Dashboard of Energy Transition

2021
Edition

ENGIE

Group Strategy Department
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Foreword

The energy transition is an imperative for ENGIE, placed at the heart of its strategy, with a commitment to carbon neutrality for all of its activities by 2045.

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

After an unprecedented economic crisis in 2020, year 2021 saw mounting pressure on the energy market in a context of strong economic recovery and increasingly urgent climate obligations. Although the COP26 commitments were the most ambitious ever made and renewable energy economics are falling into place, CO_2 emissions hit new records as a consequence of renewed fossil fuel consumption, notably of coal. Massive though they are, most of the pandemic-related recovery plans earmark only modest sums for green investment, despite its proven resilience during the crisis. The European Union was a conspicuous exception with its 'Fit for 55' package', an exemplary environmental policy. But this has created issues of its own, both for external partners and for domestic consumers unhappy with higher energy bills.

The headwinds hampering energy transition reflect the inertia of the existing energy model and the difficulty of changing it. The fact is that current investment is far from sufficient to reach carbon neutrality by the middle of the century, a target that an increasing number of states and companies have adopted in the face of the evidence of climate emergency provided in the 6th IPPC report.

The priorities are more investment in decarbonised energy and energy efficiency, a rapid phase-out of coal, developing and making economically viable new renewable sectors such as biogas and hydrogen or last resort alternatives such as CCUS, resolving the shortcomings of a higher proportion of intermittent energy and integrating energy systems, and dealing with public reticence around local renewables installations. These are the challenges for businesses in this sector, and they will be unable to overcome them without tough environmental policies and profound changes in individual and social behaviour.

Based on our expertise on energy and climate trends, and with the support of leading institutions such as the International Energy Agency and Enerdata that offer their views on current developments, we share here our analysis of the many dimensions of energy transition and compare them with environmental objectives.

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

Charlotte Roule
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. Together with our 170,000 employees, our customers, partners and stakeholders, we are committed to accelerate the transition towards a carbon-neutral world, through reduced energy consumption and more environmentally-friendly solutions. Inspired by our purpose ("raison d'être"), we reconcile economic performance with a positive impact on people and the planet, building on our key businesses (gas, renewable energy, services) to offer competitive solutions to our customers.

Turnover in 2020: 55.8 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).

IN 2020

170,000
employees

€55.8
billion revenue

101 GW
GW installed power generation capacity

13 GW
installed wind and solar capacity (at 100%)

€190
million spent on R&D

€4
billion growth investment

€12
billion green bonds issued since 2014

TARGETS FOR 2030

58 %
of renewables in our energy mix

52 %
reduction in CO_2 emissions per kWh of electricity produced compared to 2017

34 %
reduction in CO_2 emissions from the use of products sold by the Group compared to 2017

35 %
reduction in water consumption by industrial activities (compared with 2019)

50 %
of women in Group management

100 %
of employees trained

+10 %
apprentices in Europe

TARGET FOR 2045

Net zero
on all 3 scopes

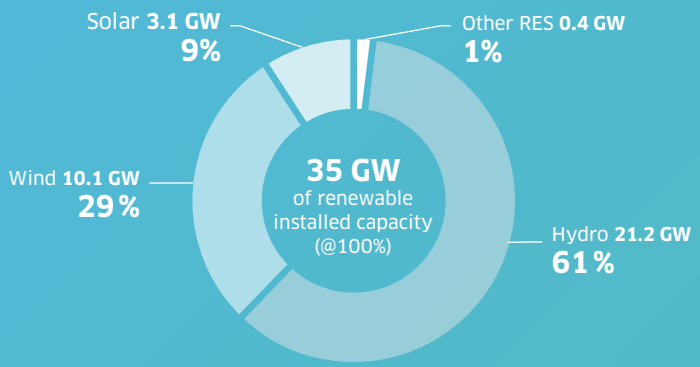
RENEWABLE ENERGY

€3 bn of revenues

1st producteur of onshore wind and solar power in France

+3 to 4 GW additional renewable capacity targeted per year between 2022-25

In 2020



GAS

Historical leader in gas marketing in France

1st operator of gas infrastructure in Europe with a portfolio including transmission networks, distribution networks, storage and LNG terminals

Among the leading sellers and importers of gas in Europe

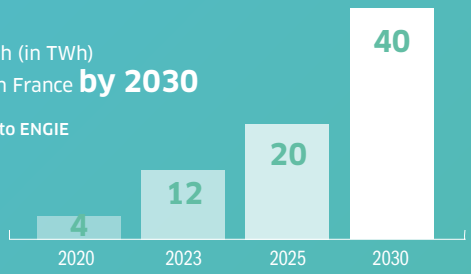
1st operator of gas infrastructure in Europe with a portfolio comprising transport networks, distribution networks, storage and LNG terminals

1st green hydrogen injection demonstrator in the gas distribution network in France

Target of **10%** green gas injected into the networks by 2030

Biomethane to reach (in TWh)
10% of gas mix in France **by 2030**

Capacities connected to ENGIE Networks in France



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The Covid-19 crisis galvanised the development of renewable energy but did not reduce the importance of coal in power generation

World economy

The world economy reacted very promptly to the Covid-19 shock, but has emerged with deeper divisions and renewed questions over its growth model

The Covid-19 pandemic sent the world economy into severe recession in 2020. GDP contracted 3.8%, which was the worst decline since the Great Depression in the 1930s. Nearly all countries reported lower output, although there were regional differences: Latin America was particularly badly affected and Asia relatively unscathed. Major differences in geographic and sector performances have been a notable feature of this crisis. The worst-affected economies have been those that imposed the most drastic and lengthy lockdowns and are heavily reliant on services, particularly tourism. Other factors include the degree of openness and vaccine efficiency. Government support for productive capacity – furlough, direct payments, household tax credits, deferral of social security contributions, guaranteed loans for businesses, etc. – only comes into play when recovery is under way.

After an unprecedented dip during the first half of 2020, the world economy quickly resumed growth in the third quarter. Spectacular though it was, this rebound was not enough to offset the loss of activity recorded at the beginning of the year. Fuelled by consumer spending when many businesses reopened during the summer, it soon faded when the second wave of the pandemic struck in the autumn. At the end of 2020, household consumption was still 4.5% lower than it had been before the pandemic.

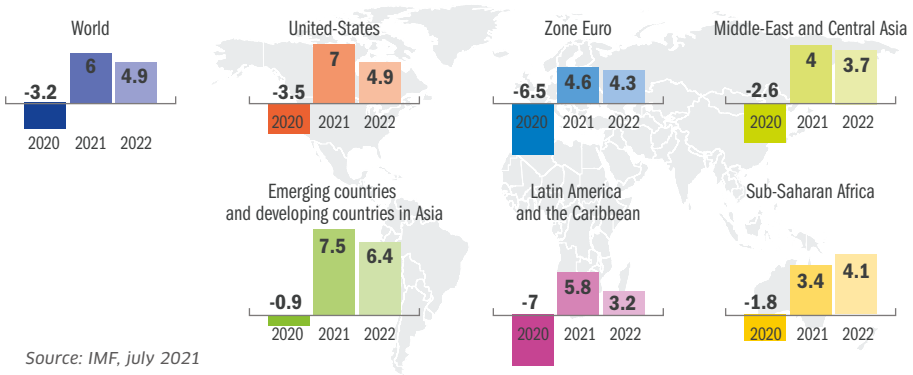
A multi-speed recovery. China renewed with pre-Covid activity levels even before the end of 2020. GDP rose 2.3% over the year as a whole, boosted by aggressive fiscal measures, an upturn in manufacturing and construction and looser restrictions. For many Asia-Pacific countries, such as South Korea (-1%), the drop in output was limited by efficient containment measures, government assistance and a rebound in manufacturing at regional level. In the USA, vigorous budgetary stimulus (13% of GDP) and financial assistance quickly bolstered activity, although momentum faded into year-end. In contrast, recovery was slower in the major European economies, where successive waves of the pandemic caused massive disruption and reduced working hours in the service sector.

The economic outlook brightened considerably in 2021, thanks to the deployment of efficient vaccines, the announcement of additional stimulus measures in some countries and economies adapting to anti-Covid measures, which themselves were better targeted. The Delta variant is spreading fast but does not pose a major risk, and the world's engines of growth remain very robust.

World GDP growth forecasts converge around 6% in 2021 and 4.5% in 2022, with a recovery in services taking over from a manufacturing sector that has stopped accelerating but is still in good shape. These expectations are also bolstering financial and commodity markets: long-term government bond yields and oil prices have resumed their pre-pandemic levels.

Fiscal and monetary policies remain very accommodating and risks associated with the fourth wave of the pandemic will encourage central banks to adopt a wait-and-see approach to normalisation.

WORLD ECONOMIC OUTLOOK IN JULY 2021
GROWTH PROJECTION BY REGION (IN %)



Source: IMF, july 2021

World economy

Although exceptional, the world economic recovery in 2021 has been neither robust nor homogeneous. Access to vaccines has been the key factor

Growth is threatened by significant uncertainty, starting with a high level of contamination in mid-2021 and fears of the virus mutating into vaccine-resistant forms. The pace of vaccination is key to containing the pandemic and therefore economic activity. It has varied across the world: by August, the share of the fully vaccinated in the total population was 60% in Israel, France, the EU and Canada, 50% in the USA, 20% in Brazil and Russia, 15% in China, 9% in India, close to nil in Africa and 15% worldwide.

Risks related to inflationary pressures and both private and public debt

Inflation has been accelerating since the spring in some economies (emerging countries, USA), as a result of a strong rise in commodity and freight prices, supply chain pressures and prices returning to normal in sectors that had been severely hit by the crisis.

The high corporate debt level, equivalent to that of the 2008 financial crisis, is a matter of concern for all economies. Public debt has soared (+17% worldwide in 2020), particularly in emerging countries, where it could translate into in higher borrowing costs, tighter credit conditions and depreciating currencies. In advanced economies, debt looks sustainable as its cost remains low.

Uncertainty related to the use of household savings. Government support for household disposable income in 2020 led to a strong build-up in savings in advanced economies. Additional savings, excluding precautionary savings, are set to reach 9% of disposable income in Germany, nearly 15% in the UK and 16% in the USA by end-2021. The outlook for the world economy will depend heavily on the use of these accumulated 'Covid savings'. Using or not using only a fifth of it would represent a 2% of GDP differential in 2022 for these countries (source: OFCE, Policy Brief 84, April 2021).

Significant disparities in the recovery process is widening income gaps between countries. According to the World Bank, nine rich countries out of ten will have resumed their pre-pandemic level of activity by 2022, while two thirds of poor and developing countries will labour under slower and longer recoveries. Penalised by a lack of vaccines, inflation and insufficient fiscal stimulus, Africa is expected to record a mere 2.8% growth in 2021, the Middle East and North Africa 2.4% and low-income countries none at all.

In the USA, GDP growth* will be close to 7% in 2021 before easing to 3.6% in 2022. Economic activity and the labour market are both strong as a result of exceptionally large fiscal stimulus (15% of GDP) and vaccination campaigns. Investment, notably in housing, is supported by an accommodating monetary policy, and private consumption is benefiting from falling savings rates.

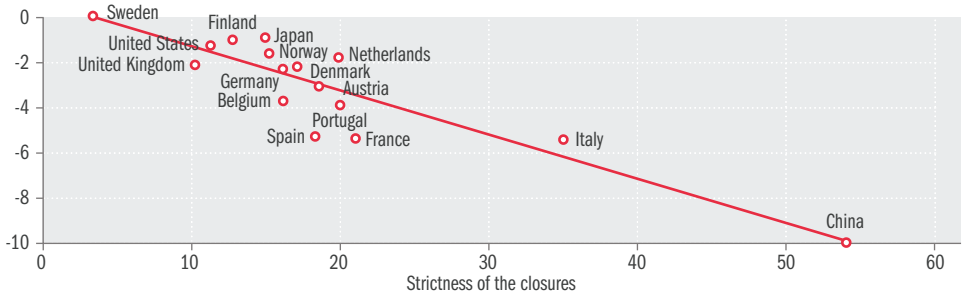
In the eurozone, manufacturing activity is benefiting from vigorous external demand and furlough measures that protected jobs. Although new restrictions weighed on recovery over the first quarter of 2021, activity picked up over the second quarter and should continue to do so until year-end as vaccination rates rise. GDP growth is expected to reach 5.5% in 2021 and 5.2% in 2022. These favourable forecasts rely on household consumption, continued easy financial conditions, the release of EU funds from the Next Generation EU plan and the end of Covid restrictions.

China will remain on its fast growth track at 8.5% in 2021 and 6% in 2022 according to the IMF. This will stem from exports, real estate and an accommodating monetary policy, and even though some elements of budgetary stimulus will be scaled down. Progress to rebalance the Chinese economy towards services and private consumption was interrupted by the pandemic and should resume.

Sources: OECD, May 2021; SOCOFI "Les cahiers verts de l'économie", august 2021

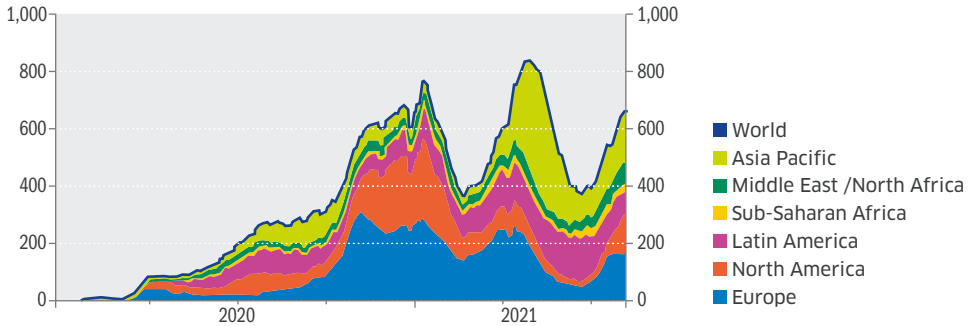
World economy

CORRELATION BETWEEN ECONOMIC GROWTH AND SEVERITY OF CLOSURE
GDP GROWTH IN THE FIRST QUARTER OF 2020, IN %



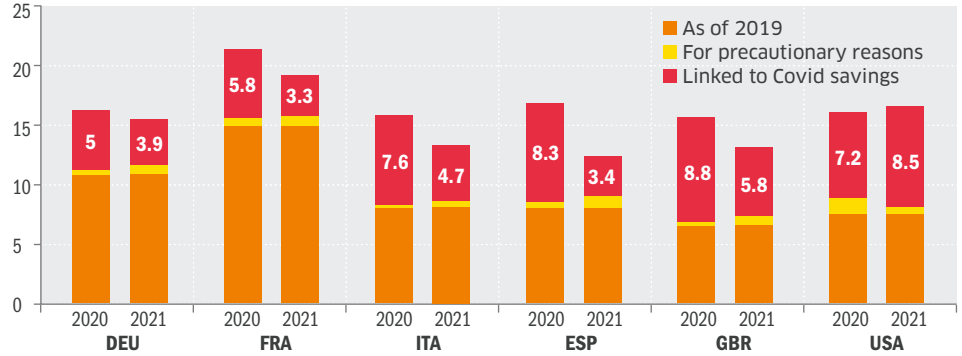
Source: Oxford & Blavatnik School of Government, Covid-19 Government Response Tracker; Calculs OFCE

WORLD: NEW CASES OF COVID-19, IN THOUSANDS



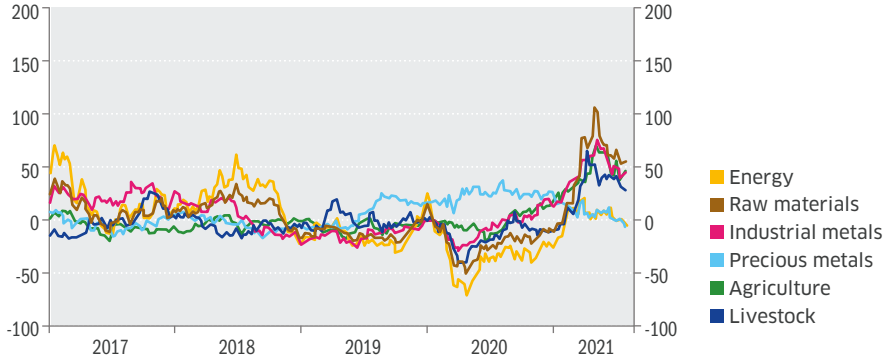
Source: Refinitiv Datastream, les cahiers vert de l'économie

HOUSEHOLDS SAVING RATE IN 2020-2021
IN % OF GROSS DISPOSABLE INCOME



Source: Calcul OFCE

COMMODITY PRICES (ANNUAL VARIATION IN %)



Source: Refinitiv Datastream, les cahiers vert de l'économie

World economy

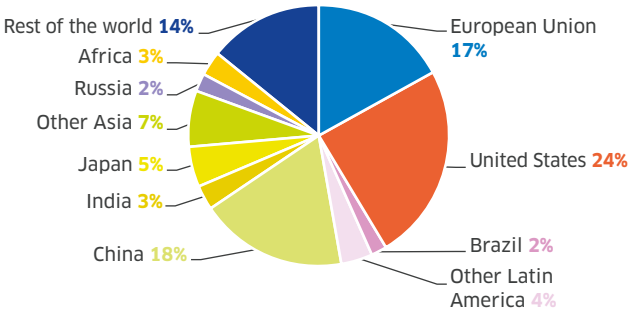
2019-2020 economic growth and 2021-2022 forecasts

GDP & Population	Real GDP growth rate*		GDP growth forecasts*		GDP (in billion $ constant 2015)			Population (in million)		
	2019	2020	2021	2022	2010	2019	2020	2010	2019	2020
Europe	1.6%	-6.1%	5.3%	4.7%	17,217	20,106	18,779	608	630	633
EU-28	1.7%	-6.4%	4.8%	4.5%	12,881	14,726	13,779	442	448	448
France	1.5%	-8.2%	6.4%	4.5%	2,317	2,603	2,389	65	67	67
North America	2.1%	-3.7%	6.1%	4.7%	17,742	21,564	20,778	343	366	369
Canada	1.7%	-5.4%	6.7%	3.9%	1,396	1,675	1,584	34	38	38
United States	2.2%	-3.5%	6.1%	4.8%	16,346	19,890	19,193	309	329	331
Latin America	3.3%	-7.1%	6.5%	2.8%	5,211	5,518	5,091	586	644	651
Brazil	1.1%	-4.4%	5.7%	2.1%	1,703	1,810	1,730	196	211	213
Asia	4.5%	-1.6%	6.6%	5.4%	17,647	27,751	27,459	3,808	4,136	4,173
China	6.1%	2.3%	8.4%	5.8%	7,541	14,194	14,520	1,338	1,400	1,407
South Korea	2.0%	-1.0%	4.2%	3.5%	1,193	1,537	1,521	50	52	52
India	4.2%	-7.4%	8.8%	7.1%	1,567	2,769	2,564	1,234	1,367	1,382
Japan	0.7%	-4.8%	2.3%	2.9%	4,178	4,567	4,348	128	126	126
Pacific	1.9%	-3.5%	4%	3.4%	1,243	1,578	1,525	36	41	42
Australia	1.8%	-2.5%	3.8%	3.5%	1,066	1,346	1,312	22	25	26
CIS	2.2%	-3.6%	4.4%	3.9%	1,725	2,070	2,000	280	292	293
Russia	1.3%	-3.6%	4.5%	2.8%	1,259	1,441	1,389	143	145	145
Middle East	-0.5%	-5.2%	2.5%	4.3%	2,053	2,563	2,417	213	252	257
Saudi Arabia	0.3%	-4.0%	2.2%	4.7%	509	679	651	27	34	35
Iran	-6.5%	-1.5%	2.9%	2.5%	402	409	403	74	83	84
Qatar	0.8%	-4.5%	2.5%	3.7%	121	172	164	2	3	3
Africa	3.2%	-3.3%	4.4%	3.8%	2,016	2,577	2,483	1,026	1,292	1,325
South Africa	0.2%	-7.2%	3.8%	2.5%	285	326	303	51	59	59
World	**2.7%**	**-3.6%**	**5.9%**	**4.8%**	**64,854**	**83,728**	**80,532**	**6,899**	**7,654**	**7,742**
OECD	1.6%	-4.9%	5.3%	4.4%	42,598	50,637	48,122	1,237	1,306	1,314
Non OECD	3.7%	-2.5%	6.6%	5.2%	22,255	33,092	32,410	5,662	6,348	6,428

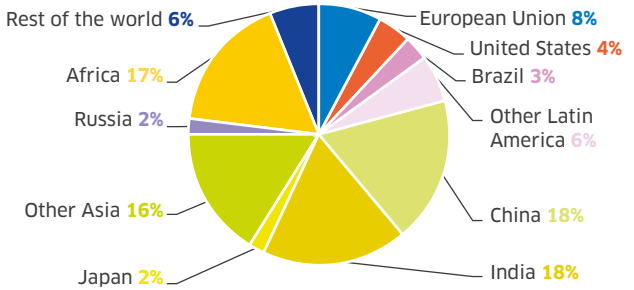
* Oxford Economics forecast, August 2021.

Source: Enerdata, Global Energy and CO2 Data, August 2021

DISTRIBUTION OF WORLD GDP IN 2020
TOTAL – 80,5 MDS $ (CONSTANT 2015)



DISTRIBUTION OF WORLD POPULATION IN 2020
TOTAL: 7.75 BILLION



Source: Enerdata, Global Energy and CO_2 Data, 2019

Green recovery plans

An insufficiently green recovery

Compared with the unprecedented efforts made to support world economies, funds dedicated to energy transition appear pathetic: barely 2%, according to the IMF.

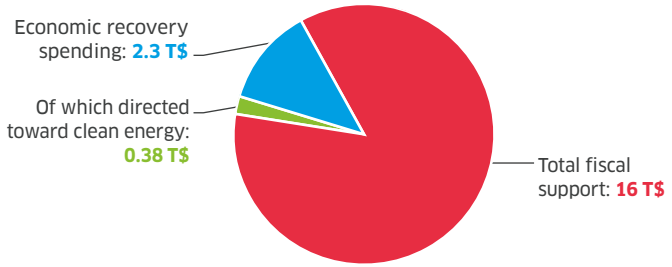
Governments have so far mobilised $16,000 bn in public spending, mostly in the form of 'rescue' packages - health expenditure and emergency assistance for businesses and households (June 2021 IMF assessment). Of this total, the sums earmarked purely for economic recovery amounted to around $2,300 bn, of which only $380 bn went to sustainable energy projects.

This meagre total contrasts with numerous government statements since the beginning of the crisis about the importance of rebuilding better, for a sounder future. As the IEA executive director Fatih Birol pointed out, many governments have yet to act on their promises.

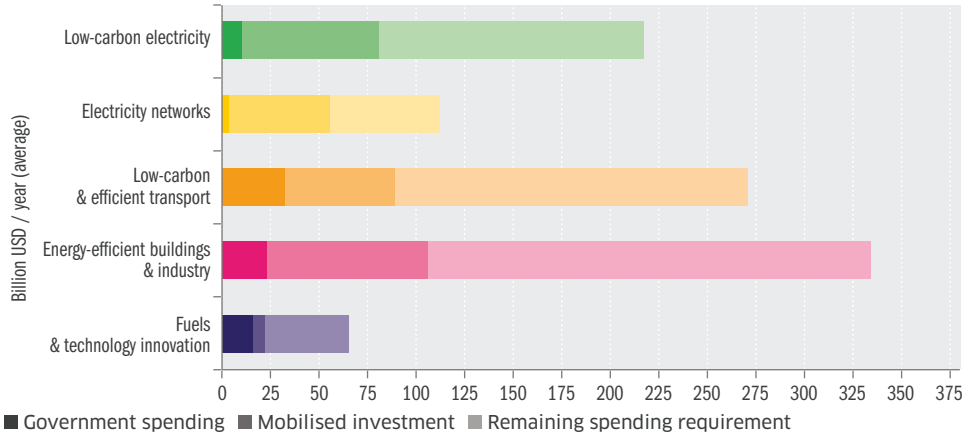
Most expenditures dedicated to green recovery have gone to pre-existing programmes, such as energy efficiency subsidies, public procurement and services and electric mobility incentives. 'Green' assistance was made up of subsidies and loans (37%), tax cuts (17% and tax breaks (11%). They focused primarily on the energy sector (20%) and land transport (16%), while other support measures towards air transport and the industrial sector perpetuated an existing, highly polluting model (source: UN, Global Recovery Observatory, 2021).

Commitments and new policies that have been implemented since last year should generate additional private investment in clean energy and power infrastructure worth about $350 bn per year from 2021 to 2023. This represents a 30% increase from previous years. But it remains far below what is required to place the world economy on its Paris Agreement track – 1,000$ per year over the next years, according to the July 2021 IEA's Sustainable Recovery Tracker.

WORLD COVID-19 FISCAL SUPPORT (IN JULY 2021)



ADDITIONAL INVESTMENT BY SECTOR COMPARED WITH LEVELS IN THE SUSTAINABLE RECOVERY PLAN, ANNUAL AVERAGE 2021-2023



Source: IEA, Sustainable Recovery Tracker, july 2021

Green recovery plans

Despite evidence that ‘green’ stimulus packages are more efficient than traditional efforts, most countries missed that opportunity. Europe is a notable exception

Green recovery plans have major multiplier effects on the economy, by creating jobs in the short term and by their capacity to attract private investment and develop resilient systems. They should also be assessed in light of the higher cost of inaction.

More precisely, investments in energy efficiency, such as thermal renovation, RES and transport infrastructure, not only save energy but are easy to implement and offer considerable potential to revive the economy, innovate and create jobs.

These benefits were demonstrated in an Oxford University study* published on 4 May 2020, edited by Nicholas Stern and Nobel prize-winner Joseph Stiglitz. With the participation of a vast number of experts worldwide and the analysis of 700 pre-Covid 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 short-term returns on every dollar spent and generate savings in the long term.

The analysis has continued in 2020 and 2021 within the Global Recovery Observatory** and shows major geographic disparities among current energy transition packages. Most of this spending is in G20 economies, and more specifically among a small group of high-income countries with relatively low borrowing costs. They are also responsible for the heaviest stimulus spending to date: Denmark, Finland, Germany, Norway, France, Poland, Spain and South Korea.

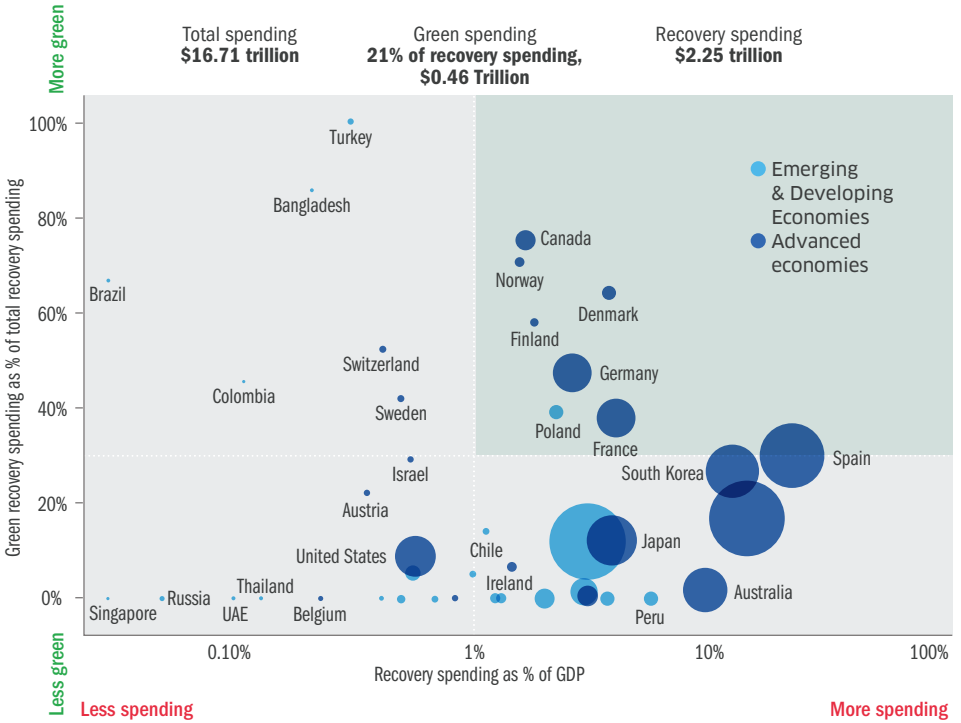
High interest rates and existing borrowing constraints impeded efforts towards recovery in many emerging and developing countries.

Even though the share of public spending dedicated to energy transition was minimal in 2020, it initiated major private investment projects in a wide range of fields from energy to transport and energy efficiency (see previous page).

* *“Will Covid-19 fiscal recovery packages accelerate or retard progress on climate change?”*, University of Oxford – SSEE, 4th May 2020.

** Global Recovery Observatory, Oxford University – SSEE & UN, 2021.

SHARE OF GREEN SPENDING IN NATIONAL RECOVERY PLANS
~21% OF RECOVERY SPENDING



Sources: https://data.undp.org/content/global-recovery-observatory/ "Global Recovery Observatory, UNDP"

Green recovery plans

The European Union is now in a position to implement the €750 bn recovery package it agreed in July 2020. Aimed at righting the economic and social damage caused by the pandemic, this 'Next Generation EU' plan is also a unique opportunity for Europe to transform its economy and make it "greener, more digital and more resilient".

Ratified on 27th May 2021, the agreement allows the EU to issue a common bond on financial markets through a temporary instrument, the Recovery and Resilience Facility (RRF), which will allocate €312.5 bn in grants and €360 bn in loans to the most affected member states.

Combined with the long term €20181,074.3 bn EU budget for the2021-2027 period, the overall envelope amounts to €2018 1,800 bn.

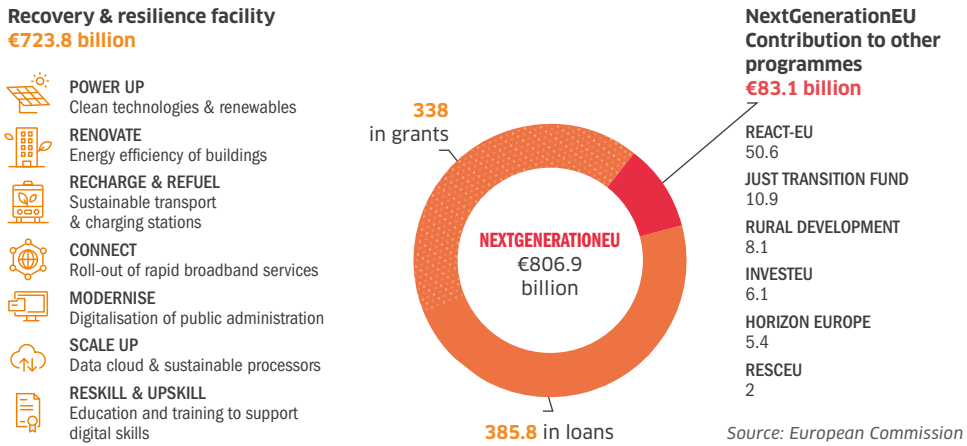
The EU has also adapted its monetary policy to deal with the Covid crisis, with the ECB launching a quantitative easing programme (the Pandemic Emergency Purchase Programme) to buy back €1,850 bn worth of financial assets. Moreover, the central bank has promised to keep its key rates low, increase banks' borrowing capacity, extend the list of collaterals for loans, and lower capital requirements in order to facilitate access to credit for businesses and households.

Climate change accounts for over a third of EU recovery funds: 33% of the long term budget is dedicated to climate and 37% of the RRF-related grants must go to transition investments. This is a strict condition. Lastly, €17.5 bn of the Next Generation EU package will be directly allocated to natural resources conservation. In total, the EU will assign over €600 bn to its green transition.

In France, the recovery package presented in September 2020 amounts to €100 bn, of which €40 bn is funded by Europe. This 'France Relance' plan has three priorities: ecology, with the double objective of becoming the first decarbonised country among the major European economies and reaching carbon neutrality by 2050; competitiveness, notably through modernising and relocating industrial projects, and improving business financing; and social cohesion, with help for young people to find jobs and support for town-centre shops.

The green component of the French recovery plan is relatively large, as €30 bn of the total is aimed at ecological transition. The four priority sectors defined in the plan are buildings' thermal renovation (€6.7 bn), transport (€11 bn, of which €1.9 bn for clean vehicles and electric charging points), agricultural transition (€1.2 bn) and energy (€9 bn, of which €2 bn for the development of green hydrogen and €1.2 bn for the decarbonization of industry).

"NEXTGENERATION-EU" THE EU RECOVERY PLAN



Source: European Commission

Green recovery plans

In March 2021, Joe Biden launched the third US recovery package, the American Rescue Plan Act, totalling $1,000 bn. It follows the Coronavirus Aid, Relief, and Economic Security Act ($2,200 bn) of March 2020, and the Consolidated Action Act of December 2020 (of which $900 bn dedicated to post-Covid recovery). The main feature of the latest plan is a direct payments to US households ($1,400/person earning less than $75,000/year or $150,000 for a couple). Other measures include extra unemployment benefits, tax credits for child care and support for schools and higher education.

The US Federal Reserve is also supporting the economy through its monetary policy. It is committed to maintaining interest rates near zero (interest rates to banks are down from 2.25% to 0.25%), by buying back $2.7 bn worth of assets in order to support financial markets (quantitative easing), and by reinjecting liquidity.

Green provisions are virtually absent from the various US recovery packages. According to the National Conference of State Legislatures, environment-related measures amount to only $195 m within the American Rescue Plan Act and merely $3 m in the Coronavirus Aid, Relief, and Economic Security Act. In both cases it is much less than 1% of the funds being committed to support the economy.

The new US president is keen to make environmental issues part of his policy, however. At the April 2021 climate summit he told around 40 heads of state that he wanted to halve US GHG emissions by 2030. The infrastructure plans amounting to a colossal $1,200 bn and that were voted in early August 2021 are a step in this direction, with $86 bn directly allocated to climate. Upgrading roads ($110 bn) and rail transport ($106 bn) are part of investments towards mitigating climate change too. Regarding energy infrastructure, $73 bn has been allocated to the development of the power grid, $18 bn to CCUS, $15 bn to electric vehicles and $8 bn to hydrogen.

In March 2021, the Chinese National People's Congress approved the 14th Five-Year Plan guidelines, the country's economic and social roadmap for the 2021-2025 period. Accelerating the process towards a greener economy is an important component of this strategy, notably since Xi Jinping's promise to the UN General Assembly in September 2020 to reach a CO_2 emission peak before 2030 and carbon neutrality by 2060. China also aims at technological autonomy, particularly regarding semi-conductors; these are currently imported massively and are fuelling Sino-American rivalry. Another major ambition is to reduce the country's dependence on exports by relying increasingly on domestic consumption through an improved welfare system and urbanisation.

Climate objectives have not been revised since the 13th plan, however. 2021-2025 targets are more or less identical to that of the 2016-2020 plan, themselves already considered moderate: energy intensity to be reduced 15% and carbon intensity by 18%, the share of non-fossil fuels to be raised from 15% in 2020 to 20% in 2025, and forest cover from 23% to 24%.

The 14th Five-Year Plan merely refers to China's longer term climate objectives and introduces the idea of a CO_2 emission cap, without setting any absolute value (reducing CO_2 emissions per GDP unit by 65% compared to 2005). In other words, the peak will depend on Chinese economic growth, for which the only given target is 6% in 2021 because of macroeconomic uncertainty.

Environmental objectives play a greater part in this roadmap than in its predecessors: out of the 20 key indicators for the period, 8 are binding, of which 6 apply to environment, climate and energy. The Plan is considered ambiguous by many experts however: *"it sends a undecided signal regarding climate"* and shows *"no significant change in China's posture concerning coal and clean energy: it promotes both"* (Climate Action Tracker).

Investment in the energy sector

The rebound of energy investment in 2021 reflects a brighter economic situation, but also a shift of capital flows towards clean technologies

Investments in the energy sector are expected to rebound about 10% in 2021 to $1,900 bn*, offsetting a contraction in 2020. This performance contrasts with several years of stagnation between the end of the oil and gas industry's rapid development in the early 2010s and the point at which clean technologies started to take off.

Energy companies are still fragile financially but are seeking to take advantage of accommodating monetary policies and government support. A growing number favour the power sector and downstream business (energy efficiency, batteries, electrification) over traditional fossil energy production.

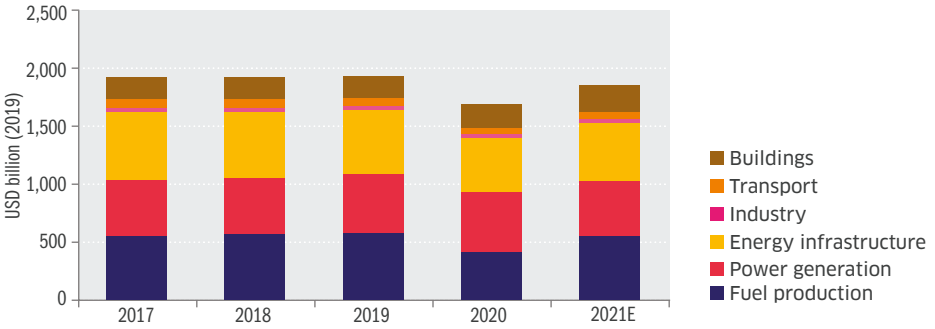
Driven by the sector's outperformance on stock markets in 2020, **investment in clean technologies** (RES, energy efficiency, CCUS, batteries) is expected to grow another 7% in 2021 to $750 bn, or to 40% of total investments.

A combination of multiple commitments by governments, companies and financial institutions to reach zero emissions by 2050 and a boom in sustainable finance ($600 bn of sustainable debt was issued in 2020) underpins this move. Recovery packages also bolstered projects in new segments, such as green hydrogen and CCUS.

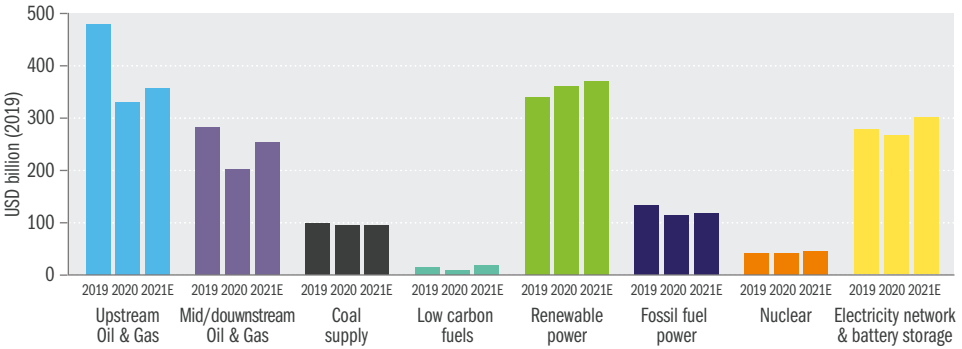
Even so, green investment is still hampered by the scarcity of quality projects, the inefficient channelling of available funds and a lack of competent intermediaries. It also remains confined to countries with large budgetary reserves, low interest rates and clear support policies.

Lastly, sums invested in clean technologies are well below climate scenarios' requirements: they ought to double over the decade to keep the global temperature rise to below 2°C and to triple for it to stabilise at 1.5°C.

GLOBAL ENERGY INVESTMENT, 2017-2021



GLOBAL ENERGY SUPPLY INVESTMENT BY SECTOR



Source: IEA World Energy Investment 2021, may 2021

Investment in the energy sector

The power sector accounts for a growing share of investment in the shape of renewable energy. Stable in 2020 while all other types of investment were plunging, it is set to increase 5% in 2021 to over $820 bn, according to the IEA. Most will be allocated to production capacity (investments estimated at $530 bn in 2021), of which 70% will focus on renewable energy and the rest on grids and storage.

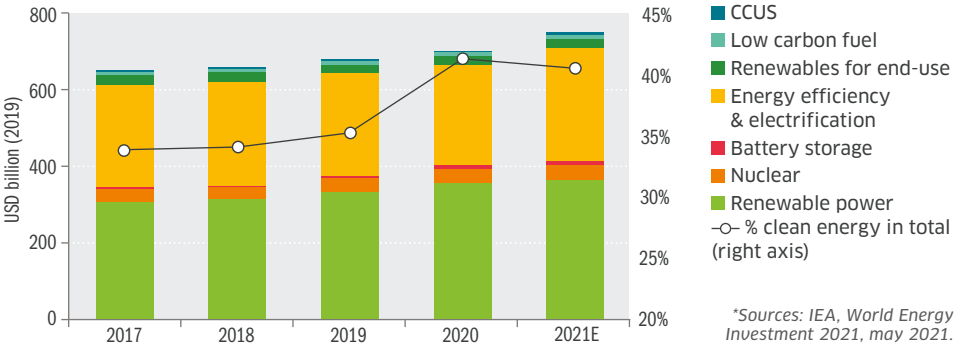
The development of power RES reflects a spectacular cost reduction and technology improvement (one dollar spent in wind or solar PV generates four times more electricity today than ten years ago). Solar energy has become very competitive. Given calls for tenders, auctions and corporate PPA, it should beat wind power in 2021. China, India, the USA and Europe are expected to increase their solar investment by over 10% in 2021.

In 2021, power RES investment showed exceptional resilience (up 7% on 2019, 45% of all power investment). But it was still restricted to a handful of markets: China, with massive wind investment, the USA and Europe. Electrification has also been driving investment, with continued sales of electrical cars boosted by the multiplication of new models.

Investment in nuclear power weathered the crisis well in 2020 and should hold up thanks to Chinese, Indian and Russian expansion plans. It represents 5% of power investment.

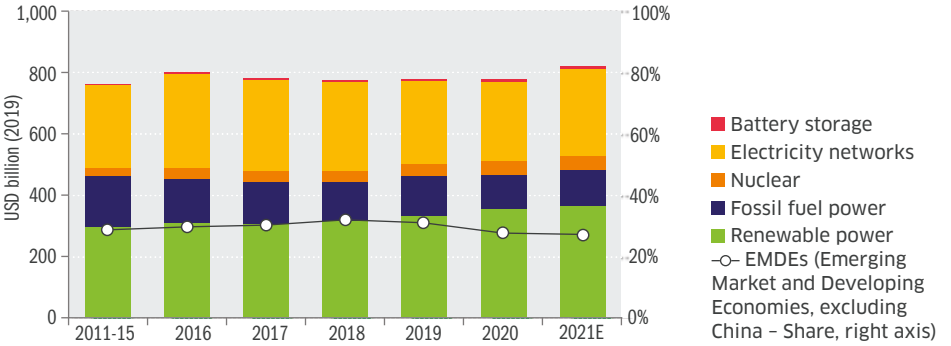
Conversely, investment in fossil power capacity dropped significantly in 2020 (-10%), albeit with geographical differences. It slumped in India, declined less steeply in China and increased in the USA. It is expected to have rebounded somewhat in 2021.

GLOBAL INVESTMENT IN CLEAN ENERGY AND ENERGY EFFICIENCY, 2017-2021*



Sources: IEA, World Energy Investment 2021, may 2021.

GLOBAL INVESTMENT IN THE POWER SECTOR BY TECHNOLOGY, 2011-2021E*



Sources: IEA, World Energy Investment 2021, may 2021.

Investment in the energy sector

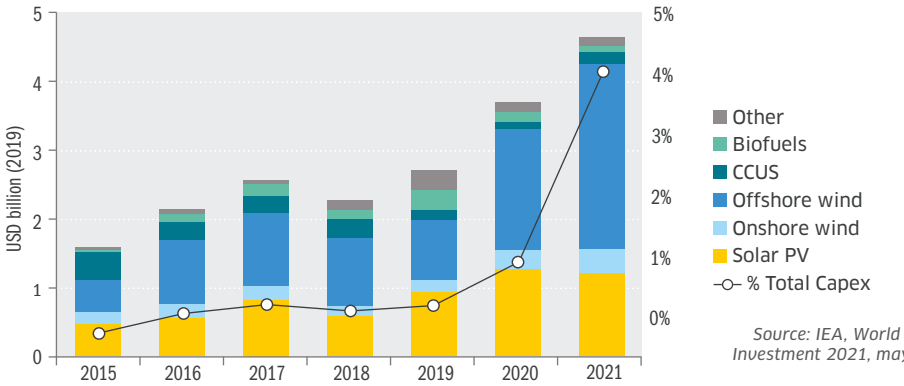
Despite the Covid-19 crisis, investment in batteries rose 40% in 2020 to $5.5 bn, and by as much as 60% in grid batteries. This performance stemmed from cost reductions (-20% on average) and a growing number of combined auctions including storage. This trend should continue in 2021.

Investments in power grids had been falling for three years and dipped another 6% to $255 bn in 2020 as grid operators lost revenues. Major projects in China, Europe and the USA should revert the trend, however. Europe committed to a power grid extension programme from 2021 to 2030, supported by the recovery plan. The USA passed an infrastructure renovation plan presented by Joe Biden, allocating $73 bn to power grids.

Investment in fossil energy will be much lower in 2021 than it was before the pandemic. After a staggering 25% plunge in 2020, it is expected to rebound 14% in 2021, from $620 bn to $720 bn. Most 2020 spending went towards oil and gas (84%), compared with 14% on coal and less than 2% on decarbonized fuels. The latter are becoming important to a growing number of businesses, however, both inside and outside the oil and gas sector, investing in low carbon fuels (hydrogen, biofuels) or in CCUS. It is expected to have a tangible effect on future trends.

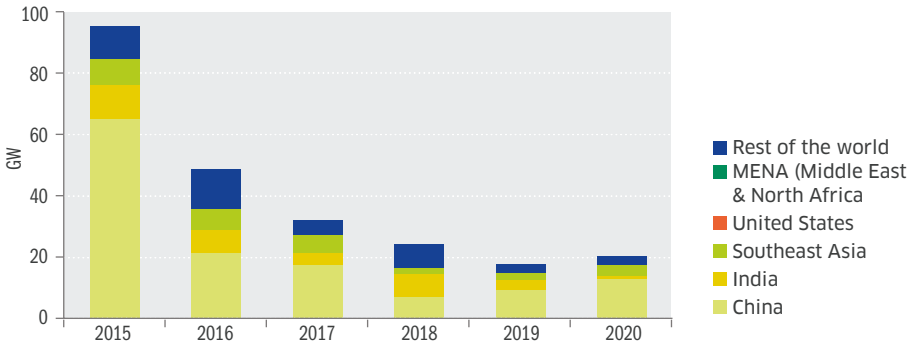
The crisis will not have accelerated the end of coal. After a sharp 9% contraction in 2020, investment resumed in 2021 on the back of power requirements in Asia. In fact, India and China did not reduce their investment at all in 2020, while the rest of the world cut its investment by a quarter. Down 80% worldwide since 2015, investment in coal-fired plants regained ground in 2020 and 2021 because of easier authorisation in China and projects across Asia.

CLEAN ENERGY INVESTMENTS MADE BY SELECTED OIL AND GAS COMPANIES, INCLUDING DATA THROUGH MAY FOR 2021



Source: IEA, World Energy Investment 2021, may 2021.

FIDS FOR COAL, 2015-2020



Source: IEA World Energy Investment 2021, may 2021

Energy balance

The pandemic had a dramatic effect on the energy market but also proved a valuable learning opportunity around clean technologies

In 2020, primary energy demand contracted by more (4%) than at any time since the Second World War. Lockdowns and other restrictions resulted in declines in energy consumption in line with economic activity. This meant a sharper drop in developed countries (-6%) than in emerging ones (-3.4% in India, -3% in South East Asia, -2% in the Middle East and -1.5% in Africa). Only China reported an increase in energy consumption in 2020 (+2%).
The transport sector was worst hit with an 11% contraction in energy demand, reflecting mobility restrictions. This was especially true of international air transport (-45%).

The recession badly dented the oil market, down 9 mbd, while sustainable technologies proved resilient. They continued to make progress, especially solar energy.
Oil demand was by far the most affected, down 8.9% in 2020, bearing the brunt of road and air travel restrictions. Fuel consumption in transport, representing 52% of oil consumption, plunged 14% in 2020.

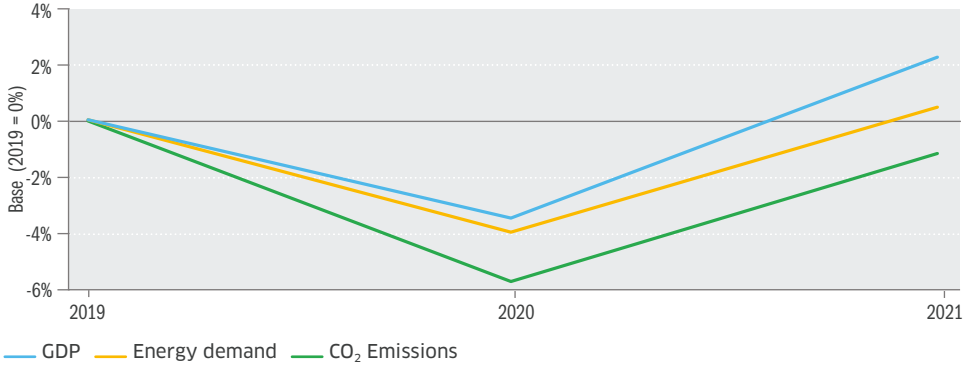
Coal consumption declined 4%. Half of that is attributable to the power sector, hit by the combined effect of lower electricity demand, a significant RES share and low gas prices. This was particularly the case in developed countries, notably the USA, the EU and Russia (coal-fired plants saw demand fall 15%), but also in Brazil. The other half of the decline in coal consumption stemmed from energy-intensive sectors, such as the steel and cement industries.

Natural gas resisted better than the other fossil sources (-1% in 2020), as its low price boosted coal substitution in power generation during the crisis, especially in OECD countries. In non-OECD countries, demand faced mixed situations, with a cold winter in China (+8%) but mild temperatures and low power demand in Russia (-5%). All in all, it held up fairly well.

Renewable energy is the winner of the crisis, maintaining a +3% rise in 2020. First in the order of merit thanks to zero marginal costs, power RES grew +7% in 2020, despite a depressed power context (-1% total decline). The power sector generated two thirds of the 2020 RES growth, and the industrial use of biomass the other third (+3%).

Renewable capacities recorded a rather exceptional year even. The wind sector gained +12% (+111 GW installed, twice more than in 2019) thanks to an acceleration in China (+72 GW), and vast infrastructures installed in the US, Australia and the EU. The solar sector recorded an even stronger performance, with a +20% rise in installed capacity (+127 GW), notably in China (+49 GW), in the EU and the USA.

COMPARATIVE TRENDS IN GDP, ENERGY DEMAND AND CO_2 EMISSIONS COMPARED TO 2019 - WORLD



Source: IEA World Energy Investment 2021, may 2021

Energy balance

The decline in energy demand is expected to be completely erased in 2021, with renewables standing out again but coal clouding the outlook by rebounding sharply

Picking up strongly, 2021 energy demand is expected to exceed the 2019 level, even if recent outbreaks of the pandemic hold some sectors back*.

This year again, energy consumption levels will evidently depend on the pandemic. That said, economic growth recovery and the almost complete removal of restrictions mid-year point to a 4.6% increase in world energy consumption in 2021 (+0.5% from 2019), according to the IEA and Enerdata.

The EIA attributes near 70% of the swing to emerging markets, for which energy consumption could exceed its 2019 level by 3.4%. Key drivers of the rise would be China (6% in 2021, up 8% from 2019) and India (7%, up 2% from 2019).

For developed countries, a return to pre-crisis levels is out of the question in 2021. US energy consumption will remain 3% lower than in 2019, despite a 5% surge in 2021. Weaker expansions are expected in the EU and Japan (3.5% and 0.9%, respectively, according to Enerdata).

The recovery in primary energy demand will depend largely on transport. The IEA anticipates demand from this sector to be much lower in 2021 than in 2019, as international mobility remains restricted. Conversely, if the sector were to resume consumption up to pre-crisis levels as soon as this year, primary energy demand could exceed its 2019 level by 2%.

The crisis galvanised renewable energy development, but the recovery generated an exceptional call for coal. This reversed 5 years of decline, with serious consequences for CO_2 emissions.

Oil demand is gaining some ground in 2021 (+6.2%), but will remain 3% lower than in 2019, since road transport was limited over an large part of the year and air traffic was much lighter than in 2019. Only Asia will exceed its 2019 level, driven by China (+7.2%) and India (+6.9%).

Boosted by Asia, coal demand will hit a growth record in 2021 at 4.5% (up 0.5% from 2019), and nearly reach its 2014 peak. This rebound will account for 80% of Asian power demand, reminding us of the central role of coal in most developing countries. China forecasts speak for themselves: coal consumption will rise 4% to its highest ever level in 2021. Conversely, coal demand USA and Europe will recoup only a quarter of the ground lost in 2020, signalling their firm desire to accelerate their exit from this energy source.

Expected up 3.2% in 2021, natural gas will record the strongest expansion amongst fossil fuels over the 2019-2021 period (1.3% from 2019), boosted by rapid economic recovery in Asia and, to a lesser extent, the Middle East and Russia. Three quarters of the rise will come from the industrial and the construction sectors, while gas-fired power production will remain lower than in 2019 amid higher prices.

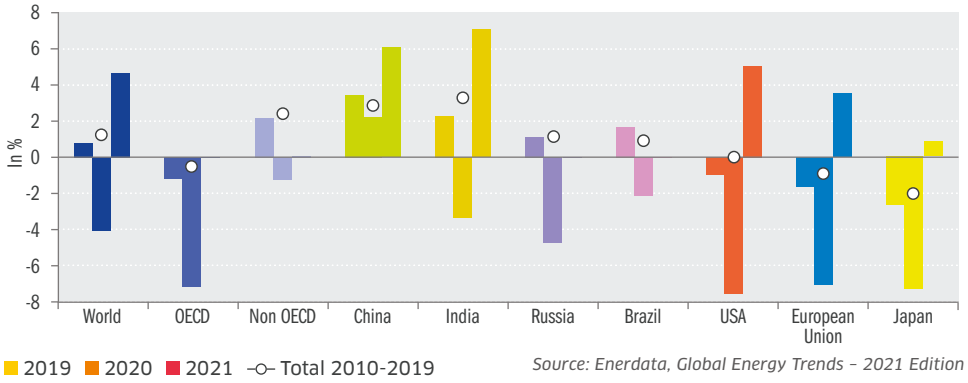
Renewable energy is on track to cross new thresholds. RES power production is expected to climb 8%, its fastest pace since the 1970s, and reach 8,300 TWh. Wind and solar energy would generate two thirds of the move (respectively +17% and +18%), together with biomass and hydroelectricity (+8.3%). These two years of rapid growth will bring the RES share in power production up to 30%, another three-point gain from 2019.

* 2021 projections presented here are taken from the IEA (Global Energy Review 2021, April 2021). They are based on 1st quarter 2021 statistics. These forecasts carry a high degree of uncertainty due to exogenous elements such as new variants, the removal of Covid restrictions, vaccinations and the economic consequences of lockdowns.

Enerdata forecasts (Global Energy Trends – June 2021) are matching them. They rely on macroeconomic projections from international organisations and on Enerdata's continuous data gathering across all countries and sectors.

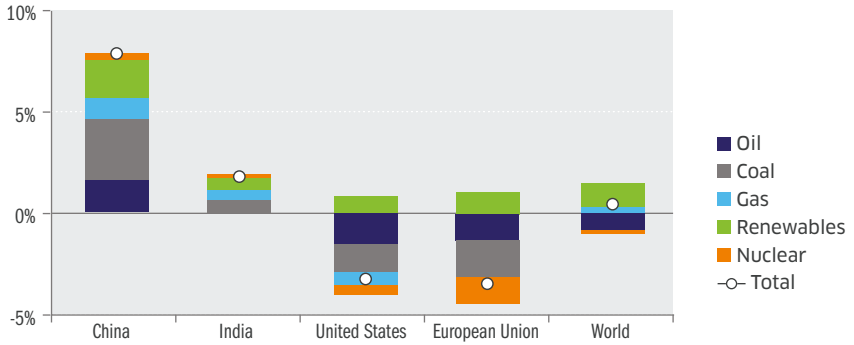
Energy balance

EVOLUTION OF PRIMARY ENERGY DEMAND BY REGION (%/YEAR)



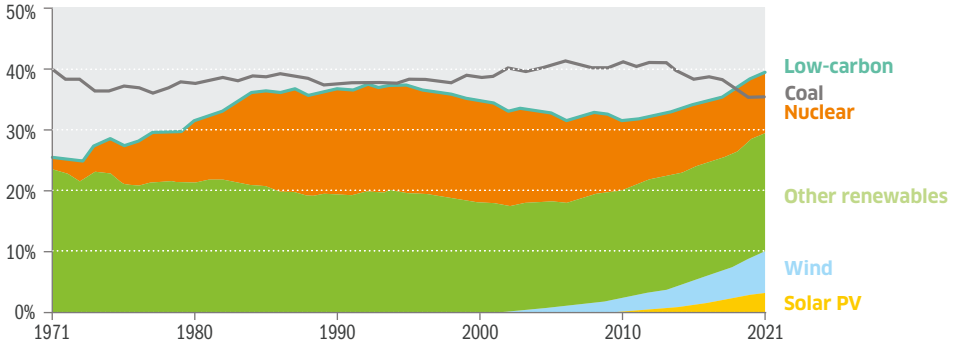
Source: Enerdata, Global Energy Trends – 2021 Edition

CHANGE OF PRIMARY ENERGY DEMAND BY REGION AND BY FUEL IN 2021 RELATIVE TO 2019



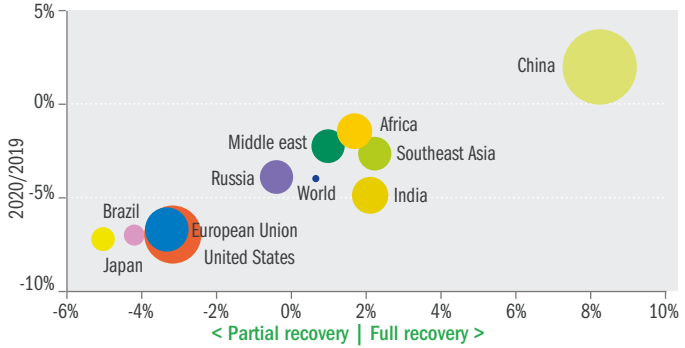
Source: AIE, Global Energy Review 2021, april 2021

SHARE OF LOW-CARBON SOURCES AND COAL IN WORLD ELECTRICITY GENERATION, 1971-2021



Source: AIE, Global Energy Review 2021, april 2021

RATE OF CHANGE OF ENERGY DEMAND IN 2020, AND IN 2021, RELATIVE TO 2019 LEVELS, BY REGION



Bubble size is relative to regional primary energy demand in 2021.

Source: IEA Global Energy Review 2021, April 2021 Assessing the effects of economic recoveries on global energy demand and CO_2 emissions in 2021

Source: IEA World Energy Investment 2021, may 2021

Primary energy production

Primary energy production in 2020 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world
Europe	113	-17%	3%	180	8%	4%	176	-7%	5%	167	1%	13%	328	-5%	24%	3	0%	10%	971	-4%	7%
EU-27	88	-16%	2%	75	-4%	2%	77	-14%	2%	157	1%	12%	279	-6%	20%	3	3%	8%	679	-7%	5%
North America	284	-24%	8%	1,002	-4%	24%	938	0%	28%	113	-7%	8%	354	0%	26%	3	17%	10%	2,695	-5%	19%
Canada	23	-22%	1%	261	-5%	6%	145	-2%	4%	13	-5%	1%	63	0.0%	5%	0	2%	0%	505	-4.3%	4%
United States	261	-24%	7%	741	-4%	17%	793	0%	24%	100	-7%	8%	291	1%	21%	3	17%	10%	2,190	-5%	16%
Latin America	48	-24%	1%	408	-5%	10%	152	-8.6%	5%	153	2%	12%	88	-1%	6%	1	5%	4%	851	-6%	6%
Brazil	2	3%	0.1%	160	7%	4%	21	-8%	1%	97	3%	7%	43	-1%	3%	1	6%	3%	324	4%	2%
Asia	2,636	0%	69%	346	-2%	8%	399	0%	12%	506	0%	38%	458	5%	33%	25	1%	72%	4,382	1%	31%
China	1,961	1%	52%	201	2%	5%	163	10%	5%	114	-1%	9%	274	7%	20%	23	0%	68%	2,749	2%	19%
India	294	4%	8%	36	-5.9%	1%	23	-12%	1%	199	4%	15%	38	2%	3%	1	8%	4%	590	2%	4%
Indonesia	288	-9%	8%	37	-5%	1%	56	-7%	2%	31	-4%	2%	27	3%	2%	0	NA	0%	438	-8%	3%
Pacific	283	-6%	8%	20	16%	0.5%	148	8%	4%	8	-4%	1%	12	4%	1%	1	6%	1%	472	-1%	3%
Australia	282	-6%	7%	19	18%	0.5%	133	8%	4%	5	-5%	0.4%	5	15%	0.3%	0	6%	1%	443	-1%	3%
CIS	286	-7.8%	8%	655	-8%	15%	753	-7%	23%	18	3.3%	1%	103	2%	8%	0	-100%	0%	1,814	-7%	13%
Russia	221	-9%	6%	515	-9%	12%	579	-6%	17%	11	4%	1%	76	5%	6%	0	NA	0%	1,402	-7%	10%
Middle East	1	4%	0%	1,291	-9%	30%	569	1%	17%	1	-1%	0.1%	5	-12%	0.4%	1	0%	2%	1,867	-6%	13%
Qatar	0	NA	0%	73	-2%	2%	149	0%	5%	0	NA	0%	0	NA	0%	0	NA	0%	222	-1%	2%
United Arab Emirates	0	NA	0%	168	-9%	4%	51	-7%	2%	0	NA	0%	1	29%	0.0%	0	NA	0%	219	-9%	2%
Saudi Arabia	0	NA	0%	520	-7%	12%	80	1%	2%	0	NA	0%	0	0%	0%	0	NA	0%	599	-6%	4%
Iran	1	4%	0%	135	-9%	3%	198	1%	6%	1	-1%	0%	4	-17%	0.3%	0	NA	0%	339	-4%	2%
Africa	147	-5%	4%	366	-11%	9%	196	-6%	6%	373	1%	28%	22	-2%	2%	0	1%	0.6%	1,104	-6%	8%
Nigeria	0	-7%	0%	89	-14%	2%	39	2%	1%	124	1%	9%	1	0%	0%	0	NA	0%	253	-5%	2%
World	**3,798**	**-4%**	**100%**	**4,267**	**-6%**	**100%**	**3,331**	**-3%**	**100%**	**1,338**	**0%**	**100%**	**1,371**	**0%**	**100%**	**34**	**2%**	**100%**	**14,157**	**-4%**	**100%**
OECD	668	-16%	18%	1,296	-2%	30%	1,278	0%	38%	326	-2%	24%	771	-2%	56%	8	7%	24%	4,351	-4%	31%
no-OECD	3,130	-1%	82%	2,972	-8%	70%	2,053	-4%	62%	1,012	1%	76%	599	3%	44%	26	1%	76%	9,806	-4%	69%

Source: Enerdata, Global Energy & CO_2 Data, august 2021

Primary energy consumption

Primary energy consumption in 2020 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world
Europe	193	-18%	5%	537	-9.2%	14%	441	-2%	13%	177	1%	13%	330	-5%	24%	9	1%	15%	1,687	-7%	13%
EU-28	143	-20%	4%	470	-10.3%	12%	390	-3%	12%	167	1%	12%	284	-5%	21%	5	2%	8%	1,458	-7%	11%
Germany	44	-18%	1%	93	-7%	2%	74	-2%	2%	31	0%	2%	33	-3%	2%	1	3%	2%	276	-6%	2%
France	5	-28%	0.1%	60	-16.0%	2%	35	-8%	1%	17	-5.6%	1%	99	-9%	7%	0.4	6%	1%	216	-11%	2%
North America	227	-21%	6%	805	-12%	21%	825	-2%	25%	110	-7%	8%	353	0%	26%	4	12%	8%	2,325	-8%	17%
Canada	12	-22%	0%	95	-12%	3%	102	-5%	3%	13	-5%	1%	58	-2%	4%	0	2%	0%	279	-7%	2%
United States	216	-21%	6.0%	711	-12%	19%	722	-1%	22%	97	-8%	7%	296	1%	22%	4	12%	7.7%	2,046	-8%	15%
Latin America	36	-17%	1%	285	-14%	7%	196	-1%	6%	153	2%	11%	84	-5%	6%	2	4%	3%	756	-7%	6%
Brazil	14	-12%	0.4%	100	-5%	3%	29	-6.6%	1%	97	3%	7%	46	0%	3%	1	5%	2%	286	-2.2%	2%
Asia	2,833	-0.6%	78%	1,456	-3%	38%	667	1%	20%	506	0%	38%	458	5%	34%	39	3%	70%	5,958	0%	44%
China	2,011	1%	56%	680	4%	18%	268	7%	8%	114	-1%	9%	272	7%	20%	37	3%	66%	3,381	2%	25%
India	400	-4%	11%	218	-10%	6%	53	-1%	2%	199	4%	15%	38	3%	3%	1	8%	2%	908	-3%	7%
Indonesia	64	-4%	2%	67	-9.8%	2%	37	-5%	1%	30	-4%	2%	27	3%	2%	0	NA	0.0%	225	-5%	2%
Japan	104	-8%	3%	144	-10%	4%	90	-3%	3%	17	5%	1%	31	-10%	2%	0.4	5%	1%	386	-7%	3%
South Korea	67	-12%	2%	103	-6%	3%	47	1%	1%	21	3%	2%	45	12%	3%	0.3	2%	1%	283	-3%	2%
Pacific	42	-4%	1%	52	-3%	1%	38	0%	1%	8	-4%	1%	12	4%	1%	1	4%	1%	153	-2%	1%
Australia	40	-4%	1%	42	-4%	1%	34	1%	1%	5	-5%	0.4%	5	15%	0.3%	0.4	6%	1%	126	-2%	1%
CIS	174	-8%	5%	202	-5%	5%	525	-6%	16%	17	4.3%	1%	101	3%	7%	1	-1%	1%	1,019	-5%	8%
Russia	108	-11%	3%	144	-4%	4%	395	-5%	12%	11	4%	1%	74	6%	5%	0	NA	0%	731	-5%	5%
Middle East	8	-4%	0.2%	318	-8%	8%	471	4%	14%	1	-1%	0.1%	5	-15%	0.4%	1	0%	1%	804	-1%	6%
Iran	1	3%	0%	74	-9%	2%	189	4%	6%	1	-1%	0%	3	-21%	0.2%	0	NA	0%	268	-1%	2%
Saudi Arabia	0	NA	0%	130	-5%	3%	80	1%	2%	0	0%	0%	0.1	0%	0%	0	NA	0%	209	-3%	2%
Africa	99	-10%	3%	172	-9.7%	5%	134	-2%	4%	373	1%	28%	22	-1%	2%	0.3	1%	1%	801	-4%	6%
World	**3,612**	**-4%**	**100%**	**3,826**	**-7.4%**	**100%**	**3,296**	**-1%**	**100%**	**1,345**	**0%**	**100%**	**1,367**	**0%**	**100%**	**55**	**4%**	**100%**	**13,502**	**-4%**	**100%**
OECD	630	-17%	17%	1,694	-11%	44%	1,490	-2%	45%	336	-2%	25%	770	-2%	56%	14	4%	26%	4,934	-7%	37%
no-OECD	2,982	-1.1%	83%	2,133	-5%	56%	1,806	0%	55%	1,009	1%	75%	597	3%	44%	41	3%	74%	8,568	-1%	64%

Source: Enerdata, Global Energy & CO_2 Data, august 2021

Final energy consumption

Final energy consumption in 2020 in Mtoe	Fossils									Biomass			Primary electricity			Heat			Total		
	Coal & Lignite			Crude oil & NGL			Natural gas			Biomass & Wastes			Primary electricity			Geothermal & Solar					
	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world	Volume	Change 2019-20	Share in the world
Europe	58	-9.7%	5%	483	-10.5%	14%	275	-3%	18%	104	0%	10%	271	-4%	14%	56	0%	16%	1,246	-6%	13%
EU-27	41	-17%	4%	421	-11%	13%	243	-3%	16%	96	0%	10%	228	-5%	12%	50	0%	14%	1,079	-7%	12%
Germany	11	-12%	1%	85	-8%	3%	56	-1.8%	4%	16	2%	2%	41	-5%	2%	10	-2%	3%	219	-5%	2%
France	2	-20%	0.2%	56	-14.4%	2%	26	-7%	2%	12	-7%	1%	36	-5%	2%	4	2.5%	1%	136	-10%	2%
North America	20	-13.6%	2%	759	-12.0%	23%	389	-6%	25%	90	-8%	9%	363	-4%	19%	11	3%	3%	1,630	-9%	17%
Canada	3	-3.9%	0%	81	-14.6%	2%	45	-4.9%	3%	10	-4%	1%	44	-3%	2%	1	-10%	0%	184	-9%	2%
United States	17	-15.3%	1.4%	678	-12%	20%	344	-6%	22%	79	-8%	8%	319	-3.9%	17%	10	3.9%	2.9%	1,446	-8%	15%
Latin America	18	-9%	2%	257	-11%	8%	67	-8%	4%	109	2%	11%	112	-2%	6%	1	4%	0.4%	565	-6.7%	6%
Brazil	10	-5%	1%	94	-4.1%	3%	10	-5%	1%	67	3%	7%	43	-2%	2%	1	6%	0.3%	226	-1.6%	2%
Asia	994	-2%	85%	1,275	-3%	38%	342	3%	22%	386	-2%	39%	917	2%	48%	167	6%	46%	4,080	-1%	44%
China	735	-1%	63%	582	3%	17%	181	9%	12%	69	-11%	7%	561	4%	29%	156	7%	43%	2,284	2%	24%
India	130	-1%	11%	194	-10%	6%	31	-2%	2%	167	4%	17%	102	-2%	5%	1	8%	0%	625	-3%	7%
Indonesia	21	-11%	2%	69	-10%	2%	17	4%	1%	22	-4%	2%	23	-1%	1%	0	NA	0.0%	152	-6%	2%
Japan	34	-18%	3%	133	-8%	4%	26	-8%	2%	6	0%	1%	77	-3.1%	4%	1	2%	0.3%	276	-8%	3%
South Korea	18	-5%	2%	89	-6%	3%	21	-3%	1%	17	-1%	2%	44	-2%	2%	6	1%	2%	195	-4%	2%
Pacific	4	-5.0%	0.4%	52	-4.5%	2%	16	0%	1%	7	-2%	1%	22	-3%	1%	1	4%	0.2%	101	-3%	1%
Australia	4	-4%	0.3%	43	-4%	1%	13	2%	1%	4	-5%	0%	18	-3%	1%	0.4	6%	0.1%	82	-3%	1%
CIS	55	-6%	5%	169	-3%	5%	212	-1%	14%	9	4%	1%	94	-2%	5%	123	-3%	34%	662	-2%	7%
Russia	33	-7%	3%	122	-3%	4%	156	-1%	10%	5	4%	0.5%	62	-3%	3%	101	-3%	28%	478	-3%	5%
Middle East	4	20%	0.4%	233	-9%	7%	199	1%	13%	1	-1%	0.1%	86	0%	5%	1	0%	0.2%	524	-3%	6%
Iran	1	3%	0.1%	65	-9%	2%	109	3%	7%	1	-1%	0%	23	2.4%	1%	0	NA	0%	198	-2%	2%
Saudi Arabia	0	NA	0%	92	-6%	3%	27	3%	2%	0	0%	0%	25	-1%	1%	0	NA	0%	145	-3%	2%
Africa	18	-16%	2%	153	-10%	5%	46	-3%	3%	291	1%	29%	57	-2.5%	3%	0.2	1%	0.1%	565	-4%	6%
World	**1,170**	**-3%**	**100%**	**3,379**	**-8%**	**100%**	**1,546**	**-2%**	**100%**	**996**	**-1%**	**100%**	**1,922**	**-1%**	**100%**	**361**	**2%**	**100%**	**9,373**	**-4%**	**100%**
OECD	133	-12.3%	11%	1,562	-10.9%	46%	733	-4.6%	47%	221	-4%	22%	796	-4%	41%	71	0%	20%	3,517	-7%	38%
no-OECD	1,036	-2%	89%	1,817	-5%	54%	813	1%	53%	775	-1%	78%	1,126	1%	59%	289	2%	80%	5,856	-2%	63%

Source: Enerdata, Global Energy & CO_2 Data, august 2021

CO_2 & Climate

IPCC'S 6TH REPORT ON CLIMATE CHANGE

Global warming now has *"irreversible consequences for centuries or millennia"*, especially regarding oceans, ice caps and sea level

CO_2 EMISSIONS

2021 wiped out most of the decrease in emissions observed in 2020 but structural changes are taking place linked to energy policies and developing technologies

Climate change

Rising temperatures in Europe breached the Paris Agreement red line in 2020

The constant rise in temperatures is the first indicator of the extent to which climate is changing. Global temperatures continued to rise in 2020. It was the third warmest year ever recorded after 2016 and 2019, and showed some notable accelerations. This was especially true of Europe, where the average temperature hit an all-time high (up 0.4°C from 2019 according to Copernicus). France was not spared: the annual average temperature was a record 14°C, beating the 13.9% posted in 2018 (13.9°C).

New heat records were set (Cuba, Australia, Japan). The 54.4°C recorded in August in Death Valley is considered the highest temperature ever observed; Verkhoïansk in Eastern Siberia reported a peak temperature of 38.8°C. This was unprecedented for a weather station regarded as the coldest in the Northern Hemisphere.

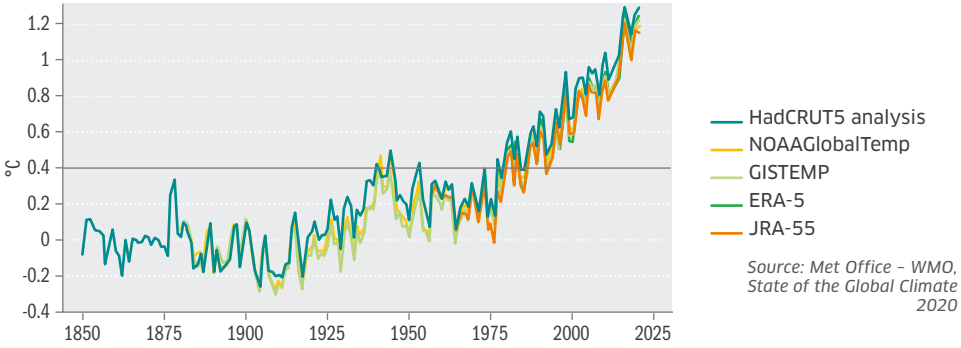
These records extend a global trend initiated in the 1980s. Since that time every decade has been 0.3°C warmer than its predecessor. All in all, temperatures have risen by 2.2°C in Europe and 1.25°C worldwide since the preindustrial era. The last six years were the warmest ever recorded.

Oceanic warming and acidification are limiting their ability to regulate climate.
On the front line of global warming – they absorb 90% of the heat accumulated in the atmosphere – oceans have been heating up to an abnormal degree since the 1970s. This phenomenon was particularly marked in 2020 and has disrupted the planet in a number of ways.

One of the most visible is a rise in sea level that has accelerated over the past few decades (+3.3 mm/year on average since 1993, or 9 cm in total, against +1.7 mm/year over 1901-2020). A third of it is due to water dilatation and the rest to melting ice.

Its corollary is an alarming deterioration in the cryosphere. The Arctic ice sheet was smaller in 2020 than ever recorded (3.74 Mkm² after the summer melt), and the 12 seasonal lows have all been observed in the past 12 years. Antarctica loses part of its ice sheet every year (175 to 225 Gt). This phenomenon started in the late 1980s and has been accelerating since 2005.

TEMPERATURE CHANGES SINCE 1850



Source: Met Office – WMO, State of the Global Climate 2020

Oceans are also a formidable carbon sink; dissolution and photosynthesis capture nearly 25% of CO_2 emissions. Excess CO_2 makes them more acidic, which combined with higher temperature reduces their ability to capture gases. Quite apart from the consequences for biodiversity, it is the ocean's capacity to restrain climate change that is being called into question.

Increasingly intense and more common, extreme climate events are a warning of climate emergency.

- **Floods:** abnormally heavy rainfall in 2020 in India, China, Korea and Japan; severe flooding in vast regions of Africa resulted in invasions of desert locusts in the Sahel.
- **Droughts:** extreme heat waves in inland regions of South America ($3 bn agricultural losses in Brazil) and the USA (unprecedented fires).
- **Storms:** storm record beaten in North Atlantic, with 30 storms named in 2020. Cyclone Amphan, hitting India and Bangladesh, was the costliest ever recorded ($14 bn confirmed damage).

Climate change

In the longer run, consequences for people and economies that will be hard to sustain

Ecosystems will be profoundly altered by higher temperatures.

IPCC's projections suggest the possibility of the ice packs vanishing in summer within a few decades, leading to an average 21 cm to 81 cm sea level rise by the end of the century. Air masses and ocean currents will be affected, while greater water evaporation will modify pluviometry (more rainfall in the high temperate latitudes and less in the Northern Hemisphere's tropical areas). According to the WMO*, most of Africa will suffer a minimum of 30 extra days of heatwave per year by 2050; drought and fire risks will increase in relation with higher interannual rainfall variability; cyclones will grow in intensity and frequency (+8% in Northern America).

Biodiversity will be profoundly affected by these changes, as they will severely affect ecosystems: nearly a fifth of wild species are threatened with extinction via habitat degradation (in a +1.5°C rise scenario, 6% of insects, 8% of plants and 4% of vertebrates will see a large part of their habitat destroyed; 99% of barrier reefs will disappear beyond a 2°C rise).

Decades of progress in public health and in poverty reduction are at risk.

Food insecurity has worsened since 2014 after decades of improvement, partly because of the impact of climate disruption on crops such as wheat, corn and soybeans. Yields are steadily declining or becoming volatile, affecting prices and supply security; ocean acidification also leads to lower fishery resources.

The FAO** expects increased food and drinking water shortages over the next decades and predicts that 1.5 billion people will be suffering from malnutrition by 2080.

Climate change undeniably affects public health, whether indirectly (famines, displacement, diseases carried by birds and mosquitoes), or directly, with heatwave-related mortality (up 54% over the last twenty years, reaching 300,000 dead in 2018 according to The Lancet).

Climate change is forcing more and more human migration, either because of extreme weather events or because of the rising sea levels that threaten 600 to 700 million people (IPCC); one person out of ten lives in a risk area. 2020 saw record displacement as a result of natural catastrophes: 31 million people, against 23 over recent years (IDMC***): 14.6 million people fled cyclones and hurricanes in South East Asia, the Horn of Africa, the Caribbean and South America (30 named storms), 14 million people fled floods in Sahel, China, the Philippines, Bangladesh and India and intense rainfall in the Middle East, and 1.2 million people fled fires.

Beyond social consequences, climate change has an economic cost: from 0.2% to 2% of world GDP by 2100 for a 2°C rise (IPCC). According to the a study called "Investing for Resilience" published in 2016 by Cambridge University (Climate Wise), within 20 years a $200 bn yearly investment will be necessary to compensate losses from climate change impacts.

In 2019, economic damage from flooding alone was estimated at $82 bn, of which $13 bn only had been insured against ("Policy opportunities on the road to net zero underwriting. Highlighting three key areas of influence for the insurance industry", 2021)

According to the World Bank and the International Bank for Reconstruction and Development, annual average losses will total $314 bn and could rise to $415 bn by 2030 given investment required in infrastructure ("Investing in Urban Resilience", 2015).

* WMO: World Meteorological Organisation.
** FAO: UN's Food and Agriculture Organisation.
***IDMC: Internal Displacement Monitoring Center, 20 may 2021.

The 6th IPCC report on climate change

"AR6 Climate Change" is the IPCC's sixth assessment report on the current state of climate, explaining how it is changing and the role of human influence. It includes knowledge about possible climate futures and limiting human-induced climate change.

The report shows very pessimistic forecasts and overwhelming evidence of human activity influence, just three months ahead of COP26 in Glasgow, the most important climate negotiations since the Paris Agreement where countries are being asked to increase ambitions in their NDCs.

IPCC launches a call to commit to net-zero CO_2 emissions targets and to tackle methane emissions from fossil fuel production, but phasing out unabated coal power remains the top priority.

The current state of the climate: According to the report, the temperature of the planet is expected to increase by 1.5°C by 2030, ten years earlier than the previous forecast by the IPCC, and within a 2°C rise in the mid-2040s. The current trend is a global warming of about 4°C by 2100.

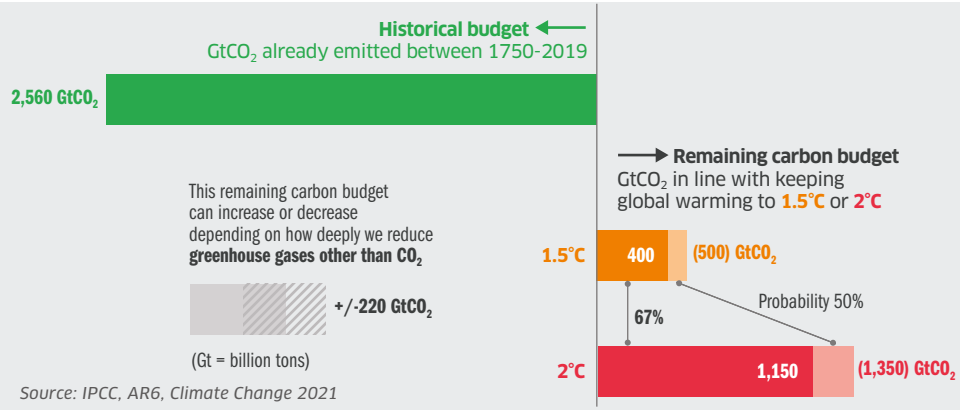
Global warming now has *"irreversible consequences for centuries or millennia"*, especially regarding oceans, ice caps and sea level: the 50°C heatwave suffered by Canada in June 2021 would have been "almost impossible" without climate change according to IPCC scientists. Ocean levels have risen by 20 cm over the past century, the rate of this rise has accelerated over the past decade with the melting of the ice caps. The sea is forecast to gain one meter by 2100, with a possibility up to two metres. The melting ice caps constitute a "breaking point". It will have devastating, radical and even irreversible consequences for the planet and humanity.

The magnitude of recent changes and the current state of many aspects of the climate system are unprecedented for centuries or millennia. The whole planet is heating up, and some regions more than others. IPCC demonstrates that human activity is "unequivocally" responsible for global warming, which causes rapid and large-scale change of various components of the climate system (atmosphere, oceans, cryosphere and biosphere), which modify extreme climatic phenomena.

What "Limiting future climate change" means.

- **Net zero CO_2:** "From a physical science perspective, limiting human-induced global warming requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other GHG."
- **Each 1,000 Gt of cumulative CO_2 emissions** is assessed to likely cause a 0.27°C to 0.63°C increase in global surface temperature with a best estimate of 0.45°C (1,000 GtCO_2 is the volume emits since the 1st IPCC report in 1990, that's almost half of our emissions since the start of the entire industrial age).
- **Carbon budget:** If we want to give ourselves an 83% chance of staying below the 1.5°C mark we must not emit more than 300 Gt of additional CO_2 (or 500 Gt with a 50% probability), knowing that humanity has emitted 2,560 GtCO_2 since 1750 (35 GtCO_2 emitted in 2020). The budget is less than 10 years of emissions. So, there is still some leeway, although the challenge seems colossal.
- **Methane:** *"Strong, rapid and sustained reductions in CH_4 emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality."*

CARBON BUDGET



Source: IPCC, AR6, Climate Change 2021

The 6th IPCC report on climate change

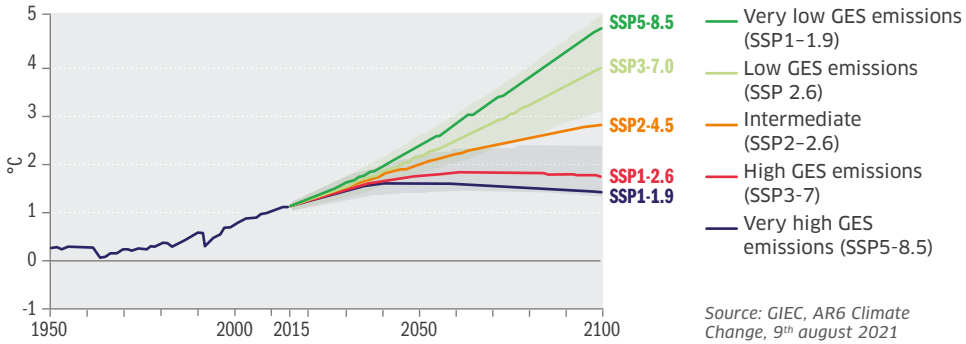
AR6 Climate Change 2021 provides a new set of 5 scenarios, describing 5 possible futures according to the degree of severity to fight global warming.

- **SSP1-1.9:** +1,4°C in 2100 - net zero CO_2 emissions around 2050, net negative CO_2 emissions afterwards.
- **SSP1- 2.6:** +1.8 °C - CO_2 emissions declining to net zero around or after 2050.
- **SSP2-4.5:** +2.7°C - CO_2 emissions stay around current level until 2050.
- **SSP3-7.0x:** +3.6°C - CO_2 emissions multiplied by 2 in 2100.
- **SP5-8.5:** +4.4°C - CO_2 emissions multiplied by 2 in 2050.

But under all emissions scenarios considered, global surface temperature will continue to increase until at least mid-century. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other GHG emissions occur in the coming decades.

The increase in emissions is subject to an acceleration phenomenon because the more CO_2 is in the atmosphere, the less ocean (which currently absorb a large part of the CO_2) and land carbon sinks will be effective at slowing the accumulation of CO_2 in the atmosphere.

GLOBAL TEMPERATURE CHANGE RELATIVE TO 1850-1900



Source: GIEC, AR6 Climate Change, 9th august 2021

IPCC REPORTS

Since its creation in 1988 by the WMO* and UNEP**, IPCC (Intergovernmental Panel on Climate Change) has produced 5 assessment reports (AR) and several special, as well as methodological reports. **IPCC has been running its 6th assessment cycle since 2017.** It is based on three Working Group (WG) studies submitted as follows:

- **9th August 2021:** Scientific elements of the climate change (AR6 Climate Change) published 9th august; WG 1
- **September 2021:** Mitigation of climate change (WG 3)
- **October 2021:** Impacts, adaptation and vulnerability (WG 2)
- **September 2022:** Synthesis Report – to be present for the first global UNFCCC stocktaking – should "synthesize and integrate materials contained within the Assessment Reports and Special Reports" and "should be written in a non-technical style suitable for policymakers and address a broad range of policy-neutral questions approved by the Panel". It is composed of two parts, a Summary for Policymakers (SPM) of 5 to 10 pages and a Longer Report of 30 to 50 pages.

AR6 (Assessment Report 6) Climate Change is the first part of its sixth report, eight years after the previous similar report. It was written by "Working Group 1", 234 scientists from 66 countries and based on more than 14,000 scientific studies. It is highly scientific, difficult to read for non climate experts.

It is composed of 4 chapters:

- Current State of the Climate
- Possible Climate Futures
- Climate Information for Risk Assessment and Regional Adaptation
- Limiting Future Climate change.

This 4,000 pages report focuses on the physical science basis of climate change and incorporates the most recent and comprehensive scientific knowledge of the climate system and climate change to date. It reflects the latest advances in climate science to offer a much clearer picture of past, present and future climate change.

*WMO: World Meteorological Organization – **UNEP: United Nations Environment Programme.

CO_2 emissions

A record decline in CO_2 emissions in 2020 failed to initiate a radical shift towards decarbonization

The pandemic led to a historical reduction in CO_2 emissions in 2020. CO_2 emissions declined 5.8% (2 Gt) in 2020, the most ever recorded. The drop was five times bigger than during the 2009 financial crisis (source: IEA).

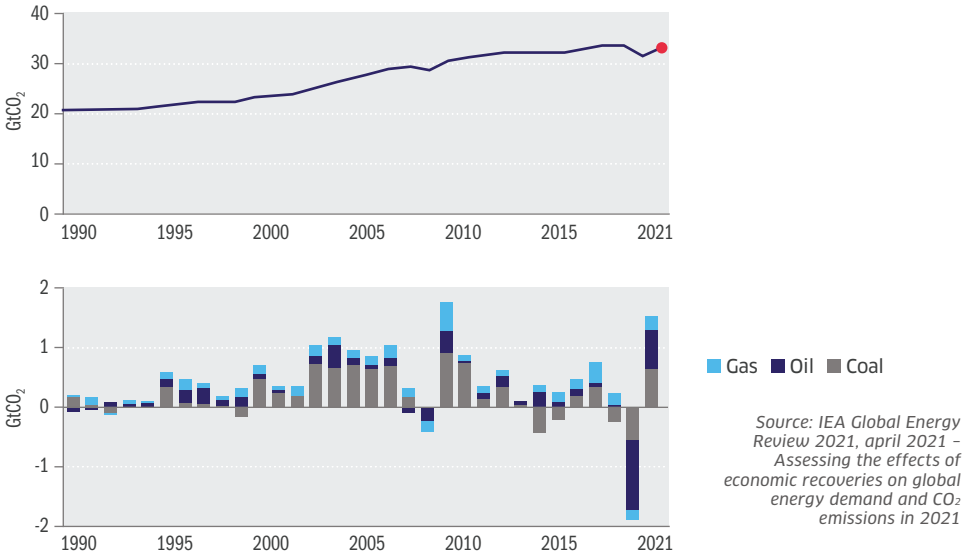
The economic recession cannot explain the move all on its own, as energy demand contracted less (by 4%) than CO_2 emissions. The point is that renewables played a major role in the electricity mix and they proved resilient, whereas lower electricity consumption mainly affected adjustable electricity production, notably the coal-fired thermal sector.

Although CO_2 emissions fell back in 2020 to 2012 levels (31.5 Gt), the annual concentration in the atmosphere remained at the peak of our era (413 ppm).

The rebound in CO_2 emissions in 2021 has been partial so far, reflecting persistent crisis effects. The increase in coal and oil demand resulting from economic recovery is expected to generate a 4.8% increase in CO_2 emissions this year according to the IEA (+1,500 Mt CO_2 from 2020). That level would be 1.2% lower than in 2019.
This partial rebound stems from restrictive measures still in place, notably regarding transport, for which emissions remain a third lower than in 2019. A return to pre-crisis levels is possible in the event of case of a full recovery in transport (+1.5% impact).

The economic stimulus and its impact on coal-fired stations is exacerbating national disparities. A structural decline in emissions is evident in developed countries (-18% since 2000). Today they represent less than a third of world emissions. The EU is leading the way (-30%), followed by the USA (-24%) and Japan (-14%).

GLOBAL CO_2 EMISSIONS (GT), 1990-2021



Source: IEA Global Energy Review 2021, april 2021 – Assessing the effects of economic recoveries on global energy demand and CO_2 emissions in 2021

In contrast, emissions are still rising by nearly 2% per year in developing countries (although that rate is half of what it was 20 years ago). China is the biggest contributor, followed by India, Russia and Indonesia.

The post-crisis recovery is aggravating variations between countries: total emissions are expected to rise 5% compared to 2019 in China (+600 Mt) and 1.4% (+200 Mt) in India, largely because of coal-fired power stations. Emissions in the USA will be 6% lower than in 2019 despite a substantial 200 Mt surge, and in the EU the rise is expected to cover only a third of the 2020 decline (+80 Mt).

CO_2 emissions

COP26 will have to address a trajectory shortfall

The recent improvement in the planet's carbon factor is insufficient to meet the 2°C objective. The carbon factor, also called carbon intensity (CO_2 emissions/energy consumption), declined by a record amount in 2020 (-1.7%), reflecting the impact of the crisis on the electricity mix (see previous page) and transport. Nevertheless, the rise expected in 2021 (+0.3%) will offset some of this progress.

The carbon factor is set to resume its trend dating back to the Paris Agreement, i.e. a 0.8% decline per year. This is far from sufficient to even draw near to the 2°C target. According to Enerdata, this would require a pace closer to -3.2% per year.

Recovery plans are doing nothing to stimulate decarbonization. Presented by the UN as a unique opportunity to invest in decarbonization, most recovery packages missed it. They lack of ecological ambition and grant major support to carbon-intensive sectors such as transport. The American Rescue Plan Act is a good example (see Recovery plans in Chapter 1); the $1,900 billion plan includes just $195 million for the environment. France stands out as one of the only G20 countries to adopt significant measures: its recovery plan assigns a third of the funds (€30 bn) to energy transition, of which €2 bn to green hydrogen.

One hopes that the health crisis has strengthened awareness of environmental issues. This could have a substantial impact: individual behaviour alone (such as not travelling by plane) could contribute to reduce CO_2 emissions by 8% (IEA's NZE scenario).

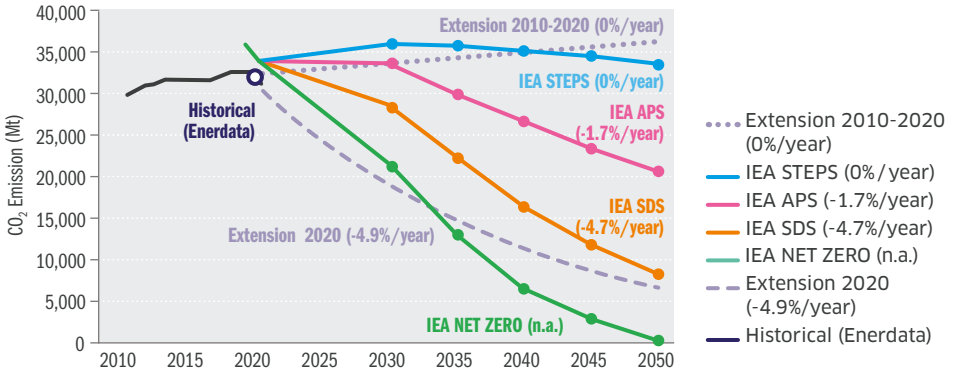
Meeting environmental objectives requires a radical and rapid change in trajectory. Despite the Paris Agreement's ratification by 184 countries on 1st June 2019, NDCs (illustrated in the IEA's STEPS scenario) remain insufficient to limit climate change to 1.8-2°C by 2100 (SDS scenario), and even more so to 1.5°C (NZE scenario).

Even the revised 2030 objectives (-3 to -4 $GtCO_2$) are incompatible with the longer term ambition. COP26 will prove decisive in ensuring abiliy of States to commit on the road to global decarbonisation in 2050.

Although more countries (China, Japan, South Korea, South Africa) have recently committed to climate neutrality by 2050-2060, they have not engaged so far in any short-term policy or action that would have tangible results by 2030. And that is the only way to respect the IPCC red line of +1.5°C.

We recall that a 2°C trajectory required cutting CO_2 emissions by three-quarters by 2050 (down to 10 $GtCO_2$), equivalent to a 4.5% decline per year from now on. A 1.5°C trajectory requires carbon neutrality by 2050, meaning an annual 5% reduction by 2030 and 8% by 2040. That would require a radical transformation of energy generation (decarbonization of production sources, electrification of uses), as well as a switch in the energy consumption trend to a significant decline.

TOTAL CO_2 EMISSIONS, WORLD



Sources: IEA, World Energy Outlook 2021 ; Enerdata 2021

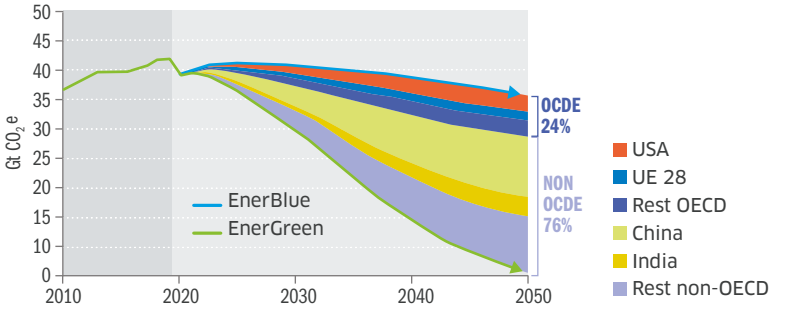
CO_2 emissions

CO_2 Emissions in Mt	1990	2000	2010	2019	2020	Change 1990-2020	AAGR 1990-2019	Change 2019-2020	Share in the world 2020
Europe	4,401	4,245	4,184	3,668	3,282	-25%	-1%	-11%	11%
EU-27	3,542	3,360	3,247	2,778	2,473	-30%	-1%	-11%	8%
EU-28	4,098	3,892	3,732	3,125	2,774	-32%	-1%	-11%	9%
Germany	953	830	781	678	617	-35%	-1%	-9%	2%
France	365	386	356	311	272	-26%	-1%	-13%	1%
North America	5,296	6,347	5,991	5,512	4,915	-7%	0%	-11%	16%
United States	4,866	5,817	5,445	4,933	4,405	-9%	0%	-11%	14%
Canada	430	530	546	580	510	19%	1%	-12%	2%
Latin America	852	1,202	1,523	1,567	1,394	64%	2%	-11%	5%
Mexico	265	369	446	436	364	37%	2%	-17%	1%
Asia	4,798	6,824	12,761	15,865	15,691	227%	4%	-1%	51%
China	2,255	3,140	7,798	9,562	9,717	331%	5%	2%	31%
India	523	912	1,570	2,319	2,191	319%	5%	-6%	7%
Korea	243	447	594	608	570	134%	3%	-6%	2%
Japan	1,055	1,138	1,115	1,044	979	-7%	0%	-6%	3%
Indonesia	145	272	410	596	558	285%	5%	-6%	2%
Pacific	286	371	428	433	414	45%	2%	-4%	1%
CIS	3,556	2,212	2,391	2,419	2,303	-35%	-1%	-5%	7%
Russia	2,189	1,522	1,610	1,719	1,619	-26%	-1%	-6%	5%
Middle East	589	963	1,609	1,935	1,866	217%	4%	-4%	6%
Saudi Arabia	156	244	435	508	492	216%	4%	-3%	2%
Iran	181	320	515	620	619	242%	4%	0%	2%
Africa	538	680	1,043	1,266	1,179	119%	3%	-7%	4%
South Africa	252	296	430	422	396	57%	2%	-6%	1%
World	20,316	22,844	29,930	32,664	31,044	53%	2%	-5,0%	100%
OECD	11,195	12,772	12,630	11,590	10,430	-7%	0%	-10%	34%
no-OECD	9,121	10,072	17,299	21,075	20,614	126%	3%	-2%	66%
BRICS	5,413	6,169	11,785	14,435	14,309	164%	4%	-1%	46%

NB: The CO_2 emissions presented here are those related to energy combustion, or 90% of CO_2 emissions (see following pages "Sources of CO_2 emissions and different GHGs ")

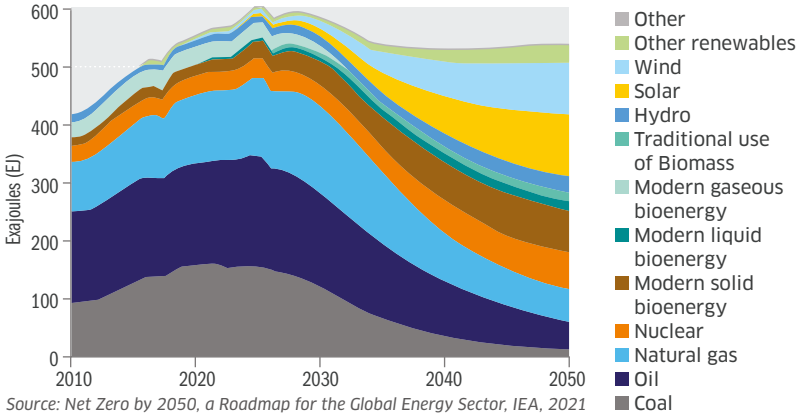
Source: Enerdata Global Energy & CO_2 Data, august 2021

REDUCTION OF CO_2 EMISSIONS BY REGION TO ACHIEVE CARBON NEUTRALITY IN 2050



Source: Global Energy Scenarios through 2050, Enerdata, april 2021

TOTAL ENERGY SUPPLY TO ACHIEVE NET ZERO EMISSIONS BY 2050



Source: Net Zero by 2050, a Roadmap for the Global Energy Sector, IEA, 2021

CO_2 emissions by sector

CO_2 emissions by sector in Mt	Energy				Services, Residential & Agriculture				Industry				Transport				Total			
	1990	2020	GR 1990-2020	GR 2019-2020	1990	2020	GR 1990-2020	GR 2019-2020	1990	2020	GR 1990-2020	GR 2019-2020	1990	2020	GR 1990-2020	GR 2019-2020	1990	2020	GR 1990-2020	GR 2019-2020
Europe	1,670	1,018	-39%	-15%	870	642	-26%	-4%	1,039	687	-34%	-6%	821	935	14%	-13%	4,401	3,282	-25%	-11%
EU-27	1,327	764	-43%	-15%	694	466	-33%	-5%	875	520	-41%	-8%	645	724	12%	-12%	3,542	2,473	-30%	-11%
EU-28	1,567	835	-47%	-15%	805	555	-31%	-4%	966	566	-41%	-8%	760	817	8%	-14%	4,098	2,774	-32%	-11%
Germany	349	192	-45%	-16%	213	128	-40%	-2%	232	135	-42%	-9%	159	162	2%	-6%	953	617	-35%	-9%
France	60	45	-26%	-13%	97	66	-32%	-9%	95	54	-43%	-11%	113	107	-6%	-15%	365	272	-26%	-13%
North America	2,299	1,967	-15%	-11%	664	616	-7%	-10%	807	685	-15%	-5%	1,525	1,647	8%	-14%	5,296	4,915	-7%	-11%
United States	145	180	24%	-13%	80	85	6%	-8%	86	88	3%	-4%	118	157	33%	-17%	430	510	19%	-12%
Canada	2,154	1,787	-17%	-11%	584	530	-9%	-10%	721	597	-17%	-5%	1,407	1,490	6%	-13%	4,866	4,405	-10%	-11%
Latin America	235	403	71%	-13%	105	151	44%	-2%	222	337	52%	-7%	289	504	74%	-15%	852	1,394	64%	-11%
Mexico	96	128	33%	-19%	26	29	12%	-2%	59	95	62%	-8%	84	111	33%	-24%	265	364	37%	-17%
Asia	1,625	8,118	400%	0%	904	1,268	40%	-1%	1,702	4,342	155%	-1%	567	1,962	246%	-8%	4,798	15,691	227%	-1%
China	724	5,389	645%	2%	524	760	45%	2%	912	2,666	192%	4%	95	902	847%	-6%	2,255	9,717	331%	2%
India	207	986	376%	-6%	85	198	134%	-2%	167	735	340%	-3%	64	272	323%	-14%	523	2,191	319%	-6%
Korea	48	231	384%	-3%	23	28	18%	-9%	42	151	264%	-10%	32	148	360%	-7%	145	558	285%	-6%
Japan	387	457	18%	-2%	138	113	-18%	-6%	317	225	-29%	-12%	213	184	-14%	-9%	1,055	979	-7%	-6%
Indonesia	50	266	434%	-8%	73	54	-27%	0%	77	150	96%	-6%	44	100	128%	-5%	243	570	134%	-6%
Pacific	144	208	45%	-4%	15	26	74%	1%	54	69	26%	-5%	72	111	53%	-6%	286	414	45%	-4%
CIS	1,986	1,160	-42%	-7%	623	381	-39%	-1%	601	499	-17%	-2%	347	263	-24%	-7%	3,556	2,303	-35%	-5%
Russia	1,276	822	-36%	-8%	382	234	-39%	-1%	310	390	26%	-3%	221	173	-22%	-8%	2,189	1,619	-26%	-6%
Middle East	193	709	267%	-3%	77	187	144%	1%	167	591	254%	1%	152	379	149%	-13%	589	1,866	217%	-4%
Saudi Arabia	40	208	424%	4%	53	144	172%	2%	49	141	187%	-1%	40	127	220%	-8%	181	619	242%	0%
Iran	53	136	156%	-3%	3	5	92%	-5%	51	232	360%	3%	49	118	139%	-14%	156	492	216%	-3%
Africa	242	562	132%	-4%	50	110	120%	-4%	132	182	37%	-11%	114	325	187%	-10%	538	1,179	119%	-7%
South Africa	143	277	93%	-5%	14	26	80%	-4%	65	46	-29%	-2.4%	30	47	61%	-17%	252	396	57%	-6%
World	8,394	14,145	69%	-4%	3,309	3,382	2%	-3%	4,725	7,390	56%	-2.2%	3,888	6,126	58%	-11%	20,316	31,044	53%	-5%
OECD	2,379	7,537	217%	-1%	1,033	1,258	22%	0%	1,509	3,938	161%	1.7%	493	1,576	220%	-8%	5,413	14,309	164%	-1%
no-OECD	4,465	4,008	-10%	-11%	1,738	1,465	-16%	-6%	2,258	1,890	-16%	-6.4%	2,734	3,066	12%	-13%	11,195	10,430	-7%	-10%
BRICS	3,929	10,137	158%	-1%	1,571	1,917	22%	0%	2,467	5,500	123%	-0.7%	1,153	3,059	165%	-9%	9,121	20,614	126%	-2%

Source: Enerdata Global Energy & CO2 Data, 2021

Sources of CO_2 emissions and different GHGs

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.

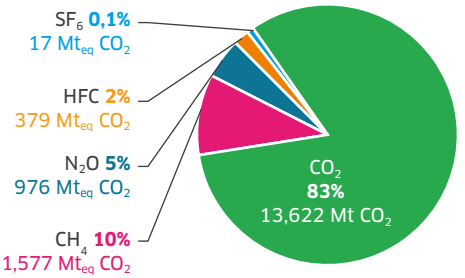
N_2O (nitrous oxide) ranks third in GHG emissions. It comes from the decay of nitrogen compounds, such as fertilizers, as well as the combustion of aviation fuels and savannah fires, amongst others. With a GWP of 265 and a lifespan of 120 years, nitrous oxide is a particularly harmful to the ozone layer.

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.

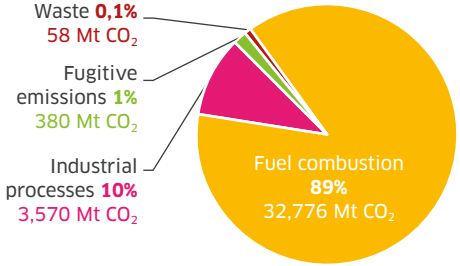
PFC (perfluorocarbons) are present in some cookware such as non stick pans. Their GWP is 7,600 times is that of CO_2. Being very volatile, they contaminate removed natural areas such as the North pole or some Himalayan lakes. Within the human body, they are powerful endocrine disrupters, affecting fertility 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 1* COUNTRIES (EXCLUDING LULUCF) TOTAL: 16,571 MT_{EQ} CO_2 IN 2018



GLOBAL CO_2 EMISSIONS (EXCLUDING LULUCF) TOTAL: 36,785 MT CO_2 IN 2018



*Annex 1: see Glossary.

Source: Enerdata Global Energy & CO_2 Data (2020), UNFCCC Greenhouse Gas Inventory Data – 2018 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	254	219
Unleaded gasoline	254	311
LPG	233	272
Natural gas	205	244
Fuelwood	18.8	29.5

Source: ADEME, Carbon base, update 2021

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

* Gas-fired: CCGT – ** HWIP: Household Waste Generation Plant.
Values calculated in 2015, updated in 2021.

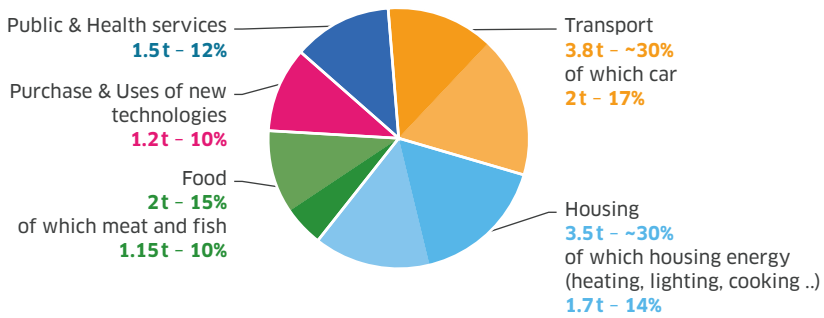
Source: ADEME, Carbon Data Base

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

Carbon pricing: carbon markets and taxes

Despite the pandemic, carbon pricing still stands out as a prime instrument in reducing CO_2 emissions. But its impact remains limited

The volume of CO_2 emissions covered by an explicit carbon pricing system expanded significantly in 2020. As of 1 April 2021, 64 carbon tax or market initiatives were operating across the world, at a national or sub-national level. Carbon pricing instruments now cover 21.5% of world GHG emissions (11.65 GtCO_2e), against 12% at the time of the Paris Agreement or 15% early 2020 (World Bank).

This acceleration stems from the development of carbon markets. They now cover 17% of GHG emissions, against 10% in 2020, following the introduction of major ETS (China for the major part, slight extension of the ETS created on the 01/01/2021 in the UK and creation of a German ETS for emissions not covered by the EU ETS). The 35 active carbon taxes represent 5% of world emissions, a stable rate despite the addition of four jurisdictions this year. (World Bank, "State and Trends of Carbon Pricing 2021")

Presented as the cornerstone of the country's low-carbon strategy, the national ETS launched by China on 1 February 2021 is the world's largest carbon market (7.4%). It will initially focus on CO2 emissions from the power sector (4 GtCO_2), and later expand to other sectors (aluminium, steel, etc.). It should at first cover 30 to 40% of China's total emissions.

Carbon pricing instruments generated $53 bn worth of revenues in 2020 (+ $5 bn from 2019), mainly due to higher EU-ETS prices (see EU-ETS prices), collecting $22.5 bn. The French and the Canadian carbon tax (respectively $9.6 bn and $3.4 bn) also generated substantial revenues. In 2019, nearly half of the revenues drawn from carbon pricing were used to finance low-carbon transition projects.

Carbon markets proved their strength during the pandemic. After an initial adjustment to lower prices and volumes in traded quotas, carbon markets rapidly stabilised before resuming pre-crisis levels (both in prices and volumes). This demonstrated their resilience to external shocks. In recent years carbon markets have developed numerous and particularly innovating mechanisms to stabilise and regulate themselves, improving their robustness, transparency and predictability.

Carbon prices remain overall too low and too limited to allow a drastic reduction in GHG emissions, however. First of all, the share of covered emissions has increased over recent years but remains limited (4/5 are still not priced). For a target of 50% of covered emissions by 2030, new pricing initiatives must be launched and existing schemes must expand to additional sectors.

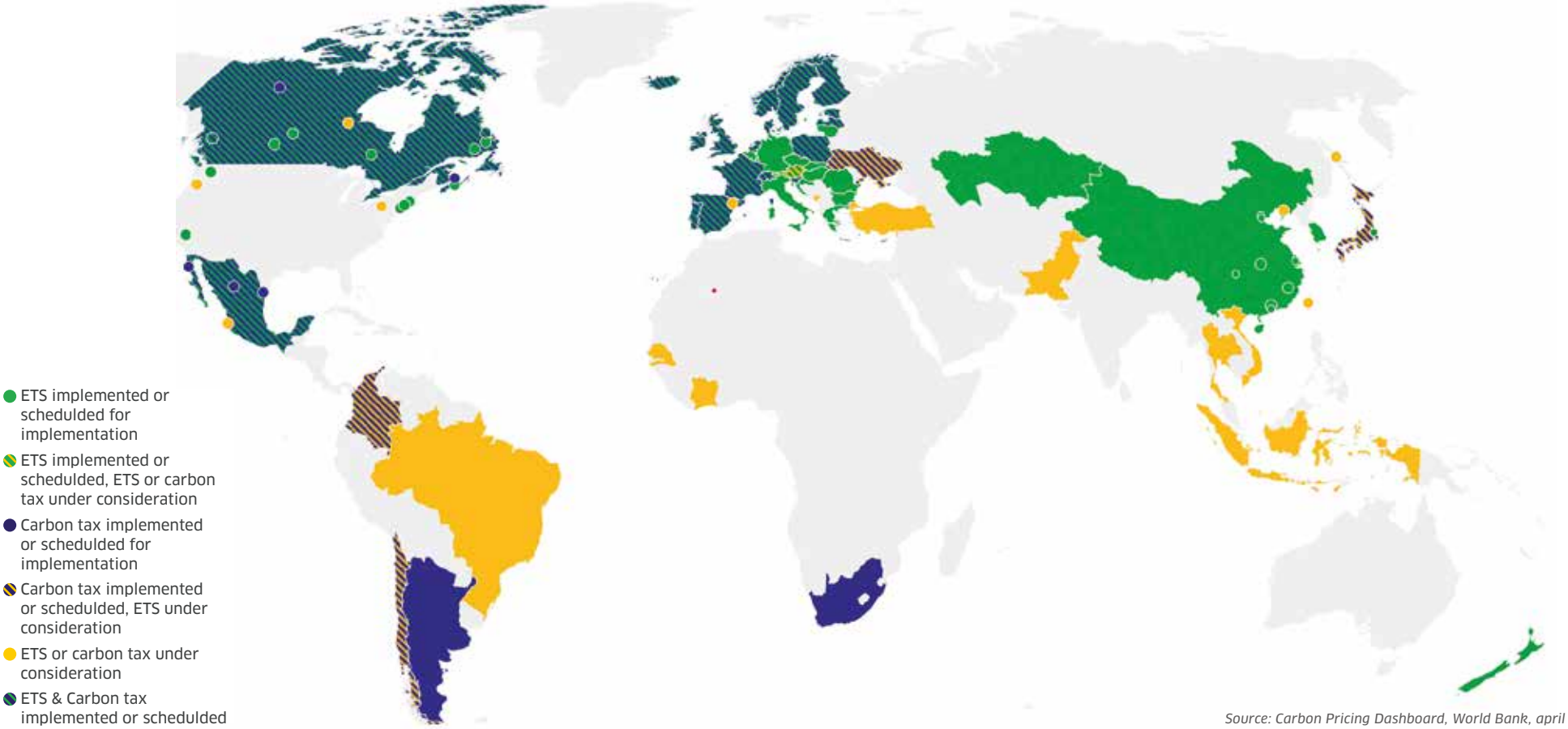
Secondly, carbon prices remain too low overall ($3/t$CO_2$ on average) to support energy transition efficiently: according to the international scientific consensus, optimal carbon prices range from $40 to $80/t$CO_2$e today and will be from $50 to 100$ by 2030 (Stern-Stiglitz). Despite episodes of particularly high levels ($137/t$CO_2$ in Sweden) and a major increase recorded on the EU-ETS (exceeding €60 in September), only 4% of emissions are covered by a carbon price over $40/t$CO_2$.

Carbon prices must be appropriate too. This is why there is no pricing on the worldwide scale. Some sectors and countries show much greater sensitivity to high carbon prices. For instance, a tonne of CO_2 at $100 would have a $0.25 impact on a litre of gasoline but $200 on a tonne of steel (40% of the sale price). And at $50/t$CO_2$ the price of cement would double in India, for example. In short, the issue of extending ETSs remains extremely complex.

To rectify the pricing instruments' lack of efficiency, the IMF suggests the creation of an international mechanism that would set a carbon price floor. To be socially acceptable, it would have to be equitable and flexible, would have to take into account each country's specific responsibility and would need to result from a collective initiative by the major emitting countries.

Carbon pricing: carbon markets and taxes

CARBON PRICING INITIATIVES AROUND THE WORLD AS OF APRIL 1, 2021



Source: Carbon Pricing Dashboard, World Bank, april 2021

European carbon market prices

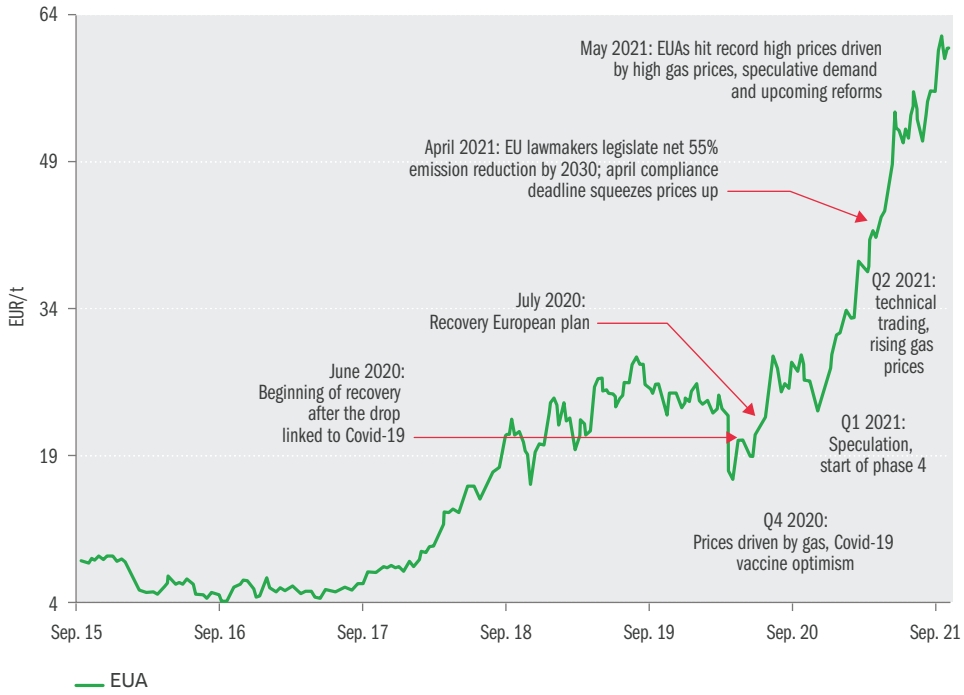
Ending a long period of low and stable levels, the upsurge observed on the European market raises questions about CO_2 prices in the future

CO_2 per tonne exceeded $60 on the European carbon market in September, an unprecedented level and a spectacular increase since the beginning of the year (+€30/t). Carbon emission allowances rose in a few months from $€_{2020}$33/t on average in January, to $€_{2020}$38/t mid-February, over $€_{2020}$50/t in May and up to €64 end-September.

This surge resulted from a combination of factors:

- The EU reinforced its climate ambitions by setting in December 2020 an emission reduction target of 55% by 2030 from 1990 level. This triggered speculation amongst mutual funds and insurance companies. Attracted by the potential for higher prices, numerous financial players joined the market.
- The financial markets' rally over the first quarter of 2021 was a sign of renewed optimism in the wake of vaccination campaigns and economic recovery plan announcements across the world. It also supported carbon allowance prices, with which they are correlated.
- Abnormally low temperatures in February, April and May played a role by boosting thermal power production from gas and coal. This triggered a boom in gas prices, which in turn reduced gas-fired plants' competitiveness relative to coal-fired, worse emitters. By boosting demand for allowances, these factors bolstered prices.

EVOLUTION OF EUROPEAN CO_2 ALLOWANCE MARKET



Source: ICE – ECX front-month futures

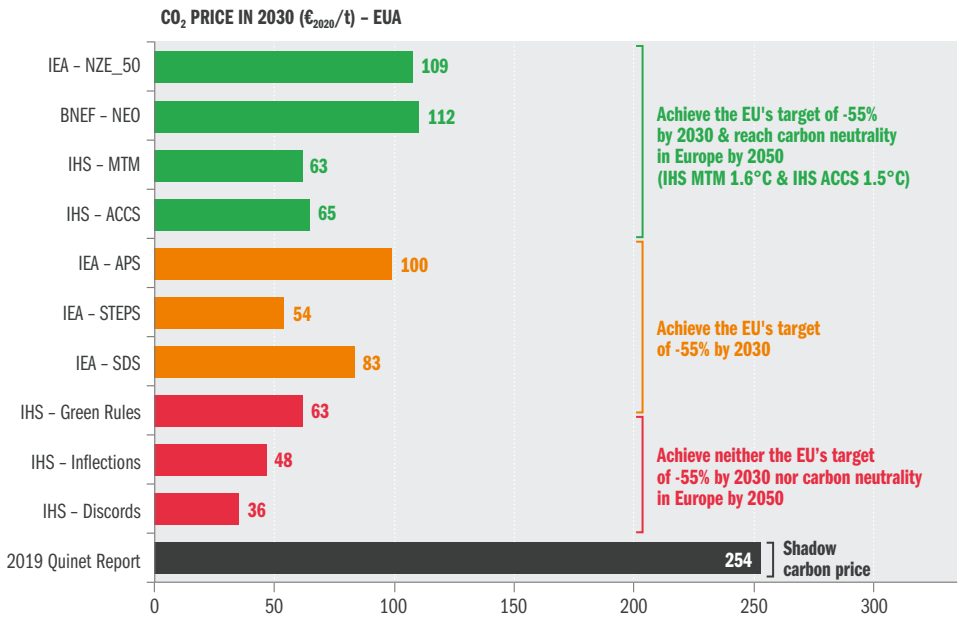
European carbon market prices

Long term carbon price forecasts remain bullish, suggesting a structural change in the market.

A certain consensus is emerging around €60/t CO_2 by 2030 on the EU ETS, a perpetuation of current levels in other words. Beyond this timeframe, the forecast of €100/t by 2050 is generally accepted, but price ranges can be very wide to all horizons.

As an example, Bloomberg foresees a rapid rise up to $€_{2020}$74/t by 2025 and $€_{2020}$94/t by 2030, as allowances are being withdrawn from the stability reserve and substitution possibilities between fuels become saturated. IHS Markit presents two scenarios: the first one gives the EU ETS* as the only emission reduction tool and forecasts $€_{2020}$46/t by 2030 and $€_{2020}$102/t by 2050; the latter relies more heavily on national measures and predicts $€_{2020}$45/t by 2030 and $€_{2020}$56/t by 2050. The IEA's SDS scenario is based on €100/t in 2030, but the Quinet report sets the shadow price of carbon much higher for this timeframe, at €250/t.

COMPARING 2030 CARBON PRICE FORECASTS ACROSS SEVERAL SCENARIOS (OCTOBER 2021)



Source: ENGIE, october 2021

*EU ETS: the EU Emissions Trading System covers emissions from about 11,000 installations in the power plants and industrial facilities, as well as airlines connecting participating countries. This represents about 40% of EU GHG.

European carbon market prices

Rising carbon prices will test the European economy's resilience in meeting climate objectives

Recent years have highlighted the EU ETS's resilience and the operational quality of its mechanisms. Despite the deep economic crisis caused by the Covid-19 pandemic, the market bounced back rapidly, Stable indicators such as increasing traded volumes since 2017 suggest decent liquidity and sustained auction participation. However, the arrival of financial investors increased volatility compared to 2020.

Several reforms were necessary to establish efficiency. Designed by the EU in 1997 to implement its Kyoto Protocol commitments, the EU ETS was launched in 2005. Two major flaws appeared in the first two years. First, the system proved vulnerable to external shocks, such as the 2008 economic crisis. Second, member states and the European Commission showed an insufficient ability to readjust allowance supply on the short run. This maintained carbon prices at very low levels for a long time (<€10/t CO_2 from 2010 to 2018).

In 2018, the European Commission set a target of 40% emission reduction by 2030 from 1990 levels and reformed the ETS. The annual decrease of allowances (intended to reduce surpluses) accelerated and carbon prices strengthened. The Stability Reserve launched in 2019 was another lever. Allowances are now transferred to this reserve in case of market surplus or reintroduced onto the market in case of shortfall.

In the most recent step to date, in December 2020, the EU agreed a more ambitious target of 55% emission reduction by 2030 from 1990 levels effective April 2021, and announced in July 2021 legislative proposals for an EU ETS revision (see Green Deal below).

A positive signal with regards to the acceleration of energy transition, this carbon price surge is not without consequences for the economy.
European industrial competitiveness may deteriorate as a result of reduced investment capacity in the industrial sector and carbon leakage may worsen (carbon intensive manufacturers relocating outside the EU). In response to this competitive threat, the EU suggested the implementation of a Carbon Boarder Adjustment Mechanism, which would apply identical carbon pricing to imported goods.

For consumers, this would impact energy bills. Without compensatory measures, higher carbon prices deepen inequalities. The consequences are not the same for high- and low-income households. The redistribution of carbon tax receipts towards lower-revenue households would limit this phenomenon. To this end, the European Commission announced in July 2021 the creation of a Social Climate Fund, aiming at reducing the economic impact of extending the EU ETS to road transport and building sectors on lower-income households and most vulnerable small companies.

Higher carbon prices have other effects that are still difficult to quantify. Since the introduction of the EU ETS in 2005, covered emissions dropped 35% in 2019 and 42% in 2020 (European Environment Agency), which is more than Phase 3's target of 21% by 2020 from 2005 levels. But it is difficult to distinguish what is attributable to the EU ETS rather than to economic activity and other policies aiming at reducing carbon emissions in Europe. According to the Institute for Climate Economics (I4CE) and the European Roundtable on Climate Change and Sustainable Transition (ERCST), carbon emission reduction stems first and foremost from renewable energies and environmental policies. The European carbon market would have particularly favoured gas-fired over coal-fired power production and would not have been particularly supportive of investments towards new low-carbon technologies.

The Green Deal

With this environmental pact, the EU is profoundly reinventing its growth model

The Green Deal is a holistic strategy aimed at a radical transformation of the European economy. The European Climate Law adopted in April 2021 sets ambitious objectives for the Green Deal: “at least 55%” GHG emission reduction by 2030 against 40% previously, and net zero emissions by 2050.

With this green pact, altogether €550 bn is to be invested in energy transition by 2027, notably in the widespread development of buildings’ energy efficiency (€175 bn), support to the hydrogen sector and acceleration of RES power projects. The Farm to Fork Strategy and the expansion of circular economy show a will to build an economy that is sustainable and efficient in its use of resources through a radical change in consumption and production modes.

By 2030, energy consumption is to drop by at least 36% (of which -25% for gas, -30% for oil and -70% for coal), while the share of RES in the energy mix is to reach 40%. Energy efficiency objectives, revised up to 36% for final energy consumption and up to 39% for primary energy, will be binding. Emission reduction will target power production and buildings (-60% GHG emission reduction), the industry (-25%) and transport (-20%).

The fair transition mechanism worth €75 bn will allow to make these changes economically and socially acceptable by helping the regions and sectors worst affected by the green transition.

The Green Deal will be financed with public as well as private resources: the EU is to raise €1,000 bn over 10 years (of which €503 bn from the budget, €279 bn from InvestEU, €114 bn from national funds for structural co-financing).

This heightened ambition raises many issues and operational difficulties. The Green Deal will lead the EU to review most of its public policies in order to align them with the sustainable growth strategy. For instance, an INRAE/AgroParisTech study presented to the European Parliament shows that negotiations towards the future CAP (2021-2027) so far diverge from the Green Deal’s ambitions and objectives.

EU industrial and foreign policies will also be affected by new strategic dependencies that are inherent to a green economy (notably rare earth metals from China).

Beyond these necessary adaptations, the Green Deal has little to say about sectors such as hot/cold networks, biomethane or funds allocated to transnational energy transport infrastructure.

Above all, the Green Deal poses a real competitiveness problem for European companies as a result of higher carbon prices (see CO_2 prices) and more drastic environmental standards. For the Green Deal to be efficient, the EU must impose compliance with strict environmental regulations as a condition of access the common market. That would encourage its trading partners to go green as well.

The Green Deal

In 2021, Green Deal political commitments become legislative proposals. The Climate Law voted in April will be followed over the next 18 months by the revision of about fifty European laws to make them consistent with the new objectives.

The first legislative package, "Fit for 55", presented on 14th July, comprises emblematic measures, such as the creation of the Carbon Border Adjustment Mechanism (CBAM) meant to fight environmental dumping by taxing imported goods in relation with their GHG emission level. Targeted sectors are electricity, steel, metal, cement and fertilisers. The other major change is the addition of buildings (heating) and transport into the EU ETS. From 2026, road transport will be part of the carbon market, as will maritime transport. So far largely exempted thanks to free emission allowances, aviation will progressively be submitted to carbon pricing. To prevent the carbon market extension to buildings and road transport worsening inequalities, the European Commission has launched a Social Climate Fund. It will be financed by the forecasted new carbon market receipts and will bring to the most vulnerable citizens financial support towards the thermal renovation of their homes and the use of cleaner transport modes.

The Commission has put forward another interesting component in favour of alternative fuels in aviation (the ReFuel Aviation initiative) and maritime transport (FuelEU Maritime), including carbon-free hydrogen. Another proposal bans from 2035 the sale of new cars and vans emitting carbon, in other words having a thermal engine (gasoline or diesel). As a consequence, the Commission shall also require member states to expand charging points for electric cars and refuelling stations for hydrogen cars. Lastly, it proposes to revise the Energy Taxation Directive so that energy products are taxed in accordance with EU climate and energy ambitions.

A second wave of legislation is due in December 2021. It will concern the gas sector's decarbonization, methane emissions and above all energy performance in buildings (EPBD directive).

This reforms will be supported by a "green taxonomy" that will steer private investors' decisions through an official classification system of activities that contribute to curtail or adapt to climate change. This proposal is still very much under discussion. The various EU positions on natural gas and nuclear power will be made clearer by year-end.

Despite some inconsistencies with current EU policies, uncertainty and shortcomings, they are being addressed as negotiations take place and the Green Deal seems to be a fundamental turning point in EU policy. Such efforts will not have their expected impact without international cooperation in energy transition, however, as the EU is by no means the biggest player in global emissions (10%). The Green Deal's objective is therefore to set an example for partner countries in supporting new environmental standards and stepping up their own decarbonization.

Decarbonization

PERSPECTIVE

Carbon neutrality by 2050 gains a foothold in prospective exercises and with decision-making bodies; many Governments have already approved it and COP26 has made it its target

SCENARIOS

However, the commitments given by states in Glasgow, while never before so ambitious, will not be enough to stabilise temperatures as demonstrated by the IEA's Announced Pledges scenario

Renewables energies, a key element of decarbonization, are covered in the chapters “Electricity & Renewables” and “Natural gas & Renewable gases”.

Decarbonization: message from Tim Gould, IEA, october 2021

A new global energy economy is emerging. The new energy economy will be more electrified, efficient, interconnected and clean. Its emergence is the product of a virtuous circle of policy action and technology innovation, and its momentum is now sustained by lower costs. Even while economies bent under the weight of Covid-19 lockdowns, renewable sources of energy such as wind and solar PV continued to grow rapidly, and electric vehicles set new sales records.

The opportunities are huge for those that make the leap to the new energy economy. In a scenario that reaches net zero emissions in 2050, we estimate that the annual market opportunity for manufacturers of wind turbines, solar panels, lithium-ion batteries, electrolysers and fuel cells reaches well above USD 1 trillion by mid-century.

This is comparable in size to the current global oil market. This creates enormous prospects for companies that are well positioned along an expanding set of global supply chains. Even in a much more electrified energy system, there are major openings for fuel suppliers: companies producing and delivering low-carbon gases in 2050 are handling the equivalent of almost half of today's global natural gas market.

However the transformation still has a long way to go. For the moment, every data point showing the speed of change in energy can be countered by another showing the stubbornness of the status quo. The rapid but uneven economic recovery from last year's Covid-induced recession is putting major strains on parts of today's energy system, sparking sharp price rises in natural gas, coal and electricity markets. For all the advances being made by renewables and electric mobility, 2021 is seeing a large rebound in coal and oil use.

Largely for this reason, it is also seeing the second-largest annual increase in CO_2 emissions in history. Public spending on sustainable energy in economic recovery packages has only mobilised around one-third of the investment required to jolt the energy system onto a new set of rails, with the largest shortfall in developing economies that continue to face a pressing public health crisis. Progress towards universal energy access has stalled, especially in sub-Saharan Africa.

Commitments made at COP26, if implemented on time and in full, will have strong implications for emissions. If all announced pledges are realised, this would lead to a temperature rise of around 1.8°C in 2100 (with a 50% probability). This is the first time that governments have come forward with targets of sufficient ambition to hold global warming to below 2°C.

This is undoubtedly significant, but our assessment needs to be accompanied by two important elements of context. First, it cannot be taken for granted that governments will implement their pledges on time and in full. In many cases, pledges have not yet been backed up by the strong and credible near-term policies needed to make them a reality.

A scenario based only on today's policy settings (a sector-by-sector analysis of policies in place and those under development, as in our Stated Polices Scenario in the WEO-2021) leads to a plateau in global energy-related emissions, rather than a rapid reduction. Second, the pledges themselves – even if implemented in full – do not yet put the world on track for a 1.5°C stabilisation in global average temperatures.

Decarbonization: message from Tim Gould, IEA, october 2021

Announced pledges would also have strong implications for energy markets. In a scenario where all pledges are implemented, over the period to 2030, low emissions sources of power generation account for the vast majority of capacity additions in this scenario, with annual additions of solar PV and wind approaching 500 gigawatts (GW) by 2030. As a result, coal consumption in the power sector in 2030 is 20% below recent highs. Rapid growth in electric vehicle sales and continued improvements in fuel efficiency lead to a peak in oil demand around 2025. Global gas demand also levels off and start to fall back before 2030, although the trends vary widely by region. Efficiency gains mean that global energy demand plateaus post-2030.

Getting the world on track for 1.5°C requires a surge in annual investment in clean energy projects and infrastructure. Over the coming decade, this will need to more than triple from today's levels of around USD 1 trillion. An international catalyst is essential to accelerate flows of capital in support of energy transitions and allow developing economies, in particular, to chart a new lower emissions path for development. Most transition-related energy investment will need to be carried out by private developers, consumers and financiers responding to market signals and policies set by governments. Alongside the necessary policy and regulatory reforms, public financial institutions – led by international development banks and larger climate finance commitments from advanced economies – play crucial roles to bring forward investment in areas where private players do not yet see the right balance of risk and reward.

Tim Gould is the IEA Chief Economist
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 2021

Although the Covid-19 crisis is far from over, it is not to soon to say that the unprecedented drop in CO_2 emissions observed in 2020 can be almost entirely explained by conjunctural factors rather than fundamental – decarbonisation related – changes.

With energy consumption and CO_2 emissions back to pre-crisis levels, there is an urgent need for breakthroughs at different levels rather than "transitions".

Limiting the long-term increase in temperature to less than 2°C would require an annual 5% drop in CO_2 emissions*. Over the past decade, global CO_2 emissions have been increasing by 1% per year on average and the Covid-19 crisis has not changed the trend: 2021 CO_2 emissions estimates** are projected to be only 1% below 2019 pre-crisis level.

By the end of the year most energy efficiency and decarbonisation indicators will have returned to pre-Covid levels, far from being sufficient to meet the Paris Agreement targets.

There is one notable positive trend though, namely the significant growth of new renewables capacities (wind, solar PV), which is not due to halt any time soon.

The main lesson learned from the Covid-19 crisis might be that the huge 2020 impact on economic activity had the same order of magnitude on CO_2 emissions than the annual reduction required by a <2°C objective. This clearly shows that drastic changes in energy systems are required to be in line with decarbonisation objectives.

Required breakthroughs have been identified and a rich, comprehensive literature covers the main pillars of energy system decarbonisation: end-use efficiency, electrification, behaviours ("energy sufficiency"), energy supply decarbonization... In theory, we have the recipe, but the current momentum is not strong enough.

On the negative side, 2030 and NDCs* targets remain insufficient** and new decisions addressing the short term do not seem to be headed in the right direction. Covid-19 recovery plans are a good illustration of how inadequate current policies are: it is a unique opportunity to trigger fundamental changes toward decarbonisation, and so far, in most countries, it embodies the lack of political willingness to change from Business as Usual. As spotted by recent studies, only a small fraction of stimulus packages is dedicated to decarbonisation investments...

On the positive side, one could say that many national and local policies or corporate strategies have defined ambitious long-term objectives. Those long-term objectives are getting closer which should trigger, at some point, some concrete measures. And finance could provide a key support with ongoing developments around decarbonisation alignment, transition risks and taxonomy for sustainable activities.

*Energy related CO_2 emissions.
**https://www.enerdata.net/publications/reports-presentations/world-energy-trends.html
***National Determined Contributions.

Morgan Crénès **Head of Data & Research – Enerdata**
Enerdata is an independent research and consulting firm specialising in the analysis and modelling of the global energy markets and its drivers. Created in 1991, Enerdata now has over 25 years of experience on past and present issues shaping the energy industry.

Decarbonize: how?

Why decarbonize ?

The 6th IPCC report published in August 2021 states that global warming now has irreversible consequences for the coming centuries, especially regarding oceans, ice caps and sea level. The 1.5°C rise in temperature – the red line beyond which ecosystems and organisms will be unable to adapt – will be crossed by 2030; this is 10 years earlier than predicted in the previous edition and highlights the acceleration of this phenomenon. For this rise to stabilise, world CO_2 emissions would have to decline 40% by 2030 and carbon neutrality must be reached by 2050. This is the target shared by the UN, most countries (led by the EU), and a growing number of economic agents.

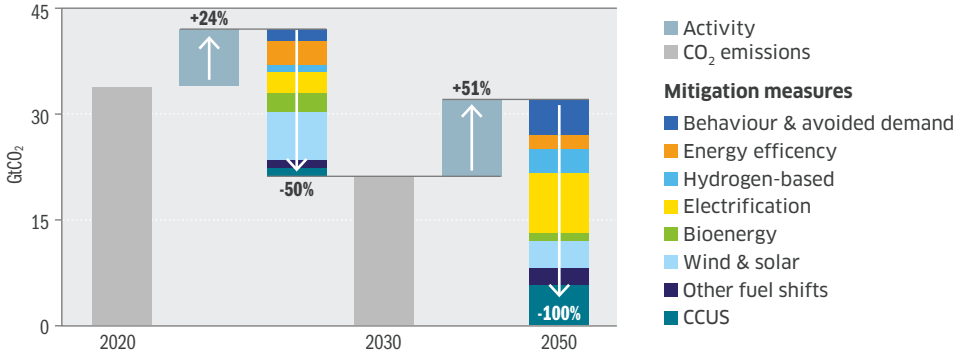
Consisting of producers, suppliers and consumers, the energy sector has serious responsibilities in the matter: 75% of GHG emissions result from energy combustion. That said, the absolute necessity to decarbonate energy is not the end of it. Humanity as a whole has to become more respectful of the environment 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 and electricity RES"* and *"Natural gas and renewable gases"* chapters.
- **Energy 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 has changed 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 decarbonating the final core of CO_2 emissions, i.e. the most expensive or most difficult emissions to eliminate.

TECHNOLOGIES AND POLICY STEPS TOWARDS CARBON NEUTRALITY BY 2050 IEA NET ZERO EMISSIONS SCENARIO (NZE 2021)



Source: IEA, Net Zero Emissions 2021

International Energy Agency scenarios (october 2021)

The scenarios* presented by the IEA ahead of the COP26 have several intentions: on the one hand, to measure the impact on climate of the policies in progress (STEPS scenario) and of the pledges given (APS scenario), and on the other hand, to assess the gap that separates them from a carbon neutral trajectory (NZE scenario); the only one capable of keeping the rise in temperatures below +1.5°C.

The underlying objective of the Glasgow conference is carbon neutrality by 2050, a target claimed by the IPCC in its 6th report of August 2021 and which many governments have made their own. However, the commitments given by states, while never before so ambitious, will not be enough to stabilise temperatures, as the comparison with the radical "Net Zero Emission" scenario shows.

Why COP26 pledges are insufficient?

- **Clean energy investments:** their doubling in over the next decade is not sufficient to overcome the energy system inertia.
- **Sharp divergences between the countries' pledges** concerning the rapidity of implementing their energy transitions.
- **The major difficulty is the crucial period to 2030,** the actions in APS fall well short that would be required to keep the door open to a Net Zero Emissions by 2050 trajectory (covers only 20% of the needed reduction in 2030). All countries need to do more to align and strengthen their 2030 goals.
- **International crispation:** the current pledges contain the seeds of new divisions and tensions, in the areas of trade in energy-intensive goods or in international investment and finance. Net Zero achievement depends on collaborative global transition in which no one is left behind.

WEO 2021 highlights four key measures to close the gap between today's pledges and 1.5°C trajectory over the next ten years – and to underpin further emissions reductions after.

- Additional push for clean electrification: doubling APS solar PV and wind deployment. Accelerating decarbonization of the electricity mix fills 1/3 of CO_2 gap between APS and NZE.
- Focus on energy efficiency (+4%/year in NZE).
- A broad drive to cut methane emissions from fossil fuel operations: key tool to limit near-term global warming and 15% of the gap between APS and NZE.
- Boost clean energy innovation, particularly for energy-intensive sector (cement, steel, long distance transport). CCS and hydrogen are critical for producers and both faces technological and commercial obstacles that must be overcome.

*Source: IEA, World Energy Outlook 2021.

International Energy Agency scenarios (october 2021)

Existing scenarios

- **Stated Policies Scenario (STEPS):** reflects measures actually put in place by governments, as well as policy initiatives under development. It holds a mirror to current plans and illustrate their consequences: Global average temperatures are still rising when they hit 2.6 °C above pre-industrial levels in 2100.
- **Sustainable Development Scenario (SDS)** was designed to achieve Paris Agreement; the rise in climate ambitions leads IEA to move to zero carbon scenarios but SDS is still shown as a landmark.

Global CO_2 emissions fall to 8 Mt in 2050 and towards net zero by 2070.
Temperature should peak in 2100 at around 1.7°C pre-industrial levels.

New scenarios

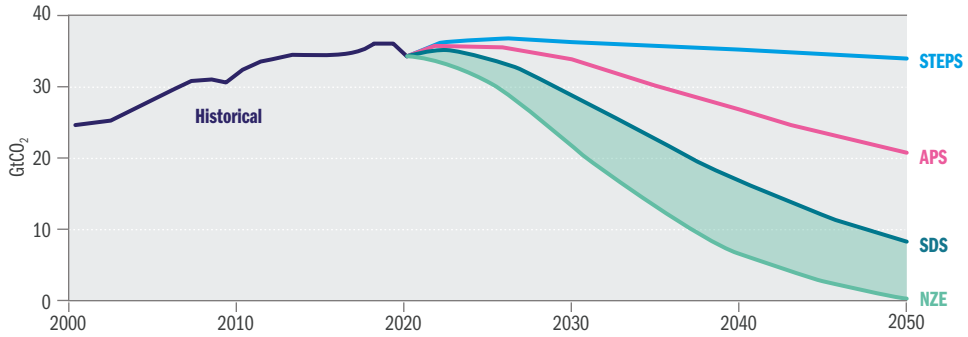
- **Announced Pledges Scenario (APS):** implementation of all climate commitments made by Governments around the world, net zero pledges and NDCs, in time and full.

Over the period to 2030, low emissions sources of power generation account for the vast majority of capacity additions and CO_2 curve down; coal consumption in the power sector is 20% below recent highs; rapid growth in electric vehicle sales and continued improvements in fuel efficiency lead to a peak in oil demand around 2025. Efficiency gains mean that global energy demand plateaus post-2030.
Over the period to 2050, considering that all announced pledges are pursued successfully, then global energy-related CO_2 emissions fall by 40% – all sectors see a decline, with the electricity sector delivering by far the largest.
Temperature rises in 2100 around +2.1°C; this scenario does not hit net zero emissions, so temperature not stabilized.

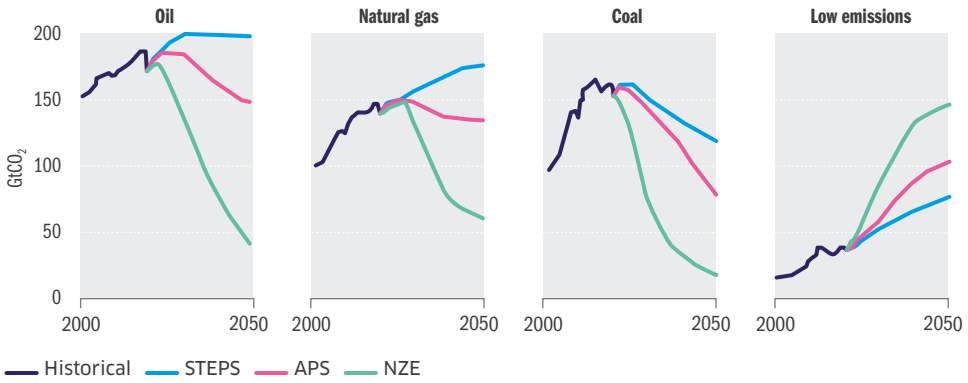
- **Net Zero Emission (NZE):** temperature stabilized at +1.5°C.

Narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050.
Total CO_2 emissions would need to fall around 40% by 2030 (to 21 Gt, 7 Gt lower than SDS).
Requires an unprecedented mobilisation of resources worldwide and all members of society, and not only the energy sector.

CO_2 EMISSIONS IN THE WEO 2021 SCENARIOS OVER TIME



OIL, NATURAL GAS, COAL AND LOW EMISSIONS FUEL USE TO 2050



Source: IEA, World Energy Outlook 2021

International Energy Agency scenarios (october 2021)

ENERGY DEMAND AND CO_2 EMISSIONS BY SCENARIO (IEA)

Energy demand in Mtoe	World			Stated Policies Scenario				Announced Pledges Scenario				Sustainable Development				Net Zero Emissions by 2050			
	2010	2020	Share 2020 (%)	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050
Total primary demand	**13,017**	**14,068**	**100%**	**16,027**	**17,768**	**100%**	**0.8%**	**15,551**	**16,108**	**100%**	**0.5%**	**14,312**	**13,803**	**100%**	**-0.1%**	**13,067**	**12,969**	**100%**	**-0.3%**
Coal	3,654	3,721	26%	3,587	2,790	16%	-1.0%	3,380	1,870	12%	-2.3%	2,651	831	6%	-4.9%	1,717	411	3%	-7.1%
Oil	4,111	4,094	29%	4,741	4,736	27%	0.5%	4,421	3,525	22%	-0.5%	4,020	2,135	15%	-2.1%	3,282	1,008	8%	-4.6%
Natural gas	2,749	3,313	24%	3,724	4,156	23%	0.8%	3,499	3,181	20%	-0.1%	3,327	2,035	15%	-1.6%	3,091	1,450	11%	-2.7%
Nuclear	719	702	5%	812	967	5%	1.1%	855	1,158	7%	1.7%	884	1,228	9%	1.9%	989	1,447	11%	2.4%
Total renewables	1,139	1,636	12%	2,603	4,598	26%	3.5%	2,880	5,933	37%	4.4%	3,408	7,557	55%	5.2%	3,979	8,649	67%	5.7%
Solar	19	112	1%	380	1,039	6%	7.7%	456	1,533	10%	9.1%	568	2,061	15%	10.2%	764	2,606	20%	11.1%
Wind	29	136	1%	344	748	4%	5.8%	430	1,228	8%	7.6%	516	1,502	11%	8.3%	681	2,123	16%	9.6%
Hydro	296	373	3%	437	580	3%	1.5%	437	590	4%	1.5%	463	681	5%	2.0%	504	728	6%	2.3%
Modern Bioenergy	733	903	6%	1,254	1,815	10%	2.4%	1,354	2,119	13%	2.9%	1,576	2,546	18%	3.5%	1,713	2,431	19%	3.4%
Other renewables	62	112	1%	189	420	2%	4.5%	203	466	3%	4.9%	287	767	6%	6.6%	315	760	6%	6.6%
Solid Biomass	626	576	4%	502	411	2%	-1.1%	494	408	3%	-1.1%	-	-	-	-	-	-	-	-

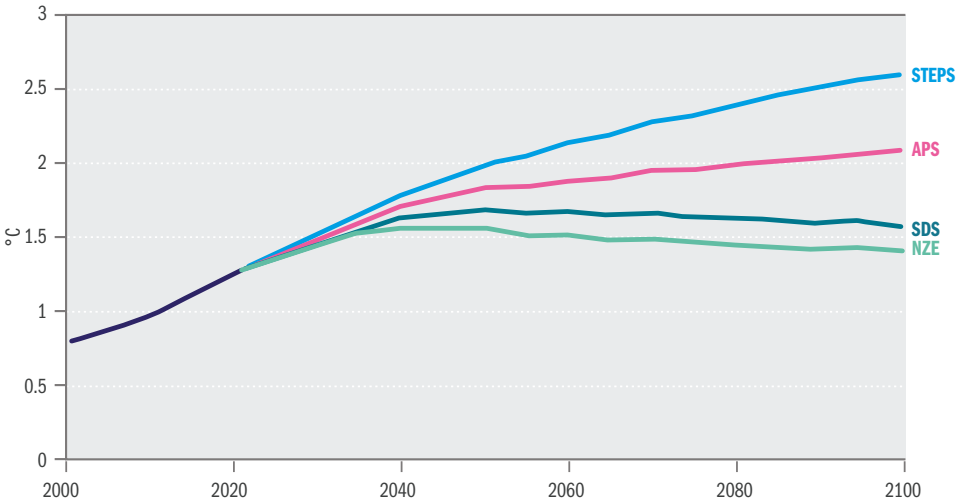
World CO_2 emissions in Mt	2010	2020	Share 2020 (%)	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050	2030	2050	Share 2050 (%)	AAGR (%) 2020-2050
Total CO_2	**32,345**	**34,156**	**100%**	**36,267**	**33,903**	**100%**	**-0.0**	**33,640**	**20,726**	**100%**	**-1.7**	**28,487**	**8,170**	**100%**	**-4.7**	**21,147**	**0**	**-**	**-**
Coal	13,828	14,240	42%	13,487	10,277	30%	-1.1	12,614	5,713	28%	-3.0	9,493	1,395	17%	-7.5	5,915	195	-	-13.3
Oil	10,530	10,123	30%	11,693	11,468	34%	0.4	10,754	7,988	39%	-0.8	9,571	3,986	49%	-3.1	7,426	928	-	-7.7
Natural gas	6,040	7,165	21%	8,091	9,123	27%	0.8	7,415	6,087	29%	-0.5	6,931	2,799	34%	-3.1	5,960	566	-	-8.1
Power sector	**12,380**	**13,530**	**40%**	**12,425**	**9,915**	**29%**	**-1.0**	**11,375**	**5,506**	**27%**	**-3.0**	**8,891**	**887**	**11%**	**-8.7**	**5,816**	**-369**	**-**	**-**
Coal	8,933	9,832	29%	8,791	6,100	18%	-1.6	8,056	3,045	15%	-3.8	5,741	179	2%	-12.5	2,950	69	-	-15.2
Oil	826	601	2%	412	256	1%	-2.8	374	238	1%	-3.0	290	121	1%	-5.2	173	6	-	-14.1
Natural gas	2,621	3,097	9%	3,222	3,559	10%	0.5	2,976	2,524	12%	-0.7	2,888	990	12%	-3.7	2,781	128	-	-10.1

Source: IEA, World Energy Outlook 2021

International Energy Agency scenarios (october 2021)

The temperatures rise by 2100: +2.6°C in STEPS, +2.1° in APS, +1.7° in SDS and +1.5° in NZE

GLOBAL MEDIUM SURFACE TEMPERATURE RISE OVER TIME IN THE WEO 2021 SCENARIOS



Source: IEA, World Energy Outlook 2021

Energy efficiency

The potential for energy efficiency remains largely untapped; the problem is not the technology, but systems and habits that need a fundamental rethink

Energy efficiency is one of the main weapons in the fight against global warming and a critical part of energy transition. It shall reduce CO_2 emissions by nearly 40% and facilitate decarbonisation in other sectors by making it cheaper and easier.

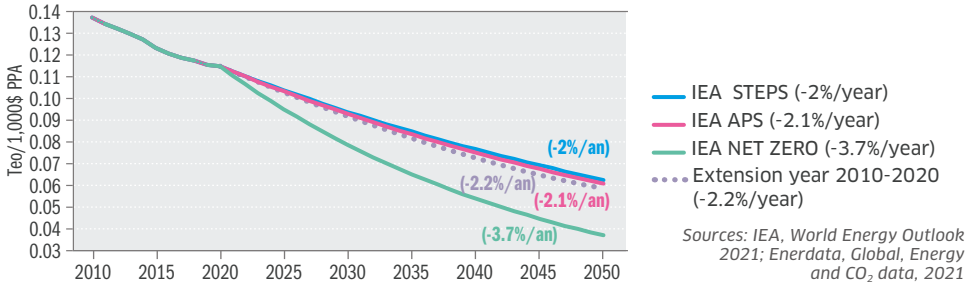
This effort has to focus on several areas: extensive renovation of the world's housing stock, not only in terms of the buildings themselves but also in terms of their equipment; imposing new standards and supporting them with public funds; the digitalisation and management of demand applied to networks, heating and cooling of buildings and in transport; changing behaviour, notably in respect of transport and smart meters; and, in the industrial sector, introducing objectives, regulations, incentives and tools (energy audits, digital management systems, financing).

Energy intensity – energy demand per unit of GDP – is the usual way we measure changes in energy efficiency. It is sensitive to other factors, however, notably structural changes in the economy, exchange rates and outliers such as the Covid pandemic. Measuring energy efficiency on its own typically involves using constant currency rates and purchasing power parities.

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 (-1.5% in 2018, -1.6% in 2019). The lesser decline recorded in 2020 (-0.8%) is not very meaningful, as the economic recession prevented the correct measurement of energy use.

ENERGY INTENSITY PROJECTION – WORLD

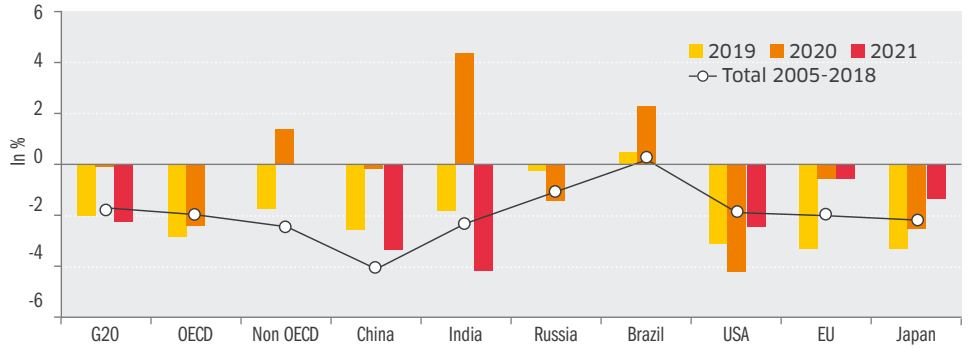


Sources: IEA, World Energy Outlook 2021; Enerdata, Global, Energy and CO_2 data, 2021

Transition not initiated

NB : Energy intensity: number of tonnes of oil equivalent per $1000 of GDP at purchasing power parity.

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



*Energy intensity: energy consumption / GDP.

Source: Enerdata

Energy efficiency

The downtrend in world energy intensity does not appear to have accelerated during the current decade. Set to remain close to -2% per year (STEPS scenario), it would need to nearly double (to -3.7%) to meet the carbon neutral trajectory (NZE scenario). If implemented, current national commitments will mean only a very slight improvement (-2.1%). But this global picture masks major regional differences; current efforts in developed countries will allow energy consumption growth to be cut by two thirds, while this contribution falls to a quarter in developing countries.

Improving efficiency depends largely on investment, and this was relatively low in 2021 at almost $300 bn. The energy transition requires a great deal more: according to the IEA's SDS scenario, investment has to double by 2030 (to $577 bn/year) and near $900 bn by 2050. Because of its efficiency/cost ratio, energy efficiency is the main mission reduction factor in this scenario. The recent increase in energy efficiency investment dedicated to buildings in Europe (from $70 bn in 2019 to $100 bn in 2021) demonstrates the importance of support policies ($30 bn in Germany, $7 bn in France, "Superbonus" of 110% of renovation expenses in Italy, etc.).The USA and China also obtained results in this area.

Substantial untapped energy efficiency potential remains. The drive towards more energy efficiency particularly concerns transport and buildings.

Buildings are a key source of improvements in energy efficiency. They represent a third of final energy demand, of which 80% is heating. Efficiency gains can be made in housing and household equipment energy performance, primarily through the renovation of existing buildings. 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%. Full implementation would reduce building consumption by 40% per square metre.

Transport also offers significant potential: it represents 25% of final energy demand and nearly 40% of CO_2 emissions (final demand). According to the IEA, unit consumption (per km) could be cut by 30% through improved combustion engine efficiency, extended hybridisation, reduced car size and tyre friction and vehicle electrification, this technology having become much more efficient.

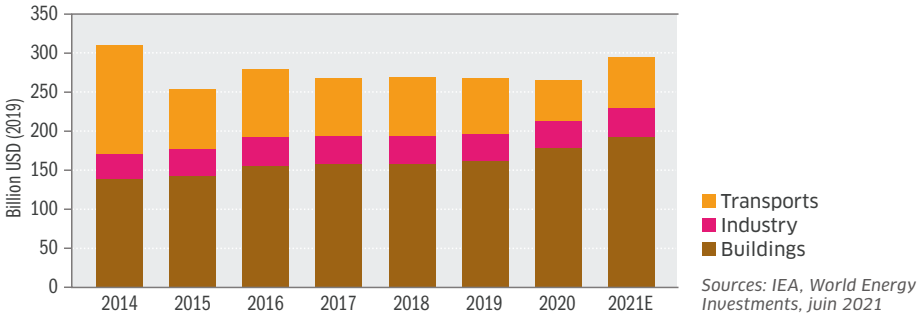
In the European Union, energy efficiency policies gain momentum

With buildings representing nearly 40% of final energy consumption and 30% of CO_2 emissions, the EU agreed in November 2018 – within the Clean Energy Package – on a non-legally binding commitment to improve energy efficiency by 32.5% by 2030. At the same time, the directive on buildings energy performance was revised 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.

The April 2021 European Green Deal raised the energy efficiency objectives to 36-39% by 2030 for primary and final energy consumption. It intends to at least double the average thermal renovation rates of housing stocks in Member States (currently between 0.4% and 1.2%). This represents 35 million renovated buildings and 160,000 jobs created by 2030, and €175 bn financing by 2027.

At the same time, the European recovery plan includes €57 bn for energy efficiency, of which 40% in buildings renovation, 30% in electrical cars, 20% in urban infrastructure and less than 1% in industry.

GLOBAL INVESTMENT IN ENERGY EFFICIENCY BY SECTOR



Sources: IEA, World Energy Investments, juin 2021

Energy sobriety

No longer confined to local initiatives, energy sobriety is now under the spotlight and has made its way into carbon neutrality scenarios

Energy efficiency 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*, which highlights the necessity of compromising between social needs and the ecosystem's environmental limits.

Based on societal shifts rather than technical progress, energy sobriety does not hinge on financing capacity and resource availability. It can therefore reduce emissions in a definite and efficient manner. But it has to complement energy efficiency if it is to avoid a potential rebound as efficiency improves.

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 sobriety 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 '2,000-watt society'*** campaign in Zurich reduced primary energy consumption from 5,000 W to 4,200 W per inhabitant in ten years. In the USA, car sharing has lowered household fuel consumption by 5% by saving duplicated mileage and via parking infrastructure savings.

That said, energy sobriety does not yet feature on a large scale in any transition programme. It is marginalised in most energy policies and scenarios, mainly because of its persistent image as a constraint. In political and economic terms it is mainly regarded as incompatible with the growth model that continues to drive public policy, although a few timid attempts are being made to challenge this orthodoxy. At the level of the individual, the notion of energy temperance that it promotes contradicts perceptions of comfort and predominant social norms that are still based largely on material abundance and consumerism. And in a more general sense it raises the question of how reducing consumption can be achieved equitably when many households are still threatened by energy poverty.

DIFFERENT TYPES OF ENERGY SOBRIETY 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

* The so-called Brundtland report, officially entitled "Our common future" was written in 1987 by the United Nations' World Commission on Environment and Development. It is in this report, which served as a basis to the 1992 Earth Summit, that the expression "sustainable development" first appeared.

** Energise: Network for research, good practice and innovation for sustainable energy.

*** The 2,000-watt society concept aims at reducing primary energy consumption down to 2,000 watts and GHG emissions down to 1 t CO_2 equivalent per person and per year. These two sets of data are calculated from final consumption by applying primary energy factors or GHG emission coefficients.

Energy sobriety

The Covid pandemic changed the game not only by imposing "sober" behaviours through lock down and prevention measures, but it also highlighted ecosystem and supply chain vulnerability.

Among the major shifts brought on by the pandemic, some will last:

- Increased teleworking and 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)
- Reduced air traffic: airlines expect a permanent change in travel patterns, with less business travel (source: Sorensen, 2020; Boone et al., 2020).
- Other attitudes could change, notably in areas such as consumption, prudential savings, health and food security, less concentration and relocation, local and circular economy, and reduced mobility.

Recent studies* in France show a distinct move towards sobriety: for 57% of French people (against 27% in 2017) consuming less is a factor in their savings, while 76% of consumers pay regard to whether the goods they buy are produced locally or not. They desire to eat better and 'bio' in particular, and have added vegetables to their diet. More and more consumers are opting for second-hand goods, and 76% of respondents said they consider the use of a good to be more important than possessing (up from 65% in 2010). Flying for leisure travel is becoming less popular, with 43% of respondents claiming to have already stopped (7% more than in 2018). Materialistic values appear to be waning in favour of of self-realisation and new forms of living; pioneering sobriety initiatives are emerging among individuals and small groups, with some development on a larger, regional scale.

At the same time, a substantial proportion of the population is not following this trend. Frugality remains a choice made by the wealthiest classes; among the poorer people it is something to be endured rather than embraced. Most French people remain attached to consumption. As with other issues, Covid-19 has widened the 'sobriety gap' between different parts of the population.

Sobriety is featuring more in net zero targets

Energy sobriety has scarcely been been mentioned in long term trajectories so far. One exception is "NégaWatt 2050", a scenario in which sobriety could reduce energy demand 28% by 2050 (in this France-based study, a total reduction of 50% would require the remaining 22% to stem from energy efficiency). Although several sobriety measures are mentioned in the the IEA's SDS, Greenpeace's Energy [R] and BP's Rapid Transition 2°C scenarios – the circular economy and modal transfers, for example – the concept of sobriety is not identified as such and these scenarios offer no proactive global approach to it.

More onerous climate ambitions have had a definite impact, as the Net-Zero scenario published by the IEA in April 2021 shows: active citizen participation is now considered indispensable to meet the carbon neutrality objective by 2050. Changing behaviour could reduce world energy demand by 10% and cumulative emissions by 10% as well by 2050; transport is the most sensitive sector. Three economic areas are prioritised: excessive or wasteful energy consumption, alternative transport modes, material efficiency gains. To reach the same emission level by 2030, no change in behaviour means a much larger burden on low emission technologies.

Out of the 35 Gt CO_2 emission reduction by 2050, 8% relies entirely on behavioural and material efficiency gains (e.g. fly less) and 55% on a combination of low-carbon technologies and citizen-level commitments (e.g. purchasing electric vehicle, installing solar heaters).

*CREDOC: "Consommation et modes de vie", February 2021; GreenFlex/ADEME: "Baromètre de la consommation responsible", April 2021; Obsoco/ADEME: "Les perspectives utopiques des Français au temps du Covid-19", June 2021.

Sustainable finance

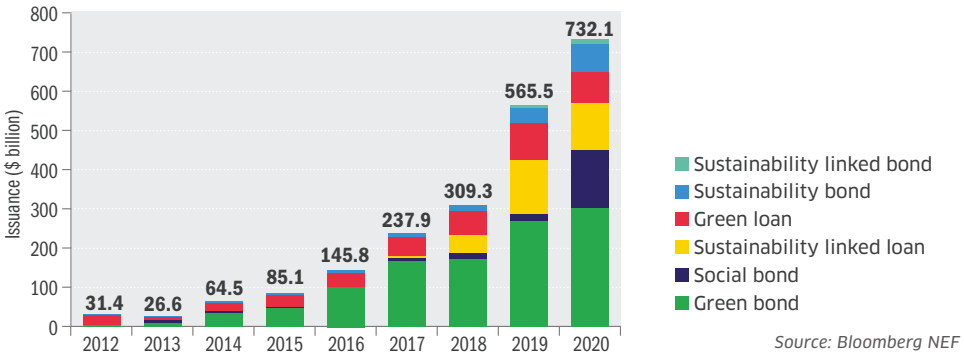
The sustainability issue is attracting attention from the financial markets

Sustainable finance seeks to reconcile economic efficiency, client protection and general interest by including social, societal and environmental criteria. Within that concept, green finance covers all financial transactions aimed at supporting sustainable development, including fighting global warming. It also comprises initiatives from the financial regulation and supervision authorities that contribute to these objectives. It is a fundamental lever of energy transition. French President Emmanuel Macron described finance as a key weapon war at the Climate Summit in April 2021.

The main tools of sustainable finance are debt instruments, bonds or loans that foster environmental and social progress (so-called sustainable debt). There are two categories. In the first, the issuer or borrower commits to use the funds to finance or refinance environmental and/or environmental projects. This includes green bonds (46% of the sustainable debt market), green loans (17%), social bonds (11%) and sustainability bonds (8%), aimed at both environmental and social projects. In the second category, the use of funds is not constrained and it is the issuer or borrower's performance in relation to sustainable development indicators that matters. This includes sustainability-linked loans (17% of the sustainable debt market) and sustainability-linked bonds (2%). Transition bonds have also been introduced to the market. They are not strictly 'green', but they play a part in energy transition as they are issued by polluting industries to finance their conversion to cleaner operations.

Despite the Covid-19 pandemic, the sustainable finance market set issuance records in 2020: a total $732 bn, up 29% from 2019. The increase was not as significant as the 83% rise observed between 2018 and 2019, but left cumulative issuance at $2,300 bn at end-2020. Sustainability bonds and green bonds issuance increased by 74% and 13%, respectively, and the cumulative total for the latter now exceeds $1,000 bn. Social bond issuance jumped by a spectacular 720% - it is used to maintain or revive the economy after the pandemic. Issuers include the EU, Unédic (French unemployment insurance) and the African Development Bank. Sustainability-linked loans and green loans issuance dropped 15%, but this decline is considered moderate in view of crisis-related economic difficulties. Bloomberg foresees a market worth more than $3,000 bn in 2021.

SUSTAINABLE DEBT ANNUAL ISSUANCE, WORLD



Source: Bloomberg NEF

More broadly, sustainable finance growth fits in with a growing interest for ESG-related investments (environmental, social, governance). ESG fund outstandings have expanded significantly over the past two years. According to Bloomberg, by 2025 ESG assets could represent a third of world assets under management, or $53,000 bn. Commitments from many companies to reach carbon neutrality by 2050 (2045 for Engie's Scopes 1, 2 and 3) are reinforcing this trend. Lastly, investors have become more and more conscious of the risks associated with climate change (1) and their negative effects on investments. They are more demanding about companies and issuers with regards to ESG information. Many share indexes have been introduced to identify and follow these "sustainable" companies.

*The Task-Force on Climate-Related Financial Disclosures divides climate-related risks into two categories: physical risks, linked to damages that are induced directly by weather and climate phenomenon; and transition risks, related to the implementation of a low carbon economic model.

Sustainable finance

Sustainable finance regulation and its limits

The development of sustainable finance was promoted by the creation of standards and their harmonisation on a global scale. The International Capital Market Association is the guardian and issuer of sustainable finance principles and guidelines. Its latest updates contributed to increase transparency and strengthen reliability, notably on the use of funds raised and the disclosure of information. States also work at regulating sustainable finance, in particular the UK, Hong Kong and within the EU.

Climate risks could therefore have a substantial impact on financial stability as well as price stability. They could also affect the value and the risk profile of assets on central bank balance sheets. For this reason, the ECB came up with a roadmap for the 2021-2024 period in early July 2021 that integrates climate change in its monetary policy. Climate issues are to be taken into consideration in macroeconomic analysis, monetary policy frameworks, risk assessment and collateral and asset purchase mechanisms.

Despite clarification and normalisation efforts, the ability of sustainable finance to support ecological transition remains precarious.

Some sustainable finance criteria lack clarity or show little connection to sustainable projects. This the case of transition bonds, which some players may be tempted to use for greenwashing purposes. Sustainability-linked bonds do not finance sustainable projects directly but are linked to self-assessed performance indicators, for example. Thus Total was able to commit in January 2021 to issued only this type of debt although it continues to fund fossil fuel exploration projects.

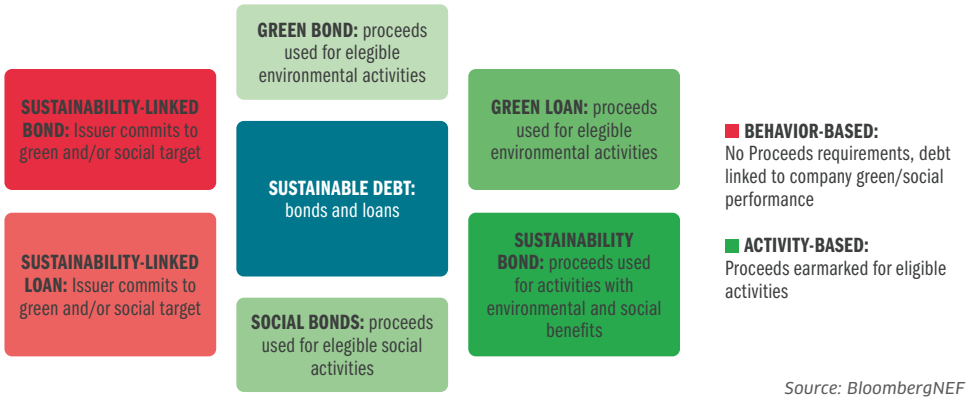
Banks are still massive investors in fossil fuels. "Banking on Climate Chaos 2021", an annual publication written by six NGOs, revealed that the 60 world largest banks have lent $3,800 bn to companies working in the oil, gas and coal sectors since the Paris Agreement, with France ranking fourth in the world and Europe first. This is more than the entire sustainable finance market (about $3,000 bn).

This situation demands more drastic regulation that promotes green over brown yields. For some analysts*, the limits to green finance stem from the very way the financial system works: it is ill-adapted to favour a transition towards a low carbon economy. As a lever, finance has a fundamental and undisputed role in curtailing climate change, but at the same time it is incapable to treat the problem by itself without more constraining regulations.

Shifting funds towards transition requires a change in green risk-reward profiles relative to brown investments. This means biasing market prices so that players are prompted to turn to green assets. There are three possibilities: increasing green yields through subsidies, eroding brown yields through tax, or lowering green risks through state guarantees. The NGOs Les Amis de la Terre and Oxfam France suggest a legal obligation for large companies – backed by financial penalties – to stick to a downward trajectory on their carbon footprint and polluting activities.

* *"L'illusion de la Finance verte"*, May 2021, Alain Grandjean and Julien Lefournier, Éditions de l'Atelier.

VARIETIES OF SUSTAINABILITY-THEMED DEBT



Source: BloombergNEF

Carbon Capture, Utilisation and Storage (CCUS)

Under the pressure of net zero commitments, and thanks to some countries' support, interest in CCUS rebounded in 2021 with numerous new projects

CO_2 capture and storage projects have multiplied since early 2021, driven by increasing environmental pressure, lower costs, stronger commercial interests and financial commitments in certain countries. By the end of September 2021, CCUS projects worldwide reached a total capacity of 111 million tonnes per annum (Mtpa), a 52% rise from their end-2020 level (73 Mtpa) according to the Global CCS Institute.

Because of CCS tax credits, most projects are in North America. Over 40 projects were announced this year, including the Houston Ship Channel, a huge Exxon Mobile concept. In Europe, encouraged by stricter emission targets and high carbon prices, 35 projects are under way, 17 of which were introduced this year in the UK, Belgium, Norway and the Netherlands. In the Asia-Pacific region, projects related to gas development have been recently approved in Indonesia and Malaysia.

Altogether, would increase CCS capacity from the current 44 Mtpa to nearly 190 Mtpa by 2030. Underpinned by growing decarbonization expectations within companies and states, lower costs (see cost range on next slide) and heightened commercial interest are also driving this boom.

In the early 2000s CCS was considered as a key technology towards decarbonization, in particular for coal-fired power plants. This failed to happen and large-scale commercial development is rare. This reflects a lack of regulation and incentives, severe competition from alternative technologies, lukewarm public approval and excessively low carbon prices. In addition, major issues remain unsettled, such as the long term reliability of underground storage. CCUS projects started to re-emerge in 2017. To date there are 63 CCUS commercial installations in the world: 26 in operation, 3 under construction, 13 in FEED study stage and 21 in initial development

The major players in the deployment of CCS technology are essentially oil and gas companies, industrial gas players, and gas transport infrastructure operators preparing diversification. Most interested clients are large industrials willing to reduce their footprint in carbon intensive sectors, such as steel, cement or hydrogen production, as well as thermal power production.

Carbon utilisation is mainly driven by the oil industry's need to 'cushion' its gas and Enhanced Oil Recovery (EOR)* (22 out of the 26 operating facilities).

But new utilisation opportunities have emerged. As a raw material, carbon can be used in combination with renewable hydrogen in the manufacture of low carbon products, such as synthetic fuels (e-methane, e-kerosene, e-methanol, other e-fuels); it can also be used in construction materials and in some industrial chemical applications.

Subject to an amendment of the regulatory framework, this would allow decarbonization in sectors that are impossible to electrify while developing CO_2 circular economy. This would imply to use at first CO_2 that has been emitted in the atmosphere, and in the longer term biogenic CO_2, or even CO_2 directly captured in the environment, for a carbon neutral cycle. Air and maritime transport sectors have an interest in these products as they are obliged to decarbonise and incorporate decarbonised fuels.

*Enhanced Oil Recovery, or EOR, is a technic allowing to extract more oil from the oil fields by injecting CO_2 and water.

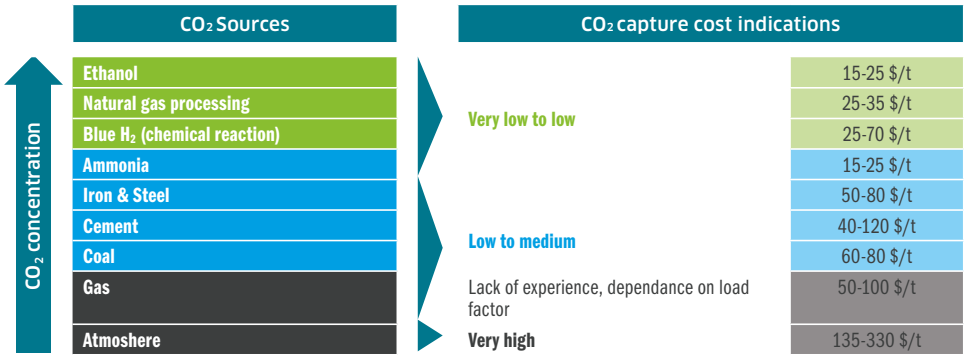
Carbon Capture, Utilisation and Storage (CCUS)

With almost 190 $MtCO_2$/year, CCUS increases but remains modest by 2030 compared to the volume of CO_2 emitted into the atmosphere

The future of CCUS still depends on political will and public support. Currently operating CCUS installations can capture and store on an ongoing basis 40 Mt CO_2/year (against 28 Mt CO_2/year in 2015), representing 0.1 % of world annual fossil fuel-related emissions. Opponents say that such a small volume means that CCUS is a waste of money that promotes the continued use of polluting fossil fuels, especially coal.

Nevertheless, several organisations, including the IEA, consider CCUS as an essential tool to reach carbon neutrality by 2050. The coming COP26 will discuss the economics of CCUS projects and the introduction by governments of regulatory frameworks that acknowledge and promote CCUS as an alternative means of reducing emissions.

COST ESTIMATES FOR CO_2 CAPTURE

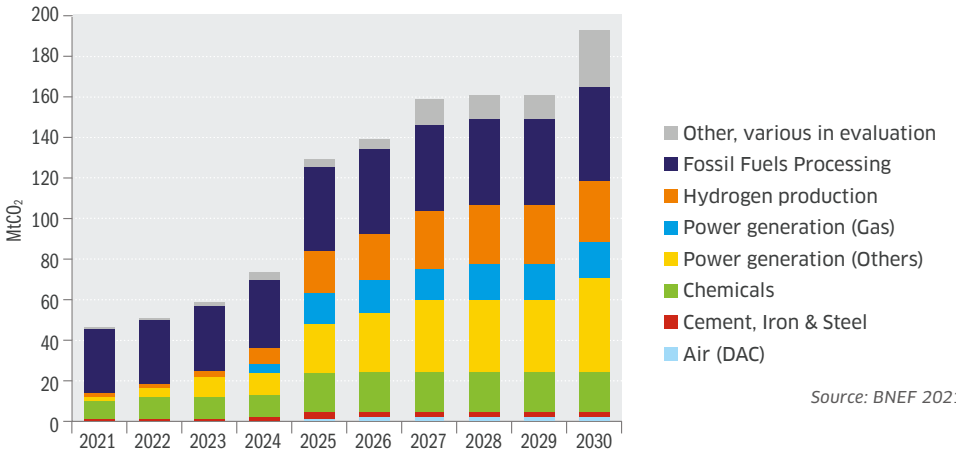


Source: ENGIE Impact 2021

High uncertainties for low concentration sources due to few installations in operation.

To comply with the Paris Agreement trajectory, CCUS capacity would have to rise by 350 Mt every year until 2030 and reach 5 Gt by 2050, according to the IEA's SDS scenario. The more ambitious IEA Net Zero scenario would need the capture of 20% of current emissions (7.6 Gt) by 2050 to reach carbon neutrality. This implies processing half of fossil fuels in CCUS facilities by that time. According to the IEA's sensitivity analysis, not developing CCUS is by far the most expensive option.

REPORTED GLOBAL CAPTURE CAPACITY BY EMISSION SOURCE



Source: BNEF 2021

Soon, the growth of CCUS will be driven by electricity production and hydrogen production. In 2030, announced gas-fired power plant projects will account for 18 Mt of captured CO_2.

Electricity & Electrical renewables

CAPACITY

Renewables capacity is expanding rapidly in advanced economies but funding remains a major challenge for developing countries

PRODUCTION

Coal-powered plants are operating flat out to meet soaring demand for electricity

Electricity and energy transition

Decarbonising the electricity sector is the primary lever in fast action to meet climate objectives

At the forefront of energy transition, the power sector has seen the rapid development of renewables and growing electrification of uses. Improved competitiveness, stronger policies and the tangible influence of environmental criteria have contributed to substantial progress in RES deployment without adverse impact from the Covid crisis. The transformation of power production remains a major challenge, however: electricity represents only 20% of final demand but generates 45% of total energy combustion-related CO_2 emissions. Reaching IEA targets as set out in the carbon neutral scenario (NZE) still requires a colossal effort.

Accelerating decarbonization is imperative. Even though RES production has doubled over the past 20 years, the share of low carbon technologies is stuck at 36% of the world electricity mix. Carbon neutrality infers that clean technologies, essentially RES, meet almost all electricity demand, which itself is increasing by 3% per year. The limited improvement in carbon intensity* is another sign of how slow progress is. Apart from 2020 (-3%), which was an exceptional year because of lower demand and reduced thermal generation, carbon intensity has been dropping by 1% per year; the climate emergency requires a 6% drop per year out to 2030. The continuing use of coal - 35% of electricity generation - is the main culprit.

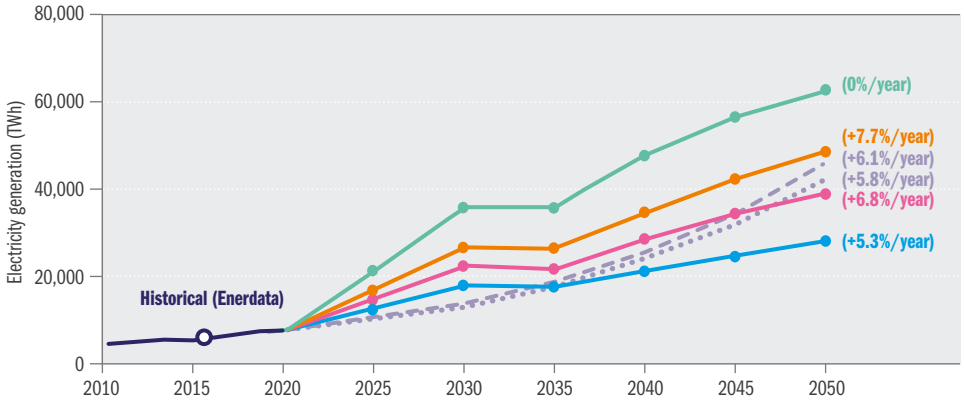
The current decade is crucial for electricity. The sector must exit coal (80% of coal is used to produce electricity), double production capacity to cope with increasing electrification and reduce its emissions by 8% per year out to 2030.

The growing use of electricity and the increasing share of RES raise questions around the resilience and security of electricity supply systems. 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. Major power cuts in several regions (Texas, Japan, China) in 2021 as a result of extreme temperatures and droughts are a case in point. The large-scale deployment of renewable technologies remain controversial, however. Key questions include the extraction of the rare metals needed to produce PV panels and batteries, the unpopularity of windfarm development in many areas and the release of methane from some hydroelectric dams.

*Electricity carbon intensity: 435 gr CO_2/kWh in 2020.

Electricity and energy transition

RENEWABLE ELECTRICITY GENERATION FORECASTS – WORLD

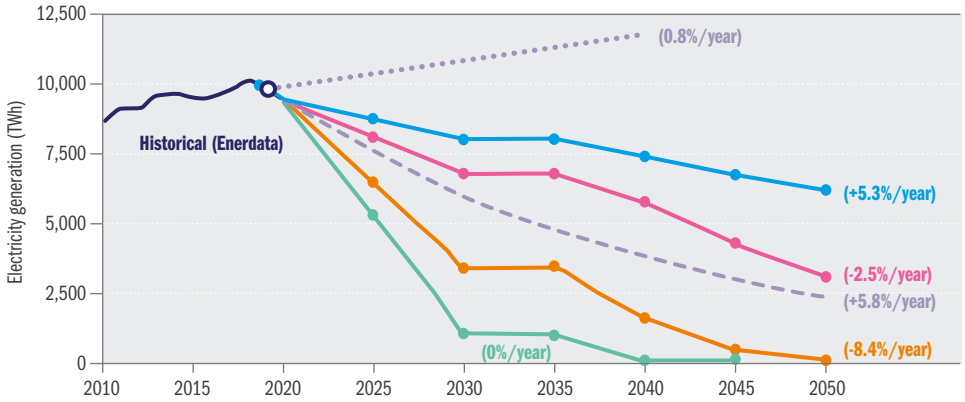


Transition started but dynamic too slow

IEA NET ZERO (+0%/year) IEA SDS (+7.7%/year) IEA APS (+6.8%/year)
IEA STEPS (+5.3%/year) Extension years 2010-2020 (+5.8%/year)
Extension year 2020 (+6.1%/year) Historical (Enerdata)

Source: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

COAL-FIRED POWER GENERATION FORECASTS – WORLD



Transition not initiated

IEA STEPS (-1.3%/year) IEA APS (-2.5%/year) IEA SDS (-8.4%/year)
IEA NET ZERO (+0%/year) Extension years 2010-2020 (+0.8%/year)
Extension year 2020 (-4.4%/year) Historical (Enerdata)

Source: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

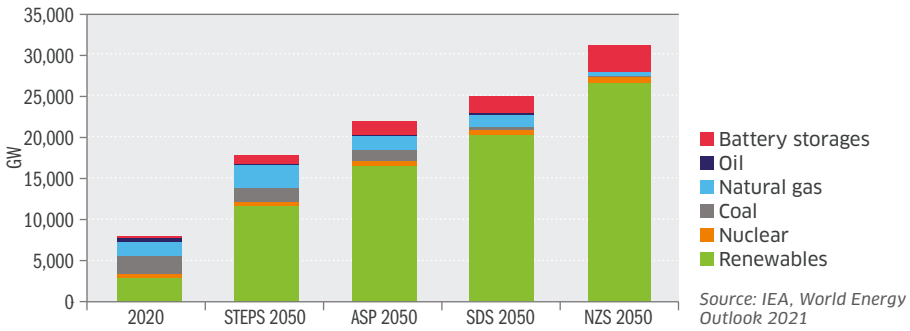
Electricity and energy transition: production capacity forecasts

ELECTRICITY CAPACITY FORECASTS BY SCENARIO (GW)

Electricity capacity forecasts, in GW		Stated Policies Scenario				Announced pledges Scenario				Sustainable Development Scenario				Net Zero Emissions by 2050 Scenario			
	2020	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050
Renewables	2,989	5,998	11,692	66%	+4.7%	6,912	16,514	72%	+5.9%	8,017	20,304	78%	+6.6%	10,293	26,568	80%	+7.6%
Solar PV	739	2,550	6,163	35%	+7.3%	3,063	9,095	40%	+8.7%	3,582	10,865	42%	+9.4%	4,956	14,458	43%	+10.4%
Wind	737	1,603	2,995	17%	+4.8%	1,943	4,633	20%	+6.3%	2,378	5,881	23%	+7.2%	3,101	8,265	25%	+8.4%
Hydro	1,327	1,564	1,995	11%	+1.4%	1,584	2,050	9%	+1.5%	1,679	2,360	9%	+1.9%	1,804	2,599	8%	+2.3%
Bioenergy	163	234	347	2%	+2.5%	257	444	2%	+3.4%	281	599	2%	+4.4%	297	640	2%	+4.7%
CSP	6	17	92	1%	+9.3%	28	173	1%	+11.6%	46	424	2%	+15.0%	73	426	1%	+15.0%
Geothermal	16	27	61	0%	+4.7%	30	73	0%	+5.3%	44	124	0%	+7.2%	52	126	0%	+7.2%
Marine	1	4	37	0%	+13.8%	7	46	0%	+14.5%	7	51	0%	+15.0%	11	55	0%	+15.3%
Nuclear	415	447	525	3%	+0.8%	465	641	3%	+1.5%	475	669	3%	+1.6%	515	812	2%	+2.3%
Coal	2,109	2,035	1,618	9%	-0.9%	1,963	1,265	6%	-1.7%	1,564	283	1%	-6.5%	1,192	158	0%	-8.3%
Natural gas	1,822	2,211	2,752	15%	+1.4%	2,071	1,786	8%	-0.1%	2,023	1,548	6%	-0.5%	1,950	495	1%	-4.3%
Oil	430	290	185	1%	-2.8%	261	156	1%	-3.3%	256	157	1%	-3.3%	178	25	0%	-9.0%
Battery storage	17	159	1,046	6%	+14.8%	302	1,613	7%	+16.4%	341	2,123	8%	+17.5%	585	3,097	9%	+19.0%
Total capacity	7,782	11,143	17,844	100%	+2.8%	11,996	22,795	100%	+3.6%	12,728	25,996	100%	+4.1%	14,933	33,415	100%	+5.0%

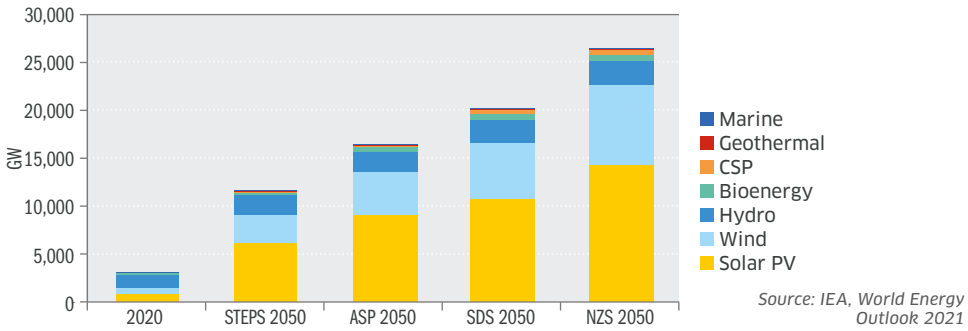
Source: IEA, World Energy Outlook 2021

ELECTRICITY CAPACITY FORECASTS BY SCENARIO (IN GW)



Source: IEA, World Energy Outlook 2021

RENEWABLE ELECTRICITY CAPACITY FORECASTS BY SCENARIO (IN GW)



Source: IEA, World Energy Outlook 2021

Electricity and energy transition: production forecasts

ELECTRICITY GENERATION FORECASTS BY SCENARIO (TWH)

Electricity generation forecasts in TWh		Stated Policies Scenario				Announced pledges Scenario				Sustainable Development Scenario				Net Zero Emissions by 2050 Scenario			
	2020	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050	2030	2050	Share in 2050	AAGR 2020-2050
Renewables	7,593	14,056	27,883	60%	+4.4%	15,917	38,959	71%	+5.6%	18,283	48,436	84%	+6.4%	22,817	62,333	88%	+7.3%
Solar PV	833	3,492	9,667	21%	+8.5%	4,190	14,194	26%	+9.9%	4,989	17,433	30%	+10.7%	6,970	23,469	33%	+11.8%
Wind	1,596	4,102	8,805	19%	+5.9%	5,115	14,384	26%	+7.6%	6,115	17,577	30%	+8.3%	8,008	24,785	35%	+9.6%
Hydro	4,347	5,087	6,739	14%	+1.5%	5,080	6,852	13%	+1.5%	5,387	7,921	14%	+2.0%	5,870	8,461	12%	+2.2%
Bioenergy	709	1,145	1,852	4%	+3.3%	1,249	2,375	4%	+4.1%	1,362	3,199	6%	+5.2%	1,407	3,279	5%	+5.2%
CSP	13	46	302	1%	+11.0%	78	589	1%	+13.5%	129	1,377	2%	+16.8%	204	1,386	2%	+16.8%
Geothermal	94	176	423	1%	+5.1%	190	449	1%	+5.3%	284	801	1%	+7.4%	330	821	1%	+7.5%
Marine	1	9	95	0%	+15.0%	15	115	0%	+15.8%	16	129	0%	+16.2%	27	132	0%	+16.3%
Nuclear	2,692	3,115	3,711	8%	+1.1%	3,282	4,449	8%	+1.7%	3,395	4,714	8%	+1.9%	3,777	5,497	8%	+2.4%
Coal	9,467	8,733	6,189	13%	-1.4%	7,926	3,047	6%	-3.7%	5,618	42	0%	-16.5%	2,947	-	0%	-40.0%
Natural gas	6,257	7,112	8,418	18%	+1.0%	6,522	5,691	10%	-0.3%	6,345	2,011	3%	-3.7%	6,222	253	0%	-10.1%
Oil	716	500	308	1%	-2.8%	450	291	1%	-3.0%	327	119	0%	-5.8%	189	6	0%	-14.6%
Total production	26,762	33,575	46,703	100%	+1.9%	34,362	54,716	100%	+2.4%	34,424	57,950	100%	+2.6%	37,316	71,164	100%	+3.3%
Capacités totales	7,782	11,143	17,844	100%	+2.8%	11,996	22,795	100%	+3.6%	12,728	25,996	100%	+4.1%	14,933	33,415	100%	+5.0%

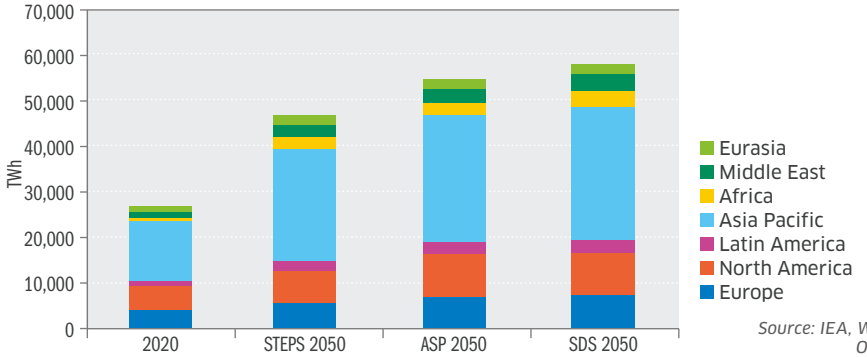
Source: IEA, World Energy Outlook 2021

ELECTRICITY GENERATION FORECASTS BY REGION (TWH)

Electricity generation forecasts in TWh	2020	Stated Policies Scenario			Announced pledges Scenario			Sustainable Development Scenario		
		2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050
Europe	3,952	4,601	5,594	1.2%	4,911	7,091	2.0%	4,926	7,267	2.1%
North America	5,221	5,618	6,726	0.8%	6,066	9,063	1.9%	6,048	9,155	1.9%
Latin America	1,277	1,616	2,435	2.2%	1,584	2,637	2.4%	1,575	2,987	2.9%
Pacific Asia	12,961	17,292	24,743	2.2%	17,320	28,195	2.6%	17,360	29,215	2.7%
Africa	827	1,215	2,384	3.6%	1,239	2,542	3.8%	1,400	3,488	4.9%
Middle East	1,189	1,616	2,764	2.9%	1,625	3,130	3.3%	1,485	3,724	3.9%
Eurasia	1,335	1,617	2,057	1.5%	1,617	2,057	1.5%	1,630	2,114	1.5%
Total production	26 762	33 575	46 703	1.9%	34 362	54 716	2.4%	34 424	57 950	2.6%

Source: IEA, World Energy Outlook 2021

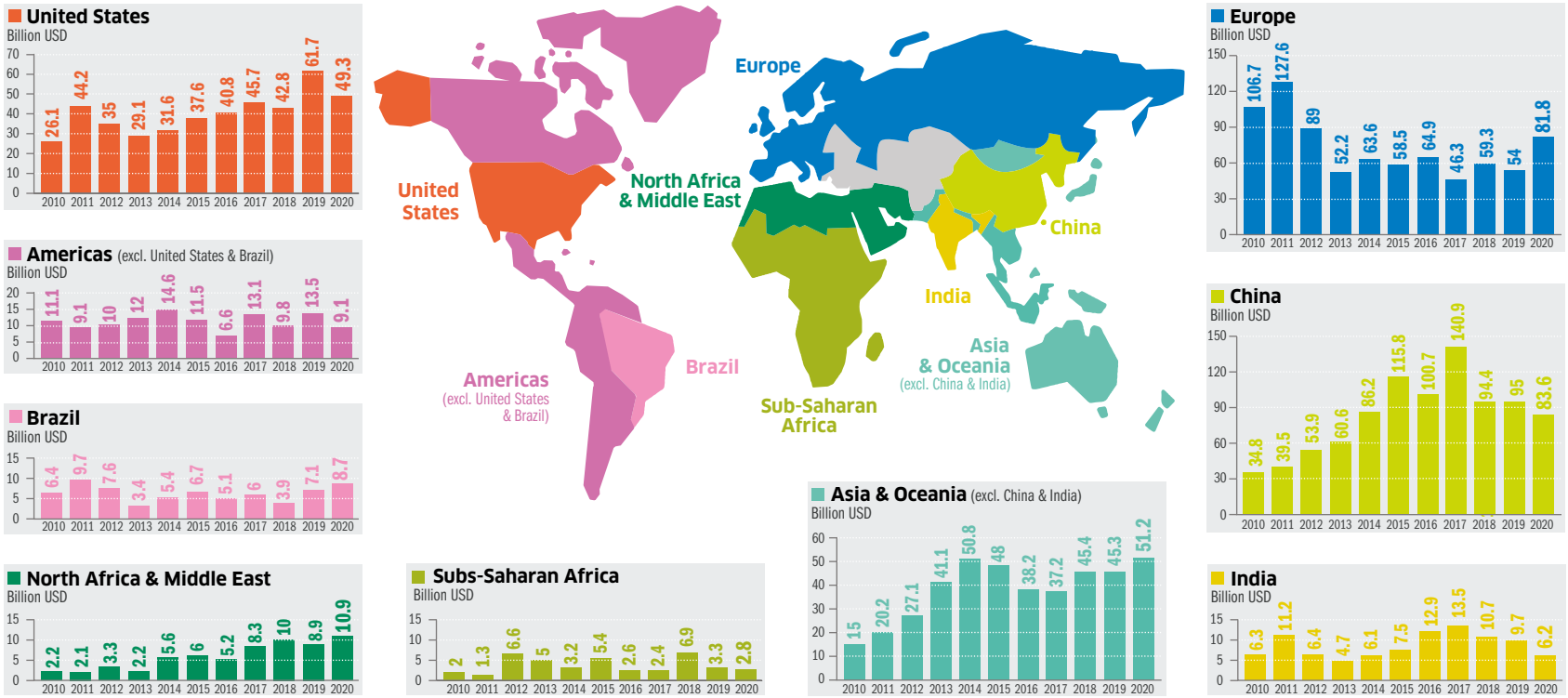
ELECTRICITY GENERATION FORECASTS BY SCENARIO (TWH)



Source: IEA, World Energy Outlook 2021

Electricity and energy transition: RES investment

GLOBAL INVESTMENT IN RENEWABLE POWER AND FUELS, BY COUNTRY AND REGION, 2010-2020



Note: Figures include utility-scale renewable energy and small-scale solar projects and exclude large hydropower projects of more than 50 MW. The regions in this chapter follow those presented in the BNEF *Energy Transition Investment 2021 report* and differ from the regional definitions included elsewhere in the GSR.

Source: REN21, Renewables 2021 Global Status Report

Electricity: production capacity

The pandemic did not affect momentum behind renewables in the developed world but it exacerbated financing difficulties in emerging countries

Rather than slowing down – as it was feared - the development of renewable capacity, the pandemic prompted an acceleration in investment. According to BNEF, $501 bn were invested in energy transition low emission assets in 2020, up 9% from 2019. Put another way, renewables captured 60% of new power capacity investment in 2020. This enthusiasm stemmed from a combination of factors: improvements to technologies and a considerable drop in their costs, the attractiveness of the sector to investors, and commitments to decarbonization on the part of governments and and businesses.

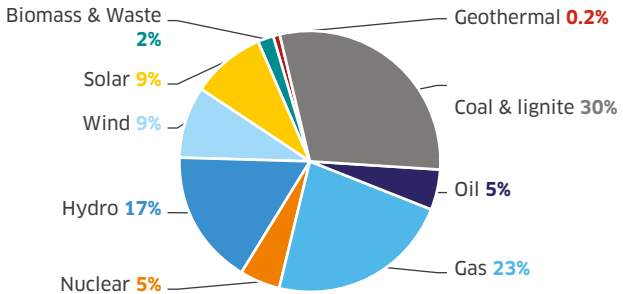
Electricity capacity continued to grow in 2020 (+335 GW), driven by the exceptional development of renewables (+260 GW, i.e. +10% increase). Most of this capacity (90%) is solar (+127 GW) and wind (+111 GW), while fossil fuels are losing ground (60 GW installed against 64 GW in 2019) – Sources IRENA and Enerdata.

Consolidating its leadership role, China contributed half of this exceptional expansion. The country increased its RES capacity by 136 GW (72 GW wind and 49 GW solar) and does not intend to stop there. Its objective is +90 GW in wind and solar in 2021, according to the Chinese National Energy Administration.

However, the other major markets are not left out. US renewable capacity increased 29 GW in 2020 (15 GW in solar and 14 GW in wind), almost double the gain in 2019. The trend is to continue, with an extra 20 GW expected in solar in 2021, while the development of wind power is due to slow down. Europe also recorded a hefty 40 GW expansion, to be continued in 2021 and 2022 with projects in Germany. The Green Deal has also given the European Union a new impetus by providing €2 billion to the solar and wind sectors. In the wake of this, a European Solar Initiative was launched in March 2021 to accelerate the deployment of PV and bring about the production of solar panels in Europe. Finally, India, despite the shortages linked to Covid, has not lowered the level of its ambitions in terms of solar and wind power and announced a 30 GW hybrid project, wind, solar and batteries, at the end of 2020.

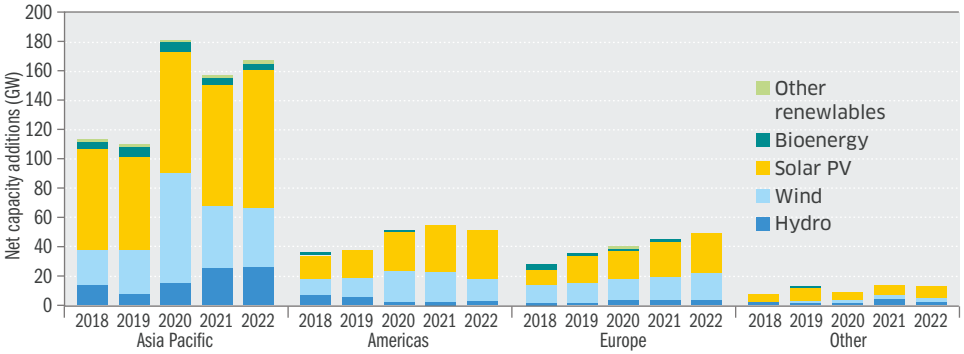
These positive results remain confined to a limited number of markets, however. The key challenge is to fund RES development in emerging countries.

SHARE OF GENERATING CAPACITY BY ENERGY IN 2020 TOTAL: 7,805 GW



Source: Enerdata Global Energy & CO_2 Data, 2021

NET ANNUAL RENEWABLE CAPACITY ADDITIONS BY REGION AND TECHNOLOGY



Source: IEA, Electricity Market Report, 2021

Electricity: production capacity

The renewal of coal capacity in Asia highlights emerging countries' difficulties in matching ecology with economics

Although more and more coal-fired plants are being shut, world coal capacity increased by 15 GW on the back of China's economic recovery. On the one hand, the rate at which coal-fired stations are being closed down is accelerating: -38 GW worth in 2020, of which -10 GW in the USA and -7 GW in the EU27. Similarly, Spain closed half of its capacity (-4 GW), Germany trimmed 1 GW in another step towards its full exit from coal by 2035, Austria and Sweden closed their last coal plants in 2020, and Portugal is to follow suit in 2021.

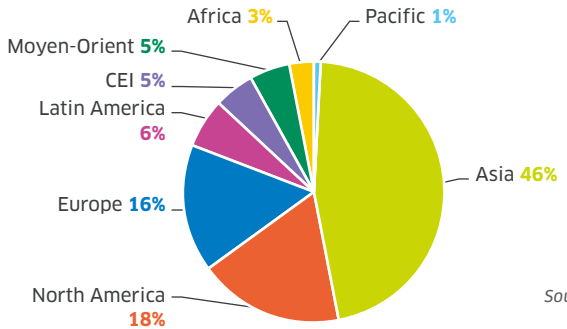
On the other hand, China, which is experiencing a real energy crisis due to an explosion in electricity demand, has no choice but to open new coal-fired power stations (+55 GW in 2020, i.e., ¾ of the world's additional capacity, and 90 GW are under construction).

There are currently 400 GW of projects and 140 GW under construction worldwide, mainly in Asia (China, India, Vietnam, Indonesia and Japan for 80%). This development runs counter to decarbonization trajectories, which require an immediate halt to new construction and combinations of CCUS or decarbonised fuels such as biomass or ammoniac in existing facilities (or their closure). Complete decarbonization by 2050 involves closing 100 GW every year out to 2030 (IEA's NZE scenario).

Gas capacity increased only moderately for the second year in a row: +1.7%, or +30 GW in 2020. The rise in gas-fired plants was mainly the result of closures of coal and oil-fuelled plants. 80% of ongoing projects (approx. 85 GW) are located in Asia-Pacific, North America and the Middle East.

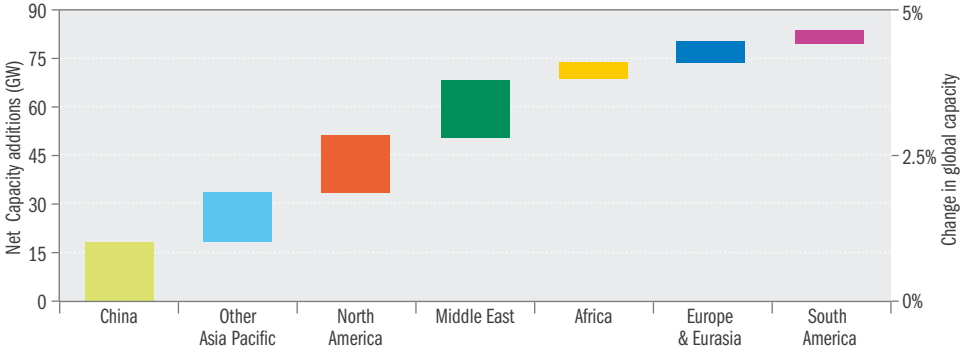
Nuclear power is also subject to mixed trends, which overall have left world capacity more or less unchanged since Fukushima. The current pace of commissioning almost balances that of decommissioning (+8.7 GW and -9.2 GW respectively in 2021, according to the IEA). Capacity declined slightly in 2020 and 2021. The outlook is more positive, with expansion expected in 2022 (+10.5 GW versus -6.8 GW) and the construction of 54 reactors in 19 countries, for a total capacity of 60 GW. The rhythm of closures is more uncertain, as extending the life of old plants in the USA, Europe and Japan is subject to tough rules on safety as well as social acceptance and market conditions. Revived by the need for carbon-neutral energy and projects of smaller and more flexible units (Small modular reactor or SMR), the debate over nuclear power remains lively. In the meantime, this energy source is a important lever of energy transition.

SHARE OF GENERATING CAPACITY BY GEOGRAPHIC REGION IN 2020
TOTAL: 7,805 GW



Source: Enerdata Global Energy & CO_2 Data, 2021

GAS-FIRED POWER GENERATION CAPACITY ADDITIONS BY REGION, 2020-2022



Source: EA, Electricity Market Report, 2021

Electricity: production capacity by power station type

Installed electricitygenerationcapacity in GW	Total capacity			Thermal capacity				Nuclear capacity				Renewable capacity			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in area total 2020	2000	2020	Change 2019-2020	Share in area total 2020	2000	2020	Change 2019-2020	Share in area total 2020
Europe	803	1,264	2.1%	445	515	-1.8%	41%	141	119	-2%	9%	217	630	6.3%	50%
EU-27	633	979	2.0%	357	405	-1.9%	41%	126	107	-2.0%	11%	150	467	6.6%	48%
EU-28	711	1,082	1.7%	419	455	-2.0%	42%	138	116	-1.8%	11%	154	511	6.2%	47%
Germany	119	238	2.7%	81	102	0.1%	43%	22	10	0%	4%	16	127	5.1%	53%
France	115	136	0.5%	26	21	2.2%	15%	63	61	-3%	45%	25	54	3.8%	40%
North America	992	1,393	1.6%	699	874	-0.7%	63%	119	115	-1.7%	8%	175	405	7.9%	29%
Canada	111	148	0.9%	33	37	3.0%	25%	10	14	0%	9%	68	98	0.2%	66%
United States	881	1,246	1.7%	665	838	-0.9%	67%	109	101	-1.9%	8%	107	307	10.6%	25%
Latin America	223	477	5.0%	94	218	5.6%	46%	4	5	0%	1%	125	254	4.7%	53%
Brazil	74	179	4.1%	10	43	4.5%	24%	2	2	0%	1%	61	134	4.0%	75%
Asia	932	3,569	7.0%	673	2,152	3.1%	60%	69	118	1%	3%	190	1,299	14.6%	36%
China	336	2,244	9.3%	254	1,289	4.5%	57%	2	50	2.4%	2%	80	905	17.3%	40%
South Korea	49	126	2.3%	32	79	-1.7%	63%	14	23	0%	18%	3	24	21.5%	19%
India	114	412	1.6%	87	278	0.4%	68%	3	7	0%	2%	25	127	4.4%	31%
Japan	259	349	2.9%	167	194	2.2%	56%	45	33	0%	9%	47	122	5.1%	35%
CIS	329	413	0.3%	234	280	-0.7%	68%	32	44	-2.2%	11%	64	90	5.1%	22%
Russia	211	271	-0.4%	147	188	-0.7%	69%	20	29	-3.2%	11%	44	53	2.4%	20%
Middle East	118	351	4.2%	111	325	3.7%	92%	0	2	147%	1%	7	24	6.5%	7%
Saudi Arabia	31	101	18.8%	31	101	18.9%	100%	0	0	-	0%	0	0	0%	0%
Iran	33	83	2.8%	31	69	3.3%	84%	0	1	0%	1%	2	13	0.5%	15%
Africa	103	243	4.2%	79	185	4.0%	76%	2	2	0%	1%	22	56	5.3%	23%
Egypt	15	61	2.0%	12	55	2.2%	90%	0	0	-	0%	3	6	0.5%	10%
South Africa	42	52	2.9%	38	38	-0.4%	73%	2	2	0%	4%	2	12	15.4%	23%
Pacific	55	94	8.3%	40	50	0.6%	54%	0	0	-	0%	15	44	18.7%	46%
Australia	46	83	8.9%	37	47	0.2%	57%	0	0	-	0%	9	36	23.2%	43%
World	3,553	7,805	4.5%	2,373	4,600	1.7%	59%	367	405	-0.6%	5%	813	2,801	10.2%	36%
OECD	2,154	3,297	2.3%	1,390	1,778	-0.4%	54%	314	288	-1.4%	9%	451	1,231	7.6%	37%
No OECD	1,399	4,508	6.1%	983	2,822	3.1%	63%	53	117	1.3%	3%	363	1,569	12.4%	35%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: detailed thermal capacity

Detail of installed thermal capacity in GW	Total Thermal capacity			Coal & Lignite capacity				Oil capacity				Gas capacity				Biomass & Waste capacity			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020
Europe	445	515	-1.8%	209	174	-4.5%	34%	87	37	-3%	7%	139	256	-0.3%	50%	10.2	49.1	1.6%	9.5%
EU-27	357	405	-1.9%	160	137	-4.7%	34%	79	32	-2%	8%	110	196	-0.2%	48%	9.0	39.1	0.7%	9.7%
EU-28	419	455	-2.0%	193	145	-5.4%	32%	84	36	-3%	8%	132	228	-0.2%	50%	9.8	47.1	0.9%	10.3%
Germany	81	102	0.1%	52	46	-2%	46%	7	3	0%	3%	20	40	2.6%	40%	1.9	12.0	0.0%	11.8%
France	26	21	2.2%	3	3	0%	14%	17	3	0.7%	16%	6	13	3.0%	60%	0.5	2.2	3.1%	10.4%
North America	699	874	-0.7%	337	248	-3.9%	28%	61	41	-3.2%	5%	286	567	1.0%	65%	14.4	18.1	-0.3%	2.1%
Canada	33	37	3.0%	18	11	0%	31%	8	6	0%	16%	7	16	7.2%	44%	1.1	3.2	0%	8.8%
United States	665	838	-0.9%	320	237	-4.1%	28%	53	35	-3.7%	4%	279	551	0.8%	66%	13.3	14.8	-0.4%	1.8%
Latin America	94	218	5.6%	11	21	0.7%	9%	43	62	4.4%	28%	36	114	8.0%	52%	3.3	21.6	2.0%	9.9%
Brazil	10	43	4.5%	2	5	-0.3%	12%	5	8	0.7%	19%	1	15	11.6%	34%	1.8	15.3	1.8%	35.4%
Asia	673	2,152	3.1%	411	1,713	3.8%	80%	135	94	-6.5%	4%	123	313	3.0%	15%	4.3	32.4	1.9%	1.5%
China	254	1,289	4.5%	225	1,217	4.7%	94%	20	15	0%	1%	8	49	1.0%	4%	0.5	8.5	0%	0.7%
South Korea	32	79	-1.7%	14	36	-3.0%	45%	5	3	0%	3%	13	40	0.0%	50%	0.6	1.3	-16.2%	1.6%
India	87	278	0.4%	71	236	0.4%	85%	5	4	0.0%	1%	10	29	0%	10%	0.0	10.3	3.1%	3.7%
Japan	167	194	2.2%	61	95	2.2%	49%	61	33	0.2%	17%	42	59	3.2%	30%	2.0	7.9	3%	4.1%
CIS	234	280	-0.7%	79	75	0.7%	27%	24	26	-1.3%	9%	130	178	-1.3%	64%	0.6	1.4	4%	0.5%
Russia	147	188	-0.7%	42	43	1.0%	23%	16	16	0%	9%	88	128	-1.4%	68%	0.6	0.6	0%	0.3%
Middle East	111	325	3.7%	4	5	0%	1%	50	94	3.2%	29%	58	226	3.9%	70%	0.0	0.0	0%	0.0%
Saudi Arabia	31	101	18.9%	0	0	-	0%	18	48	5.7%	48%	13	53	34%	52%	0.0	0.0	-	0.0%
Iran	31	69	3.3%	0	0	-	0%	9	15	0%	21%	23	54	4.2%	79%	0.0	0.0	0%	0.0%
Africa	79	185	4.0%	41	42	-0.3%	23%	13	30	3.0%	16%	24	113	6.0%	61%	0.2	1.2	0%	0.6%
Egypt	12	55	2.2%	0	0	-	0%	2	5	0%	10%	10	50	2%	90%	0.0	0.0	-	0.0%
South Africa	38	38	-0.4%	38	35	-0.4%	91%	0.3	3	0%	8%	0	0	-	0%	0.1	0.2	0%	0.5%
Pacific	40	50	0.6%	28	25	0%	50%	4	3	4.2%	6%	8	21	1%	41%	0.5	1.3	0%	2.6%
Australia	37	47	0.2%	27	25	0%	53%	4	2	0%	4%	6	19	0%	41%	0.4	1.0	0%	2.1%
World	2,373	4,600	1.7%	1,120	2,303	2.0%	50%	417	385	-0.7%	8%	804	1,787	2%	39%	33.5	125.1	1.5%	2.7%
OECD	1,390	1,778	-0.4%	641	577	-3.0%	32%	227	132	-1.6%	7%	494	990	1%	56%	28.3	79.0	0.3%	4.4%
No OECD	983	2,822	3.1%	478	1,725	3.7%	61%	190	253	-0.2%	9%	310	798	3%	28%	5.2	46.1	3.6%	1.6%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: detailed renewable capacity

Detail of installedrenewable capacityin GW	Total Renewable capacity			Hydro capacity				Wind capacity				Solar capacity				Geothermal capacity			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in area renewable total 2020	2000	2020	Change 2019-2020	Share in area renewable total 2020	2000	2020	Change 2019-2020	Share in area renewable total 2020	2000	2020	Change 2019-2020	Share in area renewable total 2020
Europe	217	630	6.3%	203	249	1.4%	39%	13	218	7.1%	35%	0.2	160	13.9%	25%	1	3	4.0%	1%
EU-27	150	467	6.6%	136	152	0.4%	32%	13	178	6%	38%	0.2	137	15.2%	29%	1	1	3.3%	0%
EU-28	154	511	6.2%	141	156	0.4%	31%	13	204	6%	40%	0.2	150	13.8%	29%	1	1	3.3%	0%
Germany	16	127	5.1%	10	11	-0.1%	8%	6	62	2.4%	49%	0.1	54	9.7%	42%	0	0	0%	0%
France	25	54	3.8%	25	26	0.1%	48%	0	18	7%	33%	0	10	8.6%	19%	0	0	0%	0%
North America	175	405	7.9%	168	183	0%	45%	3	132	12.4%	33%	0.8	86	21.0%	21%	3	4	1.2%	1%
Canada	68	98	0.2%	67	81	0%	83%	0.1	14	1.2%	14%	0	3	0.4%	3%	0	0	-	0%
United States	107	307	10.6%	101	102	0.1%	33%	2	119	13.9%	39%	0.8	83	22.0%	27%	3	4	1.2%	1%
Latin America	125	254	4.7%	123	198	1%	78%	0.1	34	16.2%	14%	0	20	36.4%	8%	1	2	-1.7%	1%
Brazil	61	134	4.0%	61	109	0.2%	82%	0	17	11.4%	13%	0	8	72.3%	6%	0	0	-	0%
Asia	190	1,299	14.6%	185	559	2.7%	43%	2	331	29.0%	26%	0.4	404	23.5%	31%	3	5	0%	0%
China	80	905	17.3%	79	370	3.4%	41%	0.3	282	35%	31%	0.1	253	24.1%	28%	0	0	0%	0%
South Korea	3	24	21.5%	3	7	0%	27%	0	2	8.1%	7%	0	16	35.4%	66%	0	0	-	0%
India	25	127	4.4%	24	51	1.0%	40%	1	39	3.0%	30%	0	38	11.1%	30%	0	0	-	0%
Japan	47	122	5.1%	46	50	0%	41%	0	4	11%	3%	0.3	67	8.9%	55%	1	1	0%	0%
CIS	64	90	5.1%	64	78	0.4%	86%	0	3	61.0%	4%	0	9	44.2%	10%	0	0	0%	0%
Russia	44	53	2.4%	44	51	0.1%	95%	0	1	458.7%	2%	0	2	26.7%	3%	0	0	0%	0%
Middle East	7	24	6.5%	7	17	2%	68%	0	1	20.3%	4%	0	7	18%	28%	0	0	-	0%
Saudi Arabia	0	0.4	0%	0	0	-	0%	0	0	0%	0%	0	0.4	0%	100%	0	0	-	0%
Iran	2	13	0.5%	2	12	0.1%	94%	0	0	0.3%	2%	0	0.4	12.8%	3%	0	0	-	0%
Africa	22	56	5.3%	22	38	2.1%	68%	0.1	7	12.6%	12%	0	10	13.9%	19%	0	0.8	0%	1%
Egypt	3	6	0.5%	3	3	0%	49%	0	1	0%	24%	0	2	1.9%	29%	0	0	-	0%
South Africa	2	12	15.4%	2	4	0%	29%	0	3	26%	21%	0	6	22.1%	49%	0	0	-	0%
Pacific	15	44	18.7%	15	14	0%	33%	0.1	10	30.9%	24%	0	18	32.8%	41%	0.4	1.1	3.1%	3%
Australia	9	36	23.2%	9	9	0%	24%	0	10	33%	27%	0	18	33.0%	49%	0	0	-	0%
World	813	2,801	10.2%	786	1,335	1.6%	48%	17	737	18.1%	26%	2	713	21%	25%	9	16	1.2%	1%
OECD	451	1,231	7.6%	428	498	0.8%	40%	16	370	9.7%	30%	1	353	16.3%	29%	6	10	2%	1%
No OECD	363	1,569	12.4%	358	837	2.0%	53%	2	367	28.0%	23%	0.1	360	26.9%	23%	3	6	0%	0%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: consumption

After a setback in 2020 due to the Covid crisis, growth in electricity demand returns to a steady pace

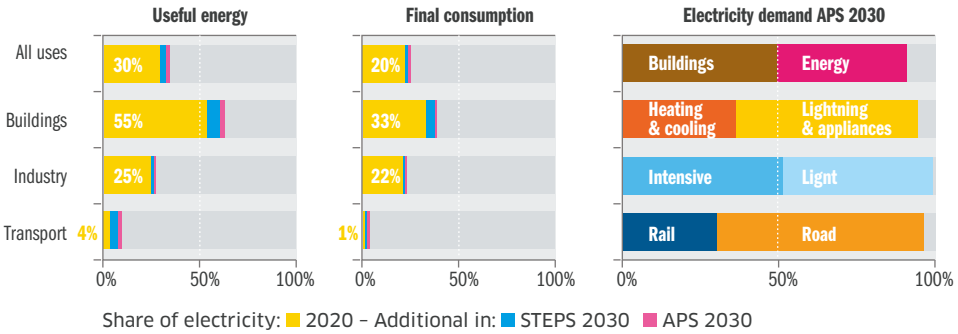
Electricity demand declined relatively little in 2020 (-1% worldwide), as household consumption partly offset reduced activity in the industrial and service sectors. The electrification of uses continued, with record sales of electrical vehicles.

The economic recovery is expected to generate a rebound in world electricity demand worth around 5% in 2021, according to the EIA. The main drivers are China and India, which are both expected to post an 8% increase in demand this year.

The impact will be more moderate in developed countries. Hit by intense cold spells at the beginning of the year, the USA should renew with its demand levels of 2019. The major European markets – Germany, France, Italy and Spain – will rebound by an average 4% but this will not completely make up for the drop in demand in 2020 (-4% to -6%). Japan is lagging behind, with an expected 1% increase nowhere near enough to make up for a 4% drop last year.

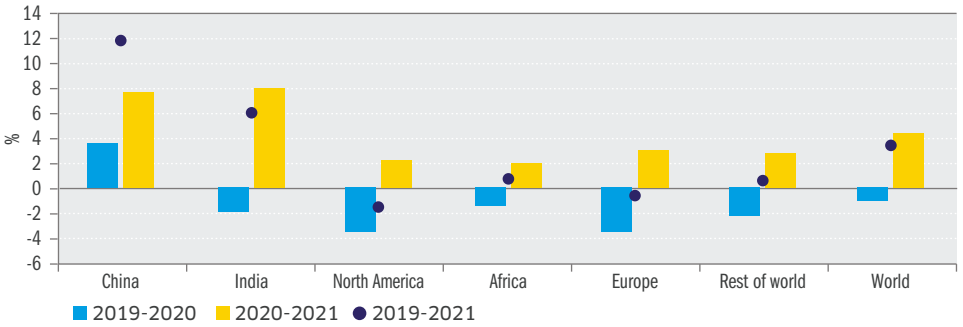
Power demand will remain vigorous over the next decade, driven by economic expansion in developing countries and the electrification of uses required for the integration of renewables. IEA power demand forecasts out to 2030 vary from +2.3% per year under current development conditions (STEPS), to +2.5% per year if COP26 commitments are implemented (APS), and up to 3.4% per year under the academic hypothesis of a carbon neutral trajectory (NZE). The differences reflect efforts made to electrify road transport, building heating and industrial processes. Hydrogen production is another important variable, as it will require a fair amount of electricity (500 TWh in the APS and up to 3,850 TWh in the NZE by 2030). To counteract this trend, better energy efficiency – notably in buildings – is imperative to avoid excessive pressure on both infrastructure and costs. Developing countries (and Asian economies in particular) account for 80% of the increase. It is only under the NZE objective that demand shifts slightly towards mature economies, boosted by electrolysers and a faster electrification of vehicles.

SHARE OF ELECTRICITY IN USEFUL AND FINAL ENERGY DEMAND ACCORDING TO THE IEA SCENARIOS



Source: IEA, World Energy Outlook, 2021

CHANGE IN ELECTRICITY DEMAND IN 2020 AND 2021 BY REGION



Source: IEA, Global Energy Review, 2021

Electricity: consumption

Electricity consumption in TWh	Total electricity consumption							Residential consumption 2020		Services consumption 2020		Industry consumption 2020		Transport consumption 2020	
	2000	2010	2019	2020	Change 2019-2020	AAGR 2010-2020	Share in thetotal World	TWh	Share in regional total	TWh	Share in regional total	TWh	Share in regional total	TWh	Share in regional total
Europe	2,837	3,253	3,278	3,150	-3.9%	-0.3%	14%	965	31%	880	28%	1,169	37%	68	2%
EU-27	2,197	2,508	2,481	2,370	-4.5%	-1%	11%	711	30%	673	28%	878	37%	57	2%
France	385	444	434	412	-5.1%	-0.7%	2%	155	38%	126	31%	113	27%	9	2%
Germany	484	532	500	477	-4.5%	-1.1%	2%	128	27%	127	27%	203	43%	13	3%
Italy	273	299	291	275	-5.4%	-0.8%	1%	66	24%	86	31%	105	38%	13	5%
United Kingdom	330	329	295	281	-4.7%	-1.6%	1%	108	38%	80	29%	83	29%	5	2%
North America	3,988	4,271	4,361	4,198	-3.7%	-0.2%	19%	1,637	39%	1,598	38%	938	22%	13	0.3%
Canada	488	482	531	513	-3.3%	0.6%	2%	179	35%	140	27%	182	36%	1	0.2%
United States	3,500	3,789	3,831	3,685	-3.8%	-0.3%	16%	1,458	40%	1,458	40%	756	21%	12	0.3%
Latin America	773	1,097	1,333	1,303	-2.2%	1.7%	6%	391	30%	311	24%	541	42%	5	0.4%
Brazil	321	438	513	504	-1.8%	1.4%	2%	148	29%	128	25%	193	38%	2	0.4%
Mexico	145	216	280	272	-2.8%	2.3%	1%	66	24%	52	19%	141	52%	1	0.4%
Asia	3,245	6,674	10,720	10,860	1.3%	5.0%	48%	2,284	21%	2,209	20%	5,750	53%	212	2%
China	1,037	3,451	6,524	6,726	3.1%	6.9%	30%	1,137	17%	1,263	19%	4,016	60%	171	3%
India	369	721	1,213	1,186	-2.3%	5%	5%	317	27%	168	14%	472	40%	17	1%
Japan	973	1,036	919	891	-3.1%	-2%	4%	260	29%	290	33%	322	36%	16	2%
South Korea	263	449	526	514	-2.2%	1.4%	2%	71	14%	160	31%	264	51%	3	1%
Middle East	379	721	1,003	1,003	0.0%	3.4%	5%	413	41%	318	32%	220	22%	0.5	0.0%
Iran	95	186	260	266	2.4%	3.7%	1%	90	34%	47	18%	90	34%	0.5	0%
Saudi Arabia	99	203	297	294	-1.0%	3.8%	1%	131	45%	116	39%	43	15%	0.0	0.0%
CIS	847	1,020	1,110	1,092	-1.5%	0.7%	5%	279	26%	211	19%	482	44%	70	6%
Russia	586	701	741	723	-2.5%	0.3%	3%	170	24%	146	20%	330	46%	57	8%
Africa	360	537	684	666	-2.5%	2.2%	3%	242	36%	134	20%	247	37%	5	1%
Egypt	64	124	155	153	-1.0%	2.2%	1%	63	41%	30	20%	42	28%	1	0.3%
South Africa	174	203	204	194	-4.6%	-0.4%	1%	50	26%	35	18%	100	51%	3	1%
Pacific	210	254	263	257	-2.5%	0.1%	1%	73	28%	78	30%	93	36%	6	2%
Australia	173	210	216	211	-2.5%	0.0%	1%	60	28%	68	32%	75	35%	6	3%
World	12,640	17,827	22,751	22,529	-1.0%	2.4%	100%	6,283	28%	5,740	25%	9,439	42%	380	2%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: production

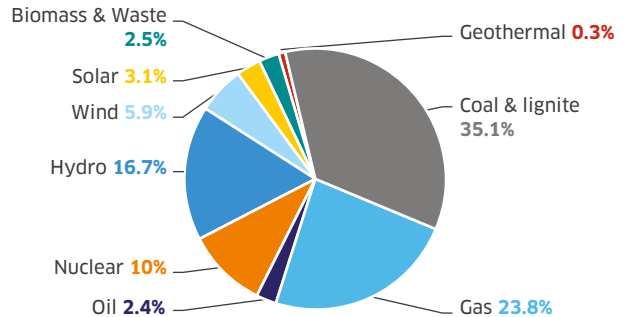
After a favorable 2020 context, renewable electricity production consolidates its growth in 2021

In 2020, when total power production fell 1% and all fossil fuel power sources were plummeting, renewables performed particularly well. Their unexpected 6.5% surge largely stemmed from the fact of their zero marginal costs. In addition, neither the crisis nor operational constraints prevented new plants coming on stream or investment in new capacity. Another growth record is to be hit in 2021 (estimated at 8%). It will bring the share of renewables up to nearly 30% of the world electricity production mix. Combined with nuclear power, carbon-free sources (36%) now exceed coal (35%) in world production. In 2020 in Europe, renewables alone generated more power than all the fossil fuels combined -37% against 36% – while nuclear plants produced the remaining 25%.

Solar and wind power generated two thirds of this growth. Wind production gained 12% in 2020, as it did in 2019, and is expected up 17% in 2021 (+270 TWh at 1,597 TWh) according to the IEA. Solar production has similar momentum: +22% in 2020 and +18% expected in 2021 (+151 TWh at 838 TWh). Three markets – China, the largest, followed by Europe and the USA – account for 90% of the progression. Hydro, representing 17% of total power production, rebounded 2% in 2020, to 4,490 TWh, thanks to major projects coming on stream in China (+12 GW) and in Turkey (+ 2.5 GW).

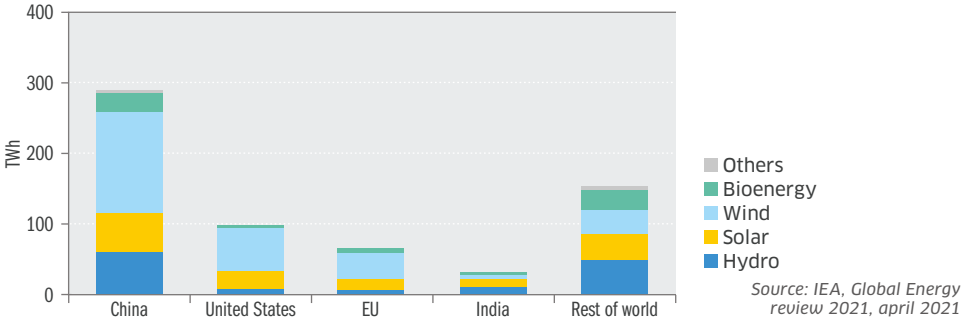
Wind and solar will continue to post rapid growth over the coming decade. Both sectors are benefiting from supportive policies in more than 130 countries as well as cost reductions that have made them competitive on most markets. Their share in the power production mix currently stands at 9%. It is forecasted at 40% in 2050 within a trend scenario, and even up to 70% under the assumption of a decarbonised power system.

SHARE OF ELECTRICY PRODUCTION BY ENERGY IN 2020
TOTAL: 26,860 TWH



Source: Enerdata Global Energy & CO_2 Data, 2021

RENEWABLE ELECTRICITY GENERATION INCREASE BY TECHNOLOGY, COUNTRY AND REGION, 2020-2021



Source: IEA, Global Energy review 2021, april 2021

Electricity: production

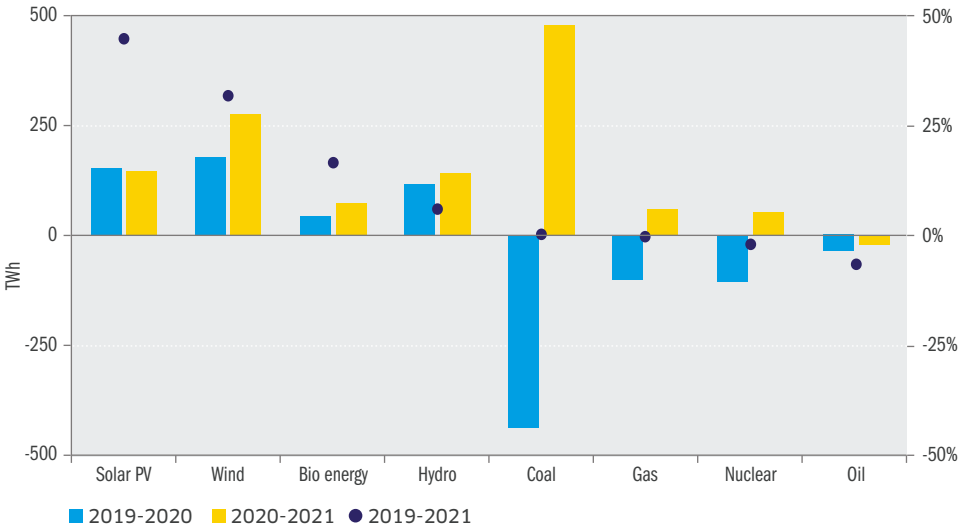
The progression of renewables has not been enough to meet the surge in power demand in 2021, which leads to a strong recovery in coal-fired generation

The context changed radically in 2021, as the rebound in electricity demand (+5%) proved much stronger than the rise in renewables production. Fossil production regained lost ground rapidly and bridged this substantial gap – in excess of 500 TWh. This situation generated extreme pressure in China and India, impacting the whole energy market.

Coal-fuelled production shall increase by 5% in 2021 (+480 TWh), topping its 2019 level and hitting a historical record. Half of the increase will have been in China, where coal stations are contributing more than ever. Their production is expected to increase 340 TWh in 2021, up 7% from 2019. Also under enormous power demand pressure, India mobilised its coal capacity too: in mid-May, the country was generating 80% of its electricity from coal. This year's coal-fuelled production is expected to be 10% greater than in 2019. In Europe and in the USA, the share of coal in power production resumed pre-Covid levels as early as this summer, as higher gas prices favoured coal over CCGT, and despite rising CO_2 prices in Europe.

Although it emits less CO_2, generation from gas remains steady due to its lack of competitiveness relative to coal. Less used in the Asia-Pacific region, where demand is huge, it also faces increasing competition from renewables in the USA and in Europe. This explains why a mere 1% growth is expected in 2021, after a slight decline in 2020 (-0,4%).

CHANGE IN ELECTRICITY GENERATION IN 2020 AND 2021



Source: IEA, Global Energy review 2021, april 2021

Electricity: production

Electricity generation in TWh	Total generation			Thermal generation				Nuclear generation				Renewable generation			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in area total 2020	2000	2020	Change 2019-2020	Share in area total 2020	2000	2020	Change 2019-2020	Share in area total 2020
Europe	3,433	3,708	-3.5%	1,807	1,564	-8.8%	42%	971	758	-10.7%	20%	655	1,386	8.5%	37%
EU-27	2,655	2,775	-4.6%	1,390	1,167	-10.2%	42%	860	684	-10.8%	25%	405	923	9.6%	33%
EU-28	3,032	3,088	-4.5%	1,673	1,334	-10.1%	43%	945	734	-10.8%	24%	414	1,020	10.0%	33%
Germany	577	571	-6.5%	372	300	-11.3%	52%	170	64	-14.4%	11%	35	207	4.8%	36%
France	539	532	-7%	53	57	-8.8%	11%	415	354	-11.3%	67%	71	121	11.3%	23%
North America	4,658	4,906	-2.8%	3,128	2,768	-6.5%	56%	871	926	-2.0%	19%	660	1,212	6.0%	25%
Canada	606	648	-0.7%	174	121	-8%	19%	73	98	-3.0%	15%	359	429	2.1%	66%
United States	4,053	4,257	-3.1%	2,954	2,647	-6.4%	62%	798	828	-1.8%	19%	301	782	8.3%	18%
Latin America	982	1,614	-2.0%	370	724	-4.2%	45%	20	36	0.4%	2%	592	854	-0.1%	53%
Brazil	349	614	-2.0%	38	139	-6.8%	23%	6	14	-13.2%	2%	304	461	0.0%	75%
Asia	3,965	12,667	1.7%	2,943	9,062	-0.1%	72%	505	664	1.9%	5%	517	2,941	7.5%	23%
China	1,356	7,798	3.7%	1,116	5,327	1.8%	68%	17	367	5.1%	5%	223	2,104	8.5%	27%
South Korea	290	563	-2.9%	176	374	-9.1%	66%	109	160	9.8%	28%	6	29	30%	5%
India	562	1,557	-2.5%	469	1,208	-4%	78%	17	43	-1.9%	3%	76	306	4.1%	20%
Japan	1,048	993	0%	625	764	0%	77%	322	51	-26.2%	5%	101	178	10.4%	18%
Pacific	253	310	-2.6%	207	217	-6.2%	70%	0	0	-	0%	46	93	6.9%	30%
CIS	1,250	1,557	-2.6%	816	958	-6.7%	62%	210	294	0.0%	19%	224	304	9.5%	20%
Russia	878	1,092	-3.0%	582	654	-8%	60%	131	216	3.3%	20%	165	222	9.8%	20%
Middle East	472	1,250	0.2%	464	1,204	0.9%	96%	0	7	0.0%	1%	8	39	-15.8%	3%
Saudi Arabia	126	363	-1.1%	126	362	-1.1%	100%	0	0	-	0%	0	1	0%	0%
Iran	121	322	2.6%	118	293	6.0%	91%	0	7	0.0%	2%	4	22	-28%	7%
Africa	445	849	-2.5%	354	659	-3.7%	78%	13	13	-7.9%	1%	78	177	2.7%	21%
Egypt	78	193	-1.0%	64	174	-2%	90%	0	0	-	0%	14	20	12.2%	10%
South Africa	211	240	-5.0%	194	209	-6%	87%	13	13	-7.9%	5%	4	18	5.0%	7%
World	15,459	26,860	-1%	10,089	17,156	-2.7%	64%	2,591	2,698	-3.5%	10%	2,779	7,006	6.3%	26%
OECD	9,784	10,746	-2.7%	6,062	5,946	-6%	55%	2,249	1,879	-5.7%	17%	1,474	2,921	7.9%	27%
No-OECD	5,675	16,114	0.9%	4,027	11,211	-0.7%	70%	342	819	2%	5%	1,306	4,084	5.1%	25%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: detail of thermal production

Detail of thermalelectricity production in TWh	Total Thermal generation			Thermal generation - Coal & Lignite				Thermal generation - Oil				Thermal generation - Gas				Thermal generation - Biomass & Waste			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020	2000	2020	Change 2019-2020	Share in area thermal total 2020
Europe	1,807	1,564	-8.8%	1,039	540	-17.8%	35%	192	36	-36%	2%	527	756	-2.4%	48%	48	232	2%	15%
EU-27	1,390	1,167	-10.2%	844	385	-20.9%	33%	173	36	-34%	3%	332	568	-2.2%	49%	42	178	0%	15%
EU-28	1,673	1,334	-10.1%	966	392	-20.9%	29%	181	38	-30.6%	3%	480	680	-4.6%	51%	46	224	2%	17%
Germany	372	300	-11.3%	304	142	-22%	47%	5	4	-13.8%	1%	53	99	4.6%	33%	10	55	-4.6%	18%
France	53	57	-8.8%	31	5	-16%	9%	7	6	4%	11%	12	35	-11.5%	61%	4	11	-2.3%	19%
North America	3,128	2,768	-6.5%	2,247	864	-22.7%	31%	133	35	-7.1%	1%	668	1,789	3.8%	65%	80	80	-3.4%	3%
Canada	174	121	-8%	118	38	-21.9%	32%	15	6	-8%	5%	34	67	2%	56%	8	10	-8%	8%
United States	2,954	2,647	-6.4%	2,130	826	-23%	31%	119	29	-6.9%	1%	634	1,722	3.9%	65%	72	70	-3%	3%
Latin America	370	724	-4.2%	43	85	-15.9%	12%	173	121	-2.8%	17%	140	440	-3.3%	61%	13	79	3.0%	11%
Brazil	38	139	-6.8%	11	19	-21.6%	14%	15	9	-17.3%	6%	4	56	-7.5%	40%	8	56	2.6%	40%
Asia	2,943	9,062	-0.1%	1,983	7,250	-0.1%	80%	375	118	-8.8%	1%	569	1,420	-0.9%	16%	16	273	11%	3%
China	1,116	5,327	1.8%	1,060	4,925	1.5%	92%	47	12	1.8%	0%	6	263	1.8%	5%	2	127	19.4%	2%
South Korea	176	374	-9.1%	111	207	-15.6%	55%	35	7	-31%	2%	30	148	0.4%	40%	0.1	13	29.5%	3%
India	469	1,208	-4%	390	1,083	-4.8%	90%	21.6	6.5	-14.30%	1%	56	74	4.0%	6%	1	45	3.4%	4%
Japan	625	764	0%	223	322	-2.0%	42%	134.3	29.1	-30.00%	4%	258	363	4.0%	47%	10	50	7.3%	7%
Pacific	207	217	-6.2%	176	151	-3.6%	69%	3	7	-14.8%	3%	26	55	-11%	25%	2	4	-8.1%	2%
CIS	816	958	-6.7%	266	277	-8.6%	29%	57	8	-27.2%	1%	491	670	-5.7%	70%	3	4	4.0%	0%
Russia	582	654	-8.4%	176	155	-13.7%	24%	33	8	-3.4%	1%	370	488	-6.8%	75%	3	3	4.0%	0%
Middle East	464	1,204	0.9%	30	21	-8%	2%	189	262	-6.9%	22%	246	922	3.6%	77%	0	0.2	0.0%	0%
Saudi Arabia	126	362	-1.1%	0	0	-	0%	68	150	-1%	41%	58	213	-1.0%	59%	0	0	-	0%
Iran	118	293	6.0%	1	1	3%	0%	25	25	-11%	8%	92	267	8.0%	91%	0	0	0%	0%
Africa	354	659	-3.7%	208	244	-6%	37%	37	60	-13.3%	9%	109	353	-0.5%	54%	1	2	0%	0%
Egypt	64	174	-2.3%	0	0	-	0%	8	20	-11.1%	12%	57	154	-1.0%	88%	0	0	-	0%
South Africa	194	209	-6%	193	209	-6%	100%	0	0.2	0%	0%	0	0	-	0%	0.3	0.4	0%	0%
World	10,089	17,156	-2.7%	5,991	9,431	-4.5%	55%	1,159	647	-9.8%	4%	2,775	6,405	0%	37%	164	674	5%	4%
OECD	6,062	5,946	-6%	3,780	2,083	-16.8%	35%	591	137	-23.9%	2%	1,548	3,343	1.5%	56%	143	383	2.0%	6%
No-OECD	4,027	11,211	-0.7%	2,211	7,348	-0.3%	66%	567	510	-5.1%	5%	1,228	3,062	-1.6%	27%	21	291	8.9%	3%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: detail of renewable generation

Detail of renewableelectricity generation in TWh	Total Renewable generation			Renewable generation Hydro				Renewable generation Wind				Renewable generation Solar				Renewable generation Geothermal			
	2000	2020	Change 2019-2020	2000	2020	Change 2019-2020	Share in total RES zone 2020	2000	2020	Change 2019-2020	Share in total RES zone 2020	2000	2020	Change 2019-2020	Share in total RES zone 2020	2000	2020	Change 2019-2020	Share in total RES zone 2020
Europe	655	1,386	8.5%	626	683	5.4%	49%	22	507	10.9%	37%	0.1	174	16.2%	13%	6	21	-0.7%	2%
EU-27	405	923	9.6%	379	374	8.0%	40%	21	395	8.5%	43%	0.1	148	17.9%	16%	5	7	-0.5%	1%
EU-28	414	1,020	10.0%	387	382	8.0%	37%	22	471	9.8%	46%	0.1	161	15.9%	16%	5	7	-0.5%	1%
Germany	35	207	4.8%	26	25	-8.4%	12%	9	130	5.0%	63%	0.1	53	11.8%	25%	0	0.2	3.1%	0%
France	71	121	11.3%	71	67	8.5%	55%	0	40	16.3%	33%	0	13	11.3%	11%	0	0.1	-2.3%	0%
North America	660	1,212	6.0%	639	699	1.0%	58%	6	376	13.1%	31%	1	118	17.4%	10%	15	19	5.6%	2%
Canada	359	429	2.1%	359	387	1%	90%	0	38	11%	9%	0	4	4.9%	1%	0	0	-	-
United States	301	782	8.3%	280	312	0.5%	40%	6	338	13.4%	43%	1	113	18.0%	14%	15	19	5.6%	2%
Latin America	592	854	-0.1%	584	709	-2.4%	83%	0.2	103	9.1%	12%	0	34	36%	4%	8	9	-9.1%	1%
Brazil	304	461	0.0%	304	395	-0.6%	86%	0	57	1.9%	12%	0	8	21.2%	2%	0	0	-	
Asia	517	2,941	7.5%	494	1,896	3.4%	64%	2	556	12.7%	19%	0.4	461	21.2%	16%	20	28	1.1%	1%
China	223	2,104	8.5%	222	1,356	3.9%	64%	1	466	16%	22%	0	282	21%	13%	0.1	0.1	0%	0%
South Korea	6	29	30%	6	7	14.4%	25%	0	3	18.1%	11%	0	18	39.7%	64%	0	0	-	-
India	76	306	4.1%	75	178	0.9%	58%	2	64	-4.6%	21%	0	64	26.8%	21%	0	0	-	-
Japan	101	178	10.4%	97	88	9.3%	50%	0.1	8	3.2%	5%	0.4	79	12.9%	45%	3	2	-3.4%	1%
Pacific	46	93	6.9%	43	42	-1.6%	46%	0.2	23	15.7%	25%	0	19	23.5%	20%	3	9	0.3%	9%
CIS	224	304	9.5%	224	292	8.1%	96%	0	5	80.6%	2%	0	6	55.9%	2%	0.1	0.4	-1.9%	0%
Russia	165	222	9.8%	165	218	9.0%	98%	0	1.5	331.8%	1%	0	2	54.3%	1%	0.1	0.4	-1.9%	0%
Middle East	8	39	-15.8%	8	25	-26.9%	65%	0	2	8.6%	4%	0	12	17.7%	31%	0	0	-	-
Saudi Arabia	0	1	0%	0	0	-	0%	0	0	-	0%	0	1	0.0%	100%	0	0	-	-
Iran	4	22	-28.0%	4	22	-29.0%	97%	0	0	12.9%	2%	0	0.3	35.0%	1%	0	0	-	-
Africa	78	177	2.7%	78	140	0.0%	79%	0.2	19	7.4%	11%	0	13	35.0%	7%	0	5	0%	3%
Egypt	14	20	12.2%	14	13	-1.0%	65%	0.1	4	22.2%	20%	0	3	116.3%	15%	0	0	-	0%
South Africa	4	18	5.0%	4	6	2%	33%	0	7	0.0%	37%	0	5	16.3%	30%	0	0	-	0%
World	2,779	7,006	6.3%	2,695	4,486	2.2%	64%	31	1,591	12%	23%	1	837	21%	12%	52	92	0.3%	1%
OECD	1,474	2,921	7.9%	1,411	1,510	3.4%	52%	29	930	12.0%	32%	1	425	18.0%	15%	33	56	0.5%	2%
No-OECD	1,306	4,084	5.1%	1,284	2,975	2%	73%	3	661	12.2%	16%	0	413	23.2%	10%	19	35	-0.1%	1%

Source: Enerdata Global Energy & CO_2 Data, 2021

Electricity: prices

Electricity prices bounced back in 2021 in line with higher fuel and CO_2 prices and stronger demand

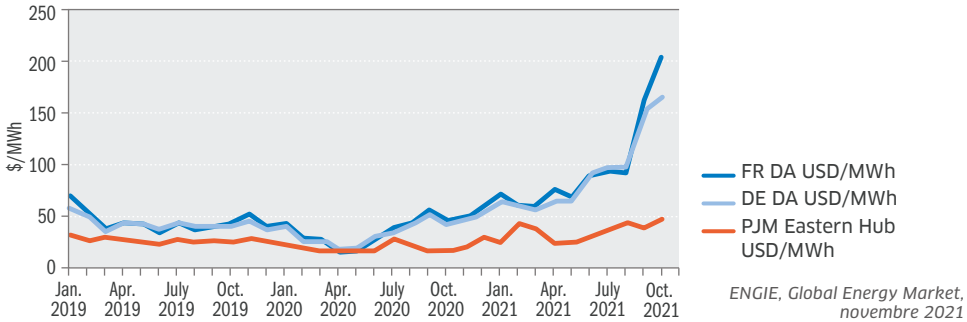
Wholesale electricity prices fell sharply in 2020, in the wake of contracting power demand and lower fossil fuel prices (between 20% and 50%); the share of low marginal cost renewable capacity in the power production mix also played a part. Particularly favourable weather conditions for solar and wind production even led to episodes of negative prices. Prices dived 25% on average in 2020.

Economic recovery and the rapid rebound in power consumption triggered an upturn in prices which return to their pre-Covid level by the middle of the year. The second half of 2021 has seen prices skyrocketing on all markets across the world.

In Europe, electricity prices have tripked since the beginning of the year (from €53 to €150/MWh on the German contract) driven by the increase in fuel prices – between 1st January and 1st November the API2 Rotterdam coal contract rose from €70 to €150/t and the TTF gas contract from €18 to €90/MWh – as well as in European CO_2 allowances (from €32 to €57/t).

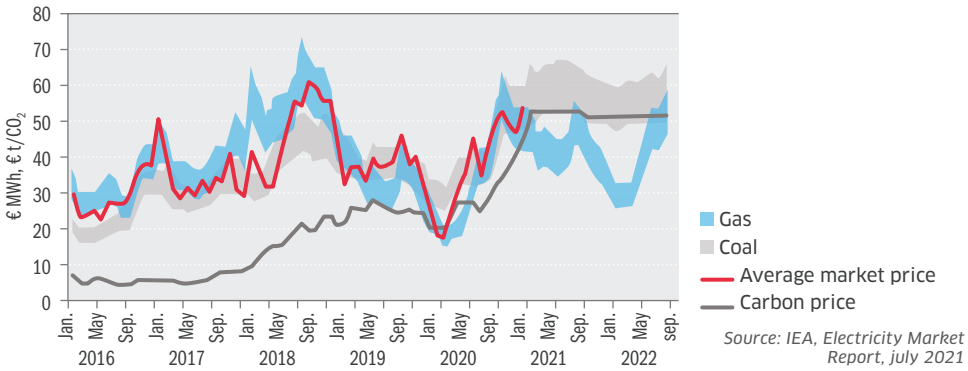
As a result of exceptional weather events in early 2021, prices hit record levels in Japan and the USA,. Extreme cold in Texas derailed the balance between supply and demand, driving wholesale prices up to $9,000/MWh (against approx. $150/MWh end 2020) for just over three days. Japan also experienced particularly intense cold in January. Increased heating demand, combined with limited gas supply, drove power prices to critical levels (over ¥200/kWh against approx. ¥30/kWh end 2020), prompting the Economy Minister to introduce price cap measures (source: IEA, Electricity Market Report).

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



ENGIE, Global Energy Market, novembre 2021

FUELS AND CO_2 PRICES COMPARED TO ELECTRICITY PRICE IN GERMANY



Source: IEA, Electricity Market Report, july 2021

Natural gas & Renewable gases

SUPPLY

Heightened pressure on gas supply following successive incidents and renewed demand is a reminder of the importance of flexible alternatives

In an increasingly integrated system with significant interdependence between power and gas markets and a growing contribution from renewables, supply security is a priority and has to be tackled in a comprehensive manner

HYDROGEN

The falling costs of electrolysers and renewable electricity will alter this market fundamentally in the coming years

Natural gas and energy transition

The distinctive role of natural gas in both the energy mix and the development of renewable gases creates options for the future

Under the spotlight in 2021 because of soaring prices, natural gas faces new questions about its sustainability in a decarbonized world. The future of natural gas is now at a crossroads, with its fate depending mostly on an exit from fossil fuels and support for renewable energy: substitutions in favour of gas allow for a rapid reduction in emissions; it is also a renewable energy when it is produced from agricultural waste (biomethane), or from renewable electricity by electrolysis of water (green hydrogen), or by combining green hydrogen and carbon dioxide emitted by industry (synthetic methane). The role it plays in balancing the electricity system and controlling costs is also crucial to energy transition.

One of the main drivers of the evolution of gas demand in the coming years is the substitution for coal in power production. According to the IEA, this is a major factor in reducing emissions (1,060 g/KWh against 418 g/kWh) which wiped out 750 Mt of CO_2 between 2010 and 2020, mainly in European and US power generation, but also in Chinese building and manufacture. National commitments given ahead of COP26 (APS scenario) involve intensive coal-to-gas conversion that would reduce CO_2 emissions by 180 Mt, and in turn increase gas demand in excess of 100 Bcm in 2030. The carbon neutral scenario requires even more substitution for coal – implying over 185 Bcm of extra gas consumption in 2030 – as well as oil-to-gas substitution in both Middle East power production and Asian manufacturing.

As natural gas emits fewer fine particles than oil and coal, it helps to improve air quality, especially in energy-intensive economies.

Energy requirements in developing countries are the second source of growth in gas demand. First and foremost this concerns the manufacturing sector, where gas can be used in a wide variety of installations, rather than coal, oil or biomass. That said, its deployment will depend on both its availability and the building of new infrastructure.

The limitations of an energy mix based solely on renewable electricity argue for the preservation of gas to reduce supply risks and to control costs. It would be impossible to build a big enough system entirely based on electricity, 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 (mainly due to electric heating), RES intermittency and physical distances between production and consumption. Climate emergency requires speedy decarbonization; given its existing infrastructure, its efficient plants and a cost-efficiency ratio better than many power RES alternatives, gas offers valuable solutions.

Conversely, competition from renewables, improved energy efficiency and electrification will weigh on demand, and particularly so in buildings in countries where gas is used for heating. This will depend on the pace of renovation and improvements in energy efficiency.

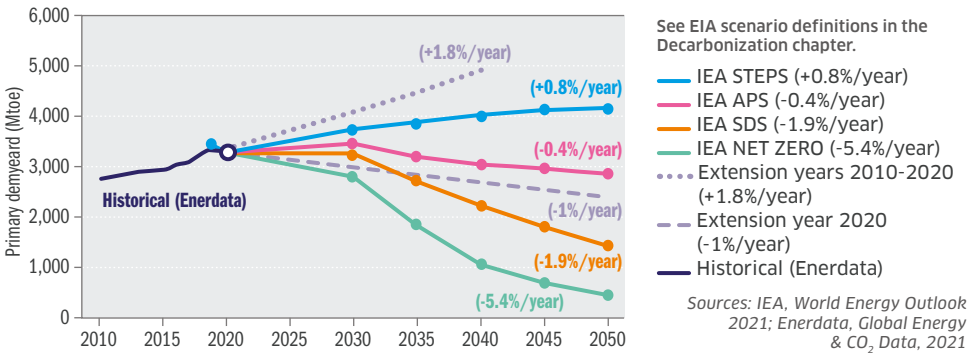
Lastly, demand for methane will depend on the development of the renewable gases, biogas, hydrogen-based fuels and synthesised gas that will gradually replace fossil gas. The main challenges of biogas expansion are building facilities on a large enough scale to reduce costs and that of a supply chain. With support from public policy and economies of scale, hydrogen could become the number one low-carbon fuel.

Natural gas and energy transition

Outlook for natural gas demand in EIA scenarios (WEO 2021). Natural gas demand holds up until 2030, thanks to substitution and emerging countries. But trajectories diverge substantially thereafter as a function of environmental policies. In a carbon neutral scenario, fossil gas is reined in strongly but renewable gases play a bigger role.

- Demand in natural gas increases over the five coming years across all scenarios, notably in emerging countries' industrial sectors and advanced economies' gas-fired power production.
- **In the STEPS scenario,** which takes INDCs into account, fossil gas demand continues to grow up to 2050 (+1,000 Bcm), driven by developing countries, and their light industry in particular (40%).
- **In the APS scenario,** which integrates commitments made ahead of COP26, natural gas world demand peaks around 2025, as increased electrification requires new CCGTs. It declines very slightly thereafter, as declining demand in advanced economies would offset additional demand in the industrial and electricity sectors of developing markets. Countries committed to zero carbon objectives offer radically different prospects, with some still using coal and rapidly decarbonizing their economy thanks to gas China, South Korea) and others about to phase out coal entirely (EU, USA, Japan, Canada, Brazil). Countries that did not set any zero carbon objectives all will report an increase in gas consumption. Within this APS scenario, renewable gas (approx. 3,650 TWh PCS of biogas) and fossil gas with CCUS each represent 9% of the gas total by 2050. Hydrogen plays an important role as soon as 2030 onwards in countries committed to carbon neutrality (3% of the global mix in 2050).
- **In the NZE scenario,** by contrast, fossil gas demand falls rapidly: halved by 2030 and cut by three quarters by 2050, with the remaining volumes covered at 70% by CCUS installations. This performance is achieved through the deployment of carbon neutral power production facilities, as well as the gradual suppression of fossil gas in buildings. The decline in fossil gas is partly offset by the expansion of green gases, however (4,200 TWh of biogas in 2050), of which low carbon hydrogen produced from natural gas combined with CCUS. By 2030, about 250 Bcm will be used in steam methane reformers equipped with CCUS. All in all, primary demand for gas, all types combined, increases nearly 5% by 2030 and contracts by just 20% by 2050, to 3,000 Bcm. Hydrogen represents 13% of the mix in 2050 (22,000 TWh, of which 70% through electrolysis).

GAS PRIMARY DEMAND FORECASTS – WORLD



See EIA scenario definitions in the Decarbonization chapter.

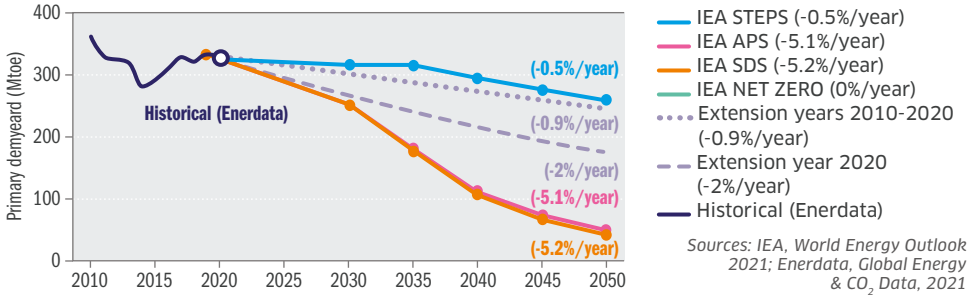
- IEA STEPS (+0.8%/year)
- IEA APS (-0.4%/year)
- IEA SDS (-1.9%/year)
- IEA NET ZERO (-5.4%/year)
- Extension years 2010-2020 (+1.8%/year)
- Extension year 2020 (-1%/year)
- Historical (Enerdata)

Sources: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

Transition started but dynamic too slow

The current natural gas progression mainly reflects coal-to-gas substitution in power production, contributing to lower CO_2 emissions. But insufficient efforts towards energy efficiency prevent a decisive decrease in global energy.

GAS PRIMARY DEMAND FORECASTS – EUROPEAN UNION (EU27)



- IEA STEPS (-0.5%/year)
- IEA APS (-5.1%/year)
- IEA SDS (-5.2%/year)
- IEA NET ZERO (0%/year)
- Extension years 2010-2020 (-0.9%/year)
- Extension year 2020 (-2%/year)
- Historical (Enerdata)

Sources: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

Transition started but dynamic too slow

In the EU – the most ambitious region – natural gas contributes to power production decarbonization through coal substitution. Green gas development must accelerate from 2030 if gas solutions are to be retained within the decarbonization process. The global reduction of energy consumption is a critical point.

Natural gas and energy transition

WORLD NATURAL GAS CONSUMPTION FORECASTS IN IEA STEPS, APS AND SDS SCENARIOS IN BCM

Natural gas demand forecast in Bcm		Stated Policies Scenario				Announced Pledges Scenario				Sustainable Development Scenario			
	2020	2030	2050	AAGR 2020-2050	Share 2050	2030	2050	AAGR 2020-2050	Share 2050	2030	2050	AAGR 2020-2050	Share 2050
Europe	596	587	497	-0.6%	10%	504	234	-3.1%	6%	483	118	-5.3%	5%
North America	1 096	1 154	1 073	-0.1%	21%	933	418	-3.2%	11%	900	328	-3.9%	13%
Central and South America	148	154	191	0.9%	4%	152	154	0.1%	4%	134	98	-1.4%	4%
Asia Pacific	839	1 114	1 442	1.8%	28%	1 105	1 164	1.1%	30%	1 146	880	0.2%	36%
Eurasia	597	663	711	0.6%	14%	668	712	0.6%	18%	634	419	-1.2%	17%
Middle East	559	658	839	1.4%	16%	665	841	1.4%	22%	541	435	-0.8%	18%
Africa	164	208	319	2.3%	6%	210	308	2.1%	8%	193	170	0.1%	7%
International bunkers	1	16	40	12.1%	1%	12	21	9.8%	1%	8	5	4.4%	0%
World	3,999	4,554	5,113	0.8%	1	4,249	3,852	-0.1%	100%	4,038	2452	-1.6%	100%

Source: World Energy Outlook 2021 © OECD/IEA, october 2021

WORLD NATURAL GAS PRODUCTION FORECASTS IN IEA STEPS, APS AND SDS SCENARIOS IN BCM

Natural gas production forecast in Bcm		Stated Policies Scenario				Announced Pledges Scenario				Sustainable Development Scenario			
	2020	2030	2050	AAGR 2020-2050	Share 2050	2030	2050	AAGR 2020-2050	Share 2050	2030	2050	AAGR 2020-2050	Share 2050
Europe	241	200	181	-0.9%	4%	179	96	-3.0%	2%	172	41	5.1%	2%
North America	1,165	1,305	1,188	0.1%	23%	1,071	549	-2.5%	14%	1,006	433	3.4%	18%
Latin America	151	154	209	1.1%	4%	150	162	0.2%	4%	133	98	2.6%	4%
Asia Pacific	643	702	782	0.7%	15%	701	639	0.0%	17%	700	450	1.9%	18%
Eurasia	926	1,088	1,183	0.8%	23%	1,038	990	0.2%	26%	1,006	601	2.3%	25%
Middle East	645	800	1,124	1.9%	22%	805	1,018	1.5%	26%	742	577	2.2%	24%
Africa	244	305	446	2.0%	9%	305	399	1.7%	10%	278	252	1.9%	10%
World	4,014	4,554	5,113	0.8%	100%	4,249	3,852	-0.1%	100%	4,038	2,452	2.5%	100%
Conventional gas	2,899	3,177	3,634	0.8%	71%	3,084	3,047	0.2%	79%	2,975	1,899	2.2%	77%
Tight gas	290	279	223	-0.9%	4%	229	71	-4.6%	2%	277	113	2.3%	5%
Shale gas	742	1,013	1,136	1.4%	22%	853	650	-0.4%	17%	705	373	3.8%	15%
Coalbed methane	80	62	94	0.5%	2%	59	84	0.2%	2%	57	68	1.1%	3%
Other production	3	24	25	7.3%	0%	24	-	-	-	24	-	-	-

Source: World Energy Outlook 2021 © OECD/IEA, october 2021

Natural gas: consumption

Strong recovery in gas demand in 2021, hampered by supply problems

Natural gas demand contracted 1.6% in 2020, with the first half of the year (-4% year-on-year) affected by the pandemic and unusually warm weather that mitigated heating needs. The decline was less marked than for other fossil energy sources, however, as gas is less dependent on power generation than coal and less important to transport than oil. The second half of the year saw the beginning of a recovery, when a combination of attractive gas prices and rising CO_2 prices in Europe conferred a competitive advantage to gas over coal in the power sector.

The situation improved further in 2021 but remains fragile. Gas demand rebounded at end-2020 and in early 2021 as a result of three positive factors: lower than average temperatures in the spring that extended the heating season, rising gas consumption in the power sector and strong economic recovery. This is particularly the case in Asia, and especially in China, which has become the largest LNG import market ahead of Japan. Demand from the industrial sector remained solid throughout the year, however, particularly in Asia and in the Middle East and in Europe.

Demand spiked at the beginning of the year on temperature-sensitive markets such as France, Japan, Korea, North China, and spectacularly so in the USA, where an extreme cold snap unbalanced supply and demand and jacked up prices.

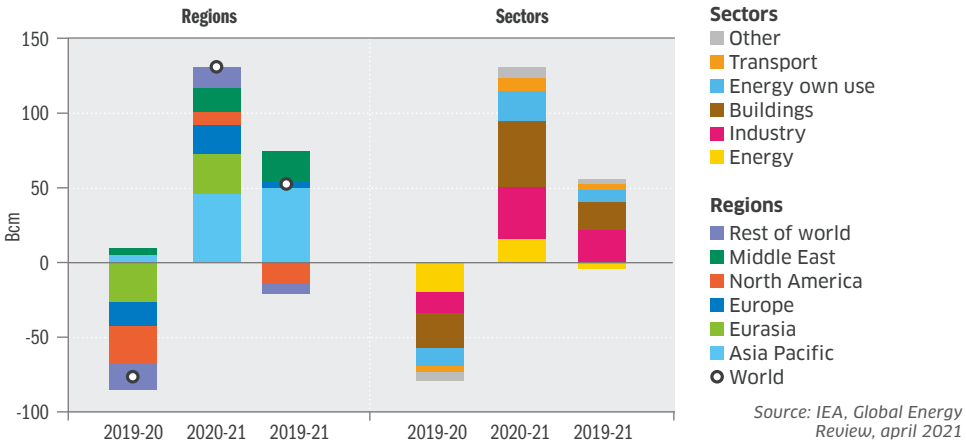
In addition, gas-fired plants benefited from weaker production in the wind, solar and hydro with droughts in key markets (China, California, Brazil, Turkey), nuclear sectors (maintenance delays as a result of Covid) and also in coal, where several plants had been decommissioned amid poor market conditions in the preceding months.

From the middle of the year, pressure on gas supply chains triggered an exceptional surge in European and Asian prices that wiped out what had been favourable arbitrage in the power sector. Even high CO_2 prices in Europe failed to safeguard its advantage.

All in all, gas demand is expected to increase 3% in 2021, according to the IEA. That would incorporate a 1% rise for power generation and a 5% gain in the industrial and residential/services sectors.

2021 is a perfect illustration of the challenges that energy systems will face as extreme weather conditions worsen. It showed the importance of gas plants in preserving flexible contingency capacity that can ensure continued power supply when major weather events occur.

DEMAND BY REGION AND BY SECTOR FROM 2019 TO 2021 IN BCM



Source: IEA, Global Energy Review, april 2021

Natural gas: primary consumption

Natural gas primary consumption in Bcm	2000	2005	2010	2015	2019	2020	Change 2019-2020	AAGR 2010-2020	Share in the world 2020
Europe	505	575	600	500	547	532	-2.8%	-1.2%	14%
EU-27	379	436	449	366	411	398	-3.2%	-1.2%	10%
EU-28	481	536	549	439	489	471	-3.7%	-1.5%	12%
France	40	47	48	39	42	39	-7.3%	-2.2%	1%
Germany	88	91	95	81	95	93	-2.4%	-0.2%	2%
Italy	71	86	83	68	74	71	-4.4%	-1.6%	2%
Netherlands	49	50	56	41	44	44	-1.9%	-2.5%	1%
United Kingdom	102	100	99	73	78	73	-6.2%	-3.0%	2%
North America	753	722	781	882	1,007	985	-2.3%	2.3%	25%
United States	661	623	683	767	884	867	-1.9%	2.4%	22%
Canada	92	99	97	115	123	117	-4.6%	1.9%	3%
Latin America	136	182	215	245	242	223	-7.9%	0.4%	6%
Argentina	37	44	45	51	52	49	-5.9%	0.9%	1%
Mexico	40	55	70	78	83	75	-9.5%	0.7%	2%
Asia	290	393	558	658	794	802	1.0%	4%	20%
China	25	47	125	192	303	325	7.2%	10.0%	8%
India	29	38	53	55	64	63	-1.4%	1.7%	2%
Japan	88	91	111	114	103	100	-3.1%	-1.1%	3%
Pacific	29	30	37	42	47	46	-3.0%	2%	1%
CIS	570	624	663	602	665	645	-3.1%	-0.3%	16%
Russia	391	426	466	445	501	485	-3.3%	0.4%	12%
Middle East	174	255	374	481	537	551	2.6%	3.9%	14%
Saudi Arabia	38	56	73	87	97	97	0.6%	2.9%	3%
Iran	62	99	144	184	212	221	4.2%	4.3%	6%
United Arab Emirates	30	42	61	74	78	75	-3.9%	2.1%	2%
Africa	57	90	108	134	164	158	-3.4%	4%	4%
World	2,515	2,870	3,335	3,543	4,004	3,941	-1.6%	1.7%	100%
OECD	1,411	1,482	1,625	1,649	1,831	1,781	-2.7%	0.9%	45%
Non OECD	1,103	1,389	1,711	1,894	2,173	2,160	-0.6%	2.4%	55%

Source: Enerdata, Global Energy and CO_2 Data, 2021

Natural gas: consumption by sector

Gas consumption by sector in Bcm	Energy		Industry		Transport		Services, Residential & Agriculture		Non energy uses		Total	
	2020	Change 2019-2020	2020	Change 2019-2020	2020	Change 2019-2020	2020	Change 2019-2020	2020	Change 2019-2020	20 2020 19	Change 2019-2020
Europe	199	-4%	109	-4%	2	-5%	202	-1%	20	-5%	532	-3%
EU-27	147	-4%	87	-4%	2	-5%	145	-2%	18	-4%	398	-3%
EU-28	176	-5%	95	-5%	2	-5%	179	-2%	18	-4%	471	-4%
France	9	-8%	10	-7%	0	-6%	19	-7%	1	-7%	39	-7%
Germany	26	-4%	23	-4%	0	0%	41	0%	3	-6%	93	-2%
Italy	32	-5%	10	-8%	1	-8%	28	-2%	1	-8%	71	-4%
Netherlands	18	3%	7	-7%	0	-5%	15	-3%	3	-9%	44	-2%
United Kingdom	30	-11%	9	-7%	0	NA	35	-1%	0.4	0%	73	-6%
North America	520	1%	174	-2.0%	2	15%	255	-8%	34	4%	985	-2%
United States	456	1%	157	-2.0%	2	16%	222	-8.6%	30	5%	867	-2%
Canada	64	-4%	17	-2.6%	0.1	1%	32	-7%	4	-2.6%	117	-5%
Latin America	144	-8%	42	-11%	6	-19%	19	-1%	12	-6%	223	-7.9%
Argentina	27	-7%	8	-7%	2	-24%	12	0%	1	-7%	49	-6%
Mexico	59	-8%	15	-16%	0.1	-15%	1	6%	0.4	-16%	75	-10%
Asia	379	-2%	196	4%	42	5%	125	4%	59	-1%	802	1%
China	93	4%	118	8%	32	9%	70	8%	11	9%	325	7%
India	27	-1%	7	-2%	3	-4%	4	-2%	22	-2%	63	-1%
Japan	71	-1%	11	-10%	0.0	-9%	18	-8%	0.2	-10%	100	-3%
Pacific	27	-5%	10	-1%	0.1	2%	7	2%	3	-6%	46	-3%
CIS	387	-4%	62	-2%	6	-2%	133	-1%	57	-1%	645	-3%
Russia	295	-5%	47	-1%	2.0	-1%	87	-1%	53	-1%	485	-3%
Middle East	312	4%	132	0%	8	2%	69	3%	31	2%	551	3%
Saudi Arabia	64	-1%	27	3%	0	NA	0	NA	7	3%	97	1%
Iran	92	7%	43	1%	8	2%	61	4%	16	1%	221	4%
United Arab Emirates	37	-2%	38	-6%	0	NA	0	NA	0.4	-6%	75	-4%
Africa	103	-4%	24	-4%	0.4	-5%	15	-1%	15	-4%	158	-3%
World	2,071	-2%	748	-1%	67	1%	824	-2%	231	-1%	3,941	-2%
OECD	906	-1%	323	-3.8%	5	0%	491	-5.3%	56	0%	1,781	-3%
Non OECD	1,165	-2%	425	1%	61	1%	334	2%	176	-1%	2,160	-1%

Source: Enerdata, Global Energy and CO2 Data, 2021

Natural gas: production

Heightened pressure on gas supply in 2021 is a reminder of the importance of supply security on the gas market

It would have been hard to imagine in mid-2020 that a severe gas supply crisis would strike in 2021. After all, output had been rising for several years, driven by both US shale gas and LNG development (Yamal, Qatar, etc.). World gas production expanded significantly between 2015 and 2019, with an annual growth rate of 3.5% lifting the total to over 4,000 Bcm threshold by the end of the period. Momentum continued into the first half of 2020, despite lower consumption as the Covid pandemic spread. This resulted in very large stocks in the USA and Europe. But from the third quarter onwards a succession of operational, commercial and climate incidents hit gas production and export capacity, and in combination with a strong recovery in demand this generated severe pressure throughout 2021. Gas production declined 2.8% (-113 Bcm) on average in 2020 and will have rebounded 3.8% in 2021 (+150 Bcm to 4,100 Bcm), according to IEA forecasts.

Still with excess supply in mid-2020, the LNG market ran into difficulty even before the end of the year, when renewed demand coincided with contracting supply. A series of breakdowns, delays and deferred maintenance related to Covid affected many producers (Australia, Indonesia, Peru, Norway, Russia, Trinidad, Nigeria and Angola). Growing pressure on the market resulted in soaring LNG prices in 2021 and fierce competition between buyers that favoured Northeast Asia at the expense of Europe. But it also caused the more flexible swing producers – mainly the USA, but also Qatar and Egypt – to raise their output to meet almost all the additional demand. All in all, LNG supply growth slowed to 1% in 2020, after an annual average of 10% from 2015 to 2019, and is expected to amount to 5% in 2021 (IEA). The end of maintenance operations at traditional suppliers should ease tensions, provided that the coming winter is not too severe.

The situation with pipeline imports has been just as difficult. Friction between Russia and Ukraine disrupted supply to Europe, which is heavily dependent on Russian gas. Russia is the world's second largest producer after the USA, and the number one exporter. Although Russian supply resumed in the third quarter of 2021 via the Blue Stream and TurkStream pipelines, serious uncertainty persists over the start of Nord Stream 2 deliveries. Stung by European accusations of holding back on supplies, Gazprom declared that it would meet a third of additional world gas demand all on its own in 2021.

Large gas inventories in 2020 were depleted significantly in 2021. Winter is setting in and gas stocks are lower than the seasonal average in the major gas regions (16% lower in Europe, 7% in the USA, 17% in Japan and South Korea), as market conditions over the summer prevented the injections needed to bring stock levels back up again. Underground storage capacity played a central role during the January-February cold snap. It also proved crucial to meet additional needs in Europe by offering the necessary flexibility across regions. Once again, 2021 highlighted the importance of storage. A clear lack of capacity in Asia has left the continent dependent on spot LNG imports; the Japanese, South Korean and Chinese authorities have since taken steps to boost storage development.

Long term contracts for large volumes and fixed destinations returned in 2020 and 2021. They represented 82% of new contracts over the first eight months of 2021, reflecting several factors: fewer flexible supply sources (mainly American), high price volatility and unprecedented peaks on spot markets. In recognition of the importance of securing stable prices, buyers and sellers signed long term contracts ranging from 2 Bcm/year (43%) to 2-4 Bcm/year (40%) and even over 4 Bcm/year (17%).

The succession of incidents that hit the gas market over the past year illustrates the importance of flexibility tools in a changing energy system. For example, storage, interconnection and LNG for proved crucial in coping with sharp and unexpected variations in demand or supply. This flexibility also helped to provide secure and continuous supply to gas and power systems that are becoming increasingly interdependent (a point highlighted by the Texan crisis last February).

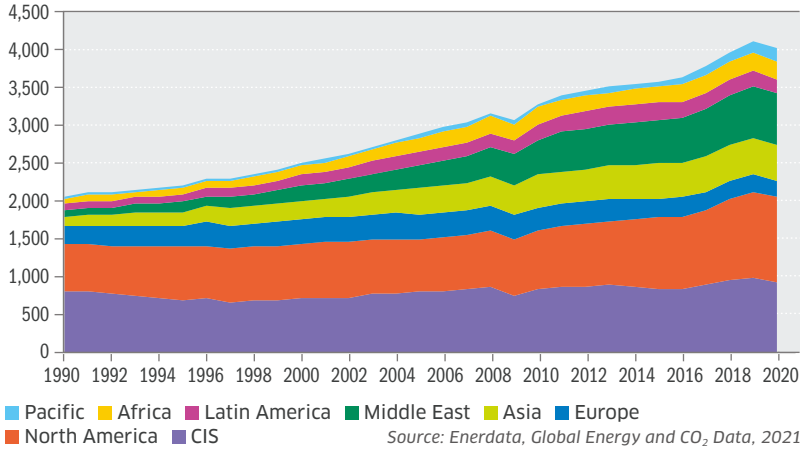
Security is all the more crucial in a energy mix that is shifting towards decarbonization via increases in the share of renewables, either through renewable gases, which require more complex, decentralised and bidirectional systems, or intermittent power renewables.

Natural gas: production

Natural gas production in Bcm	2000	2005	2010	2015	2019	2020	Change 2019-2020	AAGR 2010-2020	Share in the World 2020
Europe	320	329	317	261	230	214	-7.0%	-3.9%	5%
EU-27	150	148	148	98	71	56	-21.3%	-9.3%	1%
EU-28	265	241	206	138	111	95	-13.7%	-7.4%	2%
Norway	53	87	110	121	119	116	-2.4%	0.5%	3%
Netherlands	74	78	90	55	34	24	-28%	-12.4%	1%
United Kingdom	115	93	58	41	40	40	-0.2%	-3.7%	1%
North America	726	700	760	932	1,138	1,125	-1.1%	4.0%	28%
United States	544	512	604	767	962	953	-0.9%	4.7%	24%
Canada	182	188	156	165	176	172	-2.3%	1.0%	4%
Latin America	138	179	211	219	199	181	-8.7%	-1.5%	5%
Asi	251	335	426	449	479	478	-0.2%	1.2%	12%
China	27	49	96	135	176	193	10%	7.3%	5%
Indonesia	70	75	86	75	69	64	-6.6%	-2.9%	2%
Malaysia	50	66	61	69	71	66	-7.7%	1%	2%
Pacific	39	40	58	83	159	171	7.6%	11.5%	4%
Australia	33	36	53	68	142	154	7.9%	11.3%	4%
CEI	709	797	834	844	982	915	-6.8%	0.9%	23%
Russia	573	628	657	638	751	705	-6.1%	0.7%	18%
Turkmenistan	47	63	45	84	87	NA	NA	NA	NA
Moyen-Orient	196	302	467	585	669	674	0.7%	3.7%	17%
Saudi Arabia	38	56	73	87	97	97	0.6%	2.9%	2%
Iran	59	99	144	184	232	234	1.1%	5.0%	6%
Qatar	25	45	121	165	168	167	-0.1%	3.3%	4%
Africa	124	189	209	202	251	236	-6.1%	1.2%	6%
Algeria	82	89	85	84	90	84	-6.8%	-0.1%	2%
World	2,504	2,870	3,281	3,574	4,108	3,995	-3%	2.0%	100%
OECD	1,110	1,104	1,181	1,304	1,545	1,530	-0.9%	3%	38%
Non OECD	1,394	1,766	2,100	2,269	2,563	2,464	-3.8%	1.6%	62%

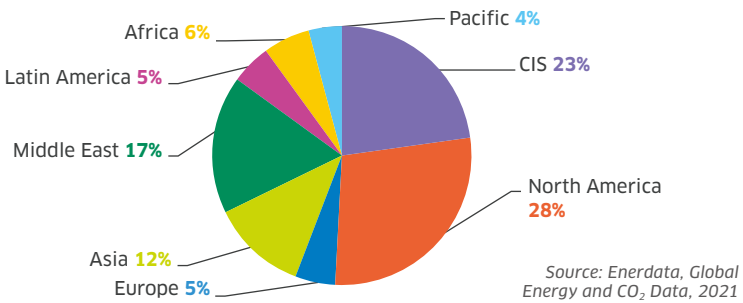
Source: Enerdata, Global Energy and CO_2 Data, 2021

NATURAL GAS PRODUCTION FROM 1990 TO 2020 IN BCM



Source: Enerdata, Global Energy and CO_2 Data, 2021

DISTRIBUTION OF WORLD NATURAL GAS PRODUCTION IN 2020
TOTAL: 3,995 IN BCM



Source: Enerdata, Global Energy and CO_2 Data, 2021

Natural gas: prices

In a very tight market situation, natural gas prices reacted violently

The economic recovery generated an exceptional rally in European and Asian gas prices in 2021.
Wholesale gas prices in Europe (TTF) and LNG spot prices in Asia climbed steeply in 2021, with an acceleration as the market tightened. From around €17/MWh ($6/MBtu) on European markets in January 2021, prices soared to over €110/MWh in the autumn as the heating season started. This was the highest level ever seen since trading on European gas hubs was introduced. The rally came at a very particular time, when strong economic recovery coincided with supply tensions and a general rise in oil and coal prices as well as in CO_2 (see the Price section in other chapters). It has also featured historically high volatility. This reflects uncertainty over the length of time the market will remain undersupplied and unusually low inventories after an atypically cold spring (European stocks were 10 Bcm lower at the start of the autumn than their average of the past five years).

An extreme cold have been experienced during the first months of 2021, first in North-East Asia and then in North America, particularly in Texas. This led to an episode of great tension and price peaks in the Henry Hub at $24/Mbtu (highest peak at $1,250/Mbtu in the OGT hub, Oklahoma).

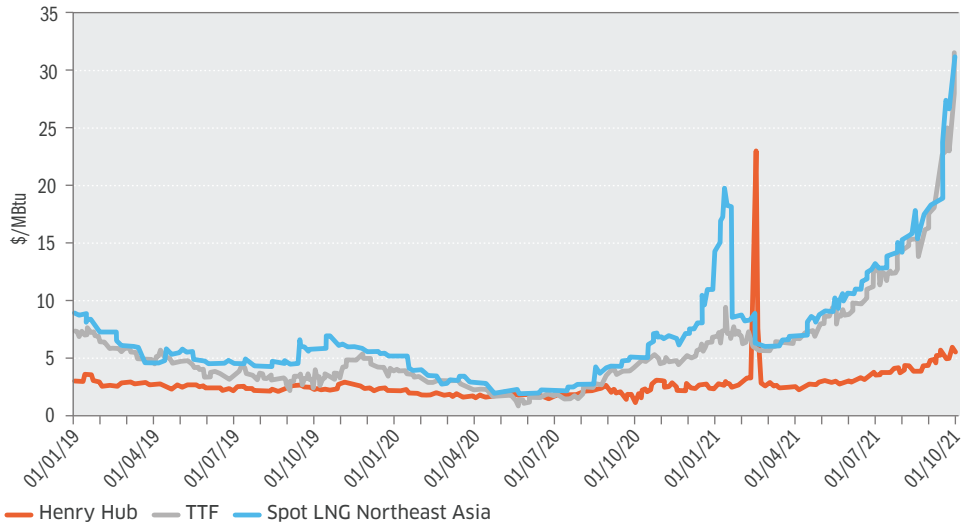
In September, international spot gas prices went stratospheric, with fresh European concern over Russia's ability to increase exports through pipelines and continued competition for cargoes coming from Asia (which are subject to liquefaction restrictions and strong local demand). The simultaneous rally in TTF and Asian LNG spot prices underlines competition between the two markets.

The US market also came under pressure, but to a lesser degree. Henry Hub prices rose above $6/MBtu in October in response to European demand dependent on US LNG deliveries.

By way of comparison, we recall that European TTF prices averaged €13.5/MWh ($4.5/MBtu) in 2019, €9.4/MWh ($3.2/MBtu) in 2020, and surged to €43/MWh ($14.8/MBtu) in early November 2021. Northeast Asian spot prices averaged $5/MBtu in 2019, $2/MBtu in 2020, and $5.8/MBtu in early November 2021.

In the USA, Henry Hub prices averaged $2.8/MBtu in 2019, $2/MBtu in 2020, and hit $4.1/Mbtu in early November this year.

NATURAL GAS PRICES EVOLUTION – DAILY SPOT IN $/MBTU



Source: Q3 2021 – International natural gas prices (CEDIGAZ)

Short term prospects are still subject to significant uncertainty, especially around Russian gas supplies. Forecasts tend to assume reduced tensions and softer prices towards the end of the year, however. This will depend not only on Russian supply but also winter temperatures in Europe, supply from other producers, such as Norway, and the availability of LNG shipments. Given inelastic demand and no scope for switching to coal to produce electricity, volatility should remain high.

Renewable gases: biogas

Green gases, alongside renewable electricity, will be essential for the energy transition

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.

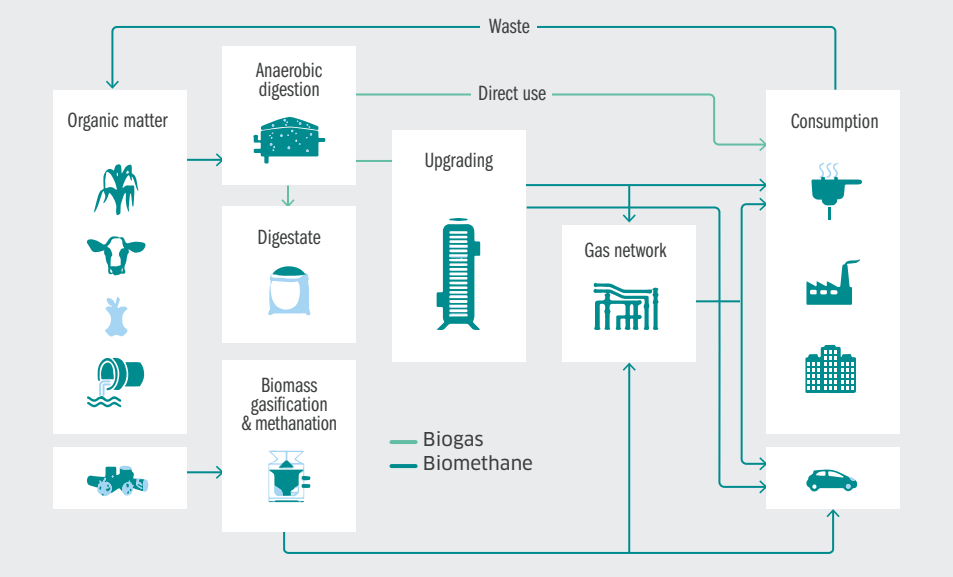
- **Biomethane** is Biogas or purified synthesis gas that can be injected into the natural gas grid as a substitute to natural gas for any type of client and use, including mobility (NGV).

- **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.

HOW BIOGAS AND BIOMETHANE ARE PRODUCED



Source: European Biogas Association, Statistical Report, 2019

Renewable: biogas

Biogas has thrived over recent years because of two major factors: the availability of raw material and the political support. 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).

European biogas production has stagnated in recent years. It experienced exponential growth until 2014, and more attenuated since, mainly as a result of changes in the EEG law* in Germany. In 2019 European Biogas production reached 167 TWh. It remains concentrated at 80% in 3 countries: Germany (82 TWh), UK (20 TWh), Italy (23 TWh).

Biomethane expansion continues in Europe.

In 2019, European biomethane production totalled 26 TWh, up 15 % from 2018. The three main producers were Germany (10 TWh), Denmark (2.6 TWh) and France (2.2 TWh). France reported the fastest growth in terms of both new facilities coming on stream and production.

A rapid expansion in biomethane capacity continued with a 16% increase in the number of facilities between 2018 and 2019. Production rose 15% per year on average between 2017 and 2019.

The potential for biomethane is estimated at approximately 400 TWh by 2030 (10% of natural gas consumption) and over 1,000 TWh by 2050.

*EEG: *Erneuerbare Energien Gesetz*, which is German legislation that favours renewables via regulated purchase prices.

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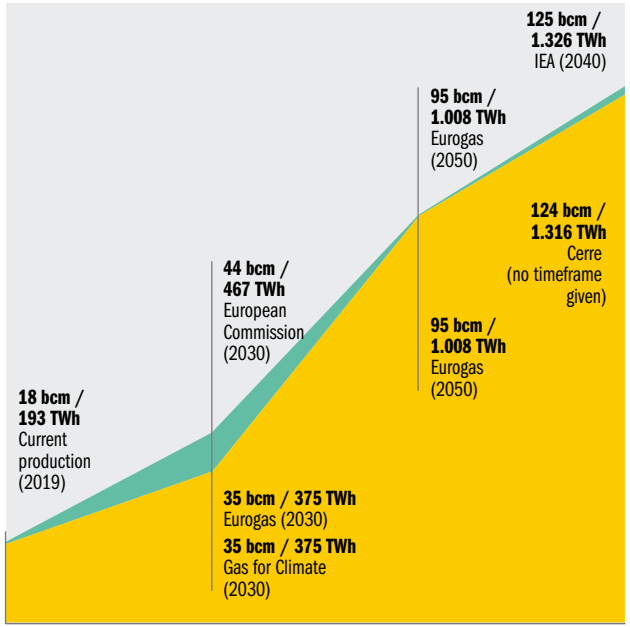
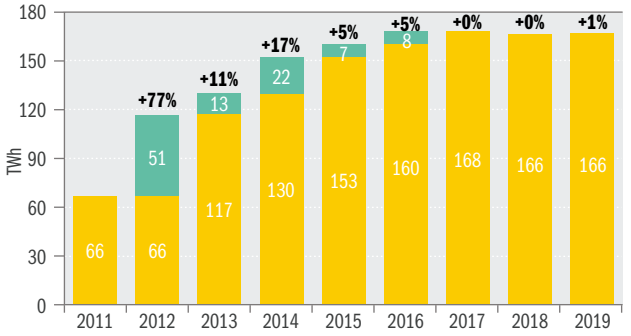
BIOGAS AND BIOMETHANE POTENTIAL IN EUROPE BY 2030, 2040 AND 2050 ACCORDING TO VARIOUS STUDIES (BCM AND TWH)

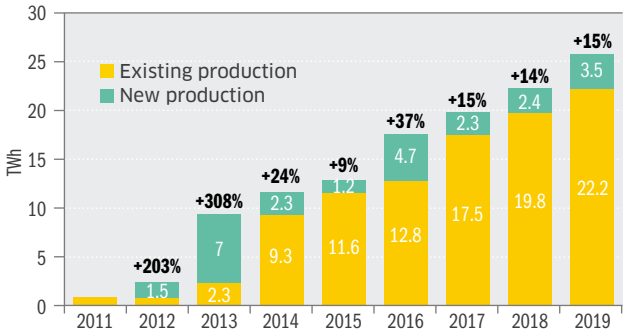


Source: European Biogas Associations « Statistical Report 2021 »

BIOGAS PRODUCTION IN EUROPE, 2011-19 (TWH)



BIOMETHANE PRODUCTION IN EUROPE, 2011-19 (TWH)



Source: European Biogas Associations « Statistical Report 2021 »

Renewable gases 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.

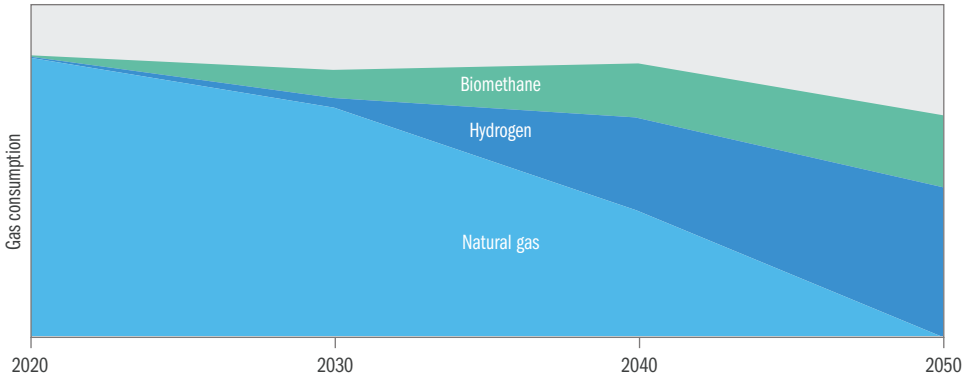
Biogas and biomethane development is very capital-intensive. Production costs largely depend on input prices, facility size and national support mechanisms. They range from €40 to €120 per MWh for production based on anaerobic digestion.

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

Renewable gases: hydrogen

Green hydrogen is about to become the keystone of the energy revolution

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 carbon hydrogen is produced.

- **This so-called "grey hydrogen" is extracted from fossil fuels, notably through natural gas steam reforming** (76% of hydrogen is produced from natural gas and the rest from coal, according to the IEA). In other words, about 96% of the world's hydrogen production is grey hydrogen.
Grey hydrogen is currently the cheapest solution available at around $2/kg H_2, depending on gas and CO_2 local prices. But it is also highly carbon-intensive: 1kg of H_2 produced generates about 10 to 20 kg of CO_2, depending on the production process. 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). Up to 90% of the CO_2 emitted during the production process is captured and stored underground, which raises technical challenges.

- **"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.

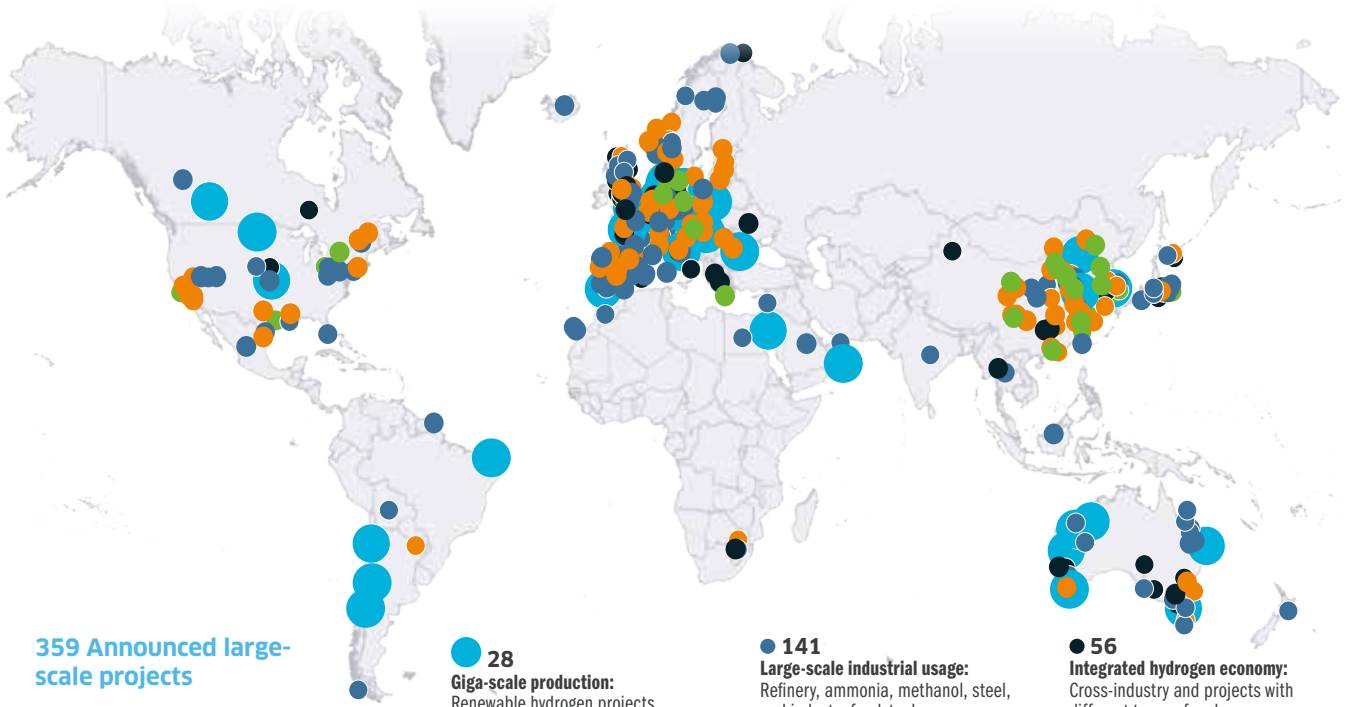
Most of the 70 million tonnes of hydrogen produced each year in dedicated facilities is used to manufacture ammonia and fertilizers, methanol and to refine oil. As it is produced in such large volumes, it is grey hydrogen.

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 65 GW in installed capacity by 2030 according to IHS. The EU has a 2030 target of 40 GW all on its own.
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**

Renewable gases: hydrogen

GLOBAL HYDROGEN PROJECTS ACROSS THE VALUE CHAIN



359 Announced large-scale projects

~USD 500 bn investment by 2030, of which USD 150 bn is associated with mature projects

28
Giga-scale production: Renewable hydrogen projects > 1 GW and low-carbon hydrogen projects >200 ktpa.

141
Large-scale industrial usage: Refinery, ammonia, methanol, steel, and industry feedstock.

96
Transport: Trains, ships, trucks, cars, and other hydrogen mobility applications.

56
Integrated hydrogen economy: Cross-industry and projects with different types of end uses.

38
Infrastructure projects: Hydrogen distribution, transportation, conversion, and storage.

Source: Hydrogen Insights, An updated perspective on hydrogen investment, july 2021

According to the Hydrogen Council, among 359 large-scale hydrogen production projects announced worldwide in mid-2021, 28 are giant projects of a scale larger than 1 GW.

Europe is leading the way, with Australia, Japan, Korea, China and the USA also emerging as future hydrogen hubs.

There is now a consensus among scientists that renewable 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 favorable locations (i.e. where wind and solar power is the most competitive).
- At the same time, establishing a high CO_2 price should accelerate the trend, as it would weigh on grey hydrogen production costs.

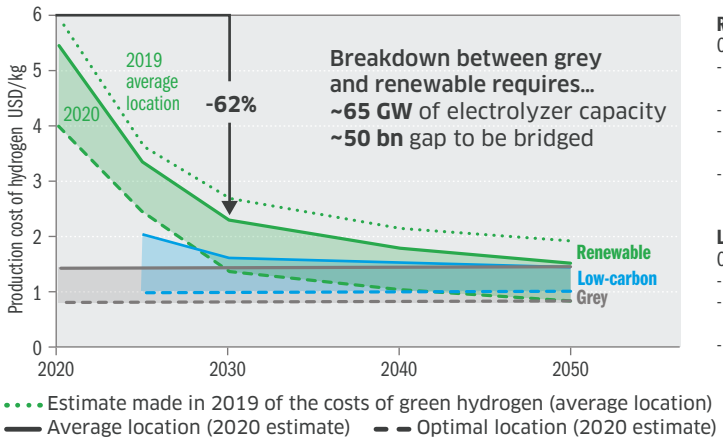
Renewable gases: hydrogen

Greener hydrogen production will go together with new uses. Decarbonising 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 in sectors where direct electrification is difficult: 'heavy' mobility (road, rail, synthetic fuel for maritime and air transport), power storage and production, heat generation and the production of decarbonized synthetic molecules.
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 uses). It can also contribute to decarbonise uses that are impossible to electrify.

Green hydrogen benefits from strong political support. By the end of 2020, over 50 countries had implemented policies aimed at its development or were in the process of doing so, according to BNEF. 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. Many non-EU European countries have followed suit by publishing their own ambitions.

HYDROGEN PRODUCTION COSTS BY PRODUCTION PATHWAY



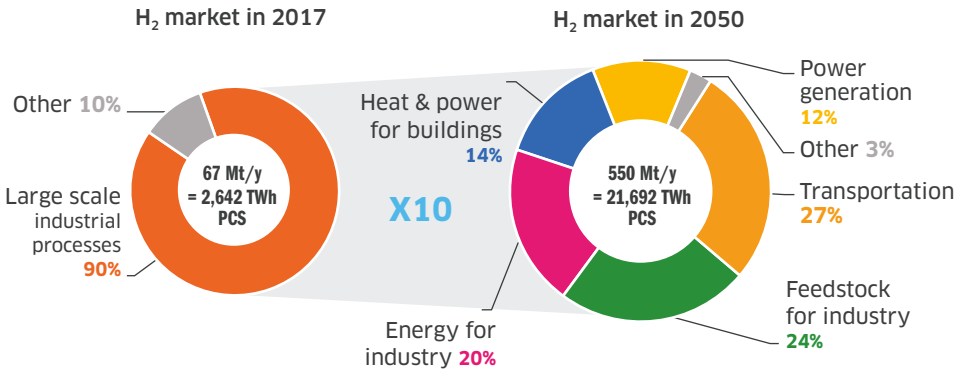
Renewable hydrogen
Conditions for lower costs:
- Dedicated renewable/electrolyser system
- Fully flexible production
- Scale up of renewable hydrogen production
- Additional costs to reach end suplly price

Low-carbon hydrogen
Conditions for lower costs:
- Development of CO_2
- Scale up of low-carbon hydrogen production
- Scale up of CCS outside of hydrogen production

Key assomptions: Gas price 2.6-6.8 USD/Mmbtu – LCOE USD/MWh 25-73 (2020), 13-37 (2030), 7-25 (2050).

Source: Hydrogen Insights: a perspective on hydrogen investment, market development and cost competitiveness, Hydrogen Council&McKinsey, 2021

2050 HYDROGEN MARKET ESTIMATES (ALL TYPES OF HYDROGEN)



Source: Hydrogen Council

Oil

OIL DEMAND

OPEC+ is the only player capable of responding to rebounds in oil demand. It has opted to maintain a canny imbalance on the market via a tight rein on supply

PRODUCTION

In a context of heightened pressure on energy prices, oil markets renewed with highs at $80 per barrel

Oil and energy transition

Comparing the current trajectory with decarbonization roadmaps: the exceptional 9% shortfall in oil consumption caused by the Covid-19 pandemic in 2020 should be entirely bridged by 2022, with world production expected to be around 100 mb/d. Under existing regulations and current technology (IEA STEP scenario), demand will keep rising 1.5% every year over the decade and peak at 103 mb/d in 2030 before levelling off.

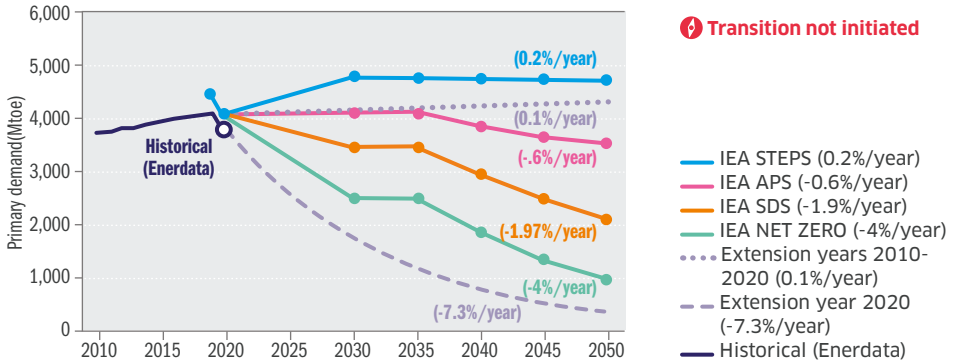
This represents a massive difference from the carbon neutral scenario (NZE) target of 31 mb/d in 2030. The latter requires consumption to drop by 2 mb/d (or by 4.6%) per year out to 2050. By that time it would be down to 22 mb/d, of which two thirds in petrochemicals. Investments in new oil fields after 2021 cannot therefore be justified.

If implemented, national COP26 commitments (APS scenario) would bring the oil peak forward to 2025 and reduce demand by about 1 mb/d per year until 2050, to 77 mb/d. But the overshoot relative to the NZE scenario would amount to 24 mb/d in 2030 and 55 mb/d in 2050.

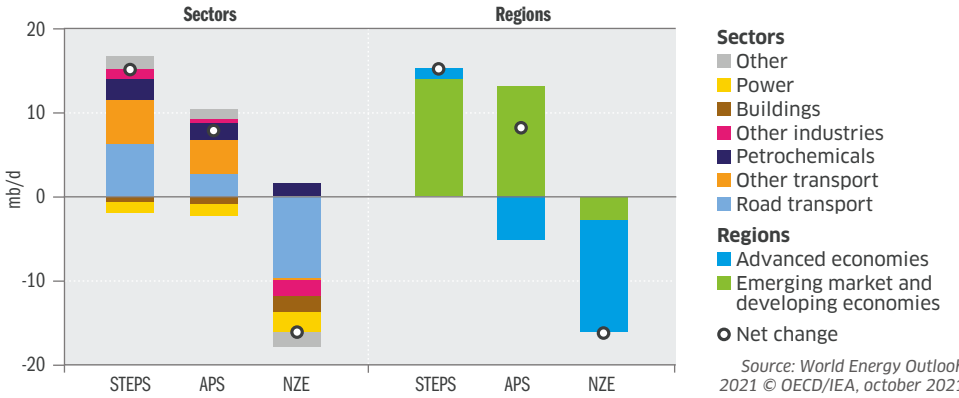
World oil demand will depend on modal shifts, technological progress, consumer choices and political ambition regarding transport. Road transport will play a key role as it is best placed to use substitutes; on the other hand, oil demand for petrochemicals is unlikely to decline. Indeed, the latter actually increases in each scenario in recognition of economic development in the Middle East, China and India. Plastics recycling rates improve in all scenarios.

Biofuels will remain the most important low emission fuel. Their volume increases rapidly under each of the scenarios, and triples in the NZE from 2030. Hydrogen-based fuels only really develop in the NZE and after 2030 to supply 45% of maritime transport and 30% of aviation in 2050. This assumes supportive public policy and large-scale investment in research and production. This scenario also assumes 300 million electrical vehicles in 2030, saving 3.5 mb/d of oil.

PRIMARY OIL DEMAND FORECASTS – WORLD



CHANGES IN OIL DEMAND UNDER DIFFERENT IEA SCENARIOS, 2020-30



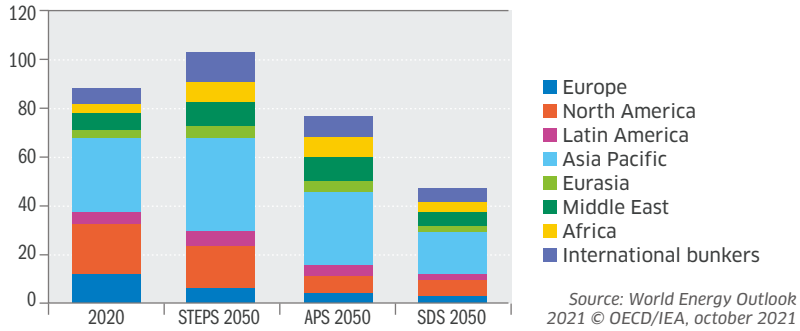
Source: World Energy Outlook 2021 © OECD/IEA, october 2021

Oil: IEA consumption and production forecasts

WORLD OIL CONSUMPTION IN IEA SCENARIOS (MB/D, WEO 2021)

Oil demand forecast in mb/d		Stated Policies Scenario			Announced Pledges			Sustainable Development Scenario		
	2020	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050
Europa	11.9	10.4	6.4	-2.0%	9.0	3.6	-3.9%	8.7	2.2	-5.5%
North America	20.1	21.3	16.7	-0.6%	18.0	7.7	-3.1%	17.7	6.8	-3.5%
Central and South America	5.0	5.4	6.0	0.6%	4.8	4.0	-0.7%	4.5	2.4	-2.4%
Asia Pacific	30.8	38.5	38.8	0.8%	37.8	30.1	-0.1%	33.0	17.2	-1.9%
Eurasia	3.7	4.4	4.5	0.7%	4.4	4.5	0.7%	4.0	2.6	-1.2%
Middle East	6.7	8.2	10.2	1.4%	8.2	10.2	1.4%	7.2	6.1	-0.3%
Africa	3.6	5.1	8.4	2.9%	5.0	7.9	2.7%	4.6	4.3	0.6%
International bunkers	6.1	9.6	11.9	2.3%	8.9	8.8	1.2%	7.9	5.4	-0.4%
World	87.9	103	103	0.5%	96.1	76.7	-0.5%	87.6	47.0	-2.1%

Source: World Energy Outlook 2021 © OECD/IEA, October 2021

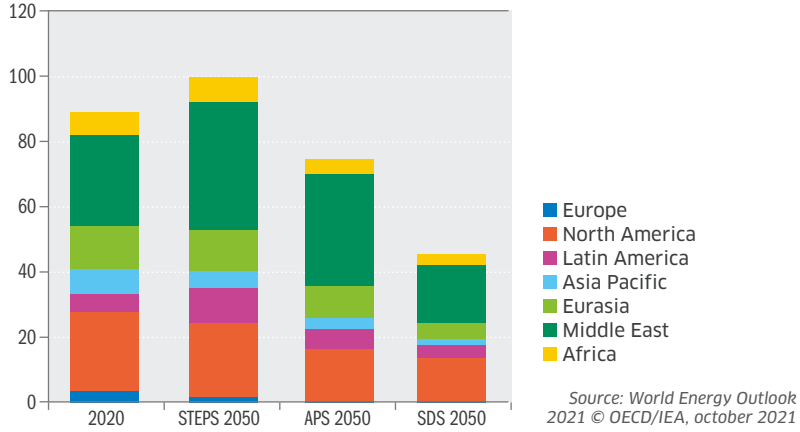


Source: World Energy Outlook 2021 © OECD/IEA, october 2021

WORLD OIL PRODUCTION IN IEA SCENARIOS (MB/D, WEO 2021)

Oil production forecasts in mb/d		Stated Policies Scenario			Announced Pledges			Sustainable Development Scenario		
	2020	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050
Europa	3.80	3.20	1.60	-2.8%	2.90	0.70	-5.5%	2.60	0.70	-5.5%
North America	23.8	27.7	23.2	-0.1%	25.2	15.6	-1.4%	23.7	13.3	-1.9%
Central and South America	5.9	7.9	10.9	2.1%	7.5	6.2	0.2%	6.7	3.4	-1.8%
Asia Pacific	7.5	6.2	4.7	-1.5%	5.6	3.2	-2.8%	5.1	1.9	-4.5%
Eurasia	13.4	14.4	12.5	-0.2%	13.9	10.2	-0.9%	11.9	5.1	-3.2%
Middle East	27.7	34.0	39.7	1.2%	32.1	34.3	0.7%	29.3	17.9	-1.4%
Africa	7.0	6.9	7.3	0.1%	6.5	4.1	-1.8%	6.0	3.4	-2.4%
OPEC	30.9	36.6	43.7	1.2%	34.6	35.4	0.5%	31.7	19.6	-1.5%
non OPEC	58.3	63.8	56.2	-0.1%	59.1	39.1	-1.3%	53.6	25.9	-2.7%
World production	89.2	100.4	99.9	0.4%	93.7	74.4	-0.6%	85.4	45.6	-2.2%
Conventional crude oil	59.6	64.1	61.2	0.1%	59.9	46.6	-0.8%	53.6	25.1	-2.8%
Tight oil	7.3	10.6	10.9	1.3%	9.8	7.8	0.2%	8.7	6.4	-0.4%
Natural gas liquids	18.1	20.4	21.4	0.6%	19.3	17.2	-0.2%	18.6	11.7	-1.4%
Extra-heavy oil & bitumen	3.3	4.1	5.0	1.4%	3.8	2.3	-1.2%	3.5	2.2	-1.3%
Other	0.9	1.2	1.4	1.5%	0.9	0.5	-1.9%	1.0	0.2	-4.9%

Source: World Energy Outlook 2021 © OECD/IEA, October 2021



Source: World Energy Outlook 2021 © OECD/IEA, october 2021

Oil: consumption

Oil was the energy source worst affected by Covid-related restrictions. Consumption resumed rapid expansion in 2021 amid strong pressure on the whole energy market in the second half of the year

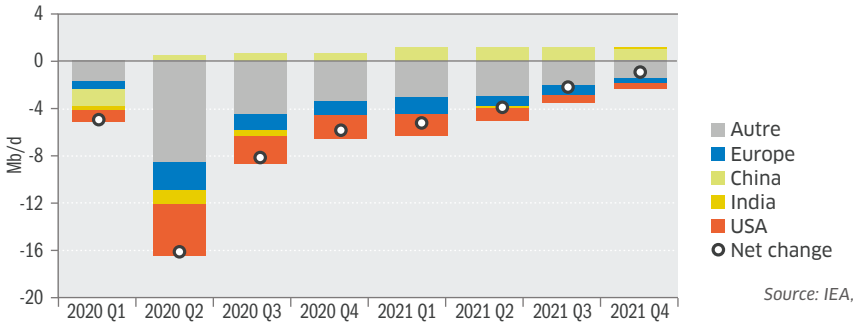
The Covid-19 pandemic and the economic crisis had an unprecedented impact on world oil demand in 2020 (down 9%, or by 8.7 mb/d). Oil was the most severely hit of all energy sources because of reduced travel: transport represents 60% of today's oil consumption. In 2020, kerosene demand dropped 41% and air traffic by 69%; overall fuel demand declined 12%. Only petrochemical-related demand rose, reflecting heightened demand for Covid-related plastic packaging and personal protective equipment.

Among the major economies, and thanks to the easing of restrictions and an early economic recovery, China is so far alone in having rebounded to pre-crisis consumption levels. By 2021, consumption was 9% above its 2019 figure.

The Covid-related drop in consumption will not be entirely made up in 2021 because air transport has recovered only slowly. International aviation is still expected 20% below pre-Covid levels by the end of 2021. In contrast, and in line with other segments, world gasoline demand is almost back to pre-Covid levels (just 2% short). Lastly, the rally in gas prices has encouraged power producers to move out of gas and into oil. This arbitrage meant an extra 500 kb/d in oil product consumption over the second half of the year.

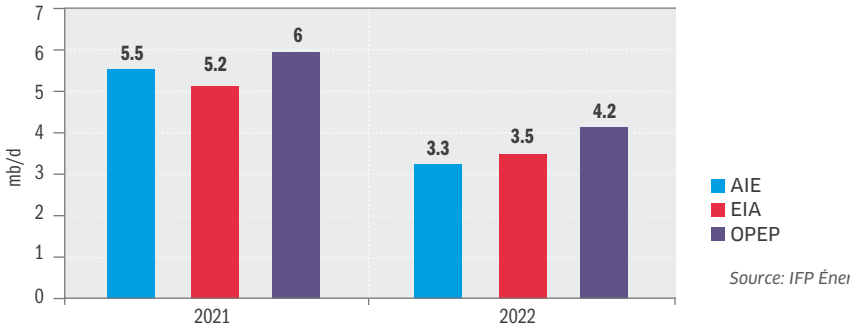
According to the IEA, world oil demand will increase 6% (or by 5.5 mb/d) in 2021, to 96.3 mb/d. This would be 3.2% less than pre-Covid. In 2022, demand is expected to rise 3.4% (by 3.3 mb/d) to 99.6 mb/d, matching its 2019 level (IEA, October 2021). These projections depend on economic activity, which is showing signs of faltering in all regions.

QUARTERLY OIL DEMAND IN 2020 AND 2021 AGAINST 2019



Source: IEA, Global Energy Review 2021

OIL DEMAND IN 2021 ET 2022 (MB/D)
IEA, EIA, OPEC



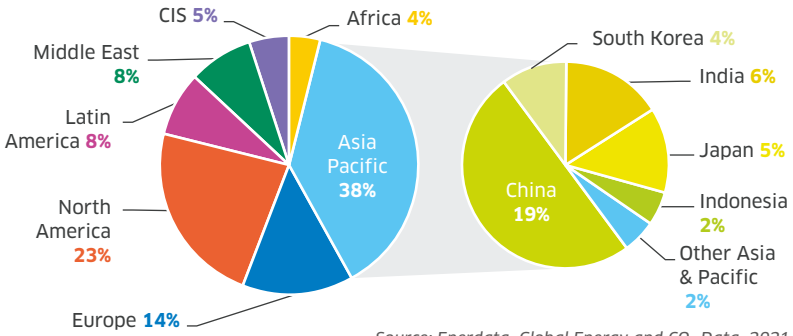
Source: IFP Énergies Nouvelles, october 2021

Oil: consumption

Total oil consumption in Mt	2000	2005	2010	2015	2019	2020	Change 2019-2020	Share of world 2020
Europe	692	704	637	593	600	485	-19.3%	14%
Germany	130	121	109	105	103	94	-8.9%	3%
France	91	91	80	78	74	63	-14.5%	2%
United Kingdom	68	68	59	57	57	48	-15.5%	1%
North America	974	1,013	906	880	917	816	-11.0%	23%
Canada	89	98	98	100	101	87	-14.0%	2%
United States	886	914	808	780	815	729	-10.6%	21%
Latin America	283	289	330	340	320	277	-13.5%	8%
Brazil	91	88	104	114	105	100	-4.4%	3%
Mexico	85	83	86	80	76	65	-14.6%	2%
Venezuela	20	25	30	27	19	-	-	-
Asia	952	1,097	1,193	1,406	1,541	1,270	-17.6%	36%
China	249	349	416	543	640	677	5.8%	19%
South Korea	107	111	118	135	139	130	-6.7%	4%
India	116	126	154	198	233	210	-9.9%	6%
Indonesia	54	63	67	73	80	72	-10.2%	2%
Japan	263	255	216	205	180	165	-8.1%	5%
Pacific	43	46	48	53	57	54	-5.0%	2%
CIS	152	156	177	177	194	169	-12.8%	5%
Russia	110	111	134	131	144	140	-2.9%	4%
Middle East	210	256	319	362	350	282	-19.5%	8%
Saudi Arabia	70	87	122	156	136	128	-5.5%	4%
United Arab States	8	10	14	17	20	16	-18.6%	0%
Iraq	20	22	29	35	38	33	-13.6%	1%
Iran	64	75	81	85	87	79	-8.8%	2%
Kuwait	9	15	20	19	19	18	-4.0%	1%
Africa	98	118	151	178	184	164	-10.8%	5%
South Africa	15	18	22	25	27	23	-13.4%	1%
World without bunkers	3,403	3,677	3,760	3,989	4,163	3,516	16%	100%
Air and sea bunkers	271	316	356	378	399	338	15%	9%
World Total	3,674	3,993	4,116	4,367	4,562	3,854	-15.5%	100%

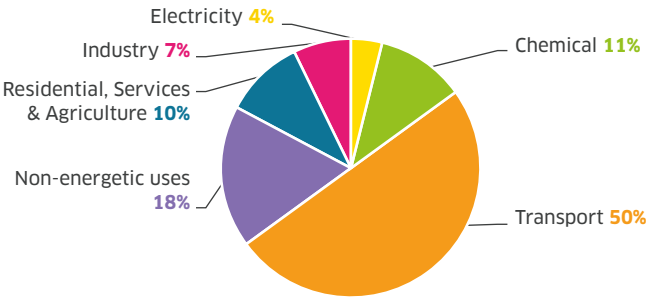
Source: Enerdata, Global Energy and CO_2 Data, 2021

GLOBAL OIL DEMAND (WITHOUT AIR AND SEA BUNKERS) BY GEOGRAPHIC REGION IN 2020
TOTAL: 3,516 MT



Source: Enerdata, Global Energy and CO_2 Data, 2021

GLOBAL OIL DEMAND BY SECTOR IN 2020
TOTAL: 3,854 MT



Source: Enerdata, Global Energy and CO_2 Data, 2021

Oil: production

OPEC+ is the only player capable of responding to rebounds in oil demand. It has opted to maintain a canny imbalance on the market via a tight rein on supply

In the face of a slump in demand, oil producers were forced to reduce supply drastically in 2020 (by 7%, or 6.7 mb/d on average over the year, to 93.9 mb/d – source: IEA). As oil inventories became completely saturated and prices plummeted, OPEC+ (+ referring to Russia) agreed a 10 mb/d cut in production as early as May. This was not enough to rebalance the oil market, however. On average, 3 mb/d in oversupply persisted over the year. This critical situation led the industry to cut investment and development projects by approximately a third.

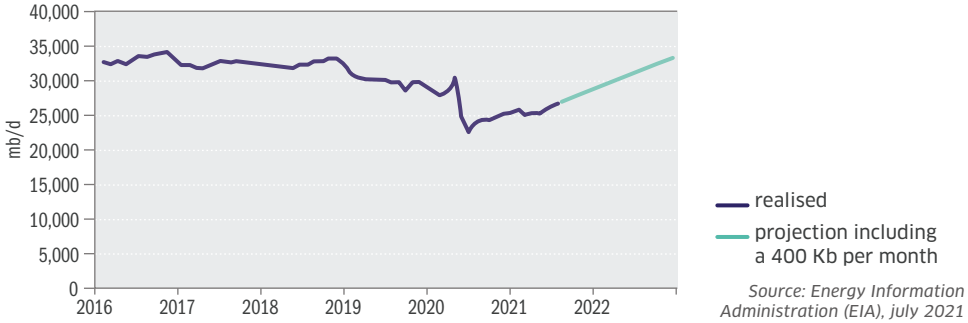
Economic recovery revitalized production in 2021. Oil supply remained essentially an OPEC+ matter, and its combined excess capacity amounted to almost 8 mb/d during the year. The cartel has raised production since January, but in July it decided on a steady 400 kb/d increase each month starting in August, to be continued until pre-Covid levels are reached, probably in September 2022. Lower US production following Hurricane Ida in early September in the Gulf of Mexico (-1.5 mb/d), combined with increasing demand (+6 mb/d) and high oil prices meant a favourable context for the agreement.

World production should rise by 1.4 mb/d in 2021, of which 1 mb/d from OPEC+, to 95.3 mb/d (source: IEA). That would represent a negative balance of 1 mb/d. The small rise in US production marked a radical change from previous years, when the US dominated world supply growth.

For 2022, the IEA expects an over 6 mb/d rise in oil production, with two thirds of it coming from OPEC+ assuming that the cartel lifts its production restrictions (6 mb/d supply gap relative to pre-Covid). But oil prices are currently above breakeven for most oilfields and this situation offers no real incentive for producers to increase supply.

Weak and only slowly recovering investment in 2021 will weigh on world production capacity in the coming years. Apart from short-term economic circumstances, investment in the oil sector has been in structural slowdown for the past 5 years.

OPEC PRODUCTION 2016-22 (MB/D)



Source: Energy Information Administration (EIA), july 2021

OPEC EXCESS CAPACITY (IN MB/D AND SHARE OF WORLD CONSUMPTION)

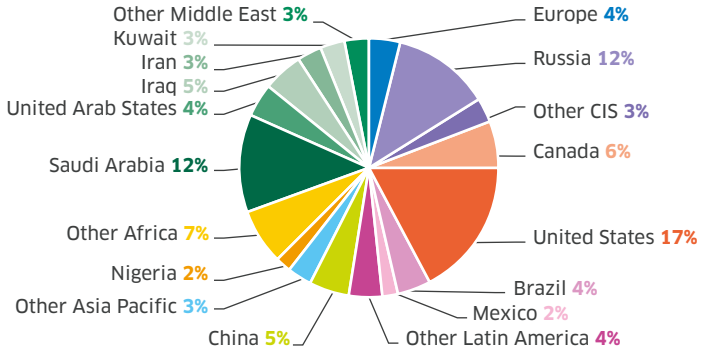
Source: Catallaxis, Les Cahiers Verts de l'Économie, August 2021

Oil: production

Crude Oil, NGL production, LNG in Mt	2000	2005	2010	2015	2019	2020	Change 2019-2020	Share of world 2020
European union	336	268	202	169	163	176	8.3%	4%
Norway	161	133	100	88	80	95	18.8%	2%
United Kingdom	126	85	63	45	52	48	-7.0%	1%
North America	478	450	498	789	1,015	977	-3.7%	23%
Canada	125	140	164	222	267	255	-5%	6%
United States	353	310	334	567	748	722	-3%	17%
Latin America	530	569	539	532	418	397	-5.0%	10%
Brazil	64	85	107	127	146	156	7.1%	4%
Mexico	169	188	145	127	95	95	0%	2%
Venezuela	179	182	165	147	57	-	-	-
Asia	340	357	375	383	349	342	-2%	8%
China	163	181	204	217	198	201	1.6%	5%
India	36	37	42	41	38	35	-5.9%	1%
Indonesia	70	52	48	40	37	35	-5%	1%
Pacific	38	28	27	19	17	19	15.5%	1%
CIS	392	573	656	677	709	650	-8.2%	16%
Russia	322	466	504	534	561	512	-8.6%	12%
Kazakhstan	35	62	81	81	92	87	-5.4%	2%
Middle East	1,135	1,234	1,207	1,371	1,386	1,263	-8.9%	30%
Saudi Arabia	436	514	461	565	547	508	-7.0%	12%
United Arab Emirates	121	133	137	178	182	165	-9%	4%
Iraq	129	94	117	173	235	206	-12.3%	5%
Iran	199	220	214	161	147	133	-9.3%	3%
Kuwait	105	135	123	152	145	131	-9.2%	3%
Africa	387	477	498	394	403	358	-11.1%	9%
Nigeria	115	129	127	106	101	87	-14.3%	2%
World	3,636	3,956	4,002	4,333	4,458	4,183	-6.2%	100%

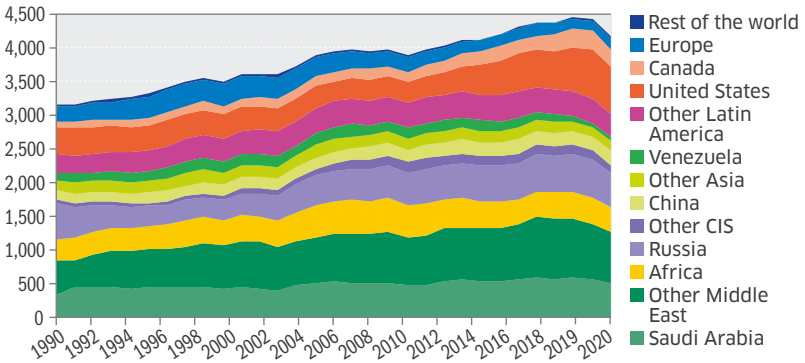
Source: Enerdata, Global Energy and CO_2 Data, 2021

GLOBAL OIL PRODUCTION BY GEOGRAPHIC REGION IN 2020
TOTAL: 4,183 MT



Source: Enerdata, Global Energy and CO_2 Data, 2021

OIL PRODUCTION EVOLUTION BETWEEN 1990 AND 2020 (MT)



Source: Enerdata, Global Energy and CO_2 Data, 2021

Oil: prices

A long way back from their slump in 2020, oil prices surged in 2021. This both highlights our continued reliance on this energy source and the difficulties of replacing it

Oil prices plummeted during the worst of the lockdowns in 2020, and consumption contracted by over a quarter. Dropping 70% in four months, they bottomed out at $ 18 in April 2020. OPEC+ responded rapidly and cut its production by 10 mb/d in May. Subsequent announcements of recovery plans and the gradual easing of restrictions allowed oil prices to rebound to $ 29 in May and $ 40 in June. The arrival of vaccines and their promise for renewed consumption underpinned bullish sentiment in the autumn, and oil prices were up to $ 50 by the end of the year. The 2020 average price was $ 42, down 35% from its pre-Covid level ($ 64 in 2019).

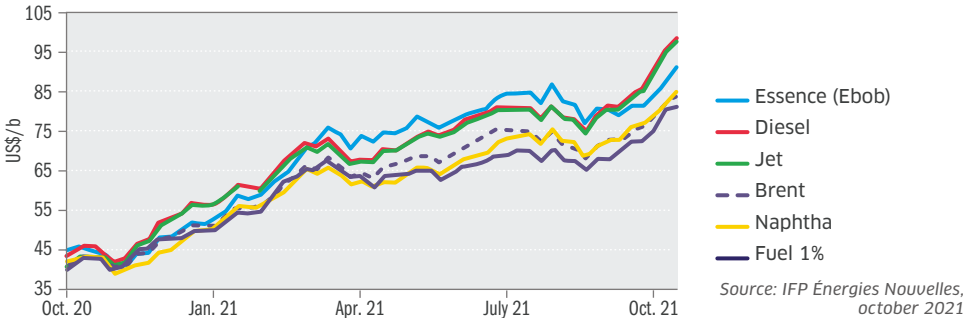
Prices continued to rise in 2021, eventually imparting a new twist to the situation. An improving economic environment took oil prices to $ 60 in April, and speculation helped lift them to $ 70 in June. In September, OPEC+ decided to limit increases in supply to what it had already agreed and this caused prices to soar. In this context of tight supply, worsened by production disruptions in the Gulf of Mexico after Hurricane Ida and depleted stocks, arbitrage by power producers in favour of oil boosted the rally further. Oil prices hit $ 85 late October, a level unseen since 2014.

The world energy market was in crisis over the second half of the year, exacerbated by rising gas and coal prices that forced power producers to turn to oil products.

Crude oil is set to remain expensive until year-end. The negative balance on the oil market (1 mb/d over 2021) will not be closed until 2022.

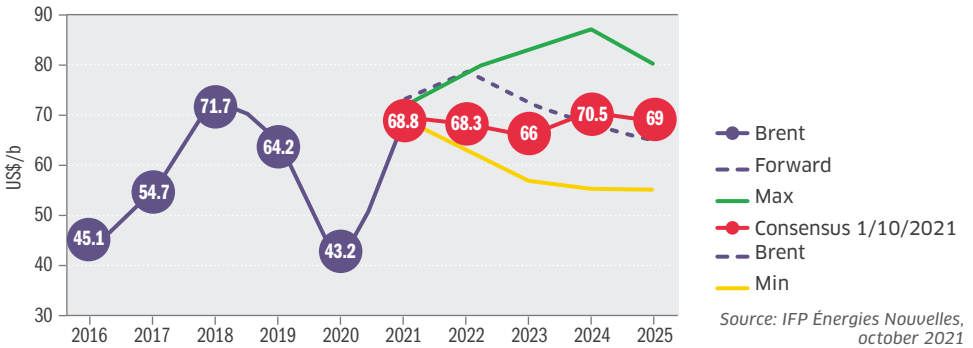
The surge in prices is a significant shock to economic actors, consumers and businesses, made worse by the fact that no substitutes are available in the short term. It raises issues such as purchasing power and inflation risks, highlighting how difficult it is to introduce a carbon tax and how complex redistribution issues are.

CRUDE OIL (BRENT) AND PETROLEUM PRODUCTS PRICES ($/B)



Source: IFP Énergies Nouvelles, october 2021

BRENT PRICE FORECASTS OUT TO 2025
BLOOMBERG CONSENSUS ($/B)



Source: IFP Énergies Nouvelles, october 2021

Coal

COAL AND ENERGY TRANSITION

China faces a dilemma between carbon emission reduction and strong economic growth

CONSUMPTION

Heightened pressure on demand in 2021 is a reminder of coal's central role in Asian economies

Coal and energy transition

An end to coal-fired power projects is the key to significantly limiting the rise in temperatures. There are signs of hope, but there is a massive gap yet to be bridged

Coal is the energy source that generates the most CO_2 emissions (1,060 gCO_2/KWh for coal-fired power stations). Two thirds of the coal production is used in power generation. Coal has become one of the major headaches in energy transition. It generated 42% of world CO_2 emissions in 2020 and represented 35% of the world energy mix.

The coal sector was severely hit by the Covid-19 crisis, and world consumption dropped 4% in 2020. The subsequent economic recovery rapidly corrected the dip, however. Reinvigorated consumption peaked in 2021, largely because of booming coal-fired power generation in Asia. The brutal contraction in 2020 has highlighted the effort required to decarbonize the world economy, as the IEA carbon neutral scenario (NZE) stipulates that coal demand has to decline 8% per year out to 2030.

In several countries, the economic recovery reinforced the use of coal, which undeniably remains an important source of energy supply. Coal station projects took shape in China, India, Indonesia, Japan and Vietnam. These countries account for 80% of new plants. This represents over 600 new power stations, together generating approximately 540 GW (China: 368 GW). These projects very clearly threaten the +1.5°C target.

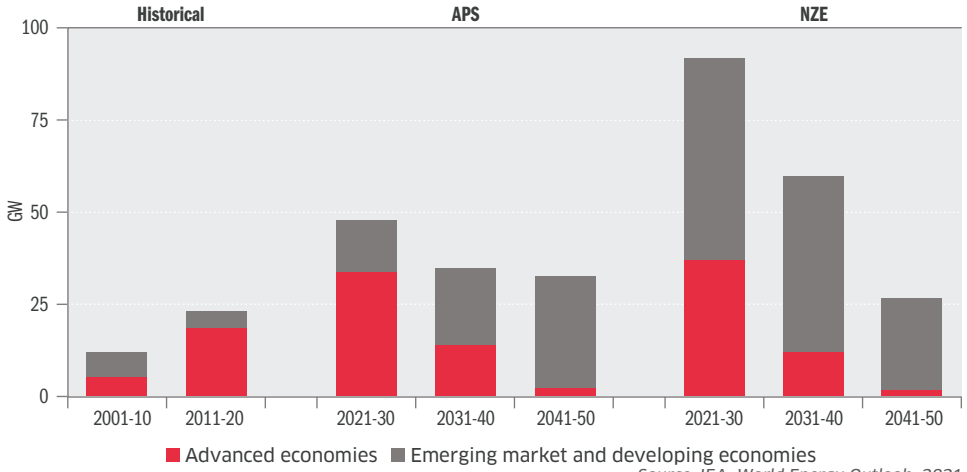
On a global scale, there are two distinct trends at work. In advanced economies (OECD countries plus Bulgaria, Croatia, Cyprus, Malta and Romania), notably within the EU and in the USA, the use of coal has sharply declined in recent years as a result of accelerated plant closures, expanding renewables, the greater competitiveness of gas (the current crisis aside) and higher CO_2 prices. Conversely, coal demand continues to grow in developing countries. The IEA trend scenario (STEPS) take account of these discrepancies by forecasting coal consumption down 3.5% on average per year out to 2050 in advanced economies, against a very limited inflexion (-0.6%) in developing countries.

There is still a massive gap between the current trend, and even that implied by national COP26 commitments, and the carbon neutral trajectory. The IEA suggests 3 ways to speed up the exit from coal: halting the construction of new plants, reducing emissions from existing stations (2,300 GW) by coupling them with CCUS installations or by using decarbonized fuels, and lastly, closing units at an annual rate of 100 GW out to 2030. This implies investing in renewables in order to transfer a third of all coal-fired production.

The future of coal is therefore intrinsically linked with the scope and content of government environment policies. Measures favouring renewable energies or restricting coal project financing could have a decisive impact. In May 2021, G7 countries committed to halt public aid for coal-fired plants. Banks, insurance companies and investment funds are also disengaging from coal assets. Xi Jinping's pledge at the UN General Assembly last September to stop building coal-fired plants abroad could have a significant impact. The end of Chinese financing would facilitate the cancellation of over planned 40 GW in about 20 countries (equivalent to German capacity) and should lead to the cancellation of 55% of coal station projects.

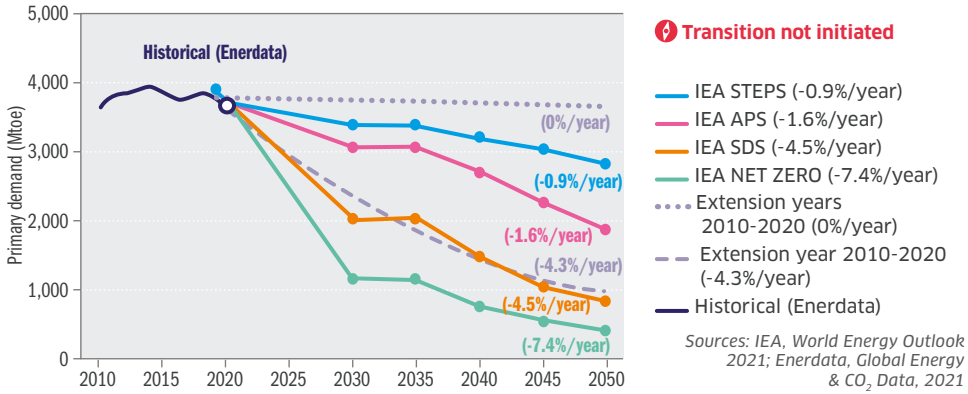
Coal and energy transition

ANNUAL AVERAGE COAL POWER PLANT RETIREMENTS IN THE ANNOUNCED PLEDGES AND NET ZERO EMISSIONS BY 2050 SCENARIOS



Source: IEA, World Energy Outlook, 2021

COAL PRIMARY DEMAND PROJECTION – WORLD

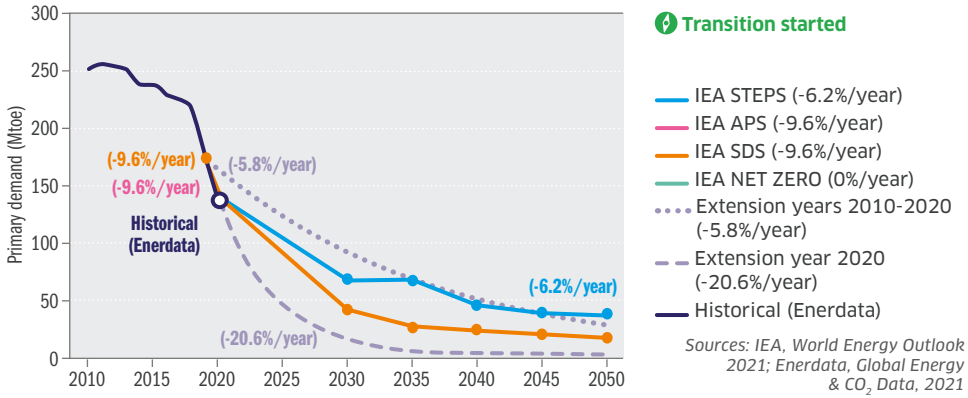


Transition not initiated

- IEA STEPS (-0.9%/year)
- IEA APS (-1.6%/year)
- IEA SDS (-4.5%/year)
- IEA NET ZERO (-7.4%/year)
- Extension years 2010-2020 (0%/year)
- Extension year 2010-2020 (-4.3%/year)
- Historical (Enerdata)

Sources: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

COAL PRIMARY DEMAND PROJECTION – EUROPEAN UNION (EU 27)



Transition started

- IEA STEPS (-6.2%/year)
- IEA APS (-9.6%/year)
- IEA SDS (-9.6%/year)
- IEA NET ZERO (0%/year)
- Extension years 2010-2020 (-5.8%/year)
- Extension year 2020 (-20.6%/year)
- Historical (Enerdata)

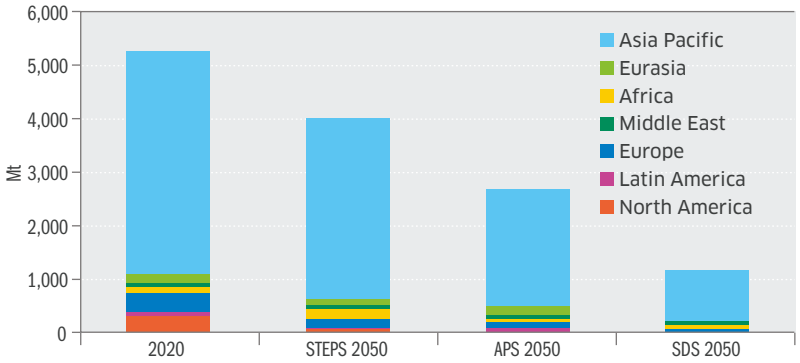
Sources: IEA, World Energy Outlook 2021; Enerdata, Global Energy & CO_2 Data, 2021

Coal: IEA consumption and production forecasts

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

Coal demand forecasts in Mtce		Stated Policies Scenario			Announced Pledges Scenario			Sustainable Development Scenario		
	2020	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050
North America	346	192	59	-5.7%	84	35	-7.4%	79	28	-8.1%
Central and South America	44	42	49	0.3%	27	25	-1.9%	23	16	-3.4%
Europe	330	197	151	-2.6%	157	124	-3.2%	116	54	-5.9%
Africa	156	168	159	0.1%	139	72	-2.5%	118	29	-5.5%
Middle East	4	11	15	4.2%	11	15	4.2%	5	3	-1.2%
Eurasia	221	221	211	-0.2%	221	211	-0.2%	137	46	-5.1%
Asia Pacific	4,216	4,301	3,375	-0.7%	4,189	2,191	-2.2%	3,310	1,014	-4.6%
China	2,986	2,847	1,980	-1.4%	2,814	879	-4.0%	2,389	614	-5.1%
India	557	729	691	0.7%	728	688	0.7%	468	215	-3.1%
Japan	153	116	72	-2.5%	107	46	-4.0%	107	46	-4.0%
Southeast Asia	257	338	393	1.4%	338	388	1.4%	214	79	-3.8%
World	5,317	5,132	4,020	-0.9%	4,828	2,672	-2.3%	3,786	1,189	-4.9%

Source: World Energy Outlook 2021 © OECD/IEA, october 2021

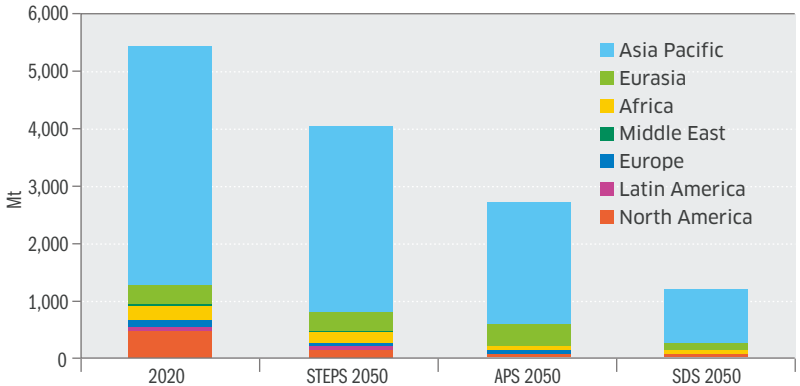


Source: World Energy Outlook 2021 © OECD/IEA, october 2021

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

Coal production forecasts in Mtce		Stated Policies Scenario			Announced Pledges Scenario			Sustainable Development Scenario		
	2020	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050	2030	2050	AAGR 2020-2050
North America	410	262	110	-4.3%	153	58	-6.3%	138	34	-8%
Central and South America	63	48	34	-2.0%	35	0	-100%	35	0	-100%
Europe	178	88	41	-4.8%	65	29	-5.9%	51	8	-10%
European Union	124	53	13	-7.2%	34	5	-10.0%	34	5	-10%
Africa	213	199	170	-0.7%	151	67	-3.8%	149	46	-5%
Middle East	1	1	2	0.2%	1	0	-100%	1	0	-100%
Eurasia	394	411	417	0.2%	391	428	0.3%	249	131	-3.6%
Asia Pacific	4,203	4,123	3,245	-0.9%	4,034	2,091	-2.3%	3,164	972	-4.8%
Southeast Asia	484	479	443	-0.3%	457	458	-0.2%	325	148	-3.9%
World	5,462	5,132	4,020	-1.0%	4,828	2,672	-2.4%	3,786	1,189	-5%
Steam coal	4,296	3,944	3,057	-1.1%	3,703	1,982	-2.5%	2,839	771	-5.6%
Coking coal	940	1,005	843	-0.4%	971	605	-1.5%	850	406	-2.8%
Lignite and peat	226	182	119	-2.1%	154	86	-3.2%	97	13	-9.1%

Source: World Energy Outlook 2021 © OECD/IEA, october 2021



Source: World Energy Outlook 2021 © OECD/IEA, october 2021

*1 Mtce: million tons of coal equivalent – Appendix.

Coal: consumption

The present crisis in the Asian coal market is a reminder of the central role of this fuel in regional economies and underlines the difficulties Asia will have in implementing a low-carbon trajectory

World coal demand fell 4% in 2020, its largest drop since World War II. This mainly stemmed from coal-fired power plants losing ground during the crisis (see our Electricity chapter), as they make up two thirds of coal consumption. In the USA and in Europe, stalling coal demand also reflected the increased competitiveness of gas-fired plants. Weaker activity in heavy industry, cement and steel works – representing a quarter of coal consumption – contributed to the move as well.

The situation reversed abruptly in 2021. The IEA forecasts that world coal consumption will rebound 4.5% and exceed its 2019 level. Boosted by accelerating economic growth, the Asian power sector represents 80% of consumption. Soaring gas prices prompted a return to coal, notably in the USA and in the EU. Runaway coal consumption has a heavy environmental cost: approximately 600 Mt CO_2 in additional emissions, equivalent to 2% of total emissions.

Problems in China question its ability to phase out coal. China consumes over half of world coal production and faces a severe energy crisis. It is reporting power cuts, entire cities plunged into darkness, companies reducing activity and power rationing. The country is simply short of coal. The world economic recovery was faster than expected and generated strong demand for Chinese manufactured goods (up 28% year-on-year in September). It also put pressure on raw materials, whose prices soared. Caught between the tripling of coal prices in the space of a year and electricity prices that are fixed and controlled by the state, several power stations chose to reduce supply rather than produce at a loss. Traditionally enjoying coal surpluses, the country now has to import cheaper coal from abroad (Chinese coal costs $310/tonne, against $240/tonne for imported coal).

In 2020, coal consumption had slightly expanded in China (+0.6%), while it had been receding in almost every other country in the world. In 2021, it is set to gain about 6%.

Xi Jinping has made strong commitments to reduce CO_2 emissions before 2030 and to reach carbon neutrality by 2060. During COP26, he specified that coal consumption by power plants will come down 1.8% per year on average out to 2035. These commitments plunge China into a dilemma, as combining lower carbon emissions with rapid economic growth is turning out to be more challenging than expected.

India is the world's second largest coal consumer and also experienced difficulties in 2021. After a 3.7% drop in 2020, coal demand felt the pressure from the power sector this year. With a 69% share in power generation, coal remains the key energy source for the country's economic growth. The IEA expects demand to increase 9% this year. India has not reduced its climate ambitions, however, and during COP26 it committed to carbon neutrality by 2070. This means that 500 GW of renewables capacity is to meet half of the country's power needs by 2030 (against 144 GW currently). Moreover, CO_2 emissions are to be reduced by 1 Gt and carbon intensity by 45% by 2030.

Coal: consumption

Although in structural decline, US coal consumption surged in 2021. The USA is the third-largest market and has halved its coal consumption over the past decade (-8% per year on average from 2010 to 2020). This was mainly a result of a loss of competitiveness against unconventional gas and renewables in power generation. In 2020, the sharp fall in electricity demand (-4%) caused coal consumption to collapse 19%, or by 105 Mt; the power sector accounts for 90% of it. In 2021, the economic recovery and the doubling of gas prices since the beginning of the year caused power stations to return to coal on a surprisingly large scale. The IEA expects production to bounce back 22% and total coal demand to jump 12% in 2021. Given that the construction of new coal-fired plants stopped in 2013, these tensions should not persist in 2022.

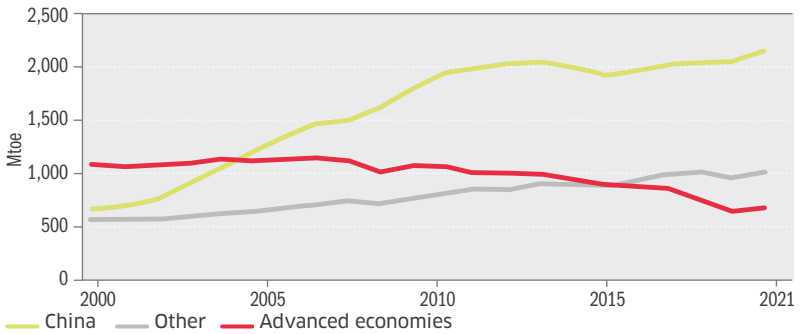
Europe has seen similar developments, despite being the most ambitious region in terms of climate protection. After a 17% drop in 2020, a combination of recovering activity, harsh weather and very low gas inventories (25% lower than average) drove coal demand up 10% in 2021, according to the IEA. But the trend in Europe is to eventually exit coal because of higher carbon prices and because a growing number of countries have adopted moratoria on coal (Austria, Sweden, Portugal, France, Greece). The last European countries running coal power stations are Germany, Poland and the Czech Republic (2/3 of consumption), although here too there is phasing-out process. The share of coal in the European energy mix declined from 25% in 2015 to 11% in 2020.

Coal: consumption

In Mt	Coal and lignite domestic consumption						CHANGE 2019-2020	AAGR 2010-2020	Share of world 2020
	2000	2005	2010	2015	2019	2020			
Europe	973	972	914	880	707	587	-17.0%	8%	7%
UE-27	772	770	699	679	502	408	-18.7%	6%	5%
UE-28	832	833	750	718	511	417	-18.4%	6%	5%
Germany	244	244	232	239	168	138	-17.8%	2%	2%
Poland	141	137	134	129	113	100	-11.5%	1%	1%
Turkey	81	77	95	93	125	109	-12.6%	2%	1%
North America	1,046	1,078	1,004	761	563	444	-21.1%	6%	9%
United States	983	1,018	954	722	533	419	-21.3%	6%	8%
Latin America	47	56	65	80	72	61	-15.2%	1%	1%
Brazil	22	21	23	30	26	23	-11.6%	0%	1%
Asia	2,059	3,296	4,617	5,323	5,615	5,568	-0.8%	76%	66%
China	1,304	2,345	3,350	3,770	3,807	3,830	0.6%	52%	47%
South Korea	72	83	120	135	131	115	-12.4%	2%	9%
India	376	466	684	885	1,013	976	-3.7%	13%	7%
Indonesia	25	41	67	87	144	139	-3.7%	2%	7%
Japan	149	177	184	195	186	171	-8.0%	2%	7%
Pacific	130	142	136	119	106	102	-3.8%	1%	6%
Australia	128	138	133	116	103	99	-3.7%	1%	6%
CIS	356	349	368	350	364	337	-7.3%	5%	7%
Kazakhstan	50	65	83	65	75	76	1.8%	1%	2%
Russia	232	214	212	222	229	205	-10.6%	3%	5%
Middle East	13	16	16	17	15	15	1.1%	0%	0%
Africa	170	192	204	204	204	190	-6.6%	3%	4%
South Africa	157	179	193	186	176	169	-4.4%	2%	3%
World	4,794	6,101	7,325	7,734	7,644	7,304	-4.5%	100%	100%

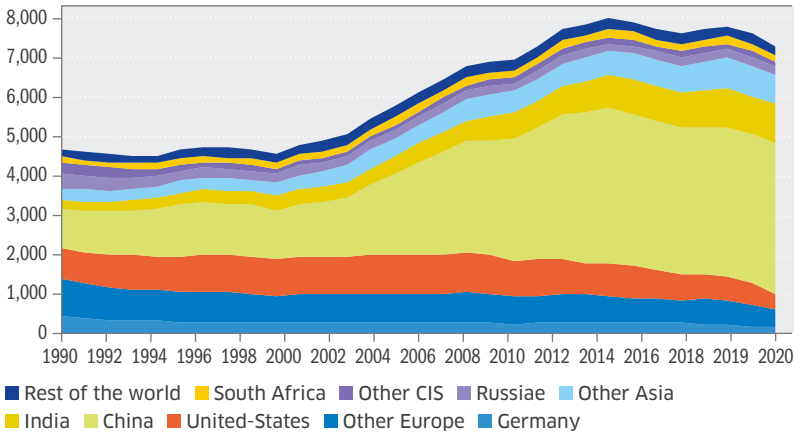
Source: Enerdata, Global Energy and CO_2 Data, 2021

COAL CONSUMPTION BY REGION, 2000 TO 2021



Source: IEA, Global Energy Review, april 2021

COAL CONSUMPTION EVOLUTION BETWEEN 1990 AND 2020 (MT)



Source: Enerdata, Global Energy and CO_2 Data, 2021

Coal: production

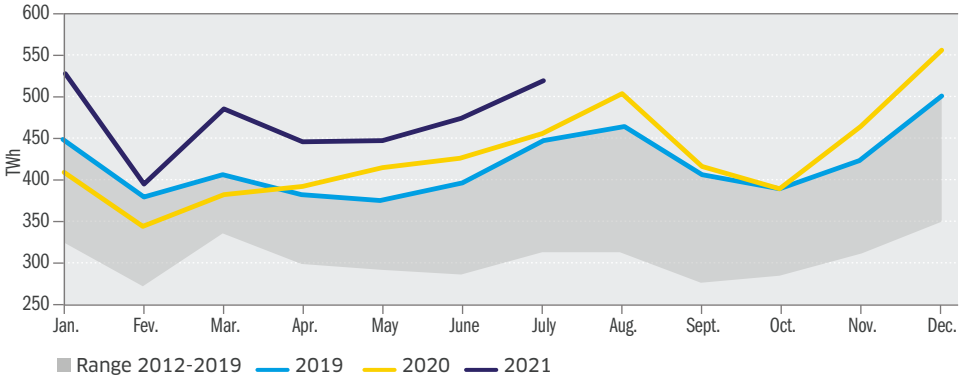
The major coal producers reactivated output and opened new mines in 2021

Interrupted by the Covid crisis, coal production renewed in 2021 with an uptrend dating back to 2017. It has gradually recovered to its highs. Intense pressure on coal demand since the economic upturn caused most production sites – notably China, India, Indonesia and Australia – to reactivate production. This will have completely cancelled out the 4.6% drop posted in 2020.
Most coal producing countries drastically reduced their output in 2020: -5.9% in Australia, -9% in Indonesia, -4.5% in South Africa. Committed to closing its mines, the EU had stopped subsidising coal-fired plants in 2018, accelerating its exit from coal. Its production fell 18% in 2019 and 17% in 2020. Output declined the most in the USA in 2020 (-24%), in the wake of weak power demand and the lack of profitability of coal compared with gas and renewables.

Even when COP26 was in full swing, China announced an steep increase in its coal production. Faced with substantial power shortages, China will add 1 Mt to its daily production, which already exceeds 11.5 Mt/day. Even though the number of mines had decreased from 10,800 in 2015 to 5,300 by end-2019, approval has been given to new mining projects. In addition, 53 existing mines (15 in North province and 38 in Inner Mongolia) resumed operations for a combined capacity of 110 Mt (Bloomberg). In the meantime, the Chinese government is continuing with its efforts to improve local players' competitiveness and profitability through mergers and via the launch of a new national Coal Trading Center.
The world's largest producer with a 50% share of the total, China is one of the rare countries to have maintained production levels in 2020 (+1.4%). Growth is expected to amount to 6% in 2021.

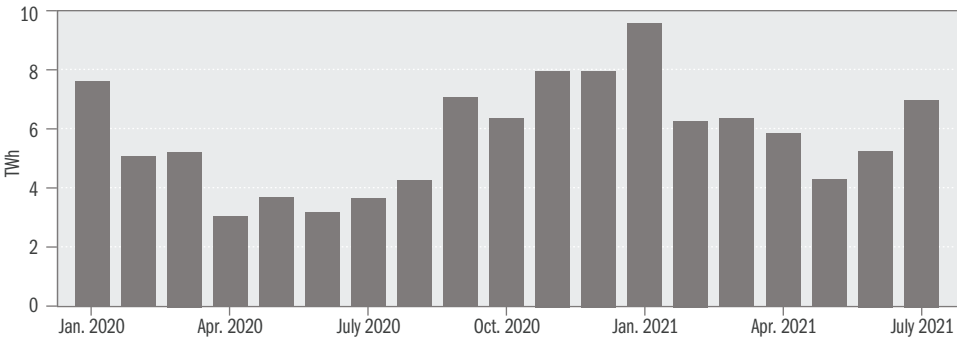
India is the world's second largest producer and also stepped up production in 2021. In order to reduce the country's dependency on imports, the Indian government authorized private commercial mining in June 2020. This brought to an end the nearly 50 years' monopoly of Coal India Limited, a 90% state-owned concern. Designed to stimulate national production, this measure also aims to help revive an economy weakened by the pandemic. The government hopes that the opening of coal mines to the private sector will generate $950 m in revenues and create 69,000 jobs.
Indian coal production expanded in 2020 (+1.2%) and is expected to accelerate further in 2021 (+3.7%), according to the IEA.

CHINA THERMAL POWER GENERATION



Source: IEA, Global Energy Review, april 2021

WESTERN EUROPE COAL-FIRED POWER GENERATION



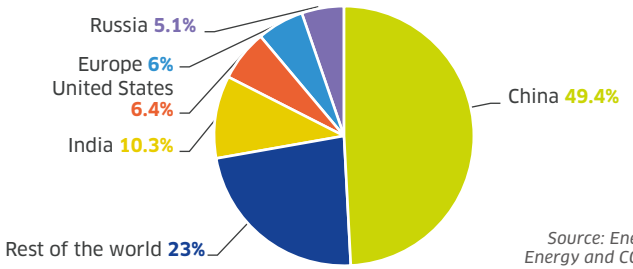
Source: NBS China, ENTSOE, august 2021

Charbon: production

In Mt	Coal and lignite production						Change 2019-2020	Share of world 2020
	2000	2005	2010	2015	2019	2020		
Europe	778	758	706	654	549	454	-17.3%	6%
EU27	626	619	546	520	392	327	-16.5%	4%
EU28	657	639	564	528	394	328	-16.7%	4%
Germany	205	206	184	185	127	105	-17.7%	1%
Poland	163	160	133	136	112	101	-10.4%	1%
Turkey	63	58	73	58	87	70	-19.2%	1%
North America	1,041	1,109	1,064	876	698	533	-23.6%	7%
United States	972	1,039	996	814	641	489	-23.8%	6%
Latin America	65	87	99	109	102	78	-23.6%	1%
Colombia	38	59	74	86	84	64	-24%	1%
Asia	1,851	3,036	4,344	4,829	5,246	5,251	0.1%	69%
China	1,355	2,317	3,316	3,563	3,691	3,743	1%	49%
India	336	437	570	683	769	779	1.2%	10%
Indonesia	79	171	325	452	606	551	-9%	7%
Pacific	310	376	441	516	506	476	-6.0%	6%
Australia	307	371	436	512	503	473	-5.9%	6%
CIS	388	439	476	488	566	524	-7.4%	7%
Kazakhstan	77	87	111	93	104	104	-1%	1%
Russia	242	285	300	353	425	386	-9%	5%
Middle East	2	2	2	2	2	2	2.6%	0%
Africa	231	250	259	270	268	256	-4.5%	3%
South Africa	224	245	255	256	254	242	-4.5%	3%
World	4,665	6,056	7,390	7,744	7,938	7,575	-4.6%	100%

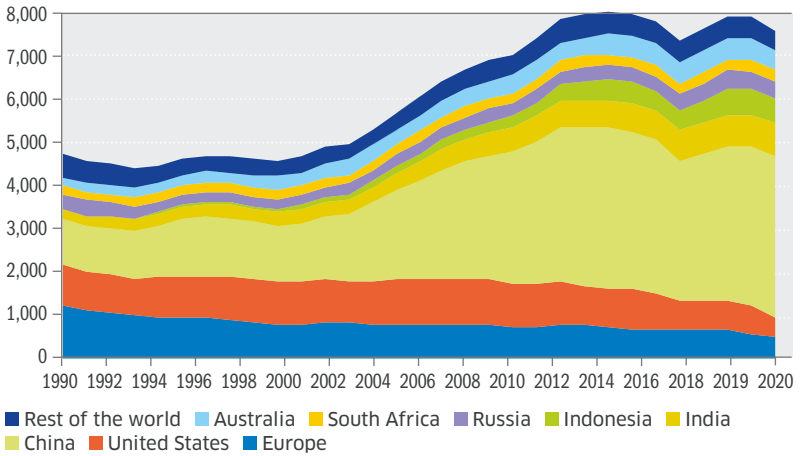
Source: Enerdata, Global Energy and CO_2 Data, 2021

SHARE OF COAL PRODUCTION BY GEOGRAPHIC REGION
TOTAL: 7,575 MT



Source: Enerdata, Global Energy and CO_2 Data, 2021

COAL PRODUCTION EVOLUTION BETWEEN 1990 AND 2020 (MT)



Source: Enerdata, Global Energy and CO_2 Data, 2021

Coal: world trade flows

Coal and lignite exports in Mt	Exports					
	2010	2019	2020	Share of world 2020	Change 2019-2020	AAGR 2010-2020
Europe	36	22	23	2%	4.8%	-4.4%
EU27	32	20	20	2%	0.8%	-4.4%
EU28	33	21	22	2%	3.7%	-4.2%
Poland	17	11	11	1%	1%	-4.0%
North America	109	122	91	7%	-25.4%	-1.8%
Canada	34	37	28	2%	-23.1%	-1.7%
United States	76	86	63	5%	-26.3%	-1.8%
Latin America	73	79	58	4%	-26.5%	-2%
Colombia	70	78	57	4%	-26.5%	-2%
Asia	337	546	485	36%	-11.2%	3.7%
China	23	9	5	0%	-46.8%	-14.5%
Indonesia	265	469	418	31%	-10.9%	4.7%
Pacific	295	397	372	28%	-6.2%	2.3%
Australia	293	396	371	28%	-6.2%	2%
CIS	175	243	235	17%	-3.6%	3.0%
Kazakhstan	31	26	26	2%	0.5%	-2.0%
Russia	135	213	204	15%	-4%	4.2%
Middle East	0	0	0	0%	-1%	10.4%
Africa	68	87	82	6%	-5.8%	2.0%
South Africa	67	81	76	6%	-5.8%	1.2%
World	1,093	1,497	1,347	100%	-10.1%	2.1%

Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal and lignite imports in Mt	Imports					
	2010	2019	2020	Share of world 2020	Change 2019-2020	AAGR 2010-2020
Europe	234	187	149	12%	-20.5%	-4.4%
EU27	181	137	96	7%	-30%	-6.1%
EU28	207	144	102	8%	-29%	-6.9%
Germany	51	43	32	3%	-26.0%	-4.5%
Netherlands	12	11	6	1%	-41.5%	-6.8%
North America	32	16	12	1%	-24.1%	-9.5%
United States	19	6	5	0%	-23.9%	-12.8%
Latin America	38	49	37	3%	-25.3%	-0.3%
Brazil	18	20	17	1%	-15%	-0.4%
Asia	744	1,100	1,024	79%	-6.9%	3.2%
China	185	299	303	23%	1.5%	5.1%
South Korea	119	136	118	9%	-12.7%	-0.1%
India	123	245	198	15%	-19.3%	4.9%
Japan	186	183	171	13%	-6.7%	-0.9%
Taïwan	64	68	63	5%	-6.2%	-0.1%
Pacific	0.30	2	2	0%	16.6%	20.4%
CIS	41	58	54	4%	-7.4%	2.8%
Russia	26	28	27	2%	-2.0%	0.6%
Middle East	15	13	12	1%	-7%	-2.5%
Africa	9	23	11	1%	-54.1%	1.1%
World	1,114	1,447	1,299	100%	-10.2%	1.6%

Source: Enerdata, Global Energy and CO_2 Data, 2020

Coal: prices

Coal prices did not rally to the extent of European gas prices, but enough to generate serious problems in China

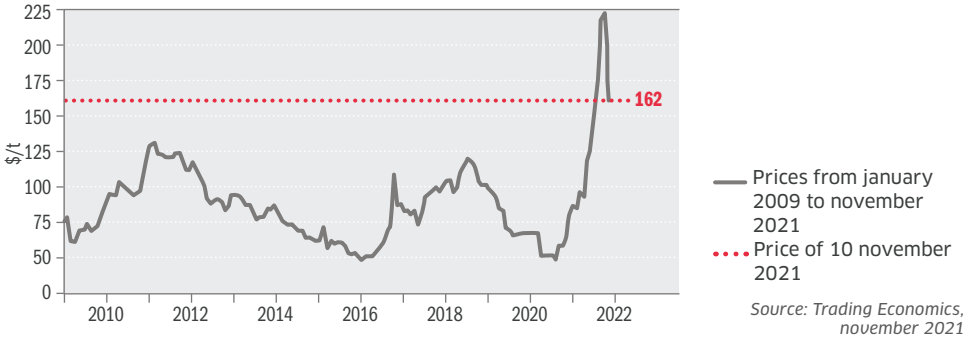
The tripling of coal prices in 2021 reflects an overheating world economy and continued raw material shortages. From $80/t at the beginning of the year, international coal prices broke through $200/t at the end of October, a level unseen since 2008, before falling back to $150/t early November.

The shock was even more brutal for the fact that coal prices had fallen sharply since 2019 amid abundant supply. In 2020, the pandemic precipitated a dip to $50/t by mid-May; the easing of lockdown measures allowed some ground to be recovered subsequently.

It is Asia that pressure is the strongest, for reasons we mentioned earlier: a return to normal industrial activity, accelerating power demand and a shortage of coal. The situation is particularly critical in China, especially after several mines were flooded in October. This explains the peak at $225/t. The consequences for the economy are already estimated at approximately one point of GDP. In mid-October the government authorized power companies to sell 20% over the fixed price in order to pass on some of the increase in supply costs to their customers. Factory gate inflation has already reached 11%. One sign that the surge in prices is critical is the government – through the NDRC – contemplating intervention to bring coal prices down to a "reasonable range".

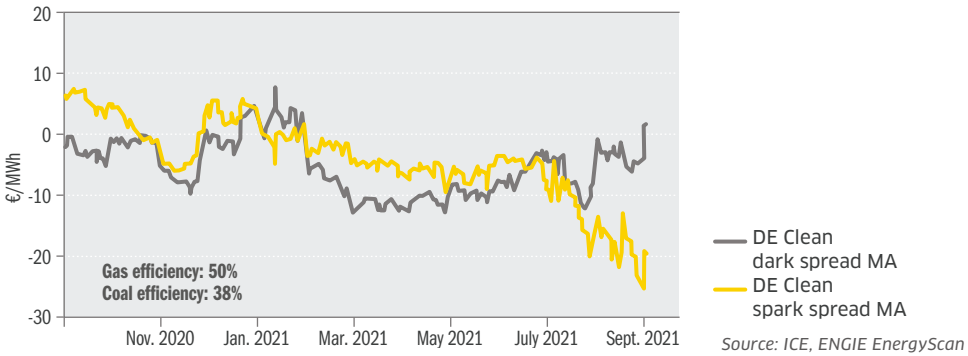
In Europe, coal remains competitive against gas in power generation, despite recent trends and record prices on carbon allowances. This situation is likely to persist over the winter, as rising heating demand will maintain pressure on natural gas prices.

COAL PRICES (IN $/T) (MONTH-AHEAD – API, CIF ARA)



Source: Trading Economics, november 2021

GERMAN CLEAN SPARK AND DARK SPREADS FOR MONTH-AHEAD MATURITIES



Source: ICE, ENGIE EnergyScan

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 1: UN Convention on Climate Change Annex 1 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, Liechtenstein, 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 inventories.

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.

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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.
EU 27 and EU 28	European Union 27 (without United Kingdom); EU 28 (with UK).
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	EU27
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.
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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