Dashboard of Energy Transition

2020 Edition

Group Strategy Department

For its 10th anniversary, *A World of Energy* is evolving and focuses on the energy transition

Published in September 2020

Foreword

This report on the state of energy transition in 2020 forms part of ENGIE's strategy, reaffirmed despite the health and economic crisis, to align all its operations on a trajectory for carbon neutrality during the first half of the century.

The climate challenges dictating this strategy extend far beyond the company's scope and are a matter for the whole of humanity. In this report we offer a detailed update on energy transition and a description of what still needs to be done to meet environmental imperatives.

While environmental indicators continue to deteriorate at an alarming rate, the inertia that characterises the world's energy system is making efforts to reverse the increase in CO_2 emissions a real struggle. We acknowledge that important steps have been taken, especially on renewable energy. The 'accidental' pandemic-related drop in emissions in 2020 is likely to be temporary and may not mean any underlying change in investment and individual behaviour. Green recovery plans are large enough to help transform the health crisis into an opportunity, but the period we are going through highlights the magnitude of the effort required to contain the rise in global temperatures to below 2°C.

Given this situation, the energy sector – producers, suppliers and consumers alike – bears a heavy burden of responsibility: 75% of greenhouse gases come from energy combustion. But by the same token, the sector could provide a large proportion of the solutions.

Thanks to the commitment of the scientific community and an increasing number of socioeconomic players, including ENGIE, the steps that need to be taken are now clearly identified. We dedicate a large part of this document to them, describing their potential and current stage of development. Our analysis has benefited from research by the renowned centres of expertise that responded to our invitation to comment on energy transition.

The two fundamental components of lower GHG emissions are reduced energy consumption and energy decarbonation. They can be achieved through a series of levers.

Energy efficiency has considerable potential and is capable of reducing global energy consumption by over a third. Renewable energy, whether electricity or gas (biomethane, green hydrogen), could result in virtually complete decarbonation in power generation and will tackle specific pockets of resistance, such as transport and intensive industry, while favouring short supply chains. We will also need to adopt other measures on a large scale, such as energy sobriety, undoubtedly the most efficient lever, but involving an indispensable change in mentalities and practices. The development of green finance should lead to a prioritisation of investments to accelerate the energy transition.

Choices on priorities, technology and the pace of change will be subject to different approaches depending on geography, but long-term energy scenarios show that global ecosystem resilience can only be achieved by combining them.

These observations drawn from the first edition of the Energy Transition Dashboard* show that while there are several ways of achieving a successful transition, we all have to accelerate their implementation.

I hope this report contributes to a better understanding of the scale of our energy challenges and proves useful to you and your work.

Anne-Laure de Chammard
Director of Group Strategy, ENGIE

*The Energy Transition Dashboard replaces "*A World of Energy*".

ENGIE in brief

Our group is a global reference in low-carbon energy and services. Our purpose ("raison d'être") is to act to accelerate the transition towards a carbon-neutral world, through reduced energy consumption and more environmentally-friendly solutions, reconciling economic performance with a positive impact on people and the planet. We rely on our key businesses (gas, renewable energy, services) to offer competitive solutions to our customers. With our 171,000 employees, our customers, partners and stakeholders, we are a community of Imaginative Builders, committed every day to more harmonious progress.
Turnover in 2019: 60.1 billion euros. The Group is listed on the Paris and Brussels stock exchanges (ENGI) and is represented in the main financial indices (CAC 40, DJ Euro Stoxx 50, Euronext 100, FTSE Eurotop 100, MSCI Europe) and non-financial indices (DJSI World, DJSI Europe and Euronext Vigeo Eiris - World 120, Eurozone 120, Europe 120, France 20, CAC 40 Governance).

171,000
employees throughout the world

€60 billion in 2019 revenues

€12 billion of investments planned between now and 2021, including about **€5 billion** in customer solutions, nearly **€2.5 billion** in renewable energies and close to **€3 billion** in gas and electricity networks

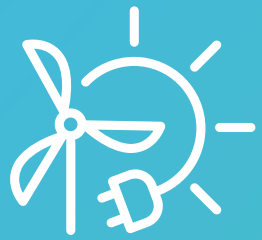
IN 2019, WE INVEST FOR THE FUTURE:
€189 million in research and development
€182 million in innovative start-ups

9 GW
of additional renewable capacity between 2019 and 2021

2 drivers of growth:
customer solutions (**€21 billion** in 2019 revenues)
and renewables (**€3 billion** in 2019 revenues)

An investment fund of **€34 million** to support energy access (ENGIE Rassembleurs d'Energies fund) for **4 million** beneficiaries.

WE COMMIT TO GREEN FINANCING:
€3.4 billion
green bonds emitted in 2019



ELECTRICITY & RENEWABLES

96.8 GW of installed power-production capacity, of which 26.9 GW in renewable energy (28% of the portfolio)

417 TWh of electricity generated in 2019

No. 2 electricity producer and supplier in France

No. 1 in solar and wind energy in France

No. 2 purveyor of installed EV charging stations

NATURAL GAS & GREEN GAS

Long-standing leader in gas distribution in France

Among the top gas sellers and importers in Europe

No. 1 gas infrastructure operator in Europe with a portfolio including transmission networks, distribution networks, storage, and LNG terminals

€800 million pledged within the next five years to develop green gases

No. 1 demonstrator of green hydrogen injection in the French gas distribution network

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World economy

By locking down 4 billion people, the Covid-19 pandemic plunged the world economy into its worst crisis since World War II

World GDP could well shrink by more than 3% in 2020, and perhaps by as much as 8%, depending on the duration of restrictions, success in easing them, the occurrence of a second wave of infections and national support measures. In individual countries, the depth of recession will also reflect the pre-existing state of the economy (debt, unemployment rate, etc.). All countries, emerging and developed alike, are under threat.

Economists' projections converge towards a U-shaped, rather than a V-shaped recovery. This means that the decline in activity in 2020 shortfall will not be overcome any time soon. Some countries could even suffer an L-shaped recovery. The problem is that unlike during the 2008 financial crisis, the real economy has been badly damaged. Industrial production (22% of world GDP) is set to contract by 5% in 2020, which will mean structural changes and adjustments across industry worldwide. The most affected sectors are transport, tourism, hospitality, oil and gas, real estate and non-essential goods and services.

Financial crisis need not follow. Governments and international organisations have introduced unprecedented fiscal, financial and socio-economic measures to keep national economies afloat, notably tax reductions or deferrals, unemployment benefits and state guarantees for bank loans. In the meantime, central banks are focusing on lowering interest rate and purchasing assets (quantitative easing). No previous health crisis has had so much impact on national economies; this explains why the current shock has much in common with wartime and post-war economics.

This crisis may leave long-term scars on the world economy in the form of additional protectionism, relocation, value chain restructuring, accelerating digitalisation, teleworking and e-business development, heightened security and environmental concern and less urbanisation. World GDP will start increasing again no earlier than the first half of 2021, and not before 2022 where a second wave to occur.

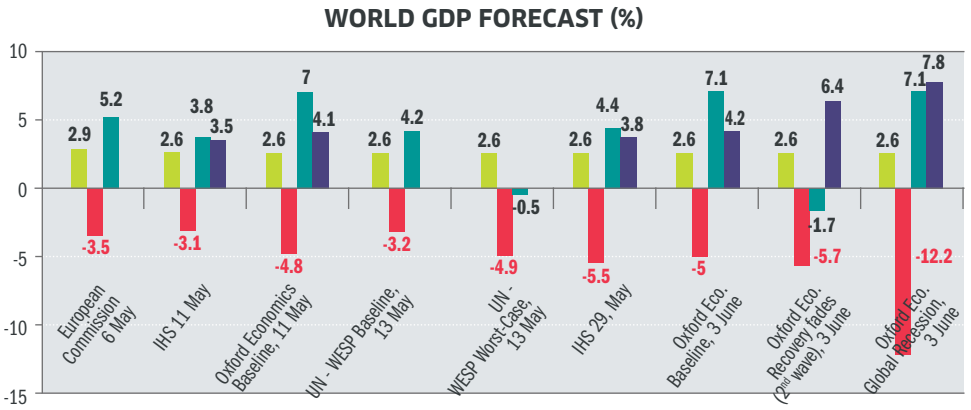
The world economy was already showing signs of slowdown in 2019. GDP rose 3%, compared with 3.6% the year before, reflecting protectionist policies and a trade war between the two largest economic powers, the USA and China. The USA maintained dynamic growth at 2.3%, while China and the eurozone disappointed at 6.1% and 1.2%, respectively.

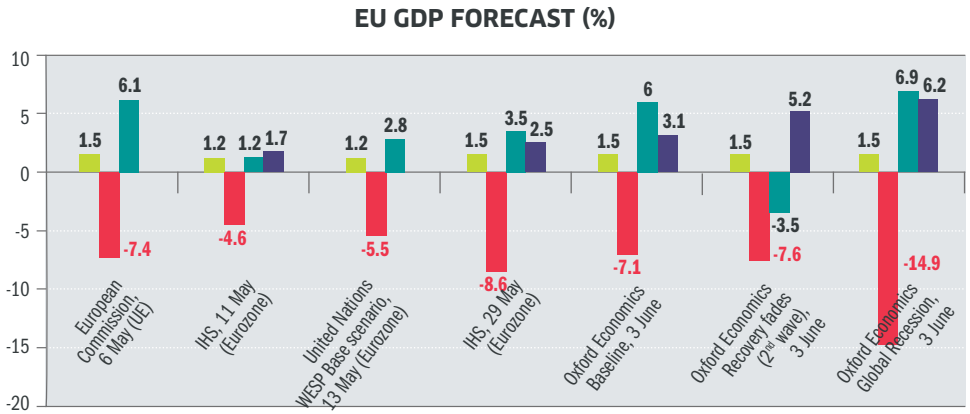
We recall that the USA started the trade war by introducing tariffs on aluminium and steal imports in March 2018. It went on to impose additional tariffs on other Chinese goods, and by end-2019 Chinese exports to the USA had plummeted 35% (Source: UN). China retaliated with tariffs on US exports, mainly of agricultural products. Against this backdrop, international trade growth slowed from 3.8% in 2018 to 1% in 2019, and particularly affected European and Asian capital goods.

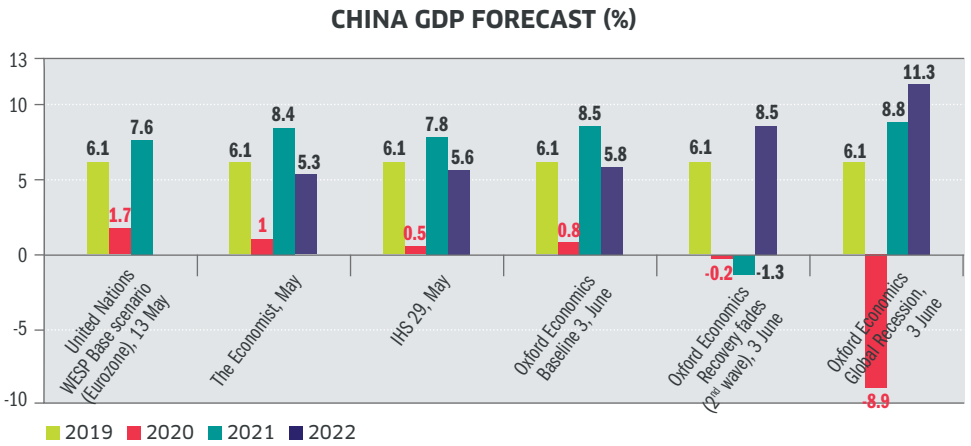
Despite this situation, share prices climbed in 2019 (S&P 500 up 28.5%) and low-revenue countries reported stable growth rates amid continued investment in infrastructure and significant support to several African countries in the form of foreign direct investment (FDI).

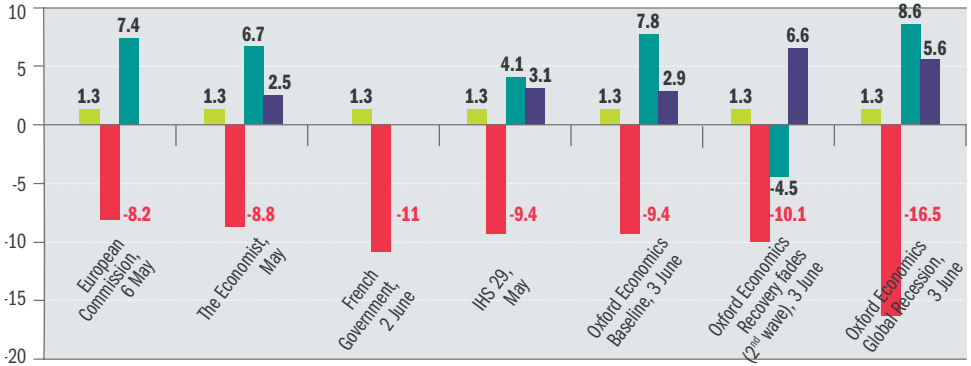
World economy

Post-Covid economic growth forecasts for 2020, 2021 and 2022, by various institutes









Source: GDP forecasts published in June 2020 by external economic research institutes

World economy

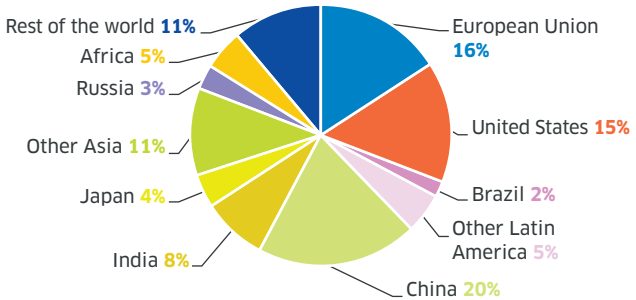
2010-2019 economic growth and 2020-2021 forecasts

GDP & Population	Real GDP growth rate*		GDP growth forecasts**		GDP, purchasing power parity, US$2015 (US$ billion)		Per capita GDP, US$2015		Population (million)	
	2010-2019	2019	2020	2021	2010	2019	2010	2019	2010	2019
Europe	1.7%	1.4%	-7.0%	6.3%	21,044	24,927	28	32	608	630
European Union	1.5%	1.5%	-7.1%	6.0%	18,610	21,432	31	34	504	515
North America	2.3%	2.3%	-7.3%	8.8%	17,770	21,647	52	59	343	367
Canada	2.1%	1.6%	-10.7%	11.0%	1,424	1,724	41	45	34	38
United States	2.3%	2.3%	-7.0%	8.6%	16,346	19,923	53	60	309	330
Latin America	1.3%	-0.2%	-5.5%	4.4%	8,404	9,517	8	8	592	654
Brazil	0.7%	1.1%	-4.8%	4.5%	3,056	3,238	9	8	197	213
Asia	5.2%	4.5%	-1.5%	7.4%	33,776	55,307	5	7	3,800	4,137
China	7.4%	6.1%	0.8%	8.5%	13,609	25,675	6	10	1,338	1,401
South Korea	2.9%	2.0%	-1.0%	3.5%	1,574	2,027	24	30	50	52
India	6.9%	5.3%	-3.0%	11.3%	5,868	10,304	1	2	1,231	1,370
Japan	2.4%	0.7%	-6.5%	3.2%	4,888	5,332	33	36	128	126
Pacific	2.7%	1.9%	-5.7%	4.9%	1,142	1,449	35	38	36	41
Australia	2.6%	1.8%	-5.9%	4.5%	959	1,207	48	53	22	25
CIS	2.1%	2.0%	-5.3%	4.2%	4,573	5,460	6	7	281	293
Russia	1.5%	1.3%	-6.5%	3.7%	3,240	3,712	9	10	143	145
Middle East	2.4%	-0.6%	-7.2%	4.4%	4,969	6,076	10	10	214	255
Saudi Arabia	3.2%	0.3%	-7.5%	5.2%	1,330	1,771	19	20	27	34
Iran	-0.2%	-10.2%	-9.7%	1.7%	1,429	1,438	5	5	75	83
Qatar	3.8%	-0.3%	-4.4%	4.3%	238	335	68	60	2	3
Africa	4.0%	3.5%	-2.7%	4.4%	4,961	6,608	2	2	1,048	1,320
South Africa	1.5%	0.2%	-7.2%	4.0%	655	752	6	6	52	58
World	**3.0%**	**2.6%**	**-5.0%**	**7.1%**	**96,639**	**130,991**	**9**	**11**	**6,922**	**7,698**
OECD	1.9%	1.7%	-6.8%	6.8%	47,941	57,256	34	39	1,240	1,312
No OECD	4.8%	3.9%	-2.1%	7.2%	48,699	73,736	4	5	5,681	6,385

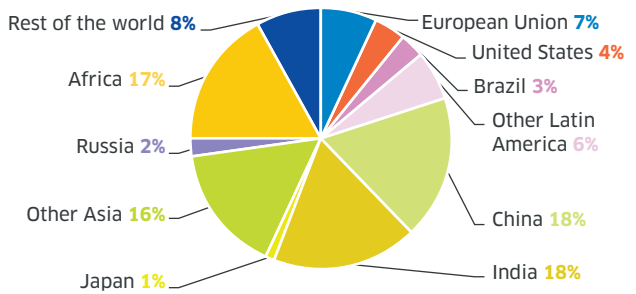
*Compound annual growth rate.
**Oxford Economics forecasts, June 2020.

Source: Enerdata, Global Energy and CO_2 Data (June 2020)

WORLD GDP IN 2019
(PURCHASING POWER PARITY)
TOTAL: US$ 131,000 BILLION



WORLD POPULATION IN 2019
TOTAL: 7.7 BILLION



Source: Enerdata, Global Energy and CO_2 Data (2019)

World economy

China, first country in and then out of lockdown, suffered in 2020 from an 11 week-long reduction of economic activity as well as contracting of foreign and domestic demand. Economic growth is projected to be around 1.2% for 2020, the slowest for half a century. Given that the pandemic hit the country three months earlier than elsewhere, the shape of China's economic rebound will help inform expectations for other regions.

The Chinese economic model has shifted recently towards a more domestic focus, which helped GDP to rise 6.1% in 2019. While this is still vigorous, it is modest compared with the past few decades. Indeed, 2019 saw the slowest growth in 28 years, after 6.6% in 2018 and 6.9% in 2017. The trade war with the USA weighed on exports, a major component of the Chinese economy (up 0.5% in 2019). Industrial production decreased, in line with the country's "economic rebalancing" policy.

In order to develop the domestic market, the Chinese government has introduced financial instruments that facilitate credit and investment for SMEs and private companies: lower personal income tax, reduced VAT for the manufacturing, transport and building sectors, and tax exemptions for cutting-edge technology.

The European Union will be one of the regions most affected by Covid-19. Its GDP is projected to decline by between 5% and 7.4% in 2020 (European Commission estimates). Despite swift intervention by the EU and national governments, the outlook for Southern member states caught between existing economic pressures and the pandemic is very bleak (-9.7% for Greece and -9.5% for Italy, according to Eurostat).

The severity of recession in 2020 also reflects economic slowdown prior to the pandemic. EU growth faded from 2.1% in 2018 to 1.2% in 2019, mainly because of stagnating exports. That said, the EU unemployment rate had eased from 11% in 2013 to 7% in 2018 and 6% in 2019.

In the USA, the Covid-19 crisis prompted an economic meltdown, and GDP is expected to decrease 6% in 2020. Amid a heavy death toll (140,000 at the end of June 2020), unemployment surged dramatically to 36 million unemployed at the peak of the crisis. The unemployment rate jumped from very low levels in 2019 to 15% in April 2020. The latest statistics (June) point towards a tangible rebound on the labour market, however. The Trump administration launched colossal recovery plans worth $2,000bn to bolster the economy.

US GDP rose 2.3% after a 2.9% gain the year before, thanks to corporate and personal tax cuts effective in December 2017 under the Tax Cuts and Jobs Act and to strong domestic demand. The labour market was particularly robust, with an unemployment dropping to a 50-year low at 3.5% despite a participation rate above 63%. This combination resulted in higher salaries and labour productivity.

By early 2020, and despite budget stimulus, the US economy's longest expansion cycle since World War II was losing steam. In the longer run, this crisis rekindles concern about softer productivity trends and the economy's potential growth rate.

World economy

The Japanese economy will also be in recession in 2020, with GDP expected to drop by around 5%, and it will not benefit from growth related to the 2020 Olympics, postponed to 2021.

Hit earlier by natural disasters, Japanese GDP growth had been steadily declining (0.8% in 2019, after 1.1% in 2018 and 1.7% in 2017). During this period, the Bank of Japan's expansionist policy resulted in a weaker yen. This in turn bolstered profits in exporting sectors and protected the labour market (unemployment rate close to 2% in 2019). The budget deficit was reduced from 4.5% of GDP in 2017 to 3% in 2019 via an increase in the VAT rate from 8% to 10%. Shinzo Abe pressed on with structural reforms ("Abenomics"), focusing in 2019 on social care in a population that is both shrinking and ageing (extending pension contribution periods and a migratory policy favouring foreign labour).

Russian GDP will decline by 5.5% in 2020. In 2019, the economy was already suffering from lower oil revenues. GDP growth was down to 1.1% after 1.7% in 2018. Domestic demand was also contracting as the impetus from the 2018 World Football Cup faded. Oil and gas production reached record highs in 2019, with increasing exports. But the economy's lack of diversification is not a negligible risk. Oil and gas represent 59% of exports and investments is focused on this sector; other sectors suffer from chronic under-investment, despite efforts in recent years directed mainly at agriculture. Unemployment remained low at 4.6%, salaries and pensions increased, but productivity remains well under that of the EU and the USA.

In India, despite the Covid-19 crisis and the lockdown declared since March 2020, GDP is forecasted to rise 1.9%, partly thanks to the opening of some public sectors to the private sector (mines, nuclear energy).

Before the pandemic, the Indian economy was experiencing a sharp slowdown, with growth slowing from 7.8% in 2018 to 4.9% in 2019. This reflected structural deficiencies such as the corporate tax burden as well as economic shocks. Amongst the most striking were the contraction of private sector investment, lower oil prices, Prime Minister Modi's decision to withdraw highest value banknotes from circulation (85% of banknotes) and the harmonisation of taxes on goods and services introduced in 2017 (GST), poorly understood by companies and shops.

Brazil became the world's second-largest casualty of Covid-19 at the end of May and its economy is expected to contract 5.3% in 2020.

Already sluggish in 2019 (GDP rose 1.1%, after 1.4% in 2018), the Brazilian economy posted an 11.2% unemployment rate and a 5.2% budget deficit in 2019. Although the deficit contracted following a deregulation of the economy, business circles await further reforms from President Bolsonaro to boost recovery.

Oil-producing economies are set to move into recession in 2020 (-4.3% in Qatar, -2.3% in Saudi Arabia), mainly because of plummeting oil prices.

These economies were already slowing in 2019 as a result of lower oil prices. Crude cheapened by over 10% over the year to an average $64/bbl because of increased US shale oil production. Unable to diversify, these countries remain vulnerable to oil price volatility.

Energy balance

The energy sector has been particularly affected by the health crisis, with a much more severe impact on fossil fuels than on renewables

The health crisis associated with Covid-19 has seriously affected energy markets, especially so in markets particularly exposed to recession. In these exceptional circumstances, IEA and Enerdata have published initial 2020 estimates based on 2019 and early 2020 analysis.

Primary energy demand will contract in 2020, from between 6% according to the IEA and 7.5% according to Enerdata. These figures are based on economic recession forecasts of -6% and -3%, respectively. During lockdown, energy consumption in industrialised countries generally fell in the same proportions as GDP, i.e. by about 25%.

Most energy types will be affected, but particularly oil (-9%), as the lockdowns brought most transport to a halt. Freight and passenger traffic dropped 50% and air transport by 60%. This sector represents 60% of world oil demand.

Coal consumption will decline 8% in 2020, its biggest fall since World War II. This reflects the heavy impact of the crisis on coal-fired plants, as well as the prominent role of China, first country to be affected by the virus. Chinese demand is expected to contract 5%. In the US and in the EU, the projected drop in consumption is even worse, at 25% and 20%, respectively, in 2020. Lower gas prices and healthy renewable electricity production during the crisis helped accelerated a withdrawal from coal that was already well under way. This market's recovery will depend mainly on leading consumers China and India, especially for power generation.

Natural gas demand will also contract in 2020, but to a lesser extent than oil and coal. The IEA forecasts a 5% drop in 2020, mainly because of the implications of the crisis for industrial activity and electricity demand over the rest of the year. Natural gas remained relatively unaffected during lockdown (-2%). According to IEA projections, natural gas demand will recede 7% in the electricity sector and 5% in the industrial sector. Moreover, unseasonably mild weather in the first quarter in the Northern Hemisphere has dampened gas demand. A faster economic recovery would reduce the fall to 2.7% (IEA).

Electricity demand, particularly sensitive to economic activity, is set to contract 5% this year (or by 2% in a fast economic recovery scenario, IEA). During lockdown, declines amounted to between 15% and 20%, depending on the country. This profile is similar to that of a long weekend, meaning an increase in residential consumption largely offset by reductions in the service sector and industry.

In 2019, world primary energy demand increased slightly (0.7% after 2.2% in 2018), with a moderate 2.2% increase in non-OECD countries and a 0.9% decline in OECD countries.

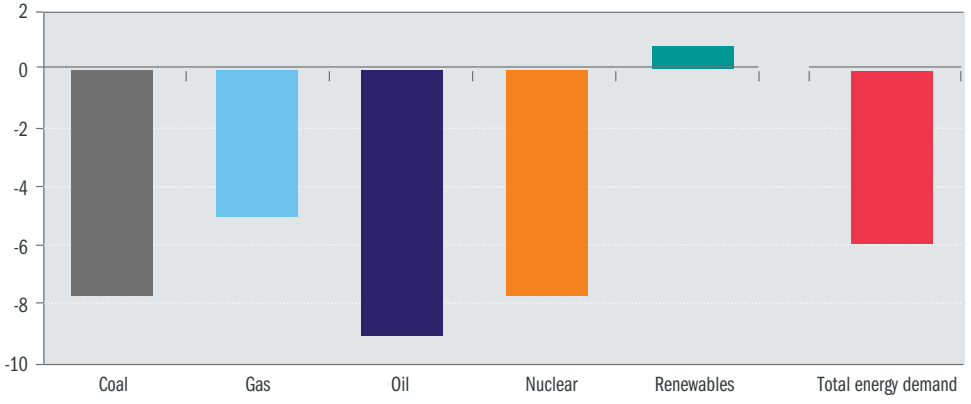
This reflects not only the economic slowdown (3% after 3.6% in 2018) **but also improved energy efficiency** (up 2.1%) compared to previous years (closer to 1.5%). It should be recalled that a 2°C climate change objective requires an annual 3.5% improvement in energy efficiency.

Another important development in 2019 was a decline in coal demand (-2.1% against +0.4% in 2018) in several major countries: slowdown in China (+1%), slight decrease in India, substantial contraction in Europe (-15%) and in North America (-13%). This performance meant better news on CO_2 emissions, which stabilised in 2019 (+0.2% after +2% in 2018). Following several years of virtually no change, the carbon factor dropped 1%.

Natural gas demand remained strong in 2019 (up 3.2%) as a result of coal substitution promoted by energy transition, while solar and wind energy continued their meteoric rise in the electricity sector (production up 22% and 12% respectively). Lastly, oil demand remained stable (up 0.3%), still subject to OPEC and Russian quotas.

Energy balance

WORLD PRIMARY ENERGY DEMAND 2019-2020 – IEA ESTIMATES

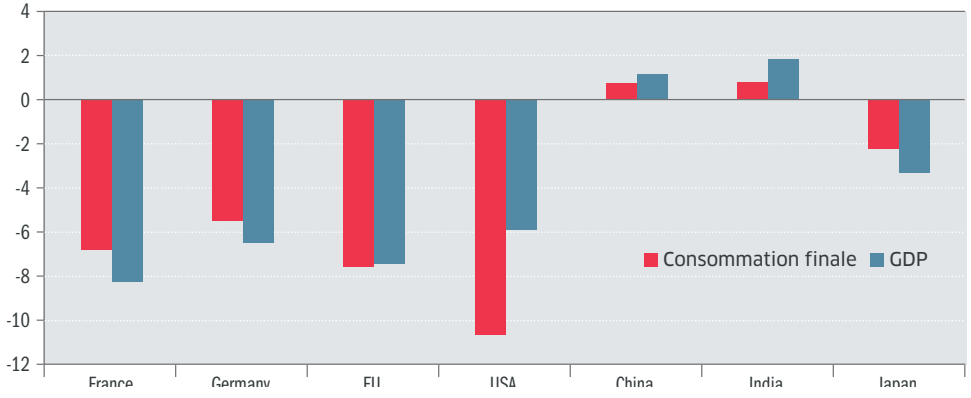


These projections were produced in April and May 2020 and will be revised over the course of the year. Energy consumption and CO_2 emissions depend greatly on the depth of national economic recessions, which remain difficult to assess, and also on the way governments deal with lockdown and subsequent easing of restrictions.

Source: IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020

This review is based on data available by mid-April 2020. They come from numerous sources and represent about two thirds of world primary energy demand.

ENERGY CONSUMPTION 2020/2019 FORECASTS (%)



Source: Enerdata Bilan énergétique mondial – 2020 edition, 2 June 2020

Enerdata estimates follow a detailed methodology, integrating year-round projection updates from major international institutions (European Commission, IMF, ADB for Asia).

Consumption and emission estimates are produced by country for each of the G-20 countries:
- at major energy consuming sector level, to take into consideration their respective sensitivities to recession and lockdown,
- at the electricity sector's level, to take into consideration changes within the electricity mix.

Energy balance

Final energy demand will contract less than primary demand in 2020. The difference, around 3 points, stems from the heavy impact of the crisis on processing, power generation and refining sectors, all of which are excluded from final demand (Enerdata).

Most severely hit are the transport and the industrial sectors, where consumption is expected down around 10% and 2% respectively in the major economies in 2020. Conversely, residential demand held up and services was hardly impacted.

Final demand growth should remain slightly positive in China at c.1%, but plunge severely in Europe (-7.5%) and the USA (-11%).

Regarding global energy production expectations for 2020, fossil energy sources will bear the brunt of lower consumption, with a c. 5% decline in 2020 (IEA).

In contrast, renewable energy production, largely represented by biomass, will enjoy continued 1% growth in 2020, driven by power generation RES. The latter will increase by a robust 5% (IEA) despite supply chain disruption slowing activity in several key countries.

Power generation RES was particularly resilient during lockdown, thanks to their precedence in the order of merit of electricity production and even though electricity production is itself expected to drop 5% in 2020 (IEA). Renewable sources offering low marginal costs and flexibility gained a foothold in power generation with 5% growth expected in 2020 in spite of supply chain difficulties and Covid-19 construction delays. This performance is being led by wind (up 12%) and solar power (16%). Some countries are set to report even more impressive increases in wind and solar power in 2020, notably France (+26%), the UK and the USA (+17%).

Progress in power generation from RES will not be as great in 2020 as expected prior to the pandemic, however, and will increase by less than it did in 2018 and 2019. Coal and gas-fired production will be severely affected, on the other hand. They are expected at -10% and -7%, respectively.

All in all, the RES in the electricity mix will continue with its upward trend initiated several years ago to reach 30% worldwide in 2020, 40% in the USA, 69% in Europe and 34% in China (Enerdata estimates).

In 2019, energy production involved continuing but slow decarbonization, with a decline in oil (-1%) and a marked slowdown in coal (+1% compared to +3% in 2018), to the benefit of natural gas (+4%) and RES (+5).

Despite an acceleration in its decline before the pandemic, the pace of coal's demise remains uncertain as it also depends on slowdowns in emerging countries.

Power generation RES increased by another solid 5% in 2019 despite a slight loss of momentum in recent years as solar and wind power gained ground.

For power generation RES to maintain an annual progression of 6%, a pace that would take their share up to 60% of the electricity mix by 2040 – in line with the IEA's 2°C scenario (SDS) – new capacity spending would have to double by the end of the decade.

The crisis has amplified uncertainty around energy transition, making the next few years even more critical. The major variables are investments in low-carbon technology, energy policies, the use of recovery plans and the behaviour companies, local authorities and individuals people. This report will examine each issue specifically in the chapters that follow and will highlight current trends.

Primary energy consumption

Primary energy production in 2019 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world
Europe	139	-12%	4%	165	-4%	4%	190	-6%	6%	163	2%	12%	345	1%	25%	7	4%	14%	1,010	-3%	7%
European Union	109	-14%	3%	78	-2%	2%	88	-7%	3%	152	2%	11%	295	-1%	22%	3	0%	7%	725	-3%	5%
North America	368	-7%	9%	1,054	9%	23%	943	8%	28%	114	-4%	8%	352	1%	26%	3	12%	6%	2,833	5%	19%
Canada	27	-4%	1%	275	2%	6%	154	-4%	5%	13	-3%	1%	62	-0.2%	5%	0	-	0%	530	-0.3%	4%
United States	342	-7%	9%	779	12%	17%	789	10%	23%	101	-4%	7%	290	1%	21%	3	12%	6%	2,303	6%	16%
Latin America	64	-2%	2%	429	-5%	9%	170	-0.3%	5%	151	2%	11%	91	2%	7%	1	8%	3%	906	-2%	6%
Brazil	2	21%	0.1%	149	7%	3%	22	3%	1%	93	2%	7%	43	2%	3%	1	11%	2%	310	5%	2%
Asia	2,618	2%	66%	351	-1%	8%	392	3%	12%	546	3%	40%	447	13%	33%	39	5%	75%	4,392	3%	30%
China	1,941	4%	49%	195	1%	4%	146	10%	4%	109	-2%	8%	256	13%	19%	37	6%	71%	2,684	4%	18%
India	277	-4%	7%	39	-0.4%	1%	26	-4%	1%	197	3%	14%	37	17%	3%	1	10%	2%	577	0%	4%
Indonesia	310	-1%	8%	40	1%	1%	57	-9%	2%	66	7%	5%	28	9%	2%	0	-	0%	501	-1%	3%
Pacific	300	1%	8%	18	15%	0.4%	133	17%	4%	8	-4%	1%	12	3%	1%	1	0%	1%	471	6%	3%
Australia	298	1%	8%	17	16%	0.4%	119	18%	4%	5	-5%	0.4%	4	9%	0.3%	0	0%	1%	443	6%	3%
CIS	313	0.3%	8%	711	1%	16%	813	3%	24%	16	-0.3%	1%	101	1%	7%	0	-	0%	1,953	2%	13%
Russia	244	1%	6%	563	1%	12%	618	3%	18%	9	-2%	1%	72	3%	5%	0	-	0%	1,506	2%	10%
Middle East	1	-7%	0%	1,407	-6%	31%	570	3%	17%	1	2%	0.1%	6	34%	0.4%	1	0%	1%	1,985	-4%	14%
Qatar	0	-	0%	-	-	-	-	-	-	0	-	0%	0	-	0%	0	-	0%	0	-100%	0%
United Arab Emirates	0	-	0%	186	2%	4%	51	1%	2%	0	-	0%	1	217%	0.1%	0	-	0%	238	2%	2%
Saudi Arabia	0	-	0%	556	-5%	12%	80	1%	2%	0	-	0%	0	305%	0%	0	-	0%	637	-4%	4%
Iran	1	-7%	0%	140	-34%	3%	203	6%	6%	1	2%	0%	4	29%	0.3%	0	-	0%	348	-15%	2%
Africa	165	2%	4%	407	2%	9%	201	1%	6%	369	3%	27%	22	6%	2%	0	0%	0.4%	1,163	2%	8%
Nigeria	0	0%	0%	101	5%	2%	37	1%	1%	126	3%	9%	1	17%	0%	0	-	0%	264	3%	2%
World	**3,966**	**1%**	**100%**	**4,542**	**-1%**	**100%**	**3,410**	**4%**	**100%**	**1,368**	**2%**	**100%**	**1,374**	**5%**	**100%**	**52**	**5%**	**100%**	**14,713**	**1%**	**100%**
OECD	795	-5%	20%	1,332	6%	29%	1,280	6%	38%	325	0%	24%	788	2%	57%	12	6%	23%	4,531	3%	31%
no-OECD	3,172	2%	80%	3,210	-3%	71%	2,131	3%	63%	1,043	2%	76%	587	8%	43%	40	6%	77%	10,182	1%	69%

Source: Enerdata, Global Energy & CO_2 Data (June 2020)

Primary energy consumption

Primary energy consumption in 2019 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world
Europe	238	-15%	6%	592	-0.2%	15%	450	1%	13%	175	3%	13%	347	1%	25%	9	4%	16%	1,810	-2%	13%
European Union	182	-18%	5%	524	0.1%	13%	402	3%	12%	164	2%	12%	298	-1%	22%	5	4%	8%	1,574	-2%	11%
Germany	55	-20%	2%	100	2%	2%	76	3%	2%	31	2%	2%	34	10%	3%	1	-2%	2%	296	-2%	2%
France	7	-20%	0.2%	70	-0.4%	2%	37	2%	1%	18	-0.3%	1%	108	-3%	8%	0.4	8%	1%	241	-2%	2%
North America	290	-13%	8%	907	-1%	22%	846	3%	25%	113	-3%	8%	351	1%	26%	3	11%	5%	2,509	-1%	18%
Canada	278	-12%	7%	808	-1%	20%	733	3%	22%	99	-3%	7%	293	1%	21%	3	12%	5%	2,214	-1%	16%
United States	13	-14%	0.3%	99	-2%	2%	113	2%	3%	13	-3%	1%	58	0%	4%	0	0%	0.1%	296	-1%	2%
Latin America	42	-3%	1%	328	-4%	8%	199	-1%	6%	150	2%	11%	91	2%	7%	2	7%	3%	811	-1%	6%
Brazil	17	-1%	0.4%	103	-1%	3%	31	-0.3%	1%	92	2%	7%	46	2%	3%	1	8%	2%	288	0.4%	2%
Asia	2,805	0.1%	75%	1,492	4%	37%	661	3%	20%	544	2%	40%	447	12%	33%	39	5%	72%	5,988	2%	43%
China	1,987	1%	53%	647	7%	16%	249	9%	7%	109	-2%	8%	254	13%	19%	37	6%	68%	3,284	3%	24%
India	387	-3%	10%	237	3%	6%	55	5%	2%	197	3%	14%	37	18%	3%	1	7%	2%	913	1%	7%
Indonesia	63	9%	2%	76	0.1%	2%	40	-3%	1%	63	5%	5%	28	9%	2%	0	-	0.0%	269	4%	2%
Japan	113	-1%	3%	160	-4%	4%	92	-5%	3%	16	1%	1%	40	18%	3%	0.3	-4%	1%	421	-2%	3%
South Korea	79	-5%	2%	107	-1%	3%	49	-3%	1%	24	5%	2%	40	9%	3%	0.3	10%	1%	298	-1%	2%
Pacific	42	-2%	1%	53	-1%	1%	47	28%	1%	8	-4%	1%	12	3%	1%	1	3%	1%	163	6%	1%
Australia	41	-3%	1%	44	-1%	1%	42	29%	1%	5	-5%	0.4%	4	9%	0.3%	0.4	5%	1%	136	6%	1%
CIS	191	-1%	5%	216	2%	5%	569	3%	17%	16	-0.3%	1%	98	1%	7%	1	7%	1%	1,090	2%	8%
Russia	120	1%	3%	156	1%	4%	423	2%	13%	9	-2%	1%	70	2%	5%	0	-	0%	779	2%	6%
Middle East	8	4%	0.2%	305	-8%	8%	457	3%	14%	1	2%	0.1%	5	28%	0.4%	1	2%	1%	776	-1%	6%
Iran	1	-7%	0%	61	-27%	2%	191	5%	6%	1	2%	0%	4	25%	0.3%	0	-	0%	258	-5%	2%
Saudi Arabia	0	-	0%	127	1%	3%	80	1%	2%	0	0%	0%	0.1	305%	0%	0	-	0%	207	1%	2%
Africa	116	2%	3%	195	0.2%	5%	128	2%	4%	369	3%	27%	22	6%	2%	0.3	5%	1%	829	2%	6%
World	**3,732**	**-2%**	**100%**	**4,086**	**0.3%**	**100%**	**3,356**	**3%**	**100%**	**1,375**	**2%**	**100%**	**1,372**	**5%**	**100%**	**54**	**6%**	**100%**	**13,975**	**1%**	**100%**
OECD	760	-11%	20%	1,891	-1%	46%	1,550	3%	46%	338	1%	25%	787	2%	57%	13	5%	24%	5,338	-1%	38%
no-OECD	2,972	0.3%	80%	2,196	1%	54%	1,806	3%	54%	1,037	2%	75%	585	8%	43%	41	6%	76%	8,636	2%	62%

Source: Enerdata, Global Energy & CO_2 Data (Juin 2020)

Final energy consumption

Final energy consumption in 2019 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world	Volume	Change 2018-19	Share in the world
Europe	70	-0.4%	6%	541	0.4%	15%	275	-2%	18%	105	2%	10%	280	-2%	15%	57	-1%	16%	1,328	-1%	14%
European Union	54	-1%	5%	478	1%	13%	248	-2%	16%	97	2%	9%	237	-2%	12%	50	-2%	14%	1,163	-1%	12%
Germany	13	-1%	1%	92	2%	3%	54	0.1%	3%	16	4%	2%	44	-2%	2%	10	-2%	3%	228	1%	2%
France	5	4%	0.4%	65	-0.4%	2%	29	-3%	2%	13	4%	1%	37	-1%	2%	4	0.4%	1%	153	-1%	2%
North America	24	-0.2%	2%	853	-0.2%	23%	406	1%	26%	91	-2%	9%	364	-2%	19%	10	5%	3%	1,747	-1%	18%
Canada	20	-0.3%	2%	764	-0.2%	21%	355	0.1%	23%	80	-2%	8%	320	-3%	17%	9	5%	3%	1,548	-1%	16%
United States	4	0.3%	0.3%	89	-1%	2%	52	6%	3%	11	-4%	1%	44	0.1%	2%	1	0.2%	0.2%	200	1%	2%
Latin America	19	-4%	2%	291	-2%	8%	72	3%	5%	109	2%	10%	115	1%	6%	1	8%	0.4%	608	-0.1%	6%
Brazil	11	-5%	1%	96	-0.1%	3%	11	-6%	1%	64	2%	6%	44	1%	2%	1	9%	0.3%	228	0.3%	2%
Asia	1,008	-1%	83%	1,341	4%	37%	343	5%	22%	443	2%	42%	899	3%	47%	154	6%	43%	4,187	2%	43%
China	18	-2%	2%	97	1%	3%	23	-4%	2%	20	3%	2%	46	-1%	2%	6	-4%	2%	209	-1%	2%
India	753	-1%	62%	580	6%	16%	171	7%	11%	78	-2%	7%	541	5%	28%	145	6%	41%	2,268	3%	23%
Indonesia	43	1%	4%	144	-2%	4%	28	-2%	2%	7	4%	1%	78	-4%	4%	1	-5%	0.2%	299	-2%	3%
Japan	115	-4%	10%	208	3%	6%	40	8%	3%	164	3%	16%	106	0.3%	6%	1	7%	0.3%	634	2%	7%
South Korea	18	7%	2%	78	7%	2%	17	1%	1%	60	5%	6%	21	5%	1%	0	-	0%	194	6%	2%
Pacific	4	0.4%	0.3%	54	-0.3%	2%	17	9%	1%	7	-2%	1%	23	1%	1%	1	3%	0.2%	105	1%	1%
Australia	3	1%	0.3%	45	-1%	1%	14	8%	1%	4	-2%	0%	19	1%	1%	0.4	5%	0.1%	85	1%	1%
CIS	63	1%	5%	172	2%	5%	196	1%	13%	8	1%	1%	95	1%	5%	132	1%	37%	666	1%	7%
Russia	36	6%	3%	123	1%	3%	148	2%	10%	4	-2%	0.4%	66	1%	3%	109	1%	31%	486	2%	5%
Middle East	4	2%	0.3%	234	-2%	6%	202	6%	13%	1	2%	0.1%	83	1%	4%	1	2%	0.2%	524	2%	5%
Iran	1	1%	0.1%	63	-8%	2%	121	8%	8%	1	2%	0%	22	0.2%	1%	0	-	0%	209	2%	2%
Saudi Arabia	0	-	0%	89	1%	2%	23	1%	2%	0	0%	0%	24	-1%	1%	0	-	0%	136	1%	1%
Africa	24	4%	2%	164	-2%	5%	42	2%	3%	295	3%	28%	58	-0.3%	3%	0.2	5%	0.1%	583	1%	6%
World	**1,216**	**-1%**	**100%**	**3,649**	**1%**	**100%**	**1,553**	**2%**	**100%**	**1,058**	**2%**	**100%**	**1,916**	**1%**	**100%**	**355**	**3%**	**100%**	**9,746**	**1%**	**100%**
OECD	159	-0.2%	13%	1,753	-0.4%	48%	753	-0.3%	49%	227	1%	22%	812	-2%	42%	69	-1%	20%	3,774	-1%	39%
no-OECD	1,057	-1%	87%	1,895	2%	52%	800	4%	52%	831	2%	79%	1,104	3%	58%	285	4%	80%	5,972	2%	61%

Source: Enerdata, Global Energy & CO_2 Data (June 2020)

Investments in the energy sector

Green investments should be spared by the very sharp decline of investments in the energy sector expected in 2020

Investments in the energy sector have suffered heavily from the consequences of the Covid-19 crisis, notably the oil sector. The IEA forecasts a -20% contraction in 2020 down to $1,520bn, against $1,891bn in 2019.

The impact of the crisis on investments stems from both reduced spending due to lower revenues, and operational constraints, such as people an goods limited circulation.

IEA projections presented here have been produced in April and May. They are based on investments data for the first months of 2020, 2019 trend and the analysis of the Covid-19 crisis impact on the energy sector presented in the IEA report Global Energy Review 2020. Underlying hypothesis are that of a -6% world economic recession in 2020, with continued mobility restrictions and social and economic activity reductions.

All sectors are impacted, but oil and gas are the most severely hit. The impact of both lockdown and economic crisis on oil demand (estimated at -9mbbl/d on average over 2020), thus on oil prices too, has affected producers and the whole supply chain. According to the IEA, investments in the oil and gas sector in 2020 (E&P and transport) shall recede -32% (-$244bn down to $511bn). Investments in the coal sector plunged too (-24%, IEA forecast), but retained some resilience in China, which represents two thirds of world investments.

Investments in non carbon technologies (CCUS, batteries, nuclear, renewables) and in energy efficiency shall hold up much better. The IEA forecasts a near -6.5% decline down to $580bn in 2020, against $620bn in 2019, a level close enough to previous years' (c. $600bn on average since 2015).

The power sector shall be relatively spared, with a decline expected at -7% (down $79bn to $678bn), although performances shall be contrasted amongst energy sources.

Investments in electricity RES shall shrink approximately -10% in 2020. The impact shall be much worse on solar at -21% than on wind power at -2%, while hydro shall gain +3.8%. Regarding thermal projects, natural gas is set to suffer more (-24%) – especially in the weakened Middle East and North African producing countries – than coal (-12%), which retains China's support.

All in all, the share of RES in power generation investments will continue to grow in 2020 (from 34% in 2019 to 37.5% in 2020), as well as net electricity RES capacity (+7.5%).

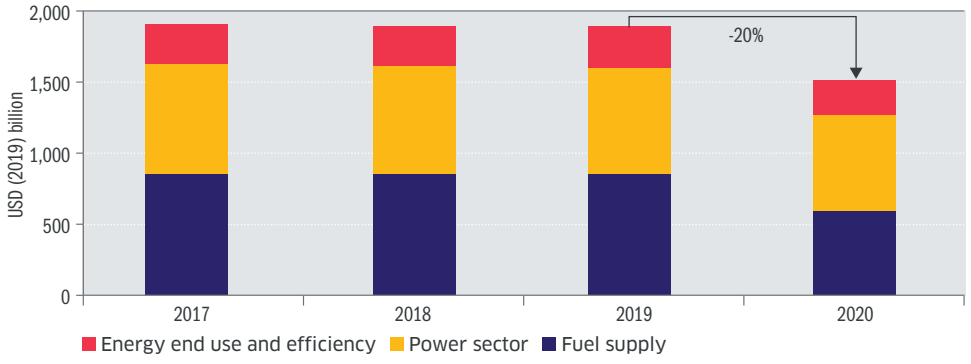
Nonetheless, at $281bn in 2020, investments in renewable power are well below what is required for a 2°C objective ($576bn per year from 2020 to 2025, according to the IEA's SDS scenario).

Investments in 2020 remain subject to how the situation develops in China and in the USA. In China, leading investor in energy, the -12% contraction forecast by the IEA will depend above all on the recovery in industrial activity. In the USA, the -25% shortfall projection stems from the predominance of the oil and gas sectors in the country's energy investments (one half). In Europe, the fall is expected at -17%, but some sectors will be spared, such as investments in electricity networks, energy efficiency and wind power.

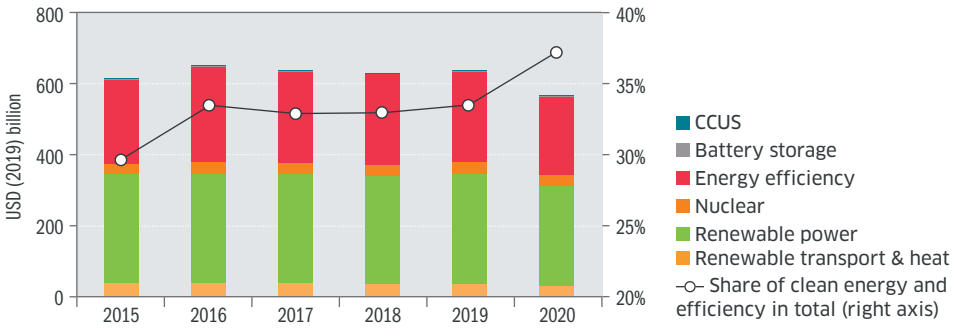
Although in favour of green technologies, these estimates are insufficient to make of 2020 the tipping point of energy transition. RES still do not offer all the guaranties that investors are looking for in terms of market capitalisation, dividends or liquidity. Low-cost financing opportunities by institutional investors remain centered on Europe and North America. In addition, although coal investments decrease in many regions, the number of new plants approvals granted in the first quarter, notably in China, has doubled compared to 2019.

Investments in the energy sector

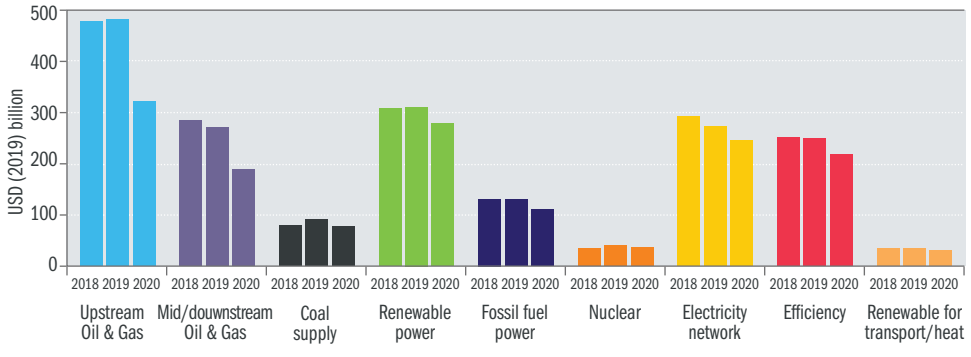
TOTAL INVESTMENTS IN THE ENERGY SECTOR
WORLD – 2017 TO 2020



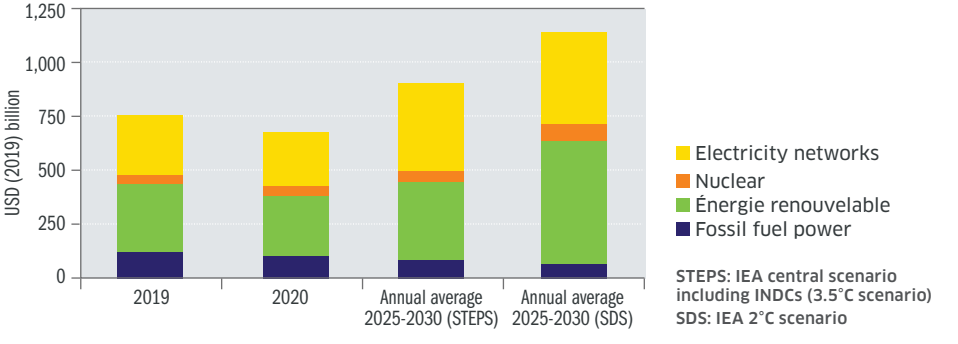
INVESTMENTS IN "CLEAN" TECHNOLOGIES COMPARED TO TOTAL INVESTMENTS
WORLD – 2015 TO 2020



INVESTMENTS IN VARIOUS ENERGY SECTORS
WORLD – 2018 TO 2020



2019 AND 2020 WORLDWIDE INVESTMENTS IN POWER GENERATION COMPARED TO IEA'S STEPS AND SDS SCENARIOS OVER THE 2025-2030 PERIOD



Source: IEA World Energy Investment 2020, May 2020

Investments in the energy sector

The Covid-19 crisis reveals a persisting weakness in energy investments

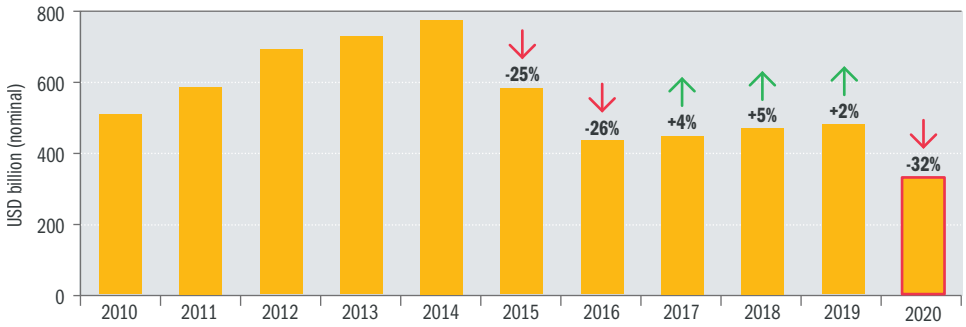
In 2019, investments in the energy sector grew 0.7% at $1,904bn against $1,891bn in 2018, in line with several years of stabilisation, if not contraction, since their share in world GDP dropped below 2%, from 3% in 2014.
This situation reflects the end of a vigorous expansion period in the oil and gas industry at the beginning of the decade, without the necessary investments in clean technologies really taking over, or not to the extent required by global warming to say the least.

Investment is weak in almost all energy sectors. Spending in oil and gas exploration has been steadily declining over the last years, to the exception of a small +2% rise in 2019. This fall results partly from abundant unconventional resources, which do not require exploration as such, and partly from low oil prices, which deepens uncertainties over the long term profitability of oil investments. At the same time, petrochemicals and LNG, despite their positive medium term perspectives, faced overcapacity, eroding margins and leading to the postponement of many projects.

Conversely, the coal industry stands in an bullish cycle after some restructurings in China in 2016-2017. In 2019, as new mines developed in China, world coal investments jumped +15% (+$90bn), in spite of public pressure.

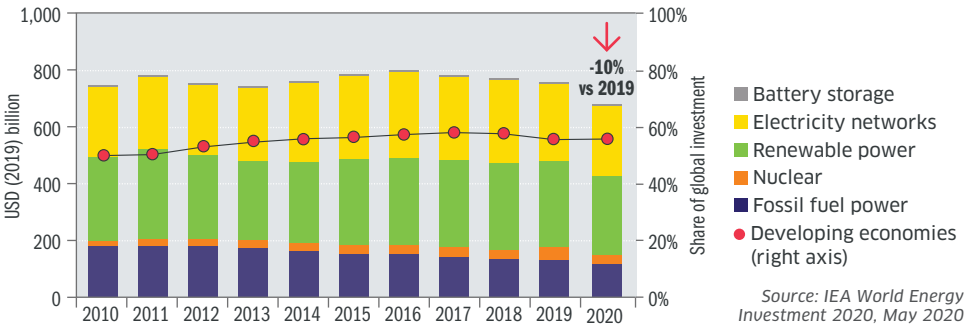
In the power sector, investments dipped -2% in 2019 at $760bn, mainly due the +7% decline in electricity network investments, driven mostly by China for regulatory reasons. This sharp fall offset the 18% gain in nuclear power linked to Japanese plants' reopening and Chinese projects, as well as the more modest surge of electricity RES (+1% at $310bn), reflecting major wind power projects in the USA and in India, but hiding lower investments in solar power. Investments in natural gas and batteries' new capacity remained stable, while that of coal receded -6%. This shortfall, attributable to China, did not prevent an increase in net capacity though.

TOTAL INVESTMENTS IN THE OIL & GAS SECTOR
WORLD – 2017 TO 2020



Sources: IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020

INVESTMENTS IN VARIOUS ELECTRICITY SECTORS
WORLD – 2010 TO 2020



Source: IEA World Energy Investment 2020, May 2020

Green recovery plans

Opportunities for a green recovery

Green recovery offers better potential than traditional recoveries. Green recovery measures rest on economic growth potential of green investments facilitated by near zero interest rates, job creation short term, resilient systems development and a lower cost than inaction.

More precisely, investments in energy efficiency, such as thermal renovation, RES or transport infrastructure, all have in common, besides saving energy, an easy implementation and a strong potential to revive the economy, innovate and create jobs.

These arguments are supported by many research institutes, think tanks, NGOs, institutions, and known politicians prompting public authorities to spend recovery funds on resilient investments, for they are readily available and offer a stronger knock-on effect than traditional investments.

These benefits have been attested in a study published 4th May by Oxford University, edited by Nicholas Stern and Joseph Stiglitz, Nobel prize in economic science. With the participation of a vast number of experts worldwide and the analysis of 700 stimulus policies, the authors measured the economic and climate impact of green recovery packages. Compared to traditional fiscal stimulus, green projects create more jobs, offer better return short term for every dollar spent and on the longer term allow savings.

The rightfulness of green recovery packages lies also on society expectations, which the crisis heightened, as shown by opinion polls and citizens initiatives.
The issue of supporting fossil fuels is also raised, on the ground that state aid should not target sectors where long term prospects are nihil. Lastly, brought to light by the crisis is the fact that economic dependence concerns RES technologies too and some relocations need to be further examined.

Far heavier than the cost of energy transition, recovery packages could be a historical opportunity to switch towards a low-carbon world. The European Central Bank committed to inject €1,000bn in the European financial system as early as March 2020. In April, the European Union decided on emergency measures mounting to €540bn. And in May, the European Commission suggested to the Parliament a €750bn community loan, in line with the French-German proposal made May 18th. Off this sum, €500bn in the form of subsidies will be transferred to member states that are the most affected by Covid-19, under the condition that they present reforms and investments that are compatible with EU priorities, in other words the Green deal, energy transition and Europe's greater sovereignty.

Since the cost of reducing CO_2 emissions in the EU has been valued by the Commission at €260bn per year until 2030, recovery plans appear to be meeting the double objective of rescuing the European economy and the climate.

Another interesting comparison is the level of support packages announced by the G20 member states at $7,300bn, and that of EIA's 2°C scenario cost, estimated at $2,000bn per year until 2040.

Public authority will play a decisive role. Energy policy represent, directly or indirectly, 70% of energy investments. Therefore, through recovery packages of unprecedented size, it would be possible to implement economic planning that would structurally reduce emissions.

That is the IEA's message to governments. *"By their size, recovery plans only happen once a century. This will structure the economy and shape our world for many years to come",* said Fatih Birol IEA's executive director. Similarly, BNEF recommends to take advantage of public authority to launch expensive projects, such as the transformation of electricity networks and storage infrastructures, in a coordinated action between public procurement and private sector.

Green recovery plans

Recovery plans' guidelines

Many governments have taken measures towards energy to exit the crisis, yet relatively few chose the way of sustainable solutions.

The above-mentioned study* by Nicholas Stern and Joseph Stiglitz also examines the impact that the major fiscal rescue measures launched during the 2nd quarter of 2020 by G20 member countries will have on climate. These emergency measures aim at protecting balance sheets, reducing bankruptcies and answering immediate concerns regarding care during lockdown. In April 2020, all G20 members (including most EU members) had enacted such fiscal measures for a total spending of over $7,300bn.

By distinguishing rescue from recovery measures, the authors observe that a large majority of these policies are of rescue type, such as vast compensation schemes for employees and companies livelihood.

The subjective assessment is that 4% of these policies are "green", with potential to reduce long-run GHG emissions, 4% are "brown" likely to increase net GHG emissions beyond the base case, and 92% are "colorless", meaning that they maintain the status quo.

While current observations lead to a certain pessimism, the international debate in favour of green recovery is very intense and should prompt some positive reactions, as shown by the recent EU decisions.

The EU stood by its ambitions to implement decarbonization. Even if some deadlines have been extended, the Commission has delivered unambiguous messages; the Biodiversity Strategy was passed in May and subsidies from the €750bn recovery plan will be submitted to meeting EU priorities: Green Deal, energy transition and sovereignty (more details in the chapter CO_2 and Climate – Climate policies).

*Référence: University of Oxford – SSEE " Will Covid-19 fiscal recovery packages accelerate or retard progress on climate change?" – Cameron Hepburn, Brian O'Callaghan, Nicholas Stern, Joseph Stiglitz, Dimitri Zenghelis, 4th May.

ENERGY COMPONENT OF NATIONAL RECOVERY PLANS

CONTINUATION

EU: Green Deal objective maintained; numerous calls for a green recovery plan. Strengthening opposition may weaken ambitions and rapid action however.

France: RES development continues during the sanitary crisis: new offshore wind projects of worth 8,7GW announced end of April.
Senate calls government to keep energy transition on track and places the carbon neutrality objective as major recovery plan incentive. During audition, senators ask Minister of Ecological Transition E. Borne's to enhance support measures towards companies and households for energy transition to be pursued. Minister of Economy B. Le Maire (7th May) expresses ambition to make France the first low-carbon economy in Europe: "Distinguish economic from environmental issues would make no sense. The current crisis does not question the necessity of the energy transition. To the contrary, it boosts it."

United Kingdom: support to green recovery. Offshore wind projects' biddings maintained. The budget passed in March 2020 includes strong support measures to energy transition (Low carbon heat support scheme aimed at CCS, biomethane, heat pumps, biomass). However, risk of insufficient financing and of taking advantage of low gas prices.

South Korea: Green deal to be passed (carbon neutrality by 2050)

New York state: announcement of a recovery plan supporting low carbon strategies, as well as measures attracting private investment towards RES projects. Other states maintain their commitments too.

STATUS-QUO

Germany: A. Merkel confirmed her commitment to the Paris Agreement during the Petersberg Dialogue on Climate (28th April). 68 major companies (Bayer, Puma, Allianz, etc.) ask for state aid to be conditioned on action over climate. The automotive sector calls for further incentives to scrap combustion engines. Conversely, coal exit could be delayed, and Environment Minister took a stand on rescuing airlines.

Canada: announcement of a $750m federal budget to reduce carbon leakage. Government in favour of a green recovery. Federal funding of a program to clean up abandoned oil wells.

India: coal's share remain significant, solar projects continue (3.6 GW announced in April). India prepares to compete with China as a manufacturing centre for solar and wind installations.

BACKWARD STEP

China: more new coal-fired power plants permitted. No mention of climate in the first recovery measures. Subsidies to EV extended another 2 years.

USA: systematic unravelling of environmental policies by the Trump administration (again in March 2020, with the reversal of automotive standards). The $2,2trn recovery plan includes no support to sustainable activities, no environmental conditionality to aids and sets priority on saving coal and oil industries.

Japan: return to coal with new plants. Weaker climate change objectives with NDCs unchanged since 2015. A policy that could cause Olympic Games boycotts. Strong hydrogen strategy however.

Indonesia: no green stimulus to maintain the economy.

South Africa: carbon tax postponed.

Mexico: all current green projects stopped.

Brazil: J. Bolsonaro announces a return to fossil fuels (oil and gas).

Netherlands: new measures to reduce CO_2 emissions cancelled

CO_2 & Climate

CO_2 EMISSIONS

CO_2 emissions dropped sharply in 2020 because of the health crisis, but could rebound swiftly unless recovery plans favour green investment

CO_2 emissions

The coronavirus-related reduction in CO_2 emissions in 2020 should only be temporary

CO_2 emissions declined during the pandemic lockdown. The subsequent economic recession will extend the impact over the rest of 2020.
The lockdown's direct impact on CO_2 emissions was around 20%, in line with that on economic activity, and reflects reduced road traffic (40%), industrial activity (30%) and coal-fired power generation (20%).

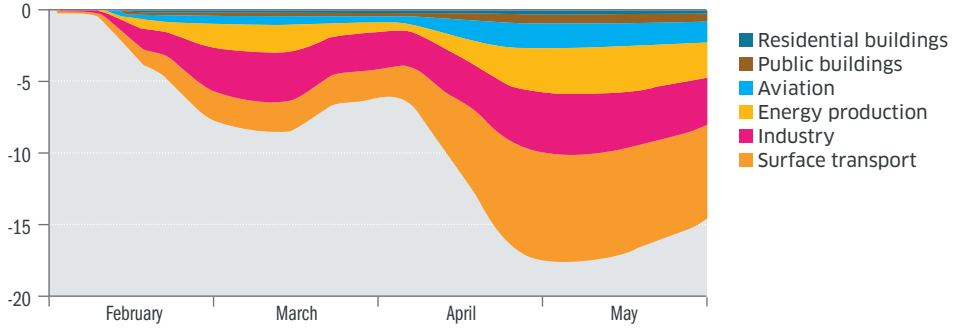
Other air pollutants such as nitrogen dioxide (NO_2) and fine particles, which are responsible for about 9 million premature deaths worldwide every year (WHO), have also been declining. NO_2 concentrations fell by 40% in Europe in April, saving 11,000 lives (CREA). Fine particles reduced only 10%, mainly because of their association with agriculture.

An historic contraction in CO_2 emissions is expected in 2020, worth around 8%, or 2.6 Gt. That would take their level back to that of 2010, or 30 Gt, against 33 Gt in 2019.
The drop is twice as great as total of all reductions since WW2 and six times as great as the dip caused by the 2007-2008 financial crisis (-0.3 Gt).
Of the 2.6 Gt decline, 1.1 Gt will come from reduced coal consumption, 1 Gt from reduced oil use and 0.4 Gt from lower natural gas consumption. Nearly a quarter (600 Mt) will stem from lower emissions in the USA, reflecting reduced road and air traffic and a slowdown in coal-fired power production.
This IEA projection is based on GDP and energy demand both declining 6% worldwide in 2020. We recall that the 1.5°C climate change objective requires an annual 6% reduction in CO_2 emissions until 2030 (IPCC estimates in its special report "Global Warming 1.5°C")*.

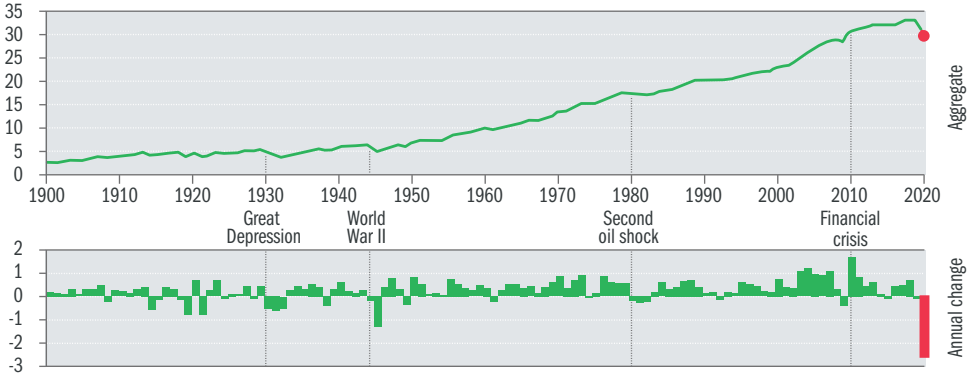
CO_2 emissions will increase as a result of massive recovery plans, unless investments are redirected towards clean energies and resilient infrastructures. Our economies are still largely based on fossil energy (nearly 80%).

*The 1.5°C target recommended by the IPCC is much more demanding than the 2°C target and requires almost double the effort: halving emissions by 2030 to reach zero emissions in 2050 and then going into negative emissions after 2050.

REDUCTION OF CO_2 EMISSIONS WORLDWIDE, JAN-MAY 2020 (%)



CO_2 EMISSIONS (GT), 1990-2020



Sources: Nature Climate Change, 19 May 2020; IEA Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020; Enerdata Bilan énergétique mondial – 2020 edition, May 2020

CO_2 emissions

The exceptional situation in 2020 should not obscure the weakness of decarbonization progress

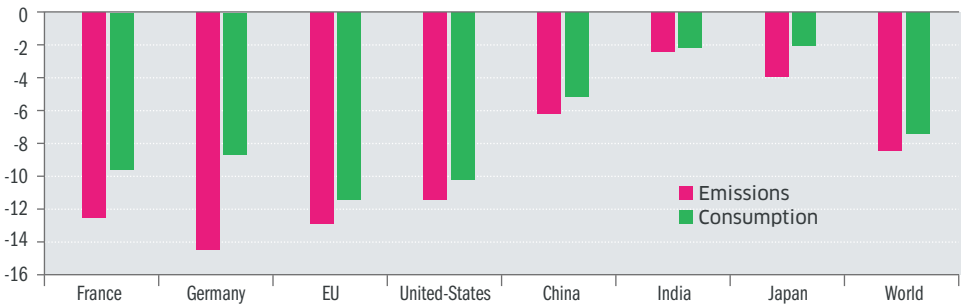
The reduction in emissions in 2020 stems from a slowdown in the transport sector and a less carbon-intensive electricity mix.

Reduced road and air traffic has had a major impact on 2020 CO_2 emissions. It is estimated to account for 42% of the CO_2 emission reduction in the EU, 30% in France, 27% in the USA and 36% in China.

The other significant impact on emissions in 2020 is the higher share of carbon-free energy in electricity production. Lower power consumption initially affects modular power production and coal-fired power, while RES and nuclear power are hardly impacted at all. According to Enerdata, for example, the share of low-carbon sources in power generation will reach 98% in France, 60% in Germany, 69% in the EU, 40% in the USA and 35% in China this year.

On a regional scale, 2020 CO_2 emissions are set to diminish by 12% in France, 13% in the EU-28, 11% in the USA, 2% in India and 5% in China (Enerdata).

ENERGY-RELATED CO_2 EMISSIONS AND ENERGY CONSUMPTION CHANGE 2020-2019 FORECASTS (%)



Source: Enerdata estimates, May 2020

2019 saw only very modest decarbonization: emissions declined 0.4% as world coal consumption plunged.

After a 2% rise in 2018, carbon emissions declined in 2019 for the first time since 2009. They dropped 2.8% in OECD countries (after a 0.8% rise in 2018) and slowed in the rest of the world (up 1.3%, after a 3% increase in 2018).

The decline was particularly noticeable in the EU (-4%), Japan (-3.5%), the USA (-2.5%), where coal retreated despite Trump's policy, and in India (-1%, against +4% in 2018), where coal demand eased in a depressed economic context.

There was no change in China, where emissions rose 3%. In contrast with other countries, this stemmed more from the industrial sector and booming steel and cement sectors than from power generation.

In France, CO_2 emissions decreased 1% in 2019, confirming a downtrend initiated in 2017. They still remain 4.5% above the national low-carbon economy (SNBC) objective, however.

Limited decarbonization also showed in a carbon factor improvement in 2019 (CO_2 emissions/Energy consumption). The carbon factor declined 1%, which was the first time since the 2000s.

This progress is extremely slow. There is no hope of reaching environmental objectives in the short run (the IEA's SDS scenario requires a 3.3% annual decline to 2040). Time will tell whether the 2020 crisis will trigger the necessary structural changes under the impetus of green recovery plans and act as a wake-up call on climate challenges, as the acceleration of the energy transition is more urgent than ever.

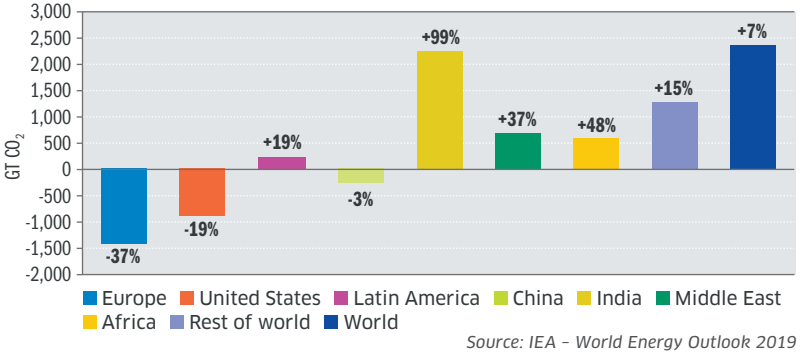
CO_2 emissions

CO_2 emissions (Mt)	1990	2000	2010	2015	2018	2019	Change 1990-2019	AAGR 1990-2019	Change 2018-2019	Share in world 2019
Europe	4,401	4,246	4,176	3,824	3,824	3,673	-17%	-1%	-4%	11%
European Union	4,098	3,892	3,727	3,331	3,267	3,136	-24%	-1%	-4%	10%
Germany	953	830	781	755	720	673	-29%	-1%	-7%	2%
France	365	386	357	317	309	301	-17%	-1%	-2%	1%
North America	5,296	6,347	5,994	5,625	5,614	5,490	4%	0%	-2%	17%
Canada	4,866	5,817	5,446	5,047	5,042	4,920	1%	0%	-2%	15%
United States	430	530	548	578	572	569	33%	1%	-1%	2%
Latin America	859	1,206	1,552	1,683	1,573	1,536	79%	2%	-2%	5%
Mexico	264	364	445	445	438	433	64%	2%	-1%	1%
Asia	4,789	6,818	12,745	14,837	15,700	15,879	232%	4%	1%	49%
China	2,257	3,145	7,799	9,083	9,463	9,729	331%	5%	3%	30%
India	523	910	1,583	2,026	2,248	2,222	325%	5%	-1%	7%
Korea	244	447	594	638	675	650	167%	3%	-4%	2%
Japan	1,040	1,123	1,104	1,135	1,082	1,045	1%	0%	-3%	3%
Indonesia	148	273	377	470	547	581	293%	5%	6%	2%
Pacific	286	371	431	421	434	440	54%	2%	2%	1%
CIS	3,553	2,208	2,373	2,316	2,464	2,488	-30%	-1%	1%	8%
Russia	2,189	1,522	1,610	1,592	1,725	1,755	-20%	-1%	2%	5%
Middle East	590	961	1,608	1,875	1,947	1,980	236%	4%	2%	6%
Saudi Arabia	156	244	435	551	530	534	243%	4%	1%	2%
Iran	181	320	515	579	626	638	252%	4%	2%	2%
Africa	538	680	1,040	1,179	1,250	1,257	134%	3%	1%	4%
South Africa	252	296	429	427	442	447	77%	2%	1%	1%
World	20,311	22,836	29,918	31,759	32,805	32,741	61%	2%	0%	100%
OECD	11,179	12,753	12,616	11,984	11,961	11,634	4%	0%	-3%	36%
no-OECD	9,132	10,084	17,302	19,775	20,844	21,108	131%	3%	1%	65%
BRICS	5,414	6,172	11,798	13,591	14,292	14,562	169%	4%	2%	45%

Source: Enerdata Global Energy & CO2 Data (2020)

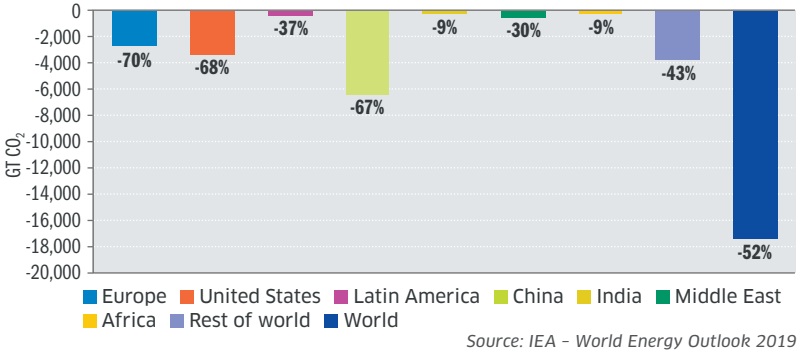
NB: The CO_2 emissions reported here are those related to the combustion of energy, i.e. 90% of CO_2 emissions (see following pages "GHG distribution").

EVOLUTION OF CO_2 EMISSIONS BETWEEN 2018 AND 2040 IN THE STATED POLICIES SCENARIO (IEA)



Source: IEA – World Energy Outlook 2019

EVOLUTION OF CO_2 EMISSIONS BETWEEN 2018 AND 2040 IN THE SUSTAINABLE DEVELOPMENT SCENARIO (IEA)



Source: IEA – World Energy Outlook 2019

CO_2 emissions by sector

CO_2 emissions by sector (Mt)	Energy sector				Residential, Services & Agriculture				Industry				Transport				Total			
	1990	2019	TC 1990-2019	TC 2018-2019	1990	2019	TC 1990-2019	TC 2018-2019	1990	2019	TC 1990-2019	TC 2018-2019	1990	2019	TC 1990-2019	TC 2018-2019	1990	2019	TC 1990-2019	TC 2018-2019
Europe	1,669	1,211	-28%	-10,5%	870	662	-24%	-1%	1,039	733	-30%	-1%	821	1,068	30%	0%	4,401	3,673	-17%	-4%
European Union	1,567	993	-37%	-11,5%	805	587	-27%	-1%	966	617	-36%	0%	760	939	24%	0%	4,098	3,136	-24%	-4%
Germany	349	231	-34%	-17,4%	213	127	-40%	1%	232	150	-35%	-1%	159	166	4%	1%	953	673	-29%	-7%
France	60	39	-36%	-13,4%	97	74	-23%	-2%	95	65	-31%	2%	114	124	9%	-1%	365	302	-17%	-2%
North America	2,300	2,212	-4%	-5,3%	664	692	4%	1%	807	708	-12%	0%	1,525	1,878	23%	0%	5,296	5,490	4%	-2%
United States	2,154	2,013	-7%	-5,4%	584	589	1%	0%	721	611	-15%	0%	1,407	1,707	21%	0%	4,866	4,920	1%	-2%
Canada	145	199	37%	-4,4%	81	103	27%	7%	86	96	12%	1%	118	172	45%	-1%	430	569	33%	-1%
Latin America	240	427	78%	-4,9%	105	150	42%	-2%	224	365	63%	-2%	290	594	105%	-1%	859	1,536	79%	-2%
Mexico	96	158	65%	-0,5%	26	30	16%	-5%	59	93	58%	2%	84	153	83%	-3%	264	433	64%	-1%
Asia	1,627	7,997	392%	0,8%	902	1,284	42%	2%	1,703	4,436	161%	0%	557	2,162	288%	4%	4,789	15,879	232%	1%
China	725	5,287	629%	2,3%	524	767	46%	2%	912	2,678	194%	3%	95	997	946%	6%	2,257	9,729	331%	3%
India	207	1,025	395%	-3,0%	85	188	121%	3%	167	694	316%	-1%	64	316	391%	4%	523	2,222	325%	-1%
Korea	50	317	536%	-6,2%	73	56	-23%	-4%	77	171	123%	-2%	44	106	142%	1%	244	650	167%	-4%
Japan	386	469	22%	-5,8%	136	123	-10%	-2%	316	252	-20%	-1%	203	202	-1%	-1%	1,040	1,045	1%	-3%
Indonesia	48	175	267%	4,9%	23	32	39%	2%	45	216	385%	7%	32	158	390%	8%	148	581	293%	6%
Pacific	144	221	53%	1,2%	15	26	73%	2%	55	75	38%	6%	72	117	62%	-1%	286	440	54%	2%
CIS	1,986	1,340	-33%	0,5%	623	340	-46%	2%	600	540	-10%	0%	344	268	-22%	4%	3,553	2,488	-30%	1%
Russia	1,276	955	-25%	1,1%	382	208	-45%	3%	310	409	32%	1%	221	182	-18%	4%	2,189	1,755	-20%	2%
Middle East	193	792	310%	0,6%	77	198	159%	6%	167	594	255%	3%	152	395	160%	1%	590	1,980	236%	2%
Saudi Arabia	53	185	248%	0,4%	3	5	83%	1%	51	243	382%	2%	49	101	105%	-1%	156	534	243%	1%
Iran	40	192	384%	-2,8%	53	157	197%	6%	49	151	209%	3%	40	138	247%	2%	181	638	252%	2%
Africa	242	579	139%	2,5%	50	133	164%	0%	133	187	41%	-4%	113	358	216%	0%	538	1,257	134%	1%
South Africa	143	285	99%	1,1%	14	45	214%	3%	65	62	-4%	0,6%	30	54	84%	0%	252	447	77%	1%
World	8,401	14,780	76%	-1,3%	3,307	3,484	5%	1%	4,728	7,639	62%	0,0%	3,876	6,840	77%	2%	20,311	32,741	61%	0%
OECD	4,463	4,546	2%	-6,3%	1,736	1,575	-9%	-1%	2,256	2,009	-11%	-0,2%	2,724	3,503	29%	0%	11,179	11,634	4%	-3%
no-OECD	3,938	10,234	160%	1,1%	1,571	1,908	22%	2%	2,472	5,630	128%	0,1%	1,152	3,336	190%	3%	9,132	21,108	131%	1%
BRICS	2,381	7,626	220%	1,4%	1,033	1,240	20%	2%	1,508	3,954	162%	1,6%	493	1,743	254%	5%	5,414	14,562	169%	100%

NB: The CO_2 emissions reported here are those related to the combustion of energy, i.e. 90% of CO_2 emissions (see following pages "GHG distribution").

Source: Enerdata Global Energy & CO_2 Data (June 2020)

CO_2 & climate: GHG breakdown

The Kyoto protocol identifies 6 major green house gases:

CO_2 (carbon dioxide) mostly comes from the combustion of fossil fuels. It represents 83% of GHG emissions. As a reference gas, its global warming potential, or GWP, is set to 1. CO_2's estimated lifespan nears 100 years.

CH_4 (methane), is mainly associated with agriculture, but it is also found in fugitive and landfill emissions. It accounts for 10% of GHG emissions, but for 20% to 30% of the increase in temperatures, due to a GWP 28 times that of CO_2.

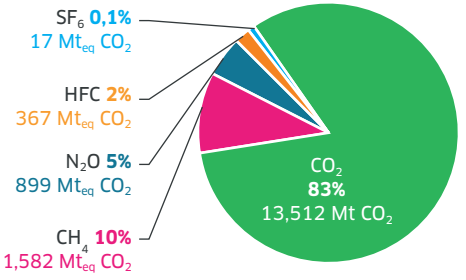
N_2O (nitrous oxide) ranks third in GHG emissions. It comes from the decay of nitrogen compounds, such as fertilizers, as well as the combustion of aviation fuels and savannah fires, amongst others. With a GWP of 265 and a lifespan of 120 years, nitrous oxide is a particularly harmful to the ozone layer.

HFC (hydrofluorocarbons) have a GWP 13,000 times that of CO_2. Made of carbon, fluor and hydrogen, there are mainly used in air-conditioners and refrigerators. An amendment to the Montreal protocol signed in 2016 in Kigali, provides for their gradual phase-out, yet millions of tonnes are still illegally placed on the market every year.

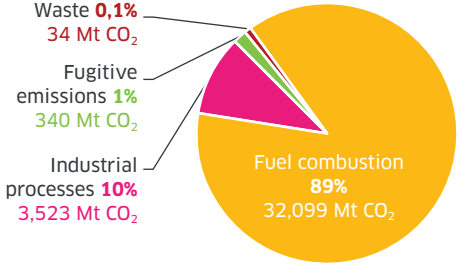
PFC (perfluorocarbons) are present in some cookware such as non stick pans. Their GWP is 7,600 times is that of CO_2. Being very volatile, they contaminate removed natural areas such as the North pole or some Himalayan lakes. Within the human body, they are powerful endocrine disrupters, affecting fertility in particular. They cause neurological adverse effects too, such as attention deficit and hyperactivity.

SF_6 (sulphur hexafluoride) represents a mere 0.1% of CO_2 equivalent GHG emissions, but remain 3,200 years in the atmosphere. Used in medium and high voltage electric equipment for stability and resistance reasons, this artificial gas has a "greenhouse" potential 22,800 times that of CO_2.

GHG EMISSIONS OF ANNEX I* COUNTRIES (EXCLUDING LULUCF) TOTAL: 16,359 MTEQ CO_2 IN 2017



GLOBAL CO_2 EMISSIONS (EXCLUDING LULUCF) TOTAL: 35,997 MT CO_2 IN 2017



*Annex I: see Glossary.

Source: Enerdata Global Energy & CO_2 Data (2020), UNFCCC Greenhouse Gas Inventory Data – 2017 figures are the latest available

Sources of CO_2 emissions:

Fossil fuel combustion represents 89% of world CO_2 emissions.

Industrial processes, including among others chemicals, steel and cement, account for 10% of CO_2 emissions. In countries where heavy industry is developing, this source of emissions is growing rapidly. This is the case in India, with a 45% rise since 2010.

Fugitive emissions or gas flaring remain very important in oil and gas producing countries. They represent just 1% of CO_2 emissions worldwide, but reach 20% of Russia's CO_2 balance. Russia, together with Iran and Iraq make up 40% of this source of emissions.

Waste treatment weighs relatively little in CO_2 emissions (even though in France waste incineration is the CO_2 equivalent to 2.3 million cars). Conversely, they weigh heavily on methane emissions (organic waste decomposition represents 16% of methane emissions every year in France). Waste recycling or recovery are among these practices that offer a major lever to emission reduction and even energy saving.

CO_2 & climate: emission factors

FUEL EMISSION FACTORS (KG CO_2 / TEP)

Fuel	Direct emissions	LCA emissions
Coal	345	377
Heavy fuel oil	283	324
Domestic heating oil	272	324
Diesel	256	323
Unleaded gasoline	253	314
LPG	233	260
Natural gas	204	243
Fuelwood	18.8	29.5

Source: ADEME's Carbon Base (Jan. 2015)

CO_2 EMISSIONS FROM POWER GENERATION (IN GRAMS OF CO_2 EQUIVALENT PER KWH OF ELECTRICITY PRODUCED)

Values for France	Coal-fired	Oil-fired steam	Gas-fired*	Nuclear	Gas cogeneration	HWIP**	Onshore wind	Offshore wind	Solar PV	Hydro with reservoir	Hydro run-of-the-river
Excluding life cycle analysis	915	676	404		230 to 380	860 to 1,548	0	0	0	0	0
Including lifecycle analysis	1,058	730	418	6	_	_	14	16	55	10	13

*Combustion turbine (50% efficiency) – ** HWIP: Household Waste Incineration Plant.
Values excluding LCA were established by ADEME in 2015; values including LCA were established by ADEME in 2017.

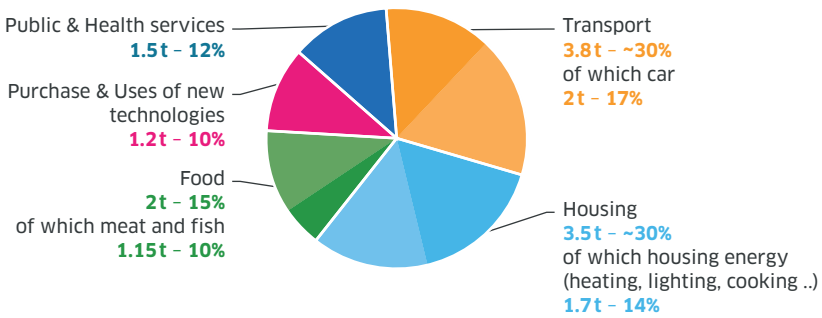
Source: ADEME's Carbon Base (latest available figures)

CO_2 emissions are evaluated according to two conventions:

- Direct emissions: only emissions resulting from the use of energy by the consumer are considered.
- Life Cycle Assessment (LCA): take into account all emissions from extraction to end use (extraction, production, transport, distribution, use, even waste management).

GHG reporting answers the GHG Protocol, an international initiative, bringing together businesses, NGO, governments and universities. It is carried out by the World Resources Institute (WRI). Launched in 1998, its mission is to provide standards, as well as GHG accounting and reporting tools that are accepted worldwide. Adopting these standards is a key element in promoting a world low-carbon economy.
The standards developed within the GHG Protocol are the most widely used accounting tools for measuring, managing and reporting GHG emissions.
The IPCC also designed a methodology aimed at measuring GHG emissions by sector.
Emission factors produced by these two institutions are considered as reference worldwide and ENGIE adopted them for its regulatory environmental reporting.

CARBON FOOTPRINT* OF A FRENCH RESIDENT: 11.2 TCO_2E PER YEAR, OF WHICH 8 T OF CO_2 (TCO_2E)



* Carbon footprint: direct and indirect GHG emissions

Source: ADEME, French Ministry of Ecological Transition

CO_2 & climate: climate change

More and more signs of climate change in the atmosphere, on land and at sea

Temperatures are the prime indicator of ongoing climate change and keep rising. 2019 was the planet's second warmest recorded year, after 2016.

Records for high temperatures are concentrated in the past few years: 2015-19 include the five warmest years ever reported, 2010-19 was the warmest decade and since 1980 each decade has been 0.3°C warmer than the previous one. Since pre-industrial times (1850-1900), average temperature on the surface of the globe has increased 1.1°C.

In France, 2019 was the third warmest year since records started in 1900, after 2018 and 2014. At 13.7°C, the average temperature for 2019 was 1.2°C higher than the 1981-2010 reference average.

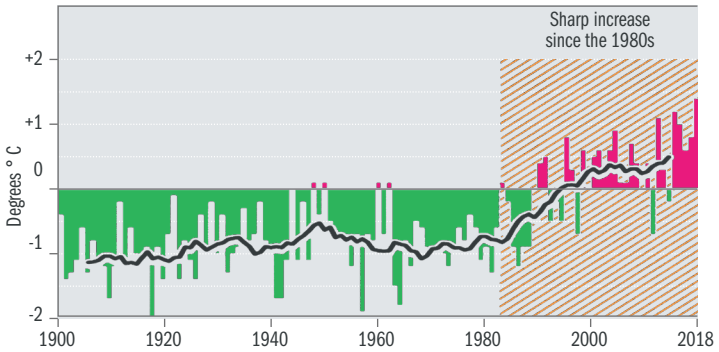
Heatwaves were also hotter in 2019. France reported a new peak at 46°C.

January 2020 also saw new highs for the month, and in June the temperature reached an unprecedented 38°C in Verkhoyansk in Eastern Siberia. This weather station is notorious for being the coldest in the Northern Hemisphere. This new record only confirmed alarming reports on accelerating climate change in the Arctic.

Were these trends to continue, global temperatures will rise by 6-7°C by 2100 (IPCC estimates).

Another feature of 2019 was a series of uncontrollable wildfires. A substantial number of large fires, reported as "unprecedented", broke out throughout the year in several regions. They were more numerous than average in high latitudes, notably in Siberia and Alaska, and affected parts of the Arctic where they had been extremely rare. Severe drought in Indonesia and neighbouring countries led to the worst fire season since 2015. South America recorded its highest number of fires since 2010. Over the summer, fires devastated the world's second 'green lung', the Congo basin. In Australia, 3 million hectares burnt between September 2019 and January 2020, releasing fumes and pollutants that spread around the globe, causing peak emissions.

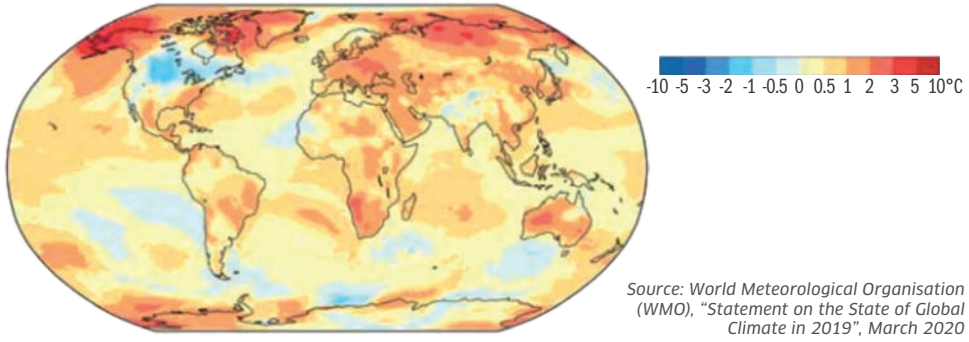
TEMPERATURE RISE SINCE 1900



Line: 11-year moving average
Bars: Temperature annual average compared to normal (reference period: 1981-2010)

Source: World Meteorological Organisation (WMO), "Statement on the State of Global Climate in 2019", March 2020

ABNORMAL TEMPERATURES IN 2019 COMPARED TO 1981-2010 AVERAGE



Source: World Meteorological Organisation (WMO), "Statement on the State of Global Climate in 2019", March 2020

CO_2 & climate: climate change

The effects of global warming are multiplying in number and proving increasingly severe, with alarming consequences for our health and the economy

The sea level has been rising at an increasing pace and hit a record high in 2019 (recording started in 1993). This mainly results from the thermal expansion of seawater and the melting of large glaciers in Greenland and Antarctica. Coastal regions and islands are exposed to increased flood risks, while low-lying areas such as Bangladesh and Florida are facing the threat of submersion.

According to IPCC estimates, the global sea level could rise by 23-82 cm by 2100. Other scientists explain that in case of runaway global warming, the sea level could rise by several metres by that time. By 2050, 300 million people could be facing annual floods (Nature Communications estimates).

The oceans are heating up much faster than expected. They were at their hottest recorded levels in 2018 and again in 2019.
As oceans retain over 90% of the excess heat accumulated in the atmosphere as a result of increased greenhouse gas, their warming is a major indicator of climate change. In 2019, the ocean heat content down to 2,000 metres beat its previous record established in 2018.

The consequences for climate are critical. Ocean warming is responsible for 30% of the rise in sea level, affects marine currents, indirectly alters hurricane paths and melts icebergs. Together with acidification and deoxygenation, ocean warming can disrupt marine ecosystems in a spectacular manner. By absorbing 23% of annual CO_2 emissions between 2009 and 2018, oceans cushioned the effects of climate change at the cost of their acidity, which in turn disrupted marine life (lower mussel, crustacean and coral reproduction).

2019 confirmed the long-term thinning of Arctic pack ice and the Antarctic icecap. The Arctic recorded its second warmest year since 1900, when records begin (the record high was 2015-16), at 1.9°C above the 1981-2010 average between October 2018 and August 2019. The 12 warmest seasonal minimums are those of the past 12 years.

Climate change affects the social determinants of human health: clean air, clean drinking water, sufficient food and secure housing. Extreme heat undermines heath, notably amongst elderly people, and accelerates the transmission of diseases by insects, such as dengue and malaria in Africa. Air pollution, indoor and outdoor, kills nearly 7 million people each year worldwide (WHO), representing one in nine deaths. Nine people out of ten breathe air containing pollutant levels higher than WHO's recommended limits. Most polluted air is found in the Eastern Mediterranean, Southeast Asia and many megacities (where pollution reaches 5 times WHO limits), followed by low or middle-income cities in Africa and the Western Pacific.

In 2019, over 7 million people were forced to migrate because of natural disasters aggravated by climate change. Last year's natural risk displacements were primarily attributable to floods and hurricanes, among which Cyclones Idai in South-East Africa and Fani in South Asia, Hurricane Dorian in the Caribbean and floods in Iran, the Philippines and Ethiopia (source: IDMC). Adding wars and resource depletion, this brings the total to nearly 22 million new refugees in 2019, of which 19 million in Asia and 3 million in Africa.

According to UN forecasts, climate refugees could number over 250 million worldwide by 2050, of which 143 million originating from sub-Saharan Africa, Southeast Asia and Latin America.

Sources: Nature Communications, "New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding", October 2019
IDMC, Global Report on Internal Displacement, 2019
World Meteorological Organisation

CO_2 & climate: carbon markets and prices

Carbon pricing is gaining ground, but will need to strike a balance between price increases and social acceptance to become more effective

So-called explicit carbon pricing systems, in the form of taxation or carbon markets, developed further worldwide in 2019. As of 1 April 2020, 61 countries, provinces or cities had introduced carbon markets or taxes on fossil fuels (31 ETS and 30 carbon taxes). They represent about 60% of world GDP and cover 12 $GtCO_2e$, or 22% of world GHG emissions. Three more countries introduced a carbon pricing policy last year: Canada, opting for a federal approach, South Africa and Singapore. Mexico launched the first South American ETS, currently in pilot phase. More and more authorities are looking to extend their ETS to a wider range of sectors (Germany, Austria, Luxembourg). Lastly, carbon prices cover an increasing number of sectors and GHGs.

Overall, explicit carbon prices remain insufficient to support the development of new low-carbon technologies. As of March 2020, they ranged from less than \$1 to \$123/tCo_2e, with 75% of total covered emissions at below \$10. The situation is contrasted, however: prices have exceeded €25/t in the EU, the world's leading market, and reached substantial amounts in China (between \$2 and \$12) given the purchasing power, playing a significant role in these regions. According to international scientific consensus estimates, optimal carbon prices range from \$40 to \$80/tCO_2e in 2020, and \$50 to \$100/tCO_2e in 2030 (Stern-Stiglitz). Currently, less that 5% of covered emissions are in that price range.

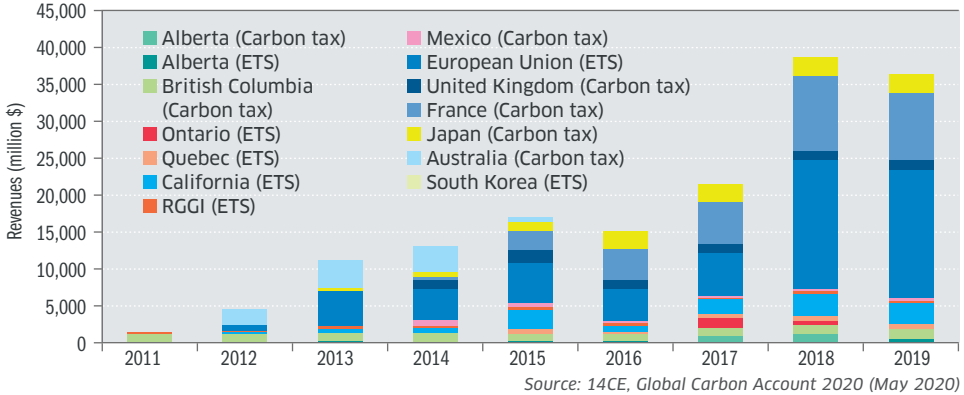
46% of world carbon revenues are earmarked for low-carbon transition projects, 44% for general government budgets and 6% for tax exemptions. 4% are directly transferred to companies and households.

Carbon pricing schemes collected \$45bn in 2019, slightly more than in 2018 (\$44bn), of which 75% in the EU. France recorded the largest carbon revenue collection, at \$9.3bn in 2019.

By sharply reducing emissions in 2020, the Covid-19 pandemic has weighed on many carbon markets and led to the postponement of several carbon tax rises or extensions due in 2020. In Norway, for instance, the removal of the natural gas tax exemption has been suspended.

Worldwide, Covid-19 related restrictions have deferred several major meetings and enhanced uncertainties over the future of the international carbon market. COP26 has been postponed to 2021, as have key international aeronautics and maritime transport meetings. Uncertainty over international funding has increased: airlines are asking what is to become of their obligations under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
That said, other authorities and private sector organisations have stepped up their efforts on climate change. COP's Chilean presidency has announced that 120 parties within the UNFCCC are working towards carbon neutrality by 2050; while 15 sub-national regions, 398 cities, 786 companies and 16 investors declare they are targeting zero emissions.

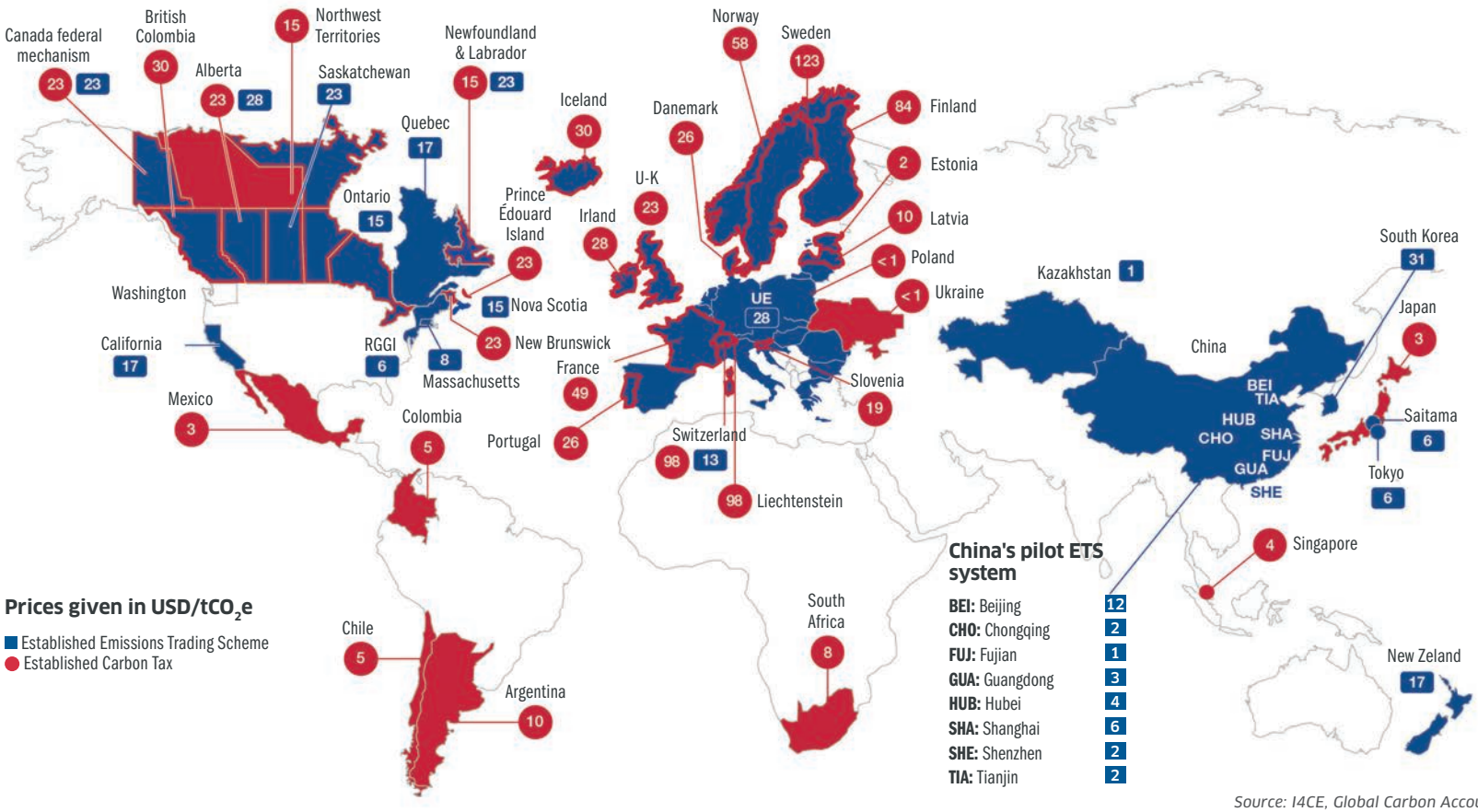
CARBON REVENUES IN G20 COUNTRIES, 2011-2019 (MILLION $)



Source: 14CE, Global Carbon Account 2020 (May 2020)

CO_2 & climate: carbon markets and prices

MAP OF EXPLICIT CARBON PRICES AROUND THE WORLD 2020



Source: I4CE, Global Carbon Account in 2020 (May 2020)

CO_2 & climate: the European carbon market

The European carbon market (EU-ETS) is gradually proving its effectiveness, with a 9% decline in covered CO_2 emissions in 2019, despite a 1.5% rise in EU GDP (European Commission publication dated 5 May 2020). Emissions contracted particularly sharply in the power sector (-15%), thanks to RES and natural gas capacity replacing coal. Emissions also decreased in industrial sectors (-2%), including heavy industries, cement, steel, refineries and chemicals. Along with lower emissions, carbon intensity receded in power and industrial sectors.

While EU-ETS played its role in 2019 thanks to the sharp rise in CO_2 prices in 2018-2019 (see details next page), it must be said that historically it has had little impact on emissions; their reduction is mostly the result of EU energy policies, in particular the support for electric renewables and energy efficiency.

Although EU-ETS - the cornerstone of EU climate policy - will meet (and even exceed) its first objective of a 20% cut in EU CO_2 emissions between 1990 and 2020, that will not be enough to meet the following targets of a 40% cut in CO_2 emissions between 1990 and 2030 (a target that the Commission plans to raise to 50-55%) and carbon neutrality by 2050. Consequently, in addition to the revision agreed upon early 2018 for phase 4 (2021-2030) that supports Co_2 prices by reducing excess quotas, the European Commission will propose in 2021 an extension of the ETS to other sectors (aviation in particular), as well as carbon prices targets outside the ETS.

Also in the EU's 2021 agenda within the Green Deal, is the carbon tax, with a twofold objective: tackling relocation aimed at escaping carbon costs ("carbon leakage") and taxing foreign and European companies equally (the tax would replace current free carbon allowance schemes or compensations for increases in electricity costs).

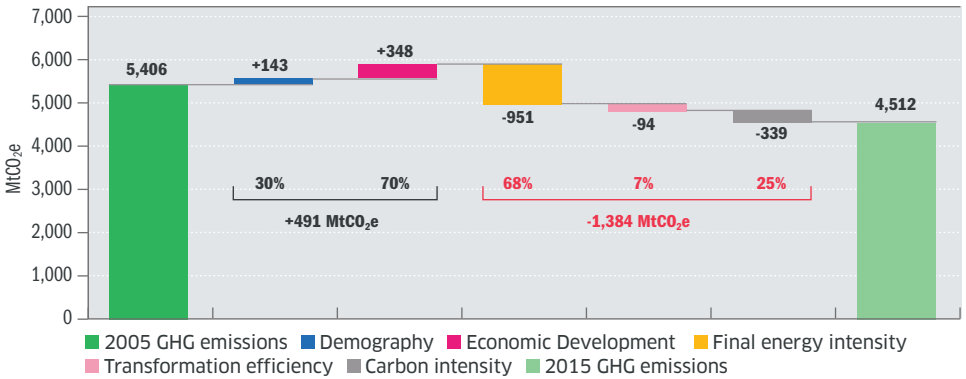
The EU directive on energy taxation, from which aviation and maritime transport are currently exempt, is scheduled to be revised in June 2021. The new directive will offer more support for alternative fuels for mobility (hydrogen, electricity, natural gas, biofuels, etc.), which the current taxation system sometimes hinders.

CO_2 emissions in the EU						
	1990	2010	2017	2018	2019	2020*
CO_2 emissions (Mt)	4,098	3,727	3,330	3,267	3138	2,730
Annual change		3.3%	1.3%	-1.9%	-4.0%	-13.0%
Change since 1990		-9%	-19%	-20%	-23%	-33%
AAGR since 1990		-0.5%	-0.8%	-0.8%	-0.9%	-1.3%

* Estimates

Source: Enerdata Global Energy & CO_2 Data (2020)

DRIVERS OF GHG EMISSIONS VARIATIONS IN THE EU 2005-2015



The decoupling of final energy demand and GDP was the most important driver of GHG emissions reductions in the EU over 2005-2015.

Source: Institute for Climate Economics (I4CE) & Enerdata, "Mind the Gap", 2018

As the world's number one carbon market, with three quarters of the international carbon trade, EU-ETS covers emissions from over 11,000 power plants, highly energy-intensive industrial facilities and airlines connecting participating countries. Altogether, this represents about 45% of EU CO_2 emissions.

CO_2 & climate: the European carbon market

Weakened by years of excess allowances and low prices, EU-ETS regained a measure of balance after the 2018 reform. CO_2 prices are currently around €25/t, which boost gas-fired plants' competitiveness relative to coal.
In adopting EU-ETS phase 4 in early 2018, the European Council meant above all to support CO_2 prices by reducing emission allowances. The pace of allowance cuts was raised from 1.7% to 2.2% per year and the Market Stability Reserve, a long-term market adjustment tool, was strengthened.

As a result, after having ranged between €5 and €10/t over 2011-2017, CO_2 prices rapidly broke the €20 threshold at end-2018 and were drawing nearer €30 by the summer 2019, for an annual 2019 average of €25/t.

Market liquidity increased, as did volatility. In April 2020, during lockdown and as oil prices plummeted, CO_2 prices fell to €15, before bouncing back to €20 as early as May, and finally 25€ in June.

Although excess allowances remain substantial, equivalent to a full year's emissions, the fact that carbon prices have stabilised around €25/t is a sign of greater confidence in EU-ETS and its ability to offer a stable and foreseeable framework for investment.

Climate roadmaps require much higher CO_2 prices, however. Depending on scenarios and requirements, EU-ETS must climb much further: towards $€_{2018}$100/t by 2030 in the IEA's SDS scenario, and even $€_{2018}$250/t according to the Quinet report (Rapport Quinet 2019, February 2019).

PRICE OF CO_2 ALLOWANCES ON THE EU-ETS MARKET (€/TONNE)

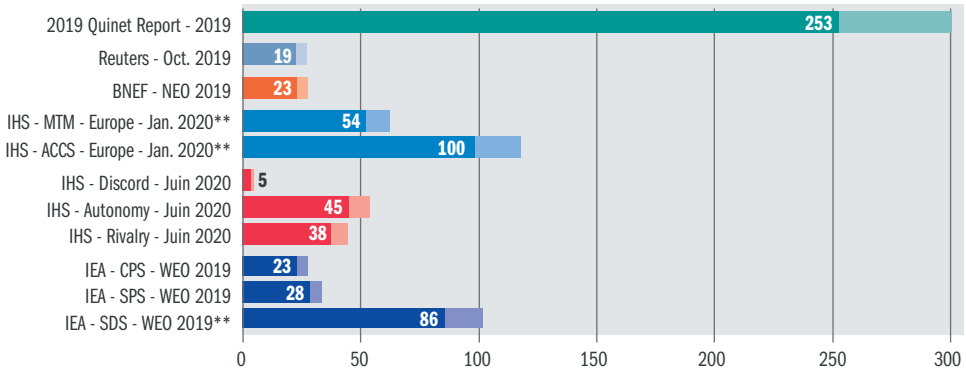
Source: EMBER, Coal to Clean Energy Policy, July 2020

MINIMUM "SWITCH" PRICE FROM COAL TO GAS COMPARED TO THE EU-ETS PRICE (€/TONNE)

This minimum "switch" price corresponds to the CO_2 price required to favour an efficient gas-fired power plant over an inefficient coal-fired power plant.

Sources: I4CE, à partir de données fournies par ICIS, la Banque de France, le GIEC et Eurostat
L'état du marché carbone européen – Édition 2019

FORECAST OF CO_2 PRICES IN 2030 – BENCHMARK IN €2019/T*



*** Darker color: in € 2019; lighter color: in € nominal**
**** Scenarios in line with the 2°C trajectory**

Source: Enerdata estimates, May 2020

CO_2 & climate: Green Deal and European recovery plan

Rather than stifling EU environmental efforts, the Covid-19 crisis kick-started a new dynamic, that materialised in the choice made towards a green recovery

The Green Deal is a plan of action laid out by the European Commission in December 2019 for the EU to reach carbon neutrality by 2050. Its main resolutions target a GHG emission reduction of at least 40% by 2030 compared to 1990 levels – a threshold that could be raised to 50% or even 55%, if the amendment obtains the Commission's approval –, a share of renewable energy brought up to a minimum of 32% of the mix, and an improvement in energy efficiency of at least 32.5%. The carbon neutrality principle will be inserted in the climate law.

In addition, the plan provides for the integration of climate issues in all European public policies (energy, industry, transport, agriculture, etc.). It rests on mutual actions, associating institutions (from mayors to heads of State) and private players.

The Commission wishes to promote circular economy and renewable technologies, such as hydrogen, fuel cells and other alternative fuels, as well as energy storage. With the planned "Just Transition" mechanism, €100bn worth of investments, according to Ursula von der Leyen, is to be mobilized in economically vulnerable regions and sectors.

Brussels will secure the financing through loans and redirected part of the traditional budgets towards emission reduction initiatives. As early as 2021, 40% of the budget for agriculture and 30% of the one for fisheries will be submitted to this priority.

To secure the completion of the Green Deal, the Commission will reform carbon pricing. As soon as 2021, the EU-ETS will extend to maritime and road transport. The two sectors will also be subject to tighter standards. Airline companies will be granted fewer free allowances. And a carbon tax imposed at EU boarders will discriminate foreign goods disrespectful of environmental policies (see previous page).

The Covid-19 crisis served as a reminder of the necessity of a carbon price floor. Fossil fuels plummeted to levels that far from reflect their environmental costs. Such market conditions jeopardize energy transition policies: they both annihilate incentive measures to decarbonize and create uncertainty, that is detrimental to energy transition investments.

What changed with the health crisis.

The crisis strengthened opposition to the Green Deal. Nevertheless, the EU stayed firm on both its ambitions and its decarbonization roadmap. Though some of the deadlines were deferred, mainly due to the postponement of COP26, the Commission delivered a clear message and was able to fulfil the 2020 agenda:

- 4 March: introduction of the draft European Climate Law; the impact assessment is to be presented in September;
- 30 March: launch of the online public consultation, regarding the enhancement of the 2030 CO_2 emission reduction target up to 50%, or even 55%, compared to 1990 levels,
- 20 May: publication of an ambitious plan towards biodiversity (EU Biodiversity Strategy to 2030) and nutrition ("From farm to fork").

Above all, the EU very much responded to calls for a green recovery.

Through its different bodies, the EU embarked on colossal recovery plans (first €1,000 bn injected by the central bank into the European financial system, then €540 bn allocated to emergency measures, and finally, in May, €750 bn granted in the form of a Community loan).

The European Commission submitted the granting of these aids to environmental conditions, however. Hence, €390 bn of the Community loan will be devoted to the hardest hit Member States, on the condition that the funds are used in accordance with EU's priorities, in other words the Green Deal, energy transition and Europe's greater sovereignty.

In addition, the Commission placed ecology at the heart of its recovery plan, giving priority to, notably, building renovation, RES, rail, and circular economy. It also presented on 8 July 2020 an ambitious plan to support renewable hydrogen, whereby catalysers are to be installed for at least a 6 GW capacity by 2025 and 40 GW by 2030. The objective is to cover 12% to 14% of the EU energy mix by 2050 (against 1% today).

Decarbonization

PERSPECTIVE

" If we fail to significantly reduce CO_2 emissions, the future will be subject to disasters whose cost to humanity will be far greater than the cost of the measures needed to achieve such reduction"

Didier Holleaux, Executive Vice President of ENGIE

SCENARIOS

The energy scenarios of the IEA, Enerdata and IHS all come to the same conclusion: existing and announced measures together can limit CO_2 emissions by 2040, but are not drastic enough to force a contraction

Renewable energies, a key element of decarbonization, are covered in the chapters "Electricity & Renewables" and "Natural gas & Green gas"

Decarbonize: how?

Why decarbonize?

Already critical, the consequences of temperature rising 1°C since the industrial revolution call for collective action to reduce GHG emissions as they are the main cause of global warming. It is widely accepted that if warming is not to exceed 2°C by 2100, the level beyond which damage would be unsustainable, GHG emissions must be halved within the next two decades and carbon neutrality reached during the second part of the century.

Consisting of producers, suppliers and consumers, the energy sector has serious responsibilities in the matter: 75% of GHG emissions result from energy combustion. That said, the absolute necessity to decarbonize energy is not the end of it. Humanity as a whole has to become more respectful of the environment in order to preserve resources and ecosystems. This will undoubtedly come at a considerable cost, especially given continuing population growth and industrialisation. But as recent history shows, the cost is tiny compared with that of inaction, with all that means for the damage associated with global warming and natural habitat destruction.

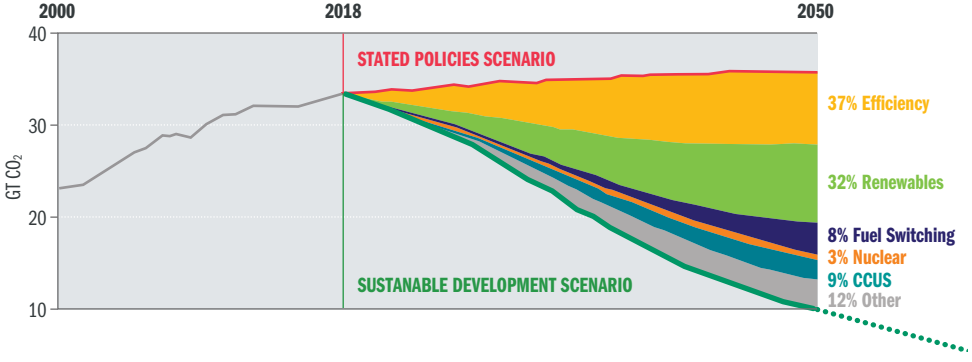
Decarbonization tools

It will take all the various means of decarbonization to deliver results and strengthen the system's overall resilience. This chapter presents the main decarbonization tools available to the energy sector, assessing their scope and current stage of development. The list is by no means exhaustive, as it does not include related areas such as reforestation, recycling and digitalisation.

- **Improving energy efficiency is the number one lever:** it applies to the whole chain and still offers real room for improvement in a context of persistent obstacles (know-how, costs, limited profitability when energy is cheap).
- **RES development,** whether electricity or gas (biomethane, green hydrogen), ought to result in nearly complete decarbonization in power generation. It should also tackle specific pockets of resistance, such as transport and intensive industry, while favouring short distribution channels (decentralised production, agricultural waste reuse, unavoidable renewable energy use). RES are discussed in the "Electricity & Renewables' and "Natural gas & Green gas" chapters.
- **Energy sufficiency** (or sobriety), largely absent from policies and projects, is probably the most efficient lever, if not the fastest and the cheapest to implement. It is seen as restrictive, however, a feature that is hindering deployment. Covid-19 may well change mentalities on the subject.
- **Green finance** is proving a necessity for the materialisation of energy transition projects that otherwise fall foul of short-termism in loan policies and the excessively demanding returns required in traditional finance.
- **Lastly, CO_2 capture, utilisation and storage** may not have the support of environmental diehards but it is capable of decarbonazing the final core of CO_2 emissions, i.e. the most expensive or most difficult emissions to eliminate.

Choices on priorities, technology and the pace of change are complex decisions that depend on the approach taken, which itself reflects varying ambitions as well as geography. These choices will determine the trajectory of global decarbonization. In order to shed light on what that trajectory might be, we invited three internationally renowned centres of expertise to expound their views on energy transition.

ENERGY-RELATED CO_2 EMISSIONS AND REDUCTIONS BY SOURCE IN THE IEA SUSTAINABLE DEVELOPMENT SCENARIO (SDS)



Source: IEA, World Energy Outlook 2019

Decarbonization: message from Laszlo Varro, IEA, August 2020

The Coronavirus epidemic brought an unprecedented macroeconomic shock with profound energy implications. Social restrictions and the subsequent deep recession constrained energy demand especially in mobility.

However, the long term energy and climate challenge remained intact: the world economy is still expected to emit around 30 billion tons of CO_2 in 2020, the reduction we observe was achieved at an unacceptable human and macroeconomic cost. The pandemic triggered social and behaviour changes but their energy impact is a double edge sword: people use more video conferencing instead of business trips, but they also became reluctant to use public transport and in home office they are more likely to use air conditioning. **Overall, if the world economy recovers without a major structural change, emissions are almost certain to rebound, quite possibly to above the 2019 level.**

The epidemic hit energy investment hard, to a level that is insufficient to power the eventual recovery of the global economy. The current underinvestment creates a fork in the road: **the nature of the investment rebound will determine the trajectory of the energy system for decades.** Corporate leaders have a responsibility to recognize the importance of this crossroad and act accordingly. As governments around the world are forced to implement expansive measures for economic stabilization and stimulus, **there is a window of opportunity to put the clean energy transition into the heart of economic recovery efforts.** A determined, coordinated push on clean energy investment from governments and the corporate sector would accelerate the recovery, create green jobs and would enable the energy system to move to an energy transition trajectory.

Such a trajectory is embedded into the IEA Sustainable Development Scenario (SDS) which depicts a comprehensive implementation of the Paris agreement for a well below 2 degrees climate stabilization. A **profound transformation and investment reallocation takes place in SDS: the largest scale up is investment in energy efficiency and end use services, keeping total final energy consumption declining despite the growth of the global economy.**

On the supply side, annual wind and solar deployment increases by a factor of 2.5 from the level prevalent in recent years, and **by 2040 wind and solar represent by far the largest component of power generation. Nevertheless the old workhorses of hydropower and nuclear continue to play an important role.** The rapid growth of variable renewables necessitates major investments into electricity networks, both into long distance transmission as well as into reinforcing and digitalizing distribution.

While the role of electricity strongly increases the gas pipeline system remains an essential infrastructure, serving homes and industrial users. Gas turbines operate with a low and volatile load factor but their contribution to supply security persist for decades. **Major new investments into both biomethane and low carbon hydrogen gradually decarbonize gas supply as well.** Meanwhile, innovation accelerates into new technologies that will provide low carbon solutions for hard to abate sectors including aviation and the heavy industry.

The IEA Sustainable Development Scenario is feasible, the industry has all the technical and project management capabilities that are needed. It would deliver major benefits beyond climate such as air pollution reduction and job creation. It is by no means easy. It will require a grand coalition of governments, the finance sector and the energy industry implementing a comprehensive set of policies, allocating investment and encouraging innovation. The energy transition is essentially a test of leadership.

NB from Laszlo Varro: please note that given the macroeconomic impact of the epidemic, our stated policies scenario will be significantly revised in WEO 2020 compared to last year's edition (WEO 2019).

Laszlo Varro Chief Economist – International Energy Agency

The International Energy Agency (IEA) is an international organization whose mission is to work with governments and industry to shape a secure and sustainable energy future for all. It is recognized worldwide, in particular for its prospective report « World Energy Outlook ».

Decarbonization: message from Morgan Crénès, Enerdata, September 2020

All eyes are on the Covid-19 crisis and its consequences on health, social and economic activities. The energy transition is of course impacted by the sanitary crisis, but the dynamics of greenhouse gases emissions just before the start of the outbreak should be reminded:

- Over the past decade, global CO_2 emissions* have been **increasing by 1%** per year on average.
- In **2019 though, they slightly decreased by 0.2%,** thanks to improved energy intensity** and carbon factor***.

With the Covid-19 outbreak we will never know whether 2019 was the beginning of a new trend towards energy transition or just an exception. In any case, the efforts to meet the Paris agreement would have required a consequent acceleration to reach at least a 3% decrease in global CO_2 emissions every year****.

For 2020, the latest Enerdata estimates **forecast a 9% decrease in global CO_2 emissions** with a 12% drop in energy consumption in the USA, an 8% drop in Europe, and a sluggish 0.5% growth in China. A very large part of this dip is directly linked to the change in activity level (economy, transport, etc.) resulting from new social standards (working from home, decrease in the use of public transport etc.) or severe prophylactic measures (lockdown).

This 2020 trend does not at this stage rely on any structural change: energy consumption and the energy mix could go back to the previous situation quite easily, and thus CO_2 emissions could see a huge rebound effect.

The "billion-dollar question" is, will the economic recovery policies put energy transition at their core?

This would not only be a way to offset the current delayed investments in energy efficiency and low carbon technologies but also a **unique opportunity to put energy systems back on track to meet the Paris agreement commitments.**

The trend in recent years was far from a +1.5-2°C scenario (and even from NDCs*****). The stimulus packages under development are currently opening short-term possibilities that did not exist six months ago - and **will significantly guide long-term trends.**

Innovation and investments in energy efficiency and the decarbonization of all vectors will be essential. Electrification of uses will play a key role: gas and electricity could account for more than 50% of final energy consumption by 2050.

Beyond national and international policies and technology developments, following and anticipating the **behaviours of socio-economic actors** is also essential: citizens, companies, local authorities, NGOs... will all play a key role in this period of uncertainties.

*Energy related CO_2 emissions
**Energy consumed per unit of GDP
***CO_2 emissions per unit of energy consumption
****https://www.enerdata.net/research/forecast-enerfuture.html
*****National Determined Contributions

Morgan Crénès Head of Data & Research – Enerdata
Enerdata is an independent research company specializing in the analysis and modelling of energy and climate issues, at world and country level. Leveraging our globally recognized databases, intelligence systems and models, we help our clients shape their policies, define their strategies and plan their business.

Decarbonization: message from Steven Knell, IHS Markit, September 2020

In July 2020, IHS Markit published its 2020 global scenarios, Rivalry (the base case), Autonomy (faster transition) and Discord (slower transition). These new energy balance projections to 2050 capture the significant impact the coronavirus 2019 (Covid-19) pandemic and resulting global economy recession has had on expectations of the energy transition.

In the Rivalry base case, we see the pandemic recession weakening the global climate effort. There are less greenhouse (GHG) emissions in 2020 due to lower economic activity - we've seen the largest year on year decline in energy related emissions in history with global GDP down more than 5% year on year – but there is also less willingness and capacity to act in most markets, especially in the first decade of the forecast. This is due to the impact Covid-19 has had on public sector and private budgets. There are some new opportunities for emissions reduction due to technology trends and local pushes for deeper reductions are to be expected, particularly in Europe, but ultimately in Rivalry climate policy goals face both existing challenges at the national and international levels as well as the new issues Covid 19 has created.

In the Autonomy scenario, where a faster transition takes place, the outlook is greener than our 2019 projections. In this case there is green recovery in the 2020s in more markets and lower energy demand through the forecast period contributing to greater policy ambition and better policy performance. Critically, we assume the mass social movements for climate action of 2019 to be very much in support of tougher national and international action in this scenario. In the Discord scenario, the outlook for climate action is dimmer than ever before. Fewer can afford climate action measures and fundamentals favour more emissions-intense activities.

The Covid-19 crisis has decreased the growth pathways for global economy and total energy demand. This has brought lower expectations of GHG emissions in all cases. Compared to last year, in 2050, Rivalry is down roughly 10% compared to our 2019 forecast, some 5.4 billion metric tonnes of carbon dioxide equivalent (Gt) – more than all the carbon dioxide (CO_2) emitted by the United States in 2019. Autonomy global GHG levels are down 12% compared to last year and Discord emissions in 2050 are 7% lower.

Covid and the pandemic recession has brought a material downward shift in our expectations of emissions over the next 30 years. That feeds into our estimation of how the world, the EU, its member states and other countries may progress towards climate policy emissions reduction goals. Looking first at the current Nationally Determined Contributions (NDCs) that support the Paris Agreement through 2030, IHS Markit analysis suggests that, when added together, the emissions goals of all the NDCs are aligned with the global emissions levels in each of our global scenarios.

EU emissions in 2030 would be well within the range of the existing 40% reduction from 1990 NDC goal in each of our 2020 projections. Key large emitting countries like France achieve their NDC emissions goals in the Rivalry and Autonomy projections but the slower transition foreseen in the Discord case leads to higher emissions above stated goals. It is notable that in the Autonomy Scenario, which includes policy, technology and market assumptions that are more conducive to further GHG emissions reductions, EU emissions in 2030 are more than 50% below 1990 levels, approaching the more ambitious 2030 target the European Commissions has proposed to support the net zero goal of the EU Green Deal.

Looking beyond 2030 to 2050 and the net zero goals the EU, the UK, Japan and host of other countries have adopted as long-term climate policy ambitions, the picture is more mixed. The IHS Markit Global Scenarios do not foresee large emitters reaching a point where sources of emissions balance sinks by mid-century, thereby re. Residual energy-related emissions in segments of the economy, such as transport, and persistent non-energy emissions, which tend to lay beyond the focus of climate policy, are key obstacles to the realisation of those the ambitious goals in the IHS Markit 2020 Global Scenarios.

Steven Knell **Senior Director Energy and Climate Scenarios – IHS Markit**

IHS Markit is a world leader in critical information, analytics and solutions for the major industries and markets that drive economies worldwide. Among other things, the company offers global energy scenarios, climate related data and expert analysis to support corporate strategy, investments, and decision making in the energy transition.

Energy scenarios

What transformation does the energy system need if it is to meet environmental objectives?

The scenarios presented here respond to two major concerns regarding climate change:

- **To assess the impacts of energy policies and measures that have been, or are soon to be, introduced on CO_2 emissions and energy demand.** This is the purpose of the IEA's Stated Policies Scenario (STEPS) and the Enerdata's Ener-Blue scenario.
- **To define what policies, technologies and changes are needed now to meet the Paris Agreement's environmental targets,** i.e. to limit the world's average temperature rise to less than 2°C – or even 1.5°C if possible – over this century, compared to pre-industrial era. These are the IEA's Sustainable Development Scenario (SDS) and the Enerdata's Ener-Green scenario.

The scenarios presented here focus on the energy system that is responsible for three-quarters of GHG emissions (see Chapter CO_2 and Climate), with a 20-year projection for some visibility.

Assessment of initiated or announced policies (STEPS and Ener-Blue scenarios).

These scenarios reflect endorsed energy policies and States' commitments, notably under COP21 (Intended Nationally Determined Contributions, INDCs), but adjust their degree of realisation by country. The assumption is that policies are pursued as they are over time, meaning neither weakened nor strengthened.

Considered to be the most probable, these scenarios serve as central scenarios: they describe energy system developments over the next 20 or 30 years based on the current situation (laws that have been implemented or soon will be, new technologies, costs, etc.). There are not static, as they take into account announced policies and current dynamics. They differ in this from scenarios that only take introduced policies into account (IEA's Current Policies and Enerdata's Ener-Base scenarios).

The main conclusions from these scenarios are as follows: by 2040 energy demand will have stabilised in OECD countries, but will still be increasing elsewhere (by 1.6% per year on average); this global rise (1% per year, i.e. 1/4 over the period) will drive energy prices higher; fossil fuels will remain prominent within the energy mix (at 74%), but policies introduced to limit climate change – energy efficiency, RES development – will allow diversification towards other energy sources. The efforts described in INDCs lack ambition, however; they imply a 7% increase in CO_2 emissions between 2020 and 2040 and a 3.5°C rise in temperature by the end of the century.

Assessment of policies and measures needed to meet the +2°C target (SDS and Ener-Green scenarios).

These are commonly called "dream", "wishful thinking", or "normative" scenarios. They are calibrated to meet environmental objectives such as those defined in the Paris Agreement, the UN's Sustainable Development Goals (SDGs) or the IPCC's Representative Concentration Pathways (RCPs) 4.5 and 6.0.

They start with the desired result (i.e. the situation sought by 2040/2050) and work back to the measures required to get there.

The conclusions are clear: for the rise in temperature to remain below 2°C, there is no choice but to transform the world energy system without delay so that total decarbonization is achieved by the second half of the century.

This transformation requires considerable efforts in the matter of energy efficiency (to reduce energy consumption) and RES technology development (to decarbonize the energy mix) – see details below. Fossil fuel subsidies have to end and carbon taxes must be introduced, so that energy prices reflect respective environmental impacts. Under theses conditions, world CO_2 emissions would drop from 33 Gt in 2019 to 10 Gt in 2050, and zero by 2070.

These scenarios are used as benchmark to compare progress achieved with what is required.

Scenario references:
International Energy Agency (IEA): World Energy Outlook (WEO)
Enerdata Global Energy Forecasting department

Energy scenarios: energy consumption and CO_2 emission trajectories according to the IEA

Existing and announced measures together can limit CO_2 emissions by 2040, but are not drastic enough to force a contraction

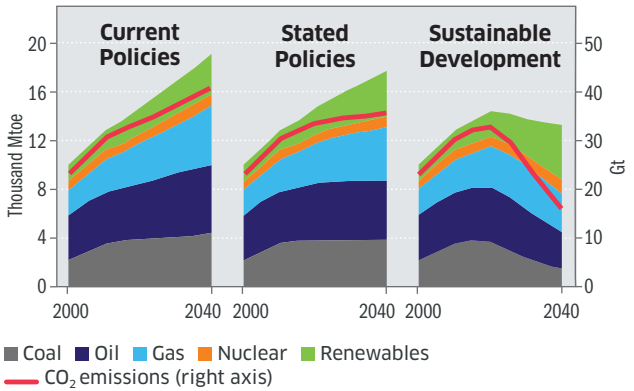
ENERGY DEMAND AND CO_2 EMISSIONS BY SCENARIO (IEA)

World Energy Demand in Mtoe	World			Current Policies (+ ~5 / 6 °C)				Stated Policies Scenario (+ ~3,5 °C)				Sustainable Development (+2°C)			
	2010	2018	Share 2018 (%)	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040
Total primary demand	**12,853**	**14,314**	**100**	**16,960**	**19,177**	**100**	**1.3**	**16,311**	**17,723**	**100**	**1.0**	**13,750**	**13,279**	**100**	**-0.3**
Coal	3,653	3,821	27	4,154	4,479	23	0.7	3,848	3,779	21	-0.1	2,430	1,470	11	-4.3
Oil	4,124	4,501	31	5,174	5,626	29	1.0	4,872	4,921	28	0.4	3,995	3,041	23	-1.8
Natural gas	2,749	3,273	23	4,070	4,847	25	1.8	3,889	4,445	25	1.4	3,513	3,162	24	-0.2
Nuclear	719	709	5	811	937	5	1.3	801	906	5	1.1	895	1,149	9	2.2
Total Renewables	659	1,391	10	2,139	2,742	17	2.3	2,287	3,126	21	2.8	2,777	4,382	34	3.7
Hydro	225	361	3	445	509	3	1.6	452	524	3	1.7	489	596	4	2.3
Modern Bioenergy	374	737	5	1,013	1,190	9	1.1	1,058	1,282	10	1.4	1,179	1,554	12	0.8
Other renewables	60	293	2	681	1,042	5	6.0	777	1,320	7	7.1	1,109	2,231	17	9.7
Solid Biomass	638	620	4	613	546	3	-0.7	613	546	3	-0.6	140	75	1	-9.0

World CO_2 emissions (Mt)	2010	2018	Share 2018 (%)	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040	2030	2040	Share 2018 (%)	CAAGR (%) 2018-2040
Total CO_2	**30,412**	**33,243**	**100**	**37,379**	**41,302**	**100**	**1.0**	**34,860**	**35,589**	**100**	**0.3**	**25,181**	**15,796**	**100**	**-3.3**
Coal	13,808	14,664	44	15,548	16,609	40	0.6	14,343	13,891	39	-0.3	8,281	3,424	22	-6.4
Oil	10,546	11,446	34	12,905	14,053	34	0.9	12,031	12,001	34	0.2	9,436	6,433	41	-2.6
Natural gas	6,057	7,134	21	8,927	10,639	26	1.8	8,486	9,697	27	1.4	7,464	6,032	38	-0.8
Power sector	**12,413**	**13,818**	**100**	**14,951**	**16,594**	**100**	**0.8**	**13,777**	**13,834**	**100**	**0.0**	**8,460**	**3,780**	**100**	**-5.7**
Coal	8,942	10,066	73	10,839	11,813	71	0.7	9,920	9,641	70	-0.2	5,126	1,552	41	-8.2
Oil	844	692	5	555	497	3	-1.5	526	418	3	-2.3	325	200	5	-5.5
Natural gas	2,627	3,060	22	3,558	4,284	26	1.5	3,332	3,776	27	1.0	3,009	2,123	56	-1.7

Source: IEA – World Energy Outlook 2019

WORLD PRIMARY ENERGY DEMAND BY FUEL AND RELATED CO_2 EMISSIONS BY SCENARIO (IEA)



Source: IEA – World Energy Outlook 2019

IEA energy scenarios (WEO - November 2019)

		Stated Policies Scenario (STEPS)	Sustainable Development Scenario (SDS)
Policies & results	Political commitments	Environmental policies, including those pursued so far and those that have been announced and have a good probability of implementation.	Policies that have to be implement without delay in order to meet specific environmental objectives: complying with the Paris Agreement and tackling global warming.
	Global warming	**Temperature rise:** from 3°C to 4°C. CO_2 emissions: +0.3% p.a. by 2040.	**Temperature rise:** limited to 2°C with efforts towards 1.5°C. CO_2 emissions: -3/3% p.a. by 2040. The scenario is not decarbonization by 2040: the share of fossil fuels is 58%.
Eco	Growth	GDP growth 3.4% p.a. until 2040 and over 9 billion people by 2040 (+70 million p.a.).	GDP growth 3.4% p.a. until 2040 and over 9 billion people by 2040 (+70 million p.a.).
Energy demand	Energy efficiency & primary demand growth	**Energy demand:** +0.98% p.a. until 2040. Investments in energy efficiency step up from an annual $238bn in 2018 to $635bn in 2040. **Energy efficiency** progresses 2.3% p.a. by 2040.	**Energy demand:** -0.34% p.a. by 2040. Investments in energy efficiency step up from an annual $238bn in 2018 to $916bn in 2040. **Energy efficiency** progresses 3.6% p.a. by 2040.
	Mobility	**Share of electrical cars in new cars:** 15% in 2030 and 27% in 2050. **Oil (gasoline) demand:** up 0.41% p.a. until 2050. Demand breakdown in 2040: 82% oil, 5% electricity, 6% biofuels.	**Share of electrical cars in new cars:** 47% in 2030 and 72% in 2050. **Oil (gasoline) demand:** down 3.04% p.a. until 2050. Demand breakdown in 2040: 60% oil, 13% electricity, 14% biofuels.
	Industry	**Rate of electrification:** 29% in 2030 and 31% in 2050. Breakdown of energy demand in the industrial sector in 2040: 22% coal, 8% oil, 28% natural gas, 30% electricity, 8% bioenergy.	**Rate of electrification:** 31% in 2030 and 40% in 2050. Breakdown of energy demand in the industrial sector in 2040: 16% coal, 6% oil, 28% natural gas, 36% electricity, 9% bioenergy.
	Residential & services	**Energy intensity:** 0,94 in 2030 and 0.88 in 2050. Breakdown of energy demand in the residential and services sector in 2040: 22% natural gas, 43% electricity, 19% bioenergy.	**Energy intensity:** 0.72 in 2030 and 0.59 in 2050. 2030 objective of "zero energy" buildings, and use hydrogen fuel cells (notably in boilers) after 2030. Breakdown of energy demand in the residential and services sector in 2040: 17% natural gas, 53% electricity, 10% bioenergy.
Energy supply	Hydrogen	70 Mt/yr of so-called grey hydrogen **(fossil fuel-based) consumed in 2018, mainly in refining and chemicals (small share of the total).**	Share of hydrogen in energy consumption (all hydrogen production combined): 0.06% in 2030 and 0.68% in 2040. Hydrogen injections to gas grids: 25 Mtoe in 2040. 10 GW of offshore wind necessary to produce 1 Mt of hydrogen per year.
	Shares of primary energy in the mix	**Breakdown of primary energy in 2040:** 21% RES, 28% oil; 25% natural gas, 21% coal, 5% nuclear. Biogas: 320 Mtoe, of which 200 Mtoe of biomethane (6% of gas demand in 2040).	**Breakdown of primary energy in 2040:** 34% RES, 23% oil; 24% natural gas, 11% coal, 9% nuclear.
	Electricity production	**Electricity production breakdown by energy source in 2040:** 44% RES (of which 13% wind, 11% solar and 15% hydro), 25% coal, 1% oil, 22% natural gas, 8% nuclear.	**Electricity production breakdown by energy source in 2040:** 67% RES (of which 21% wind, 19% solar and 18% hydro), 6% coal, 0.5% oil, 14% natural gas, 11 nuclear. RES costs decrease and digital technology improves.
	CCS / CCUS	**CO_2 storage by par CCUS:** 71 Mt in 2030 (approx. one-tenth of the SDS scenario) and 154 Mt in 2050 (approx. one-twentieth of the SDS scenario).	**CO_2 storage:** 700 Mt/yr by 2030 and 2,800 Mt/yr by 2050. Allows an additional 9% reduction in CO_2 emissions compared to the STEPS scenario.

Enerdata energy scenarios (EnerFuture - January 2020)

		EnerBase	EnerBlue	EnerGreen
Policies & results	Political commitments	Target NDCs unfulfilled. No efforts to reduce CO_2 emissions.	Target NDCs fulfilled for 2030. Slower growth of CO_2 emissions.	Target NDCs (Paris Agreement) fulfilled and exceeded thanks to more ambitious environmental policies to limit global warming to +2°C.
	Global warming	Temperature rise: from 5°C to+6°C. CO_2 emissions: +1.12% p.a. by 2040.	Temperature rise: from 3°C to 4°C. CO_2 emissions: +0.25% p.a. by 2040.	Temperature rise: limited to 2°C (low carbon pathway by 2050). CO_2 emissions: -3.12% p.a. by 2040.
Eco	Growth	GDP up between 3.5% and 3.6% p.a. out to 2040.	GDP up between 3.5% and 3.6% p.a. out to 2040.	GDP up between 3.5% and 3.6% p.a. out to 2040.
Energy demand	Energy efficiency & primary demand growth	Energy demand up 1.44% p.a. out to 2040. Strong demand growth in developing countries, moderate in OECD. Little improvement in energy efficiency.	Energy demand up 0.99% p.a. out to 2040. Increased demand in developing countries, although limited by NDCs.	Energy demand down 0.37% p.a. out to 2040. Energy efficiency policies increasingly ambitious.
	Mobility	Share of electricity: 5.1% in 2040 and 6.3% in 2050. Share of biofuels: 11.3% in 2040 and 11.9% in 2050.	Share of electricity: 8.4% in 2040 and 11.1% in 2050. Share of biofuels: 10.1% in 2040 and 10.9% in 2050.	Share of electricity: 18.9% in 2040 and 25.4% in 2050. Share of biofuels: 13.1% in 2040 and 16.5% in 2050.
	Industry	Share of electricity: 23.5% in 2040 and 23.5% in 2050. Share of biomass: 8.1% in 2040 and 8.7% in 2050.	Share of electricity: 24.6% in 2040 and 25.8% in 2050. Share of biomass: 9.3% in 2040 and 10.6% in 2050.	Share of electricity: 28.5% in 2040 and 30.6% in 2050. Share of biomass: 17.8% in 2040 and 24.3% in 2050.
	Residential & services	Share of electricity: 44.5% in 2040 and 49.3% in 2050. Share of biomass: 16.9% in 2040 and 14.4% in 2050.	Share of electricity: 44.0% in 2040 and 49.6% in 2050. Share of biomass: 17,3% in 2040 and 14.7% in 2050.	Share of electricity: 45.9% in 2040 and 54.2% in 2050. Share of biomass: 25.4% in 2040 and 23.8% in 2050.
Energy supply	Hydrogen	n/a	n/a	n/a
	Shares of primary energy in the mix	Slight increase in RES share: 19.7% in 2040 and 21.2% in 2050.	RES contribute to diversification: 22.9% share in 2040 and 26.7% in 2050.	Strong increase in RES share: 40.3% in 2040 and 50.2% in 2050.
	Electricity production	RES share in electricity production: 33.9% in 2040 and 37.5% in 2050. Electrification rate: 25.7% in 2040 and 27.6% in 2050.	RES share in electricity production: 41.5% in 2040 and 48.2% in 2050. Electrification rate: 26.7% in 2040 and 29.8% in 2050.	RES share in electricity production: 65.5% in 2040 and 73.0% in 2050. Electrification rate: 32.4% in 2040 and 38.6% in 2050.
	CCS / CCUS	n/a	n/a	n/a

Energy efficiency

Not nearly enough progress in energy efficiency, but substantial untapped large potential

Energy efficiency is one of the main weapons in the fight against global warming and a critical part of energy transition. It is one of the goals recognised in the UN 2030 agenda; published in 2015, the agenda calls for the doubling of its rate of improvement by 2030. Energy efficiency not only saves energy and reduces GHG emissions. It also contributes to socioeconomic development (industrial productivity, employment, public budget, health).

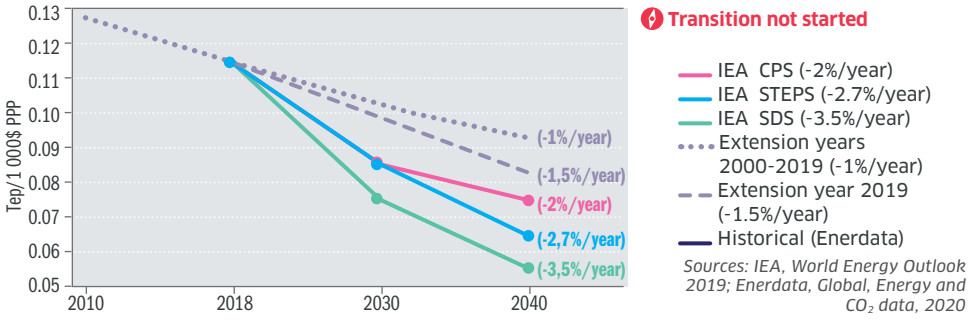
Its practical implementation can be divided into three themes: energy performance standards, market mechanisms and individuals' behaviour.

Energy intensity – energy demand per unit of GDP – is the usual means of measuring changes in energy efficiency. The IEA and Enerdata measure total primary demand per $1,000 of GDP at constant prices and at purchasing power parity.

Energy efficiency has improved so much worldwide over the past two decades that it is already the main component of energy services and one of the 'largest energy resources' in many countries. It has enabled energy consumption to contract nearly 20% over the period in the world's major economies (IEA members, Argentina, Brazil, Indonesia, Russia, South Africa). This is the equivalent of a 12% reduction in final demand and has avoided an additional 12% in GHG emissions.

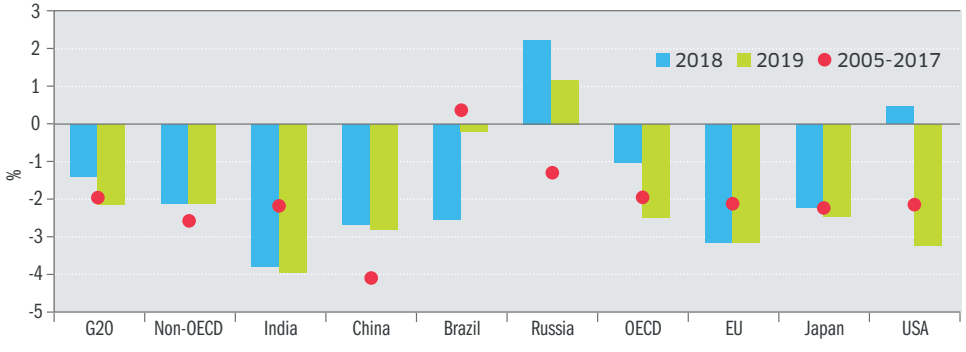
The trend represents an almost 2% annual average decline in energy intensity, although the fall has been slower in recent years. The trend rate resumed in 2019 (-2.1%, after -1.5% in 2018) on the back of favourable weather conditions, however. The past two years have seen a clear acceleration within the OECD, driven by the USA and Europe. In India, where modernisation in underway, energy intensity fell sharply; in China, where the economy is maturing, the decline in energy intensity slowed.

ENERGY INTENSITY PROJECTION (TOE/$1,000 PPP) – WORLD



Sources: IEA, World Energy Outlook 2019; Enerdata, Global, Energy and CO_2 data, 2020

ENERGY INTENSITY TRENDS IN THE G20 COUNTRIES (%/YEAR)



NB: Energy intensity: number of tonnes of oil equivalent per $1,000 of GDP at purchasing power parity

Source: Enerdata

Energy efficiency

Progress in reducing energy intensity to date is still inadequate to meet the 2°C global warming trajectory, however. This requires energy intensity to decline 3.6% par year until 2040. In a nutshell, world energy consumption has to stabilise over the coming two decades and CO_2 emissions – with the support of renewable energy – have to be halved. So far, energy intensity and carbon intensity have been tracking each other.

Improving efficiency depends largely on investment, but it stagnated at $250 bn in 2019. The energy transition requires a great deal more: according to the IEA's SDS scenario, investment has to double by 2025, reach $625 bn per year by 2030 and total $920 bn by 2040. Because of its efficiency/costs ratio, energy efficiency is the main emission reduction factor in this scenario (it attributes 37% of the decline in CO_2 emissions to efficiency, with RES accounting for 32%, substitution between energy sources for 8%, nuclear for 3%, CCUS for 8% and others for 12%).

Substantial untapped energy efficiency potential. The drive towards more energy efficiency particularly concerns transport and buildings, and especially residential buildings.

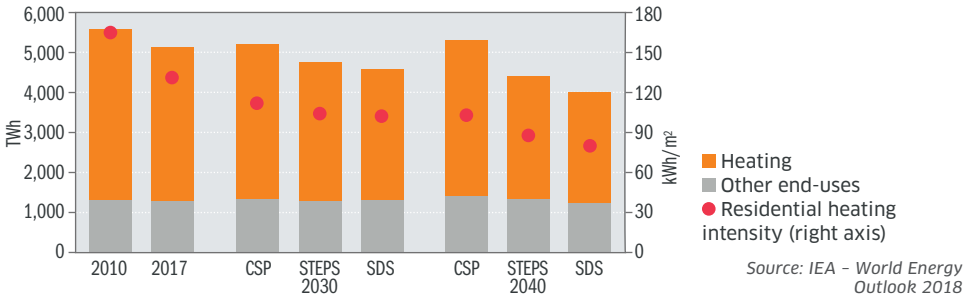
Buildings are a key source of energy efficiency improvement. They represent 30% of final energy demand, and nearly 40% in the EU, of which 80% is heating. They also weigh heavily in GHG emissions, accounting for nearly 20% of direct emissions and much more when electricity consumption and construction are included. Efficiency gains can be made in housing and household equipment energy performance, primarily through the renovation of existing buildings (60% of the EU's likely housing stock in 2040 has already been built). Substantial renovation efforts are required: currently, only 1% of the housing stock is renovated each year, and tangible reductions in heating consumption would require at least 4%.

Transport also offers significant potential: it represents 30% of final energy demand and nearly 40% of CO_2 emissions (final demand). There is room for improvement in such areas as Internal combustion engine efficiency, hybrid vehicle use, vehicle size and tyre friction.

In the European Union, energy efficiency policies gain momentum. With buildings representing nearly 40% of final energy consumption and 30% of CO_2 emissions, the EU's Clean Energy Package includes a non-legally binding commitment to improve energy efficiency by 32.5% by 2030. The directive on buildings energy performance was revised in 2018 to include ambitious thermal renovation objectives such as near-zero energy buildings by 2050. It plans heavy investment in new technologies, such as smart grids, to lower energy consumption in buildings.

In addition, the European Green Deal intends to "at least double" the average thermal renovation rates of housing stocks in Member States (currently between 0.4% and 1.2%). This started in 2020 with the assessment of national long-term renovation plans.

ENERGY CONSUMPTION IN BUILDINGS BY END-USE AND RESIDENTIAL HEATING INTENSITY BY SCENARIO IN THE EUROPEAN UNION



Source: IEA – World Energy Outlook 2018

Renovation rates in the different scenarios are as follows:
CPS: 0.8% of the housing stock is renovated each year, which generates a 3% rise in energy consumption attributable to buildings.
STEPS : 2% of the housing stock, implying a 10% decline in energy consumption.
SDS: 2.5% until 2025 and 4% beyond, implying an over 20% decline in energy consumption.
Each of the scenarios embed other measures, but renovation has the greatest impact.

Energy sufficiency

An essential lever but still confined to local initiatives

Energy sufficiency', or sobriety, has long been overlooked but is now emerging as a crucial lever in the fight against global warming. Reducing energy consumption through changes in behaviour, lifestyle and social organisation extends the logic of the 1987 Bruntland report*, highlighting the necessity of compromising between our material and social needs and the ecosystem's environmental limits.

A society committed to energy sobriety would alter its social norms, perceptions of individual needs and collective organisation to obtain **a voluntary and orderly reduction in energy consumption.** This collective effort would both limit the negative externalities associated with consumption and production (pollution, noise, health problems, etc.) and, more broadly, improve quality of life. It entails measures such as limiting room temperature at home, reducing the number of electronic devices, promoting cycling and working more from home, in other words "doing less to use less" (see table). In the context of climate emergency, more radical measures have also been suggested, notably by young people. Sweden's *flygskam* ('flight shame') initiative is a good example.

Current energy sufficiency strategies mainly consist of incentives to reduce energy consumption, usually at local level. The effectiveness of individual schemes has been measured and a great many practical examples have been collated. The Energise** consortium lists 1,067 sustainable energy consumption initiatives in the EU, covering a wide variety of local projects. For example, France's *Familles à énergie positive* ('positive energy families') initiative promoted energy savings in 30,000 households, resulting in a average 12% reduction in consumption. Similarly, the '2000-watt society'*** campaign in Zurich reduced primary energy consumption from 5,000 W to 4,200 W per inhabitant in ten years.

In the private sector, sharing has been one of the pillars of energy sobriety. In the USA, car sharing has lowered household fuel consumption by 5% by saving duplicated mileage and via parking infrastructure savings.

Energy sufficiency has still not been deployed on a large scale, however. It remains the blind spot in most energy policies and scenarios, mainly because it continues to be seen as restrictive. In political and economic terms, the concept is widely perceived as incompatible with the growth models that still guide public policy, with only timid attempts to challenge them. At the level of private individuals, preaching energy temperance runs counter to prevailing notions of comfort and social norms based on material abundance and consumerism. More generally, it also raises questions over the fair sharing of consumption reduction when energy poverty remains a threat to many households.

*The Brundtland Report is the name commonly given to the publication officially titled "Our Common Future", produced in 1987 by the United Nations World Commission on Environment and Development. Used as a basis for the Earth Summit of 1992, this report uses for the first time the expression "sustainable development".

**Energise: Research network, good practices and innovation for sustainable energy.

*** The concept of a 2,000-watt society aims to reduce primary energy consumption corresponding to a continuous average power of 2,000 watts per person for a year and to GHG emissions of 1 tonne of CO_2 equivalent per person and per year; primary energy consumption and GHG emissions are calculated from final energy consumption by applying primary energy factors or GHG emission factors.

Typology of energy sufficiency measures

	INDIVIDUAL LEVEL	COLLECTIVE LEVEL
USE	**USAGE SUFFICIENCY** Limitation of the level and duration of equipment use. ○ e.g., speed reduction, repairing, eco-design...	**COLLABORATIVE SUFFICIENCY** Collective organizations and pooling of goods. ○ e.g., carpooling, house share, third places...
DESIGN	**SIZING SUFFICIENCY** Adaptation of equipment sizing to needs. ○ e.g.,room temperature, car size, reduced diet...	**SPACIAL ORGANIZATION SUFFICIENCY** Collective incentive organization (land use planning). ○ e.g., urban design, circular economy, local distribution...

Source: NégaWat

Energy sufficiency

Despite its limited cost and its potentially immediate impacts, energy conservation measures at the global level are hardly considered in long-term trajectories. 'NégaWatt 2050', one of the rare energy scenarios that explicitly takes account of sobriety, considers that it could reduce energy demand by 28% by 2050 (out of a 50% total contraction, the other 22% coming from energy efficiency - study for France).

IEA's SDS (2°C scenario), Greenpeace's Energy [R]evolution and BP's Rapid Transition scenarios include some sobriety measures, notably the circular economy and changes in transport modes, but do not identify sufficiency concept as such. For instance, recycling improves with a used plastics collection rate rising from 15% currently to 30% by 2040 in the Rapid Transition, and to 34% in the SDS; modal shifts accelerate with less than 200 million private cars by 2040 to the benefit of 2 and 3 wheelers and public transport in the SDS; rail is gradually preferred to air travel and road freight in the Energy [R]evolution; car sharing and the functional economy are part of the Rapid Transition; and reducing unnecessary journeys by teleworking and videoconferencing is mentioned in all three.

These scenarios offer no proactive or forward-thinking on energy sobriety, however, and the subject is often marginalised. Urban eco-design is not handle; changes in lifestyle are not central to any vision but are assumed to arise from exogenous trends. Measures relating to food systems and agricultural production are ignored altogether.

As we have seen, reaching the 2°C trajectory will prove difficult if it is to rely solely on energy efficiency and electrification of final uses, which in turn put severe pressure on the development of new technologies and questions their feasibility. **In contrast, energy sufficiency offers a certain and accessible reduction in energy consumption.** Focused on social changes rather than on technical progress, sobriety contributes to a more resilient model that depends less on financing capacities and the availability of raw materials. It is also less exposed to the rebound effects that have so far neutered most energy efficiency progress. By promoting behaviour that uses less energy, sobriety relieves pressure on renewable sources, particularly in terms of demand, thereby facilitating RES development.

The Covid-19 pandemic has had marked environmental consequences. By highlighting ecosystem vulnerability, it may have a lasting effect on behaviour and encouraged energy sufficiency. Many of the solutions put forward to stave off future pandemics match sobriety choices, such as local and circular economies, industrial relocation, digitalisation and reduced mobility.

Some of the major changes that the crisis triggered in a very short time could last:

- Teleworking and further digitalisation: a third of the world's workforce is expected to keep working from home at least part of the time post-crisis (source: Global Workplace Analytics, 2020).
- Air traffic: airlines expect a permanent change in travel patterns, with less business travel (source: Sorensen, 2020; Boone et al., 2020). The number of flights is expected to resume pre-crisis levels only slowly (source: IATA, 2020).
- Other attitudes could change, notably in areas such as consumption, prudential savings, health and food security, less concentration and relocation.

In France, for instance, the *Le jour d'après* ('the day after') online consultation launched in April by Matthieu Orphelin and 66 other parliamentarians from different parties showed what French people consider to be priorities: health, sobriety, solidarity and sovereignty.

Green finance

Financing the energy transition requires the development of specific instruments, collectively known as green finance

Energy transition financing has long struggled with a number of difficulties related to poor returns on low-carbon projects, the higher risk of these projects compared with traditional projects and a lack of appropriate financial tools. Moreover, the economic situation has tended to favour projects with the highest GHG emissions..

- Traditional financing is not sufficiently geared towards the specifics of energy transition projects: economic analysis of project financing is short-term, the banking system's macro-prudential rules limit access to credit for such projects and risks related to global warming are not factored in (physical risks: destruction of infrastructure; legal risks: compensation to victims; financial risks: stranded assets).
- Moreover, low carbon projects lack competitiveness because of their high capital costs (RES projects are very capital intensive and expensive), slow return on investment (20-40 years), low rates of return, high technical and economic risks and their failure to take positive externalities into account.
- Finally, a number of countries around the world still maintain economic regulations that favour high-carbon growth; these include in particular subsidies to fossils (coal and oil for 90%) through lower sales tariffs. By masking price signal, their enormous weight ($5 trillion* according to a 2017 IMF assessment) hampers economic incentives for energy transition projects.

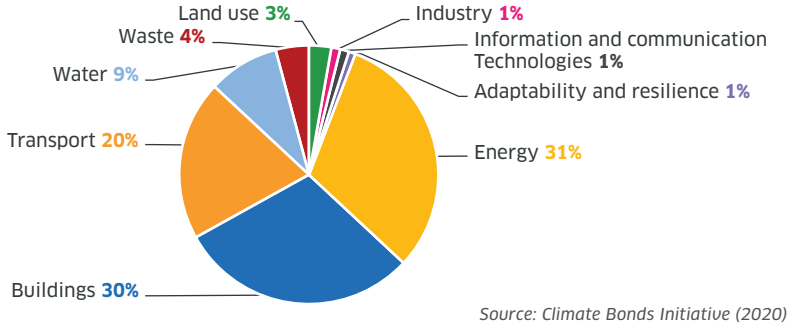
This explains why, despite of evident demand, abundant savings and low interest rates, private investment is still directed largely at fossil fuels.

- In 2019, out of a total of $1,900 bn invested in energy, $600 bn went to clean technologies (RES, energy efficiency, batteries), $50 bn to nuclear, $250 bn to power networks, and over half of the total to coal, oil and gas ($1,000 bn).
- Green investments are far from sufficient to secure energy transition. Investment in renewable electricity amounted to $310 bn in 2019, for example, and $600 bn per year is required under 2°C scenario projections. Similarly, energy efficiency schemes totalled $250 bn in 2019, compared with the $900 bn annual requirement.

In order to bypass these difficulties, the financial system adapted and developed specific instruments. In the space of a few years, green finance has become an important part of ecological transition financing. The term covers all financial actions and operations aimed at redirecting funds towards the decarbonization of the economy and the fight against global warming (energy efficiency, RES, green mobility, electricity infrastructures, etc.). Dating back to a 2007 initiative on the part of the IPCC and European Investment Bank and the first-ever green bond issue, green financing has been booming recently. Cumulated issues exceeded $1,000 bn in 2019, although it has to be said that they accounted for just 0.9% share of the bond market at the end of that year. Such a trend, which reflects the fact that environmental issues are increasingly part of financial players' and investors' decision-making (climate risk mitigation, stakeholder pressure, willingness to act on climate issues), involves standardisation of processes, innovative tools and favourable regulations.

* After-tax public subsidies for the consumption of coal, motor fuels and petroleum fuels.

DETAILED ALLOCATION OF GREEN BONDS AND LOANS IN 2019 (WORLD)
TOTAL: $257.7 BN



Source: Climate Bonds Initiative (2020)

Green finance

Faster development of green finance following instrument standardisation and diversification

Green bonds are currently the main instrument used in green finance. They are issued on the bond market by financial institutions (37%) and states (29%), but also by large companies, such as Engie (the leading industrial issuer of green bonds in 2019 with €3.4 bn issued, and a total of €11 bn issued since 2014), and a few local authorities. They involve sustainable projects meeting specific ethical, environmental and social criteria in areas such as renewable energy, energy efficiency, clean transport and water management. In the USA, the Federal National Mortgage Agency has issued nearly $75 bn of green bonds to fund the renovation of rental accommodation in order to improve their energy and water efficiency.

World bond issues and green loans hit a new record in 2019 at $257.7 bn, up 51% from 2018. The European Union alone represents 45% of this volume; this share is set to increase further in the coming years, with the launch of the Green Deal Investment Plan, which is expected to fund at least €1,000 bn worth of green investment over the coming decade. Asia-Pacific and North America account for 25% and 23%, respectively. Driven mainly by China, emerging countries' issuance increased by 21% in 2019, to $52 bn. Continued geographical diversification saw green bond issues for the first time for Russia, Kenya, Greece, Ecuador and Saudi Arabia.

The global standardisation and harmonisation of green finance principles has boosted its expansion. The International Capital Market Association has circulated its 'Green Bond Principles', a set of rules and indicators providing a frame of reference for selecting investment projects and the use of funds. The EU is also pioneering in this area: apart from its 'Green Bond Standard' project, it is working on a common classification system to distinguish 'green' and 'sustainable' sectors. This will enhance market efficiency and help to direct capital flows towards assets that genuinely contribute to ecological transition.

Momentum behind greener finance also depends on the diversification of its instruments and, more broadly, a change in attitudes. New labels are emerging, such as Greenfin, introduced in June 2019 by the French ecological transition ministry. Their objective is to improve the efficiency, transparency, comparability and credibility of green investments and the market as a whole. So-called transition bonds are designed to help polluting industries fund conversion to cleaner operations. Their increasing popularity among issuers has led to fears among observers that they are being used for greenwashing purposes. In the light of these developments, some banks now specifically embed climate risk in their macro-prudential assessment systems and take environmental impacts into consideration in their credit decisions.

The development of green finance is not obstacle-free, however, and needs continuing close support from government. Green bond issuance involves demanding and complex formalities, notably with regard to the preparation and the release of environmental reporting. This turns many players away from green bonds, especially as the financial incentives – apart from demonstrating ecological commitment and diversifying sources of funding – are uninspiring. Investor demand for green financing now exceeds issuers' ability to identify eligible projects, resulting in a supply shortage.

CO_2 Capture, Utilization and/or Storage (CCUS)

The interest for the CCUS chain has been gaining momentum, as the need to decarbonize is becoming increasingly critical. Despite significant progress and the technical maturity of the technology, CCUS is still facing challenges from a commercial and public acceptance side

Over the last 10 years, notable progress has been made in the deployment of the CCUS industry. In 2019, the number of large-scale CCS facilities increased to 51: 19 are operating, 4 are under construction, 10 are in advanced development in a front-end engineering design phase (FEED); and 18 are in early development (CCS Institute).

- Most projects take place in the US in the oil & gas sector, where the captured CO_2 is largely being used for Enhanced Oil Recovery (EOR)*. Other key areas for the capture business include the natural gas processing as well as chemical and hydrogen production. Large industrial sites have also recently started operation in the power sector (coal). CCUS seem to be gaining momentum, with new projects in advanced and early development phase.

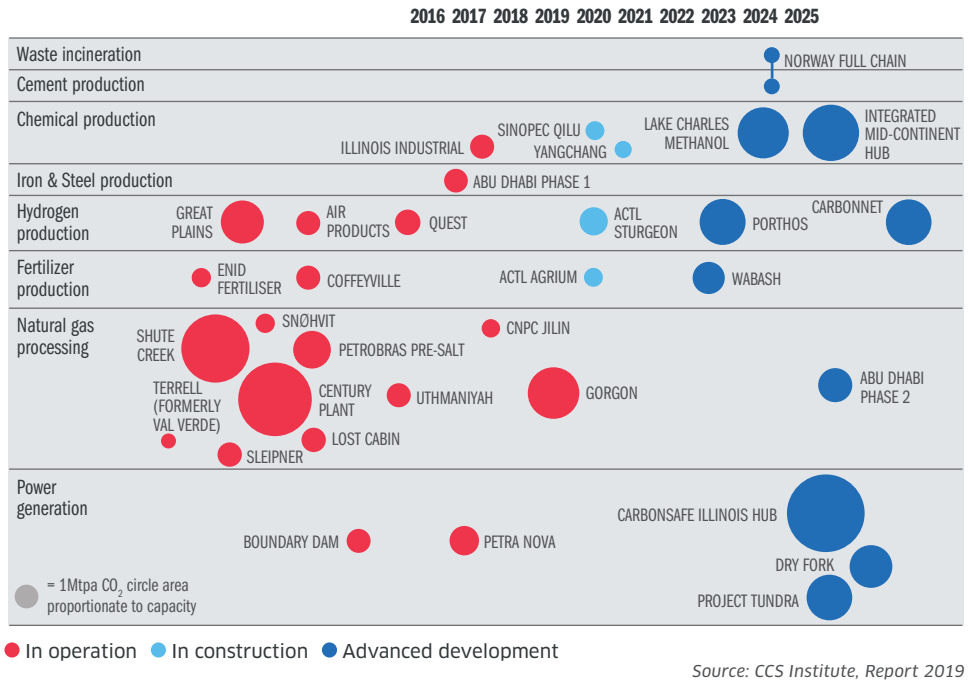
- The key players promoting the CCUS technology encompass mostly the oil & gas companies (to preserve their assets and resources), the mid-stream gas companies (TSO, to start decarbonizing their networks), power producers (to decarbonize their fleet) and industrial players (like iron & steel, cement or hydrogen producers, to decrease their carbon footprint).

- The CCUS chain is however still facing difficulties and there are only a limited number of large-scale commercial operations worldwide, in particular due to the lack of regulatory policy and incentives, tough competition from alternative technologies, public acceptance challenges, and the insufficient value of CO_2. The main issues to be tackled are however quite well known, including the question over the long-term liability on underground storage.

- New paths for the utilization of CO_2 are also emerging, as it can become a valuable feedstock to create new low carbon products, in particular decarbonized synthetic fuels (e-methane, e-kerosene, etc), but also for building materials for example.

*Enhanced oil recovery (EOR) is a technique based on CO_2 and water injection which allows to upgrade crude oil extraction from oil fields.

INSTALLATIONS OF CCUS IN THE WORLD



Source: CCS Institute, Report 2019

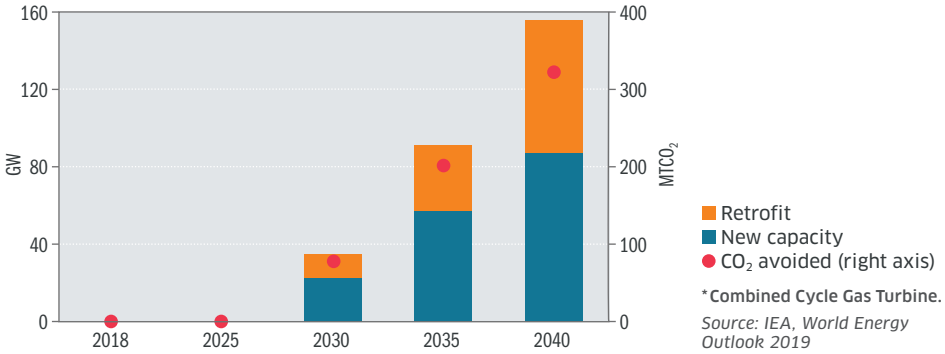
CO_2 Capture, Utilization and/or Storage (CCUS)

On top of renewable energies, energy efficiency and green gases, CCUS is likely to play a role in the scenarios which target the highest decarbonization goals

There is a broad consensus that CCUS should be one of the technologies in the portfolio of solutions to change the emissions trajectory of the energy systems in a cost effective way; CCUS has indeed a role to play to reach the most ambitious climate targets, however it should be noted that its potential should be limited to certain segments like the harder-to-abate sectors, where alternatives are immature, too costly or unavailable. It should be noted that CCUS also offers the possiblity to foster negative emissions using bio-energy (BECCS).

- According to the IEA (WEO 2019), CCUS will need to contribute to 9% of the cumulative emissions reduction by 2050 in order to reach the targets of the Sustainable Development Scenario (SDS). They estimate that ~0.7 Gt of CO_2 should be captured each year by 2030, rising to 2.8 Gt in 2050, split between power and industry.
- According to IPCC (5th Assessment Report), the costs for achieving CO_2 levels consistent with temperatures 2°C above preindustrial levels will be more than twice as expensive without CCUS.
- The development of CCUS should not however hinder the resources allocated to energy efficiency and renewables (including green gases), which should remain the main pillars of the energy transition. The results on the role of CCUS in the mix and the cost of decarbonization are moreover very dependent on the costs of the CCUS chain, which remain uncertain in particular for storage. The storage volume potential is also uncertain.

INSTALLED CCGTs* EQUIPPED WITH CCUS AND EMISSIONS AVOIDED IN THE SUSTAINABLE DEVELOPMENT SCENARIO (IEA)



*Combined Cycle Gas Turbine.

Source: IEA, World Energy Outlook 2019

Electricity & Renewables

PRODUCTION CAPACITY

Renewable energy accounted for three quarters of additional power capacity in 2019

COVID-19

Lower demand during lockdown benefitted RES.
Their share in the electricity mix climbed to 28% over the first quarter of 2020

Electricity and energy transition

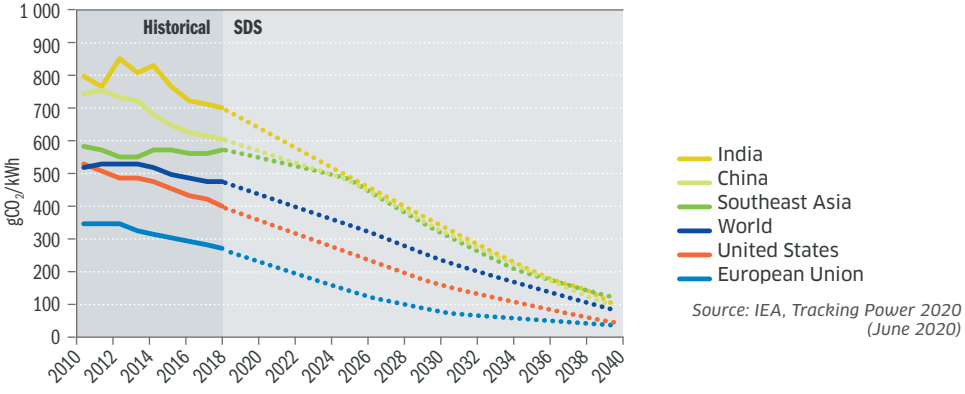
Despite recent progress, more effort on RES is needed to meet energy transition goals

As electricity represents a rapidly growing share of energy consumption (20% of final demand in 2019) and is also the biggest source of energy-related CO_2 emissions (45% in 2019), power generation has become a critical element in the energy transition process. The power sector's transformation started some twenty years ago and it is now a major lever in fighting global warming and extending energy access worldwide. Renewable energy costs have decreased – solar PV has become the most competitive power source in China and India in 2020 – and power generation is increasingly green, but additional efforts remain indispensable to meet the IEA's Sustainable Development Scenario (SDS) objectives.

Despite improving results and a positive overall dynamic, power sector trends are generally below SDS requirements. This is the case of carbon intensity, for which the decline recorded in 2019*, although substantial (-2.5%, against -1% in 2018), remains far from sufficient compared to the 5.6% contraction that is required annually until 2030. Coal's resilience is particularly troublesome: despite a record contraction in output, coal still represented 36.4% of the power mix in 2019. That is far greater than its SDS targets (16.5% by 2030 and 6% by 2040). The main indicator of clean energy progress is the share of low carbon technologies (RES, nuclear, CCS**) in the power generation mix; it rose 1.1% to 37% in 2019, but is still a long way from the 60% objective set for 2030. Only the rapidly growing solar PV and biomass sectors, up 22% and 5%, respectively, were showing trends in line with the SDS at end-2019.

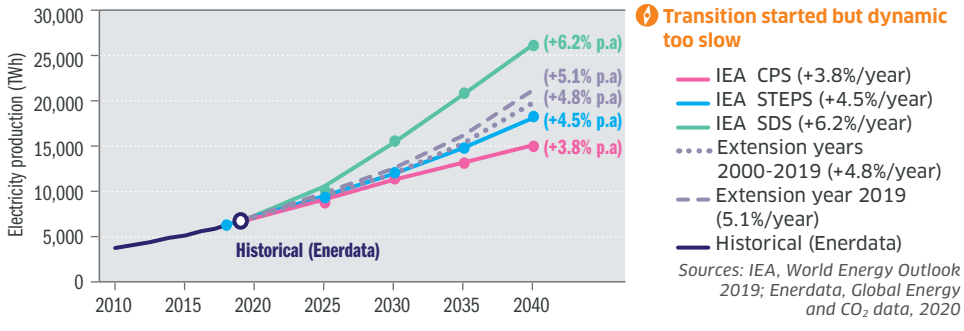
*Carbon intensity of world power generation in 2019: 463 gCO_2/KWh.
**Decarbonization of fossil fuel-based electricity generation through carbon capture and storage (see chapter Decarbonization).

CARBON INTENSITY OF ELECTRICITY GENERATION



Source: IEA, Tracking Power 2020 (June 2020)

RENEWABLE ELECTRICITY PRODUCTION – WORLD



Sources: IEA, World Energy Outlook 2019; Enerdata, Global Energy and CO_2 data, 2020

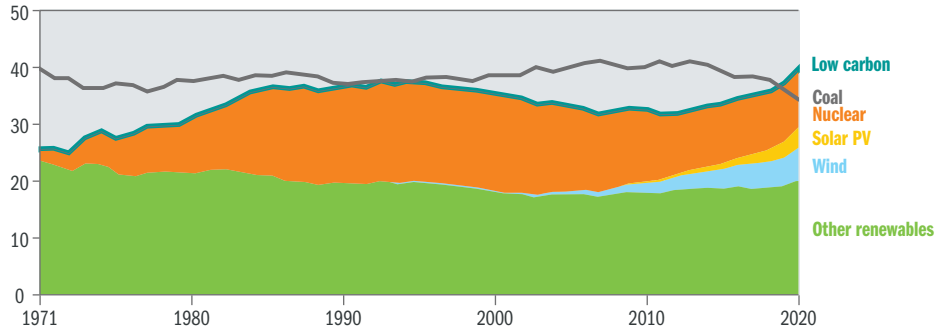
Electricity and energy transition

By causing unprecedented upheavals in demand, the Covid-19 crisis has ironically helped – temporarily at least – energy transition within the electricity sector. While fossil power generation was severely hit – coal-fired production is expected to contract 10% in 2020, much more than the -6.4% SDS target out to 2040 –, renewable energy proved particularly resilient, reaching 28% of the electricity mix over the first quarter. Even though these figures are exceptional and may falter once the crisis is over, they do point to the magnitude of what is required to meet the Paris Agreement and offer early insight on the challenge facing the electricity sector in the coming years.

The growing use of electricity and the increasing share of RES raise questions, notably regarding the robustness and security of electricity supply systems. While electricity demand is expected to increase 50% by 2040 in the SDS (900 million people accessing the network, wider use of air conditioning, affordable electrical cars, etc.), the intermittency of renewable production, notably in solar and wind power, makes the balancing of electricity supply with demand a critical issue. Flexibility is a prominent concern. Apart from extending and upgrading networks (investments worth $270 bn in 2019), developing natural gas, biomethane and hydrogen production capacity, and enhancing demand-side management mechanisms, the deployment of battery storage capacity (+2.9 GW in 2019) stands out as a high-potential alternative, specially since it has become much cheaper over the recent years (-45% between 2012 and 2018) and offers great modularity.

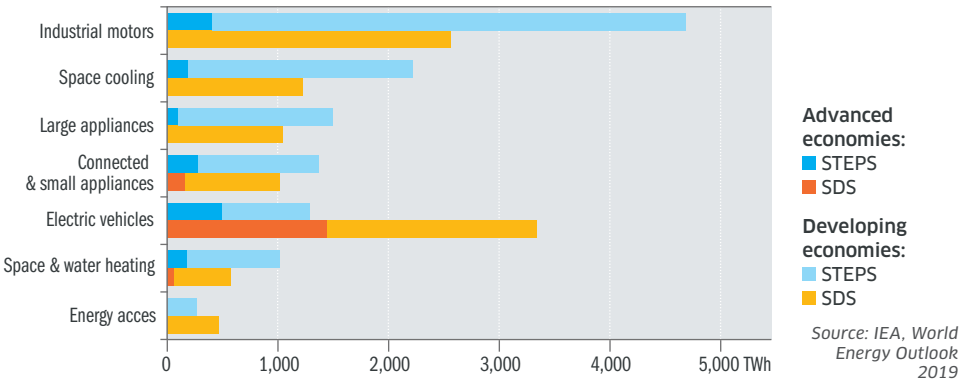
Moreover, although the necessity for energy transition is increasingly accepted, large-scale deployment of renewable technology continues to fuel some debates. Among them, the controversy surrounding the extraction of the ores needed to produce PV panels and batteries, the impact of hydroelectric dams on ecosystems and local populations, or the protest movement against windfarm installation – 70% of these projects in France are subject to legal proceedings on the grounds of noise and visual pollution.

GLOBAL GENERATION SHARES FROM COAL AND LOW-CARBON SOURCES (1971-2020)



Sources: IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020

ELECTRICITY DEMAND GROWTH BY END-USE AND SCENARIO IN ADVANCED AND DEVELOPING ECONOMIES (2018-2040)



Source: IEA, World Energy Outlook 2019

Electricity and energy transition: generating capacity forecast

GENERATING CAPACITY FORECAST BY SOURCE IN THE IEA SCENARIOS (GW)

Generating capacity forecast by source (GW)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Coal	2,079	2,111	2,171	0.2%	16.6%	1,644	1,153	-2.6%	7.4%
Oil	450	298	239	-2.8%	1.8%	294	240	-2.8%	1.6%
Natural gas	1,745	2,254	2,651	1.9%	20.2%	2,084	2,304	1.3%	14.9%
Nuclear	419	436	482	0.6%	3.7%	482	601	1.7%	3.9%
Renewables	2,517	5,019	7,233	4.9%	55.2%	6,359	10,626	6.8%	68.7%
Hydro	1,290	1,586	1,822	1.6%	13.9%	1,728	2,090	2.2%	13.5%
Bioenergy	146	224	286	3.1%	2.2%	272	425	5.0%	2.7%
Wind	566	1,288	1,856	5.6%	14.2%	1,721	2,930	7.8%	18.9%
Geothermal	14	27	46	5.5%	0.4%	,43	82	8.3%	0.5%
Solar PV	495	1,866	3,142	8.8%	24.0%	2,537	4,815	10.9%	31.1%
CSP	6	23	61	11.4%	0.5%	52	254	18.9%	1.6%
Marine	1	4	20	17.8%	0.2%	6	30	20.0%	0.2%
Total capacity	7,218	10,244	13,109	2.7%	100%	11,042	15,478	3.5%	100%

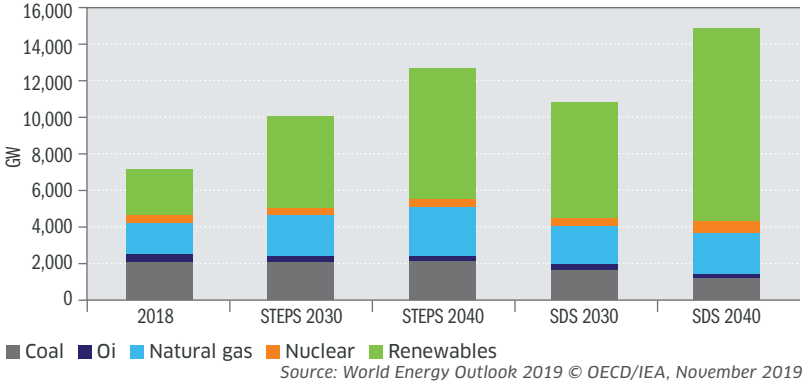
Source: World Energy Outlook 2019 © OECD/IEA, November 2019

GENERATING CAPACITY FORECAST BY REGION IN THE IEA SCENARIOS (GW)

Generating capacity forecast by region (GW)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	1,305	1,579	1,753	1.4%	13.4%	1,691	2,066	2.1%	13.3%
North America	1,429	1,655	1,934	1.4%	14.8%	1,702	2,228	2.0%	14.4%
Latin America	359	483	600	2.4%	4.6%	472	603	2.4%	3.9%
Asia Pacific	3,218	5,287	7,161	3.7%	54.6%	5,841	8,522	4.5%	55.1%
CIS	331	365	407	0.9%	3.1%	344	424	1.1%	2.7%
Middle East	331	476	641	3.1%	4.9%	508	783	4.0%	5.1%
Africa	244	400	614	4.3%	4.7%	484	852	5.9%	5.5%
Total capacity	7,218	10,244	13,109	2.8%	100%	11,042	15,478	3.5%	100%

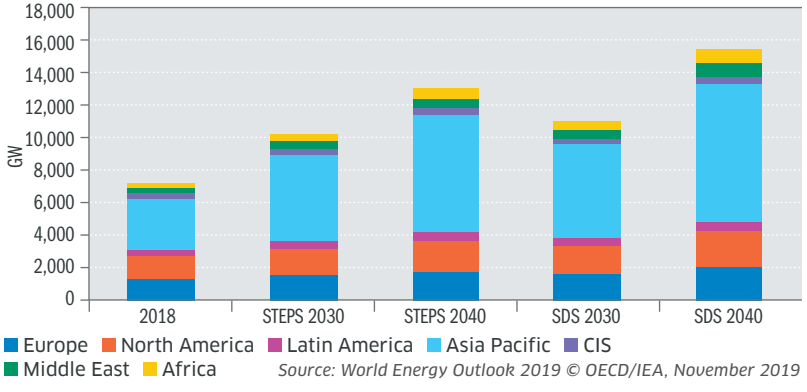
Source: World Energy Outlook 2019 © OECD/IEA, November 2019

GENERATING CAPACITY FORECAST BY SOURCE IN IEA STATED POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIOS



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

GENERATING CAPACITY FORECAST BY REGION IN IEA STATED POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIOS



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

Electricity and energy transition: generation forecast

ELECTRICITY GENERATION FORECAST BY SOURCE IN THE IEA SCENARIOS (TWH)

Electricity generation forecast by source (TWh)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Coal	10,123	10,408	10,431	0.1%	25.2%	5,504	2,428	-6.3%	6.3%
Oil	808	622	490	-2.3%	1.2%	355	197	-6.2%	0.5%
Natural gas	6,118	7,529	8,899	1.7%	21.5%	7,043	5,584	-0.4%	14.4%
Nuclear	2,718	3,073	3,475	1.1%	8.4%	3,435	4,409	2.2%	11.4%
Renewables	6,799	12,479	18,049	4.5%	43.6%	15,434	26,065	6.3%	67.3%
Hydro	4,203	5,255	6,098	1.7%	14.7%	5,685	6,934	2.3%	17.9%
Bioenergy	636	1,085	1,459	3.9%	3.5%	1,335	2,196	5.8%	5.7%
Wind	1,265	3,317	5,226	6.7%	12.6%	4,453	8,295	8.9%	21.4%
Geothermal	90	182	316	5.9%	0.8%	282	552	8.6%	1.4%
Solar PV	592	2,562	4,705	9.9%	11.4%	3,513	7,208	12.0%	18.6%
CSP	12	67	196	13.7%	0.5%	153	805	21.2%	2.1%
Marine	1	10	49	19.0%	0.1%	14	75	21.3%	0.2%
Total generation	26,603	34,140	41,373	2.0%	100%	31,800	38,713	1.7%	100%

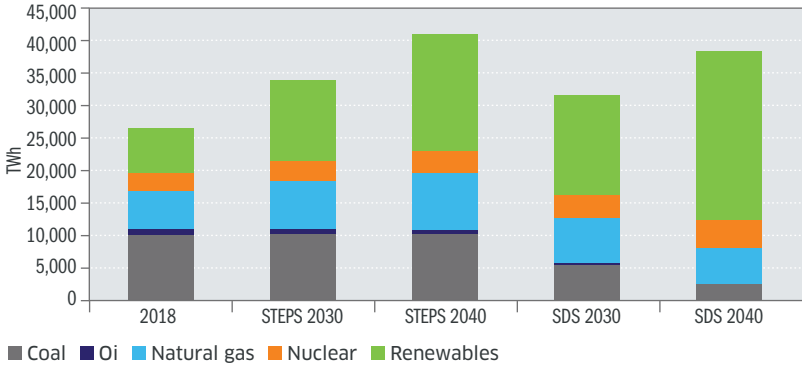
Source: World Energy Outlook 2019 © OECD/IEA, November 2019

ELECTRICITY GENERATION FORECAST BY REGION IN THE IEA SCENARIOS (TWH)

Electricity generation forecast by region (TWh)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	4,163	4,478	4,840	0.7%	11.7%	4,429	5,246	1.1%	13.6%
North America	5,430	5,780	6,277	0.7%	15.2%	5,527	6,186	0.6%	16.0%
Latin America	1,310	1,734	2,198	2.4%	5.3%	1,592	1,975	1.9%	5.1%
Asia Pacific	12,327	17,731	22,245	2.7%	53.8%	16,208	19,984	2.2%	51.6%
CIS	1,360	1,565	1,747	1.1%	4.2%	1,362	1,437	0.3%	3.7%
Middle East	1,147	1,570	2,169	2.9%	5.2%	1,416	1,909	2.3%	4.9%
Africa	866	1,284	1,898	3.6%	4.6%	1,267	1,976	3.8%	5.1%
Total generation	26,603	34,140	41,373	2.0%	100%	31,800	38,713	1.7%	100%

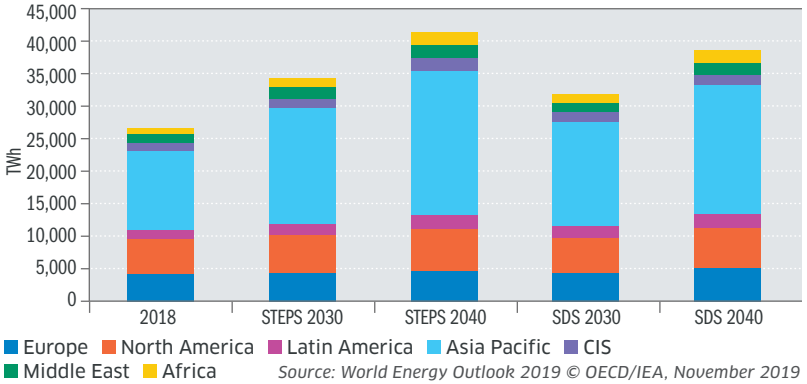
Source: World Energy Outlook 2019 © OECD/IEA, November 2019

ELECTRICITY GENERATION FORECAST BY SOURCE IN IEA STATED POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIOS (TWH)



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

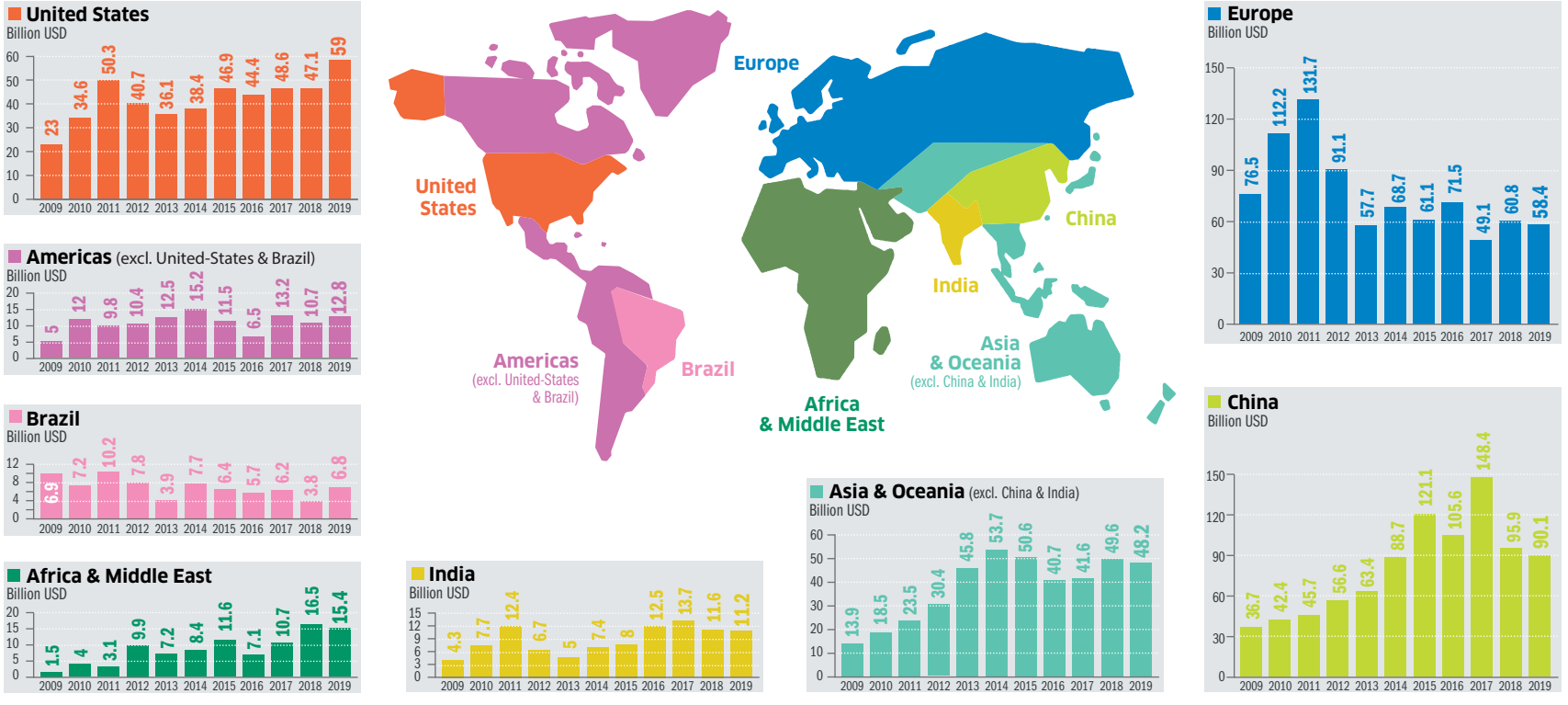
ELECTRICITY GENERATION FORECAST BY REGION IN IEA STATED POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIOS (TWH)



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

Electricity and energy transition: renewable electricity investment

GLOBAL INVESTMENT IN RENEWABLE POWER AND FUELS BETWEEN 2009 AND 2019 (BILLION USD)



Source: REN21, Renewables 2020 Global Status Report; Bloomberg New Energy Finance

Electricity: production capacity

RES represented three-quarters of additional power capacity in 2019, and should remain largely prominent in 2020

World electricity net capacity growth decelerated slightly to 3% (+223 GW) in 2019, following an average 4% since 2000. Total installed capacity reached 7,399 GW. A geographical breakdown confirms Asia's prominent role, with a 65% share of world additional capacity (+147 GW), despite a certain loss of steam in 2019 (up 4.6%), compared to 2018 (up 5.4%). The Pacific region (up 7.5%) and Latin America (up 5.7%) progressed strongly, confirming momentum dating back to 2018. The trend is less marked in OECD countries, with Europe in the 2% range (up 2.2% in 2019 and 1.8% in 2018), and North America nearly unchanged (up 0.3% in 2019 and 0.6% in 2018). In Africa, and after a decade of vigorous growth worth an annual average 5.4% since 2010, capacity growth was limited to 0.9%, up just 2 GW.

RES including biomass represented three-quarters of additional power capacity in 2019, with 176 GW coming on stream (up 7.6%). Their share in the world electricity mix is now 34%, with over 2,535 GW installed. Benefitting from lower technology costs and ambitious environmental policies, solar and wind power made up 90% of the additional capacity, at +97 GW (up 21%) and +59 GW (up 11%), respectively.

China maintained its leading position in the solar sector with an additional 30 GW in 2019, despite fewer new PV installations (+17.4% in 2019 versus +33.7% in 2018) on the back of subsidy-related uncertainty. Including the 26 GW of wind power that came on stream in 2019, the country's RES capacity rose to 771 GW, representing 31% of the world total.

In Europe, solar capacity growth was a record 13.5% (+17 GW) in 2019. Wind capacity also rose sharply, by 14 GW (up 7.2%), driven by the connection of nearly 3.6 GW additional offshore capacity in the UK, Germany and Belgium (source: WindEurope).

Similarly, RES capacity rose significantly throughout the American continent, notably in the USA (up 6%), where the development of wind power accelerated (+9 GW; up 9.5%), and in Brazil, where hydro capacity gained 5 GW and solar capacity doubled.

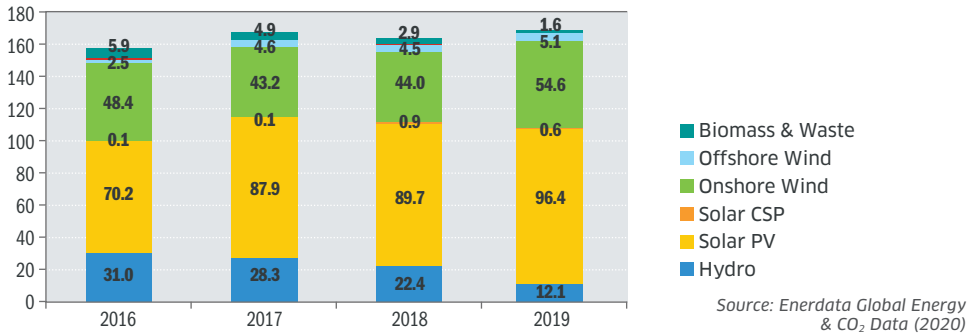
Despite increases in Egypt (+25,5%) and the United Arab Emirates (+217%) - although volumes remain relatively low –, Africa and the fossil fuel producers of the CIS and Middle East did not participate in these trends.

The pace of RES development should slow in 2020 however; supply chain disruption and financing issues have already caused construction delays.

According to the IEA, new RES capacity could be 13% lower in 2020 than it was in 2019, with solar PV down 17% and wind down 12%. Despite this downturn, world capacity is set to rise 6% in 2020 before resuming its previous rhythm, notably with two hydro mega-projects partially coming on stream in China.

Given the impact of Covid-19 on power investments (see Chapter 1, Energy investments), RES should suffer less than fossil fuels and remain largely prominent in terms of new power capacity in 2020.

ANNUAL INCREASE IN GLOBAL ELECTRICAL RES CAPACITY BY SOURCE (IN GW)



Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: production capacity

Additional natural gas capacity slowed abruptly to just 1% in 2019, well below the 4% annual average recorded since 2000. This represents an additional 17 GW worldwide, compared to 45 GW in 2018, for a total gas-fired capacity of 1,713 GW (23% of power capacity). The main contributors to the past few years' expansion, the US (+4 GW), the Middle East (+3 GW) and Africa (+2 GW) saw much weaker progressions in 2019 than in 2018. Led by Mexico (+3.2 GW), Latin America posted the biggest rise (up 5%).

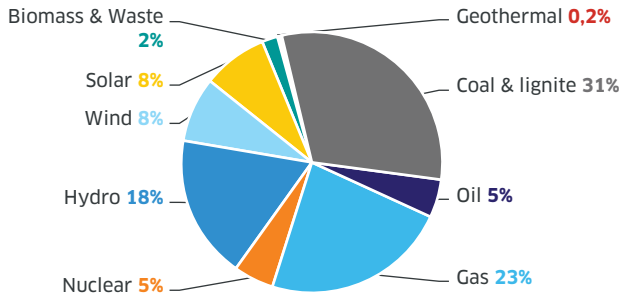
Coal-fired capacity is now growing at a much slower pace than it was in the 2000s: up 1.6% in 2019, 1.4% in 2018 and 2% in 2017, against an annual average 3% over the two previous decades.

Asia hosts 90% of the world's coal-fired power plants aged under 20 and is the only region reporting substantial new capacity. Its additional 55 GW (up 3.5%) mainly come from China (+46 GW; up 4.1%). Africa, up 1.7%, and Latin America, up 1.6%, are far behind. In Europe, energy transition policies are proving effective: coal capacity contracted 4%, and this momentum should strengthen given Germany's intention to exit coal by 2038. Similarly, coal-fired capacity contracted 14 GW (5.3%) in the US, as low gas prices sharpened competition.

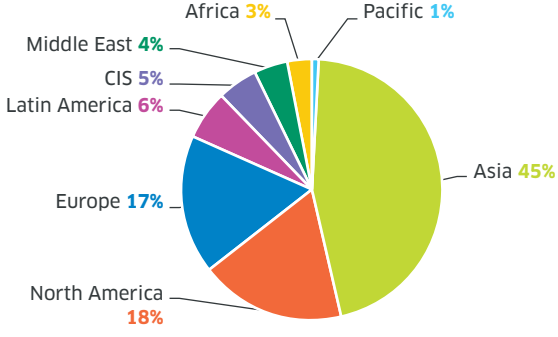
However, despite an increasing number of early shutdown plans and new project cancellations worldwide (Australia, Indonesia, South Africa), over 130 GW of capacity was under construction in early 2020 and an additional 500 GW were in planning stage (of which 180 GW in China and 100 GW in India), according to the IEA.

Nuclear power capacity dropped 4.5 GW (0.9%) in 2019, after five years of steady growth (1.5% per year on average between 2014 and 2018). The addition of 4 GW in China was not enough to offset the shutdown of 13 reactors, five of which in Japan, not counting the final decommissioning of the Fessenheim plant in France in June 2020. Nuclear capacity expansion is set to resume, however, since 54 reactors (57.4 GW), 35 of which in Asia (36.5 GW), are currently under construction in 19 countries (source: IAEA).

SHARE OF GENERATING CAPACITY BY ENERGY IN 2019
TOTAL: 7,399 GW



SHARE OF GENERATING CAPACITY BY GEOGRAPHIC REGION IN 2019
TOTAL: 7,399 GW



Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: generating capacity by power station type

Installed electricity generation capacity (GW)	Total capacity			Thermal capacity				Nuclear capacity				Renewable capacity (excluding biomass)			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area total 2019	2000	2019	Change 2018-2019	Share in area total 2019	2000	2019	Change 2018-2019	Share in area total 2019
Europe	800	1,226	2.2%	442	514	-0.9%	42%	141	122	-1%	10%	217	591	5.6%	48%
European Union	709	1,053	2%	416	453	-1.5%	43%	138	119	-0.7%	11%	154	481	6.3%	46%
Germany	119	223	2.1%	81	91	-1.5%	41%	22	11	0%	5%	16	121	5.1%	54%
France	115	135	1.7%	26	21	0.5%	15%	63	63	0%	47%	25	52	4.9%	38%
North America	958	1,343	0.3%	666	882	-1.1%	66%	118	116	-1.4%	9%	174	345	4.6%	26%
Canada	111	147	0.9%	33	36	1.1%	24%	10	14	0%	9%	68	97	0.9%	66%
United States	847	1,197	0.2%	633	847	-1.2%	71%	108	103	-1.6%	9%	106	247	6.1%	21%
Latin America	222	459	5.7%	93	213	5.1%	46%	4	5	0%	1%	125	241	6.3%	53%
Brazil	74	172	5.4%	11	41	1.7%	24%	2	2	0%	1%	61	129	6.7%	75%
Asia	932	3,321	4.6%	673	2,074	2.7%	62%	69	116	0%	3%	190	1,131	8.8%	34%
China	336	2,054	5.7%	254	1,235	3.9%	60%	2	49	9.1%	2%	80	771	8.4%	38%
South Korea	49	121	3.1%	32	79	-1.7%	65%	14	23	6.4%	19%	3	19	23.3%	15%
India	114	399	3.3%	87	270	0.6%	68%	3	7	0%	2%	25	121	10.1%	30%
Japan	259	342	0.8%	167	194	0.5%	57%	45	32	-13.2%	9%	47	116	5.7%	34%
CIS	329	411	1.8%	234	284	0.3%	69%	32	42	-1.7%	10%	64	86	9.3%	21%
Russia	211	272	1.2%	147	190	0%	70%	20	30	4.1%	11%	44	52	3.8%	19%
Middle East	118	323	2%	111	300	1.3%	93%	0	1	0%	0%	7	22	12.7%	7%
Saudi Arabia	31	86	0%	31	85	-0.5%	99%	0	0	-	0%	0	0.4	300%	0%
Iran	33	80	2.2%	31	67	2.1%	83%	0	1	0%	1%	2	13	2.4%	16%
Africa	102	227	0.9%	78	178	1.3%	78%	2	2	0%	1%	22	47	-0.2%	21%
Egypt	15	57	2%	12	52	0%	90%	0	0	-	0%	3	6	25.5%	10%
South Africa	42	51	1.7%	38	41	2%	80%	2	2	0%	4%	2	9	1.2%	17%
Pacific	55	89	7.5%	40	49	0.2%	55%	0	0	-	0%	15	40	18.6%	45%
Australia	46	78	8.5%	37	46	0%	59%	0	0	-	0%	9	32	23.6%	41%
World	3,516	7,399	3.1%	2,337	4,493	1.3%	61%	366	403	-0.9%	5%	813	2,503	7.2%	34%
OECD	2,118	3,181	1.6%	1,355	1,777	-0.5%	56%	313	291	-2.1%	9%	450	1,114	6.4%	35%
No OECD	1,398	4,218	4.2%	982	2,717	2.5%	64%	53	112	2.5%	3%	363	1,389	7.9%	33%

Source: Enerdata Global Energy & CO2 Data (2020)

Electricity: detail of thermal capacities

Detail of installed thermal capacity (GW)	Total Thermal capacity			Coal & Lignite capacity				Oil capacity				Gas capacity				Biomass & Waste capacity			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019
Europe	442	514	-0.9%	208	189	-3.3%	37%	87	39	2%	8%	137	240	0.3%	47%	10	46	1.4%	9%
European Union	416	453	-1.5%	192	160	-4.1%	35%	84	38	1%	8%	130	211	-0.2%	47%	10	45	0.3%	10%
Germany	81	91	-1.5%	52	51	-2%	56%	7	3	0%	3%	20	27	-1.4%	29%	2	11	0.6%	12%
France	26	21	0.5%	3	3	0%	14%	17	3	-2.8%	16%	6	12	0.4%	59%	1	2	3.7%	10%
North America	666	882	-1.1%	332	260	-5.1%	29%	56	43	-0.7%	5%	263	561	0.9%	64%	14	19	-2.1%	2%
Canada	33	36	1.1%	18	11	0%	30%	8	6	0%	17%	7	16	2.9%	44%	1	3	0%	10%
United States	633	847	-1.2%	315	249	-5.3%	29%	49	37	-0.9%	4%	257	546	0.8%	64%	13	15	-2.6%	2%
Latin America	93	213	5.1%	11	23	1.6%	11%	42	64	7.8%	30%	36	105	5.1%	49%	3	21	1.6%	10%
Brazil	11	41	1.7%	2	5	7.4%	12%	5	8	-1.3%	19%	1	13	1.9%	32%	2	15	1.6%	36%
Asia	673	2,074	2.7%	412	1,638	3.5%	79%	130	106	-2.1%	5%	127	297	0.4%	14%	4	34	3.3%	2%
China	254	1,235	3.9%	225	1,163	4.1%	94%	20	15	0%	1%	8	48	2.2%	4%	1	9	0%	1%
South Korea	32	79	-1.7%	14	37	0.7%	47%	5	3	0%	4%	13	36	-4.5%	46%	1	3	6.9%	3%
India	87	270	0.6%	71	228	0.5%	84%	5	4	-3.1%	1%	10	28	0%	11%	0	10	8.6%	4%
Japan	167	194	0.5%	61	91	0.1%	47%	61	38	-0.9%	20%	42	57	2.1%	29%	2	8	0%	4%
CIS	234	284	0.3%	79	74	-0.5%	26%	24	27	2.6%	9%	130	183	0.3%	64%	1	1	0%	0%
Russia	147	190	0%	42	42	-0.8%	22%	16	16	0%	8%	88	132	0.3%	69%	1	1	0%	0%
Middle East	111	300	1.3%	4	5	0%	2%	49	90	0.5%	30%	58	205	1.7%	68%	0	0	0%	0%
Saudi Arabia	31	85	-0.5%	0	0	-	0%	18	46	-0.7%	54%	13	39	0%	46%	0	0	-	0%
Iran	31	67	2.1%	0	0	-	0%	9	15	0%	22%	23	52	2.9%	78%	0	0	0%	0%
Africa	78	178	1.3%	41	45	1.7%	25%	13	29	-0.9%	16%	24	103	1.7%	58%	0.2	1	0%	1%
Egypt	12	52	0%	0	0	-	0%	2	5	0%	10%	10	47	0%	90%	0	0	-	0%
South Africa	38	41	2%	38	38	2%	92%	0.3	3	0%	7%	0	0	-	0%	0.1	0.2	0%	0%
Pacific	40	49	0.2%	28	25	0%	52%	4	3	3.6%	6%	8	20	0%	40%	1	1	0%	2%
Australia	37	46	0%	27	25	0%	55%	4	2	0%	4%	6	18	0%	40%	0.4	1	0%	2%
World	2,337	4,493	1.3%	1,115	2,258	1.6%	50%	407	399	0.9%	9%	783	1,713	1%	38%	33	123	1.3%	3%
OECD	1,355	1,777	-0.5%	635	605	-3.1%	34%	222	141	0.4%	8%	469	953	1%	54%	28	78	0.5%	4%
No OECD	982	2,717	2.5%	479	1,654	3.4%	61%	184	258	1.2%	10%	314	760	1%	28%	5	45	2.7%	2%

Source: Enerdata Global Energy & CO2 Data (2020)

Electricity: detail of renewable capacities

Detail of installed renewable capacity (GW)	Total Renwable capacity (excluding biomass)			Hydro capacity				Wind capacity				Solar capacity				Geothermal capacity			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019
Europe	217	591	5.6%	203	244	0.3%	41%	13	204	7.4%	34%	0.2	140	13.5%	24%	1	3	8.2%	1%
European Union	154	481	6.3%	141	155	0.3%	32%	13	193	7%	40%	0.2	132	13.2%	27%	1	1	0.7%	0%
Germany	16	121	5.1%	10	11	0%	9%	6	61	3.4%	50%	0.1	49	8.7%	41%	0	0	18.8%	0%
France	25	52	4.9%	25	26	0.1%	50%	0	17	9%	32%	0	9	10.4%	18%	0	0	0%	0%
North America	174	345	4.6%	168	182	0%	53%	3	118	8.9%	34%	0.4	41	15.5%	12%	3	4	-0.1%	1%
Canada	68	97	0.9%	67	81	0.1%	83%	0.1	13	4.7%	14%	0	3	6.6%	3%	0	0	-	0%
United States	106	247	6.1%	100	102	-0.1%	41%	2	104	9.5%	42%	0.4	38	16.4%	15%	3	4	-0.1%	2%
Latin America	125	241	6.3%	123	197	3%	81%	0.1	30	17.5%	12%	0	15	54.6%	6%	1	1	-53.4%	0%
Brazil	61	129	6.7%	61	109	4.8%	85%	0	15	6.9%	12%	0	4	93.6%	3%	0	0	-	0%
Asia	190	1,131	8.8%	185	540	1.1%	48%	2	258	12.7%	23%	0.4	328	20.9%	29%	3	5	5.1%	0%
China	80	771	8.4%	79	356	1.1%	46%	0.3	210	14%	27%	0.1	205	17.4%	27%	0	0	0%	0%
South Korea	3	19	23.3%	3	7	0.3%	35%	0	2	6.4%	8%	0	11	47.3%	57%	0	0	-	0%
India	25	121	10.1%	24	50	0.3%	41%	1	38	6.7%	31%	0	34	33.8%	28%	0	0	-	0%
Japan	47	116	5.7%	46	50	0%	43%	0	4	1%	3%	0.3	62	11.4%	53%	1	1	9.1%	0%
CIS	64	86	9.3%	64	77	2.1%	90%	0	2	94.8%	2%	0	7	221.6%	8%	0	0	0%	0%
Russia	44	52	3.8%	44	50	2.8%	97%	0	0	96.2%	0%	0	1	98.9%	2%	0	0	0%	0%
Middle East	7	22	12.7%	7	16	1%	73%	0	1	1.5%	3%	0	5	72%	24%	0	0	-	0%
Saudi Arabia	0	0.4	300%	0	0	-	0%	0	0	0%	0%	0	0.4	369%	100%	0	0	-	0%
Iran	2	13	2.4%	2	12	1.3%	94%	0	0	7.1%	2%	0	0.4	28.3%	3%	0	0	-	0%
Africa	22	47	-0.2%	22	34	-5.2%	71%	0.1	6	5.5%	12%	0	7	21.8%	15%	0	1	23.9%	2%
Egypt	3	6	25.5%	3	3	0%	47%	0	1	22.2%	24%	0	2	116.3%	29%	0	0	-	0%
South Africa	2	9	1.2%	2	3	0%	40%	0	2	0%	24%	0	3	3.4%	36%	0	0	-	0%
Pacific	15	40	18.6%	15	15	0.1%	37%	0.1	8	22.3%	20%	0	16	40.7%	41%	0	1	0%	3%
Australia	9	32	23.6%	9	9	0.1%	27%	0	7	25%	23%	0	16	40.9%	50%	0	0	-	0%
World	813	2,503	7.2%	786	1 304	0.9%	52%	17	625	10.6%	25%	1	559	21%	22%	9	14	-1.6%	1%
OECD	450	1,114	6.4%	428	493	0.2%	44%	16	337	8.9%	30%	1	275	16.6%	25%	6	9	-7%	1%
No OECD	363	1,389	7.9%	358	812	1.4%	58%	2	287	12.6%	21%	0.1	284	25.5%	20%	3	6	7.3%	0%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: generating capacity – long series

GW	Installed electrical capacity								
	2000	2005	2010	2015	2018	2019	Change 2018-2019	AAGR 2010-2019	Share of world 2019
Europe	800	866	1,012	1,140	1,200	1,226	2.2%	2.2%	17%
European Union	709	763	892	991	1,032	1,053	2%	1.9%	14%
Germany	119	128	162	203	219	223	2.1%	3.6%	3%
Spain	55	77	102	107	107	113	5.6%	1.1%	2%
France	115	116	124	129	133	135	1.7%	1%	2%
Italy	76	86	107	117	115	117	1.5%	1%	2%
United Kingdom	78	82	94	96	106	107	0.2%	1.5%	1%
North America	958	1,186	1,275	1,309	1,340	1,343	0.3%	0.6%	18%
Canada	111	122	131	142	145	147	0.9%	1.3%	2%
United States	847	1,064	1,144	1,168	1,194	1,197	0.2%	0.5%	16%
Latin America	222	263	315	382	434	459	5.7%	4.3%	6%
Brazil	74	93	113	143	163	172	5.4%	4.8%	2%
Mexico	42	52	62	67	76	83	8.3%	3.3%	1%
Asia	932	1,226	1,834	2,633	3,174	3,321	4.6%	6.8%	45%
China	336	531	1,012	1,564	1,944	2,054	5.7%	8.2%	28%
South Korea	49	64	77	96	117	121	3.1%	5.1%	2%
India	114	143	202	318	386	399	3.3%	7.9%	5%
Japan	259	276	286	320	339	342	0.8%	2%	5%
Pacific	55	60	73	80	83	89	7.5%	2.3%	1%
Australia	46	50	62	69	72	78	8.5%	2.6%	1%
Middle East	118	148	217	298	317	323	2%	4.5%	4%
Saudi Arabia	31	39	60	82	86	86	0%	4.1%	1%
Iran	33	44	61	73	79	80	2.2%	3%	1%
CIS	329	337	357	393	404	411	1.8%	1.6%	6%
Russia	211	216	231	259	269	272	1.2%	1.8%	4%
Africa	102	117	142	185	225	227	0.9%	5.4%	3%
Egypt	15	20	27	36	56	57	2%	9%	1%
South Africa	42	43	45	48	51	51	1.7%	1.5%	1%
World	3,516	4,202	5,224	6,420	7,176	7,399	3.1%	3.9%	100%
OECD	2,118	2,464	2,751	2,981	3,130	3,181	1.6%	1.6%	43%
No-OECD	1,398	1,737	2,473	3,439	4,046	4,218	4.2%	6.1%	57%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: consumption

Already weakened by the 2019 economic slowdown, world electricity consumption contracted sharply in 2020 because of Covid-19

In 2019, electricity demand broke its uptrend and decelerated sharply. Slower economic growth and warmer temperatures in several major countries limited the increase in electricity consumption to 0.7% that year, compared with growth worth 3.7% in 2018 and 2.5% per year over the previous decade. In China, which accounted for 28% of the world total, demand remained vigorous, but the 4.5% increase was noticeably weaker than in 2018 (8.5%). The picture was similar in other developing countries, where a combination of increased industrial production, higher revenues and an expanding service sector drove albeit slower growth. All in all, nearly 78% of the additional demand since 2010 is attributable to BRICS alone (Source: Enerdata). In the OECD countries, a stagnation in consumption resulting from improved energy efficiency over recent years turned into outright decline (-1.9%), with lower demand from the industrial and residential sectors. OECD countries' share in world electricity demand has dropped to 42%, against 56% in 2000.

Worldwide, buildings (residential and services) represent 51% of final electricity consumption (11,910 TWh). Industry accounts for 41% (9,380 TWh). Despite higher numbers of electrical vehicles (1.52 million new units on the road in 2019; up 46%), transport still accounts for less than 2% of total demand.

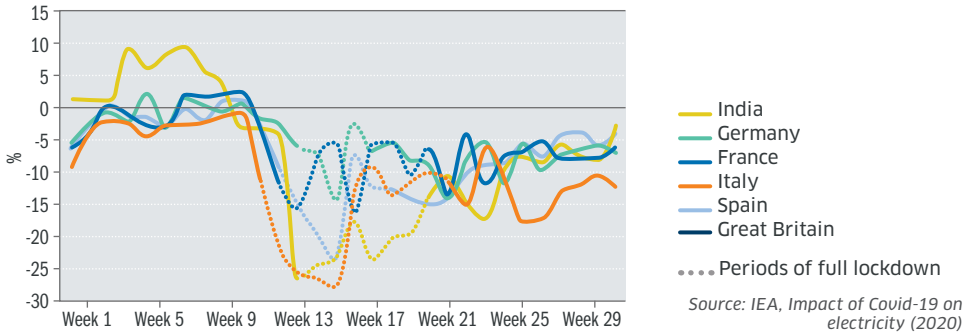
The Covid-19 pandemic and the lockdown measures that followed completely derailed electricity demand in 2020. It dropped 2.5% over the first quarter and will be down 5% over the whole year, according to IEA's early estimates. This would be a decline eight times bigger than that caused by the 2008 economic crisis and would be the deepest plunge since the Great Depression in 1929. According to the IEA, each month of complete lockdown reduces demand by 20% on average, or by 1.5% per year.

China was first country to be hit and recorded the largest decrease in electricity demand over the first quarter, at -6.5%. The impact proved more limited in other regions, where restrictions were introduced more gradually: declines ranged from 2.5% to 4.5% in Europe, Japan and South Korea. At the height of the crisis, France, India and the USA saw daily electricity consumption drop almost 15%.

At sector level, the massive reduction in commercial and industrial demand was only partially offset by an increase in residential consumption as more people stayed at home and worked from there (the rise in residential demand exceeded 40% by the end of March in some European countries). Lockdown also coincided with unseasonably warm weather. Economies heavily dependent on services (retailing, tourism, etc.) were hit particularly hard. This was especially true of Italy, where the impact on electricity has been the most severe in Europe (up to 75% drops in average electricity demand on weekdays in the service sector compared to the same period last year). In the USA, closures of business premises and reduced use of offices and plants is expected to translate into a 3.6% contraction in electricity consumption over 2020, according to the Energy Information Administration.

Although the easing of lockdown measures produced signs of recovery, electricity demand in June was still 10% below its pre-crisis levels in most regions (source: IEA).

YEAR-ON-YEAR CHANGE IN WEEKLY ELECTRICITY DEMAND, WEATHER CORRECTED (2020)



Source: IEA, Impact of Covid-19 on electricity (2020)

Electricity: consumption

Electricity consumption TWh	Total consumption							Residential 2019		Services 2019		Industry 2019		Transport 2019	
	2000	2010	2018	2019	Change 2018-2019	AAGR 2010-2019	Share in area total	TWh	Share in area total	TWh	Share in area total	TWh	Share in area total	TWh	Share in area total
Europe	2,952	3,376	3,410	3,358	-1.5%	-0.1%	15%	941	28%	951	28%	1,225	36%	68	2%
European Union	2,637	2,949	2,892	2,850	-1.4%	-0.4%	12%	799	28%	823	29%	1,013	36%	63	2%
Germany	501	547	525	517	-1.5%	-0.6%	2%	129	25%	141	27%	217	42%	12	2%
Spain	195	250	243	239	-1.5%	-0.5%	1%	69	29%	73	31%	79	33%	5	2%
France	410	472	441	437	-1.1%	-0.9%	2%	158	36%	138	32%	115	26%	10	2%
Italy	279	310	303	301	-0.8%	-0.3%	1%	65	22%	94	31%	115	38%	11	4%
United Kingdom	340	338	308	303	-1.7%	-1.2%	1%	104	34%	91	30%	92	30%	5	2%
North America	4,093	4,439	4,496	4,408	-2.0%	-0.1%	19%	1,595	36%	1,670	38%	941	21%	13	0.3%
Canada	503	544	543	543	0.1%	0%	2%	170	31%	146	27%	181	33%	1	0.2%
United States	3,590	3,894	3,953	3,865	-2.2%	-0.1%	17%	1,425	37%	1,524	39%	760	20%	11	0.3%
Latin America	787	1,129	1,360	1,376	1.2%	2.2%	6%	377	27%	335	24%	573	42%	5	0.4%
Brazil	329	459	528	536	1.6%	1.7%	2%	140	26%	140	26%	201	37%	2	0.4%
Mexico	148	221	295	307	4.1%	3.7%	1%	66	21%	59	19%	164	53%	1	0.4%
Asia	3,374	6,886	10,446	10,716	2.6%	5%	46%	2,145	20%	2,175	20%	5,568	52%	186	2%
China	1,138	3,626	6,230	6,510	4.5%	6.7%	28%	1,058	16%	1,159	18%	3,813	59%	146	2%
South Korea	263	458	560	553	-1.2%	2.1%	2%	70	13%	169	31%	278	50%	3	1%
India	376	729	1,227	1,230	0.3%	6%	5%	304	25%	201	16%	491	40%	15	1%
Japan	986	1,051	960	918	-4.3%	-1.5%	4%	256	28%	303	33%	325	35%	16	2%
Moyen Orient	400	742	982	989	0.7%	3.2%	4%	405	41%	303	31%	206	21%	0.5	0.0%
Saudi Arabia	114	212	290	289	-0.3%	3.5%	1%	129	45%	108	38%	36	12%	0	0%
Iran	96	188	258	258	0.2%	3.6%	1%	84	33%	49	19%	82	32%	0.5	0.2%
CIS	984	1,197	1,286	1,284	-0.1%	0.8%	6%	273	21%	223	17%	498	39%	71	6%
Russia	693	851	918	922	0.4%	0.9%	4%	173	19%	166	18%	352	38%	58	6%
Africa	379	554	690	692	0.2%	2.5%	3%	227	33%	136	20%	272	39%	6	1%
Egypt	64	124	163	163	0.6%	3.1%	1%	70	43%	40	24%	45	28%	1	0.4%
South Africa	190	214	208	204	-1.9%	-0.5%	1%	38	19%	29	14%	115	56%	4	2%
Pacific	218	266	279	282	1.1%	0.7%	1%	73	26%	81	29%	96	34%	6	2%
Australia	180	221	232	235	1.1%	0.7%	1%	60	26%	70	30%	78	33%	6	3%
World	13,187	18,588	22,948	23,104	0.7%	2.4%	100%	6,036	26%	5,874	25%	9,380	41%	356	2%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: generation

Slower world generation has bolstered the share of RES in the electricity mix

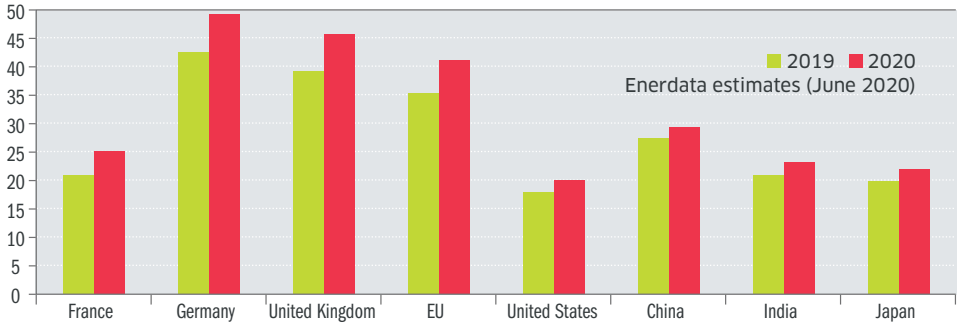
After many years of robust progression (3% per year over 2000-2018), power generation decelerated noticeably to a meagre 1% gain in 2019, reflecting the drop in demand due to milder weather conditions and slower economic growth. China kept the lead, recording a 4.7% increase, ahead of Brazil (2.2%) and Russia (0.9%), while India (0.3%) and Africa (0.5%) stagnated. Amongst OECD countries, virtual flatlining in recent years gave way to contraction in Europe (-1.8%), driven by a sharp fall in Germany (-4.9%), and in North America (-1.2% in the USA).

The downtrend is set to strengthen and broaden over 2020, as the Covid-19 pandemic caused a 2.6% contraction of world electricity production over the first quarter. The drop will near 5% for the whole year, according to IEA projections.

Shrugging off this environment, RES power generation expanded further in 2019 (up 5.2%), driven by solar and wind production, up 24% and 12%, respectively, as well as favourable hydro conditions in China, India, Turkey, Russia and Nigeria. RES (including biomass) generated 7,240 TWh, representing 27% of the world electricity mix, up 1.1% compared to 2018. China (+169 TWh) and India (+36 TWh) together made up 57% of the world's additional generation, boosted by solar production, up 31% (+61 TWh) and 25% (+10 TWH) respectively. In OECD countries, RES generation (including biomass) reached over 3,000 TWh (up 3%), widening the gap with coal-fired production, which fell behind for the first time in 2018. In the USA, good wind power results (+25 TWh) spurred RES generation growth (up 2.5%), while Germany's strong 11.5% gain lifted Europe 4.7%.

This trend strengthened during the health crisis, as RES proved particularly resilient (up 3% in the first quarter of 2020). Their share in world electricity supply reached nearly 28% (against 26% in the first quarter of 2019), a mechanical increase explained by their short-term economic preeminence due to lower marginal costs, in a context of slowing demand. By country, RES production increased sharply during the weeks that followed the beginning of lockdown, notably in China and in India, where the pace accelerated respectively from 23% to 28% and from 16.9% to 22% between January and March (source: IEA). All in all, the IEA expects RES generation to rise almost 5% in 2020.

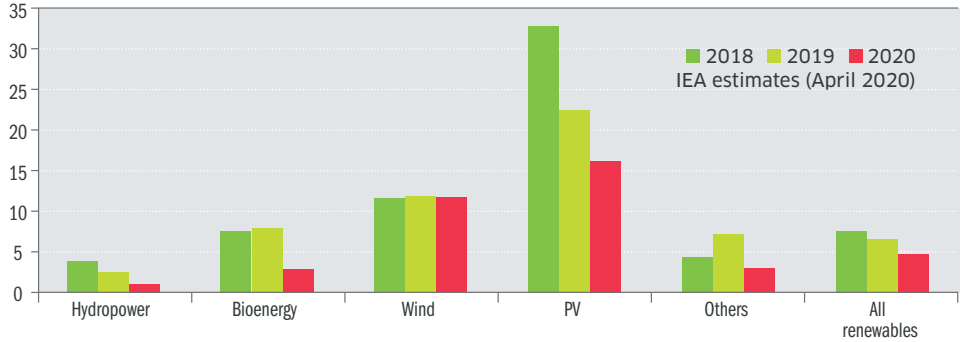
SHARE OF RENEWABLE SOURCES* IN ELECTRICITY GENERATION BY COUNTRY



* Hydro, wind, solar, geothermal, biomass

Source: Enerdata, Global Energy Statistical Yearbook 2020 (2 june 2020)

ANNUAL GROWTH IN GLOBAL RENEWABLE ELECTRICITY GENERATION BY SOURCE



Source: IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions (28 April 2020)

Electricity: generation

Acknowledged as a major element of flexibility within power systems, natural gas-fired generation progressed 3.2% in 2019 (up 3.8% in 2018) and reached 6,324 TWh, a level three times higher that of 1996. Boosted by much lower prices, natural gas consolidated its leading position in the OECD's power mix (30%). Its development was particularly marked in the USA, where an additional 117 TWh represented 60% of the world increase, but also in the EU (up 14.8%), where production expanded in 16 of the 27 countries, notably in Spain (+28.2 TWh; up 48.2%), the Netherlands (+13.6 TWh) and France (+10.6 TWh). Production was unchanged in Asia, where the 33 TWh decline recorded in Japan, partly due to the upswing in nuclear generation, entirely offset the rise in China (+34 TWh). Globally, this overall momentum resulted in a further increase in the load factor* of gas-fired power plants, which stood at 42.2% (41.3% in 2018).

Gas-fired power generation has been affected by the pandemic, however. According to IEA forecasts, the contraction will amount to 7% in 2020. The downturn looks particularly sharp in Europe (-20% over the first quarter), where demand decreased markedly in the industrial sector and RES proved resilient. In Italy and the UK, the two largest gas-fired power consuming countries in Europe, production dropped by 25% and 36%, respectively, between early March and end of May (source: IEA). In the USA, where natural gas remains the main power source, continued low gas prices should cushion the fall.

2019 saw a historical 3.5% decline in coal-fired generation. Its share in the world mix dropped from 38% in 2018 to 36.3%. Within the OECD, the production was 13.2% lower than in 2018; this was the largest drop ever recorded and reflects higher carbon prices, lower gas prices and plant closures. Apart from the USA (-176 TWh; down 14%), the biggest contractions were recorded in Germany (-59.8 TWh; down 25%) and Spain (-25.8 TWh; down 69.4%) and highlighted European efforts to remove coal from the electricity mix. In India, where it had been expanding by an average 5.8% per year since 2000, coal-fired power production contracted for the first time since 1973, at -3.3%. China, the world's leading producer, also posted a drastic deceleration at up 1.7%. The country's coal-fired plant utilisation rate dropped to 48%, against 54% worldwide (source: Carbon Brief).

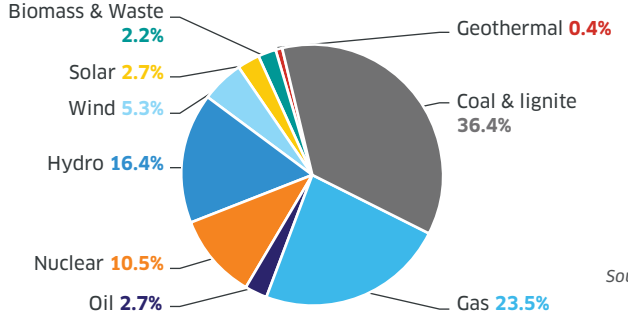
*The load factor of a power plant is the ratio between the energy actually produced over a given period of time and the energy it could have generated by operating at full nameplate capacity during the same period.

The decline in coal-fired electricity production accelerated during the weeks that followed the beginning of lockdown measures (-8% in the first quarter of 2020), driven by China (-100 TWh) and the USA (-33%). With a 10% drop in production in 2020, according to IEA's forecasts, coal is set to be the fuel most affected by Covid-19.

The rise in nuclear production that started in 2015 continued with a 3.6% increase in 2019 to 2010 pre-Fukushima levels, driven by further expansion in China (up 18.3%) and upturn in Japan (up 33.2%). Nuclear energy has effectively confirmed its leading position in low-carbon power generation amongst OECD countries, with a 18% share of the mix. It declined 1.7% in Europe, however, as Germany, Belgium and Spain are planning to abandon nuclear energy and France intends to reduce its share to 50% in 2035 (compared to nearly 70% currently).

Despite its overall uptrend, nuclear production did not escape Covid-19 turmoil and dipped 3% over the first quarter of 2020. According to the IEA, the contraction will amount to 2.5% over the year as a result of lower electricity demand and maintenance delays on several reactors.

SHARE OF ELECTRICY GENERATION BY ENERGY IN 2019
TOTAL: 26,868 TWH



Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: generation by power station type

Electricity Generation TWh	Total generation			Thermal generation				Nuclear generation				Renewable generation (excluding biomass)			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area total 2019	2000	2019	Change 2018-2019	Share in area total 2019	2000	2019	Change 2018-2019	Share in area total 2019
Europe	3,433	3,822	-1.8%	1,807	1,701	-6.3%	45%	971	839	-1.7%	22%	655	1,282	4.7%	34%
European Union	3,032	3,221	-1.6%	1,673	1,475	-4.9%	46%	945	817	-1.2%	25%	414	929	3.7%	29%
Germany	577	614	-4.9%	372	336	-13.3%	55%	170	75	-1.2%	12%	36	202	11.5%	33%
France	539	569	-2%	53	61	4.8%	11%	415	399	-3.4%	70%	71	110	-0.5%	19%
North America	4,658	5,029	-1.1%	3,128	2,951	-2.4%	59%	871	944	0.3%	19%	660	1,134	1.3%	23%
Canada	606	649	-0.2%	174	134	1%	21%	73	101	0.5%	16%	359	414	-0.6%	64%
United States	4,053	4,380	-1.2%	2,954	2,817	-2.6%	64%	798	844	0.3%	19%	301	719	2.5%	16%
Latin America	982	1,644	1.3%	370	727	-0.6%	44%	20	37	-1.6%	2%	592	880	2.9%	54%
Brazil	349	614	2.2%	38	147	1.7%	24%	6	16	2.8%	3%	304	451	2.3%	73%
Asia	3,973	12,363	2.8%	2,951	8,929	0.1%	72%	505	674	18.2%	5%	517	2,760	8.8%	22%
China	1,356	7,482	4.7%	1,116	5,184	2.2%	69%	17	348	18.3%	5%	223	1,949	9.5%	26%
South Korea	290	574	-1.5%	176	408	-4.9%	71%	109	146	9.3%	25%	6	19	0%	3%
India	570	1,614	0.3%	477	1,282	-3%	79%	17	47	24.3%	3%	76	285	14.3%	18%
Japan	1,048	987	-4%	625	739	-8%	75%	322	87	33.2%	9%	101	161	0.6%	16%
Pacific	253	315	0.7%	207	232	-0.3%	74%	0	0	-	0%	46	83	3.9%	26%
CIS	1,250	1,596	0.2%	816	1,022	-0.5%	64%	210	294	1.1%	18%	224	280	1.9%	18%
Russia	878	1,122	0.9%	582	712	0%	63%	131	209	2.2%	19%	166	201	3.8%	18%
Middle East	472	1,243	1.3%	464	1,189	-0.4%	96%	0	7	-6.9%	1%	8	47	81.4%	4%
Saudi Arabia	126	350	-0.3%	126	349	-0.5%	100%	0	0	-	0%	0	1	400%	0%
Iran	121	315	1.4%	118	278	-2.9%	88%	0	7	-6.9%	2%	4	30	79.5%	9%
Africa	445	856	0.5%	354	672	-0.9%	79%	13	13	28.2%	1%	78	171	4.3%	20%
Egypt	78	195	0.6%	64	176	-1%	90%	0	0	-	0%	14	20	12.6%	10%
South Africa	211	252	-1.5%	194	224	-3%	89%	13	13	28.2%	5%	4	16	1.9%	6%
World	15,467	26,868	1%	10,097	17,423	-1.1%	65%	2,591	2,808	3.6%	10%	2,779	6,637	5.7%	25%
OECD	9,784	11,005	-1.3%	6,062	6,304	-4%	57%	2,249	2,005	1.2%	18%	1,474	2,696	3.4%	24%
No-OECD	5,682	15,864	2.6%	4,035	11,120	0.6%	70%	342	803	10%	5%	1,306	3,941	7.3%	25%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: detail of thermal generation

Detail of thermal electricity generation TWh	Total Thermal generation			Thermal generation - Coal & lignite				Thermal generation - Oil				Thermal generation - Gas				Thermal generation - Biomass & Waste			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019	2000	2019	Change 2018-2019	Share in area thermal total 2019
Europe	1,807	1,701	-6.3%	1,039	638	-21.9%	38%	192	65	16%	4%	527	770	6.9%	45%	48	227	2%	13%
European Union	1,673	1,475	-4.9%	966	484	-26.2%	33%	181	57	2.2%	4%	480	716	14.8%	49%	46	219	1%	15%
Germany	372	336	-13.3%	304	179	-25%	53%	5	5	-1.9%	2%	53	93	10.3%	28%	10	59	-0.8%	17%
France	53	61	4.8%	31	4	-62%	7%	7	7	7%	11%	12	41	34.6%	67%	4	9	-15.7%	15%
North America	3,128	2,951	-2.4%	2,247	1,127	-13.8%	38%	133	35	-21.9%	1%	668	1,708	7.7%	58%	80	81	-5.4%	3%
Canada	174	134	1%	118	47	-8.5%	35%	15	7	1%	6%	34	73	8%	54%	8	8	1%	6%
United States	2,954	2,817	-2.6%	2,130	1,080	-14%	38%	119	27	-26.4%	1%	634	1,636	7.7%	58%	72	74	-6%	3%
Latin America	370	727	-0.6%	43	97	-1.9%	13%	173	113	-9.2%	16%	139	441	1.9%	61%	14	75	1.2%	10%
Brazil	38	147	1.7%	11	25	8.8%	17%	15	7	-44.9%	5%	4	60	9.7%	41%	8	55	1.5%	37%
Asia	2,951	8,929	0.1%	1,983	7,159	0.3%	80%	382	153	-7.3%	2%	569	1,407	-0.1%	16%	16	211	0%	2%
China	1,116	5,184	2.2%	1,060	4,856	1.7%	94%	47	11	12.4%	0%	6	236	16.7%	5%	2	82	-3.7%	2%
South Korea	176	408	-4.9%	111	243	-5.2%	59%	35	8	-36%	2%	30	148	-2.7%	36%	0.1	9	13.5%	2%
India	477	1,282	-3%	390	1,138	-3.3%	89%	29	25	0.2%	2%	56	69	-4.5%	5%	1	50	3.1%	4%
Japan	625	739	-8%	223	323	-4.6%	44%	134	31	-30.8%	4%	258	343	-8.8%	46%	10	42	-3.4%	6%
Pacific	207	232	-0.3%	176	153	-3.8%	66%	3	9	1.8%	4%	26	67	9%	29%	2	4	-13.5%	2%
CIS	816	1,022	-0.5%	266	317	-1.4%	31%	57	7	-18.9%	1%	491	695	0.2%	68%	3	3	-0.2%	0%
Russia	582	712	-0.3%	176	188	-1.3%	26%	33	7	1.4%	1%	370	515	0.1%	72%	3	3	-0.5%	0%
Middle East	464	1,189	-0.4%	30	23	6%	2%	188	278	-3.6%	23%	246	888	0.5%	75%	0	0.2	3.4%	0%
Saudi Arabia	126	349	-0.5%	0	0	-	0%	68	122	-4%	35%	58	228	1.4%	65%	0	0	-	0%
Iran	118	278	-2.9%	1	1	0%	0%	25	29	-4%	10%	92	249	-2.8%	90%	0	0	0%	0%
Africa	354	672	-0.9%	208	253	-3%	38%	52	70	-4.4%	10%	94	347	1.5%	52%	1	2	0%	0%
Egypt	64	176	-0.5%	0	0	-	0%	22	22	-2.1%	13%	42	153	-0.3%	87%	0	0	-	0%
South Africa	194	224	-3%	193	223	-3%	100%	0	0.2	0%	0%	0	0	-	0%	0.3	0.3	0%	0%
World	10,097	17,423	-1.1%	5,992	9,767	-3.5%	56%	1,181	729	-5.1%	4%	2,760	6,324	3.2%	36%	164	603	0%	3%
OECD	6,062	6,304	-4%	3,780	2,496	-13.2%	40%	591	160	-18.1%	3%	1,548	3,282	4.9%	52%	143	366	-0.5%	6%
No-OECD	4,035	11,120	0.6%	2,212	7,271	0.4%	65%	589	569	-0.7%	5%	1,213	3,042	1.4%	27%	21	237	0.9%	2%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: detail of renewable generation

Detail of renewable electricity generation TWh	Total Renewable generation (excluding biomass)			Renewable generation Hydro				Renewable generation Wind				Renewable generation Solar				Renewable generation Geothermal			
	2000	2019	Change 2018-2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019	2000	2019	Change 2018-2019	Share in area renewable total 2019
Europe	655	1,282	4.7%	626	647	-2.3%	50%	22	462	14.3%	36%	0.1	149	8.6%	12%	6	23	16.2%	2%
European Union	414	929	3.7%	387	350	-8.3%	38%	22	434	14.2%	47%	0.1	138	8.2%	15%	5	7	7.1%	1%
Germany	36	202	11.5%	26	26	12.3%	13%	9	128	14.6%	63%	0.1	48	3.6%	24%	0	0.2	6.6%	0%
France	71	110	-0.5%	71	62	-12.1%	57%	0	35	22.8%	32%	0	12	13.7%	11%	0	0.2	33.1%	0%
North America	660	1,134	1.3%	639	675	-3.5%	60%	6	333	8.3%	29%	1	106	14.7%	9%	15	20	0.3%	2%
Canada	359	414	-0.6%	359	380	-1%	92%	0	31	3%	7%	0	4	11.1%	1%	0	0	-	
United States	301	719	2.5%	280	296	-6.4%	41%	6	303	8.9%	42%	1	101	14.9%	14%	15	20	0.3%	3%
Latin America	592	880	2.9%	584	738	-2.2%	84%	0.2	99	26.7%	11%	0	34	149%	4%	8	10	1.4%	1%
Brazil	304	451	2.3%	304	389	0.1%	86%	0	57	16.5%	13%	0	5	55.6%	1%	0	0	-	
Asia	517	2,760	8.8%	494	1,850	5.6%	67%	2	477	9.4%	17%	0.4	404	26.1%	15%	20	29	5.6%	1%
China	223	1,949	9.5%	222	1,298	5.9%	67%	1	393	10%	20%	0	258	31%	13%	0.1	0.1	0%	0%
South Korea	6	19	0%	6	6	-14.3%	32%	0	3	5.6%	14%	0	10	10.6%	54%	0	0	-	
India	76	285	14.3%	75	174	16.1%	61%	2	62	2.4%	22%	0	50	25.2%	17%	0	0	-	
Japan	101	161	0.6%	97	78	-10.1%	49%	0.1	8	13.3%	5%	0.4	72	13.4%	45%	3	3	5.7%	2%
Pacific	46	83	3.9%	43	40	-8.8%	48%	0.2	21	23.3%	26%	0	13	29.8%	16%	3	8	0.7%	10%
CIS	224	280	1.9%	224	273	1.3%	98%	0	3	28.7%	1%	0	3	53.1%	1%	0.1	0.4	-0.7%	0%
Russia	166	201	3.8%	165	199	3.6%	99%	0	0.3	47.2%	0%	0	1	69.4%	1%	0.1	0.4	-0.7%	0%
Middle East	8	47	81.4%	8	33	77.5%	70%	0	2	10.3%	3%	0	13	107.7%	27%	0	0	-	-
Saudi Arabia	0	1	400%	0	0	-	0%	0	0	-	0%	0	1	304.1%	100%	0	0	-	-
Iran	4	30	79.5%	4	29	81.2%	97%	0	1	7.3%	2%	0	0.3	28.1%	1%	0	0	-	-
Africa	78	171	4.3%	78	140	2.2%	82%	0.2	17	13.9%	10%	0	9	20.3%	5%	0	6	11.2%	3%
Egypt	14	20	12.6%	14	14	0.2%	70%	0.1	5	37.5%	23%	0	1	143.5%	7%	0	0	-	
South Africa	4	16	1.9%	4	6	0%	37%	0	6	0.7%	38%	0	4	6.6%	26%	0	0	-	
World	2,779	6,637	5.7%	2,695	4,396	1.3%	66%	31	1,414	12%	21%	1	731	24%	11%	52	96	6.2%	1%
OECD	1,474	2,696	3.4%	1,411	1,433	-3.8%	53%	29	838	12.6%	31%	1	367	15.8%	14%	33	58	4.6%	2%
No-OECD	1,306	3,941	7.3%	1,284	2,964	4%	75%	3	576	11.3%	15%	0	364	33.6%	9%	19	38	8.8%	1%

Source: Enerdata Global Energy & CO_2 Data (2020)

Electricity: prices

2019-2020 trends confirm the impact of both the carbon market and renewables production on electricity prices

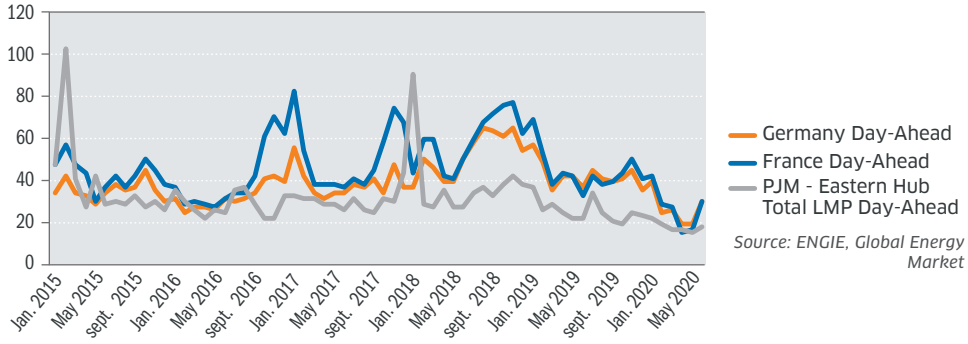
Wholesale electricity prices continued their uptrend in 2018 but slumped in Europe in the second half of 2019 on the back of lower carbon and fossil fuel prices (natural gas and coal). The year-ahead contract finished 2019 at €44.7/MWh in Germany, down €6.4/MWh from end 2018 (-14.2%), and at €46.3/MWh in France, after a peak at €55.4/MWh in July (Source: ENGIE Global Markets).

The drop in prices accelerated with the Covid-19 pandemic and its negative effect on electricity demand. This context benefited renewable energies with low marginal production costs, which raised their share within the mix. Weather conditions particularly favoured solar and wind power, so much so that prices turned negative on several occasions. On Monday 13 April for instance, electricity traded at -€91.4/MWh in Belgium, -€70.1/MWh in Germany and -€14.6 €/MWh in France (Source: EPEX Spot).

In highly volatile market conditions throughout the health crisis, prices finally picked up in April 2020. In the EU, discussions regarding the Green Deal and the spectre of a reform of the EU ETS (Emission Trading System) pushed carbon prices up. In France, prices were further supported by uncertainty over the availability of nuclear energy in the fourth quarter of 2020; lockdown measures hampered reactors' maintenance schedules.

Despite these short-term fluctuations, electricity prices remain on a general uptrend, supported by increasing taxes and RES subsidies. In 2019, the average retail price of electricity for a European residential client was €205/MWh, up 14% from €182/MWh in 2010; taxes accounted for 37%, up from 26% in 2010. In Germany, electricity prices have risen sharply in recent years following the implementation of an RES support mechanism. Household costs have climbed to an average €293MWh, the highest level in the EU, compared with €163/MWh in France, where the predominance of nuclear generation keeps the cost of supply relatively low.

ELECTRICITY PRICES IN FRANCE, GERMANY AND USA ($/MWH)



Source: ENGIE, Global Energy Market

RESIDENTIAL AND INDUSTRIAL ELECTRICITY PRICES

Electricity prices in €2015/MWh	Residential prices in €2015/MWh				Industrial prices in €2015/MWh			
	2010	2019	Change 2018-2019	AAGR 2010-2019	2010	2019	Change 2018-2019	AAGR 2010-2019
Germany	258	293	1.8%	1.4%	110	124	4.9%	1.4%
France	131	163	-2%	2.4%	79	98	8.1%	2.4%
Italy	215	249	7.4%	1.6%	163	165	14.1%	0.1%
United Kingdom	182	219	-1.8%	2.1%	120	145	6.9%	2.1%
United States	113	109	-0.9%	-0.5%	67	57	-3.2%	-1.7%
China	82	73	0.2%	-1.3%	126	89	-6%	-3.9%
India	62	58	1.4%	-0.8%	98	112	0.3%	1.5%
Japan	165	203	4.4%	2.3%	105	132	1.6%	2.7%

Source: Enerdata Global Energy & CO_2 Data (2020)

Natural gas & green gas

CONSUMPTION

Favoured by environmental policies and lower gas prices, the substitution of coal for gas is helping to reduce CO_2 emissions Covid-19 has not halted this trend

GREEN GAS

The integration of green gases can maintain gas alternatives within the zero-carbon mix and offers diversification from electricity

Natural gas and energy transition

The role of natural gas in the energy transition

Environmental scenarios suggest that natural gas is part and parcel of the energy transition and will be a particularly effective lever for decarbonization over the coming two decades. Almost all of the projections that would meet climate targets* involve a largely unchanged share of natural gas in the energy mix between now and 2040-50. The IEA enhances the natural gas share from 23% in 2019 to 24% in 2040 in its SDS scenario (2°C target), for instance, and to 25% in its STEP scenario (including INDCs – environmental intended contributions announced at COP21). Volume projections offer another good indication of the importance of natural gas in energy transition: virtually no change over the period within the SDS (-0.2% per year) and rising moderately within the STEPS (+1.4% per year), compared with declines for oil and coal volumes (see scenario definitions in the Decarbonization chapter).

Natural gas is included in medium-term decarbonization trends for several reasons:

- **Lower carbon content and great flexibility of use.** It has a lower carbon content than other fossil fuels, has a large range of uses, combines availability with storage capacity and complements RES (bio gas or power RES).
- **Gas solutions can be implemented quickly and offer a higher cost-efficiency ratio than many power RES alternatives.** This mainly reflects existing gas infrastructures and the efficiency of gas-fired plants.
- **The energy mix cannot rely exclusively on renewable electricity.** It would be impossible to build a system big enough, for many reasons: costs, raw materials, land availability, public acceptability and networks. The use of gas considerably reduces the oversizing of power infrastructures required to cope with peak demand, RES intermittency and physical distances between production and consumption.

This is precisely what we are seeing now, with natural gas benefiting from a surge in substitution for coal in the power generation sector on the back of environmental policies and competitive prices. This trend is widespread in developed countries and is contributing to better control of CO_2 emissions, as gas-fired power plants emit 50% less GHG than their coal-fired equivalents. According to the IEA, the immediate replacement worldwide of coal-fired plants by gas-fired plants would reduce the power sector's emissions by 10%, or total emissions by 4%. Since 2010, these substitutions have cut CO_2 emissions by 500 Mt. In 2019, they were the main GHG reduction factor, notably in the USA and in Europe (see chapter CO_2 and climate).

Although favourable to natural gas, environmental scenarios require an end to current growth rates (+2% per year over the decade and +2.6% in 2019). The 2°C target requires a firm hand on world energy demand, as it has to be no higher than current levels by 2040. De facto natural gas consumption has to decline after 2030 and also to its current level by 2040 (see graphs).

The reduction in natural gas demand will mainly follow from increased energy efficiency (in buildings, industry, power generation), mixed solutions (gas and biomass or gas and heat pumps), and later on with the gradual introduction of zero-carbon gas (green gases), which is classed as renewable energy.

In the second phase of energy transition, involving the complete decarbonization of the energy system, green gases will gradually replace natural gas as technology improves and costs decline.

There are several zero-carbon gas solutions offering economic, environmental and social benefits:

- Biomethane, produced from fermentation of wastes, notably agricultural wastes,
- Green hydrogen, produced from renewable electricity through electrolysis of water,
- Synthetic methane, produced by combining green hydrogen with industrial carbon dioxide emissions (see 'Green gases' in the Natural gas and green gases chapter)

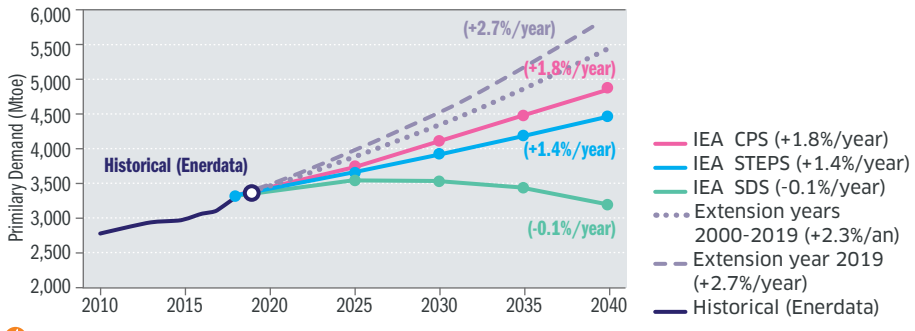
One of the advantages is the continuation of a mixed multi-energy system that is more resilient than a system relying on electricity alone. It is also more competitive, as it can combine solutions according to their performance with the advantages of gas (flexibility, infrastructures) and without GHG emissions.

Note also that locally-produced green gases reduce energy dependency, contribute to circular economies and create local value.
Lastly, residual natural gas can be decarbonized through carbon capture, utilisation and storage, or CCUS (see CCUS in the Decarbonization chapter).

*Scenarios: Greenpeace – R-Evolution; IEA – SDS; Enerdata-Green; IHS - Autonomy; NégaWatt and Ademe scenarios for France.

Natural gas: consumption and production forecasts

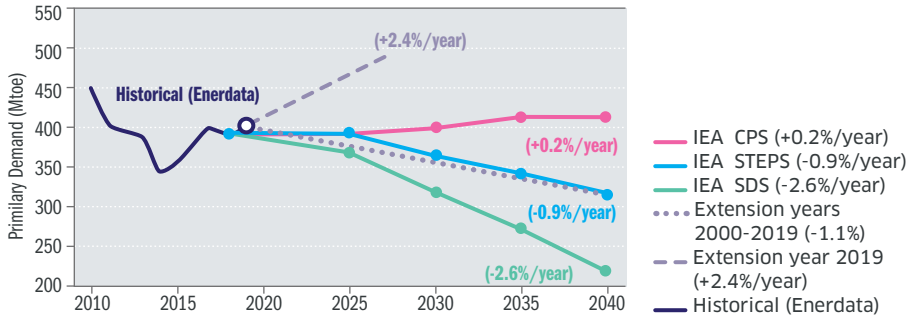
GAS PRIMARY DEMAND FORECAST – WORLD



Transition started but dynamic too slow

The current growth of natural gas largely corresponds to substitutions for coal in electricity production, which contributes to reducing CO_2 emissions; but, insufficient efforts in terms of energy efficiency do not make it possible to weigh on overall energy demand.

GAS PRIMARY DEMAND FORECAST – EUROPEAN UNION



Transition started but dynamic too slow

In the EU, the most demanding area, natural gas contributes to the decarbonization of the electricity system by replacing coal; from 2030, it will be necessary to accelerate the development of green gases in order to maintain gas solutions while decarbonising them; the overall reduction in energy consumption is a critical point.

FORECASTS OF WORLD GAS CONSUMPTION IN STEPS AND SDS SCENARIOS FROM IEA (IN BCM)

Forecast of Gas consumption In bcm		Stated Policies Scenario				Sustainable Development Scenario			
	2018	2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	607	593	557	-0.4%	10.3%	519	380	-2.1%	9.9%
North America	1,067	1,183	1,221	0.6%	22.6%	1,052	791	-1.4%	20.5%
Central and South America	172	198	257	1.8%	4.7%	168	169	-0.1%	4.4%
Asia Pacific	815	1,218	1,522	2.9%	28.2%	1,234	1,322	2.2%	34.3%
CEI	598	639	674	0.5%	12.5%	551	471	-1.1%	12.2%
Middle East	535	646	807	1.9%	14.9%	550	507	-0.2%	13.2%
Africa	158	221	317	3.2%	5.9%	176	200	1.1%	5.2%
OECD	1,823	1,905	1,910	0.2%	35.3%	1,699	1,262	-1.7%	32.7%
non OECD	2,129	2,794	3,444	2.2%	63.7%	2,551	2,577	0.9%	66.9%
Bunkers	0	21	50	34.3%	0.9%	14	15	27.0%	0.4%
World	3,952	4,720	5,404	1.4%	100%	4,264	3,854	-0.1%	100%

Source: World Energy Outlook 2019 © OECD/IEA, November 2019

FORECASTS OF WORLD GAS PRODUCTION IN STEPS AND SDS SCENARIOS FROM IEA (IN BCM)

Forecast of Gas production In bcm		Stated Policies Scenario				Sustainable Development Scenario			
	2018	2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	277	206	188	-1.7%	3.5%	189	151	-2.7%	4%
North America	1,083	1,336	1,376	1.1%	25.5%	1,209	909	-0.8%	24%
Latin America	177	209	285	2.2%	5.3%	187	189	0.3%	5%
Asia Pacific	598	757	889	1.8%	16.5%	745	786	1.3%	20%
CIS	918	1,054	1,143	1.0%	21.1%	921	786	-0.7%	20%
Middle East	645	787	1,016	2.1%	18.8%	681	651	0.0%	17%
Africa	240	372	508	3.5%	9.4%	333	383	2.2%	10%
OECD	1,454	1,693	1,735	0.8%	32.1%	1,542	1,209	-0.8%	31%
non OECD	2,484	3,027	3,669	1.8%	67.9%	2,722	2,645	0.3%	69%
Monde	3,937	4,720	5,404	1.4%	100%	4,264	3,854	-0.1%	100%
Gas conventionnel	3,004	3,293	3,694	0.9%	68.4%	3,004	2,689	-0.5%	70%
Tight gas	274	267	238	-0.6%	4.4%	262	141	-3.0%	4%
Shale gas	568	1,020	1,290	3.8%	23.9%	863	871	2.0%	23%
Coalbed methane	88	103	129	1.7%	2.4%	101	103	0.7%	3%
Autres productions	3	36	54	14.2%	1.0%	34	50	13.9%	1%

Source: World Energy Outlook 2019 © OECD/IEA, November 2019

Natural gas: consumption

Although more resilient than other fossil fuels during the pandemic, natural gas demand is down sharply in 2020

The pandemic will severely dent gas demand worldwide, but not to the extent of coal and oil. Natural gas depends less on electricity production than coal and is not as exposed as oil in the transport sector. Though relatively untouched during lockdown (down 2%), natural gas consumption will contract significantly over 2020 as a whole because of sluggish economic activity. The drop is expected to amount to 4-5% (-160 to -200 bcm), according to several sources*. This would be the greatest ever shock to the gas markets, and twice as bad as that triggered by the 2008 financial crisis (-2% in 2009).

The annual decline in 2020 will be more severe than the correction in the first quarter because of the enduring impact of the pandemic on industrial activity and electricity generation (expected -5% and -7%, respectively, over the year); moreover, temperatures in the northern hemisphere were unusually mild over the first half of the year. A faster economic recovery would limit the fall in demand in 2020 to 3% (source: IEA).

The 2020 recession will be just as bad on European markets, if not worse. Mild weather, with a winter that was 5% warmer in degree days, significant wind production and the Covid-19 pandemic all contributed to drive natural gas consumption 7% lower in the year to the first half of 2020.
Some countries reported sharp declines in gas consumption during lockdown. In countries with strict lockdown regimes, such as Belgium, France, Italy, Spain and the UK, industrial consumption dropped over 15% year-on-year (-1 Bn m^3) from March to May. In Italy and the UK, gas-fired plants' consumption plunged around 30%.

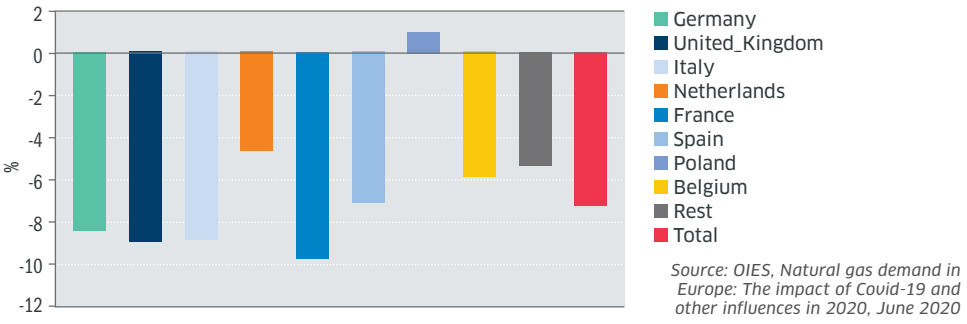
Gas demand is expected down 7%** for the whole year. This estimate is based on a 7-8% fall in European GDP, assuming some benefit from substantial recovery plans, demand for air-conditioning during the summer and, above all, competitive gas prices. Prices are likely to stay low over the rest of 2020, favouring the arbitrage of gas over coal in electricity production. Stable CO_2 prices at around €20 per tonne will only amplify this effect. An EU directive on industrial CO_2 emissions will further hasten the decline in the use of coal by imposing upgrades on coal-fired plants, as will decisions by several EU Member States to close these installations down gradually.

The 2008 crisis impacted European markets in fairly similar proportions, weakening both industry and electricity production. The recovery proved laborious: apart from during a cold winter in 2010, gas demand continued to decline until 2014. This offers little clue to what is likely to happen after 2020, however, as the whole structure of the gas market has changed since that time.

There is a degree of consensus around a worldwide pick-up in natural gas demand post-pandemic, based on gas cost competiveness, tougher environmental policies and demand from Asian emerging countries led by China and India, where gas enjoys strong political support. The recovery will be gradual, however, and the repercussions of the crisis will resonate for some years to come. The IEA expects an annual loss of 75 bcm up until 2025.

*IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020; IEA, GAS Report 2020, June 2020; International Gas Union (IGU), "Global Gas Report 2020" published in August 2020.
**IEA, Global Energy review 2020 – Covid-19 impacts on energy and CO_2 emissions, 28 April 2020;
Oxford Institute of Energy Studies, Natural gas demand in Europe: The impact of Covid-19 and other influences in 2020, June 2020.

NATURAL GAS DEMAND CHANGE IN 2020 VS 2019 IN EUROPE (%)



Source: OIES, Natural gas demand in Europe: The impact of Covid-19 and other influences in 2020, June 2020

Natural gas: consumption

Since 2019, natural gas has benefited from a shift out of coal in all major consumption areas

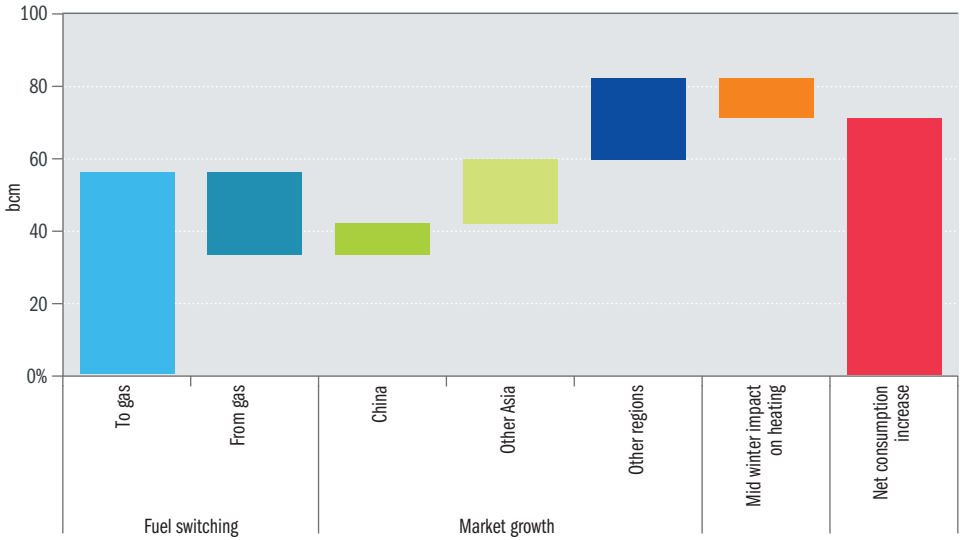
This crisis has halted a several year-old positive trend in gas consumption in both OECD and non-OECD countries. After two strong years (+5% in 2018, +4% in 2017), boosted by US shale gas and environmental policies, gas demand rose another 2.6% in 2019 to 4,018 bcm, while world energy demand progressed 0.7%. Although slower economic growth and a continuing rise in global temperatures – crucial to gas consumption – hampered its momentum, gas largely benefited from lower prices that made it more competitive against coal in power generation.

The main drivers of gas demand are the USA and Asia. They are the largest markets in volume terms and represented half of additional demand in 2019. In the USA (+3% in 2019), very low Henry Hub prices (high shale gas production) favoured gas within power generation and invigorated fertiliser production. In Asia (+3%), aggressive policy measures reduced coal power both in China (+8.6%), where a gas-against-coal programme was introduced in 2017 to address air pollution, and in India (+4.4%). China is the world's third largest gas consumer behind the USA and Russia, and the second largest LNG importer after Japan. Japanese gas consumption dropped 4.8% in 2019, when nine nuclear reactors were restarted and RES expanded.

Demand was just as dynamic in Europe (+3% in 2019 to 494 bcm), notably in Germany (+3.3%), Spain, Italy and France in a context of persistent economic weakness and high temperatures. As already described, Europe is seeing a wave of substitution out of coal and into gas in electricity production. Gas-fired plants increased production by 11% in 2019, or nearly 70TWh, while coal-fired plants reported a 24% drop. The most spectacular change was in Spain, where consumption from gas-fired plants jumped 50%.

In the Middle East and North Africa, consumption continued to rise thanks to power generation and the extension of distribution networks (Algeria, Iran). On the other hand, Russian demand growth slowed to 2.4% after three years of robust expansion, reflecting weaker economic activity and unusually mild weather.

BREAKDOWN OF ESTIMATED NATURAL GAS CONSUMPTION GROWTH BY MAIN (IN BCM)



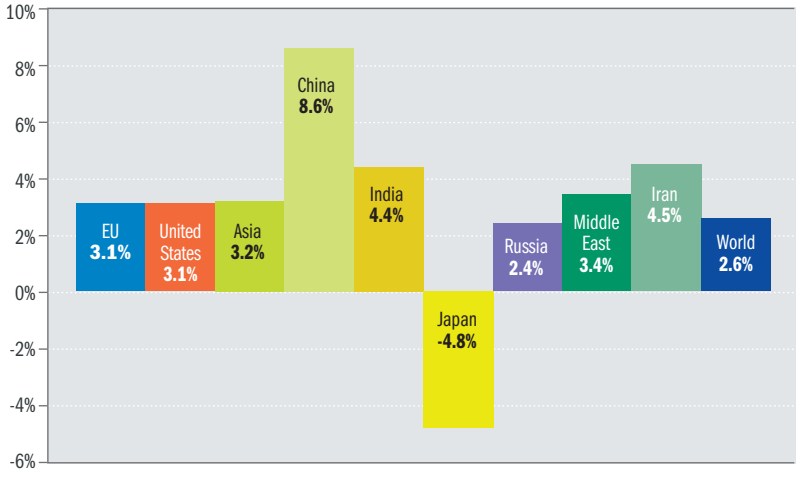
Source: IEA, Gas Report 2020, May 2020

Natural gas: primary consumption

Bcm	Natural gas primary consumption						Change 2018-2019	AAGR 2010-2019	Share in the world 2019
	2000	2005	2010	2015	2018	2019			
Europe	505	575	597	499	543	552	1.7%	-0.9%	14%
EU	481	536	546	438	479	494	3.1%	-1.1%	12%
France	40	47	48	40	42	42	1.8%	-1.4%	1%
Germany	88	91	95	81	92	95	3.3%	0.1%	2%
Italy	71	86	83	68	73	74	2.3%	-1.2%	2%
Netherlands	49	50	56	41	43	45	4.2%	-2.5%	1%
United Kingdom	102	100	99	73	80	80	-0.5%	-2.4%	2%
North America	753	722	781	882	977	1,005	2.9%	2.9%	25%
United States	661	623	683	767	850	877	3.1%	2.8%	22%
Canada	92	99	97	115	127	129	1.7%	3.2%	3%
Latin America	136	178	222	244	231	231	-0.1%	0.4%	6%
Argentina	37	41	47	51	51	50	-0.9%	0.8%	1%
Mexico	40	53	70	75	74	77	4.4%	1.1%	2%
Asia	282	386	563	662	774	799	3.2%	4%	20%
China	25	47	125	192	280	304	8.6%	10.4%	8%
India	28	38	64	53	61	64	4.4%	-0.1%	2%
Japan	81	84	103	120	114	108	-4.8%	0.6%	3%
Pacific	29	30	37	42	46	53	14.0%	4%	1%
CIS	568	622	655	616	657	668	1.7%	0.2%	17%
Russia	391	426	466	445	489	501	2.4%	0.8%	13%
Middle East	174	255	374	480	538	557	3.4%	4.5%	14%
Saudi Arabia	38	56	73	87	97	98	1.4%	3.3%	2%
Iran	62	99	144	184	217	226	4.5%	5.1%	6%
United Arab Emirates	30	42	61	74	74	75	1.1%	2.4%	2%
Africa	57	90	108	131	151	154	2.2%	4%	4%
World	2,504	2,858	3,336	3,555	3,917	4,018	2.6%	2.1%	100%
OECD	1,403	1,473	1,613	1,651	1,801	1,841	2.2%	1.5%	46%
Non OECD	1,101	1,385	1,723	1,904	2,116	2,177	2.9%	2.6%	54%

Source: Enerdata, Global Energy and CO_2 Data, 2020

CHANGE IN PRIMARY CONSUMPTION OF NATURAL GAS IN 2019



Source: Enerdata, Global Energy and CO_2 Data, 2020

Natural gas: consumption by sector

Gas consumption by sector Bcm	Energy		Industry		Transport		Services, Residential & Agriculture		Non energy uses		Total	
	2019	Change 2018-2019	2019	Change 2018-2019	2019	Change 2018-2019	2019	Change 2018-2019	2019	Change 2018-2019	2019	Change 2018-2019
Europe	216	9%	114	-3%	2	-3%	201	-2%	19	-2%	552	2%
European Union	191	12%	100	-2%	2	-3%	183	-2%	18	-2%	494	3%
Germany	28	12%	26	-1%	0	0%	39	1%	3	1%	95	3%
France	10	21%	11	-290%	0	-3%	20	-3%	1	-3%	42	2%
Italy	34	10%	10	-3%	1	-3%	28	-3%	1	-3%	74	2%
Netherlands	20	25%	7	-8%	0	-6%	15	-8%	3	-8%	45	4%
United Kingdom	34	1%	9	-3%	0	-	37	-1%	0.4	0%	80	-1%
North America	516	5%	178	0.1%	2	2%	279	1%	32	0%	1,005	3%
United States	448	6%	158	0.1%	2	1%	241	0.1%	28	0%	877	3%
Canada	67	-2%	20	-0.4%	0.1	10%	38	10%	4	-0.3%	129	2%
Latin America	145	-2%	46	2%	7	4%	19	4%	15	3%	231	-0.1%
Argentina	26	-4%	9	2%	3	2%	11	2%	2	2%	50	-1%
Mexico	61	3%	15	11%	0.1	11%	1	11%	0.4	11%	77	4%
Asia	393	2%	174	5%	39	5%	127	4%	65	7%	799	3%
China	104	12%	86	7%	29	7%	73	7%	13	7%	304	9%
India	17	-4%	16	8%	3	8%	2	8%	25	8%	64	4%
Japan	75	-6%	13	-2%	0.1	-2%	20	-2%	0.3	-2%	108	-5%
Pacific	32	18%	12	12%	0.1	8%	7	3%	2	7%	53	14%
CIS	434	2%	63	2%	1	2%	115	1%	56	2%	668	2%
Russia	326	2%	49	2%	0.3	2%	74	2%	51	2%	501	2%
Middle East	315	1%	127	5%	9	8%	73	8%	33	6%	557	3%
Saudi Arabia	70	1%	22	1%	0	-	0	-	7	1%	98	1%
Iran	83	-1%	49	8%	9	8%	67	8%	18	8%	226	5%
United Arab Emirates	46	-1%	29	4%	0	-	0	-	0.4	4%	75	1%
Africa	104	2%	21	1%	0.4	2%	15	3%	13	2%	154	2%
World	2,154	3%	734	2%	61	5%	835	1%	235	3%	4,018	3%
OECD	932	5%	337	-0.2%	5	-1%	516	-0.3%	51	-1%	1,841	2%
Non OECD	1,222	2%	397	4%	56	6%	318	4%	184	4%	2,177	3%

Source: Enerdata Global Energy & CO2 Data (June 2020)

Natural gas: conventional and unconventional gas

The development of hydraulic fracturing in the 2000s profoundly transformed assessments of world natural gas reserves, low-permeability bedrock suddenly became exploitable. By convention, traditional exploitation supplies so-called "conventional gas" and bedrock "unconventional gas", although there is no difference in their chemical composition.

Recoverable* natural gas reserves are estimated at à 803 Tm^3, almost evenly split between conventional and unconventional gas. This represents 200 years of current consumption.

Conventional gas reserves are the better known of the two. Their share of so-called proven reserves (exploitable under current economic conditions) was estimated at 225 Tm^3 in 2019 (+15% over the decade). They lie mostly in the Middle East (40% of world reserves, of which Iran 16% and Qatar 13%) and in Eurasia (Russia 17%, Turkmenistan 10%). The USA possess only 7%. Conventional gas currently represents 75% of total gas production.

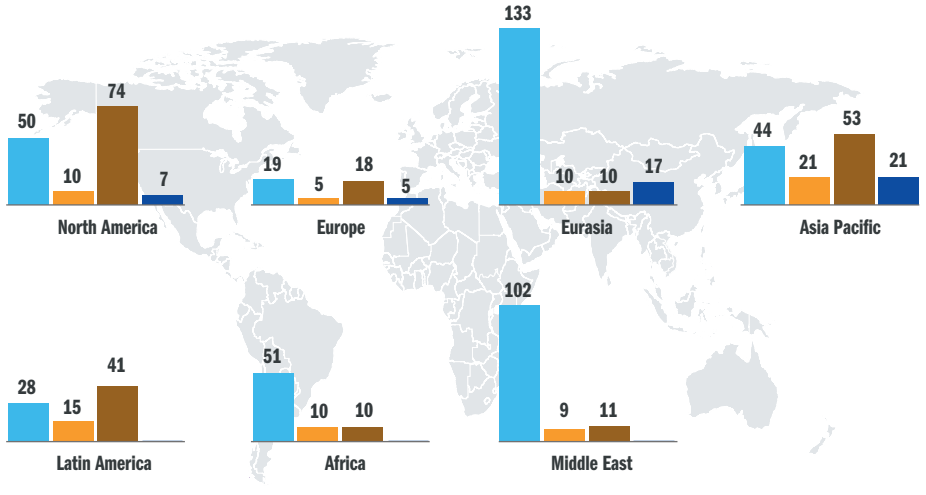
Unconventional gas, despite offering considerable potential and being more evenly spread around the planet, is mainly exploited in the USA** (85% of world production), and to a lesser extent in Canada, China and Australia. Other regions planning to produce it are still in exploration phase or produce little volumes (India, Argentina, South Africa, Algeria, etc.). Shale gas is developing rapidly in China, however (40% of gas production in 2019), and Australia has long produced coal bed methane (CBM). In Europe, where the focus is on energy transition and RES expansion, unconventional gas will not be developed further. The UK was the last European country to resort to fracking and ceased doing so in November 2019.

World production of unconventional gas represents 25% of total gas production, split between shale gas (15%), tight gas (8%) and CBM (2%). (Source: CEDIGAZ).

*Recoverable reserves are split according to their probability of being exploited: 90% for proven reserves, 50% for probable reserves, 10% for possible reserves, Cf. "Reserves" in the Glossary.

**Among unconventional gas, coal gas (Coal Bed Methane - CBM) differs from tight gas and shale gas. Unconventional resources are mainly shale gas (66%), tight gas and CBM respectively representing 21% and 13%.
Unconventional gas exploitation started with CBM around the end of the twentieth century. Shale and tight gas fields are more difficult to produce. They require specific drilling technics (horizontal drilling and hydraulic fracturing).

CONVENTIONAL AND UNCONVENTIONAL GAS RESSOURCES (IN TCM)



Source: World Energy Outlook 2019 © OECD/IEA, Nov. 2019

Natural gas: conventional and unconventional gas

Shale gas has boomed in the USA since 2008 and accounted for 75% of the country's gas production in 2019. This has dramatically altered the gas market, not to mention the US and Atlantic basin energy balance.

In its latest WEO version (November 2019) the IEA said it expected US shale gas to supply nearly 60% of world additional production until 2025 and then plateau. Beyond that point, shale gas is expected to develop in Canada, China and Argentina, and conventional gas will resume after 2030.

By severely denting gas demand and prices, Covid-19 sent the US unconventional gas sector into unprecedented turmoil. It could call into question the sustainability of this industry as well as LNG exports. Already undermined by economic constraints (shale gas is not economically viable below $52/bbl) and environmental considerations (fracking causes chemical pollution), shale gas faces challenges related to global warming: US natural gas consumption is set to stabilise then decrease, and green gas are to be introduced.

Conventional and unconventional gas ressources (in Tcm)						
Natural gas Trillion cubic meters	Proven reserves	Ressources	Conventional gas	Tight gas	Shale gas	Coalbed methane
North America	15	141	50	10	74	7
Central & South America	8	84	28	15	41	-
Europe	5	47	19	5	18	5
Africa	19	101	51	10	40	0
Middle East	81	122	102	9	11	-
Eurasia	76	170	133	10	10	17
Asia Pacific	20	138	44	21	53	21
World	225	803	426	80	247	50

Source: World Energy Outlook 2019 © OECD/IEA, Nov. 2019

Natural gas: production

Thanks to US shale gas, production significantly exceeded demand in 2019. The resulting build-up in stocks only worsened in 2020, when gas demand fell

World natural gas production has been rising very rapidly over recent years (+4% in 2018 and 2019), exceeding 4 Tm3 for the fist time. This strength is largely due to US shale gas, which represents nearly 60% of world additional supply. As production increased far more than demand (+67 bcm), stocks built up significantly in Europe and the USA. The gap widened further in the first half of 2020, as production remained high and barely adjusted to the Covid impact on demand. By the end of the spring, stocks had reached very high levels (20% and 80% higher than usual in the USA and in Europe, respectively).

US production has been setting records from year to year (+10% in 2019, or +89 bcm). A decade of uninterrupted growth (+4.6% per year on average since 2000) lifted the country to the top spot among rank gas producers. The USA is now well ahead of Russia in that respect. Taken together, the two major sites of unconventional gas – the Appalachian and Permian basins – account for two-thirds of that growth.

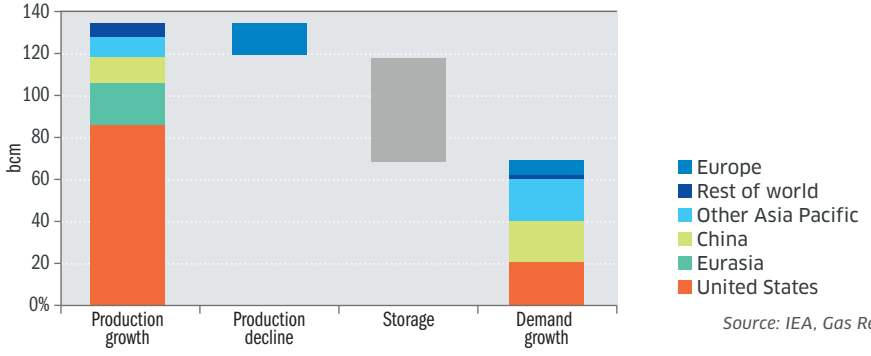
US shale production was still rising quickly in early 2020 (+6% over the first half). The pandemic could mean a sharp correction, however. Shale gas loses competitiveness rapidly when oil prices dip below $50/bbl. In June 2020, fracking pioneer Chesapeake filed for bankruptcy. 46 new pipelines for a total capacity of 165-175 bcm/year started operations in 2019. Built to facilitate exports towards Mexico and East Coast LNG terminals, they may well remained underutilised in 2020.

China has become an important producer over the past two decades and now ranks equal to Qatar. This rapid development (+10% in 2019) was largely based on shale gas (40%).

Russia's production (+3.4%) was boosted in 2019 by higher exports, partly related to the ramp-up of the LNG Yamal project. In the first half of 2020, production contracted 9% as exports plummeted and mild temperatures weakened domestic demand. Azeri gas production surged spectacularly with the exploitation of the Shah Deniz II field (+28 % in 2019, or +5 bcm).

European gas production is in structural decline and dropped ed 6% in 2019 (-14 bcm). The Norwegian Troll and Oseberg sites, swing fields, are losing steam, and production from the Dutch Groningen field is falling because of earthquake risks.

BREAKDOWN OF THE GAS PRODUCTION-CONSUMPTION BALANCE IN 2019 (IN BCM)



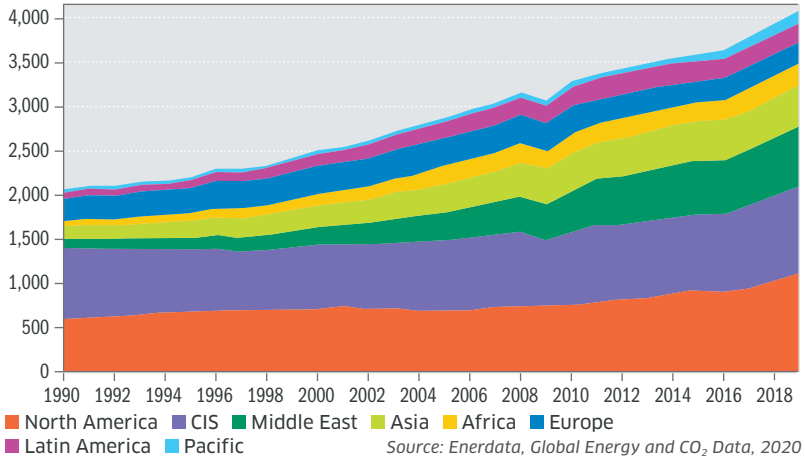
Source: IEA, Gas Report 2020, May 2020

Natural gas: production

Bcm	Natural gas production						Change 2018-2019	AAGR 2010-2019	Share in the world 2019
	2000	2005	2010	2015	2018	2019			
Europe	320	329	317	261	246	232	-5.7%	-3.4%	6%
European Union	265	241	206	138	120	111	-7.1%	-6.6%	3%
Norway	53	87	110	121	126	118	-5.7%	0.8%	3%
Netherlands	74	78	90	55	39	34	-13%	-10.4%	1%
United Kingdom	115	93	58	41	41	40	-2.2%	-4.1%	1%
North America	726	700	760	932	1,053	1,135	7.8%	4.6%	28%
États-Unis	544	512	604	767	863	951	10.3%	5.2%	23%
Canada	182	188	156	165	190	183	-3.6%	1.8%	5%
Latin America	138	179	212	219	203	202	-0.2%	-0.5%	5%
Asia	251	335	426	449	459	472	2.8%	1.1%	12%
China	27	49	96	135	159	175	10%	6.9%	4%
Indonesia	70	75	86	75	72	66	-8.9%	-2.9%	2%
Malaisia	50	66	61	69	65	66	2.6%	1%	2%
Pacific	39	40	58	82	132	155	17.5%	11.7%	4%
Australia	33	36	53	68	118	139	17.9%	11.4%	3%
CIS	709	797	828	861	941	973	3.4%	1.8%	24%
Russia	573	628	657	638	715	740	3.4%	1.3%	18%
Turkmenistan	47	63	45	84	81	83	2.7%	7%	2%
Middle East	196	302	467	587	654	674	3.1%	4.2%	17%
Saudi Arabia	38	56	73	87	97	98	1.4%	3.3%	2%
Iran	59	99	144	184	228	240	5.5%	5.9%	6%
Qatar	25	45	121	167	171	173	1.2%	4.1%	4%
Africa	124	189	209	198	240	241	0.5%	1.6%	6%
Algeria	82	89	85	84	97	91	-6.8%	0.7%	2%
World	2,504	2,870	3,276	3,588	3,928	4,085	4%	2.5%	100%
OECD	1,110	1,104	1,181	1,305	1,451	1,539	6.1%	3%	38%
Non OECD	1,394	1,766	2,095	2,283	2,476	2,545	2.8%	2.2%	62%

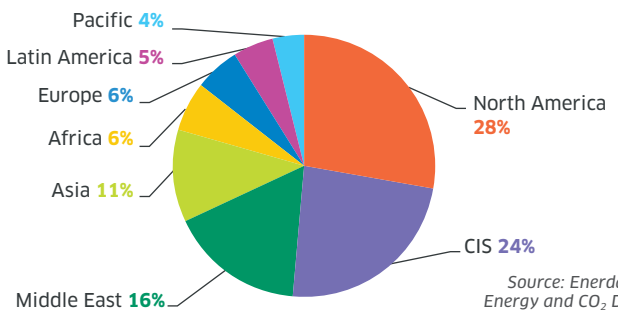
Source: Enerdata, Global Energy and CO2 Data, 2020

NATURAL GAS PRODUCTION BY REGION FROM 1990 TO 2019 (IN BCM)



Source: Enerdata, Global Energy and CO_2 Data, 2020

DISTRIBUTION OF NATURAL GAS PRODUCTION WORLDWIDE IN 2019 – TOTAL: 4,085 BCM



Source: Enerdata, Global Energy and CO_2 Data, 2020

Natural gas: prices

Natural gas prices were unable to avoid an historical plunge across all markets, except where indexed

A long uptrend in natural gas prices in major consuming regions reversed in early 2019, when booming world gas production far exceeded consumption.

Europe was the most affected region, as a record inflow of LNG added to an abnormally mild winter. Prices dropped 40% in 2019, averaging $4.5/MBtu on the NBP.

A similar trend was observed in Asia, where LNG prices plummeted 44%, averaging $5.5/MBtu on the Japan Korea Marker, in a context of abundant supply and moderate growth in traditional import markets (Japan and Korea). This did not translate into lower import prices, however, thanks to a continuing high proportion of oil-indexed contracts.

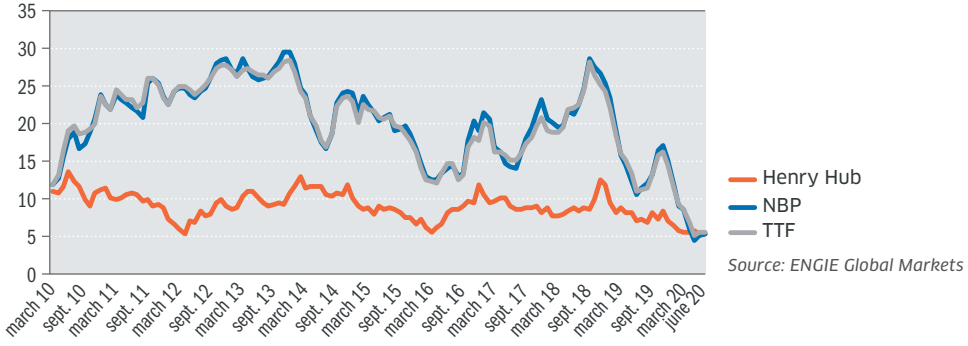
On the US market, Henry Hub prices shed 20% and averaged $2.5/MBtu in 2019. Again indexed prices proved resilient, as oil prices were stable.

The situation deteriorated further over the first half of 2020, reflecting a combination of continued strong production, mild winter temperatures and lockdowns. The shock has been unprecedented across all gas markets, associating historically low prices with high volatility.

Over the first half of 2020, the Henry Hub dived to its lowest average since 1999 ($1.9/MBtu) and the European TTF to its lowest level since its introduction back in 2003 ($1.5/MBtu in May). Oil-indexed prices have not suffered the same fate as yet. The 3- to 6-month indexation gap will have delayed it to the second half of the year.

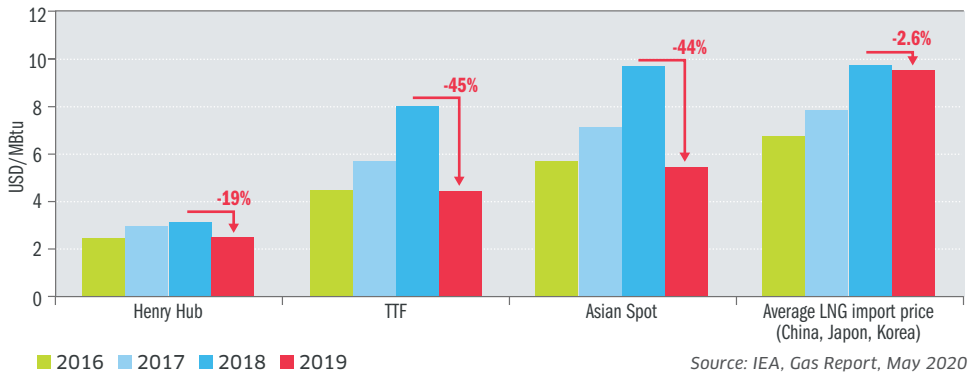
Natural gas prices will remain depressed throughout the summer in a context of grim demand, high stocks and continued LNG supply growth from liquefaction projects that have recently started operations.

NATURAL GAS PRICES IN €/MWH (MONTH AHEAD)



Source: ENGIE Global Markets

NATURAL GAS PRICES IN SELECTED MARKETS, 2016-2019 (IN $/MBTU)



Source: IEA, Gas Report, May 2020

Green gas

Green gases are set to play an important role in the transformation of the global energy system

Green gases: what are they?

- **Biogas** is produced from either landfill gas, sewage sludge, agricultural or agri-food residues through an anaerobic digestion process (also called methanisation). It can be used directly to generate electricity and heat (cogeneration).
Anaerobic digestion or methanisation is a biological process using microorganisms to decompose organic matter in the absence of oxygen. This process produces Biogas (methane, CO_2 and other gases) and a digestate that can be used as fertiliser.

- **Syngas** is produced by either pyrogasification or reformation of green hydrogen and carbon dioxide (methanation).
Pyrogasification or gasification is a thermo-chemical process that produces a gaseous fuel, called syngas, from lignocellulosic material (wood, straw, etc.). Syngas mainly consists of methane, hydrogen, carbon monoxide and carbon dioxide. It can be used directly in cogeneration or purified to produce biomethane.

- **Biomethane** is Biogas or purified synthesis gas that can be injected into the natural gas grid as a substitute to natural gas for any type of client and use, including mobility (NGV).

- **Green hydrogen** is produced from renewable electricity through electrolysis (power-to-gas) or through biomass (steam reforming or pyro-gasification). Mainly used as an industrial raw material today, hydrogen can be injected directly into the natural gas grid directly or in the form of methane after reformation with carbon dioxide (see following section).

Biomethane, synthesis methane or hydrogen can either be injected in the natural gas grid (up to a certain percentage for hydrogen) or used directly, off the grid, for specific purposes, such as transport.

Most of today's green gases are Biogases from methanisation, with heat and electricity produced through cogeneration engines. The production of biomethane for injection into the natural gas grid is developing, however, thanks to regulatory incentives in several European countries.
Pyrogasification and power-to-gas have not yet reached the technological maturity of methanisation, and their share of production remains limited compared to methanisation.

Biogas has thrived over recent years because of two major factors: the availability of raw material and the political support given to Biogas production and use. This explains its uneven development across the world. Europe, China and the USA together made up 90% of world production in 2018, for an estimated 35 Mtoe (approx. 410 TWh). This represents a tiny fraction of world potential however, estimated near 600 Mtoe (approx. 7,000 TWh).

Biogas expansion continues in Europe

In 2018, European Biogas production reached 18 Mtoe (~20 bcm or 200 TWh), or 8% of European gas production. Biogas experienced exponential growth until 2014, and more attenuated since, mainly as a result of changes in the EEG law*. This law, promulgated in April 2000, creates a dedicated purchasing tariff in Germany, which until now remains the main producer in Europe. Indeed, Biogas production is still concentrated at 80% in 3 countries: Germany (10 bcm), UK (3 bcm), Italy (3 bcm). Biogas is the "bioenergy" that has the most rapidly increased since 2010, surpassing biofuel production.

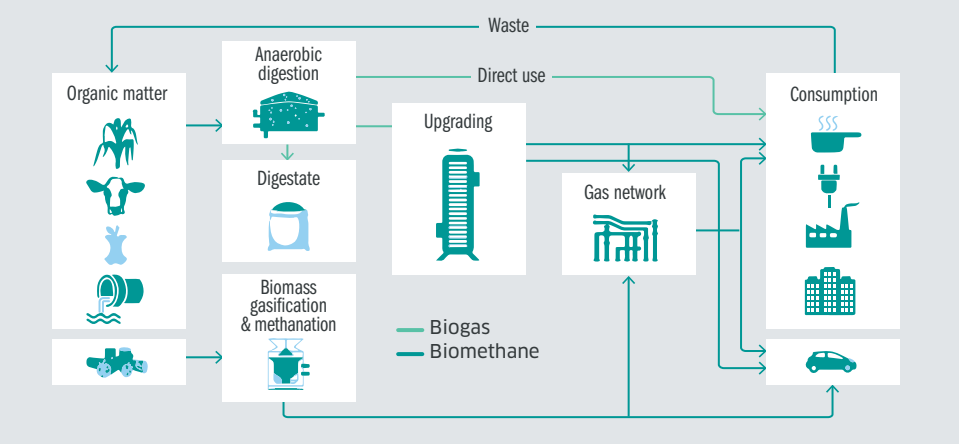
In Europe, 76% of Biogas is for power and heat production – to produce 63 TWh of electricity (i.e. 6% of renewable electricity in Europe) - then it is consumed for 7% in residential, 5% in agriculture, 2% in industry and 1% in transport. Finally 4% are injected into natural gas networks in the form of biomethane, thanks to 729 biomethane injection stations today (source: EBA / GIE, early 2020).

According to the European Biogas Association, renewable gases could reach 10% of natural gas consumption in the EU by 2030 (approx. 43 Mtoe, or 500 TWh). And by 2050, according to the Gas for Climate consortium, sustainable biomethane production could amount to 1,072 TWh (near 22% of current gas consumption).

*EEG: Erneuerbare Energien Gesetz, German law giving priority to renewable energies thanks to dedicated purchase prices.
1 Mtoe = 11.63 TWh = 41.9 PJ (petajoules).

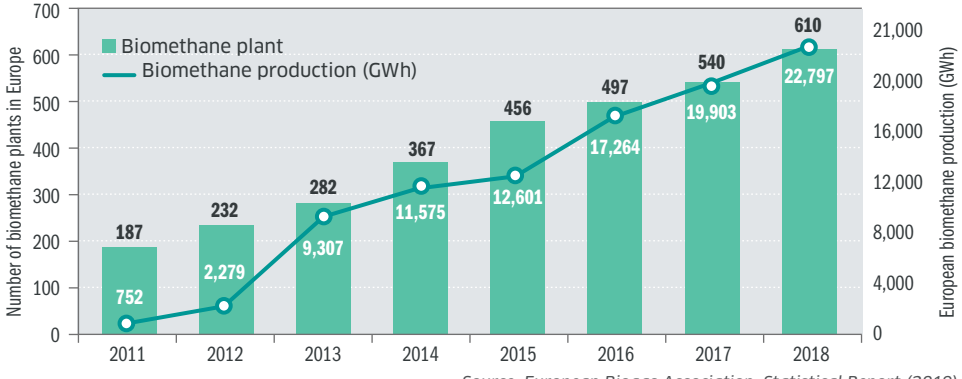
Green gas: biogas and biomethane

HOW BIOGAS AND BIOMETHANE ARE PRODUCED



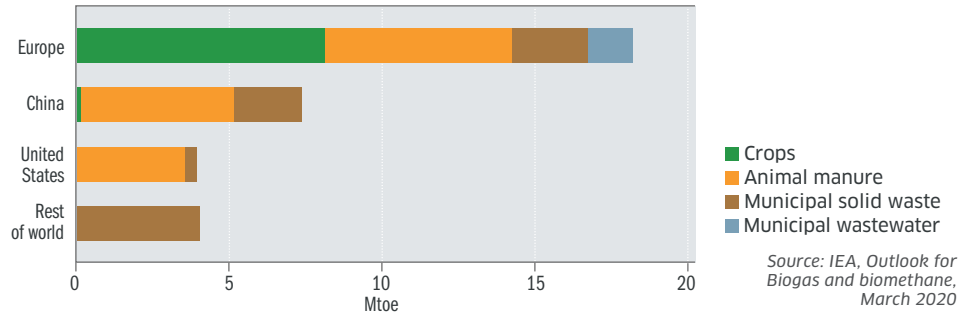
Source: European Biogas Association, Statistical Report (2019)

EU BIOMETHANE PRODUCTION AND NUMBER OF INJECTION FACILITIES



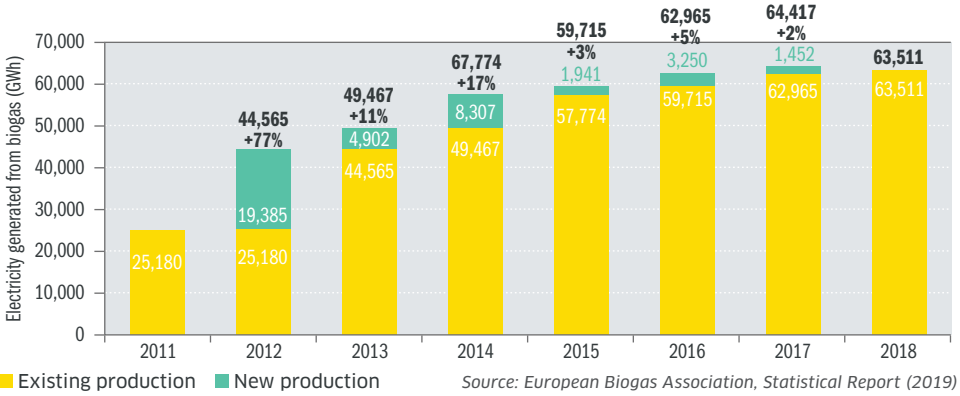
Source: European Biogas Association, Statistical Report (2019)

WORLD BIOGAS PRODUCTION BY SOURCE IN 2018



Source: IEA, Outlook for Biogas and biomethane, March 2020

EU ELECTRICITY PRODUCTION FROM BIOGAS – IN GWH



Source: European Biogas Association, Statistical Report (2019)

Green gas within the energy transition

Green gases meet energy transition requirements on several counts.

As they can be injected into natural gas grids, green gases offer specific advantages over other renewable sources: low transport costs, massive and competitive storability, and high inter-seasonal flexibility. In Europe in particular, green gases can benefit from existing and well-amortised infrastructures. For these reasons, green gases are an indispensable vehicle of energy transition and an integral part of decarbonization roadmaps, in which they are complementary to other renewables for electricity generation (see the Scenarios section in the Decarbonization chapter).

Because it is produced locally, biogas is an opportunity for decentralised solutions and non-relocatable job creation (about 3-4 direct jobs per facility). It helps address the community challenge of waste treatment, favours sustainable agriculture, helps to improve air quality and opens access to 'modern' energy for communities deprived of it.

Market design is essential to take advantage of biogas and biomethane potential.

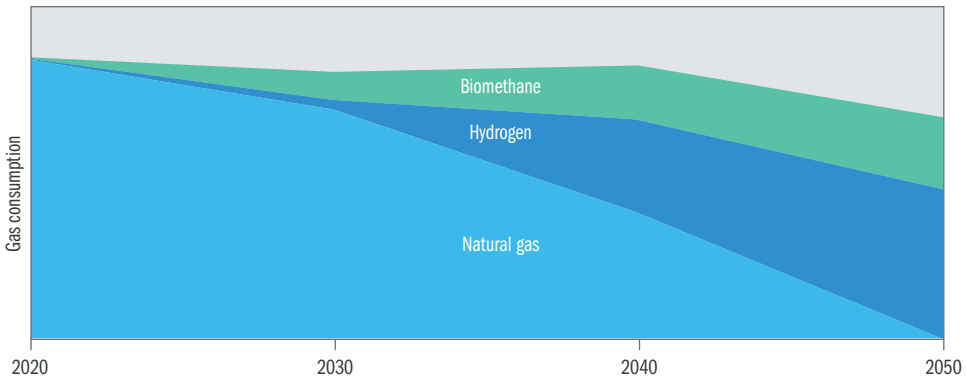
Biogas and biomethane development is very capital-intensive. Production costs largely depend on input prices, facility size and national support mechanisms. They range from €40 to €120 per MWh for production based on anaerobic digestion.

For biomethane and biogas to compete with fossil fuels, carbon prices must reflect their environmental benefit. Until then, support such as injection tariffs, support mechanisms as green certificates, or fiscal incentives will be needed for the market to develop.

The establishment of support policies, as was the case for electric renewables, should improve the productivity of anaerobic digestion units, professionalize the sector by massifying operations and standardizing them. The objective is to reduce biomethane production costs by a third by 2030.

At last, the cost of these mechanisms must be balanced with the positive externalities generated by biogas and biomethane.

GREEN GAS PRODUCTION FORECASTS TO 2050 IN THE EUROPEAN UNION



Source: Gas for Climate (2020)

USE OF GREEN GAS BY SECTOR IN THE EU TO 2050

Source: Navigant (2019)

Green gas: green hydrogen

Green hydrogen as the missing link in energy transition

Hydrogen (H_2) is the most widespread chemical element on earth. It is found in water (H_2O), for example, and in hydrocarbons such as oil and natural gas. **The molecule has a particularly high energy content and it can be transported and stored.** 1kg of hydrogen generates roughly three times more energy than 1kg of gasoline.

Today, mainly "grey" hydrogen is produced.

- **Grey hydrogen** is extracted from fossil fuels, notably through natural gas steam reforming. 48% of hydrogen is produced from natural gas, 30% from oil products and 18% from coal. In other words, 96% of the world's hydrogen production is grey hydrogen.

- Grey hydrogen is currently the cheapest solution available at around \$2/kgH_2, depending on gas and CO_2 local prices. But it is also highly carbon-intensive: 1kg of H_2 produced generates about 10kg of CO_2. The sector emits 830 million tonnes of CO_2 each year, according to the IEA. By comparison, Germany's total emissions are smaller than that.

- **Blue hydrogen** is derived from grey hydrogen, complemented with carbon capture and storage (CCS). 60-90% of the CO_2 emitted during the production process is captured and stored underground. Huge storage capacity is required and its full costs are poorly understood.

- **Green hydrogen is the only fully decarbonized solution.** It produces hydrogen via the electrolysis of water, using renewable electricity (hydro, solar or wind) without CO_2 emissions or polluting particles. Renewable hydrogen remains about twice as expensive as grey hydrogen, and today only 4% of world hydrogen production uses electrolysis.

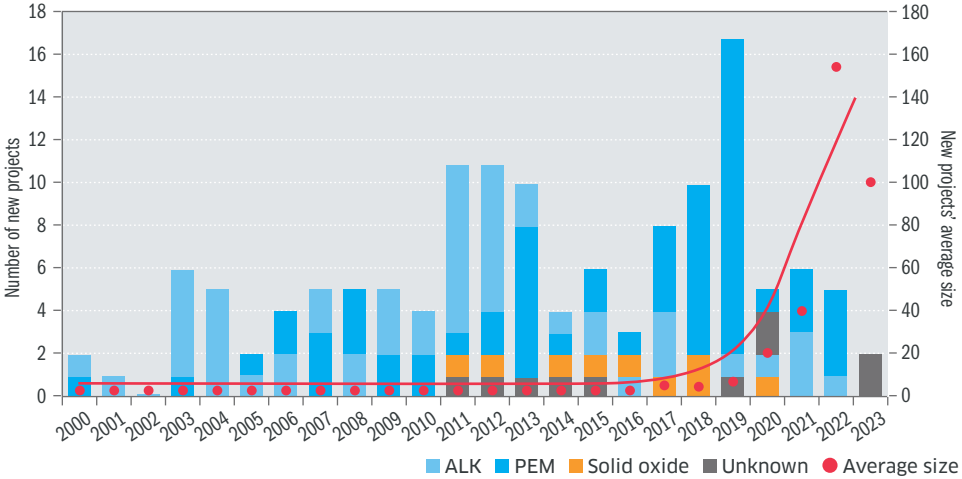
Hydrogen is used mainly as an industrial raw material.

Most of the 70 million tonnes of hydrogen produced each year in dedicated facilities is used to manufacture ammonia and fertilisers (44%), methanol (18%) and to refine oil (26%).

Cheaper electrolysis and renewable energy will extensively reshape the hydrogen market in the years ahead.

Converging private initiatives and public support have helped the electrolysis sector to start scaling up. In combination with process industrialisation, electrolysers' production costs are coming down. Taken together, planned electrolysis projects represent 8.2 GW in installed capacity by 2030, according to the European Commission in March 2020. The cost of producing renewable hydrogen is nearly equally divided between the costs of the electrolyser and that of green electricity. **The downtrend in renewable power and electrolysis costs reduced renewable hydrogen production costs by 45% on average between 2015 and 2020, according to IHS.**

HYDROGEN PRODUCTION PROJECTS BY ELECTROLYSIS



More numerous and larger projects for H2 production by electrolysis.
Source: IRENA, 2019

Green gas: green hydrogen

There is now a consensus among scientists that green hydrogen will soon be a competitive alternative.

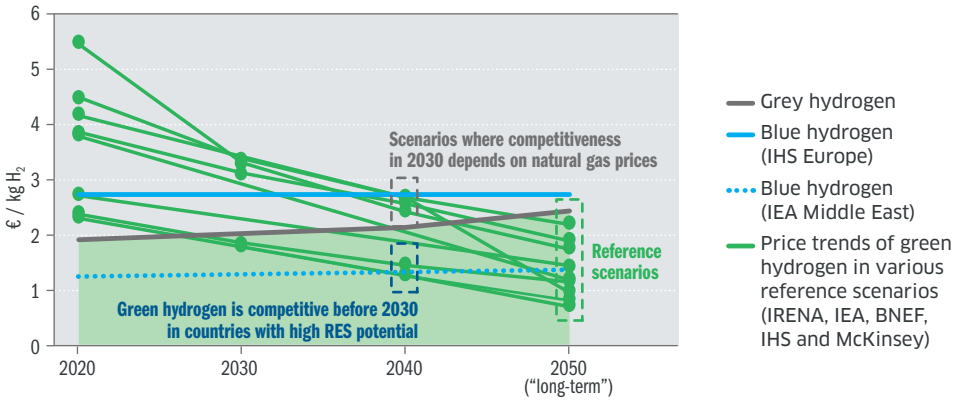
- The continuing decline in renewable electricity and electrolysers' costs is expected to halve production costs by 2030.
- Most analysts consider that green hydrogen will be cheaper than grey hydrogen before 2030 in the most favourable locations (i.e. where wind and solar power is the most competitive).
- Establishing a high CO_2 price should accelerate the trend, as it would weigh on grey hydrogen production costs.

Greener hydrogen production will go together with new uses. Decarbonizing current hydrogen uses (refining, chemicals and steel production) is a first step in market development. Beyond that, most experts consider that green hydrogen will expand as a low carbon solution for 'heavy' mobility (road, rail, synthetic fuel for maritime and air transport), power storage and production, and heat generation.
The Hydrogen Council forecasts that the global market for hydrogen will increase tenfold by 2050, driven by renewable hydrogen and its new uses, and that hydrogen will account for about 20% of final energy demand by then (see opposite).

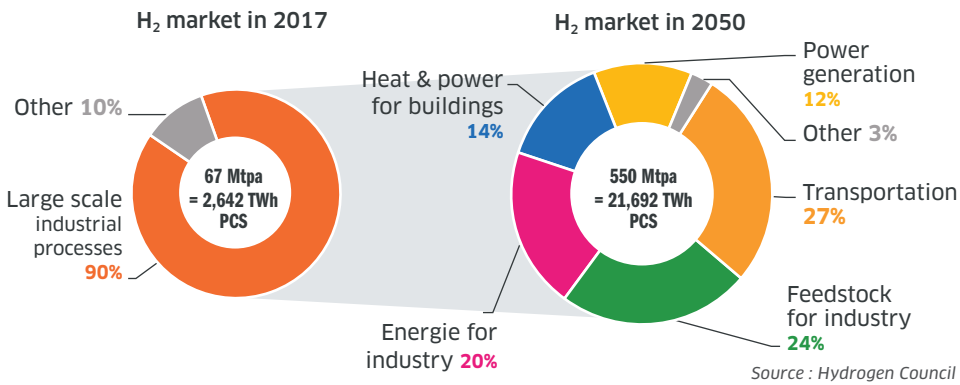
In most energy transition scenarios, green hydrogen is a key element in unlocking the full potential of electricity renewables. It can be stored to cope with intermittent renewable energy and to meet seasonal demand (heating and cooling).

Green hydrogen benefits from strong political support. Many countries have implemented policies aimed at its development. In July 2020, for example, the European Commission published a hydrogen deployment strategy as part of carbon neutrality. The objective is 40 GW electrolysis installed capacity by 2030, producing 10 Mt of green hydrogen.

HYDROGEN PRODUCTION COSTS IN THE MAIN BENCHMARKS



2050 HYDROGEN MARKET ESTIMATES (ALL TYPES OF HYDROGEN)



Source : Hydrogen Council

Oil

OIL DEMAND

The key question will be to know how prolonged the demand destruction will be, and if the post-Covid pathways will lead to faster decarbonization & steeper decline of oil demand

PRODUCTION

All the major producers, OPEC, Russia and the United States, were forced to unite to face overproduction and the collapse of oil prices

Oil and energy transition

Comparing current oil trends with decarbonization roadmaps. Although world oil demand slowed below the decade's trend growth in 2019, it is still far stronger than the annual 1.7% contraction required until 2040 to meet climate objectives.

The current growth rate is in line with national commitments made at COP21 (STEPS scenario), however: they call for limiting oil demand rather than actually reducing it (moderate growth until 2030, then stabilisation).

The health crisis severely dented oil demand, but temporarily. The challenge is to extend the recent contraction over coming years.

How long and to what extent will the decline in oil demand last? And will post-Covid developments hasten decarbonization and oil demand contraction? These are the key questions. In this respect, Europe could diverge from the rest of the world if it commits and invests decisively in 2050 carbon neutrality objectives.

At world level, most forecasts indicate no consumption peak before 2025-2035. Given its importance to the world economy, exiting oil is an immense challenge.

The major hurdles to a reduction in oil consumption are the rapid growth of demand in Asia and the development of transport and petrochemicals.

China will be the leading contributor to growing demand. It will become the world's largest consumer by 2040, ahead of the USA, where demand will decline significantly. India will also become a major contributor, with its oil consumption set to double by 2040.

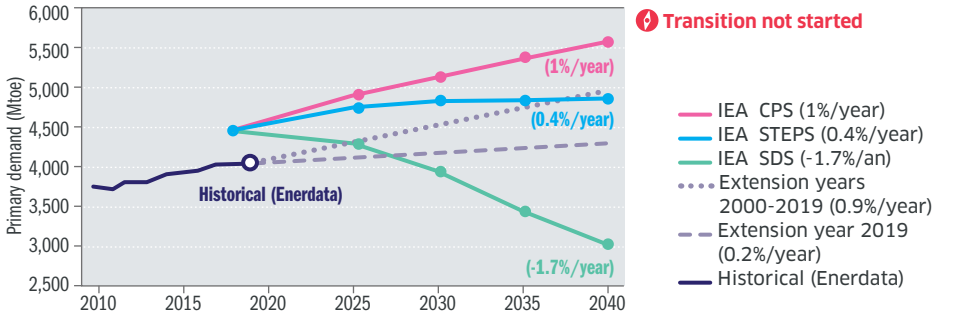
The key determinants of additional demand will be the expansion of the world's car fleet, aggravated by the SUV craze (translating into a +2 Mbd impact by 2040), trucks, maritime and air transport, as well as petrochemicals.

Considered the most probable scenario, these STEPS trends would mean increasing oil demand until 2040, and no decline until after that.

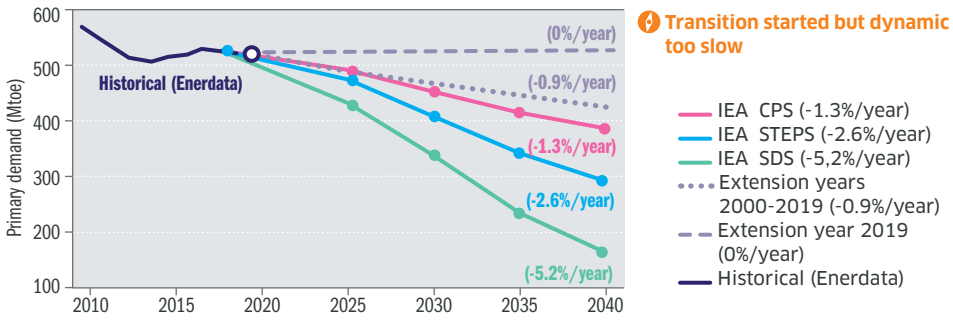
The implication for meeting environmental objectives is a need to trigger a downtrend earlier, and notably by bringing China's oil consumption peak forward 10 years (projected in 2035 in STEPS).

This would require enhanced environmental policies worldwide, including faster development of electrical cars (STEPS foresees 330 million units by 2040, reducing consumption by 4 Mbd, when 3 times more are required), biofuels, and plastic recycling (only 15% are currently recycled; STEPS expects an increase to 20% by 2040, whereas a 35% objective would save1.7 Mbd).

OIL PRIMARY DEMAND PROJECTION – WORLD



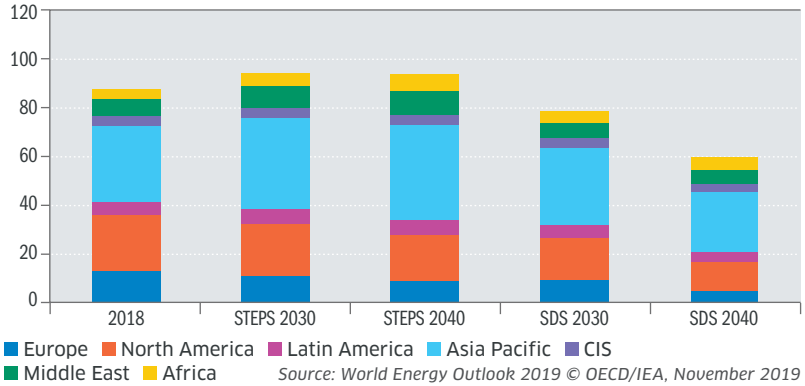
OIL PRIMARY DEMAND PROJECTION – EUROPEAN UNION



Oil: consumption and production forecasts in the IEA scenarios

FORECAST OF OIL DEMAND IN THE STATED POLICIES SCENARIO AND SUSTAINABLE DEVELOPMENT SCENARIO, IEA 2019 (MB/D)

Forecast of oil consumption in IEA scenarios (in mb/d)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	13	11	9	-1.9%	8%	9	5	-4.3%	7%
North America	23	22	19	-0.8%	18%	18	12	-3.0%	17%
Latin America	6	6	6	0.5%	6%	5	4	-1.8%	6%
Asia Pacific	32	38	39	1.0%	37%	32	25	-1.0%	38%
CIS	4	4	4	0.4%	4%	4	3	-1.0%	5%
Middle East	7	9	10	1.4%	10%	7	6	-0.7%	9%
Africa	4	6	7	2.7%	7%	5	5	1.3%	8%
OECD	42	38	32	-1.3%	30%	31	19	-3.5%	29%
No OECD	46	57	63	1.4%	59%	48	41	-0.5%	61%
International bunkers	8	10	11	1.5%	11%	8	6	-1.2%	10%
World	97	105	106	0.4%	100%	87	67	-1.7%	100%
World oil	54	60	61	0.6%	58%	48	32	-2.3%	48%
Road, aviation & shipping	18	22	23	1.0%	21%	19	19	0.0%	28%
Industry & petrochemicals	2	4	5	4.2%	4%	6	8	6.6%	12%
World biofuels	99	109	111	0.5%	100%	93	75	-1.3%	100%

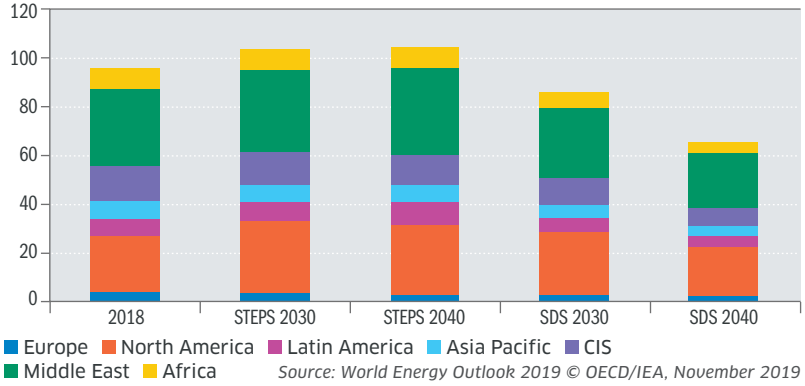


Source: World Energy Outlook 2019 © OECD/IEA, November 2019

FORECAST OF OIL PRODUCTION IN THE STATED POLICIES SCENARIO AND SUSTAINABLE DEVELOPMENT SCENARIO, IEA 2019 (MB/D)

Forecast of oil production in IEA scenarios (in mb/d)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	4	3	3	-1.5%	3%	3	2	-3.0%	3%
North Amercica	23	30	29	1.0%	28%	26	21	-0.5%	32%
Latin America	7	8	10	1.8%	9%	6	5	-1.7%	7%
Asia Pacific	8	7	6	-0.8%	6%	5	4	-3.0%	6%
CSI	14	14	12	-0.7%	12%	11	7	-3.2%	11%
Middle East	32	34	36	0.5%	34%	29	22	-1.6%	34%
Africa	8	8	8	-0.1%	8%	6	5	-2.4%	7%
OECD	27	33	32	0.8%	31%	29	23	-0.7%	35%
No OECD	68	69	71	0.2%	69%	56	42	-2.2%	65%
World	95	103	104	0.4%	100%	85	65	-1.7%	100%
Conventionnal crude oil	67	65	62	-0.4%	58%	53	37	-2.7%	55%
Tight oil	6	12	13	3.5%	13%	10	9	1.7%	14%
Natural gas liquids	17	20	22	1.0%	20%	18	15	-0.7%	22%
Extra-heavy oil and bitumen	4	4	5	1.1%	5%	3	3	-1.2%	4%
Other production	1	1	2	3.1%	1%	1	1	2.0%	2%

Source: World Energy Outlook 2019 © OECD/IEA, November 2019



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

The difference between world consumption and production comes from "processing gains", or "refinery processing gain", an increase in volume during crude oil refining due to a lower density of petroleum products compared to crude oil.

Oil: consumption

Oil demand was on a growing trend in 2019 and even crossed the 100 mb/d threshold, driven in particular by China, before collapsing during Covid-19

World oil consumption rose steadily in 2019 (+1,1 mb/d, +0.2% vs 2018) to overpass the 100 mb/d threshold. China was the largest energy consumer in the world and pushed oil demand upwards as demand was thriving thanks to vehicle and freight growth.

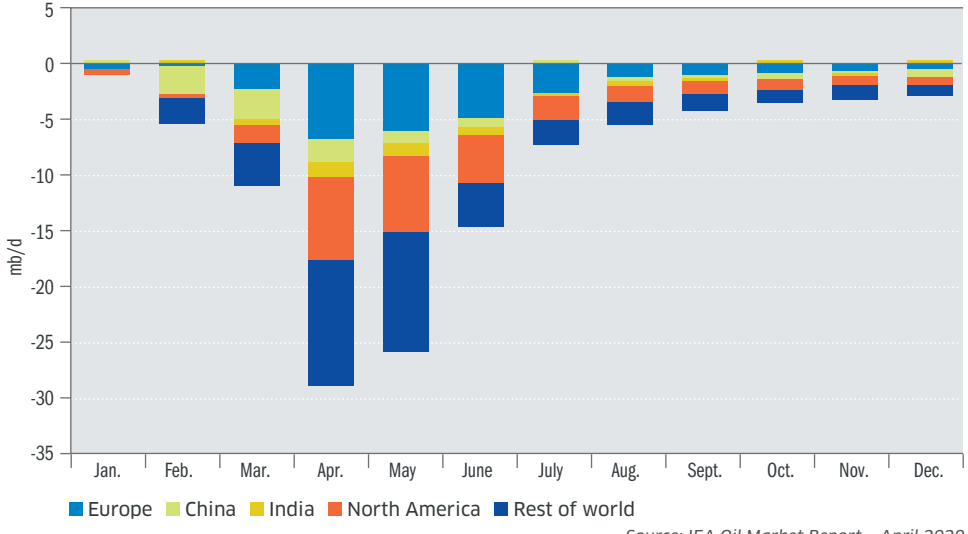
The Covid-19 pandemic created an unprecedented whirldwind for the oil markets. Indeed, in 2020, the impact on oil demand has been far worse than the 2008-2009 financial crisis, notably because transportation fuels have been deeply affected, especially mobility and aviation. The peak of the demand destruction is likely to have been reached in 2Q 2020 (~minus 20 mb/d).

The total 2020 demand change year-on-year is estimated to be around -8 to -9 mb/d vs 2019 (IEA, EIA, OPEC). It is expected that demand in 2021 will still remain below 2019 levels, the IEA expecting still a -2,4 mb/d under 2019 levels.

The lack of control over the virus spread makes the short-term outlook for demand and prices highly uncertain. In any case, a fast pick up seem unlikely and most forecast do not envisage a return to 2019 level before 2022.

Longer term, in the Sustainable Development Scenario (IEA, Fall 2019), oil demand is peaking and reaching a plateau in the next few years, before a slow decreasing trend to 87 mb/d in 2030 then 67 mb/d in 2040. While some oil majors like TOTAL expect to reach a plateau in oil demand around 2030, it is likely that even in 2° scenario, oil will continue to play a part in the energy mix and that decline will be gradual.

CHANGE IN MONTHLY OIL DEMAND IN 2020 RELATIVE TO 2019 (IEA ESTIMATION)



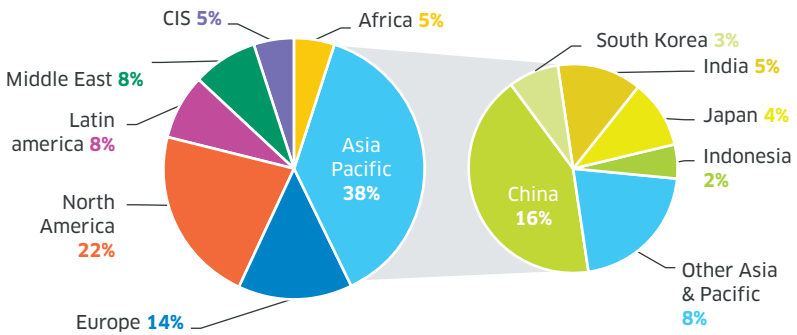
Source: IEA Oil Market Report – April 2020

Oil: consumption

Total oil consumption (Mt)	2000	2005	2010	2015	2018	2019	Change 2018-2019	AAGR 2010-2019	Share of world 2019
Europe	681	693	623	575	585	588	0.6%	-0.6%	13%
Germany	123	114	103	99	96	98	2.1%	-0.5%	2%
France	87	86	76	71	68	67	-0.5%	-1.3%	2%
United Kingdom	70	69	61	58	58	57	-2.1%	-0.7%	1%
North America	952	981	864	875	893	888	-0.6%	0.3%	20%
Canada	88	103	104	110	104	102	-1.8%	-0.3%	2%
United States	864	878	759	765	789	786	-0.5%	0.4%	18%
Latin America	302	313	353	364	334	324	-2.8%	-0.9%	7%
Brazil	87	86	101	113	101	99	-1.5%	-0.2%	2%
Mexico	92	93	92	91	85	81	-5.1%	-1.4%	2%
Venezuela	23	29	37	30	19	17	-10.1%	-8.1%	0%
Asia	884	1,005	1,131	1,312	1,421	1,465	3.1%	2.9%	33%
China	220	317	429	539	608	648	6.6%	5%	15%
South Korea	93	90	92	102	110	109	-1.5%	1.9%	2%
India	109	121	154	194	218	224	2.9%	4.3%	5%
Indonesia	55	63	64	74	79	84	6.6%	3%	2%
Japan	241	230	190	178	161	152	-5.1%	-2%	3%
Pacific	43	47	51	57	61	60	-1.2%	2%	1%
CIS	175	176	185	194	204	206	1%	1.2%	5%
Russia	127	127	137	143	151	152	0.9%	1.2%	3%
Middle East	219	263	313	350	341	336	-1.7%	0.8%	8%
Saudi Arabia	66	80	113	146	133	134	0.4%	1.9%	3%
United Arab States	8	10	13	18	19	18	-3%	3.8%	0%
Iraq	23	24	31	39	44	46	3.3%	4.2%	1%
Iran	69	81	81	79	79	73	-8.2%	-1.2%	2%
Kuwait	12	17	21	21	17	17	-2.8%	-2.3%	0%
Africa	104	127	156	186	193	187	-2.9%	2%	4%
Nigeria	17	21	24	27	27	27	-0.4%	1.4%	1%
Bunkers	271	316	356	378	415	399	-3.9%	1.3%	9%
World	3,629	3,920	4,031	4,290	4,446	4,453	0.2%	1.1%	100%

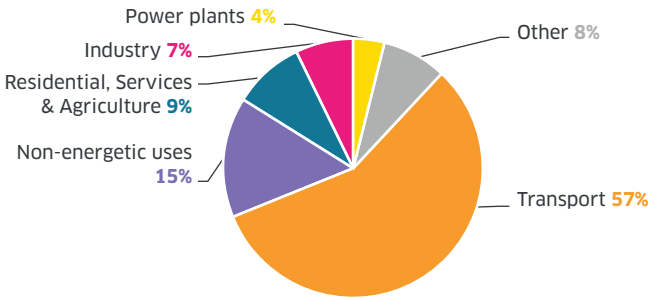
Source: Enerdata, Global Energy and CO_2 Data, 2020

GLOBAL OIL DEMAND BY GEOGRAPHIC REGION IN 2019 (EXCLUDING BUNKERS) – TOTAL: 4,054 MT



Source: Enerdata, Global Energy and CO2 Data, 2020

GLOBAL OIL DEMAND BY SECTOR IN 2019 – TOTAL: 4,453 MT



Source: Enerdata, Global Energy and CO_2 Data, 2020

Oil: production

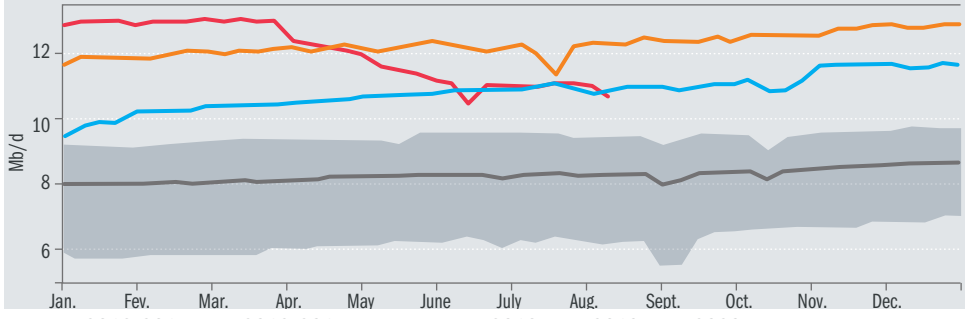
Following a slight decrease in 2019, oil production had to undergo severe cuts in 2020 to adjust to the drop in consumption; all the major producers were forced to unite to face the collapse of oil prices

Globally, the world oil production decreased slightly in 2019 (-0.7%), mainly due to Iran and Venezuelan production disruptions. The US shale oil production showed very healthy figures with continued growth in 2019, to the point that in September 2019 the US registered its first oil trade surplus from 1978, as production and exports surged to a record.

However, following the massive slump in demand in 1Q/2Q 2020, OPEC+ members (including Russia) agreed to massive cuts, slashing output by 9.7 mb/d in April 2020, reconducted in June, hence helping to push prices back up. G20 members, including the US, joined the cuts without binding obligation. Saudi Arabia, Russia and the US are the main contributors to these massive cuts.

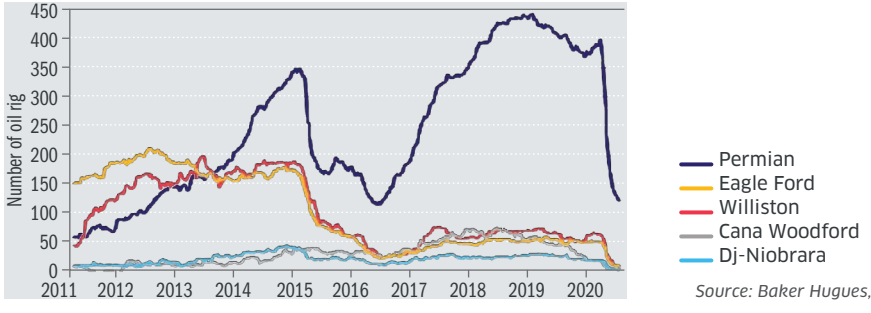
The downturn in prices led to a significant collapse of upstream investments globally. In the US, a sharp decrease of drilling occured, with decreasing rigs remaning in operation (274 vs 2000 at the peak of the shale boom). A large number of bankrupcies in the US should lead to market consolidation before a pick up in production can be expected. Overall, the impact of investment lagging could create a surge in pricing in the medium term, should demand recover faster than anticipated.

US CRUDE PRODUCTION PER YEAR



Source: US Energy Information Administration (EIA), July 2020

HORIZONTAL OIL RIGS



Source: Baker Hugues, EGM, 2020

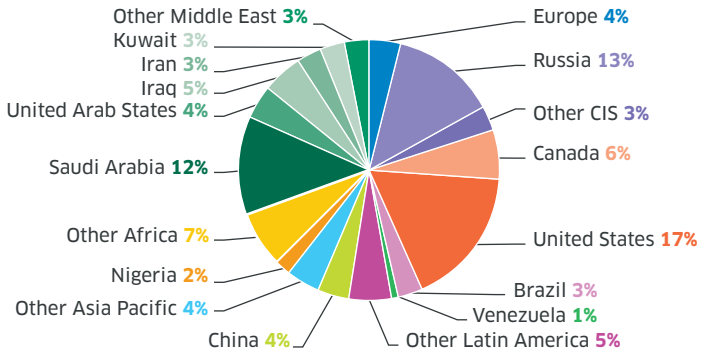
Oil: production

Crude Oil, NGL production, LPG* (Mt)	2000	2005	2010	2015	2018	2019	Change 2018-2019	AAGR 2010-2019	Share of world 2019
European union	336	268	202	169	167	161	-3,2%	-2,4%	4%
Germany	4	5	4	4	3	3	-6,8%	-1,9%	0%
United Kingdom	126	85	63	45	51	52	1,8%	-2,2%	1%
North America	478	450	498	789	934	1 013	8,4%	8,2%	23%
Canada	125	140	164	222	263	268	2%	5,6%	6%
United States	353	310	334	567	671	745	11%	9,3%	17%
Latin America	524	567	534	532	439	416	-5,2%	-2,7%	9%
Brazil	64	85	107	128	136	146	7,3%	3,4%	3%
Mexico	169	188	145	127	101	94	-7%	-4,7%	2%
Venezuela	174	182	159	146	86	58	-31,8%	-10,5%	1%
Asia	340	357	376	383	350	347	-1%	-0,9%	8%
China	163	181	204	217	194	195	0,9%	-0,5%	4%
India	36	37	42	41	39	38	-0,4%	-1%	1%
Indonesia	70	52	48	40	39	39	1%	-2,2%	1%
Pacific	38	28	27	19	15	17	14,5%	-4,9%	0%
CIS	392	573	656	676	702	705	0,5%	0,8%	16%
Russia	322	466	504	534	555	560	0,8%	1,2%	13%
Kazakhstan	35	62	81	81	90	90	0,2%	1,2%	2%
Middle East	1 135	1 234	1 204	1 367	1 467	1 377	-6,1%	1,5%	31%
Saudi Arabia	436	514	461	565	573	545	-4,9%	1,9%	12%
United Arab Emirates	121	133	134	178	179	183	2%	3,5%	4%
Iraq	129	94	117	173	223	232	3,8%	7,9%	5%
Iran	199	220	214	161	207	137	-33,7%	-4,8%	3%
Kuwait	105	135	123	152	148	144	-2,2%	1,8%	3%
Africa	387	477	498	394	395	401	1,6%	-2,4%	9%
Nigeria	115	129	127	106	95	99	4,8%	-2,7%	2%
World	3 630	3 954	3 994	4 329	4 469	4 438	-0,7%	1,2%	100%

*Liquified Petroleum Gas.

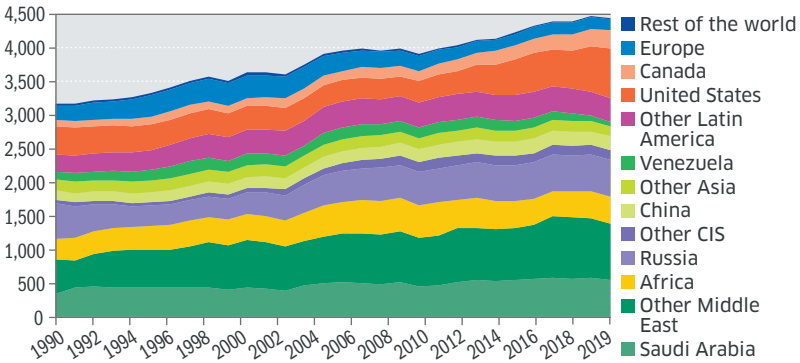
Source: Enerdata, Global Energy and CO_2 Data, 2020

SHARE OF OIL PRODUCTION BY GEOGRAPHIC REGION TOTAL: 4,438 MT



Source: Enerdata, Global Energy and CO_2 Data, 2020

OIL PRODUCTION EVOLUTION IN VOLUME BETWEEN 1990 AND 2019 (MT)



Source: Enerdata, Global Energy and CO_2 Data, 2020

Oil: prices

OPEC+ production cuts helped to contain the price decline in 2019 due to trade tensions between the US and China, until the 2020 Covid-19 demand crash brought prices to a critical low

BRENT	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Brent Dated en $/bl (nominal)	2	12	37	28	24	17	29	55	80	111	112	109	99	52	44	54	71	64
Brent Dated en €/bl (nominal)	2	8	24	37	20	13	31	44	60	78	87	82	74	48	40	48	60	57

Source: Enerdata, Global Energy and CO_2 Data, 2020

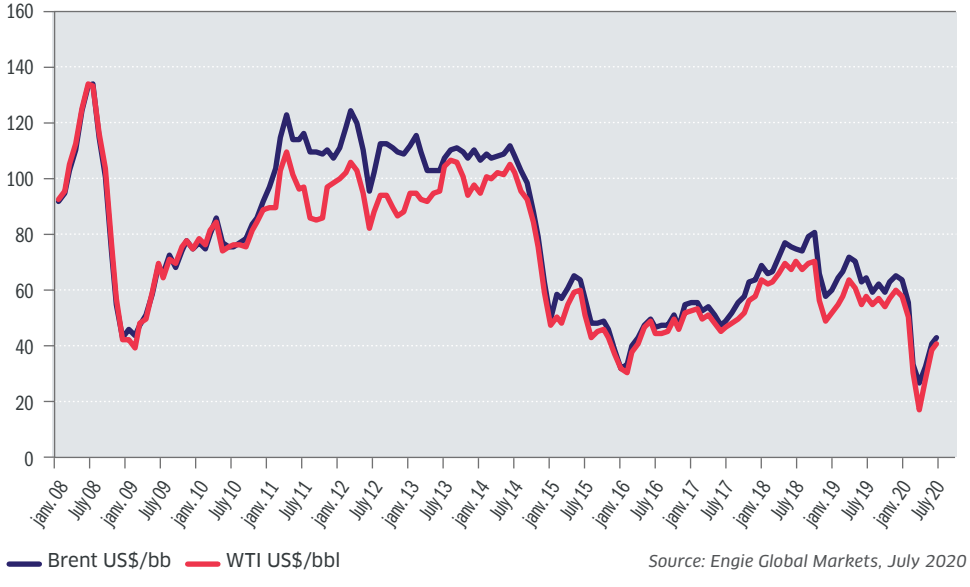
In 2019, prices decreased from end-2018 levels on the back of macroeconomics worries (81$/bl in October 2018, with a yearly average in 2018 at 71$/bl). They were however supported by unexpected OPEC+ cuts, allowing to reach a yearly average of 64$/bl, with a peak in April/May, and a spike in September after drone attacks against Saudi Arabia oil complex. This spike was however short-lived as the Kingdom successfully brought back production in the announced timeframe (by month-end).

Breaking severely with the 2018-2019 path, 2020 was a very harsh year so far for oil prices. Facing the worst demand destruction ever, the Brent crude fell to 18-year lows in April below $20/bl and WTI even faced negative pricing.

Following this dramatic fall in early 2020, the OPEC+ historic agreement (-10 mb/d) allowed to push prices above the 40$/bl threshold from May on and the market now seems stabilized.

Medium term, while the potential to see a resurgence of Covid-19 remains an important threat, Forwards are increasing as demand is expected to gradually return to pre-Covid levels while supply could tighten on the back of low investments during 2020.

BRENT AND WTI PRICES (IN $/BARIL)



Source: Engie Global Markets, July 2020

Coal

PRODUCTION

Softer world demand has largely unaffected coal production, which remains close to its 2013 record

PRICES

Despite much lower prices, coal is now suffering from heightened competition from natural gas in power generation

Coal and energy transition

The future of coal will depend mainly on environmental policies and the availability of cost-effective substitutes in industrial processes

Coal is the energy source that generates the most CO_2 emissions (1,058 gCO_2/KWh for coal-fired power plants) and is the most widely used in power generation (36.4% of the world mix in 2019). It has become one of the major headaches in energy transition. Despite a dip recorded in 2019, when consumption contracted 2.6%, current coal trends remain far short of the 4.2% average annual cut required by the IEA Sustainable Development Scenario (SDS) out to 2040. Although the impact of Covid-19 will temporarily improve the picture – world coal demand is expected to be down 8% in 2020, according to the IEA – such passing developments will not be enough to meet Paris Agreement commitments.

On a global scale, this overview masks two distinct tendencies. In developed economies (EU, USA), the use of coal has fallen steeply in recent years amid earlier than planned plant closures, the rapid expansion of RES, the competitiveness of natural gas and higher CO_2 prices. The situation is completely different in developing countries: the IEA Stated Policies Scenario (STEPS) projects a considerable increase in coal demand both in India (up 97%) and Southeast Asia (up 90%), offsetting western countries' efforts to downsize almost completely.

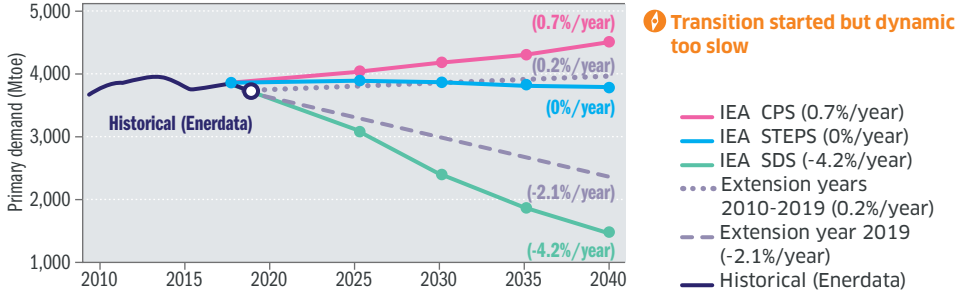
Despite growing awareness of the damage it does to the environment, coal remains an abundant and cheap resource. It is still vital to countries where power demand and industrial activity are booming. According to the STEPS forecasts, Indian coal production will double by 2040 to meet the government's productivity targets. Poland is Europe's leading producer and does not intend to exit coal before 2070. In China, the official line may favour reduced coal consumption to improve air quality and to promote greener energy, but over 180 GW in new coal-fired power plants are in planning phase, according to the IEA.

Without cost-efficient substitutes, the use of coal in industrial processes (especially iron, cement and chemicals) – representing a third of total demand – is expected to increase consumption by 225 Mtce by 2040.

Although cut by half since their 2012 record, investment in the coal sector (mining infrastructures and transports) remains substantial at almost $80 bn per year.

The future of coal is therefore intrinsically linked with the contents of government environment policies. Measures favouring natural gas, 2.5 times less polluting than coal (418 gCO_2/KWh for gas-fired power plants), penalising high-emission facilities and developing CO_2 sequestration technology (see chapter Decarbonization) could have a decisive impact. In the meantime, other stakeholders are in a position to hamper coal use and accelerate the sector's transition. Several banks, insurance companies and investment funds such as those run by BNP Paribas, BlackRock, Goldman Sachs, AXA, Generali and the European Investment Bank announced in 2019 their intention to reduce or halt investments in coal projects.

COAL PRIMARY DEMAND PROJECTION – WORLD

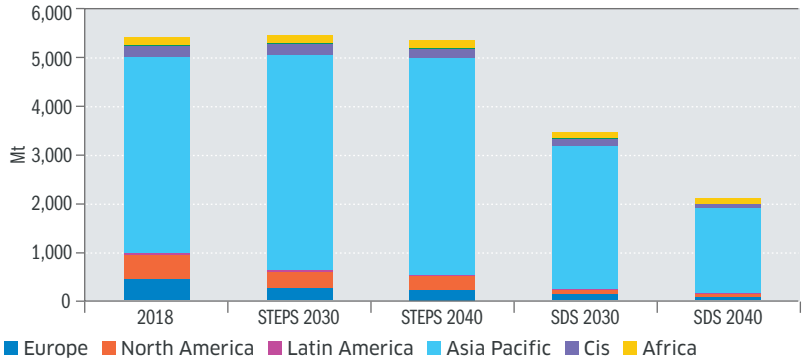


Coal: consumption and production forecasts

WORLD COAL CONSUMPTION FORECASTS WITHIN IEA'S STEPS AND SDS SCENARIOS (MTCE*)

Forecast of oil consumption in IEA scenarios (Mtce)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	447	263	203	-3.5%	4%	129	84	-7.3%	4%
North America	492	328	285	-2.5%	5%	81	50	-9.9%	2%
Latin America	46	47	49	0.3%	1%	30	23	-3.0%	1%
Asia Pacific	4,079	4,76	4487	0.4%	83%	2,976	1,771	-3.7%	84%
CIS	229	212	199	-0.6%	4%	136	74	-5.0%	4%
Middle East	6	10	14	4.2%	0%	7	6	0.6%	0%
Africa	159	160	161	0,0%	3%	113	92	-2.5%	4%
OECD	1,218	803	651	-2.8%	12%	312	206	-7.8%	10%
No OECD	4,240	4,694	4,748	0.5%	88%	3,159	1,894	-3.6%	90%
World	5,458,	5,498,	5,398,	-0.1%	100%	3,471,	2,101,	-4.2%	100%

Source: World Energy Outlook 2019 © OECD/IEA, November 2019

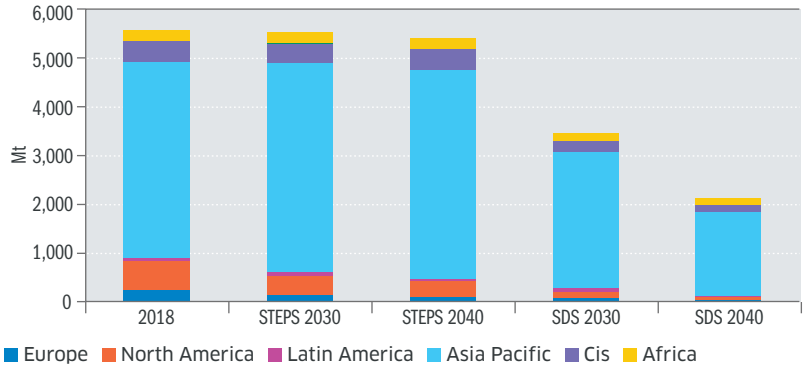


Source: World Energy Outlook 2019 © OECD/IEA, November 2019

WORLD COAL PRODUCTION FORECASTS WITHIN IEA'S STEPS AND SDS SCENARIOS (MTCE*)

Forecast of oil production in IEA scenarios (Mtce)	2018	Stated Policies Scenario				Sustainable Development Scenario			
		2030	2040	AAGR 2018-2040	Share in 2040	2030	2040	AAGR 2018-2040	Share in 2040
Europe	230	131	80	-4.7%	1%	63	24	-9.8%	1%
North America	576	385	329	-2.5%	6%	139	72	-9.0%	3%
Latin America	82	75	62	-1.3%	1%	59	11	-8.6%	1%
Asia Pacific	4 039	4 297	4 282	0.3%	79%	2 788	1 742	-3.7%	83%
CIS	414	409	424	0.1%	8%	246	127	-5.2%	6%
Middle East	1	2	2	0.7%	0%	2	2	0.2%	0%
Africa	225	199	221	-0.1%	4%	174	122	-2.7%	6%
OECD	1,169	883	830	-1.5%	15%	430	297	-6.0%	14%
No OECD	4,397	4,615	4,569	0.2%	85%	3,041	1,803	-4.0%	86%
World	5,566	5,498	5,398	-0.1%	100%	3,471	2,100	-4.3%	100%
Steam Coal	4,342	4,393	4,394	0.1%	81%	2,672	1,515	-4.7%	72%
Coking coal	955	857	790	-0.9%	15%	676	497	-2.9%	24%

Source: World Energy Outlook 2019 © OECD/IEA, November 2019



Source: World Energy Outlook 2019 © OECD/IEA, November 2019

* Mtce: million tonnes of coal equivalent – Conversion table in Appendix.

Coal: consumption

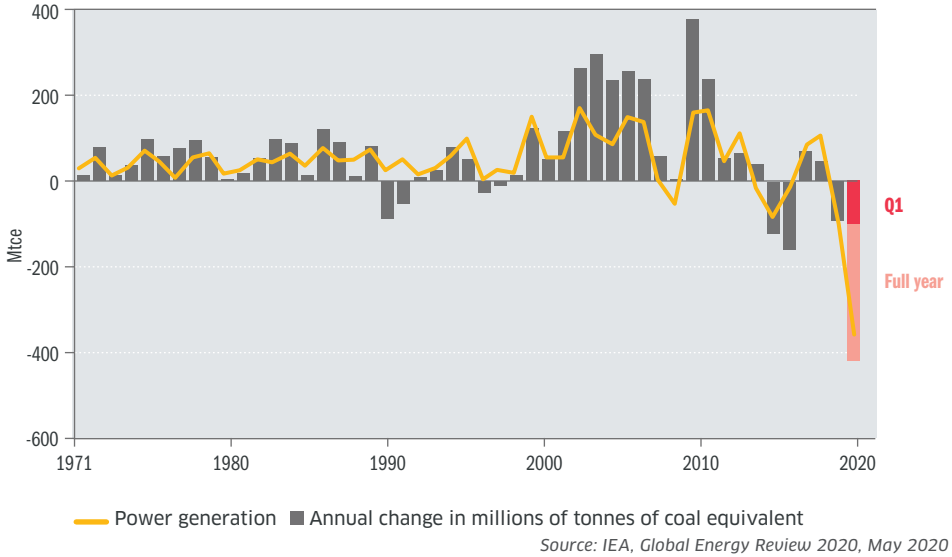
Ambitious climate policies and gas-fired plant competitiveness drove world coal demand down again in 2019, after two years of expansion

After a 2.6% dip in 2019, world coal demand is set to record its largest drop in 75 years. The projected 8% decline in 2020 mainly reflects the impact of lockdown measures on power generation. These short-term developments should not mask an overall increase in coal consumption over the 2010-2019 period (+0.4% per year on average), however, nor divergent geographical trends.

In the USA, coal consumption waned 6% per year over the 2010-2019 period, mainly as a result of a loss of competitiveness against unconventional gas and renewables in power generation. The Trump administration's support to the coal industry has not been enough to overcome market realities and failed to reverse the underlying trend. US coal-fired power generation decreased 14% in 2019, to its lowest level in 42 years, while coal capacity declined by 14 GW. The pandemic is expected to have accelerated this trend further. According to the Energy Information Administration, US coal consumption could fall 26% in 2020 before rebounding 20% in 2021.

Backed by ambitious climate policies, and taken as a whole, European countries also reported another decrease in coal demand in 2019. There were national divergences, however. Apart from France (-20%) and the Netherlands (-23%), Germany and Poland, two countries historically very dependant on coal, posted substantial contractions (-20.4% and -11%, respectively), partly because of the LCP directive on the gradual closure of the most polluting plants. In the UK, coal had dropped to only 2% of the mix by the end of 2019, and could disappear entirely from the power generation sector well ahead of the 2024 target date. The decline in coal consumption is expected to amount to 20% overall in Europe, reflecting a combination of lockdown measures, milder winters and the LCP directive. The sharp fall in carbon prices during the health crisis will not have been enough to derail this trend.

ANNUAL CHANGE IN GLOBAL COAL DEMAND



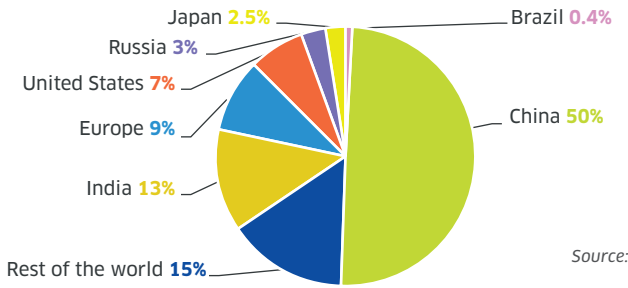
Source: IEA, Global Energy Review 2020, May 2020

Coal: consumption

In Asia, coal demand remains comparatively vigorous despite a steep deceleration in its growth from 2.1% in 2018 to 0.1% in 2019. This is particularly true of Indonesia (up 8.9%), where the share of coal in the energy mix is still increasing. India is the world's second-largest coal consuming country and the key driver of Asian growth in recent years but reported a 3.4% decline in coal consumption in 2019. South Korea and Japan (-5.7% and -1.3%, respectively) were in a similar position, following lower power demand and given growing air pollution-related constraints.

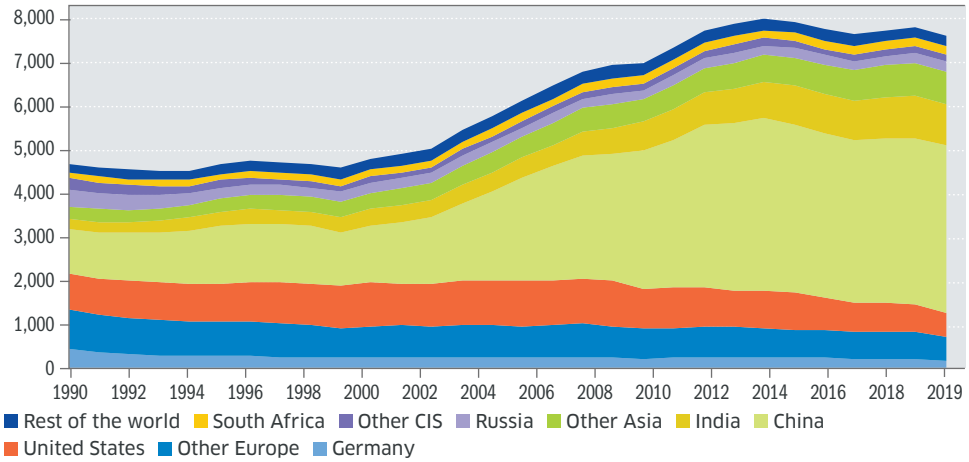
China accounts for half of the world's annual coal consumption and recorded a modest 1% increase in demand in 2019. This was in line with 2017 and 2018. The consequences of the health crisis and green energy policy announcements are expected to dampen demand growth further, but exiting coal does not look realistic in a country where it represented 65% of the electricity mix in 2019. In addition, 17 GW of new capacity received a green light during the first quarter of 2020, more than over the 2018-2019 period, while over 180 GW were in planning phase. If this momentum continues, China's Paris Agreement commitments could be seriously compromised. The new five-year plan expected early 2021 will help clarify the outlook for Chinese coal therefore the fight against climate change worldwide.

SHARE OF COAL CONSUMPTION BY GEOGRAPHIC REGION
TOTAL: 7,595 MT



Source: Enerdata, Global Energy and CO2 Data, 2020

COAL CONSUMPTION EVOLUTION BETWEEN 1990 AND 2019 (MT)



Source: Enerdata, Global Energy and CO2 Data, 2020

Coal: consumption

In Mt	Coal and lignite domestic consumption						Change 2018-2019	AAGR 2010-2019	Share in world 2019
	2000	2005	2010	2015	2018	2019			
Europe	973	972	914	879	823	704	-14.5%	-2.9%	9%
European Union	832	833	750	717	630	518	-17.8%	-4%	7%
Germany	244	244	232	238	215	171	-20.4%	-3.4%	2%
Poland	141	137	134	129	127	113	-11%	-1.9%	2%
Turkey	81	77	95	93	123	122	-1.3%	2.8%	2%
North America	1,046	1,078	1,004	763	657	577	-12.2%	-6%	8%
United States	983	1,018	954	722	624	546	-12.4%	-6%	7%
Latin America	47	56	65	79	72	70	-2.6%	0.8%	1%
Brazil	22	21	23	30	27	27	-0.6%	1.5%	0%
Asia	2,059	3,296	4,600	5,324	5,534	5,537	0.1%	2.1%	73%
China	1,304	2,345	3,350	3,770	3,788	3,826	1%	1.5%	50%
South Korea	72	83	120	135	140	132	-5.7%	1%	2%
India	376	466	684	885	981	948	-3.4%	3.7%	13%
Indonesia	25	41	51	90	125	136	8.9%	11.6%	2%
Japan	148	177	184	194	189	187	-1.3%	0.2%	3%
Pacific	130	142	136	119	106	104	-2.2%	-2.9%	1%
Australia	128	138	133	116	104	101	-2.6%	-3%	1%
CIS	356	349	368	362	379	375	-1.1%	0.2%	5%
Kazakhstan	50	65	83	77	93	91	-1.9%	1%	1%
Russia	232	214	212	222	223	225	0.7%	0.6%	3%
Middle East	13	16	16	17	15	15	4.3%	-0.6%	0%
Africa	170	192	203	202	210	213	1.6%	0.5%	3%
South Africa	157	179	193	186	190	192	1.4%	0%	3%
World	4,794	6,101	7,306	7,745	7,795	7,595	-2.6%	0.4%	100%

Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal: production

Driven by China, coal world production has shrugged off falling demand

After two years of steady growth (4.2% in 2018 and 3.6% in 2017), world coal production stabilised at 7,911 Mt in 2019 (against 4,665 Mt in 2000), reflecting lower consumption in relation to fading electricity demand. This slowdown is unlikely to mark the beginning of a sustainable trend, however. Despite the impact of the Covid-19 crisis, coal production could increase again – albeit only slightly – as early as 2020 (up 0.1% according to GlobalData summer estimates).

In China, the world's leading producer with a 47% share, coal production rose for the third year in a row in 2019 (up 4%). This was in a context of structural reforms on the supply side aimed at improving local players' competitiveness. Despite upheavals linked to the health crisis, the concentration and merger of public companies has continued in 2020. The objective is a more efficient coal industry; the country still has over 5,300 mines (down from 10,800 in 2015), of which 900 have a capacity limited to 0.3 Mt/year. Initiated in 2015, these reforms have already helped to lift the share of the top ten producers from 40.2% of the national total in 2016 to 44.5%, and have increased average production per mine from 0.85 Mt/year in 2017 to 1.16 Mt/year in 2019.

In India, the world's number two producer, output fell 3.3% in 2019 against a backdrop of economic downturn, lower electricity demand and an extended monsoon season. The government's ambition is to increase domestic production from 745 Mt in 2019 to to 1 Gt by 2024, thereby reducing the country's dependence on imports. Unfavourable conditions in 2020 (-15% over the first half) could again thwart this plan.

In the USA, where lower electricity demand and falling prices prompted a wave of bankruptcies in the coal industry, production contracted 6.7% in 2019 (source: Enerdata). This was its sharpest slump since 1978. The downtrend started in 2012 upon the rapid expansion of unconventional gas. Another plunge is to be expected in 2020 (-27%, according to the Energy Information Administration).

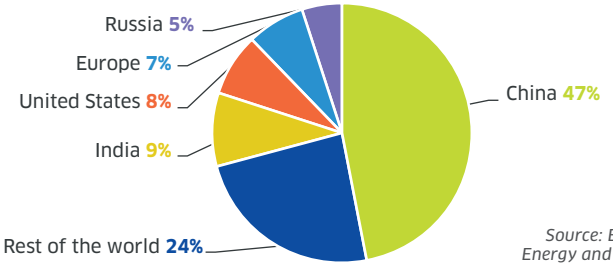
With the exceptions of Australia (up 0.8%) and South Africa (up 2.2%), coal production was sluggish all around the globe in 2019. Growth in Russia slowed from 4.6% in 2018 to 1% and slipped into negative territory in Indonesia (-1% after +19.5% in 2018). It declined another 15.1% in the EU, where an end to coal subsidies was voted in 2018.

Coal: production

In Mt	Coal and lignite production						Change 2018-2019	AAGR 2010-2019	Share in the world 2019
	2000	2005	2010	2015	2018	2019			
Europe	778	758	706	654	628	551	-12.3%	-2.7%	7%
European Union	657	639	564	528	477	405	-15.1%	-3.6%	5%
Germany	205	206	184	185	170	132	-22.2%	-3.6%	2%
Poland	163	160	133	136	122	112	-8.2%	-1.9%	1%
Turkey	63	58	73	58	84	84	0.1%	1.5%	1%
North America	1,041	1,109	1,064	876	741	692	-6.6%	-4.7%	9%
United States	972	1,039	996	814	686	640	-6.7%	-4.8%	8%
Latin America	65	87	99	109	103	102	-1.4%	0.4%	1%
Colombia	38	59	74	86	84	83	-2%	1.2%	1%
Asia	1,851	3,036	4,344	4,832	5,081	5,195	2.2%	2%	66%
China	1,355	2,317	3,316	3,563	3,550	3,692	4%	1.2%	47%
India	336	437	570	683	771	745	-3.3%	3%	9%
Indonesia	79	171	325	455	591	585	-1%	6.8%	7%
Pacific	310	376	441	516	499	503	0.8%	1.5%	6%
Australia	307	371	436	512	496	500	0.8%	1.5%	6%
CIS	388	439	476	503	578	579	0.2%	2.2%	7%
Kazakhstan	77	87	111	107	119	117	-2%	0.6%	2%
Russia	242	285	300	353	421	425	1%	4%	5%
Middle East	2	2	2	2	2	2	-5.7%	-0.4%	0%
Africa	231	250	259	269	282	288	2.1%	1.2%	4%
South Africa	224	245	255	255	259	264	2.2%	0.4%	3%
World	4,665	6,056	7,389	7,760	7,914	7,911	0.0%	0.8%	100%

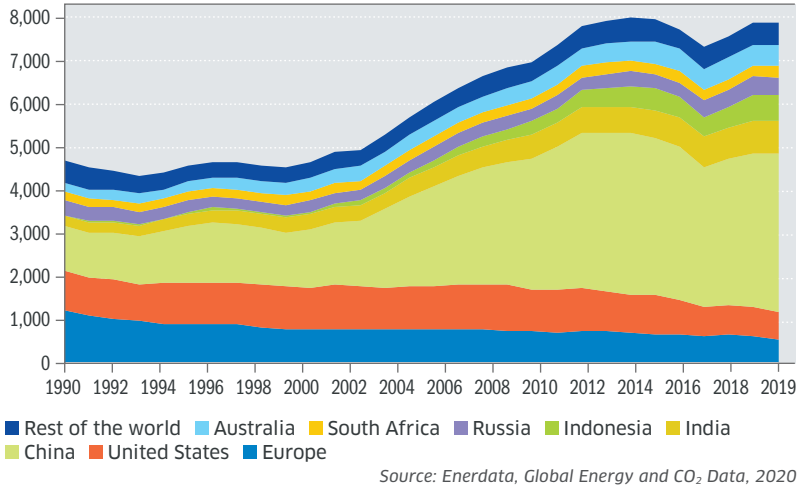
Source: Enerdata, Global Energy and CO_2 Data, 2020

SHARE OF COAL PRODUCTION BY GEOGRAPHIC REGION
TOTAL: 7,911 MT



Source: Enerdata, Global Energy and CO_2 Data, 2020

COAL PRODUCTION EVOLUTION BETWEEN 1990 AND 2019 (MT)



Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal: world trade flows

Coal and Lignite exports (Mt)	2000	2018	2019	Share in world 2019	Change 2018-2019	AAGR 2000-2019
Europe	45	22	21	1%	-1.9%	-3.8%
European Union	44	21	20	1%	-0.7%	-3.9%
Poland	27	12	11	1%	-9%	-4.6%
North America	86	136	114	8%	-16.3%	1.5%
Canada	32	30	29	2%	-4.2%	-0.6%
United States	54	106	85	6%	-19.7%	2.4%
Latin America	44	89	77	5%	-13.3%	3%
Colombia	36	87	75	5%	-13.5%	4%
Asia	135	552	532	36%	-3.6%	7.5%
China	70	16	13	1%	-14.5%	-8.3%
Indonesia	57	471	456	31%	-3.2%	11.6%
Pacific	189	384	393	27%	2.5%	3.9%
Australia	187	382	392	27%	2.5%	4%
CIS	78	241	240	16%	-0.4%	6.1%
Russia	40	213	213	15%	0.1%	9.2%
Kazakhstan	34	27	26	2%	-4%	-1.6%
Middle East	0.1	0.2	0.2	0%	0%	5.6%
Africa	71	86	89	6%	3.6%	1.2%
South Africa	70	69	72	5%	4.3%	0.2%
World	647	1 510	1 468	100%	-2.8%	4.4%

Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal and Lignite imports (Mt)	2000	2018	2019	Share in world 2019	Change 2018-2019	AAGR 2000-2019
Europe	216	221	184	13%	-16.5%	-0.8%
European Union	199	177	141	10%	-20%	-1.8%
Germany	36	47	41	3%	-14.2%	0.7%
Netherlands	13	13	10	1%	-20.4%	-1.2%
North America	39	13	14	1%	1.9%	-5.4%
United States	15	5	6	0%	12.5%	-4.5%
Latin America	25	50	47	3%	-5.4%	3.5%
Brazil	15	23	22	2%	-4%	2.1%
Asia	313	1 084	1 082	77%	-0.2%	6.8%
China	3	295	314	22%	6.3%	28.6%
South Korea	65	140	140	10%	-0.1%	4.1%
India	23	245	229	16%	-6.4%	12.8%
Japan	153	186	182	13%	-2.1%	0.9%
Taïwan	46	67	68	5%	1.2%	2.1%
Pacific	0.02	1	2	0%	44.3%	27.1%
CIS	35	56	54	4%	-2.6%	2.3%
Russia	26	28	28	2%	-2.7%	0.4%
Middle East	11	12	12	1%	5%	0.4%
Africa	8	13	16	1%	16.5%	3.4%
World	646	1 450	1 411	100%	-2.7%	4.2%

Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal: prices

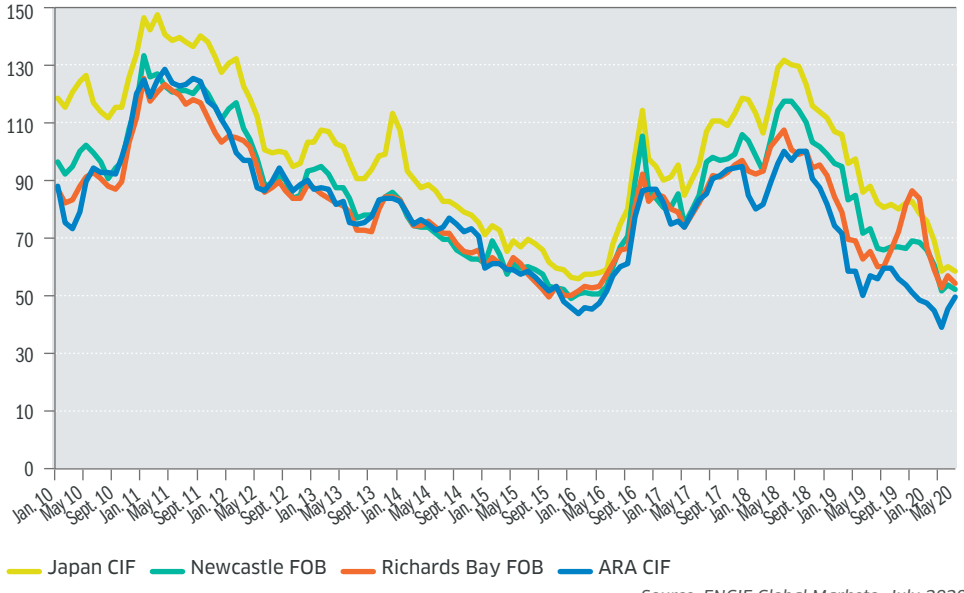
The downtrend in coal prices continued in 2019 and 2020, driven by excess supply

Sustained excess production in a context of contracting demand from electricity and steel pushed coal prices down in 2019. Already weaker in the second half of 2018, prices dipped again on all markets. Northwest Europe closed the year at $60.90/t (-34%). In China, strict government controls over supply contained fluctuations (-14% in 2019) and maintained prices at relatively high levels ($85.90/t at year-end).

The pandemic initially buoyed coal prices because of disruption to Chinese production, but they plummeted when key consuming countries such as India entered lockdown. Global Coal Newcastle, the Asia-Pacific reference index, fell 20% over the first half of 2020. By the end of June it was down to $48.10/t, its lowest level since 2006.

Despite this extended decline in prices, coal is now suffering from the enhanced competitiveness of natural gas in power generation, notably in the US and in Europe. Coal-to-gas switching has accelerated on many networks, with gas-fired plants becoming more competitive than their coal-fired equivalents over the last quarter of 2019 (source: ENGIE Global Markets). In Germany, these substitutions reached a record level during the summer 2020 (source: BNEF).

INTERNATIONAL COAL PRICES 2010-2019 ($/TONNE)



Source: ENGIE Global Markets, July 2020

Appendix

Conversions

Weight	kilograms
1 pound	0.453
1 American ton (short ton)	907
1 British ton (long ton)	1,016

Denominations in the American system

10^{0}	unit
10^{1}	tens
10^{2}	hundreds
10^{3}	thousands
10^{6}	millions
10^{9}	billions
10^{12}	trillions

The French billion is 10^{12}

Multiples and decimal sub-multiples of the units of measurement

Abbreviation	Name	Value	Power
P	peta	1,000,000,000,000,000	10^{15}
T	tera	1,000,000,000,000	10^{12}
G	giga	1,000,000,000	10^{9}
M	mega	1,000,000	10^{6}
k	kilo	1,000	10^{3}
h	hecto	100	10^{2}
da	deca	10	10^{1}
unit	unit	1	10^{0}
da	decu	0.1	10^{-1}
c	centi	0.01	10^{-2}
m	milli	0.001	10^{-3}
µ	micro	0.000 001	10^{-6}

Other energies

	Heavy fuel	Super fuel	Dry wood	Household waste	Paper waste	Natural uranium
Physical unit	1 ton	1,000 liters	1 ton	1 ton	1 ton	1 ton
Tons of oil equivalent	0.95	0.79	0.33	0.18	0.33	12,000
MWh	11	9.1	3.9	2.1	3.9	140,280
GJ	40	33	14	7,6	14	505,000

Source: Joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency – Uranium 2005: Resources, Production and Demand

Volume unit

From	To				
	m^3	liters	ft^3	US gallon	barrel
	Multiply by				
m^3	1	1,000	35.32	264	6.28
liters	0.001	1	0.0353	0.264	0.00629
ft^3	0.0283	28.3	1	7.47	0.178
US gallon	0.00379	3.79	0.134	1	0.0238
Barrel	0.159	159	5.62	42	1

Energy unit

From	To				
	MWh	toe	GJ	MMBtu	Therm
	Multiply by				
MWh	1	0.0860	3.6	3.412	34.12
toe	11.63	1	41.9	39.68	396.8
GJ	0.2778	0.0239	1	0.948	9.48
MMBtu	0.293	0.0252	1.055	1	10
Therm	0.0293	0.00252	0.105	0.1	1

Conversions

Crude oil

From	To					
	Tons	1,000 liters	Barrels	US Gallons	MWh	GJ
	Multiply by					
Tons (Metric)	1	1.212	7.6	320	12.1	43.5
1,000 liters	0.825	1	6.290	264.17	10.0	35.9
Barrels	0.132	0.159	1	42	1.587	5.710
US Gallons	0.00313	0.0038	0.0238	1	0.0378	0.136
MWh	0.0827	0.100	0.630	0.630	1	3.60
GJ	0.0230	0.028	0.028	7.35	0.278	1

Coal

From	To				
	Short ton	Metric ton	Ton of oil equivalent	MWh	GJ
	Multiply by				
Short ton	1	0.9071847	0.6248	7.560	27.22
Metric ton	1.102	1	0.6887	8.333	30
Ton of oil equivalent	1.601	1.452	1	12.1	43.5
MWh	0.1323	0.1200	0.08264	1	3.6
GJ	0.03674	0.03333	0.02299	0.278	1

Natural gas (GN) & liquefied natural gas (LNG)

From	To								
	Bcm	Gft³	Mtoe	Million tons of LNG	Millions of m3 of LNG	TBtu	Million barrels of oil equivalent	TWh	PJ
	Multiply by								
1 billion cubic meter NG (1 Bcm)	1	**35.3**	0.93	0.739	1.63	37.0	6.37	10.8	**39.0**
1 billion cubic feet NG	0.0283	1	0.026	0.0209	0.0460	1.05	0.18	0.307	1.10
1 million tons of oil equivalent	1.07	37.9	1	0.794	1.74	39.69	6.84	**11.6**	41.9
1 million tons of LNG	1.35	47.7	1.26	1	2.20	50.0	8.62	14.7	**52.7**
1 million cubic meter of LNG	0.615	21.7	0.573	**0.455**	1	22.8	3.92	6.67	24.0
1 trillion British thermal units	0.0270	0.955	0.0252	0.0200	0.0440	1	0.17	**0.293**	1.05
1 million barils of oil equivalent	0.157	5.54	0.146	0.116	0.255	**5.8**	1	1.70	6.12
TWh	0.0923	3.258	0.0860	0.0683	0.150	3.41	0.588	1	**3.6**
PJ	0.0256	0.905	0.0239	0.0190	0.0417	0.948	0.163	0.278	1

1 m³ NG: 0.9 of crude oil – 1 m³ NG: 10,000 kcal – 1 m³ NG: 41.860 kJ.

NB: These conversions are based on eight assumptions identified by the figures in bold.

The change from cubic meters to kWh and more generally from volume units to energy units depends on the quality of the gas. We speak of HHV and LHV depending on whether we use the lower or higher estimate of the heating value of the gas. The HHV estimate includes heat recoverable from steam (including energy recoverable from condensation). In a gas context, we generally speak of HHV. We speak of LHV in domestic inter-energy reports, for example.

1 kWh LHV. . . . . = 0.9 kWh HHV
1,000 m³ of HHV Natural Gas = 0,9 toe
1,000 m³ of LHV Natural Gas = 0,81 toe
1 toe (HHV context) . . . . . = 1,111 m³ of Natural Gas
1 toe (LHV context) . . . . . = 1,234 m³ of Natural Gas
1 m³ of HHV Natural Gas . . . . = standard of 42 MJ (HHV) (between 38 and 42 MJ)
. . . . . standard of 11.7 kWh (HHV) (between 9 and 12 kWh)
. . . . . European conversion: 39 MJ (HHV)
. . . . . European conversion: 10.8 kWh (HHV)
. . . . . conversion in France: 11.5 kWh (HHV)
1 Tcf PCS . . . . . = 25.48 Mtoe
1 ton of LNG . . . . . = 1,320 – 1,380 m³ of gas

Glossary

Added value: Usual method for measuring the net production of a branch or a sector in monetary units; added value is equal to the difference between the gross production and intermediate consumption; added value can be measured at the cost of the factor or at the market price. Added value of agriculture measures the activity of farming, fishing and for-estry. Added value of industry measures mining, manufacturing and construction activities, and electricity, gas and water. Added value of services or of the tertiary sector measures the activity of all services, both public and private: retail and wholesale commerce, banking, and public administration.

Annex I: UN Convention on Climate Change Annex I countries: Germany, Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Denmark, Spain, Estonia, United States of America, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechten-stein, Lithuania, Luxembourg, Malta, Monaco, New Zealand, Norway, Netherlands, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Switzerland, Czech Republic, Turkey, Ukraine, United Kingdom.

ATEE: Association Technique Énergie Environnement, a French association of energy and environmental operators (institutional, private, etc...).

Aviation and marine bunker oils: Marine bunker oils are the duty-free fuels for ocean vessels and aviation bunker oils are the aircraft fuels consumed for international transport. At coun-try level, they are excluded from primary consumption and are considered to be exports. At global level, they are included in primary consumption.

Biogas: a gas resulting from the fermentation, also called methanisation, of organic matter (animal or plant) in the absence of oxygen. It consists primarily of methane (from 50% to 70%), but usually also carbon dioxide, water vapour, hydrogen sulphide, etc. The energy pro-duced by Biogas solely comes from methane.

Biomethane: a Biogas whose undesired components have been removed (carbon dioxide, water vapour, hydrogen sulphide, etc.), so that methane only remains. Methane's properties are similar to those of natural gas. Biomethane can be handled in natural gas distribution and transport networks.

Bituminous coal: Type of coal transformed into coke.

CAPEX-OPEX: Operating expense (often abbreviated as OPEX) is the ongoing cost for running a product, business, or system. Its counterpart, capital expenditure (CAPEX), is the cost of developing or providing non-consumable parts for the product or system.

CEA: Commissariat à l'énergie anomique (French Atomic Energy Commission)

CediGas: International association of manufacturers for gas (GDF SUEZ is a member).

CERA: Cambridge Energy Research Associates.

CH_4: Methane, a hydrocarbon with a global warming potential 25 times greater than that of CO_2.

Change in inventories: In principle, these are the changes in inventory levels between two identical dates one year apart. The inventories are those of the energy producers and gene-rally exclude consumer inventories. However, depending on the measurement methods adopted by each country, these changes in inventories represent real data or may include statistical deviations or non-metering between the primary supply and the inputs trans-formed or consumed. The + sign indicates a decrease in inventories during the year; the - sign indicates an increase in inventories during the year. Changes in inventories that syste-matically have the same sign are an indication of accounting distortions or poor allocation.

CI: Cost Insurance Freight. CIF price, in contrast to FOB price, includes shipping costs, and the various taxes and insurance; the seller is responsible for the merchandise up to the port of arrival.

CIS: Community of Indiapendent States, composed of 11 of the 15 former Soviet Republics: Armenia, Azerbaijan, Belarus, Georgia, Kyrgyzstan, Kazakhstan, Moldavia, Russia, Federation of Tajikistan, Turkmenistan (Associate State), Ukraine, Uzbekistan - Mongolia as an observer.

Coke: Transformed coal used primarily in making steel.

Coking plants and blast furnaces: The inputs of coking plants are the coking coal consumed by coking plants. The inputs of blast furnaces are the coke consumed.

Coking plants, briquette plants: The inputs of coking plants are the coking coal consumed by coking plants. The inputs of blast furnaces are the coke consumed. The outputs of coking plants are coke and coking gas. The outputs of the blast furnaces are the blast furnace gases.

DEP: Department of Exploration Production.

DGEMP: Department of Energy and Raw Materials (Direction Générale de l'Énergie et des Matières Premières).

DFO: Domestic fuel oil (home heating oil).

Glossary

Domestic consumption: Domestic consumption, for each energy product, is the balance of the total production, foreign trade, air and marine bunker oils (for oil) and changes in inven-tories.

EIA-DOE: Energy Information Agency - Department of Energy (USA).

Electric power plants: The inputs of electric power plants correspond (for thermal plants) to the consumption of fuels by the power plants. The production of the electric power plants corresponds to the gross production.

Electric power plants (thermal): The inputs of electricity power plants are the fuels consumed by public plants and by self-producers (including co-generation).

Electricity production: Gross electricity production including public production (private and public power companies) and the self-producers, by any type of power plant (including co-generation).

Electricity production from co-generation: Gross production of electricity by power plants that produce electricity and heat (power companies and self-producers).

Energy sector self-consumption: Consumption to run energy transformation units (power plants, refineries).

ENTSO-E: European Network of Transmission System Operators for Electricity.

EU: The European Union has 27 states members since the withdrawal of the United Kingdom January 1, 2020: Germany, Austria, Belgium, Bulgaria, Cyprus, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Czech Republic, Romania, Slovakia, Slovenia, Sweden. Croatia's membership is effective July 1, 2013, in the enlargement process in the Balkans started nine years earlier. The EU matters in total 515 million inhabitants and covers an area of 3,930,000 km^2.

Exploration and development cost: The average cost of exploration and development represents the dollar cost per barrel equivalent of additional reserves of a country coming from exploration activities, discoveries, improved recovery or update assessments. This cost does not include the licensing of proven reserves

Exports: Exports are the volumes of energy product exported from the national territory to another country, minus simple transit volumes and volumes "custom" processed on behalf of a third party country. In the case of geographic or geopolitical regions, exports are the aggregates of national exports, including those that are part of flows within the region. For accounting consistency, exports appear with a negative sign.

Final consumption: Final consumption is the balance between the interior consumption and consumption from the energy transformations and various losses. It measures the needs of the end consumers in the country. They are broken down by category as follows: industry, transport, residential, services, agriculture and non-energy uses. Final consumption of industry is broken down by business line or sector: steel, chemical, non metallic minerals (construction materials), and so on.

Final consumption for non-energy uses: This is the consumption of the products intended for petrochemicals (naphtha), the fabrication of ammonia (natural gas), use in electrode (carbon) form and the use of all products used for their physical-chemical properties (bitumen, paraffins, motor oils, etc.). They are divided into chemicals and other.

FOB: Free On Board. FOB price, in contrast to CIF price, does not include any transport cost, tax or insurance.

Forward price: Forward = forward price - given for different expirations.

Fugitive emissions: Intentional and non-intentional greenhouse gas emissions, from the extraction of a fossil fuel up to the point of use.

GDP: Gross Domestic Product: Measurement of the economic activity of a country; it is currently measured at market prices. GDP at market price is the sum of the value added to the cost of factors, plus indirect taxes, minus subsidies.

GHG: Greenhouse Gases.

Henry Hub: Point of determination of the prices of the gas traded on the NYMEX (New York Mercantile Exchange).

HFC: Hydrofluorocarbon (a category of fluorinated gases that actively contribute to the deterioration of the ozone layer, with a global warming potential 3,000 times greater than that of CO_2).

IEA: International Energy Agency.

IIASA: International Institute for Applied Systems Analysis.

Imports: Imports are the volumes of energy product imported from another country into the national territory, minus the volumes that are transiting to a third party country and the quantities intended to be "custom" processed on behalf of a third party country. In the case of geographic or geopolitical regions, imports are the aggregates of the national imports, including those that are flows within the region.

Glossary

Industry final consumption: Industry final consumption includes the consumption of the mining, manufacturing and construction sectors. They exclude the consumption of fuel for transport activities, even when the means of transport belong to the industrial companies, and the consumption of fuels for the self-production of electricity. The energy products used as raw materials or maintenance products are in general separate, or at least identified under the name "non-energy uses."

LNG: Liquefied Natural Gas.

Light Tight Oil (Tight Oil): Light tight oil or tight oil is a type of oil present in relatively impermeable, non-porous layers and requires extraction techniques similar to those of shale gas. Tight oil primarily differs from shale oil in its degree of viscosity and is found in particular in the Niobrara and Eagle Ford formations in the United States.

Lignite: A type of low-carbon coal with a low calorific value.

Liquefaction (of gas): The inputs of gas liquefaction plants are natural gas consumptions. The production of liquid gas is the output.

LPG: Liquefied Petroleum Gas.

ULUCF: Land Use, Land Use Change and Forestry, with implications for CO_2, CH_4 and N_2O emissions and capture. The notion covers tree felling and planting, woodland conversion (clearing) and prairies as well as soils whose carbon content is sensitive to the use to which it is put (forest, prairie, cultivated).

Marginality: In the production of electricity, the duration of marginality represents the time when the production method used is the one with the lowest marginal cost (cost of an additional unit).

Mbl: Million barrels.

MMBtu: 1,000,000 Btu (1 million Btus).

NBP: National Balancing Point is a virtual trading location for the sale and purchase and exchange of UK. It serves as a reference for forward contracts.

Net production (electricity): The net production of electricity is the balance between gross production and the auto-consumption of electric power plants.

Nitrogen oxide: NO, nitrogen oxide.

NO_2: Nitrogen dioxide.

N_2O: Nitrogen protoxide (also known as nitrous oxide) with the chemical formula N_2O is a powerful greenhouse gas that remains in the atmosphere for a long time (about 120 years). It is partially responsible for the destruction of the ozone. The soil and oceans are the principal natural sources of this gas, but it is also produced by the use of nitrogen fertilizers, the combustion of organic matter and fossil fuels, the production of nylon, etc. In France, farming contributes to the 3/4 of N_2O emissions that essentially come from the transformation of nitrogen products (fertilizer, manure, liquid manure, crop residues) in farm land. N_2O is a colorless and non-flammable gas, stable in the lower levels of the atmosphere, but it decomposes in the higher levels (stratosphere) through chemical reactions involving sunlight.

Non-conventional gases: Like the gas known as "conventional", "non-conventional gases" are essentially composed of methane, but are trapped in relatively impermeable rock, which until recently had limited their development. In fact, extraction requires production technologies that are much more complex than for traditional reservoirs.

Non-conventional oils: Oil extracted by methods other than from a well (in oil sands, for example).

OECD: Organization of Economic Cooperation and Development. Member countries: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Germany, Finland, France, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, South Korea,,Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Particulate Matter: Particles in suspension (PM 2.5 corresponds to the fine particles that can enter the pulmonary alveoli).

PFC: Perfluorocarbon (category of fluorinated gases, with a global warming power on average 7500 times greater than that of CO_2).

Primary consumption: Primary consumption is the balance from primary production, foreign trade, bunker oils, and changes in inventories. Primary consumption aggregated over all products measures the country's total energy consumption, including all losses and self-consumption during transformations. For primary energies, primary consumption = domestic consumption.

Glossary

Primary production: Primary production measures the quantity of natural energy resource extracted and produced for the purpose of consumption as is, on the production site or elsewhere, or for subsequent transformations. It excludes the quantities not use for energy or transformation purposes, particularly for natural gas, the quantities flared, reinjected into wells or discharged as is. On the other hand, it includes auto-consumption on the production sites (electricity generation, auxiliary motors, for example). The production of hydraulic, geothermal, wind and nuclear electricity is considered to be primary production.

Private consumption: Total consumption of goods and services in monetary units by households.

Production: Energy production corresponds to gross domestic production. It measures the volume of energy product produced directly or resulting from a transformation process, including the volume reused in the transformation process itself (hence the concept of gross production).

Production cost: The average production cost is the average lifting cost of oil and gas from the reservoir to the shipping interface towards the processing center.

Power generation from cogeneration: Gross production of electricity by power plants that produce electricity and heat (power companies and self-producers).

Public production (electricity): The public production of electricity is the gross production of electricity production companies, whatever their status (public or private).

Pumping: Pumping station inputs are their electricity consumption. The output is the gross production of hydroelectricity.

RES: Renewable energy sources.

Sources

POST-COVID CONTEXT

Enerdata 2020
IEA – Global Energy Review 2020
IEA – World Energy Investment 2020
IEA – WEO 2019
Macroeconomic forecasts from Oxford Economics, The Economist, IHS, World Bank, European Union
Stimulus packages: various sources

CO_2 & CLIMATE

Enerdata 2020
IEA – Global Energy Review 2020
IEA – WEO 2019
IDMC
World Meteorological Organization 2020
World Bank, « State and Trends of Carbon Pricing », 2020
I4CE

DECARBONIZATION

IEA – WEO 2019
Enerdata – EnerFuture 2020
NégaWatt
Climate Bonds Initiative 2020
CCS Institute, Rapport 2019

ELECTRICITY & RENEWABLES

Enerdata
IEA – WEO 2019
BNEF – NEO 2019
REN21 – Renewables 2020 Global Status Report
IEA – Global Energy Review 2020
IEA – Tracking Power 2020

NATURAL GAS & GREEN GAS

Enerdata
IEA – WEO 2019
IEA, Gas Report 2020, May 2020
IEA, Global Energy review 2020 Covid-19 impacts on energy and CO_2 emissions, 28 April 2020
Oxford Institute of Energy Studies, Natural gas demand in Europe: The impact of Covid-19 and other influences in 2020, June 2020

OIL

Enerdata
IEA – WEO 2019

COAL

Enerdata
IEA – WEO 2019

Enerdata methodology

Primary energy data comes from the International Energy Agency (IEA). It is completed with data from regional organizations (EUROSTAT, OLADE, ADB, OPEC) or specialized institutions (CediGas), as well as by data from national sources (national statistics or data specially prepared by local correspondents with more than 100 partners in around 60 countries). This complementary data is used for the assessment and correction of primary data, and for the quick update of our own data.

The methodology and definitions used by Enerdata are the same as that of IEA and Eurostat.

Energy statistics in physical units are converted into energy units (ktoe or Mtoe) on the basis of the following coefficients:

Crude oil: fixed coefficient for most countries: 1.02 toe/ton
Oil products: fixed coefficient for all countries – same as EUROSTAT or IEA
Natural gas: national coefficients for key countries and fixed coefficients for the other countries (0.82 toe/1000 m^3); the national coefficients are indicated in the database

Coal, Lignite: fixed coefficient for coke; national coefficient for production, imports and exports for key producers or importers; the national coefficients are indicated in the database.
Electricity:
- nuclear: 1 TWh = 0.26 Mtoe
- hydroelectricity: 1 TWh = 0.086 Mtoe
- geothermal: 1 TWh = 0.86 Mtoe
- total production: 1 TWh = 0.086 Mtoe
- imports, exports: 1 TWh = 0.086 Mtoe
- consumption: 1 TWh = 0.086 Mtoe

Geographical scope of the sources

Enerdata	
Europe region	
Europe	European Union (27), Albania, Bosnia-Herzegovina, Croatia, Iceland, Macedonia, Norway, Serbia and Montenegro, Switzerland, Turkey.
UE-28	European Union (25), Bulgaria, Romania, Croatia.
America region	
America	North America, Mexico, Central America, South America, Caribbeanv
Latin America	Central America, Mexico, South America, Caribbean.
North America	Canada, USA.
Central America and Mexico	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama.
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela.
Caribbean	Bahamas, Barbados, Bermuda, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Netherlands Antilles and Aruba, Saint Vincent and the Grenadines, Saint Lucia, Trinidad and Tobago.
Asia region	
Asia	ASEAN, Afghanistan, China, Hong Kong, Japan, Macao, Mongolia, North Korea, South Asia (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka), Soth Korea, Taiwan.
ASEAN	Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam).
Pacific region	
Pacific	Australia, Pacific Islands, New Zealand.

Enerdata	
Africa region	
Africa	North Africa, Sub-Saharan Africa.
North Africa	Algeria, Egype, Libya, Morocco, Tunisia.
Sub-Saharan Africa	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, DR Congo, Ivory Coast, Djibouti, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Equatorial Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.
Middle East region	
GCC	Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates).
OPEC Middle East	Iran, Iraq, Kuwait, Qatar, Saudi Arabia, UAE.
OAPEC	Organization of Arab Petroleum Exporting Countries (Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Syria, Tunisia, UAE).
CIS region	
CIS	Commonwealth of Indiapendent States (former USSR, excluding Baltic countries).
Soviet Union (former)	Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.

Source: Enerdata

Geographical scope of the sources

International Energy Agency	
Europe region	
European Union	EU28
Eastern Europe / Eurasia	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, the former Yugoslav, Republic of Macedonia, the Republic of Moldova, Romania, Russian Federation, Serbia (incl Montenegro until 2004 and Kosovo until 1999, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. For statistical reasons, this region also includes Cyprus, Gibraltar and Malta.
OECD Europe	Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.
America region	
OECD North America	Canada, Mexico and the United States.
OECD Latin America	Chile.
Latin America	Antigua and Barbuda, Aruba, Argentina, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, the British Virgin Islands, the Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, the Dominican Republic, Ecuador, El Salvador, the Falkland Islands, French Guyana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, Saint Lucia, Saint Pierre et Miquelon, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, the Turks and Caicos Islands, Uruguay and Venezuela.
Asia-Pacific region	
China	Refers to the People's Republic of China, including Hong Kong.
ASEAN	Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.
OECD Asia	Japan and Korea.
Non-OECD Asia	Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Chinase Taipei, the Cook Islands, East Timor, Fiji, French Polynesia, India, Indonesia, Kiribati, the Democratic People's Republic of Korea, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, New Caledonia, Pakistan, Papua New Guinea, the Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vietnam and Vanuatu.
Other Asia	Non-OECD Asia regional grouping excluding China and India.
OECD Oceania	Australia and New Zealand.
OECD Pacific	Includes OECD Asia and Oceania.

International Energy Agency	
Zone Africa	
Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic of Congo, Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, United Republic of Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.
North Africa	Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia.
Sub-Saharan Africa	Africa regional grouping excluding South Africa and North Africa regional grouping.
Zone Moyen-Orient	
Middle East	Bahrain, the Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, the United Arab Émirates and Yemen. It includes the neutral zone between Saudi Arabia and Iraq.
Autres zones spécifiques	
OECD	Includes OECD Europe, OECD Latin and North America and OECD Pacific regional groupings.
OECD+	OECD regional grouping and those countries that are members of the European Union but not of the OECD.
Other Major Economies	Comprises all countries not included in OECD+ and Other Major Economies regional groupings, including India, Indonesia, the African countries (excluding South Africa), the countries of Latin America (excluding Brazil), and the countries of non-OECD Asia, (excluding China) and the countries of Eastern Europe/Eurasia (excluding Russia).
Other Countries	Algeria, Angola, Ecuador, the Islamic Republic of Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Émirates and Venezuela.

Source: Enerdata

Geographical scope of the sources

BP Statistical Review	
North America	US (excluding Puerto Rico), Canada, Mexico.
South and Central America	Caribbean (including Puerto Rico), Central and South America.
Europe	European members of the OECD plus Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Former Yugoslav Republic of Macedonia, Gibraltar, Malta, Romania, Serbia and Montenegro, Slovenia.
Former Soviet Union	Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.
Europe and Eurasia	All countries listed above under the headings Europe and Former Soviet Union.
Middle East	Arabian Peninsula, Iran, Iraq, Israel, Jordan, Lebanon, Syria.
North Africa	Territories on the north coast of Africa from Egypt to western Sahara.
West Africa	Territories on the west coast of Africa from Mauritania to Angola, including Cape Verde, Chad.
East and Southern Africa	Territories on the east coast of Africa from Sudan to Republic of South Africa. Also Botswana, Madagascar, Malawi, Namibia, Uganda, Zambia, Zimbabwe.
Asia Pacific	Brunei, Cambodia, China, China Hong Kong SAR*, Indonesia, Japan, Laos, Malaysia, Mongolia, North Korea, Philippines, Singapore, South Asia (Afghanistan, Bangladesh, India, Myanmar, Nepal, Pakistan, Sri Lanka), South Korea, Taïwan, Thailand, Vietnam, Australia, New Zealand, Papua New Guinea, Oceania.* Special Administrative Region.
Australasia	Australia, New Zealand.
OECD members	Europe: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Republic of Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK. Other member countries: Australia, Canada, Israel, Japan, Mexico, New Zealand, South Korea, US.
OPEC members	Middle East: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Émirates. North Africa: Algeria, Libya. West Africa: Angola, Nigeria. South America: Ecuador, Venezuela.

BP Statistical Review	
European Union members	Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Republic of Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, UK.
Other EMEs (Emerging Market Economies)	South and Central America, Africa, Middle East, non-OECD Asia, non-OECD Europe.
Methodology	The primary energy values of both nuclear and hydroelectric power generation have been derived by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38% (the average for OECD thermal power generation).
Percentages	Calculated before rounding of actuals. All annual changes and shares of totals are on a weight basis except on pages 6, 14, 18, 20 and 22.
Rounding differences	Because of rounding, some totals may not agree exactly with the sum of their component parts.
Tonnes	Metric equivalent of tons.
Disclosure	Statistics published in this Review are taken from government sources and published data. No use is made of confidential information obtained by BP in the course of its business.

Country groupings are made purely for statistical purposes and are not intended to imply any judgement about political or economic standings.

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