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

Head editor• **THIBAULT LACONDE** • *Consultant, Energy & Development*
in collaboration with • **GERMÁN BERSALLI** • *researcher, Univ. Grenoble Alpes, CNRS, INRA, Grenoble INP, GAEL*

CONTENTS

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).

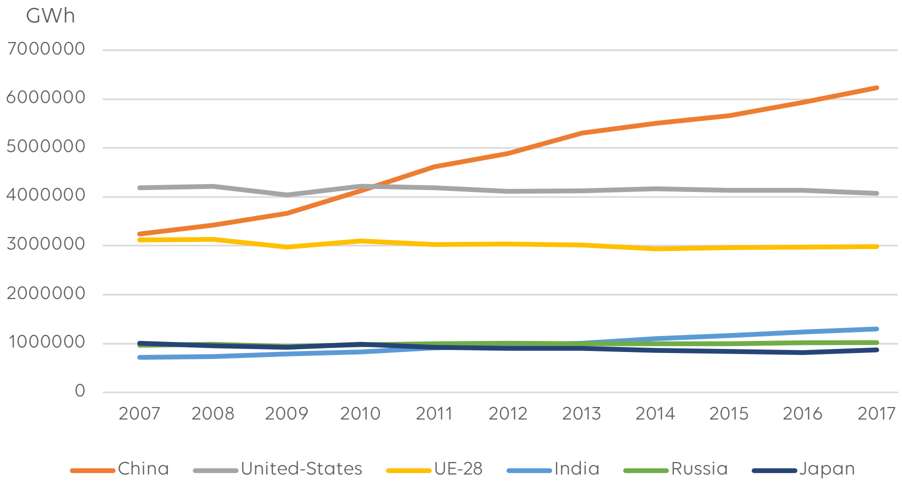

FIGURE 1. PUBLIC ELECTRICITY PRODUCTION

(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 CO_2 per kilowatt-hour produced) or oil (710gCO_2/kWh), while others such as gas emit lower amounts (390gCO_2/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 - 180gCO_2/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.

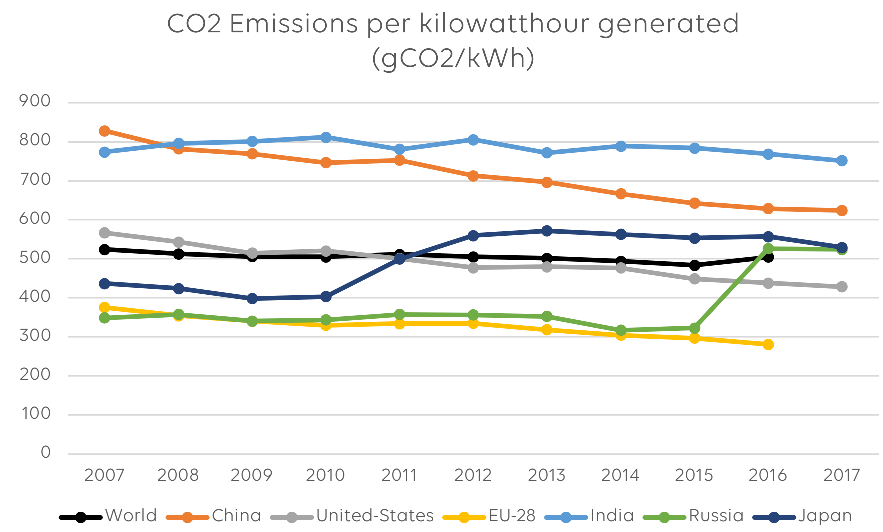

FIGURE 2. CARBON INTENSITY OF THE ELECTRICITY MIX

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.

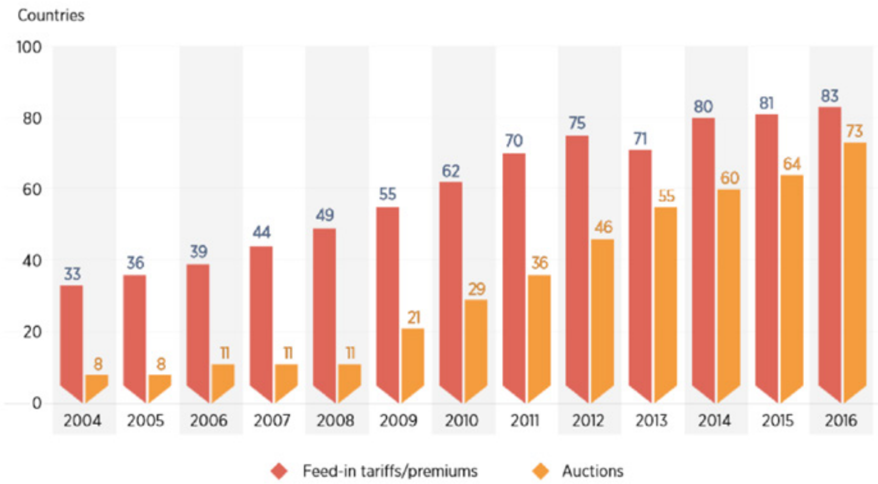

FIGURE 5. NUMBER OF COUNTRIES USING FEED-IN TARIFFS AND/OR AUCTIONS

(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.

PLEASE DO NOT HESITATE TO RESPOND TO THIS DOCUMENT, OR TO SUGGEST ANY RELEVANT ADDITIONAL REPORTS OR DATA BY WRITING TO THE FOLLOWING ADDRESS: CONTRIBUTION@CLIMATE-CHANCE.ORG

REFERENCES

DATABASE:

- Base Carbone
- BP Statistical Review 67th edition (juin 2018).
- ENERDATA, Global Energy & CO_2 Data
- IEA, Statistics
- World Bank Open Data.

REPORTS AND REVIEWS:

- ADEME (septembre 2017), L'effacement de consommation électrique en France.
- Arabella Advisors (2018), The Global Fossil Fuel Divestment and Clean Energy Investment Movement.
- Buttigieg (2016), Transition énergétique : Stratégies d'innovation des groupes électriques européens, École Doctorale de Dauphine.
- BP (2018), BP Energy Outlook.
- Carbon Tracker (13 September 2017), No country for coal gen – Below 2°C and regulatory risk for US coal power owners.
- Energie et Développement (13 septembre 2017), Contract for Difference Que retenir du round 2 ?
- Hermanus (2017), Local Governments' Changing Power in South Africa's Energy System.
- HYSTRA (mai 2017), Reaching scale in access to energy.
- IEA (2018), World Energy Investment.
- IEA (2017), World Energy Outlook.
- IEA/OCDE/World Bank (2010), The scope of fossil-fuels subsidies in 2009 and a roadmap for phasing out fossil-fuel subsidies.
- IPCC (2014), Climate Change 2014 : Mitigation of Climate Change (AR5 WG3 chp7 : Energy Systems).
- IRENA (2018), Renewable Energy Policies in a Time of Transition.
- IRENA (juillet 2017), Stranded assets and renewables.
- OCDE (mai 2018), Measuring and reforming support for fossil fuels.
- OCDE/IEA (2018), Global Energy & CO_2 Status Report 2017.
- Pfeiffer et al. (4 mai 2018), Committed emissions from existing and planned power plants and asset stranding required to meet the Paris Agreement, Environmental Research Letters.
- Rennkamp et al. (2017), Competing coalitions : The politics of renewable energy and fossil fuels in Mexico, South Africa and Thailand, Energy Research & Social Science.
- Shirai et al. (2017), Fossil-fuel consumption subsidies are down, but not, IEA.
- Zimmermann (septembre 2017), Capacity reserve in Germany, Karlsruhe Institute of Technology.

PRESS PRESENTATIONS:

- Bloomberg (3 janvier 2018), Weekly brief sustainable finance.
- Carbon Brief (29 September 2016), Factcheck : The carbon floor price and household energy bills.
- Enerdata (30 mai 2018), Bilan énergétique mondial 2017.
- Financial Times (11 février 2015), Germany's green goals have profound consequences for Eon and RWE.
- Financial Times (18 mai 2016), Eon and RWE pursue radical restructurings.
- Financial Times (14 août 2018), RWE on track with Eon energy deal.