government – the main contributor – to halve its contribution to the fund for the preservation of the Amazon rainforest in 2017, compared to the $100 million paid in 2016.

The causes of this deforestation are known: keeping livestock and agriculture, and notably soybean exports. The port of Lorient, in France, also received the biggest cargo of soya in its history on 25 September 2018: 63,000 tonnes of soybeans from Brazil and Argentina were landed in one go by the Chloé freighter flying the flag of the Marshall Islands. This unloading aroused the anger of anti-GMO activists who demonstrated on the site, denouncing the transgenic and glyphosate resistant soya destined as Breton pig feed, and making reference to the wish of the region of Brittany – the owners of the port – which has still not been acted on, who in 2004 had passed a motion on the limitation of imports of GMO products.

Low carbon agriculture in Brazil?

Faced with criticism over its climate policies and the increase in its greenhouse gas emissions due to its agricultural sector, the Brazilian government, in partnership with the Brazilian Agricultural Research Institute (Embrapa), is highlighting its strategy for «*Low Carbon Agriculture*» (the ABC Plan). It is a Crop-Livestock-Forest Integration (ILPF) technique that alternates cattle breeding during the dry season with growing legumes in the summer on a plot where eucalyptus trees can also be planted. which generate income from felling, enrich the land, capture emissions of gases emitted by cattle and give them shady areas... The organic matter of the cattle allows them to nourish the soil and the nutrients to be retained in the earth. Developed in 2005 by Embrapa in the Centre-West region, this technique has already been applied on 11.5 million hectares in about ten years. The goal? By developing this technique on 55,000 hectares by 2030, the aim is to reduce greenhouse gas emissions by almost 300 million tonnes of CO_2 equivalent, or almost 13% of Brazil's total emissions in 2016. But no authority has been in control of the effectiveness of the implementation so far, and of the €5.3 billion unlocked, only €3.6 billion were used...

Source: La Croix, 11 February 2017

TEXT BOX 2

• OTHER AMAZON BASIN COUNTRIES •

In this report we publish a study on Peru, a country strongly committed to the facilitation of the climate convention, but struggling to curb deforestation on its territory, despite commitments made at COP21. It is not the only one causing anxiety. In Colombia, deforestation doubled in just one year in the Amazon part, reaching 2200km2 in 2017 i.e. the surface area of Luxembourg (Source: IDEAM, 2018).

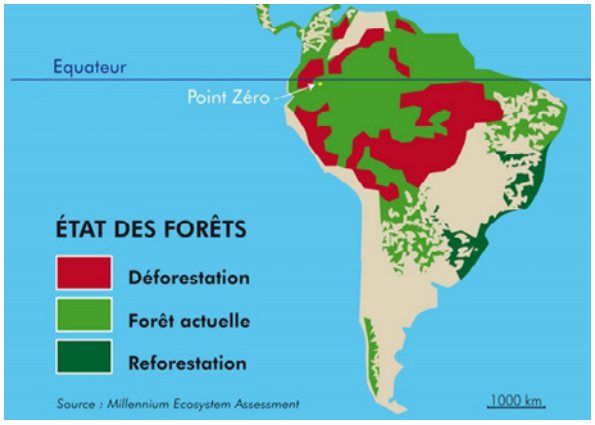

FIGURE 2. STATE OF LATIN AMERICAN FORESTS IN 2012

(Source: Millennium Ecosystem Assessment)

Colombia's supreme court rules in favour of an NGO on behalf of its international commitments

In January 2018, 25 children and young people prosecuted the Colombian State, accompanied in their initiative by the NGO Dejusticia, which styles itself as an «*investigation-action*» centre. The group demanded that the government guarantee their fundamental rights to life and the environment, and respect their constitutional rights. The Colombian Supreme Court has ruled in favour of the young plaintiffs. On 5 April 2018, it recognised the Colombian Amazon as a «*subject of law*». The government was served an order to prepare an action plan to preserve the forest in four months. Among the failings of the Colombian State identified by the Supreme Court, the fact that the severity of deforestation has not been measured to its true extent, «*despite the many international commitments*» of Colombia, emphasises the issue of greenhouse gas emissions.

Source: Dejusticia Centre for Legal and Social Studies

TEXT BOX 3

The reasons for this deforestation repeat themselves from one country to the next: logging and agriculture, mining activities and the depletion of land that leads farmers to clear new ones. Oil drilling is another important factor of deforestation, including the creation of roads and infrastructures leading to sites for the exploitation of deposits, which open the way to other exploitations (wood, gold panning, etc.). Symbolising this race for oil and currency, in August 2013, the Ecuadorian President Rafael Correa authorised the exploitation of hydrocarbons in the Yasuni Natural Park. This exceptional reserve, created in 1979, was classified as a World Biosphere Reserve by UNESCO in 1989. It covers 982,000 hectares in the Aalto Napo basin and is home to two indigenous groups living in voluntary isolation: the Tagaeri and Taromenane. Rafael Correa attempted to bury the Yasuni ITT project launched in 2007, which proposed to abandon drilling for 900 million barrels of oil on condition of an international contribution of $3.6 billion, half of the shortfall for the country. The fundraising, managed by the UN, has raised only $13 million, and $116 million in borrowers' notes (Lavaud JP, Mediapart 2016). On 7 September 2016, the Ecuadorian government launched drilling for the deposit despite the mobilisations of environmental defenders and associations for the defence of indigenous peoples from this region. In Venezuela, and especially in Bolivia, where President Morales has also authorised oil exploration in several major reserves, the situation is being repeated with the mobilisations of indigenous communities failing to block projects.

• ACCELERATING DEFORESTATION IN AFRICA • According to the FAO, deforestation on the African continent is the fastest growing in the world, faster than in the Amazon rainforest. It estimates that this loss of forest area is of the order of 3.1 million hectares per year, in the last five years. In its 2016 report «*State of the World's Forests 2016*», it underscores the particularity of the African continent, where many poor households are adopting «low-risk, low-yield» farming and income-generation strategies, and where subsistence farming remains the main driver of deforestation. Large-scale commercial agriculture accounts for one-third of Africa's deforestation, compared to an average of 40% in all tropical and subtropical countries.

The situation remains very different between the countries of the Congo Basin, with a profile known as «high forest canopy, low deforestation» (CEFD) where deforestation is still localised, but where the main threats are now concentrated, and the catastrophic situation in West Africa, where it exceeds 2% per year with the forest having lost about 85% of its original area.

A country, such as the Ivory Coast, which has a special feature in this report, has lost almost all of its primary forest and its remaining classified forests continue to be invaded by illegal plantations, principally cacao. The Ivory Coast now has the highest rate of deforestation on the continent according to the REDD+ Ivory Coast report, 2017. Between development issues with the possibility of resources linked to export crops for poor people, and weak States, the situations remain very difficult to control; even if governments multiply statements about their desire to preserve or restore their forest cover, while looking towards climate finance, in particular linked to the REDD+ mechanism.

Emissions trading systems: Prospects for the forestry sector?

In 2015, forest carbon projects accounted for 29% of the volumes traded, and ranked second, just behind renewable energy development projects. Taking into account the credits exchanged on both the voluntary and compliance markets, the main projects are the REDD+ projects, followed by improved forest management projects. While REDD+ projects largely dominate the international voluntary market, the improved forest management projects are mainly present in the compliance markets, principally in California and Australia. Despite a significant and continuous decline since 2011, the prices achieved by forestry projects remain higher than the average observed for the entire voluntary market ($5.7/tCO$_2$eq for forestry projects compared to an average of $2.8/tCO$_2$eq for 2015, a historic minimum).

Source: French Agriculture Academy (AAF)

TEXT BOX 4

As part of the Central African Forest Initiative (CAFI), two conventions have been signed; one with the Democratic Republic of Congo, the other with Gabon for $18 million to protect the country's forests and accelerate the fight against climate change. «*This agreement is a big step forward. Gabon commits to measures that, once implemented, will preserve 98% of its forests*», said Vidar Helgesen, Norwegian Minister of Climate and Environment and President of CAFI. «CAFI is proud to support this ambitious but pragmatic plan, which aims to ensure that the economy of a middle-income country grows while preserving its invaluable natural capital, for the Gabonese and for the whole world.» (Source: UNDP)

In the Democratic Republic of Congo (DRC), alerted by NGOs including Greenpeace, on 6 March 2018, CAFI publicly announced that it will suspend funding to the government until illegally re-allocated timber licences are revoked. The DRC Ministry for the Environment had reinstated three timber licences owned by Chinese companies, SOMIFOR and FODECO, for a total of 6500km2 (an area equivalent to that of the French department of Drôme). Two of these concessions encroach on 145,000km2 of recently discovered peatlands containing some 30 billion tonnes of carbon, with a significant risk of methane emissions associated with the opening of this massif to logging (Greenpeace, 2018).

The Central African Forest Initiative (CAFI) for Sustainable Forests in Africa

CAFI is a collaborative partnership that brings together the Central African countries: Cameroon, Gabon, Equatorial Guinea, Central African Republic, Republic of Congo, Democratic Republic of Congo, and a coalition of donors: Germany, South Korea, France, Norway, the Netherlands, the United Kingdom and the European Union, and finally Brazil as South-South partner. Partners' commitments are formalised through the CAFI Declaration. CAFI is a unique initiative that supports national strategic and holistic domestic investments in REDD+ and low-emissions development, while focusing on Central African countries with high forest cover. Its purpose is to recognise and preserve the value of forests in the region so as to mitigate climate change, reduce poverty and contribute to sustainable

FIGURE 3 THE CENTRAL AFRICAN FOREST IN FIGURES

Source: CAFI infographic

development.
CAFI's support is focused on:
• The development and implementation of **National Investment Frameworks** (NIF) validated at the highest level by national institutions whose mandate is cross-sectoral;
• Funding based on the achievement of programmatic and political milestones as set out in letters of intent;
• Donor coordination and alignment of assistance with the NIFs of partner countries;
• Inclusive participation of all stakeholders
• CAFI support goes through the CAFI Fund, a trust fund managed by the UN Multi-Partner Trust Fund Office.

TEXT BOX 5

• TRENDS FOR THE TIMBER INDUSTRY IN AFRICA • The trend for logging in Africa is also an important piece of information. At the start of 2018, the Africa branch of the Rougier Group filed for bankruptcy. A listed family company, Rougier is one of the oldest and biggest timber companies in Africa. Its first okoumé tree operations started in the 1950s in Gabon; it is also present in Cameroon, Congo and, since 2015, in the Central African Republic (CAR). The total area owned by the Rougier Group is over 2.3 million hectares and it employs 3000 people, mainly in Africa. It should totally or partially divest itself of its operational activities on the continent, except in Gabon. Other forestry companies, most of them European, have had to sell some of their assets in recent months. The Wijma Cameroon Group, with Dutch capital, had to sell four of its five timber licences in Cameroon in 2017 to a competing company (Vicwood SA, with headquarters in Hong Kong). The Italian company Cora Wood SA, a well-known plywood manufacturer established in Gabon, had to sell one of its concessions to a Chinese company.

This mutation is a concern. It would mean for Alain Karsenty, researcher at CIRAD, and who has published a long article on the subject: «*the end of a cycle opened by the first forest management plans in the 1990s, and which continued with the revival of the "good forest management" certification» (the Forest Stewardship Council label, FSC) some 15 years later. It was then thought that sustainable forest exploitation of the natural forest – reconciling economic profitability, ecological dimension and social progress – had demonstrated its feasibility in Central Africa, despite the well-known governance problems in this region (...). However, the profitability of exploiting natural forests has relied, until now, on the collection of a handful of species well known to timber consumers (...). The advantage of this extremely selective exploitation is that the forest is scarcely damaged by taking rarely more than, on average, one or two trees per hectare, i.e. 10 to 12m3 (...). European dealers, formerly essential in African timber operations and industry, are gradually yielding their assets to Asian investors. While Malaysian operators have been present in Central Africa since the mid-1990s, Chinese companies have entered the industry properly since the 2000s, and more recently Indian investors, including the multinational Olam, have made their presence known in Gabon and Congo. These operators have significant capital and the markets in which they operate accept qualities sometimes lower than those demanded by European buyers (...). European operators are wondering if they are on a level playing field with some of their Asian competitors. Large European companies have gradually complied with legal standards by preparing forest management plans, made compulsory by the new generations of forestry laws that appeared in the years 1990-2000. Some of them went further, adopting a rigorous logging certification, the FSC. This label is important to gain or maintain market share in certain Western markets sensitive to environmental issues (in Northern Europe, in particular) and hope for a higher purchase price for the timber thus labelled. Certification is therefore an investment that drives companies to self-regulate in order not to lose*

the label whose implementation in the field is regularly checked by independent auditors. However, apart from Olam, which bought a large concession already certified in north Congo from a Danish company in 2011, no Asian-owned operator has seriously sought, at least until now, to obtain the FSC label for its permits."

Source: http://www.willagri.co m/2018/06/28/la-crise-de-la-filiere-europeenne-du-bois-tropical-en-afrique-centrale/

In this situation, which sees the threat of progression from exploitation of a specific species to a more complete deforestation, the decision of Gabon against the trend of the sector cannot go unnoticed. Gabonese President Ali Bongo Ondimba has announced that Gabon will withdraw logging permits from any operator that is not engaged, between now and 2021, in a process of certification of the Forest Stewardship Council (FSC), with 2022 as the cut-off year. Gabon, which has not exported logs since 2009, but already provides some of the processing in its territory, is principally targeting markets in Northern Europe, where certification is necessary.

Other threats weigh on African forests without us being able to detail them all here. Illegal deforestation to provide softwood for Africans (timber exploited by large international companies being too expensive for local populations and reserved for export) is a developing phenomenon, leading to specific programmes financed, for example, in the framework of REDD+ in the Ivory Coast. Deforestation related to firewood is well known, and initiatives to control it are numerous without so far demonstrating any significant impact. As for many African cities in development, the search for firewood today requires traveling great distances, which also causes an increase in its price. Finally, the risk of land grabbing is real, as shown by the arrival of the Korean company Daewoo Logistic in Madagascar, where it took out a 99-year lease on 1.3 million hectares, creating a major political crisis.

• **MALAYSIA AND INDONESIA** • Malaysia, which derives 11% of its GDP from the exploitation of palm oil, has not reduced its rate of deforestation in 2017 according to the estimates of the NGO Global Forest Watch.

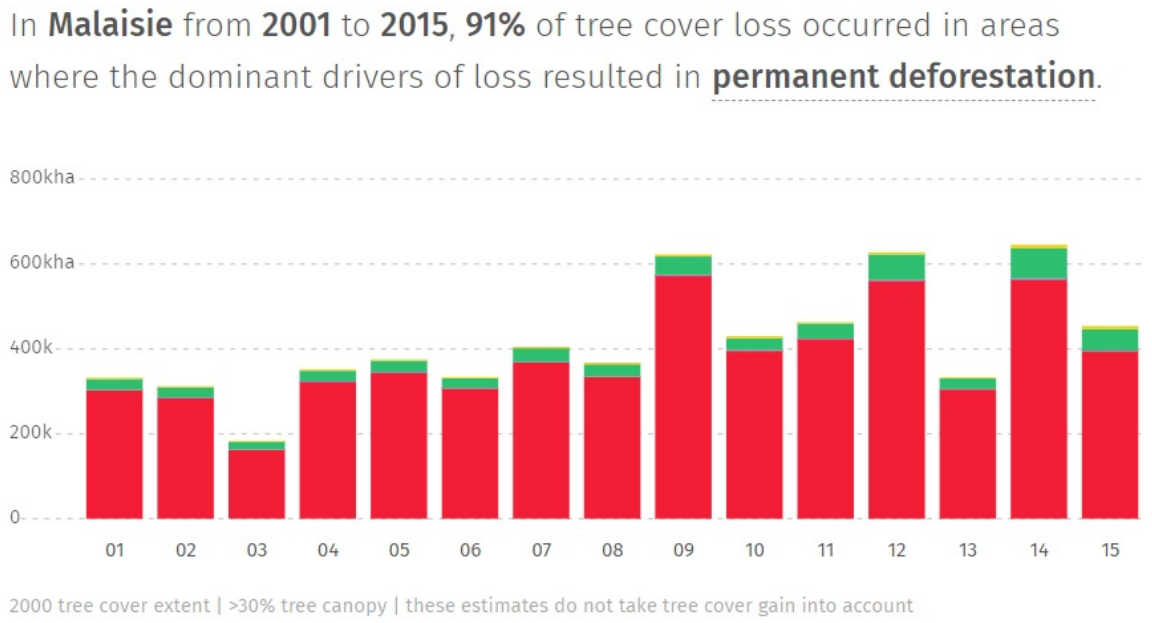

FIGURE 4. LOSS OF THE FOREST CANOPY IN MALAYSIA BETWEEN 2001 AND 2015 SOURCE: GLOBAL FOREST WATCH, 2018.

Source: Global Forest Watch, 2018

On the other hand, Indonesia has decided to significantly reduce its deforestation, with a moratorium on forests introduced by the Indonesian government in 2016. This has enabled the reduction of deforestation by 88% in the primary forest areas of protected peatlands. This political will has also resulted in the application of stricter laws and media coverage of the arrest of logging company managers. Finally, weather conditions, notably wet weather, have also played a role in reducing forest fires on the archipelago (Source: Global Forest Watch). The many toxic fires and clouds, with strong consequences for human health, were also driving forces in the Indonesian government's decision.

FIGURE 5. LOSS OF PRIMARY FORESTS IN INDONESIA (IN HECTARES).

Sources: World Resources Institute / Global Forest Watch

Indonesia comes to the aid of its peatlands

A team of European and Indonesian scientists, offering satellite imagery and an aerial mapping system to prevent peatland fires ravaging forests in Indonesia, won a $1 million (€900,000) prize in 2017 awarded by the Indonesian government. These organic-rich wetlands contribute annually to forest fires in the South-East Asian archipelago. To fight against this scourge, the government launched this competition, to which more than 40 teams of scientists applied, with participation from experts in remote sensing from all over the world, according to the organisers.

The winners, the international peatland mapping team with scientists from Indonesia, Germany and the Netherlands, have developed a method combining an airborne laser mapping system and ground measurements to determine the depth and the extent of the wetlands and peatlands. This technology should enable increasing the measures taken to protect the peat – a particular and fragile ecosystem – and prevent forest fires. The Indonesian authorities have already tightened peatland protection legislation to prevent the conversion of carbon-rich soils into plantations, particularly for palm oil, which fuels the devastating annual forest fires during the dry season.

Drainage of these waterlogged lands to extend oil palm plantations increases the risk of peat fires that are very difficult to control, and the Indonesian government has also tightened water management legislation to avoid their drying out.

Source: Le Figaro with the AFP

TEXT BOX 6

The destruction of primary forests, particularly on the island of Borneo, threatening orangutans, has become one of the great symbols of harm to the environment in the world, generating questions about consumption patterns via the question of palm oil.

In June 2018, the European Parliament voted in favour of banning palm oil for agro-fuels as early as 2021 – a deadline postponed until 2030 after a difficult negotiation with the European

Commission – but their consumption should have begun to decrease in 2023. In France, the authorisation of the oil company Total to use 300,000 tonnes of palm oil for its La Mède refinery also provoked huge controversy, highlighting public awareness of this issue.

Malaysian and Indonesian producers, who account for 85% of the world's production, are paying close attention to European debates, using the weapon of commerce to threaten European countries, primarily France, with retaliation that would limit access to palm oil in their market.

3 • REFORESTATION

On a global scale, the balance is still very clearly negative, but reforestation is nevertheless an important element of the global forest canopy action, even if these replantings rarely equal the rich biodiversity of the deforested territories.

The figure above shows a net loss of forest area in tropical zones in each of the three five-year periods between 2000 and 2015. By contrast, temperate zones recorded a net increase in forest area during each of these periods. Finally, only relatively minor changes were observed in boreal and subtropical forest zones.

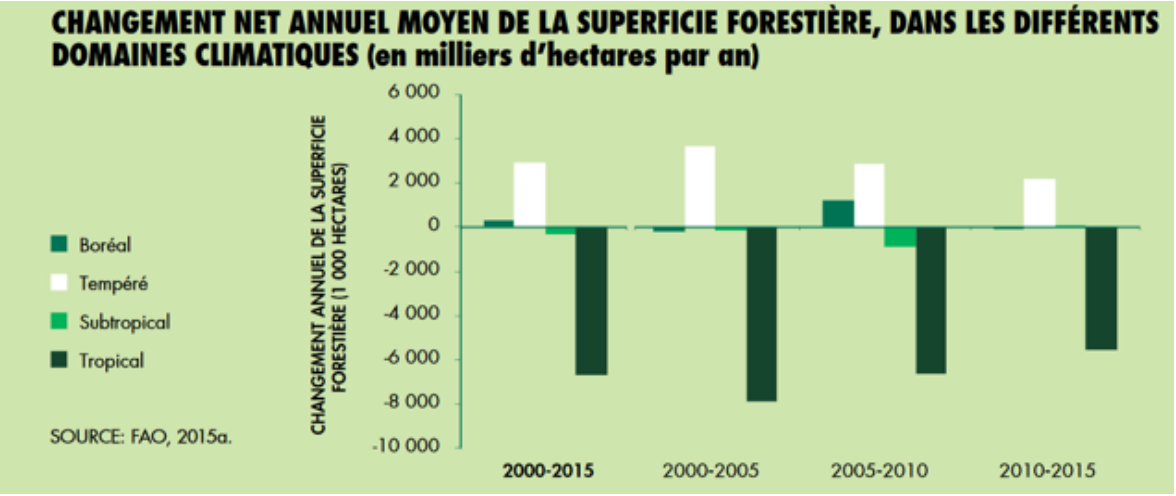

FIGURE 6. AVERAGE ANNUAL CHANGES IN FOREST AREAS BY GLOBAL REGIONS BETWEEN 2000 AND 2015

Source: FAO, 2016

• THE COMPLEXITY OF EUROPEAN ACCOUNTS IN THE LULUCF SECTOR • The European Commission's report to the European Parliament and the Council of 7 November 2017 provides a relatively positive overview of the LULUCF sector in Europe, with a view to achieving the European Union 2020 climate objectives: «In 2015, according to the information provided, the LULUCF sector of the Union has, through its carbon sink function, absorbed 305Mt of CO_2 equivalent (cropland and pasture included). The credit recorded, which represents the difference between the reported value and a baseline scenario, increased from 115 to 122Mt of CO_2 equivalent between 2013 and 2015. This credit is largely due to forest management (see Figure 4). The Union therefore remains on track to ensure that its LULUCF sector is not in debit and is likely to meet the commitment under the Kyoto Protocol."

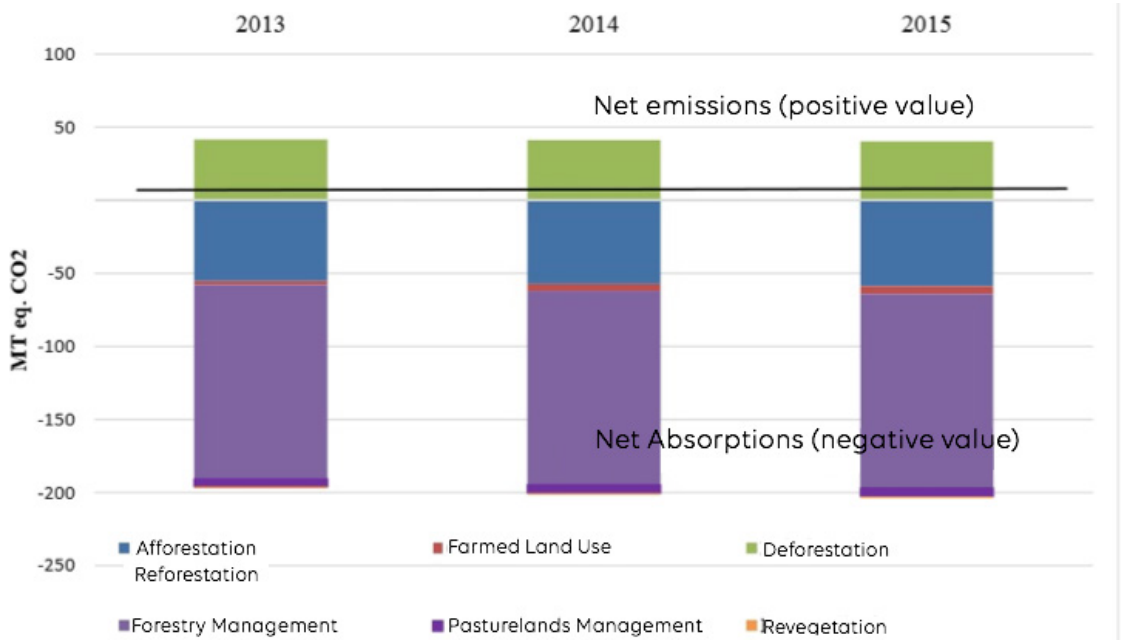

FIGURE 7: EMISSIONS AND REMOVALS RECORDED FOR LULUCF BY ACTIVITY FROM 2013 TO 2015

«It should be noted that LULUCF accounting will be cumulative for the period 2013-2020; therefore, the full accounting results cannot yet be calculated and are thus provisional. However, as mentioned above, there is currently no significant risk of non-compliance at Union level.» concludes this communication from the European Commission.

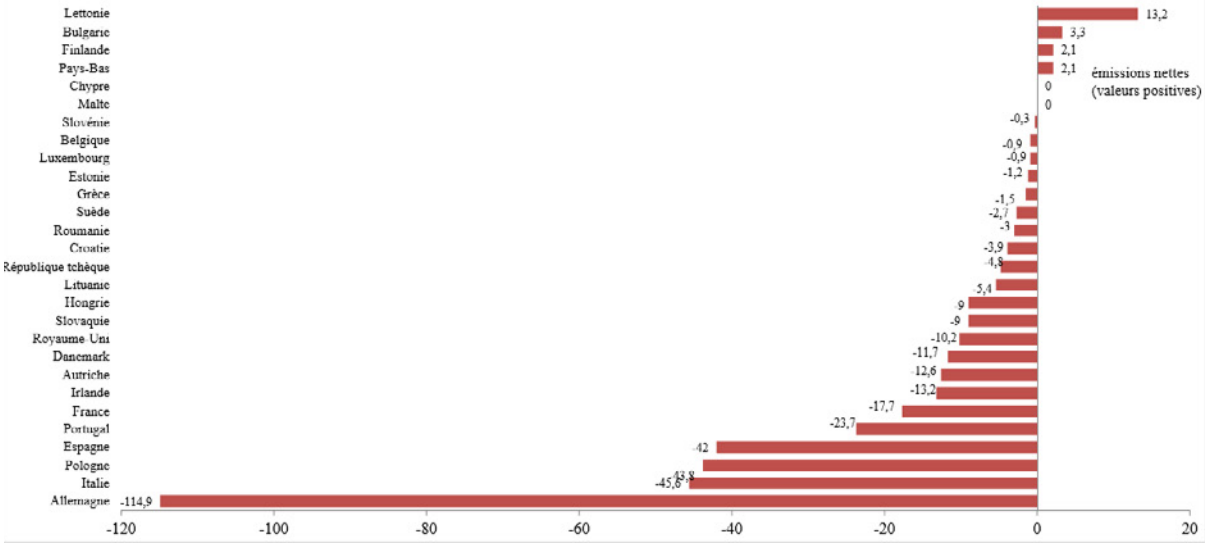

FIGURE 8. PROVISIONAL ACCOUNTING OF LULUCF CUMULATIVE NET EMISSIONS AND REMOVALS BY EU MEMBER STATES BETWEEN 2013 AND 2015

Source: European Commission, 2017

This Commission communication is nonetheless tempered by another internal note, which shows how governments have recovered carbon credits by exaggerating the logging targets of their forests and thus posting a positive but «fictitious» rate of preservation (it is considered that preservation efforts qualify for credits). But these fictitious credits are not trivial: they were then used to offset the emissions of polluting sectors, under the Kyoto Protocol. «This scam has gone on for too long. Member States must be serious about their forests and correctly calculate the impact of their management practices on the climate "declared the NGO FERN, specialising in these forest issues. It considers that this laissez-faire approach could reduce the European emission reduction

result by 3 to 7 points compared to the 40% reduction target by 2030 (Euractiv 2018). The European Union has issued a new regulation in 2018, which should reduce this risk.

The new European regulation

On 30 May 2018, the European Union published a new regulation (2018/841) on taking into consideration greenhouse gas emissions and removals resulting from land use. The preamble to this regulation emphasises that Member States must ensure the conservation and enhancement of the forest sinks and reservoirs needed to meet the European Union's commitments to the Paris Agreement.

To maintain the carbon stocks of forests and other natural areas, the regulation stipulates that Member States should make sure that the LULUCF sector does not produce net emissions and strengthens long-term sinks. Member States will provide two forest plans at the end of 2018 for the 2021-2025 period and in 2023 for the 2026-2030 period, which will be aggregated at the European level. Member States are allowed to use part of the forest credits created by improving storage to offset their domestic emissions, but with a European ceiling corresponding to 10% of the sink. Today, the annual European «net» sink is estimated at around 30MtCO_2.

TEXT BOX 7

• THE RACE FOR TREES IN INDIA AND CHINA • In 2009, China announced its intention to build «The Great Green Wall of China», the largest ecological project in the world, to extend over 4480km and designed to curb the progression of the Gobi Desert, to combat global warming and restore deforested land. According to the observatory Global Forest Watch, 8 million hectares of forest were lost between 2001 and 2016 in China. Only 6% of the country's forests are primary, 57% are of natural origin and 37% are planted, estimates the observatory.

The Chinese authorities have planned, for 2018, reforestation of about 84,000km2, and the newspapers of the whole world echoed the mobilisation of the People's Liberation Army. According to China Daily, **60,000 soldiers were moved from the northern borders of the country to the central part of China, reassigned to planting trees. Zhang Jianlong, Chairman of the Public Forestry Administration was able to point out that, between 2012 and 2017, the equivalent of €68.3 billion were spent to replant trees in the country, bringing the total area of forests in China to 208 million hectares.** Voices have been raised in the past to emphasise that this effort has not always been done by integrating biodiversity issues, and that few species have been used, with significant losses on the plantations.

India is not to be outdone by its neighbour, and is committed to increasing its forest area by 95 million hectares by 2030, a project put forward in the Paris Climate Agreement and is estimated to cost about $6.2 billion. But in this race for the record, India has managed the feat of planting 66 million trees, of 20 different species, in 12 hours. As in China, communication was assured and Shirvraj Singh Chouhan– Chief Minister of the State of Madhya Pradesh, where these plantations were carried out – was able to declare: «*the world is talking about global warming and climate change, but Madhya Pradesh has taken a concrete step to deal with it*».

Pakistan has succeeded in planting no less than a billion trees

This project, dubbed «The Billion Tree Tsunami», was launched in 2015 in Khyber Pakhtunkhaw Province in North-Western Pakistan, located between Afghanistan, Iran and India. Between 2000 and 2010, Pakistan lost 430,000 hectares of forest. Today, Pakistan has a forest cover of between 2 and 5% of its area. This is the lowest rate on the Asian continent. This project, started in 2015, aims to restore 350,000 hectares of old forests. Indeed, for several decades this region has suffered significant deforestation related to human activities that has exacerbated the consequences of natural disasters. In 2016, sudden floods hit the province, killing dozens of people. For three years, more than 16,000 workers worked tirelessly to plant trees of 42 different species and promote the natural regeneration of the forest. As a result, by August 2017, several months ahead of schedule, 1 billion trees had been planted, half of them by the general public, covering the hills of Khyber Pakhtunkhaw province.

Pakistan's Prime Minister Imran Khan has announced that 100 million trees will be planted by 2023, when his term ends. From August 2019, the «Rung Do Pakistan» campaign is already planning to plant 1.4 million trees on 1400 hectares.

Source: WWF Pakistan

TEXT BOX 8

Thus, Asia appears today as one of the regions of the world intervening most in the reforestation of the planet.

• REFORESTATION IN AFRICA • While increased deforestation is occurring throughout the African continent, a number of countries are also symbols for the reclamation of soil quality, with the support of the United Nations Convention on Desertification, whose role is often unknown (this is the third convention planned by the Rio Earth Summit in 1992, with the framework agreements on climate and biodiversity).

Often cited as an example, Rwanda is halfway to reaching its goal of 30% reforestation in 2020, or 2 million hectares of degraded land to restore. In this country characterised by its high population density, the highest in Africa, overexploitation of the land resulted in the loss of a significant part of the forest canopy in the 1990s. Since the commitment was made in 2011, all regions have been involved, and planting days have been set up to mobilise the population. "Rwanda's National Forest Planting Day and Season" is a programme supported by IUCN, a Belgian technical cooperation and a joint Rwanda/Netherlands platform on the management of water resources (Fonerwa, 2018).

Reforestation actions are also being undertaken in many other African countries, such as Ethiopia, Togo, and Senegal with the great green wall project supported by the African Union...

An important initiative was launched at COP 21 to reclaim, by 2030, the equivalent of 100 million hectares of forests and agricultural land that has become unproductive in Africa. Supported by the African Union, the German Ministry of Cooperation and the World Resources Institute and named AFR100 for «African Forest Landscape Restoration Initiative», this initiative, originally brought by Ethiopia, Democratic Republic of Congo, Kenya, Niger, Uganda, Burundi, Rwanda, Liberia, Madagascar, Malawi, and Togo, today brings together 26 African countries. At the last meeting of the technical partners, in August 2018, the commitments made by the States amounted to 91.4 million hectares, through specific projects, many of which remain to be financed (€1.3 billion according to CIRAD experts, also a partner of the initiative).

CONCLUSION

The continuing destruction of tropical forests is one of the most serious environmental threats today, in terms of both climate and biodiversity. While the Indonesian moratorium will have to be carefully monitored elsewhere in the world, the situation remains critical, with increased risks for recent political developments or the strengthening of the role of companies with little regard for certification. If they do not represent all the LULUCF emissions, forests are an essential element of carbon capture; they are essential for the credibility of carbon neutrality scenarios by 2050. Building an international coherence between their preservation, growing demand for biofuels and changing dietary habits remains a challenge that the world still fails to meet.

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Preserving Peruvian Amazon rainforest : a societal challenge

By hosting COP20 in Lima in 2014, Peru has taken the place of a leader in the fight against climate change in Latin America. While deforestation and forest degradation are the largest source of CO_2 emissions from Peru with 143,000 ha disappearing in 2017 alone out of the 69 million ha in the country, the target of 0% deforestation by 2021 proclaimed by the government appears ambitious. The diversity of economic activities that destroy forests makes these goals difficult to achieve. Both industrial and family plantations of coffee, cocoa and palm oil, gold mining and logging operations each call for different measures. In parallel with the government setting up a legislative framework called the Framework Law on Climate Change of 2018 and the continued zonification of forests, NGOs, researchers, independent press, local authorities and local communities monitor, report and fight deforestation on the ground, often using the UNFCCC REDD+ program.

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CONTENTS

1 • AMBITIOUS BUT SOMETIMES CONFLICTING NATIONAL OBJECTIVES
• Deforestation, the largest source of emissions
• Ambitious commitments and refining the legislative framework
2 • FROM MULTINATIONALS TO ORGANISED CRIME – DRIVERS OF DEFORESTATION
• Agricultural expansion
• Gold mining
• Timber logging
• Indirect drivers of deforestation
3 • THE MANY TYPES OF BATTLE AGAINST DEFORESTATION
• Researchers and NGOs organise real-time monitoring of deforestation
• The role of local authorities
• REDD+ – framework of preference for action by non-state actors

1 • AMBITIOUS BUT SOMETIMES CONFLICTING NATIONAL OBJECTIVES

• DEFORESTATION, THE LARGEST SOURCE OF EMISSIONS • More than 50% of Peru's greenhouse gas emissions are due to the Land use, land-use change, and forestry (LULUCF) sector. Its relative share has decreased in the last decade in response to increasing emissions from other sectors (MINAM, 2016). The major role of the land sector in Peru's greenhouse gas results stems from the fact that 60% of Peruvian territory is covered by rainforest. These 69 Mha, 94% of which are part of the Amazon rainforest, make Peru the 2nd country in the world with the largest area of the Amazonian forest after Brazil (MINAM, 2016). As in Brazil, deforestation and forest degradation are political, economic and social issues that are decisive in reducing national and global emissions. In 2017 alone, the loss of the Peruvian Amazon forest is estimated to be 143 thousand hectares, 13% less than in 2016 but still a worrying figure because nearly 2 Mha of rainforest have disappeared in total between 2001 and 2016 (Finer et al., 2018).

• AMBITIOUS COMMITMENTS AND REFINING THE LEGISLATIVE FRAMEWORK • The Peruvian government is a historic signatory of international agreements on environmental issues, for example by ratifying the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973, the Convention on Biological Diversity (CBD), United Nations Convention to Combat Desertification (UNCCD) and United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and recently the Paris Agreement on climate change in 2017. The Intended Nationally Determined Contributions (INDCs) submitted by Peru upon ratifying the Paris Agreement do not specify the means of implementing the commitments, but they set quantified targets for reducing emissions by 20% (30% in case of international financing and favourable conditions) compared to a Business as Usual scenario. For the LULUCF sector, these objectives translate into a reduction target of 48 Mt CO_2 eq compared to a Business as Usual scenario which forecasts 159 Mt CO_2 eq in 2030. In addition to its commitment under the Paris Agreement, the government of Peru has a goal of zero deforestation by 2021 – an ambitious goal announced several times by the Environment Minister at international conferences (COP14 in Poznan, COP15 in Copenhagen) and repeated by the President at the 65th United Nations General Assembly (CIFOR).

With these objectives in mind and after adopting the Forest and Wildlife Act and the National Strategy on Climate Change in 2015 and the National Strategy on Forests and Climate Change in 2016, in 2017 and 2018, the Peruvian government continued to strengthen its institutional and legislative arsenal. On 18 April 2018, the president of Peru issued Law No. 30754 (Congreso de la República, 2018) unanimously approved by the congress a month earlier, and made his country the 1st in Latin America to translate its commitments to the Paris Agreement into its legislative corpus. This law sets the main principles and provisions for articulating climate action in the country. Among the priority strategies to limit and adapt to climate change, the LULUCF sector is the main lever with the objectives of increasing carbon sinks, protection, conservation and sustainable management of forests, afforestation and reforestation and controlling land use and change of use. In terms of implementing the measures, the INDC planned in the Paris Agreement is defined as binding, and the Environment Minister is responsible for its follow-up. The Minister is now accountable to the congress through an annual report on climate action. The role of non-state actors is also a central element of the law defining the principle of transversality, according to which the action of the government relies on the involvement of the private sector, civil society and indigenous peoples, and the principles of transparency and accountability of the authorities to citizens whereby the authorities ensure access to public information on climate change for all citizens. As for concrete measures, one of the major advances brought by this new text is the obligation to use climate projections in environmental impact studies, for example for the construction of roads. The next step in the legislative process is the development of regulations that will specify how the law is

to be implemented, which is currently the subject of a participatory process called Dialoguemos (see Text box 1).

Dialoguemos

To encourage interest in the issue of climate change by all actors in society and ensure that each of their expectations is taken into account, the Ministry of the Environment has set up the Dialoguemos participatory process. The Ministry of the Environment has launched several Dialoguemos processes – on the implementation of the national contributions planned in the Paris Agreement, on the fight against deforestation via a financing agreement between Peru and Norway and via the REDD+ mechanism, on the fight against desertification and on the regulation of the framework law on climate change. For this, after the preparation of a "zero" document by the Ministry, 28 decentralised, multi-actor or multi-thematic workshops were conducted between June and September 2018. With the aim of gathering the contributions of all the actors in society, the workshops were open to all following simple registration, and some were held in five native languages – Quechua, Aymara, Shipibo Conibo, Awajún and Asháninka. For example, among the submitted contributions, a group of indigenous associations (including Aidesep, CNA and Onamiap) is pushing to be able to participate in the commission that will propose actions to combat climate change and for establishing an indigenous climate platform.

TEXT BOX 1

Despite these efforts, there are many contradictions between commitments and acts at the national level, as with the vote of 15 December 2017 on a law declaring the construction of roads in the Ucayali region a priority of national interest. Notably, this law paves the way for the construction of a 280 km motorway along the Brazilian border which environmental NGOs and associations of indigenous communities have been opposing for several years. According to the MAAP research programme (see "Researchers and NGOs organise real-time monitoring of deforestation") which draws on the precedent of the Interoceanic Highway completed in 2011 connecting Brazil with 3 Peruvian ports and along which the deforestation fronts multiply, this new project would endanger 2750 km² of virgin forest a part of which is in protected areas.

2 • FROM MULTINATIONALS TO ORGANISED CRIME – DRIVERS OF DEFORESTATION

• AGRICULTURAL EXPANSION • With its many forms – agro-industrial or food, cocoa, coffee, palm oil, papaya, rice or maize, growing or raising – farming is the primary cause of deforestation in Peru. In terms of area, the agricultural expansion of small and medium-sized plots is responsible for most of the deforestation with 73% of deforestation on plots of less than 5 ha and 96% on plots of less than 50 ha in 2016. On the other hand, the sociology of the actors involved is more difficult to determine. The hypothesis of deforestation being caused mainly by small migrant farmers has recently been shown to be obsolete (Ravikumar et al., 2017) due to the diversity of types of small-scale deforestation. Small farmers sometimes use crop cycles on a stable total area with cycles of livestock, crops, fallow and forest. They then deforest secondary forests on fallow areas. Newcomers clear uncultivated areas, which represents deforestation of primary forest. Small farmers can also convert a set of plots that have been previously cultivated using a rotation system with fallow into single plots of intensive monocultures. All these causes are identified as the same type of deforestation, but they result in different carbon emissions and require different political actions to make them into sustainable practices.

The report of the national ombudsman released in 2018 (Defensoría del Pueblo, 2017) focuses on

deforestation caused by agro-industrial exploitation in Peru. This report highlights the failures of the government that led to the deforestation of 30,773 hectares between 2010 and 2014. Most of the time, these are Peruvian or international companies to whom the government allocates farm concessions. They acquire them by taking advantage of loopholes or corruption of regional governments, or local communities sell them to them, sometimes under pressure.

United Cacao

An example of investor land grabbing is described by sociologist Juan Luis Dammert Bello in his 2017 report (Dammert Bello 2017) that focuses on the company called United Cacao. Led by the American Dennis Melka, the United Cacao company based in the Cayman Islands arrived in Peru in 2012 and acquired several thousand hectares via its subsidiary Cacao del Peru Norte SAC, including the forests of Tamshiyacu in the state of Loreto, in order to found a cocoa plantation. United Cacao's strategy was based on obtaining higher yields than those obtained in West Africa (2.5 versus 0.6 t/ha) and on the forecast of a cocoa shortage compared to demand up to at least 2020. The goal was to become the largest cocoa plantation in Latin America. Neither the environmental formalities required at the national level, such as the soil survey or the environmental impact assessment, nor the official agreement of the regional government were validated before the start of operations. The scandal in the media and the government's legal actions to stop the activities were not enough and the plantation project continued to expand to occupy nearly 3,500 hectares of which 2,400 had been deforested. In May 2016, a dozen NGOs and indigenous communities wrote to the London Stock Exchange and regulatory authorities denouncing the illegality of the activities of United Cacao, which is listed on the market of alternative investments. In January 2017, United Cacao was removed from the London Stock Exchange and in February from the Lima Stock Exchange. Deforestation and planting activities have stopped in this area.

TEXT BOX 2

• **GOLD MINING** • Depuis le début des années 2000, le prix de l'once d'or a augmenté pour atteindre des niveaux records en 2013 et s'est aujourd'hui stabilisé à un niveau 4,5 fois supérieur à celui de 2000. Au Pérou, qui est le 6e producteur mondial d'or, ce cours élevé stimule l'extraction artisanale et souvent illégale dans la forêt amazonienne, dont les couches géologiques sont favorables à la présence du minerai (Asner & Tupayachi 2017, Alvarez Berrios et Aide 2015). Pour extraire l'or des cours d'eau et plaines inondables, les mineurs rasent la forêt, explosent les rives des rivières et creusent avec des bulldozers pour atteindre les dépôts de graviers desquels l'or est extrait en utilisant arsenic, cyanide et mercure qui empoisonnent les cours d'eau.

Expulsion of gold miners in the Tambopata National Reserve

In the Madre de Dios region bordering Brazil where 50% of GDP is based on gold mining, the completion of the Interoceanic Highway in 2010 has improved access to remote areas. According to the Ministry of the Environment, approximately 50,000 illegal miners extract 16 to 18 tonnes of gold each year. In 2016, even the Tambopata National Reserve – a protected area of 275,000 ha – was invaded by miners. In 2 years, more than 550 hectares of virgin forest have been deforested along the Malinowski River (Finer, Novoa & Olexy, 2017). However,

the government succeeded in stopping the extraction activity in 95% of the invaded area thanks to the intervention of the navy alongside the rangers (Daley, 2016). Even though this is a victory, it is not the end of the battle yet, as the illegal extraction activities have increased in the buffer zone around the nature reserve (Finer, Novoa, Olexy & Durand, 2017). And in 2017, the rate of deforestation in Madre de Dios reached its highest level in 17 years with the loss of 20,826 hectares of which 1,320 were directly attributable to mining (Sierra Praeli, 2018). In the first half of 2018 alone, 1,725 hectares of forest were razed. Corruption and organised crime associated with illegal gold mining complicate the fight against these practices.

TEXT BOX 3

• TIMBER LOGGING • The forestry law that governs timber logging in Peru was revised in 2015, giving birth to SERFOR – the body in charge of the management of the resource of wood – under the supervision of the Ministry of Agriculture. Timber logging is permitted in certain forest categories for which concessions are granted which, depending on the type of forest, are supplemented by land use change or deforestation permits. All logging is subject to an annual operational plan validated by the regional authorities. This plan must accurately describe the inventory of the parcels in question and the trees selected for cutting or, in the opposite case, for protection. From its extraction in the forest to the sawmill, the warehouse or the port, all transported wood is accompanied by a document called a forest transport guide establishing the place of origin of the timber. Timber trade is also supervised at the international level. For example, the US–Peru Free Trade Agreement signed in 2009 includes a specific annex establishing the commitment of both parties to combat illegal logging. According to this annex, the United States may impose product or exporter audits in Peru and seek to verify the compliance of specific shipments with the power to impose sanctions in case of illegally logged timber.

OSINFOR, set up in 2000, is the institutional body responsible for controlling the use of forest resources and compliance with the rules for logging. In 2014, its controls led to the cessation of all activities at nearly 50% of the visited concessions due to serious and proven fraud. In 55% of the inspected concessions, timber was cut outside the concession boundaries, and 69% of the inspected concessions facilitated logging or transport of protected species (Finer, Jenkins, Sky & Pine, 2014). OSINFOR played a key role in the 2015 record capture of the vessel Yacu Kallpa vessel during Operation Amazonas 2015 (see Text box 4). More than 90% of the cargo destined for the Dominican Republic, Mexico and the United States was illegal. In July 2017, a family-run criminal organisation – "the beavers of the central forest" – active in the three regions of Junín, Ucayali and Lima – was dismantled thanks to the help of three employees of SERFOR (Urrunaga, Johnson, & Orbegozo Sánchez, 2018).

Despite the hope generated by these resounding successes, a report published in February 2018 by the British NGO Environmental Investigation Agency highlights the limits of the measures for fighting illegal logging of Peruvian wood (Urrunaga, Johnson & Orbegozo Sánchez, 2018). The authors describe the practices of falsifying certificates of origin, making up every piece of the forest inventories, the approval by local authorities of wrong annual operational plans allowing wood traffickers to export their products especially to China, the Dominican Republic, Mexico and the United States, with the authorities struggling to cope with the pressure from the forest industry. The EIA survey indicates that SERFOR is now publicly opposing the traceability measures and that its inspection reports have changed from 900 in 2015 to 23 in 2016 and 0 in 2017.

Operation Amazonas: an example of international and interinstitutional collaboration

Operation Amazonas is the product of interinstitutional collaboration between OSINFOR, the specialist in environmental issues FEMA, the Peruvian customs (SUNAT), INTERPOL and the World Customs Organization (WCO) (OSINFOR, 2016). At the heart of the operation, SUNAT systematically monitored all exports from the port of Iquitos via documents indicating the origin of the traded timber, the GTF. From these documents, OSINFOR officers were able to go into the field and verify the accuracy of the statements. FEMA was in charge of ensuring the legality of the inspection operations of SUNAT and OSINFOR. The WCO in direct contact with SUNAT allowed the inspection of the shipment of timber at its destination and INTERPOL supported the operation by identifying the criminal organisations involved in the trafficking. This unprecedented collaboration has paid off. In 2014, one hundred and forty-four places of logging were visited, of which 94% were found to be in violation, and led to the seizure 15,700 m^3 of wood. In 2015, the controls of Operation Amazonas uncovered 433,000 m^3 of illegally logged timber and exposed the practices of the ship Yacu Kallpa, which regularly traveled to the Dominican Republic, Mexico and the United States. The investigation revealed that among the 5 trips of the ship in 2015, 82% of the 32,000 m^3 transported had an illegal origin. Seventy-one illegal timber containers were seized in Houston by US justice and the ship was detained in Mexico.

TEXT BOX 4

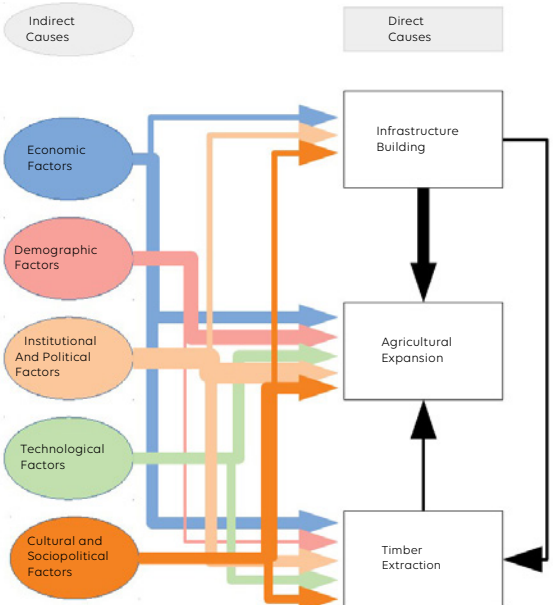

FIGURE 1. REPRODUCED FROM GEIST AND LAMBIN 2002. DIRECT CAUSES OF DEFORESTATION (RECTANGLES) INFLUENCE EACH OTHER (BLACK ARROWS) AND ARE INFLUENCED (COLOURED ARROWS) BY INDIRECT CAUSES (OVALS). THE SIZE OF THE ARROWS INDICATES THE RELATIVE IMPORTANCE OF THE INFLUENCES BASED ON THE STUDY OF THE 152 CASE STUDIES.

• INDIRECT DRIVERS OF DEFORESTATION •

Direct causes of deforestation (farms, mining, road construction) themselves have indirect drivers that are not always easy to identify, and they highlight the contradictions between environmental and economic objectives. A report from CIFOR (Center for International Forest Research) lists and highlights these complex factors, such as population growth via birth rates and internal migration – sometimes supported by state aid, increased demand for agricultural products and driven by increased purchasing power and international demand (coffee, gold, timber, palm oil and cocaine), national policies to support agricultural expansion and mining companies, or weakness of institutions or the lack of a precise judicial framework on land exploitation (Piu and Menton 2014). Quantifying the importance of each of these mechanisms is difficult, and it is a subject of debates.

In a study of the mechanisms that led to deforestation in 152 case studies, Geist and Lambin (2002) show that tropical forest deforestation can only be attributed to the synergy between direct causes (agricultural expansion, infrastructure development, wood harvesting) and indirect causes (demographic, economic or technological factors or institutional, cultural or socio-political policies) as explained in Figure 1. For example, the case of the extension of the Manu-Amarakaeri road, which has been in progress since 2015, was described in 2017 in a report by the newspaper Ojo Público (REF) rewarded by the Inter American Press Society, which highlights the institutional, economic and demographic factors that intermingle

to define the fate of many hectares of forest. The hectares in question are located in the buffer zone of the Amarakaeri Communal Reserve protected for its ecological value. The institutional factors in this case are double because while the national institutions refused the construction of the road, only one prosecutor and 12 forest rangers were assigned to ensure the application of the ban, and they did not manage to prevent the regional governor from getting the works carried out anyway with the support of a part of the local population. For these indigenous communities, the motivation is both economic and socio-cultural – the construction of a road is seen as a means to develop commercial activities, tourism and access to better medical and educational services. The same economic reasons are driving people in indigenous communities to participate in the illegal mining of gold and timber. Estimates for timber logging around the road are 80 m^3 per week and by maintaining the current rate of progress of the road, it would mean that 43,000 hectares of forest could be lost by 2040.

3 • THE MANY TYPES OF BATTLE AGAINST DEFORESTATION

• RESEARCHERS AND NGOS ORGANISE REAL-TIME MONITORING OF DEFORESTATION • Spatial and aerial imagery has become a key element in the fight against deforestation in recent years thanks to collaboration between researchers, NGOs and public institutions that have developed a range of operational tools and broadcast platforms. Two main tools are now in use in Peru. The Department of Global Ecology of the Carnegie Institution (USA) has been developing CLASLite since 2009. It compares two successive images coming mainly from the LandSAT satellite to convert them into deforestation and forest degradation maps (Asner, Knapp, Balaji & Páez-Acosta, 2009). The GLAD alert system developed at the University of Maryland (USA) also uses images from LandSAT satellites at a 30 m resolution but automatically searches all LandSAT archives for changes in forest cover and produces weekly alerts. Advances in the field of imaging are numerous and fast, and the current limits are slowly being lifted as the cost of very high resolution imagery is becoming affordable and cloud cover is dealt with by using data from European satellites Sentinel-1 and 2 at a 10 m resolution and radar bands that are provided for free.

The tools for detecting deforestation provide very rich raw data, but at the scale of a country the size of Peru, their interpretation is essential to make sense of them. The statistical treatment of deforestation maps, the use of very high resolution images or the survey of specific areas by drones are some of the methods used to identify the type of deforestation detected by the algorithms. For example, roads cleared for timber extraction are difficult to detect on their own because few trees are cut down, but algorithms can identify the small straight line variations characteristic of forest roads. Data processing and dissemination of results is done in part by the developers, as is the case with the online platform of Global Forest Watch, a GLAD partner that has implemented a mobile app giving access to alerts from the field and allowing users to contribute by sharing their

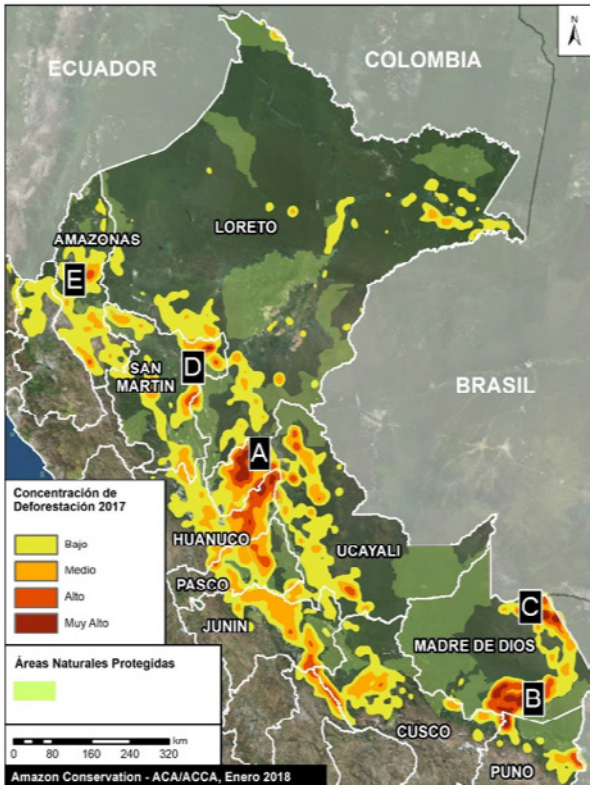

FIGURE 2. MAP DEVELOPED BY MAAP SHOWING THE HOTSPOTS OF PERUVIAN DEFORESTATION IN 2017

reports. The Peruvian Ministry of the Environment also uses GLAD alerts for its official Geobosques deforestation monitoring portal, which is intended as a tool to support political decision-making and awareness-raising and information for citizens. Users have access to the latest reports on deforestation in the country and, following registration, they may choose to receive continuous alerts or weekly newsletters for areas of their choice.

MAAP (Monitoring the Andean Amazon Project) whose website was launched in April 2015 by the NGO alliance of Amazon Conservation Association and Acca-Conservación amazónica is specialised in analysing the causes of deforestation events in the field. Their weekly reports point out concrete cases by showing high resolution images of the same area, for example, before and after the installation of a mining area. By decoding trends, hotspots (Figure 2), and the main causes of deforestation, MAAP's objective is to provide visual, easy-to-understand and high-quality technical information on deforestation in near real time.

• THE ROLE OF LOCAL AUTHORITIES • The process of decentralisation is underway in Peru as defined by a 2002 law that sets out the transfer of jurisdiction from the national level to the regional and local levels. On the environmental level, regions are responsible for controlling the use of natural resources in their territory and issuing permits, authorisations and concessions, and monitoring forest law enforcement. One of the functions of regional governments in this process is to achieve forest zoning and territorial planning (SERFOR, 2016) as a technical tool to support decision-making. Forest zoning consists in assigning one of four categories to each forest parcel in the region as defined by the national forest service SERFOR: ecological protection and conservation zone, permanent production zone, restoration zone, zone of special character (including reserves for indigenous peoples and areas of agroforestry or silvopastoralism). The criteria used to define the parcel categories are, for example, the type of forest (wet, dry, plain, mountain), the presence or absence of fragile habitats or the estimate of the volume of wood in the parcel. This classification should allow the regional governments to know the potential and limits of the use of the natural resources in their territory and to legally regulate the uses to avoid frequent conflicts between local population and mining operations or migrant farmers while limiting illegal practices. Zoning is driven by regional and local governments with the technical support of SERFOR, and is based on a participatory process through workshops that bring together local decision-makers, members of ministerial services and local communities. Since August 2018, the "national mosaic of satellite images" provides a map of the country's forests for free for both citizens and decision makers at a 1.5 m resolution composed of images of the French SPOT satellite from 2016 to 2018. One of the satellite's priority missions is to simplify forest zoning to accelerate its implementation. Out of 25 regions, by the end of 2017 only 4 regions had started properly zoning (Reaño, 2018).

• REDD+ – FRAMEWORK OF PREFERENCE FOR ACTION BY NON-STATE ACTORS • REDD+ (Reducing Emissions from Deforestation and Forest Degradation) is a programme of the United Nations providing funding for forest protection by allocating carbon credits that can be sold on the carbon market. In Peru, the national REDD+ strategy is currently in the process being defined under the coordination of the Ministry of the Environment. The government has chosen a nested approach, i.e. a combination between national scale and local scale, in line with the ongoing decentralisation in the country. Approximately 30 local or regional projects have already been voluntarily funded by private players, NGOs or by international cooperation (Althelia Text box), which should help to inform the definition of the national Peruvian REDD+ strategy by providing reference emission levels and tools for monitoring, reporting and verification. However, this multi-scale approach raises questions. Some REDD+ projects date back to 2008 when there was still no national REDD+ plan, and each project developed its own methodology, baseline and measurement criteria. These disparities complicate integrating these projects into a single national reference level of forest emissions, which is a prerequisite for the national REDD+ framework. The government's current plan

is to use historical data from 2001–2014 to establish this national reference level. Project-focused NGOs are critical of this approach because it does not reflect possible increases in deforestation in the future under socio-economic pressures and therefore minimises avoided emissions.

In parallel with these reflections, REDD+ projects continue to develop independently of the national strategy within the framework of the voluntary carbon market. In this case, projects can apply for certification and thus generate carbon credits that are sold on the voluntary carbon market mostly for communication purposes to companies not subject to quotas.

Althelia

On 21 May 2018, Althelia – a management company owned by a subsidiary of Natixis Bank specialising in investments impacting the natural resources sector – announced that two REDD+ projects financed by it will be integrated into the national commitments vis-à-vis the Paris agreement. In more concrete terms, it is a world first in which the nested approach by which projects developed by private actors guide the strategy and the national objectives is more concretely defined. The carbon credits generated by these two projects between 2015 and 2018 will therefore be logged in the country's emissions register, and project emission reductions will become part of the national baseline starting in 2018.

The Cordillera Azul National Park project was created to preserve an area of 1.3 Mha of primary forest located at the intersection of the Andes and the Amazon basin – the largest protected areas in the country. The project consists in supervising the forest management practices in the buffer zone of 2.5 Mha around the national park. Preserving the park has three simultaneous objectives. First, avoiding the emission of 15 Mt CO2 in 6 years by preventing deforestation and forest degradation. Then, protecting the unique biodiversity that lives in the heart of the park with more than 6,000 species of plants, 600 species of birds and 80 species of large mammals, 11 of which are endangered species. And finally, providing support to the approximately 400 indigenous communities in the buffer zone living on food crops in order to develop sustainable agroforestry systems of both food crops such as banana or cassava and cash crops such as coffee and cocoa. This project is based on the collaboration between the private Althelia Climate Fund in charge of financial aspects in the form of a loan of €8.55 million over 6 years repaid by the sale of the generated carbon credits and the Peruvian NGO CIMA-Cordillera Azul responsible for surveillance, biological monitoring, research activities as well as improving the skills of institutions and local populations. The Tambopata-Bahuaja reserve REDD+ project is supposed to avoid the emission of 4.5 Mt CO2 in 7 years. The collaboration of Althelia with the Peruvian NGO AIDER and the National Service of Natural Protected Areas providing funding of $12 million over 5 years should allow the preservation of 570,000 ha of forest in the area of Madre de Dios. The project focuses on two axes: developing the economic activity of local communities and protecting biodiversity. In 2014, 249 ha of agroforestry systems and 70 nurseries had been created thanks to funding from the project for technical and commercial support and the establishment of cooperative sales structures for production. Fauna and flora monitoring in the area as well as a patrol against illegal logging were also set up.

TEXT BOX 5

CONCLUSION

In conclusion, in recent years the Peruvian government has set up a rich institutional and legislative framework that should increase the government's capacity in its fight against deforestation. However, this regulatory framework, is fragile in the face of the economic interests of local actors and the lack of cohesion between the different layers of government to enforce laws. Civil society plays a key role in stimulating environmental action by developing local forest conservation projects and developing alternatives for their sustainable exploitation and tools for monitoring deforestation. The link between local initiatives and the national framework will be crucial in the coming years for maintaining a dynamic that is currently still struggling to produce results.

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Ivory Coast winning back its forests

In the country's Intended Nationally Determined Contribution (INDC), submitted in preparation for the COP 21 in 2015, Côte d'Ivoire signaled its intention to reduce gross GHG emissions by 28% by 2030 compared to 2012 levels. Due to the lack of precise data and measurement difficulties, emissions from land use, land use change and forestry (LULUCF) were not specifically included in the low carbon scenario, but have since become the subject of greater attention at the national and international levels. The interest in this issue is due to the fact that Côte d'Ivoire based its development on agricultural expansion, which is the primary factor behind the loss of 3/4 of the country's forests: in 2015, the country had 3,401,146 hectares of forests, down from 16 million hectares in 1900. Forest recovery is a priority for the country, not only in order to meet its international commitments in terms of reducing GHG emissions, but also to preserve local socio-economic and environmental conditions. Furthermore, building and adhering to sustainable strategies is now seen as essential for this developing country, which hopes to continue its strong growth record. NGOs, companies and local communities working in partnership with state bodies are undertaking to help alleviate the catastrophic decline of Ivorian forests. This study on emissions from Côte d'Ivoire's LULUCF sector provides an overview of the trends and causes, while also highlighting the various operators being mobilized to recover the country's forests

Head editor • **AÏCHA KONÉ** • *environmental sustainability consultant*

CONTENTS

1 • CLIMATE CRISIS AND MAJOR SOCIO-ECONOMIC ISSUES

2 • REDUCTION OF EMISSIONS IN THE LULUCF SECTOR

3 • DIVERSITY OF CAUSES AND PREDOMINANCE OF AGRICULTURE

- Deforestation in figures
- Disparity of involvement levels and deforestation stakeholder

4 • ACTIONS TO REDUCE EMISSIONS FROM THE LULUCF SECTOR

- The LULUCF sector at the heart of national policy
- The central role of REDD+
- Examples of activities in civil society, the private sector and local communities

1 • CLIMATE CRISIS AND MAJOR SOCIO-ECONOMIC ISSUES

Climate change is a major issue for Ivory Coast: according to the World Bank's recent 2018 report on the country, its vulnerability index is among the highest in the world (147th out of 178). The economic impact of climate change on the country is estimated at a loss of between 380 - 770 billion CFA Francs by 2040 (in constant 2017 value). Although the average Ivorian citizen emits 10 times less atmospheric CO2 than the global average, mitigation and adaptation remain key priorities for the country.

Several changes have already been observed in the national climate, notably including lower and more irregular rainfall, shorter rainy seasons, and a temperature rise of 0.5°C since the 1980s (Djé, 2014). In addition, an average temperature increase of 2°C is forecast for the entire country by 2050, along with rainfall variations and a sea level rise of 30cm along the country's coastline (World Bank, 2018).

The LULUCF sector has strong socio-economic influence, as it depends on one of the country's primary natural resources: its forests. This resource has enabled national growth via wood exports and soaring agricultural development, on which 2/3 of working-age Ivorians depend for their livelihood. The country's forests sustain many rural families through harvesting-gathering, sale of non-timber forestry products, hunting, medicinal and pharmaceutical products and casual work (MINSEDD, 2017). In a country whose poverty rate was 46.3% in 2014 (10,497,000 individuals living below the poverty line, 6 million of whom live in rural areas), any discussion of the LULUCF sector requires climate concerns to be addressed in tandem with underlying social and economic issues.

2 • REDUCTION OF EMISSIONS IN THE LULUCF SECTOR

The LULUCF sector was the main source of emissions over the 1990-1995 period, representing 49% and 61% respectively of net national emissions (Graph 1). Over the 2000-2012 period, the sector became a carbon sink, absorbing more CO2 than it emitted (with the exception of 2011, during which it accounted for 15% of net national emissions). Given that the most recent data for the country dates from 2012, it has not been possible to provide a more up-to-date assessment.

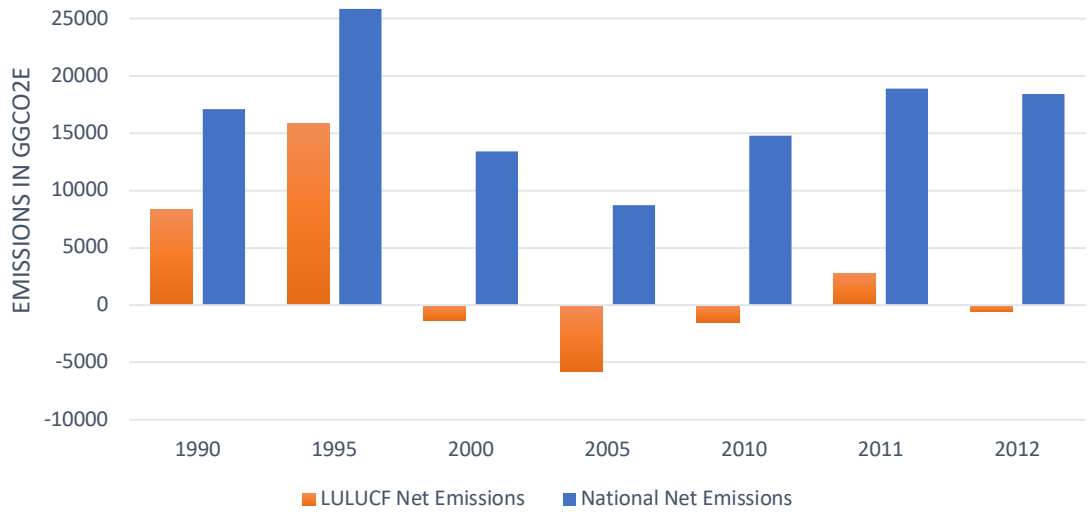

FIGURE 1. EVOLUTION OF LULUCF EMISSIONS

Data source: MINSEDD, 2017

The contribution of the LULUCF sector to net national emissions has waned over time due to its high absorption levels. Emissions from the LULUCF sector stood at 8,402.77 GgCO2eq in 1990, compared to -548.29 GgCO2eq in 2012, while national net emissions were 17,077.59 GgCO2eq in 1990

and 18,409.02 GgCO2eq in 2012. In 2012, the main emissions sectors were (in order of significance): Energy, Agriculture, Waste, Industrial processes and product uses, and finally LULUCF.

3 • DIVERSITY OF CAUSES AND PREDOMINANCE OF AGRICULTURE

• DEFORESTATION IN FIGURES • Deforestation, which is the principle cause of emissions in the LULUCF sector, has taken place at such a frantic pace in Ivory Coast that forests have become a much rarer resource. Estimated at 16 million hectares in 1900, the forest cover had fallen to 7,850,864 ha in 1986 and 3,401,146 ha in 2015 (Graph 2).

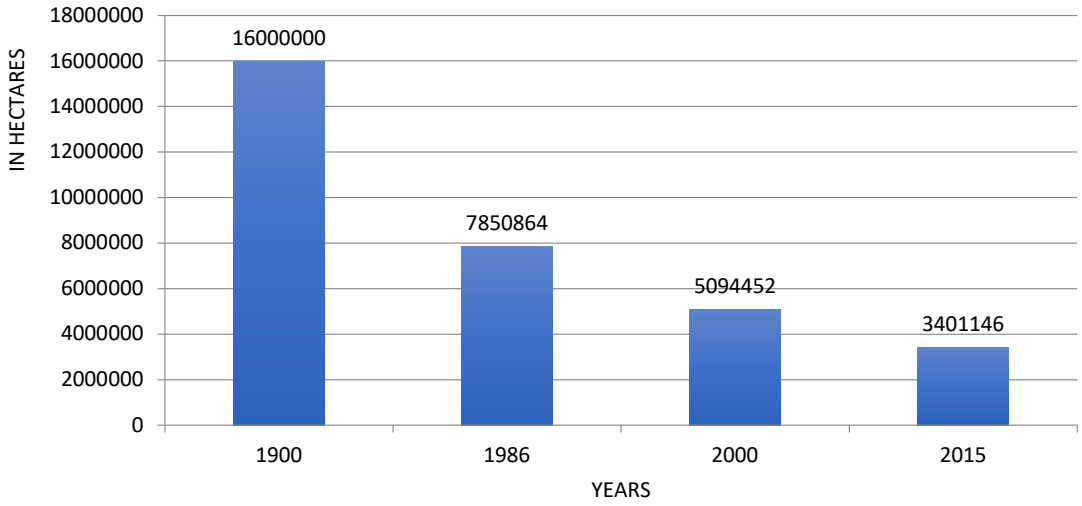

FIGURE 2. EVOLUTION OF FORESTED SURFACE AREA IN IVORY COAST

Data Sources:: SEP-REDD+ Côte d'Ivoire (2017) and REDD+ Côte d'Ivoire (2017)

The pace of deforestation has decreased over the years: 183,760.78 hectares of forests were converted into other types of land use each year over the 1986-2000 period, compared to 112,887.05 hectares per year over the 2000-2015 period (SEP-REDD+ Côte d'Ivoire, 2017). One of the causes of this slowdown is the increasingly rarefied nature of forestry resources as forest clearance proceeded. In total, the country has lost 78% of its plant cover. Consequently, this loss of forested land has largely contributed to the LULUCF sector's lower contribution to national emissions over the 2000-2012 period (Graph 1).

Today, the remaining forestry resources are largely contained within protected areas. In 2015, 64% of Ivorian forests were located within protected zones and listed forests. However, current deforestation hotspots are localized within listed forests, where the annual rate of deforestation was 3% over the 1990-2000 period and 4.2% over the 2000-2015 period. In 2015, 844,938 hectares of listed forests remained, compared to 1,585,626 hectares in 2000 and 2,129,729 hectares en 1990. The surface area of protected zones fell from 1,406,676 hectares in 1990 to 1,323,685 hectares in 2015. (REDD+ Côte d'Ivoire, 2017; Koné, 2018).

• DISPARITY OF INVOLVEMENT LEVELS AND DEFORESTATION STAKEHOLDERS • Compiled by the NGO Etc Terra as part of the REDD+ program, the report of the Qualitative analysis of deforestation and forest deterioration factors in Ivory Coast helped identify the main factors in deforestation and forest deterioration, based on a survey of 394 individuals. These factors are organized into two categories: direct factors (Table 1) and indirect factors.

Direct factors in deforestation	Proportion %	Evolution over the 1986-2015 period:
Agriculture	**62**	↗
Cacao farming	38	↗
Natural rubber farming	23	↗
Palm farming	11	↗
Cashew plantations	7	↗
Food crops	6	↗
Rice farming	5	↗
Coffee farming	5	↘
Other cash crops	4	→
Logging	18	
Clear-cut logging > 1000m²	64	→
Production of charcoal	36	↗
Infrastructures	10	
Habitat (rural, urban)	94	↗
Transport	6	↘
Mining	8	↗
Artisan gold panning	80	↗
Industrial gold panning	20	↗
Bush fires	3	→

TABLE 1. DIRECT FACTORS IN DEFORESTATION IN IVORY COAST

Data sources:: Etc, Terra & Al. (2016); SEP-REDD+Côte d'ivoire (2017)

Government, multinationals and farming

Agricultural activity was identified as the main cause of deforestation in Ivory Coast (responsible for 62%). Table 1 highlights the critical role played by agricultural exports, represented by key products such as cacao, rubber, palm oil and cashews. This role is not surprising given the country's economic policy and the characteristics of Ivorian agriculture.

Indeed, Ivory Coast's economic development policy has long been focused on its agricultural sector, and more precisely on agricultural exports. Between 1960 and 1978, the period of the "Ivorian

economic miracle", economic growth was strongly linked to the boom in coffee, cacao and wood exports (Cogneau & Mesplé-Somps, 2002). It was during this period that Ivory Coast became a middle-income country. Forests were cleared away in order to make room for export crops. Coffee, cacao and wood made up 82% of exports in 1965, and 74% in 1972 (Cogneau & Mesplé-Somps, 2002). Although agricultural products now account for a smaller portion of national exports, overall export volumes are rising. In 2017, agricultural exports still accounted for 9.2% of Ivorian GDP (Ministry of Economy and Finances, 2017). Ivory Coast is the world's largest producer/exporter of cacao (40% of global export volumes), cashew nuts and cola, and is also the largest African exporter and seventh-largest global exporter of natural rubber. It is the largest African producer/exporter of dessert bananas, the second-largest African producer (ninth-largest global producer) of palm oil, and the third-largest African producer of cotton and coffee. Agricultural exports and an agricultural model still largely based on extensive farming are therefore implicated: the area covered by cacao plantations, for example, rose from 1,566,500 hectares in 1990 to 2,693,904 hectares in 2012 (FAO, 2018; Koné 2018). However, the environmental impact of deforestation presented in these figures must also be put into perspective, since the expansion of agricultural areas does not mean plant eradication, but rather reconversion.

The private sector plays a decisive role in Ivory Coast's agricultural success. However, it has been criticized for its role in deforestation, as evidenced by the frequent controversies surrounding chocolate (text box 1) and palm oil (text box 2).

Deforestation and the chocolate industry in Ivory Coast

In its report entitled Chocolate's Dark Secret, released in 2017, the NGO Mighty Earth denounced the chocolate industry for its role in causing deforestation in Ivory Coast, notably in the clearing of protected zones and national parks. A study cited in the report, carried out by the University of Ohio along with Ivorian researchers, concluded that of 23 protected zones, 7 had been almost entirely converted into cacao cultivation areas. As a result, according to SODEFOR, 40% of Ivory Coast's cacao production comes from protected areas. The inquiry accuses the major cacao traders (Olam, Cargill and Barry Callebaut, which account for almost half of the global market) of buying cacao sourced from these protected areas, before selling it on to the major multinational chocolate producers and distributors (Mars, Ferrero, Nestlé, Mondelez, etc.). The supply chain begins when farmers illegally set up operations in these protected areas, clearing the forest and planting cacao crops, before selling their produce to traders who go on to sell to chocolate companies. The traders and chocolate companies admitted to the researchers that they were aware that some of their cacao was sourced from protected zones. The report's findings support the ambition demonstrated in the Collective Statement of Intent drafted by the sector in March 2017 at the initiative of the Prince of Wales Foundation, followed by the implementation of a framework for action in November 2017 (cf. section 4.3) in order to end deforestation and forest deterioration.

TEXT BOX 1

Deforestation and palm oil in Ivory Coast

Palm oil is the most productive oil crop in the world, producing around 35% of the world's vegetable oil despite occupying less than 10% of land allocated to oil crops. The palm oil industry has been the target of international criticism, causing repercussions within Ivory Coast. According to the International Union for the Conservation of Nature (IUCN, 2018), on a global scale palm oil crops are responsible for less than 0.5% of deforestation, but in certain areas of the tropics this figure can rise to 50%. While most of the debate surrounding deforestation caused by palm oil is focused on Asia, as the 9th-largest global producer and 2nd-largest African producer of palm oil, Ivory Coast is very much involved in this issue. In Ivory Coast, 60 - 65% of production comes from small farms, occupying some 175,000 hectares (Commodafrica, 2017). Industrial plantations are therefore not the majority producers in the country. According to the figures for direct factors in deforestation, oil palm plantations are the third-biggest causeof agricultural deforestation (11%), some way behind cacao plantations (38%) and rubber (23%).

TEXT BOX 2

The role of small producers in deforestation is highlighted in text boxes 1 and 2: they are the foundation of the supply chain. The analysis of indirect drivers of deforestation in the country underlines the role of economic factors (36%), political and institutional factors (35%, and 53% for forest deterioration), as well as demographic (24%), technological (4%) and cultural factors (1%) (Etc Terra, 2016). Accordingly, aside from the scandals and industrial groups targeted, it is a combination of the economic attractiveness of crops (higher revenues and more regular earnings, etc.) in a context of high poverty rates (46.3%), rampant demographic growth (2.55% per year), inefficient application of the law (due or not to political crises), and a low level of technical control that leads producers to convert forests into new plantations.

Among the institutional and political factors behind deforestation (35%), war and economic crises (34%) as well as ineffective or non-application of laws (28%) seem to provide the most fertile ground for the proliferation of illegal activities, including by agents of the State. "Corruption/ complicity" on the part of State departments, the Ministry of Waterways and Forests, or local political leaders was cited by 15.9% of respondents as an indirect factor in forest deterioration, and by 5.2% in deforestation (Etc Terra, 2016). While local media coverage of these cases tends to be erratic and unequal, in August 2018 the Ivorian government ensured widespread media coverage of the suspension of 5 agents, via ministerial order, from the Regional Directorate of Waterways and Forests in the Gbêkê region for the offences of wood trafficking and clandestine gold panning activities.

Timber industries, illegal operators and urban households

Logging represents around 18% of all deforestation (table 1), a large proportion of which involves clear-cutting. Despite the increasing rarity of quality timber, leading to a drop in exports and factory closures, the timber industry still exerts pressure on forests, leading industrial groups to work with lower-quality wood and therefore trees with smaller diameters. Companies operating legally in the timber sector are also competing with illegal operators. Illegal timber production, which relies on small-scale processing techniques to transform raw wood into semi-finished products, using chainsaws, portable sawmills or other similar materials at a cutting site, bypasses the legal timber industry. This informal sector consumes, for example, 3 million m3 of logs per year (2011), or triple the amount used by the industrial export sector. (Louppe, 2013; REDD+ Côte d'Ivoire, 2017)

The amount of wood attributed to the production of charcoal is lower, but on the rise. The production of wood charcoal rose from 400,850 tonnes in 2003 to 488,128 tonnes in 2012, in order to

satisfy demand from a growing and increasingly urbanized population. Indeed, charcoal is one of the main domestic energy sources in Ivory Coast, particularly in urban areas where it is used by 47% of households (compared to 35% for wood burners and 18% for butane gas). In rural areas, it is used by only 4% of households (95% use wood burners and 1% butane gas) (PNUD, 2015). This consumption of wood energy, particularly charcoal, leads to pressure on forestry resources and represents a threat to the country's remaining forests, especially given the rate of demographic growth (MINSEDD, 2017).

Mining industries and traditional gold panning

Mining operations are the cause of 8% of deforestation in Ivory Coast, and this rate is increasing. Traditional placer mining is the main cause of this type of deforestation; it is estimated to cause 80% of mining-related deforestation compared to 20% for industrial gold mining.

According to the Ministry of Planning and Development (2016), two industrial companies currently mine for gold and two others for manganese. Industrial production reached 18.4 tonnes of gold and 308,401.78 tonnes of manganese in 2014, up from 12.4 tonnes of gold and 50,000 tonnes of manganese in 2011. According to REDD+ Côte d'Ivoire (2017), 140 mining research permits were issued in 2015, of which eight were for gold and three for manganese, and many of which involved prospecting in listed forests. In addition, industrial mining operations contribute to deforestation via the use of surface mining (open cast) techniques. This situation is often exacerbated by the failure to reforest areas used for mining. In addition to industrial operations, unsanctioned small-scale extraction is also on the rise for gold and diamonds (traditional placer mining), which saw a significant uptake and extension into national parks and listed forests during the Ivorian socio-political crisis of 2002-2011. In 2016, around 22 tonnes of gold were illegally exported (Abié, 2018).

Bush fires

Bush fires account for 3% of deforestation in Ivory Coast (table 1). While climate conditions - especially the prolonged and harsh dry season - are a primary factor in the scale of these fires, their causes and origins remain largely man-made: most fires originate from the practice of shifting cultivation by rural farmers, in order to prepare their lands for crops and hunting (Durrieu de Madron, Gballet and Balou Bi, 2015). In 2016, bush fires killed 17 people, destroyed 10 villages, decimated 1,100 ha of forests, destroyed 15,000 ha of crops, and caused major material damage estimated at over 204 bn FCFA, or €365 m (official government portal, 2018).

4 • ACTIONS TO REDUCE EMISSIONS FROM THE LULUCF SECTOR

• THE LULUCF SECTOR AT THE HEART OF NATIONAL POLICY • Ivory Coast has been a member of the REDD+ international organisation since 2011. In concrete terms, REDD+ in Côte d'Ivoire aims to reduce deforestation and deterioration of listed forests, and to win back 80% of protected zones compared to 2015 levels, which equals a reduction of 74,400 ha per year. REDD+ is also seeking to reconstitute the country's forest cover through agroforestry practices, by planting 5,000,000 hectares by 2030 (REDD+ Côte d'Ivoire, 2017). The country also entered into a Voluntary Partnership Agreement for Forest Law Enforcement Governance and Trade (VPA-FLEGT) with the European Union in 2013, with the objective of effectively combating illegal logging and timber production and associated trading operations. In 2014, Ivory Coast signed up to the New York Declaration on Forests (NYDF), which aims to end deforestation by 2030. The objectives of the NYDF include the ambition to eliminate deforestation caused by supply chains in the agricultural industry and other economic sectors. During the 2014 World Climate Summit at the UN, Ivory Coast committed to transitioning towards zero-deforestation agriculture from 2017 onwards. This type of agriculture is more productive in terms of rural real estate, preserving parks and reserves, listed forests, and forests with special characteristics, as well as contributing to the restoration of forest cover in

order to partially compensate for previous deforestation. It is also more resilient to the impacts of climate change, and respects the rights of local communities while also improving their sources of livelihood.

In all these commitments, a major focus has been the necessity of improving forest governance in Ivory Coast, as thus far none of the country's existing forest policies have been correctly applied. In 1988, the Ivorian government adopted a Forestry Master Plan (PDF) for the 1988-2015 period. Observing that the plan was failing, in 1999 the government adopted the Forest Policy Declaration, which was not applied due to the sociopolitical crisis (REDD+ Côte d'Ivoire, 2017). In 2014, a new forestry code was adopted, but so far this has also not been applied (APA, 2018). Given the catastrophic effect these failings have had on the nation's forest cover, a new national policy for the preservation, recovery and extension of forests was introduced by the government in May 2018. Based around realistic voluntary commitments, it has four objectives: preservation of biodiversity, preservation and reconstitution of a national climate favourable to agricultural activity and living spaces; compliance with international commitments, and economic and social development. In this new forestry policy, four of the six key strategic topics involve listed forests. They also introduce the concept of Agro-forests, which refers to listed forest zones in which agroforestry may be practiced (Ministry of Waterways and Forests, 2018). Finally, in July 2018, the Minister of Waterways and Forests, Alain-Richard Donwahi, also announced an investment plan worth 616 bn FCFA (€940 m) over 10 years, in the form of public-private partnerships aiming to achieve a commitment to restore 20% of the country's forest cover.

• THE CENTRAL ROLE OF REDD+ • The REDD+ organisation plays a central role in the implementation of the national strategy to combat climate change in Ivory Coast. In Ivory Coast, its ambition is to stabilize and sustainably reverse the trend of natural forest disappearance from 2017 onwards, and to simultaneously restore 20% of forest cover by 2030. The next stage involves managing these forests in a sustainable fashion, while also achieving its goals in terms of poverty reduction, human and social development in local communities (social equality), culture and gender equality. Following the completion of the preparatory phase, during which the country developed its REDD+ strategy in partnership with public bodies, the private sector and organisations from civil society, REDD+ Côte d'Ivoire is now in its second phase: strategy implementation. According to REDD+ Côte d'Ivoire (2017), this strategy is based on an approach that is integrated, landscape-orientated, multi-sectoral, transparent, robust, participative and inclusive, in order to make the strategy as efficient as possible. As a result, non-governmental stakeholders will play a significant role in the implementation of this national strategy (Table 2).

	Direct factors in deforestation					Indirect factors and obstacles		
	1	2	3	4	5	6	7	8
Strategic options	Zero-deforestation agriculture via public-private partnerships	Sustainable domestic energy, with monetization of agricultural biomass	Sustainable management of listed forests, and conservation of protected zones and sacred forests	Wooding / reforestation, restoration of forests and damaged landscapes	Environmentally-friendly mining operations	Incentive schemes such as Payment for Environmental Services (PSE)	Regional development and land security	National planning and structural reforms for the transition to a green economy

TABLE 2. APPROACHES AND STRATEGIC OPTIONS FOR REDD+ IN CÔTE D'IVOIRE

Source: REDD+ Côte d'Ivoire (2017)

• EXAMPLES OF ACTIVITIES IN CIVIL SOCIETY, THE PRIVATE SECTOR AND LOCAL COMMUNITIES • Several non-governmental bodies are involved in the fight against deforestation: Local and international NGOs, multinationals, local communities, etc. These groups carry out

studies on deforestation (such as the previously-cited Mighty Earth report or the Etc Terra study), and actively participate in the fight against bush fires (text box 3).

Progress of knowledge

Scientific research has for long looked into deforestation in Ivory Coast. If several scientific articles have made possible to establish a global picture, NGOs also are also taking part in extending knowledge on deforestation in Ivory Coast. With financial support of FAO within the frame of ONU-REDD and in collaboration with REDD+ and other State actors and civil society, the NGO Nitidæ (merging of the NGOs Etc Terra and Rongead) carried out in 2016 a qualitative analysis of the factors of deforestation and degradation of forests in Ivory Coast. The results of this landmark study, largely quoted in most of national and international reports have improved the understanding of the drivers of deforestation. (Etc Terra, 2016)

TEXT BOX 3

Preventing bush fires

The fight against bush fires is also a hobby horse for local communities. Over 1000 committees have been set up to prevent bush fires, such as Boman Gouli in Oumé or Ebo Agnan Iti in Abengourou; these organisations are made up of local villagers, and are supported by the SODEFOR and the International Tropical Timber Association (ITTO) (AIP, 2018). These committees have been set up in villages to increase awareness of the dangers of bush fires, to prevent fires from being started, limit their spread and make containment efforts more effective.

TEXT BOX 4

Chasing farmers, placer miners and loggers off protected forest lands is a sensitive issue for the Ivorian government. In certain places, these protected areas have become functioning villages with their own infrastructures: schools, hospitals, water and electricity systems, etc. For this reason, several NGOs are involved in the upstream and downstream phases of these operations (text box 4). Ivory Coast has 234 listed forests (SODEFOR, 2018). These forests have long been illegally infiltrated following migration into forested areas: 80,404 people settled in forests between 1996 and 1999 (CEDEAO, 2015). These occupations were exacerbated by the period of socio-political crisis between 1999 and 2010: almost 229,560 heads of families are now settled in the forests, and depend on them for their survival (REDD+ Côte d'Ivoire, 2017). These forests are often the subject of land disputes, as was the case for Goin-Débé in the west of the country. Clearing human settlements from these areas is a necessity in order to meet the commitments the government has entered into. Around 9,000 people have been removed from the Mount Peko national park (OCHA, 2013) and over 10,000 people have been removed from the Niégré listed forest (Léonard & Ibo, n.d.).

Combating the illegal occupation of listed forests and protected zones

For several years now NGOs have been raising awareness among the population of the benefits of preserving listed forests and protected zones. For example, in 2017 the wild chimpanzee foundation (WCF) initiated an awareness drive in villages around the listed forest of Cavally, using a theatrical

production to spread their message. The play showed viewers what kinds of things were happening in listed forests: people entering illegally, armed gangs bringing in and extorting illegal occupants, who clear the land to make way for cacao plantations - all with the complicity of certain local officials who encourage these practices and contribute to the destruction of the forest. This awareness campaign was designed to support the emergency plan implemented by the SODEFOR (a government agency), which enables surveillance operations to be carried out each month in listed forests, including the destruction of shelters and plantations in the Cavally forest, and the arrest of clandestine occupants. Several local NGOs such as Nofna, Oprft, and IDEF are also working with government authorities and international NGOs to raise awareness amongst the population. (Diédri, 2017)
These clearances often attract fierce criticism, as one of the immediate consequences is the overpopulation of neighbouring villages and the various issues this causes. The government's lack of support measures for these cleared populations (and slowness in providing them) are also criticized. As a result, these populations are often tempted to resettle back in the forests. In a recent incident report, the Ivorian Association of Human Rights Bodies (RAIDH, 2017) revisited these points, reiterating the rights of these occupants during evacuations, and called upon the government to recognize the necessity of improving support measures in order to facilitate the re-integration of these populations. The challenge therefore lies in retaking control of these protected areas and listed forests while also taking into account the social and economic impact of settlement clearances.

TEXT BOX 5

In response, the new forest policy transforms the government's method of intervention in these areas. The policy suggests redeveloping forests having suffered deterioration levels of over 75% into agro-forests. In these listed forests, environmentally-friendly agricultural activities will be permitted (under clear and strict conditions), as will other controlled economic activities and human settlements. Development plans will be implemented in order to preserve and re-wood existing forests. For forests that have experienced lower levels of deterioration, settlement clearances will be carried out in adherence with human rights regulations. (Ministry of Waterways and Forests, 2018).

Within the strategy implementation framework, REDD+Côte d'Ivoire has established several pilot projects, which are being managed by NGOs (text box 5). The private sector is also involved in one of these projects. Elsewhere, civil society organisations and private bodies have created a coalition to push forward the application of the new forestry code (text box 6).

Implementation of several REDD+ flagship pilot projects

The REDD+ Project in the Mé region (in the south-east of Ivory Coast) is currently being coordinated by the NGO Nitidæ (which was formed via the merger of Etc Terra and Rongead). This is the first REDD+ project in Ivory Coast. Its aim is to combat deforestation and forest deterioration on a regional scale in the Mé. The scope of this pilot project covers the listed forests of Mabi-yaya and their surrounding buffer zone. It will benefit 7 villages, 2250 planters, 5000 hectares of plantations, 150 forest owners, 15 charcoal producers, 5 NGOs and 3 local companies. The project, which has been underway since December 2016, has already achieved significant progress, including the mapping of land use in the region, increasing awareness of land use and forestry legislation, reforestation of 58 hectares of land and the

establishment of a reference level for forests in the region. (Nitidœ, 2018)
A Payment for Environmental Services (PSE) pilot project has been implemented by the NGO Impacture since September 2017 in the region of Nawa (south-east of Ivory Coast, and part of the "cacao triangle"). The PSE, which is an incentive instrument implemented by REDD+, aims to create a collective dynamic among local communities to support the reforestation and conservation of biodiversity in the area's remaining forests. The project has already increased awareness among 2000 producers and community members. Almost 600 producers and community members have been mobilized in agroforestry, reforestation and forest conservation, and 200 contracts have already been signed. 79% of the funding for this project was provided by the chocolate company Mondelez, which was singled out by Mighty Earth; its aim is to improve the environmental quality of this multinational chocolate company's supply basin. (REDD+ Côte d'Ivoire, 2018).

TEXT BOX 6

At a level applying to all agricultural sectors, several actions have been carried out in pursuit of the "zero-deforestation agriculture" policy. Applying to the cacao sector, for example, in November 2017 (alongside the COP23) a group of 22 multinationals from the cacao and chocolate industries signed a "Communal Action Framework for a deforestation-free cacao value chain". In partnership with the Ivorian government and NGOs, they will commit to working together to pursue shared objectives in order to end deforestation and forest deterioration throughout the global cacao supply chain. The Ivorian ministers of the environment, waterways and forests launched work on this action framework on January 18th 2018 in order to established a roadmap to zero-deforestation objectives for the sector.

Pushing for effective application of the new forestry code

Initiated by the NGO Impactum, a coalition of organisations from civil society and the private sector was created in August 2018 to incite the government to fully apply the new forestry code adopted in 2014. This coalition also includes the NGOs OPRFT (Observatory for the Protection and Recovery of Tropical Flora and Fauna), AMISTAD, SAFI (Save the Ivorian Rainforest), IDH, UTZ Certified and Rainforest Alliance (Kouassi, 2018). The coalition aims to promulgate the forestry code and help ensure its widespread application. The ultimate goal of this push to effectively apply the code is to encourage producers and local communities to participate in the recovery and conservation of the country's forest cover (APA, 2018).

TEXT BOX 7

By giving companies public and symbolic recognition of their positive agricultural practices and forest preservation efforts, the Rainforest Alliance, UTZ Certified and "Fair Trade" certifications also have a role to play in making producers more responsible and increasing consumer awareness. In 2017, a total of almost 330,000 cacao producers carried the UTZ certification (UTZ, 2018), and 120,000 producers were certified as "Fair Trade" (Le Monde, 2018). According to Ouattara (2015), 206 cooperatives carried the Rainforest Alliance certification in 2013. As regards the palm oil sector, the country has joined the Africa Palm Oil Initiative (APOI) set up by the Tropical Forest Alliance 2020 (TFA2020, 2018). The sector has also committed to a sustainable production approach via the RSPO industrial standard (Roundtable on Sustainable Palm Oil).

CONCLUSION

This study of LULUCF emissions in Ivory Coast has demonstrated the urgent need for the country to regain its forest cover. With its forest resources practically depleted, a high level of vulnerability to climate change, social improvements needed, and the desire for economic growth, the country has a significant number of challenges to contend with. It has become clear that proper management of listed forests will be an essential factor in responding to these challenges. The LULUCF emissions sector is a multi-lateral issue: forest protection efforts are linked to the agriculture, energy and mining sectors. As such, it mobilizes significant amounts of resources and a range of stakeholders. REDD+, national and international NGOs, food manufacturing firms, producer organisations in agricultural sectors and local communities are all knuckling down to tackle the monumental task of recovering and preserving Ivory Coast's forest cover.

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The indispensable role of biomass and soils in France, concrete actions still being discussed

In 2016, in metropolitan France, the land sector was used to offset 9% of the emissions of other sectors. The goal is to reach 100% or more by 2050, both by reducing emissions and increasing this carbon sink. Research organisations play a key role for this sector where scientific uncertainties are still very significant and where debates on the effects of the actions carried out are not yet settled. The mobilisation in recent years of private actors (timber industry, forest owners, farmers) has resulted in the growing establishment of the private sector, the development of the wood energy and timber markets, national voluntary carbon offset projects and agricultural practices that promote the storage of carbon in soils, through the 4 per 1000 initiative.

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CONTENTS

1 • CURRENT SITUATION AND UNCERTAINTIES ABOUT THE ANALYSIS

The current role of the land sector in France's GHG balance sheet

What are we talking about?

What is the current sink due to? What levers can be used to maximise it?

Recent research

In 2017 and 2018, strategic discussions brought together state and non-state actors

2 • ACTIONS IN THE FOREST-TIMBER SECTOR

Recent debates between non-state actors on the best actions to be taken in forestry

Mobilisation and organisation of the sector

The forestry sector is mobilising in carbon recovery

Local authorities now include LULUCF sector in their climate strategies

Carbon storage actions in hedges have been developed

Afforestation and reforestation are being developed

The rise of wooden constructions

Wood fuel and biomass heating plants: manufacturers and communities are investing

3 • ACTIONS TO MAINTAIN AND INCREASE CARBON IN SOIL

The launch of the 4 per 1000 initiative brings together scientists, decision-makers and local stakeholders for the storage of carbon in soil

The agri-food sector is developing labels and actions for storing carbon in the soil

The actions of elected representatives, developers and citizens make it possible to start limiting the artificialisation of land

1 • CURRENT SITUATION AND UNCERTAINTIES ABOUT THE ANALYSIS

• THE CURRENT ROLE OF THE LAND SECTOR IN FRANCE'S CARBON FOOTPRINT • In 2016, the balance sheet of the Land Use, Land Use Change and Forestry sector (LULUCF, or more simply land sector) in France was a net sink of -41 MtCO2e. This means that the absorptions (mainly through the growth of trees in the forest) of this sector exceed its emissions (deforestation, wood extraction, artificialisation of soil, etc.). This carbon sink increased between 1990 and 2000, from around -30 MtCO2e to -50 MtCO2e, to -45 MtCO2e in the 2010s (Citepa, 2018). LULUCF is currently able to offset about 9% of emissions from other sectors.

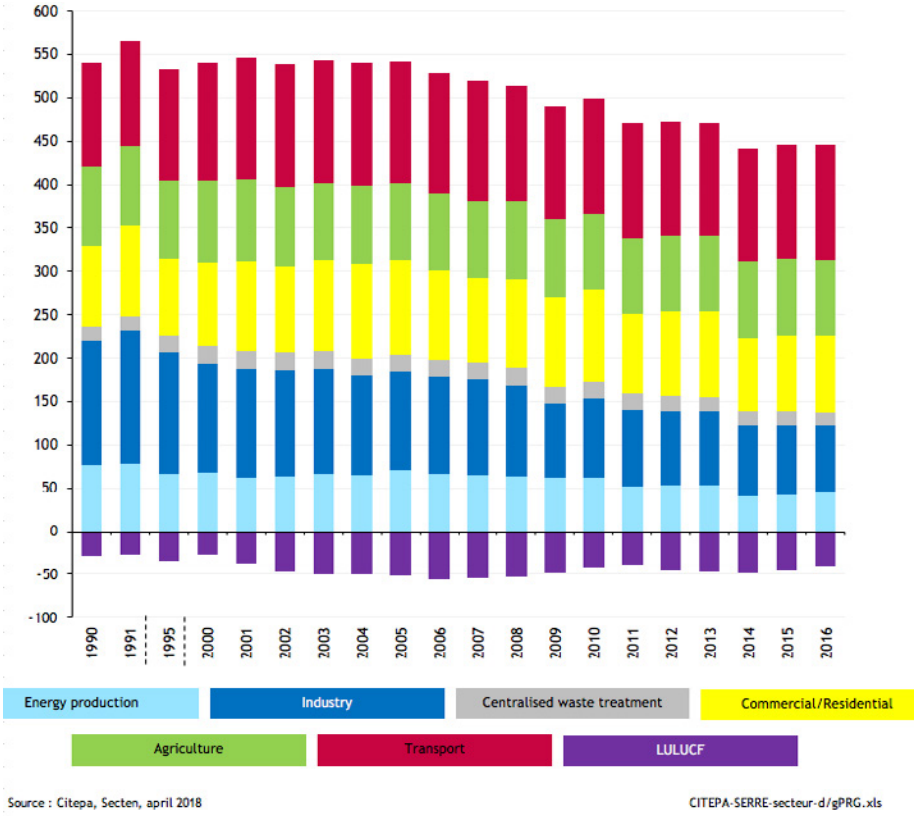

FIGURE 1. ABSORPTIONS IN THE LULUCF SECTOR WITH RESPECT TO GHG EMISSIONS FROM OTHER SECTORS, METROPOLITAN FRANCE, 1990-2016

• WHAT ARE WE TALKING ABOUT? • The LULUCF sector accounts for greenhouse gas flows directly or indirectly related to human activities; under a national approach (emissions occurring abroad but attributable to French consumption of wood, biofuel or food raw materials are excluded). It includes:

• the carbon footprint of the managed forest (absorptions related to tree growth and emissions related to mortality and timber harvesting) and timber products,

• the carbon footprint of farmland (variation of their organic carbon stock due to practices)

• the soil carbon footprint after change of use (cultivation of permanent grassland, deforestation, afforestation, artificialisation, etc.).

It is important to note that at no time are stocks (total carbon in a reservoir) counted as such. Only flows are counted. Thus, the mere presence of a forest, however extensive, does not guarantee a carbon sink.

• WHAT IS THE CURRENT SINK DUE TO? WHAT LEVERS CAN BE USED TO MAXIMISE IT? • The current sink is mainly due to the growth of biomass in the forest, associated with a low rate of wood extraction. The extension of the forest on the surface plays only a secondary role. The carbon footprint has generally been stable over the last few years, with a slight downward trend in the

sink linked to stagnant organic production and higher extractions. Thus, the wood extraction rate is an important adjustment variable for the carbon sink.

The balance of farmland has less impact in the inventory. The carbon flows associated with these farmed soils remain highly uncertain, both because of the difficulty in tracking relevant land-use changes (Robert, 2016) and the difficulty of matching soil carbon stock changes with management factors (current CSOPRA research programme).

Finally, land use changes as a source of CO2 emissions are less significant than the carbon footprint of forests. The artificialisation of land alone (mainly by urban sprawl) has accounted for annual gross emissions of about 10 MtCO2e in recent years.

• RECENT RESEARCH • To facilitate the climate actions of non-state actors in the LULUCF sector, a crucial problem is still to be solved: the major uncertainty regarding the estimate of the LULUCF sector's carbon footprint and the real impact of the different levers of action.

Various research projects have led to progress, especially in 2017, on these issues and the scientific community is mobilising to reduce these uncertainties. Accordingly, very recent works have led to:
• improved monitoring of carbon stocks and flows (harvests, destinations and lifecycle of wood products, monitoring of land-use change surfaces, forest and non-forest biomass, etc.). For example, for the monitoring of land use, recent studies by the IGN (OCSGe project whose interim results were produced in 2016) and the CESBIO laboratory (OSO project financed by the Théia Unit, with results available since 2016) have led to better quantification of the LULUCF sector and monitoring of afforestation actions in particular.
• evaluation of the impact of the various actions carried out by forest and agricultural stakeholders, with expertise from various research organisations (INRA, IGN, Ademe, CNRS, Irstea, IPSL, ONF, Citepa, FCBA, etc.) (Colin, 2014; Colin & Thivolle-Cazat, 2016; Roux et Dhôte, 2017; Valade et al. 2017).
• better estimates of certain flows, currently not calculated in the national inventory, such as forest soils (without conversion of use), whose sink may represent 7 to 15 MtCO2e/ year (Jonard, 2017, Roux and Dhôte, 2017); dead wood with a sink of 10 MtCO2e/ year (Roux et Dhôte, 2017); or the Guianese forest (excluding deforestation and harvesting).

• IN 2017 AND 2018, STRATEGIC DISCUSSIONS BROUGHT TOGETHER STATE AND NON-STATE ACTORS • In 2017 and 2018, forest, agricultural and NGO stakeholders participated in producing the review of the National Low Carbon Strategy (SNBC) and in discussions on the implementation of the European LULUCF Regulation (2018/841). There is no political and scientific consensus on the best actions to be taken by non-state actors to address the climate issue in the short and long term, whether it involves conserving timber in the forest or increasing harvesting. Numerous stakeholder discussions in recent years have not resolved these strategic debates. However, a number of messages have emerged:
• the need for maximum development of negative emissions
• the need to structure the French timber industry and provide incentives for private owners to remedy the inertia of the sector,
• the desire to prioritise the sustainable storage of wood in timber products rather than wood fuel,
• caution regarding the non-permanence of carbon storage in agricultural soils,
• the difficulty of acting through multiple stakeholders (foresters, landowners, sawmills, builders, developers, elected officials, farmers, etc.).

2 • ACTIONS IN THE FOREST-TIMBER SECTOR

• RECENT DEBATES BETWEEN NON-STATE ACTORS ON THE BEST ACTIONS TO BE TAKEN IN FORESTRY • Forest biomass is currently the main building block of carbon sinks of the French LULUCF sector. According to the latest IGN figures (2017) the Metropolitan French forest is private (75%), fragmented (53% of the private plots occupy less than 25 ha (FCBA, 2016)); and characterised by hardwoods (67%). Its surface area, 16.9 million ha in 2017, is increasing (+100,000 ha/year), as is its volume (+27 million m3/year) (Hervé et al., 2016). As wood extractions (45 Mm3/year) are lower than production (92 Mm3/year), it continues to act as a carbon store (IGN, 2017).

Thus, forest biomass and the decision to optimise its role as a carbon sink (storage, sequestration, carbon replacement) are the focus of the bulk of scientific and political debate (Grassi, et al., 2017; Kauppi & Mäntyranta, 2014). Sequestration consists of prioritising increases in forest carbon stocks (biomass, deadwood and soils) with extensification of harvesting. For proponents of this approach, increasing timber harvesting would create a «carbon debt» that will only be offset by the regrowth of trees in the long term - while the urgent task is to limit emissions in the short term, by 2050. This approach is particularly critical of the use of wood for fuel, resulting from short rotations. During the past two years, NGOs and scientists have promoted this strategy (Beddington et al., 2018; Fern 2016). During these debates, economic stakeholders have rather emphasised substitution, involving prioritising the use of the forest for wood extraction which stores carbon temporarily and replaces other materials of other non-renewable energies with higher emissions. Furthermore, sustainable forest management ensures its ability to continue storing carbon and reduces the risk of mortality (Seidl et al., 2014; Galik & Jackson, 2009; Rautiainen et al., 2010; Nabuurs et al. 2015).

Even if it is possible to advocate an approach using a wide range of levers, in recent years there has been conflict between some economic stakeholders in the timber industry and scientific organisations and NGOs.

• MOBILISATION AND ORGANISATION OF THE SECTOR • Recent reports (Houpert & Botrel, 2015; Colin & Thivolle-Cazat, 2016; Alexandre, 2017; Ballu, 2017) take up the well-known finding of the French «paradox» of the under-exploitation of French forestry resources - which are actually expanding. Faced with this challenge, forest stakeholders are mobilising little by little.

At the beginning of 2018, the CNPF launched a platform (laforetbouge.fr) providing forest owners with free tools for training and documentation for better management and use of their plots (forestry work, management, sale of wood, etc.). This site therefore provides a response to certain brakes that have resulted in the under-exploitation of the French forests, to promote the long-term role of carbon sinks and to boost the timber industry.

Between 2014 and 2015, the number of private owners joining a cooperative increased by 4.5%, which made it possible to strengthen the supply of timber and contributed to national harvesting of 6.9 Mm3 (+4.5% in one year).

In 2014, the forest-timber sector (FBF-FBIE) published its «pact for the future 2020 - the commitments of the sector». The commitments adopted include 110,000 ha/ year in renewal, improvement and adaptation of the forest; an increase of 14.5 Mm3 by 2020 in sustainable timber mobilisation; maintenance of the carbon sink; a recalibration of the trade balance of timber; a rise of 3Mtep of wood energy, etc.

• THE FORESTRY SECTOR IS MOBILISING IN CARBON RECOVERY • The French forest cannot currently be used directly as a carbon pump by foresters. In the absence of a binding market, a market for voluntary projects has developed in recent years in order to promote this ecosystem service provided free of charge by the forest and the stakeholders who maintain it. On the one hand, more and more companies want to invest in forest carbon sequestration work.

La Poste Group and GIP Massif Central invest in forest carbon credits

In 2015, a programme was launched by the National Centre for Forest Ownership (CNPF) in partnership with the Massif Central Public Interest Group to define forestry carbon offset projects to provide carbon credits: afforestation in non-forested areas, reforestation (replacement of diseased, burned, poorly adapted areas, etc.) and improvement of forest management. La Poste Group has invested nearly EUR 300,000 in this programme. The private owners of the Forêt Agir Limousin association have thus been able to finance actions to reinforce carbon sequestration in the forest (monitoring of chestnut coppice, increases in hardwoods, (re) afforestation of conifers), whose effectiveness has been verified by the CRPF.

TEXT BOX 1

This approach to ensuring the monetisation of a tonne of carbon avoided or sequestered in a French forest project is still to be certified. With this in mind, since 2016 I4CE has been developing a labelling scheme for voluntary carbon projects. Potential in France has been estimated at between 2 and 2.5 MtCO2e/ year (Tronquet, Grimault & Foucherot, 2017), i.e. nearly 0.5% of non-LULUCF metropolitan emissions. The implementation of a low-carbon label, resulting from this I4CE work, supported by the Ministry of Ecology, aims to promote the emergence of these projects by ensuring the reliability of avoided emissions calculations.

• LOCAL AUTHORITIES NOW INCLUDE THE LULUCF SECTOR IN THEIR CLIMATE STRATEGIES • Moreover, communities required to produce a climate-air-territorial energy plan (PCAET) are doing the same. The CNPF recently developed a calculation tool to assist councils for better integration of forests in their GHG emissions assessments. This tool is used to compare several ways in which silvicultural programmes can be used to improve the local carbon footprint. Accordingly, communities, businesses and consumer groups now have the tools to encourage them to maximise their carbon sinks.

• AFFORESTATION AND REFORESTATION ARE BEING DEVELOPED • Actions aimed at avoiding growth in logging or even reducing forestry management in some forest areas, serve several purposes: carbon storage in standing trees and dead wood, forest litter and soil; improved productivity and better economic use of species; the protection of biodiversity, in particular through the preservation of old-growth patches and by limiting human presence; ecological tourism.

Reforest'action

Reforest'action, a company that was founded in 2010, is one of the key players in reforestation from private funds in France. It was created in response to the finding that forest plantations were decreasing in France, with a consequent reduction in forest renewal, making it more vulnerable to crises. It restores degraded forests (burned, flooded, diseased, destroyed by storms, etc.), reforests areas with limited forest coverage and supports sustainable harvesting and recovery methods for harvested timber. More than a million trees have been replanted in France since 2014.

TEXT BOX 2

• THE RISE OF WOODEN CONSTRUCTIONS • The timber sector is not very competitive, the business is fragmented with limited coordination between upstream production (in a predominantly hardwood forest) and downstream processing (with strong demand for softwoods). In recent years, timber for construction, driven by the success of the CLT (Cross Laminated Timber) manufacturing technique, has led to the creation of new outlets and appreciation of wood-material. Regardless of the origin of the wood, even if it comes from foreign forests, the construction of long-lasting wooden furniture and buildings makes it possible to store carbon sustainably in France, as a substitute for materials with higher emissions. The recent rise in the use of structures built wholly or partly from wood is an indicator of change in the construction sector, technical solutions and demand.

The rise of wooden buildings in recent years

Wood real estate projects, including high-rise buildings, have proliferated in France since 2016. Since 2016, the AdivBois (Association pour le développement des immeubles à vivre bois) technical commission has been seeking to facilitate these programmes and to remove technical, economic and regulatory obstacles, for example by promoting technical support for the construction of demonstrators of the first wave of wooden buildings. These projects are also supported by Future Investment Programmes (PIA of the future agriculture and forestry law 2014).

In particular, «the market for buildings with timber structures and concrete infrastructure is booming" (O. Messéant, 2017). In 2017, a call for projects selected the project for two timber-framed towers in Bordeaux, including the Hyperion tower which, at 57 metres, will be the highest tower of this type in France. Another 50 m wooden tower, WoodUp, was also selected in 2017 in Paris. In Strasbourg, the highest tower in France with a 100% timber frame, 38 m high, was delivered in 2018.

TEXT BOX 3

• WOOD FUEL AND BIOMASS HEATING PLANTS: MANUFACTURERS AND COMMUNITIES ARE INVESTING • The benefits of biomass energy for the climate is subject to debate. These actions are based on the idea that wood is a carbon neutral and renewable energy source. Nevertheless, this widespread view does not match the actual balance of carbon flows (Leturcq, 2011; 2013).

Indeed, the supposed carbon neutrality of wood fuel is based on the idea of systematic offsetting, of a cycle at equilibrium between emissions and sequestration. But in reality, this balance is not always achieved and, when it is, it occurs over a long time span. Excluding the emissions of wood fuel on the pretext that the carbon had already been captured in the past or will be recaptured in the future introduces bias in the estimate of the LULUCF carbon footprint: from the moment when the sequestration flows are calculated each year, all emission flows for the year must also be accounted for.

The development of biomass combustion plants in recent years is largely based on two types of incentives: firstly, under the European Emissions Trading System, biomass consumption leads to eligibility for free quotas but the associated emissions are not counted; secondly, the Heat Fund, managed by ADEME, supported the production of 2 Mtoe with € 1.6 billion between 2009 and 2016. Many biomass plants have been built in recent years, making it possible to replace other energies. Ademe has published a document with 54 typical examples of companies that have invested in biomass energy (wood boilers, wood chips, end-of-life wood products, etc.) (Ademe, 2018).

Some examples of recent investments in biomass

• Bordeaux (2015): creation of a wood boiler at the Charles Perrens hospital, with a total capacity of 9.5 MW, consuming 18,000 t of wood per year and avoiding 10,700 t/ CO2/ year.
• Nantes (2017): extension of a 57 km heat system and construction of two wood boilers (Malakoff), with 84% local renewable energy supply (waste recovery or biomass, consuming 45,000 t of wood per year and avoiding 45,000 t/ CO2/ year.
• Suez (2018) invests in the CogeBio start-up, which offers innovative solutions for the production of heat and electric energy by gasification of biomass and waste. «Biomass consumption for industrial heat production has doubled in the last five years in Europe and is expected to reach 20 million tonnes in 2021» (Suez, 2018).
• Lyon (2018): creation of the largest public biomass boiler in France. The Surville plant, managed by Dalkia, will prevent 44,000 t/ CO2/ year.

TEXT BOX 4

3 • ACTIONS TO MAINTAIN AND INCREASE CARBON IN SOIL

• THE LAUNCH OF THE 4 PER 1000 INITIATIVE BRINGS TOGETHER SCIENTISTS, DECISION-MAKERS AND LOCAL STAKEHOLDERS FOR THE STORAGE OF CARBON IN SOIL • While forest biomass has been the major focus of strategic considerations on organic carbon storage, the role of agricultural soils in France and in the world was underlined by the launching of the «4 per 1000» programme, during COP21.

The 4 per 1000 project

The 4 per 1000 initiative aims to increase organic carbon storage in soils. It has resulted in the establishment of a scientific committee to enable research to identify agricultural practices for carbon storage and disseminate them to farmers, agricultural advisers and chambers of agriculture. In 2017, INRA therefore began a study on the feasibility of the 4 per 1000 target in agricultural soils in France.

TEXT BOX 5

As yet, there is no consensus on the long-term effects of storing practices and on their wider deployment, although recent research has made progress in this area (Arrouays, et al. 2002; Pellerin, et al. 2013). Practices are, however, being developed:
• the reduction of ploughing, or even the implementation of cultivation techniques without ploughing.
• increased organic contributions to the soil (crop waste, etc.)
• intermediate crops, intercrops and grass strips
• agroforestry and the planting (or preservation) of hedgerows

The difficulty of setting up a carbon storage policy on agricultural land is due to several obstacles: scientific uncertainties related to understanding and monitoring long-term dynamics and spatio-temporal variability; the interconnection of factors, the immensity of the spaces involved; the number of operators; socio-economic barriers to the adoption of new practices; the complexity of existing environmental standards and arrangements affecting agriculture; consideration of other environmental issues (air pollution, water, landscape, soil quality, biodiversity, erosion, etc.).

• THE AGRI-FOOD SECTOR IS DEVELOPING LABELS AND ACTIONS FOR STORING CARBON IN THE SOIL • Some farmers indirectly render an eco-systemic service by storing carbon in the soil, but their management is constrained by many economic, agronomic, environmental and technical

factors. Beyond European aid (CAP payments subject to virtuous ecological practices in terms of soil carbon, such as the maintenance of permanent grasslands, areas of ecological interest and agro-ecological infrastructures) and national support (reward for the eco-systemic services mentioned in recent discussions around the Climate Plan (July 2017), the National Food Conference (2017), the SNBC (2018) and the Biodiversity Plan (2018), the private sector has also put some actions in place.

Thus, farmers and cooperatives have created labels enabling consumers to opt for agri-food products from soil conservation agriculture, for example the «Ferme Carbone Vert» label (first two farms labelled in Seine-Maritime in 2017); or the "Pour une agriculture du vivant» label, created in 2018 to distinguish products from agroforestry.

Finally, localities have been increasingly concerned to consider carbon in agricultural soils since the integration of the land sector into the PCAETs in 2016.

• THE ACTIONS OF ELECTED REPRESENTATIVES, DEVELOPERS AND CITIZENS MAKE IT POSSIBLE TO START LIMITING THE ARTIFICIALISATION OF LAND • Fighting against artificialisation (urban sprawl, construction of infrastructures) makes it possible to avoid losing (most of the time forever) the carbon stock already present in the soil. The objective of «zero net artificialisation by 2050» has been broached at European level (COM (2011) 571) and at national level (C. Duflot, 2013; N. Hulot, 2018). The construction of suburban housing and estates is the main cause of consumption of agricultural land. Developers, local authorities and citizens all have a role to play in limiting the obstacles to densification in urban areas and limiting the economic appeal of construction on agricultural land.

In 2013, the BIMBY project (Build in my BackYard) was completed bringing together research establishments, technical departments and local authorities. It led to the definition of a new habitat production sector, where the «traditional» sectors are unable to act: within the existing suburban fabrics. Identifying this potential for recycling urban space has made it possible to group together different parallel projects and create a network (Bimby+), facilitating exchanges between professionals in this new development sector.

On the side of promoters and owners, initiatives have emerged for the densificaiton of suburban areas. Some metropolitan areas are seeking to limit urban sprawl, such as Rennes or Aix-Marseille-Provence (goal in 2017 of «zero consumption of green space in 2040»).

In terms of citizens and NGOs, the last few years have been marked by the emergence of strong, high-profile opposition movements against projects that consume large amounts of agricultural and forestry land. For example, the opposition to the Notre-Dame-des-Landes airport project, in the holiday village of Roybon Isère and the major motorway bypass west of Strasbourg, among others.

CONCLUSION

To conclude, we can say that in recent years, the climate role of biomass and soils is increasingly recognised by non-state actors. Even if many structural obstacles remain, France's strengths (its agricultural and forestry heritage) are the target of an increasing number of projects by forestry and agricultural stakeholders and research organisations. The years 2016 to 2018 marked the transition to the post-Paris Agreement era in which the overarching principle of carbon neutrality is beginning to be reflected in the actions of forest and agricultural stakeholders.

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