Electricity Market Report

July 2022 - Update

INTERNATIONAL ENERGY AGENCY

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Abstract

In the first half of 2022, many electricity markets continued to experience skyrocketing prices, particularly in Europe, reflecting deep uncertainties over both fossil fuel supplies and the economic outlook. Russia's invasion of Ukraine shattered any hope of energy prices declining in the near term following the strong increases seen in the second half of 2021. In Europe, the situation prompted heightened ambitions and strengthened policies to advance clean energy transitions and reduce dependency on fuel imports. But in the short term, it also resulted in a partial return to coal-fired electricity generation. Sluggish economic growth is expected to dampen global electricity demand growth in 2022 and 2023 to less than half the rate seen in 2021. Despite gas-to-coal switching and low nuclear power plant availability in Europe, global electricity sector emissions may decline slightly in 2022 and 2023 – reflecting a combination of slowing power demand and displacement of fossil fuels by renewables.

This July 2022 update of the IEA *Electricity Market Report* presents our latest forecasts for global electricity demand, supply and emissions through 2023. In light of Russia's invasion of Ukraine, we also provide a special focus on the situation in Europe, discussing recent developments and future plans.

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Executive summary

Executive summary

Electricity demand growth is slowing significantly in 2022. After global electricity demand grew by a strong 6% in 2021, propelled by rapid economic recovery as Covid-19 lockdowns eased, we expect growth to slow to 2.4% in 2022 – about the same as the average from 2015 to 2019. This reflects slower global economic growth, higher energy prices following Russia's invasion of Ukraine, and renewed public health restrictions, particularly in China.

Tight natural gas markets are favouring coal-fired power plants. Due to high gas prices and supply constraints, coal is replacing gas for power generation in markets with spare coal plant capacity. In Europe, governments delayed coal plant phase-outs and lifted restrictions to increase the availability of coal generation, thereby reducing gas consumption to improve security of supply.

Renewables are growing faster than demand and replacing fossil fuels. Strong capacity additions are helping global renewable power generation towards growth of more than 10% in 2022. Despite nuclear's 3% decline, low-carbon generation is set to rise by 7%, resulting in a 1% drop in total fossil fuel-based generation. Globally, coal power increases slightly as declines in China and the United States are balanced by growth in Europe. Gas power falls by 2.6% as growth in North America and the Middle East offsets some of the decline in Europe and in Central and South America.

Electricity sector emissions are set to decline slightly. After having risen to an all-time high in 2021, CO_2 emissions from the global electricity sector are set to decline in 2022, albeit by less than 1%. Emissions intensity is set to fall by more than 2%.

Wholesale electricity prices are skyrocketing in many countries. In the first half of 2022, gas prices in Europe rose fourfold and coal more than threefold from the same period in 2021, resulting in wholesale electricity prices more than tripling in many markets. Our price index for major global electricity wholesale markets reached levels that were twice the first-half average from 2016 to 2021.

Europe is gearing up to reduce its reliance on Russian fossil fuel imports by accelerating its clean energy transition. The implementation of the European Commission's REPowerEU plan would greatly accelerate deployment of renewables in the coming years, doubling their share in EU gross final energy consumption from 2020 to 2030 and significantly reducing fossil fuel use. The continued energy price crisis is fuelling debate on wholesale electricity market design, while governments are trying to cushion high electricity prices with diverse support schemes.

Large uncertainties for 2023. The main uncertainties affecting our 2023 forecasts for electricity demand and generation mix concern fossil fuel prices and economic growth. As of mid-2022, we expect global electricity demand growth in 2023 to remain on a similar path as this year. Strong renewables growth of 8% and recovering nuclear generation could displace some gas and coal power, resulting in the electricity sector's CO_2 emissions declining by 1%.

Global developments

Demand

War in Ukraine aggravated the economic outlook for 2022 and 2023

In 2021, an overall economic rebound reflected easing Covid-19 restrictions. In 2022, war in Ukraine, high energy prices, supply chain disruptions and high inflation led to downward revisions of near-term economic growth forecasts. Pointing out high uncertainties, in April 2022, the International Monetary Fund (IMF) lowered growth forecasts for global GDP to 3.6% for 2022 and 2023 – from 4.9% for 2022 and 3.6% for 2023 in October 2021. The World Bank forecast in June an annual growth of only about 3% in 2022 to 2024.

For the **United States**, the IMF revised its forecast from 5.2% to 3.7% for 2022 and 2.2% to 2.3% for 2023. The changes relate to a variety of factors such as high inflation and supply chain disruptions.

For the **euro area**, GDP growth is estimated at 2.8% for 2022 (from 4.3%) and 2.3% for 2023 (from 2%). The reduction in 2022 results mainly from high inflation led by high energy prices, supply chain disruptions and reliance on Russian fossil fuels, particularly in the manufacturing sector. Annual inflation in the area was about 8% in March 2022, pushed up by energy inflation of 44%.

The **United Kingdom** is set to grow by an estimated 3.7% in 2022 (from 5%) and 1.2% in 2023 (from 1.9%), amidst high inflation, tight labour markets and expectations of weaker investment.

Ukraine's economy is severely impacted by Russia's invasion, with GDP estimated to fall by 35% (IMF) or even 45% (World Bank) in 2022. For 2023, economic activity is very likely to remain significantly below previous levels.

In the **People's Republic of China** (hereafter "China"), the expected impacts of lockdowns and supply disruptions following the Omicron outbreak in the first half of 2022 led to downward revisions of near-term growth estimates, to 4.4% for 2022 (from 5.6%) and 5.1% for 2023 (from 5.3%). **Japan**'s growth expectation was revised to just below 2.5% in 2022 and 2023 (from 3.2% in 2022 and 1.4% in 2023). **India**'s GDP growth forecast was revised to 8.2% in 2022 (from 8.5%) and 6.9% in 2023 (from 6.6%).

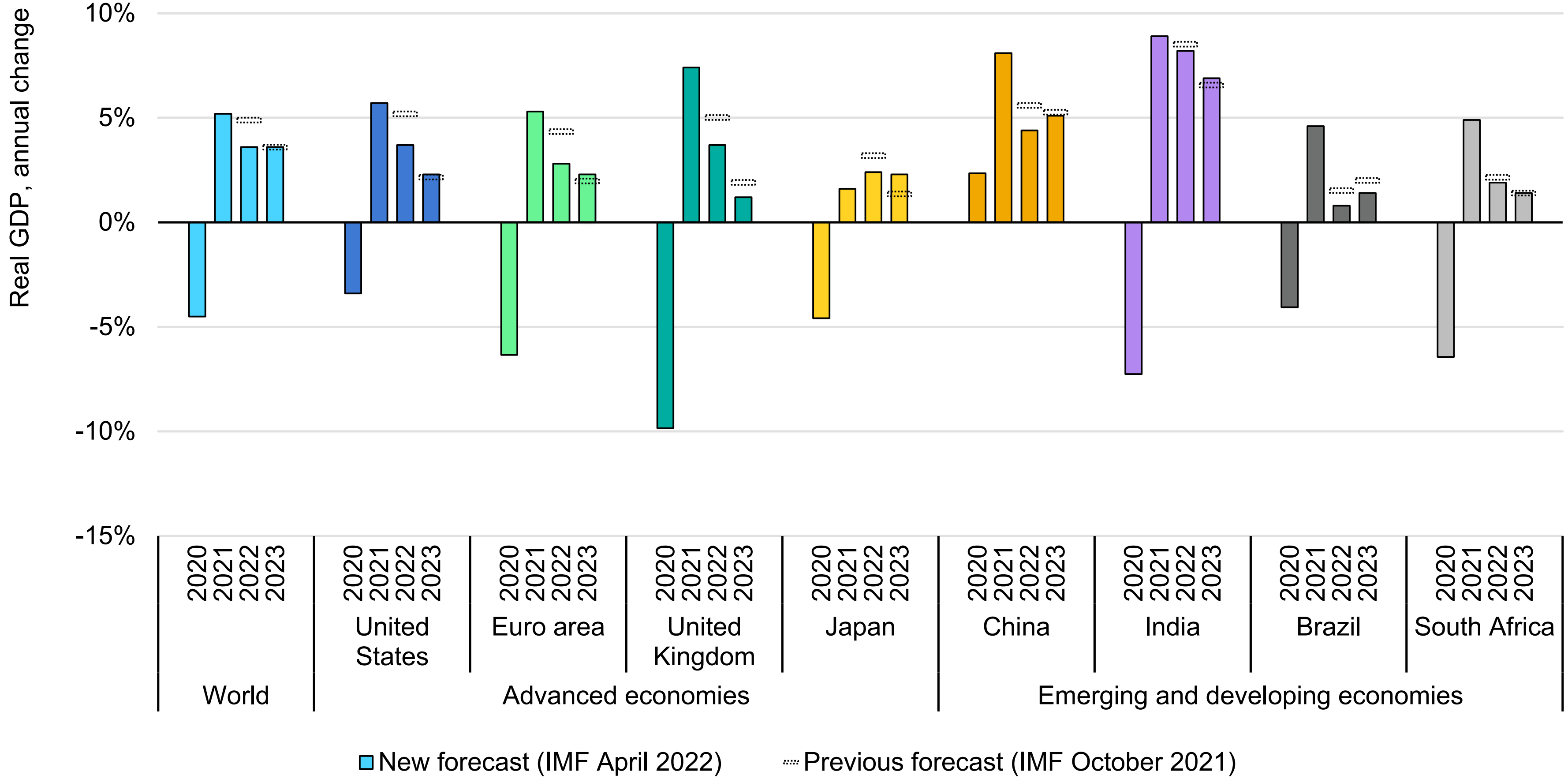
Economic prospects for **Sub-Saharan Africa** remained rather stable, comparing the IMF's April 2022 and October 2021 forecasts. The region is expected to see the combined effects of inflation (led by high food prices) and social and political unrest (for instance, military coups in several countries) somewhat counterbalanced by higher oil prices benefitting oil exports. Overall, the region's economic output is set to grow by around 4% in 2022 and 2023.

Latin America and the Caribbean are set to grow by 2.5% in 2022 and 2023 (relatively unchanged), with inflation impacts and weaker domestic demand expected in some countries of the region.

Due to sanctions and other negative impacts of the ongoing war, the IMF expects the **Russian Federation**'s (hereafter "Russia") economy to contract in 2022 (by 8.5%) and 2023 (by 2.3%).

A slower-than-previously-expected economic rebound is forecast across many countries

GDP assumptions by country and region, 2020-2023



Note: GDP growth estimates for India are based on its fiscal year (April to March).
Sources: Based on International Monetary Fund (2022), World Economic Outlook April 2022; International Monetary Fund (2022), World Economic Outlook October 2021.

Slowdown of global electricity demand growth

Global development

After 6% growth in 2021 (which followed a small drop in 2020), we expect **global** electricity demand in 2022 to grow by 2.4% (about the same as the average from 2015 to 2019), lower than the about 3% we forecast at the beginning of this year. While the wearing off of rapid economic recovery that boosted demand in 2021 was to be expected, several developments during the first half of 2022 negatively impacted the demand outlook. Continued high energy prices as a consequence of the Russian invasion of Ukraine resulted in overall high commodity prices. In turn, high inflation rates led central banks around the world to increase interest rates. Strict sanitary measures in China affected industrial production and increased tension across already tight global supply chains. Considering that industry is responsible for more than 40% of final electricity demand and 20% is consumed by commercial and services, the resulting slow-down of economic activity has triggered declining consumption. A notable exception is India, where unusually hot temperatures in the second quarter of 2022 pushed electricity demand to new record heights.

For 2023, we expect global demand growth rates similar to those forecast in 2022 – in line with similar global economic growth. However, high uncertainties exist linked to several (interconnected) factors: global economic growth, high and volatile fossil fuel prices, and ongoing sanitary measures related to Covid-19.

Regional development

In **Asia Pacific**, we expect demand to grow at around 3.4% for 2022, a downward revision by more than one percentage point from early 2022. Lower economic growth, high energy prices, strict sanitary measures and extended effects from the coal shortage for power generation are the main drivers. For 2023, we expect demand growth of close to 4%, making up for some of the 2022 slowdown.

In China**,** in absolute terms the fastest-growing country from 2016 to 2021, demand in the first five months of 2022 exhibited a mere 0.5% growth compared to the same period in 2021. In April and May, demand even declined year on year as the authorities adopted zero-Covid strategy measures in response to new outbreaks, which strongly affected energy consumption and forced some industries to stop operating. The outlook for the rest of 2022 remains highly uncertain and will depend on the stringency of sanitary measures. Potential reform of China's "dual control" policy, which would replace caps on total energy consumption and energy intensity by caps on total carbon emissions and carbon intensity, could trigger an increase in total demand. In practice, if renewables supply the additional demand, an increase in total demand beyond the existing caps becomes possible. Overall, we expect electricity demand to increase by about 3% in 2022. For 2023, we forecast over 4% demand growth, supported by recovery from suppressed demand in the previous year.

In India, the second-fastest growing country in terms of absolute demand in recent years, a significant heatwave is driving an upwards revision of our electricity demand forecast for 2022 – to 7% from previously 6%. Causing temperatures upwards of 50°C, the heatwave pushed up use of air conditioning and created a significant surge in electricity demand, including new all-time highs accompanied by supply shortages. For 2023, we revise our expectations for demand growth down to 5% (from 6%), reflecting the expected impact of high global prices and a correction against temperature-driven growth in 2022.

In the **Americas**, we expect demand growth to moderate to almost 2% in 2022 and fall to below 1% in 2023 – after exceptional growth of about 2.4% in 2021 (due to the strong rebound in economic activity after the lockdowns in 2020). These projections are slightly higher for 2022 and lower for 2023 than in our January 2022 forecast, largely due to rapid economic recovery in the United States.

For the United States, we updated our demand forecast to 2% growth in 2022 (from stagnation in our January forecast). Higher-than-expected residential demand in the first quarter of 2022, driven (at least in part) by on average colder temperatures compared to 2021, and faster-than-expected demand recovery in the industrial and commercial sectors (at least during the summer) are the main drivers. For 2023, against the background of expected slow economic growth, we estimate electricity demand to remain flat compared to 2022.

In Mexico, based on lower economic output forecasts, we revised down our year-on-year electricity demand growth estimate for 2022 to 2.3% (from 3.6% in our January 2022 forecast), picking up again (plus 4%) in 2023 with higher economic growth and relaxing fossil fuel markets. Up until June 2022, Brazil registered about 2% year-on-year increase in electricity demand. A new record demand level of 80 454 MW in the national power system was reached in March as higher temperatures led to increased cooling and refrigeration demand. However, due to lower economic growth expectations, we revised our demand growth forecasts to below 1.5% (from almost 4%) in 2022, followed by 2.3% in 2023.

In **Europe**, energy prices – and consequently impacts on the economy – have been particularly high. Additionally, sanctions on imports from Russia into the EU and retaliation measures by Russia worsened the outlook for economic recovery and, with it, electricity demand growth in 2022. Milder temperatures in the first quarter of 2022 compared to 2021 also dampened demand. In countries where electricity supplies a high share of heating (e.g. France and Scandinavian countries), demand in the first four months of the year decreased by more than 5% year on year. In Turkey, in absolute terms the country with the highest demand growth in 2021 (plus 8%), demand growth slowed down to about 2.8% in the first half of 2022, primarily due to lower economic growth. In Ukraine, monthly electricity demand declined by more than 30% year on year after Russia's invasion and until publication of this report.

For the full year 2022, we expect demand in Europe to increase by below 1%, less than half the value expected early this year. Possible fossil fuel shortages, in particular of natural gas, and a further slowdown of economic growth could reduce demand growth even more. For 2023, the outlook is rather uncertain. Assuming continued tense energy markets and suppressed economic growth, electricity demand growth could remain on a similarly low level as in 2022.

In **Eurasia**, electricity demand grew by an estimated 2% year on year in the first half of 2022, as colder temperatures in March and April pushed up electricity demand for space heating. For the full year, however, we expect electricity demand to decline by over 1%, driven by the worsened economic outlook for Russia (which accounted for 80% of absolute electricity demand and demand growth in the region in 2021). Russia's GDP is projected to decline by 8.5% as a result of sanctions imposed in response to Russia's invasion of Ukraine. The region's electricity demand decline follows an estimated growth of 6% in 2021 – the highest since the collapse of the Soviet Union – reflecting recovering economic activity, together with colder-than-average first and fourth quarters.

Reduced economic growth prospects in Russia are set to linger into 2023 and will weigh into Eurasia's electricity demand, which we expect to decline by another 1%.

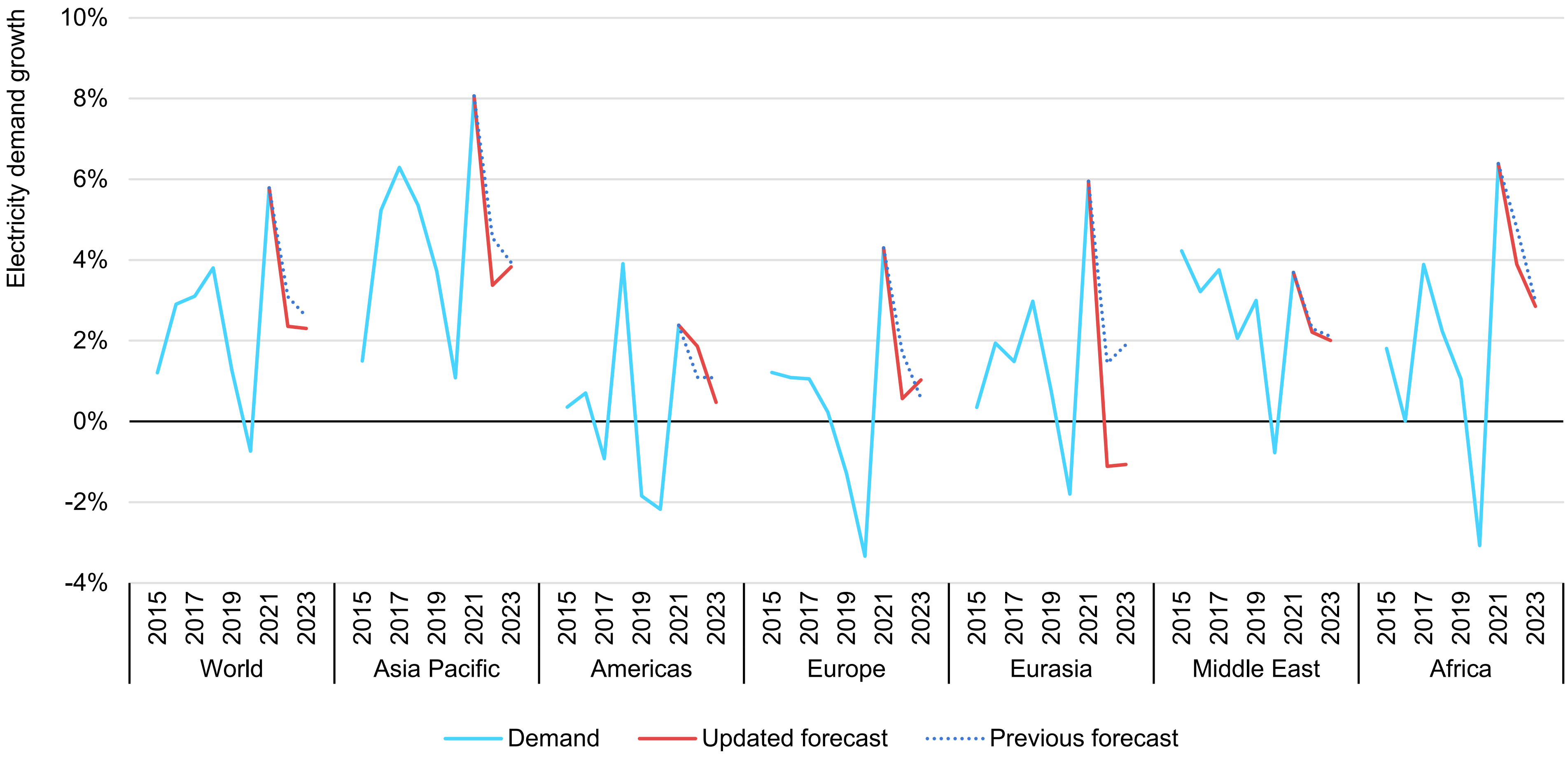
In the **Middle East**, we expect power demand to increase at around 2% in both 2022 and 2023, following a strong (3.7%) rebound in 2021 from declines induced by Covid-19 in the previous year.

Ongoing GDP recovery is supporting demand growth in the region – with rising commodity prices further bolstering the economies of oil- and gas-exporting countries in recent months. This growth is tempered, however, by insufficient generation capacity to meet rising peak requirements in the region's key power markets, including Iraq and Iran. In the first quarter of 2022, Oman launched the first spot electricity market in the Middle East, aiming to increase system-wide efficiency, lower costs to end users and better match supply with demand.

In **Africa**, the outlook for the forecast period, and in particular 2022, has been revised down by about one percentage point to 4%. South Africa is grappling with ongoing capacity shortages driven by the declining availability of its ageing coal fleet and teething issues on newly-commissioned units of its two coal megaprojects (Medupi and Kusile). Additionally, delays to IPP procurement programmes that were meant to relieve some of these shortages mean that load shedding and suppressed demand are likely to continue in the short term. One of the measures Eskom (the state-owned utility) has adopted to deal with the situation is appealing to consumers to reduce consumption to help alleviate stress on the system. Capacity shortages on the continent are not isolated to South Africa. While electricity outages are not uncommon in Nigeria (Africa's largest economy), the situation worsened notably with two nationwide blackouts occurring within the space of a month in March and April 2022. For 2023, we expect around 3% electricity demand growth for the continent.

Russia's war on Ukraine lowers expectations for electricity demand growth

Global change in electricity demand, 2015-2023



Sources: IEA analysis based on data from IEA (2022), Data and statistics.

Supply

Tight gas and coal markets resulted in new highs for thermal generation costs

Tightness of gas and coal markets was evident in 2021, with prices reaching unprecedented highs in October 2021. Russia's invasion of Ukraine put even more pressure and increased uncertainty across energy commodity markets. European gas and coal prices surged to all-time highs and displayed strong volatility in the first half of 2022. Asian spot LNG and coal prices followed suit, reflecting the strong interconnection of the regional markets. In the United States, low storage levels, together with elevated weather-driven demand in the first quarter and muted response from suppliers, led to decade-high gas and coal prices. Tight supply-demand fundamentals, accompanied by large uncertainties, are expected to linger well into 2023, for both coal and gas across all key markets.

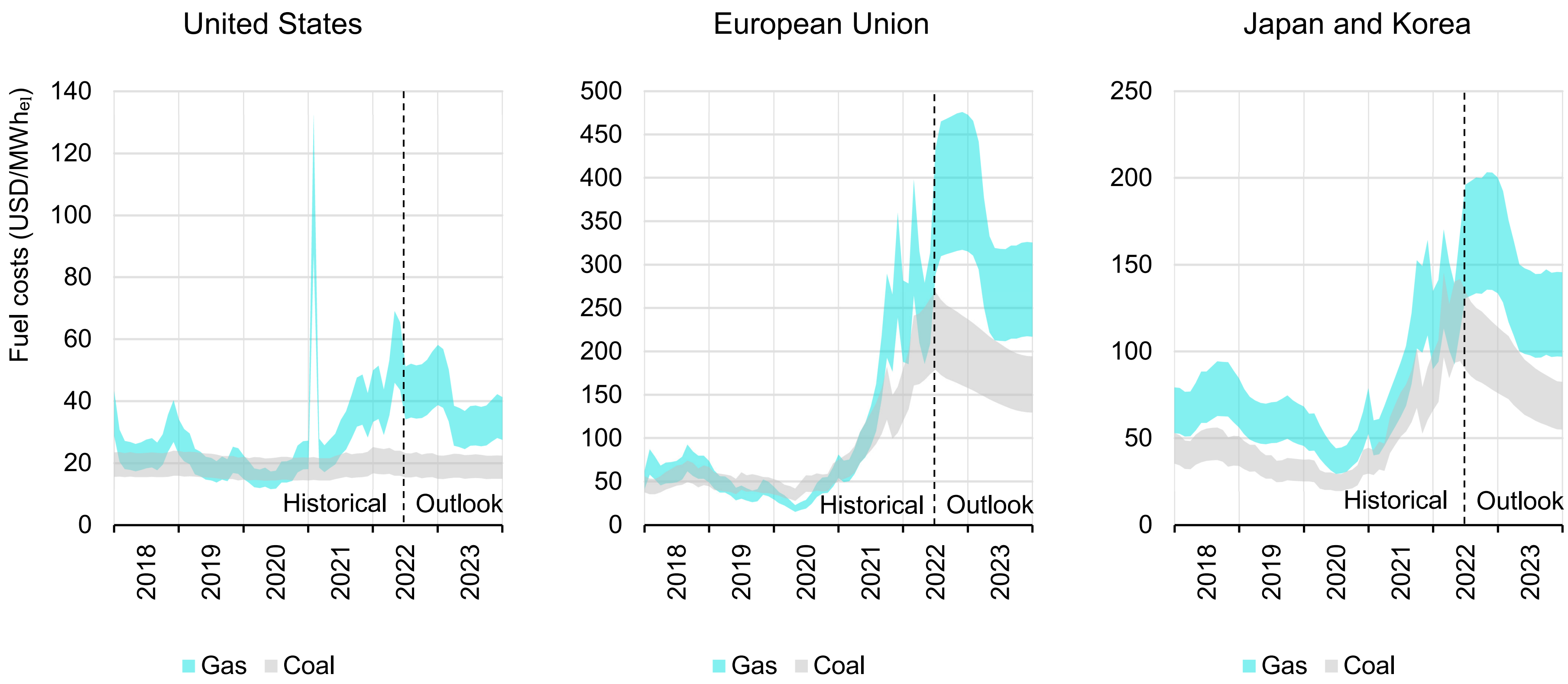
In the **United States**, Henry Hub prices averaged at USD 6/MBtu (USD 20.6/MWh) in the first half of 2022 – the highest for this period since 2008. Several factors supported this strong growth. Colder-than-average weather drove up residential and commercial space heating. Gas-fired electricity generation rose by 5% in the first half of 2022, supported by a sharp increase in coal spot prices as US coal stocks plummeted (by April 2022) to their lowest level since at least the 1970s (earliest available data). As most coal in the United States is sold on term contracts, prices for power plants are less volatile; however, spot Northern Appalachian coal prices averaged at USD 125/t in the first half of 2022, their highest level for over a decade. Higher domestic gas demand coincided with strong growth in LNG exports and weak supply response from US producers favouring capital discipline. Forward prices as of early July 2022 indicate that gas and coal prices fall only slightly in the second half of 2022, and decline by 20% and 27%, respectively, in 2023 year on year – remaining well above the 2016-2020 average prices.

In **Europe**, gas and coal prices surged to all-time highs in the first quarter of 2022, following Russia's invasion of Ukraine. Low storage levels and growing uncertainty around Russian supply drove up European hub prices. Gas prices on TTF averaged at USD 31.5/MBtu (USD 107/MWh) in the first half of 2022 – over five times their 2017-2021 average for this period of the year. Thermal coal prices rose to an average of USD 281/t – four times their 2017-2021 average level. Forward prices as of early July 2022 indicate rising prices for both gas (up 58%) and coal (up 20%) in the second half of 2022, declining in 2023 by 7% (gas) and 18% (coal). Notably, even with these declines, they will remain well above historical averages. EU carbon prices almost doubled in the first half of 2022 compared to 2021 levels, averaging at USD 91.5/t CO_2.

In **Japan** and **Korea**, LNG import prices rose by 90% year on year in the first five months of 2022, to an average of USD 16/MBtu (USD 55/MWh). Spot coal prices in the first six months more than tripled to an average of USD 257/t. Oil-indexed gas prices are expected to increase in the second half of 2022 (up 24%), while coal prices could moderate down by 2% compared with the first half. Forwards indicate a decline by 7% (gas) and 23% (coal) in 2023.

High thermal generation costs expected to linger well into 2023

Fuel costs of coal- and gas-fired power plants including emission costs, 2018-2023



Notes: Coal range reflects 33-45% efficiency; gas range reflects 43-55% efficiency. Due to the large geographic areas covered in each region, costs can differ between and even within countries and should therefore be interpreted as general trends. In the United States, natural gas prices increased significantly (exceeding USD 15/MBtu) in February 2021 due to supply constraints.

Sources: United States: based on EIA (2022), STEO July 2022. European Union: natural gas prices TTF; coal prices CIF ARA; emission costs EU ETS. Japan and Korea: natural gas prices are oil-indexed LNG prices; coal prices are Japan marker prices. Latest update: 12 July 2022.

Renewables grow faster than demand and squeeze out fossil fuel-based generation

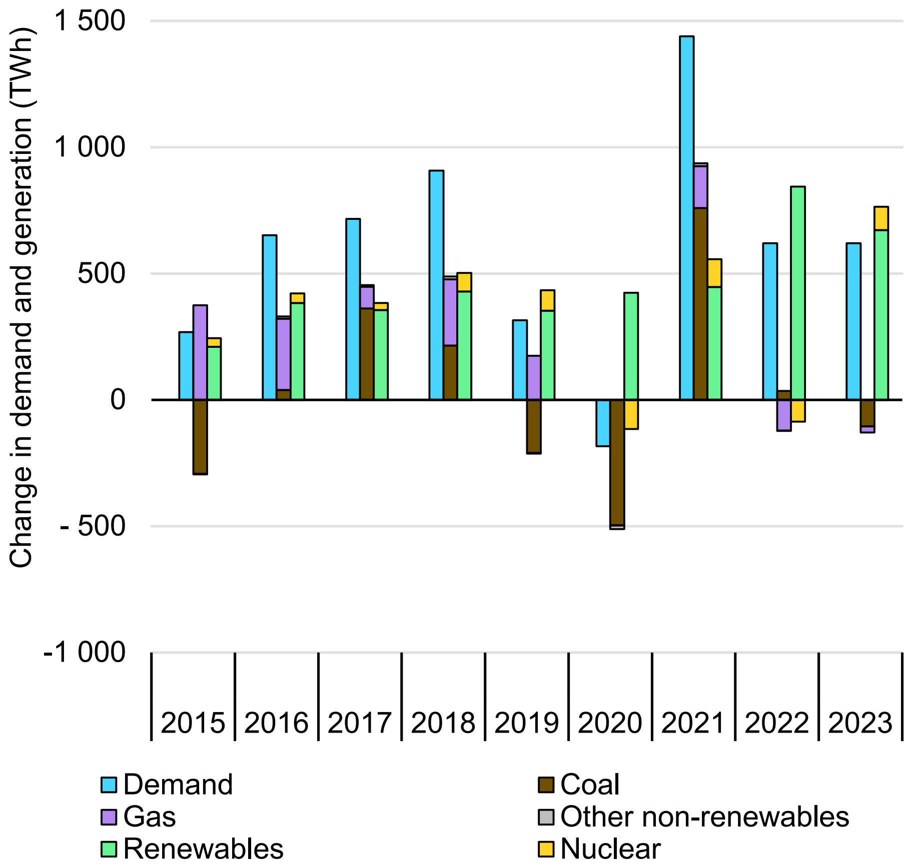
Global development

For 2022, we expect renewables to reclaim the title of, in absolute terms, fastest-growing source of electricity supply, after having held it from 2018 to 2020 already but losing to coal in 2021. Boosted by record new capacity installations in 2021 and another expected record in 2022, and after being hampered by unfavourable weather in 2021, output could grow by over 10% in 2022. This is the highest value on record and elevates the share of renewables in the supply mix to 30% (plus two percentage points). As nuclear generation is down 3% (induced by lower capacity availability and retirements in Europe), low-carbon generation grows in total by 7%, exceeding demand growth and pushing down global fossil fuel use by 1%.

Despite high gas prices causing gas-to-coal switching and coal-fuelled electricity demand growth in India, we expect global coal-based output to increase only slightly in 2022, mainly due to weak electricity demand in China and coal-supply restrictions in the United States. Global gas-based generation declines by 2.6%, as moderate growth in North America and the Middle East partly compensates losses in Europe, Eurasia and the Asia Pacific region.

For 2023, we expect global renewables growth (plus 8%) to again exceed additional electricity demand. Along with rebounding nuclear (plus 3%), this results in a further decline of fossil fuel-fired power generation. Continued high gas prices could push down gas-fired generation by another 0.5%, while coal use declines by 1%.

Evolution of global electricity demand, fossil fuel and low-carbon electricity generation, 2015-2023



Note: Other non-renewables includes oil, waste and other non-renewable energy sources.
Source: IEA analysis based on data from IEA (2022), Data and statistics.

Regional developments

In **Asia Pacific**, we expect generation from renewables to grow by more than 13% in 2022, exceeding additional demand and resulting in declining capacity factors for fossil fuel plants. This continues in 2023, when growing renewables (up by 9%) could again supply the majority of new demand. We also expect nuclear generation to continue growing in the short term, driven by India, China and Japan. Korea announced a policy change regarding nuclear power, now aiming to expand nuclear generation to meet climate targets and reduce the reliance on fossil fuels.

In China, supply disruptions in autumn 2021 led the authorities to focus on security of supply, reflected in the 14th Five-Year Plan for Energy (FYP-E), which sets the country's strategy for 2021-2025. The target for the growth of renewables output in this time frame is set at more than 50% of incremental power demand. The FPY-E also highlights the importance of flexible and efficient coal plants for complementing variable renewables output. As China implements reforms towards better use of renewable power and inter-provincial trade, the share of coal in electricity is set to decline slowly. Due to low demand and high renewables generation (forecast to grow by 14% in 2022), thermal electricity output declined by more than 10% year on year in April and May 2022. For the full year, coal-fired electricity could drop by 1% – the first decline since 2015. In 2023, we expect coal to roughly make up for losses in 2022.

In India, as opposed to most of the rest of the region, coal is expected to grow significantly in 2022 (up 6%) and to meet the majority of new demand, with rising renewables generation (up 9%) providing most of the rest. Supply has been challenged since 2021 due to fuel supply issues for coal power plants, which has resulted in a 9-year-low inventory of coal. In response, India's Ministry of Power is implementing measures to increase coal supply. High temperatures in spring 2022 triggered demand spikes, further straining the electricity system and leading to supply interruptions in several states. For 2023, we expect coal growth to slow to less than 2%, at which point it contributes to serving growing demand on a level similar to additional nuclear generation, which could grow by more than one-third as more than 4 GW are scheduled to start operating by 2023. The majority of incremental generation is set to come from renewables, which could grow by more than 10%.

In the **Americas,** renewables continue to drive growth, led by the United States, where we expect year-on-year increases exceeding 11% in 2022 and 6% in 2023. Five states updated or adopted new clean energy standards in 2021, three of which committed to 100% clean energy or carbon-free electricity. Nuclear capacity is expected to increase by 1.4 GW by the end of 2023, as the Vogtle Units 3 and 4 in Georgia (1.1 GW each) come online, partially offsetting recent retirement of the Palisades in Michigan (0.8 GW). In February 2022, the Biden Administration launched a USD 6 billion programme to support continued operation of nuclear reactors that are subject to retirement pressure due to economic factors. Despite high gas prices, no significant gas-to-coal switching in power generation is expected due to fuel delivery and coal stock constraints, on top of the diminishing coal-fired capacity due to phase-outs.

In Mexico, most growth in generation in 2022 is expected to come through increases in renewables (plus 15%) and coal (plus 26%), compensating lower gas-fired generation (expected to decline by 3%). These trends reflect that the Federal Commission of Electricity (CFE) is preparing to replace gas in certain power plants with alternative fuels to avoid shortages and high prices. The CFE has stated plans to continue investing up to MXN 219 million (about EUR 10 million) in isolated distributed PV systems and to advance ambitious plans to modernise and re-equip its hydropower fleet. Still, we expect growth in renewable generation to slow down to 5% in 2023, while fossil fuels serve the remainder of growing demand.

In Brazil, higher hydropower generation availability has driven an increase in its share in the generation mix, with the last week of April 2022 seeing 17% higher output than in 2021. In light of these developments, in April the federal government announced the end of electricity extra charges known as the “water scarcity flag”, which will reduce power bills. Given current water levels, the removal of the extra charge is expected to remain in place until the end of 2022, according to the electricity authorities. Higher renewables generation replaces fossil fuels in 2022 and 2023, at which point it could almost reach a share of 90% in the generation mix.

Europe is particularly affected by rising fossil fuel prices and supply shortages, most of all for natural gas. The situation is exacerbated by a significant decline in nuclear generation, which we expect to decrease by 12% (more than 100 TWh) in 2022. Lower plant availability in France (following safety investigations over corrosion problems) is the main contributor, with additional drops reflecting the retirement of 4 GW of nuclear power in Germany and the impact of the Russian invasion of Ukraine’s nuclear plants. These drops are only partially offset by the grid connection of Olkiluoto-3 (1.6 GW) in Finland. Growing renewables generation in 2022 compensates some of the decline in nuclear generation. With high gas prices driving gas-to-coal switching and governments intervening to reduce gas consumption in favour of coal (e.g. delaying coal power plant retirements and extending permitted operating hours), coal-fired electricity generation has increased in countries with spare coal capacity while gas has declined (for example, Germany). In total for 2022, we expect coal-fired electricity generation to increase by 8% (50 TWh) while gas declines by close to 7% (60 TWh).

For 2023, renewables growth of 7% could again meet or exceed demand increase. With about stable nuclear generation compared to 2022 (as French nuclear rebounds to offset closures in Germany and Belgium), fossil-fuel electricity generation could decline by close to 6% (coal by 8% and gas by 4%). However, this depends heavily on the availability and price of gas and measures taken to reduce import dependency from Russia (such as delayed coal retirements).

In **Eurasia**, power generation rose by 5% in 2021, driven by strong electricity consumption growth and higher exports. Russia alone accounted for around 80% of incremental power generation, with power output rising by over 5%. Additional power generation in the region came primarily from natural gas, providing about 85% of the net increase, with renewables providing the majority of the remaining increase in overall generation.

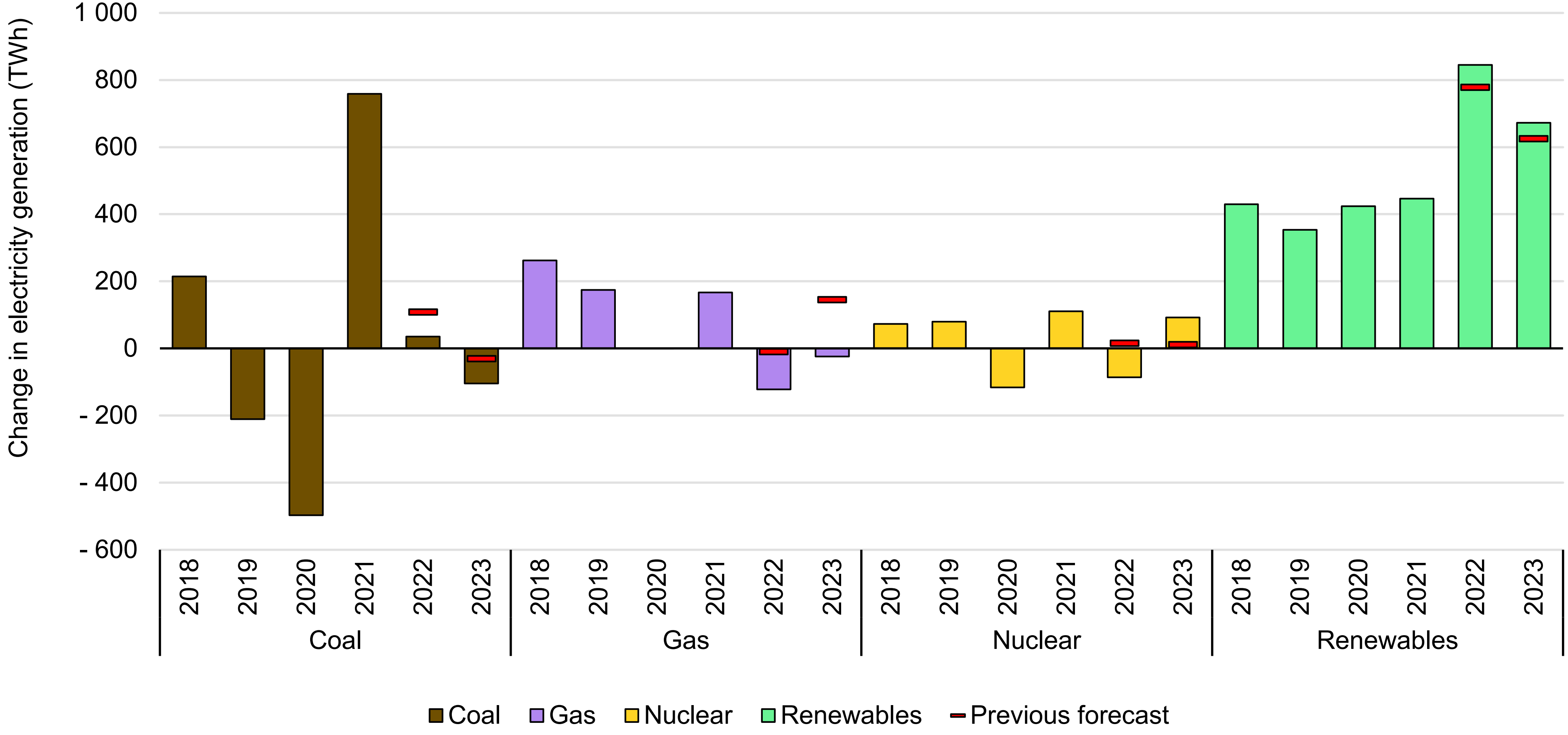
In the first half of 2022, Eurasia's power generation rose by an estimated 2% year on year. In Russia, total generation increased by 3% year on year, primarily supported by higher thermal and nuclear output. Total power generation in Kazakhstan and Uzbekistan remained almost flat, and increased in Azerbaijan (plus 2%) on the back of higher gas-fired generation. We expect Eurasia's power output to decline by 2% for the full year of 2022, and by 1% in 2023, due to the worsening economic outlook of Russia.

In the **Middle East**, we expect natural gas to account for nearly two-thirds of the net increase in total generation in 2022 and 2023, and to retain its dominant share (over 70%) in the region's electricity mix. Increasing gas-fired generation is supported by rising gas supply availability across the region. Oil, at 21% the second-largest share in the regional electricity mix in 2021, is on course to register a significant decline. In Saudi Arabia, the largest electricity consumer in the region, surging crude prices since the start of 2022 have driven up the opportunity costs of burning oil. As such, oil-fired generation is replaced with domestically produced natural gas, which cannot be exported due to lacking infrastructure. Nuclear output is set to nearly triple in the Middle East, following the start of commercial operation of the second (in 2022) and third (in 2023) units of the Barakah nuclear plant in the United Arab Emirates. Renewable generation is expected to increase by one-third, boosted by recent project completions (e.g. Phase 1 of the 800 MW Al Kharsaah solar project in Qatar in April 2022) and major awards (e.g. the Ar Rass and Saad solar developments totalling 1 GW in Saudi Arabia in March 2022). Coal-fired generation is set to halve between 2021 and 2023 (compared to a less than 10% decline in our previous forecast) following the February 2022 decision in the United Arab Emirates to convert the Hassyan coal plant (under construction) in Dubai to natural gas.

In **Africa**, we forecast a major increase in renewables generation as numerous projects (including hydro, solar PV and wind) are expected to come online as several countries (including Algeria, Morocco and Egypt) realise stated ambitions. A number of wind and solar projects in South Africa are also expected to come online: most are from auctions concluded in 2014 that were delayed due to contractual disputes around their PPAs, which have now been resolved. In February, the Grand Ethiopian Renaissance Dam (GRED) in Ethiopia started to generate electricity. When completed, it will have more than 5 GW capacity and produce more than 15 TWh annually, making it the largest hydropower plant in Africa. A number of gas projects are also expected to come online, especially in North Africa. The last units of two coal megaprojects, Medupi and Kusile, are expected to come online before 2023, alleviating some (though not all) of current capacity shortages in South Africa. In fact, a separate "emergency" IPP procurement programme aimed to alleviate the capacity shortages. However, delays in reaching financial close mean these projects, originally expected to come online in August 2022, would come online in August 2023 at the earliest, though further delays are possible.

Global fossil fuel-based electricity generation comes under pressure

Global change in electricity supply, 2018-2023



Source: IEA analysis based on data from IEA (2022), [Data and statistics](#).

Emissions

Emissions remain high due to continued strong coal-fired generation

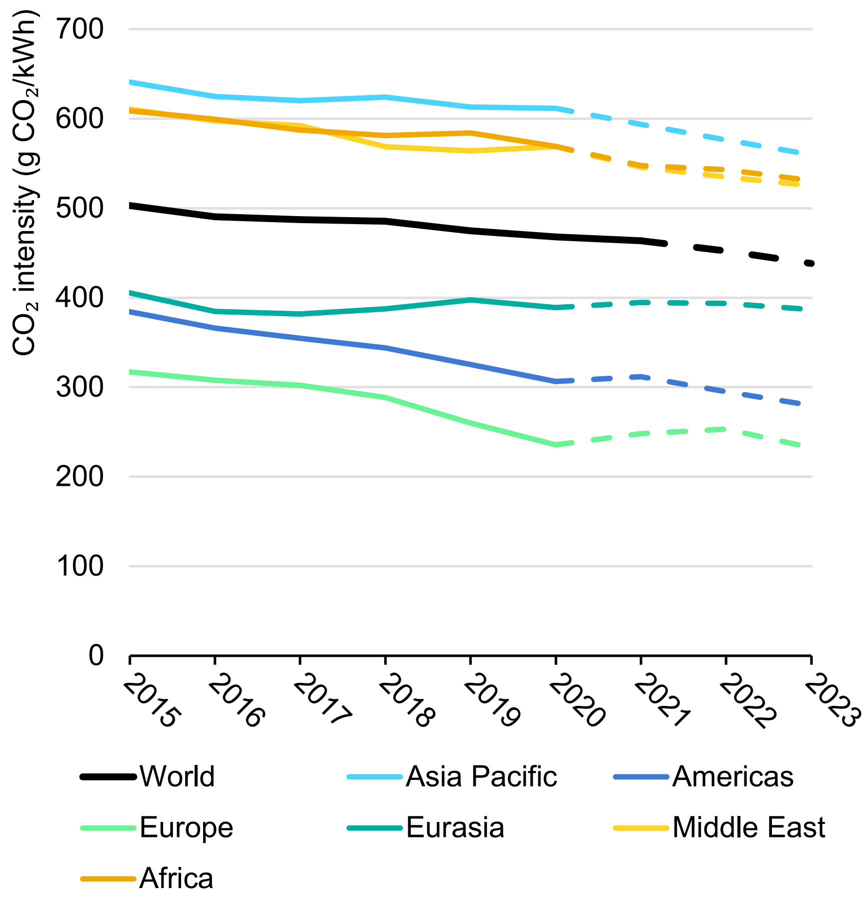
While our January forecast indicated global electricity sector emissions would remain flat in 2022 and 2023, we now expect a decline of around half a percent in 2022 and one percent in 2023 – following the all-time high of over 13 Gt CO_2 in 2021. A combination of two main factors comes into play: lower-than-expected electricity demand growth and higher renewables generation. Both result in declining fossil fuel use.

Only for Europe do we expect an emissions increase (up 3%) in 2022 as, despite renewables growth, use of coal rises to reduce gas consumption (and to compensate the drop in nuclear generation). The Americas are the largest contributors to declining emissions, as additional renewable generation replaces fossil fuel use.

For 2023, we expect the largest emission declines in the Americas (down 5%) and Europe (down 8%), both enabled by renewables growth. Asia Pacific, however, could again see emissions rise (up 1%) as incremental demand growth exceeds additional renewables generation, and is thus met by increasing coal-based generation.

We expect global electricity generation emissions intensity to decline by on average 3% in 2022 and 2023. Only in Europe does intensity increase in 2022 (up 2%), followed by an 8% decline in 2023.

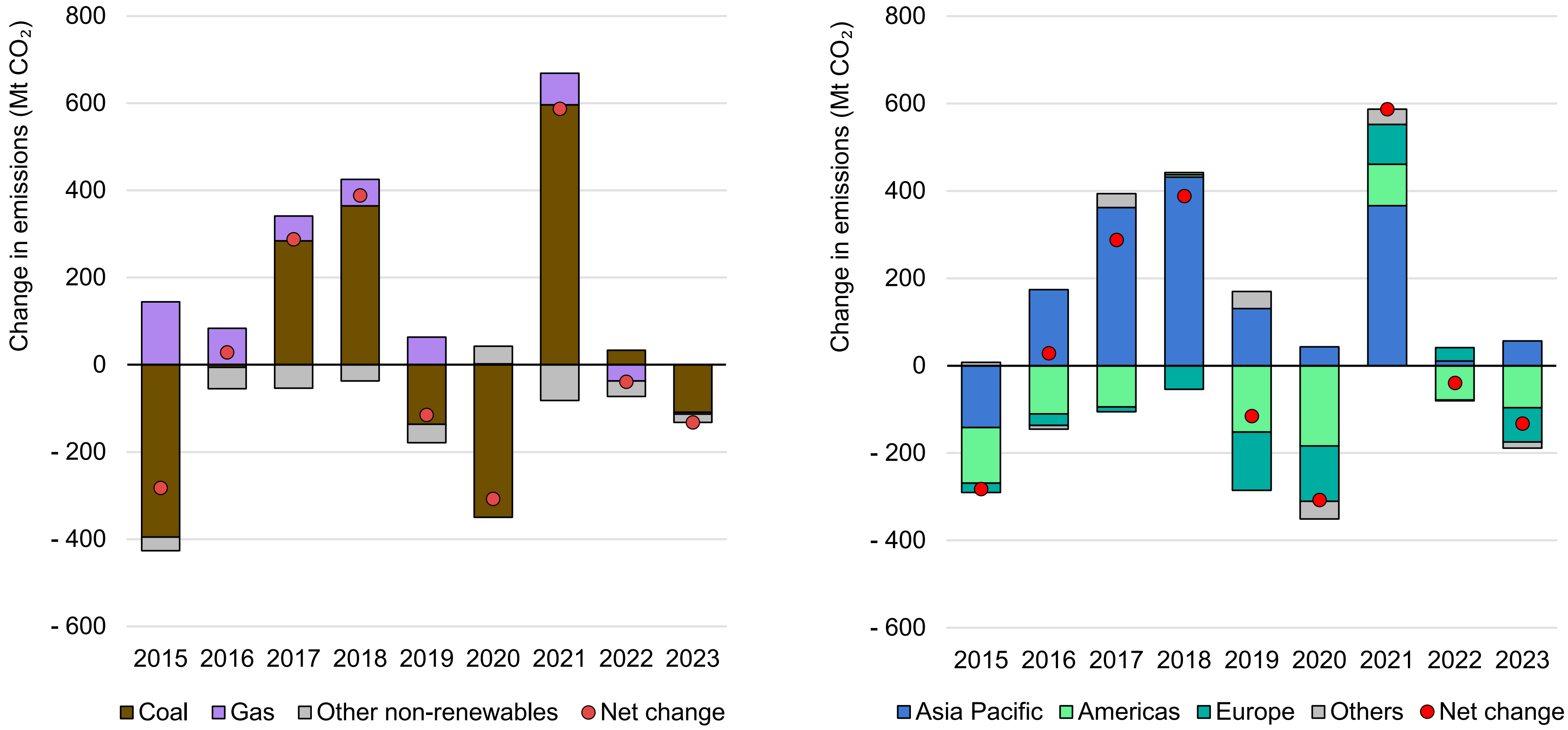
Regional evolution of global power system emissions intensity, 2015-2023



Source: IEA analysis based on data from IEA (2022), Data and statistics.

Emissions from coal-based electricity generation show little decline in the short term

Global change in electricity emissions by source and region, 2015-2023



Note: Other non-renewables includes oil, waste and other non-renewable energy sources.
Source: IEA analysis based on data from IEA (2022), Data and statistics.

Wholesale prices

Electricity prices in many wholesale markets continue to be on the rise…

Wholesale electricity prices rose significantly in many countries in the first half of 2022, especially in Europe, pushed up by tight fossil fuel markets. Our price index, representing a four-quarter rolling average of weighted prices in major electricity markets, reached almost 300 points in the second quarter of 2022, indicating three times higher average wholesale prices than in the reference period in 2016 and 60% higher prices than in the same quarter of 2021.

In many **European** markets, wholesale power prices in the first half of 2022 were three to more than four times as high as the average in the first half of 2016 to 2021, primarily due to gas prices climbing to more than five times the value of the reference period. In Germany, average baseload prices reached EUR 186/MWh. Carbon prices also increased significantly – up by 90% in the first half of 2022 compared to the same period in 2021, averaging EUR 84/t CO_2 – but made a minimal contribution to the electricity price increase. In Spain, wholesale prices declined with a cap on gas prices for power introduced in June. The real costs of electricity are however not fully visible as gas plants have to be compensated.

Based on electricity futures, we expect power prices in Europe to slightly decline during the Northern Hemisphere's summer, then peak in the winter 2022/2023. In France, due to low expected nuclear availability, future prices as of early July 2022 show baseload prices exceeding EUR 800/MWh for the winter quarters of 2022/2023 – with peak load prices of more than EUR 1 400/MWh.

In **Nord Pool**, average wholesale prices for the first half of 2022 were 2.7 times those of a year earlier. While prices rose to EUR 115/MWh, they remained significantly below the European average due to the high share of hydro-based generation.

The average wholesale price in the **United States** in the first half of 2022 was lower than in the first half of 2021 (supply disruptions in Texas in February 2021 made prices surge). In the second quarter of 2022, average wholesale prices rose by 130% year on year. Gas prices (more than 150% higher year on year) are the main driver.

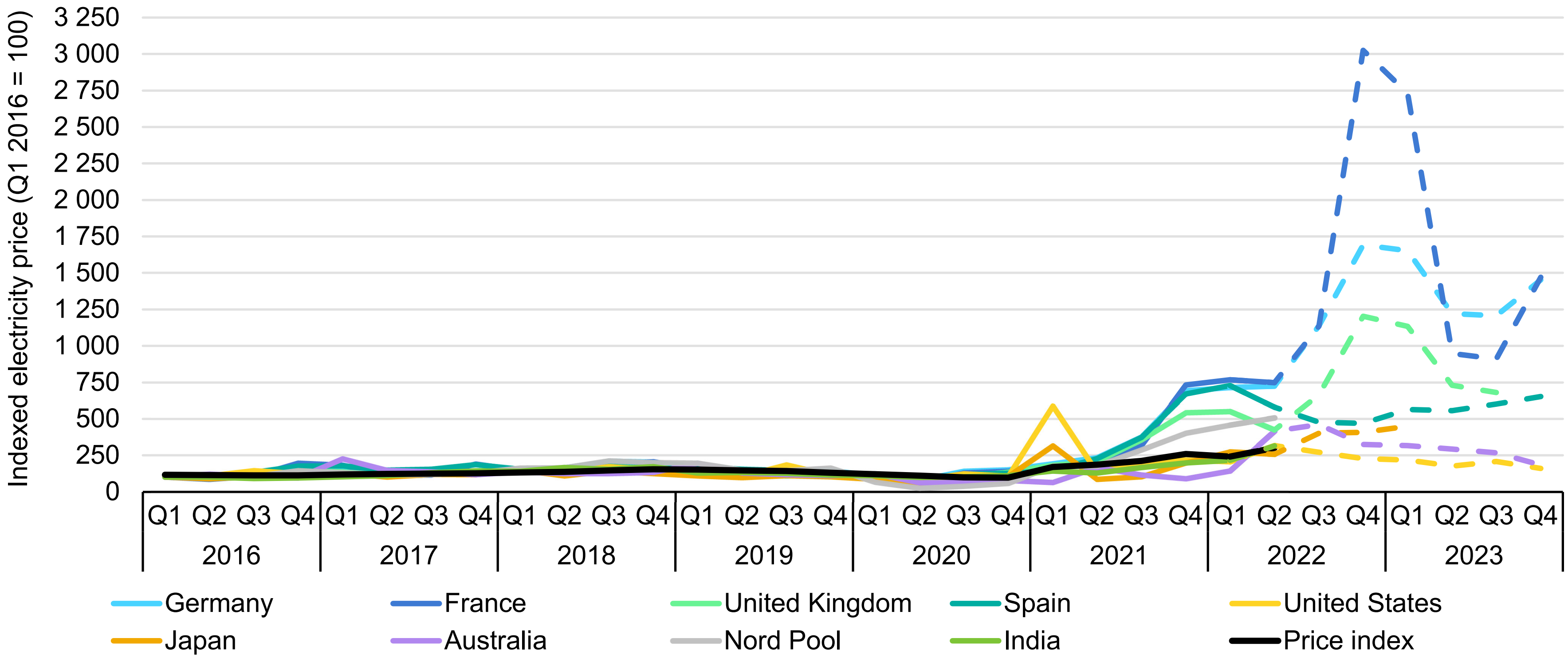
Japan was confronted with a tight supply situation in January 2021 and accordingly very high electricity prices. In the second quarter of 2022, average prices doubled year on year, caused by a mix of higher prices for both coal (up 150%) and gas (up 90%).

In **Australia**, wholesale prices rose by 144% in the first half of 2022 (year on year) due to higher gas prices (at the East coast plus 65%), higher temperatures and lower availability of thermal plants. Trading in Australia's spot National Electricity Market was suspended from 15 to 24 June 2022, amidst generation shortfalls that made it "impossible to operate" under the usual market rules.

In **India,** wholesale prices soared since March 2022, as higher power demand outpaced coal availability, leading to severe power shortages. The average price almost doubled in the first half of 2022 year on year, reaching a record high in more than a decade.

…reaching new highs in many economies during 2022, especially in Europe

Quarterly average wholesale and futures prices for selected regions, 2016-2023



Notes: The price index aggregates wholesale electricity prices across the depicted regions. It is calculated as the demand-weighted rolling average of the current and previous three-quarter indexed prices. The prices for Australia and the United States are calculated as the demand-weighted average of the available prices of their regional markets. Continuous lines show historical data and dashed lines refer to futures. Price estimates for the third quarter of 2022 and beyond are based on the latest forward baseload electricity prices, except for the United States, where we use EIA (2022) values. The forecasted prices for Japan are volume-weighted estimates of the latest JPX settlement prices, considering the baseload contracts (areas B1 and B3).

Sources: IEA analysis using data from RTE (France) and Red Eléctrica (Spain) – both accessed via the ENTSO-E Transparency Platform; Bundesnetzagentur (2021), SMARD.de; Elexon (2022), Electricity data summary; AEMO (2022), Aggregated price and demand data; EIA (2022), Short-Term Energy Outlook July 2022; Nord Pool (2022), Market Data; IEX (2021), Area Prices; EEX (2022), Power Futures; JPX (2022), Daily Data (Electricity Futures); ASX (2022), Electricity Futures © ASX Limited ABN 98 008 624 691 (ASX) 2020. All rights reserved. This material is reproduced with the permission of ASX. This material should not be reproduced, stored in a retrieval system or transmitted in any form whether in whole or in part without the prior written permission of ASX. Latest update: 12 July 2022.

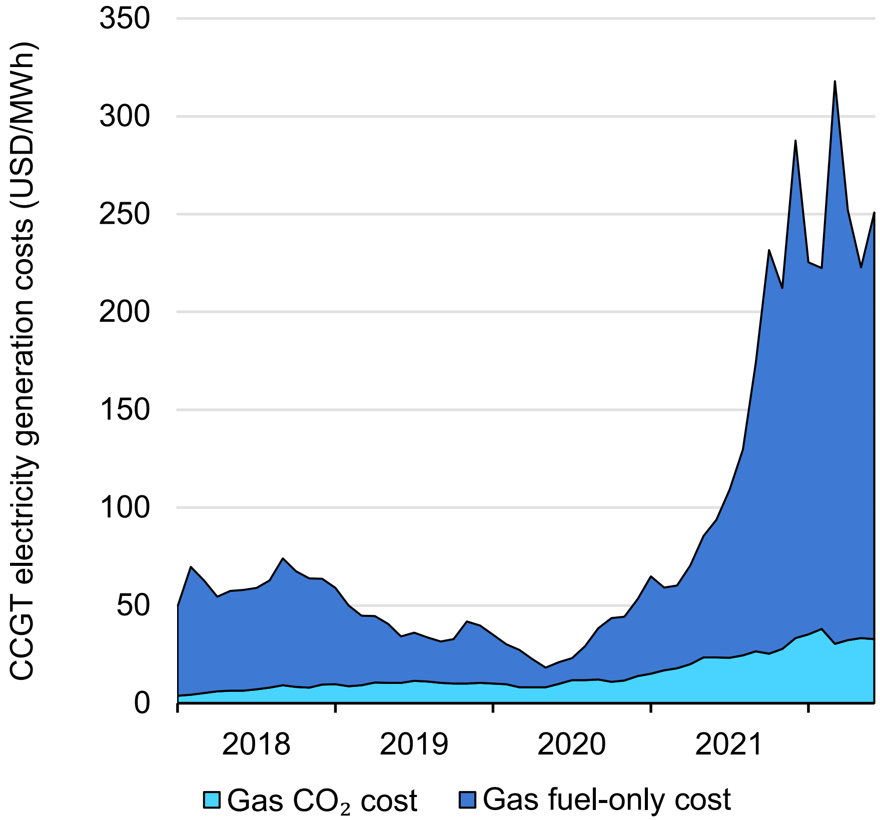
High natural gas prices are main driver for increasing wholesale electricity prices in Europe

Soaring fossil fuel prices on global markets resulted in very high electricity prices. High costs for natural gas are a main driver, as gas-fired plants frequently set the wholesale electricity price in Europe. In addition, carbon prices in Europe have risen markedly since 2021, sparking discussions around their contribution to the electricity price increase.

In June 2022, EU ETS allowances prices were over three times higher than in January 2020. Despite the significant increase, carbon costs remain a minor contributor to total gas-fired generation costs. In January 2020, they accounted for about 30% of total costs; as gas prices rose by over eight times during the period, that share dropped to below 15% in June 2022. Overall, 90% of the cost rise from January 2020 to June 2022 reflects the higher gas price and only 10% is due to the increase in carbon prices.

European carbon prices rose due to several factors. One major driver is gas-to-coal switching induced by high gas prices. With coal power CO_2 emissions being about twice as high as gas, this boosted demand for emissions allowances. In parallel, proposals for more ambitious emissions reduction targets for the EU ETS, from currently 43% to 61% (European Commission) or 63% (European Parliament) by 2030 compared with 2005, led to an anticipated lower allowance availability. In turn, the worsening economic outlook and the proposal to increase the amount of auctioned allowances in the REPowerEU plan had price-dampening effects.

Monthly average natural gas-fired electricity generation costs breakdown, European Union, January 2018 to June 2022



Notes: CCGT = combined-cycle gas turbine. Assuming a CCGT natural gas plant with 50% efficiency. The carbon price data used correspond to historical EU ETS prices.
Sources: Ember (2022), Carbon pricing; Natural gas prices TTF.

Europe focus

Europe’s current dependency on energy imports

Russia's invasion of Ukraine challenges energy security in Europe

Russia is one of the largest global producers of fossil fuels. In 2021, it was the world's second-largest producer (behind the United States) and the largest exporter of natural gas. Also, it was a top-three crude oil producer (together with Saudi Arabia and the United States) and accounted for about one-fifth of global coal exports.

Russian energy exports are particularly important for Europe. In 2020, close to 30% of total natural gas consumed in the European Union and the United Kingdom was imported from Russia; the share of oil was more than 20% and coal was about 12%. While oil plays only a minor role for European electricity generation, the share of gas in the EU electricity mix was about 19% in 2021 and that of coal 16%.

Russia plays an important role for the operation of nuclear power plants in Europe. In 2020, around 20% of uranium delivered to the European Union came from Russia and Russian companies provided 24% of conversion and 26% of enrichment services to EU utilities. Because of its higher energy density, nuclear fuel can more easily be stockpiled than fossil fuels. In its annual report from mid-July 2021, the European Atomic Energy Community (Euratom) estimated current uranium inventories can fuel EU nuclear plants for 2.75 years on average (the figure varies among plants). Some reactors, however, could run out of stock by the end of 2023. Depending on the reactor design, some nuclear plants can switch to alternative suppliers; others depend solely on Russian nuclear fuel.

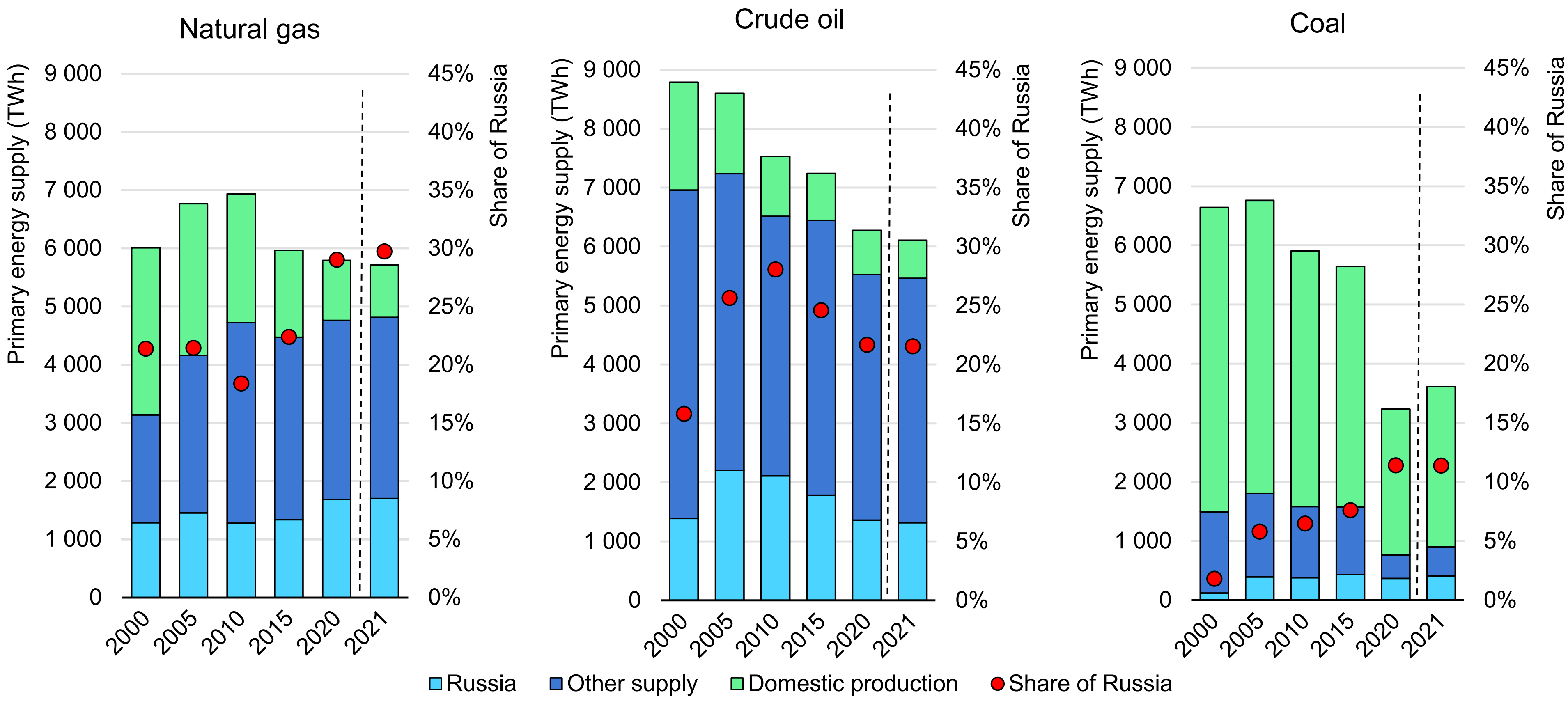
In total, 12 electricity interconnectors connect four EU member states with Russia. The electricity grids of the three Baltic States (Estonia, Latvia and Lithuania), despite plans to join the European system by 2025 at the latest, currently operate in a synchronous mode with the Russian and Belarusian systems (called the BRELL ring). In 2020, Finnish net imports from Russia relative to national electricity demand amounted to 5%. Norway's connection with two Russian hydro-power plants, a total of 56 MW, is rather negligible. In 2022, Russian trade with Finland and Norway stopped.

Due to Europe's energy dependency, the Russian invasion of Ukraine on 24 February 2022 has had severe consequences for the entire continent. On top of already tight natural gas markets and low availability of French nuclear plants, the invasion resulted in energy scarcity and high energy prices, constituting a burden for consumers and dampening the economic recovery from the downturn in 2020. As of July 2022, countries in Europe and globally continue to suffer under tight fossil fuel markets and significantly increased energy prices.

A lack of sufficient (low-cost) procurement alternatives, particularly for gas, carry potential consequences for security of energy supply and for energy prices – and thus limit options for imposing sanctions on Russia. Any such sanctions might also trigger retaliation measures, for exemple in the form of export reductions or stops, as already seen in many countries, with similar consequences.

Europe depends on imports from Russia for large shares of its energy supply

Estimated shares of Russian gas, crude oil and coal imports in the EU and UK energy supply, 2000-2021



Note: The “Share of Russia” indicators refer to how much Russian imports account for in the total supply (domestic production + imports from Russia + other supply) of the European Union and the United Kingdom combined.
Source: IEA analysis based on data from IEA (2022), Data and statistics.

Pathways to energy independence

The electricity sector is crucial to reduce energy import dependency

The electricity sector can play a central role in reducing Europe's needs for fossil fuel imports. In its 10-Point Plan on Gas and 10-Point Plan on Oil, the IEA highlights ways to reduce dependency on fossil fuels, particularly imports from Russia, in the short and longer term. Available measures can be categorised in four groups. First, using alternative procurement options for fossil fuels. Second, implementing austerity measures that reduce energy consumption at the expense of utility (e.g. slower driving speed, moderate heating and cooling). Third, deploying energy efficiency measures that reduce energy need while maintaining the utility level (e.g. improved insulation of buildings). Finally, increasing use of domestic energy sources.

In light of targets for climate change and societal prosperity, switching to other fossil fuel suppliers and implementing austerity measures are only suited for short-term interventions. For the longer term, improving energy efficiency and harvesting domestic low-carbon energies can not only reduce Europe's energy import dependency, but also deliver a more sustainable energy system. However, establishing secure, resilient and sustainable clean energy supply chains are essential to safeguard the energy transition. Renewable energies are by far the largest and fastest-growing source of domestic low-carbon energy. Accelerating their deployment can significantly reduce the need for energy imports.

Energy efficiency improvements in the form of direct demand reductions (e.g. improved building insulation or more fuel-efficient internal combustion engine [ICE] vehicles) have immediate effects on overall energy consumption. Due to limits regarding the achievable efficiency improvements (with reasonable efforts), energy supply must also shift to domestic low-carbon sources.

While nuclear energy has mostly stagnated or declined in Europe, use of renewable energies, particularly wind and solar PV, has risen significantly in recent years, primarily in the electricity sector, due to increasingly favourable economics and policy support. Electrified end-user energy consumption enables wider use of these renewables in other sectors. Frequently, simultaneous efficiency gains can be achieved. The buildings and transportation sectors show strong potential to reduce use of fossil fuels and related CO_2 emissions by deploying heat pumps instead of gas boilers (or coal or oil heaters) and electric vehicles (EVs) instead of ICE vehicles.

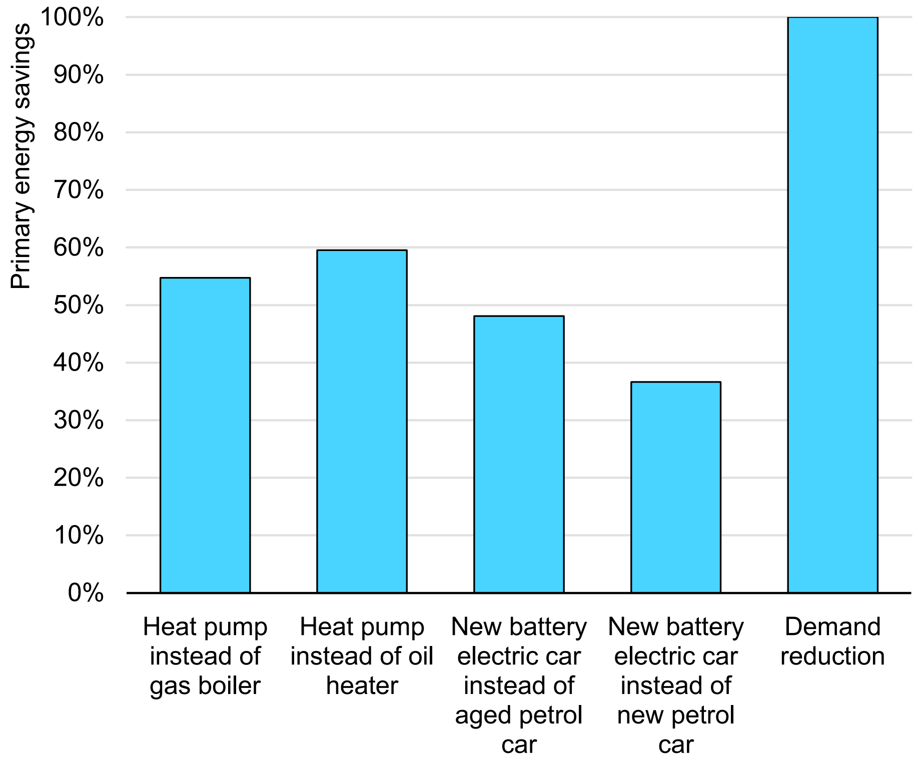
In the European Union, the share of battery (pure) electric vehicles (BEVs) on total car sales reached 9.1% in 2021, while plug-in hybrid electric vehicles (PHEVs) had a share of 8.9%. Sales increased significantly compared to 2020, by 25% for BEVs and 71% for PHEVs. Despite the growth in sales, BEVs and PHEVs constituted less than 2% of total passenger cars in use in 2021. In terms of primary energy consumption, EVs are more than 35% more efficient than new petrol cars (about 50% than older conventional cars).

Heat pumps are highly efficient for space heating, saving about 55% primary energy when replacing gas boilers (60% for oil boilers). New heat pump installations have grown notably in recent years, with over 2 million new units in Europe in 2021 (up 25% on 2020). Still, gas boilers dominate annual sales in many EU markets. In 2020, 2.8 times as many gas heaters than heat pumps were sold in France and 4.6 times as many in Germany. In the European Union and the United Kingdom, over half of all residential heating appliances run on gas. In total, the EU residential sector uses 40% of all gas, the majority for space (75%) and water (19%) heating.

Due to their technical characteristics (higher efficiency with lower heat generation), heat pumps are best suited for well-insulated buildings. However, many existing buildings in Europe were built without significant energy efficiency requirements in place. Various studies show that the current building envelope renovation rate of 1.3% (with below 1% primary energy reduction) must be expanded to 2% to 4% to reach long-term decarbonisation targets.

Direct electrification remains challenging, particularly in some industry sectors, long-distance transport, aviation and shipping. Suitable technologies are still under development or costly. For some applications, indirect electrification can be an alternative, meaning using electricity to produce hydrogen or hydrogen-based fuels to replace fossil fuels. While further research and cost reductions are needed, such fuels – if produced with low-carbon electricity – hold strong potential as an essential part of the transition to low-emission energy systems.

Primary energy savings of different energy efficiency and electrification options

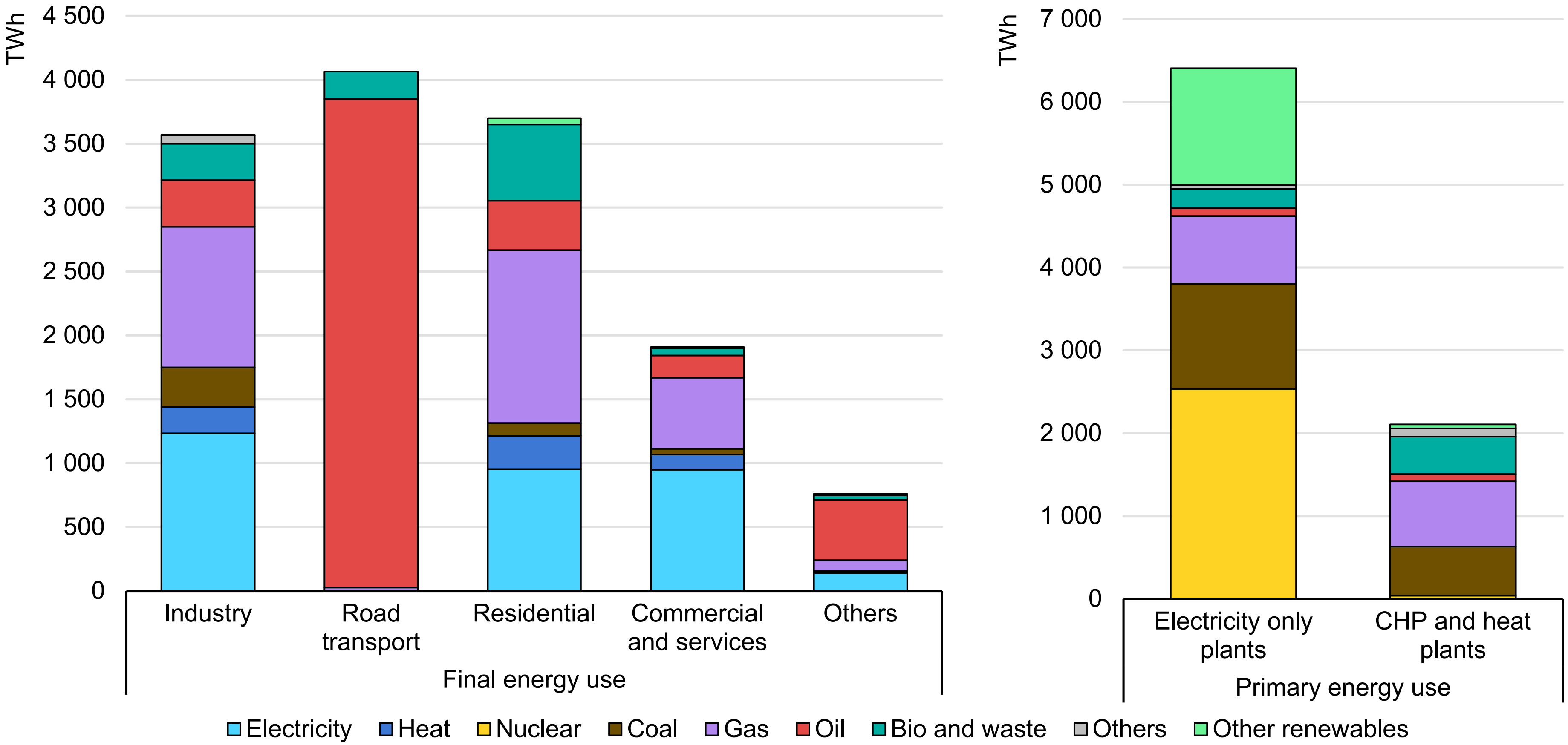


Notes: The figure illustrates the amount of primary energy that is **not consumed** due to the listed options. To calculate the primary energy consumed for electricity generation, we assume a gas-fired plant with 50% efficiency. The analysis focusses purely on the energy savings. To evaluate economic efficiency, it would be necessary to also take into account the costs per energy consumption reduction. Additionally, we focus on variable energy consumption. Thus, energy needed to construct wind turbines is not included, for example.

Sources: IEA analysis based on data from IEA (2022), Data and statistics; HARP (2019), Building vs heating stock (space and water) matrix, EU and country level.

Low-carbon energy sources in Europe dominate only in the power sector

Final energy consumption by sector and primary energy use in electricity and heat generation in Europe, 2019



Notes: CHP = combined heat and power. Other renewables include everything but bioenergy and waste, thus mainly hydro, wind and solar PV. An input-output efficiency of 100% is assumed for solar PV and wind power plants. Heat plants (including heat pumps and electric boilers) refers to large-scale units selling heat or producing heat for (partly) own use to support their primary activity. It excludes applications in the buildings sector (i.e. distributed heating appliances).

Sources: IEA analysis based on data from IEA (2022), Data and statistics.

Europe rolled out measures to reduce energy consumption and advance the energy transition

As a reaction to the Russian invasion of Ukraine and the ongoing energy crisis, the European Union as a whole and European countries individually took measures to reduce their import dependency on Russia. These efforts aimed to contain the impact of high prices and potential supply shortages on the economy and on vulnerable customers. Measures were also necessary to enable sanctions, such as an import ban on Russian coal, a partial embargo on oil imports and others.

Many of the measures continue and accelerate climate protection policies launched in recent years, reflecting that energy transitions are necessary to dampen climate change but also contribute significantly to improving security of energy supply.

The European Commission (EC) published on 18 May 2022 its REPowerEU plan to reduce dependence on Russian fossil fuels by accelerating the clean energy transition. The proposals build on the Fit for 55 package, which intends to align EU laws with more ambitious climate protection targets for 2030 and 2050. Alongside measures specifically targeting the gas sector, the plan identifies transforming the electricity sector – via accelerated roll-out of renewable energies, electrification of end uses and renewable hydrogen – as a critical means to reduce energy import dependency. The electricity sector is also central to national European initiatives, typically in line with EU proposals. Some countries also include nuclear energy in their transition strategies.

Short-term energy savings

In its aim to rapidly reduce dependence on fossil fuels from Russia, the European Union considers energy savings to be an essential building block. While most other measures discussed in this section take effect over time (including energy efficiency measures), energy savings through behavioural changes (austerity) can have immediate effects.

With its "Playing my part" campaign, developed in co-operation with the IEA, the European Commission hopes to reduce gas consumption in the European Union by 13 bcm (127 TWh) per year (5% of annual demand). The plan sets out nine ways to reduce energy consumption in the short term in the buildings and transportation sectors. In parallel, national measures being implemented include a new law in Italy that temporarily requires thermostats in public buildings to be set no lower than 27°C for cooling (with two degrees tolerance) while heating temperatures should not exceed 19°C. To reduce energy consumption in transportation and provide affordable options, some European countries reduced tariffs for public transportation.

Renewable energies

As part of REPowerEU, the European Commission proposed to increase its target for renewable energies to 45% of gross final energy consumption by 2030 (up from the 40% proposed in the Fit for 55 package and the current target of 32%). Against a share of 22.1% in 2020 (up from 14.4% in 2010), a significant acceleration of renewables deployment is necessary to reach the new target.

Several national governments also raised their renewable electricity ambitions. In its Easter package, the German government included a proposal to declare accelerated expansion of renewable energies as being of "outstanding public interest" and reiterated the target formulated in the coalition contract at the end of November 2021 to increase renewables generation to 80% of gross electricity consumption by 2030 (up from the previous target of 65%). Portugal increased its target for renewables on total electricity generation to 80% by 2026, up from a share of close to 65% in 2021.

In its British energy security strategy, the United Kingdom emphasises that renewable expansion "must go further and faster" than it has so far, acknowledging that renewables already play a significant role in limiting the impact of high fossil fuel prices.

Efficiency and electrification

As part of the Fit for 55 proposals, the European Commission has set a target of 9% lower final energy consumption in 2030 than was projected in its 2020 Reference Scenario. The REPowerEU plan proposes to increase the target to 13%. Improving building insulation is specifically mentioned as a way to improve energy efficiency while also supporting the integration of efficient heating technologies, in particular heat pumps.

REPowerEU also proposes adding 10 million units to double the number of currently installed individual heat pumps by 2027. Additionally, it provides recommendations for EU member states on how to accelerate the deployment of large-scale heat pumps.

In its Fit for 55 package, the Commission proposes a target of 100% emission reduction for new cars and vans by 2035, practically banning ICEs in all new cars and vans. The European Parliament decided to support the proposal to reduce the emissions produced by new passenger cars and light commercial vehicles to zero, which now has to be negotiated with EU member states. The REPowerEU plan encourages governments to implement tax measures to support the dissemination of electric (and hydrogen) vehicles.

In late March 2022, the United Kingdom presented a GBP 1.6 billion plan to reach 300 000 public EV charging points by 2030.

Several European countries recently launched new support schemes to promote installation of heat pumps. In May 2022, Poland started a programme to provide funding for heat pumps in single-family houses. In its British energy security strategy, the UK government announced measures to reach its target of 600 000 heat pump installations per year by 2028, which was set in 2020. The Netherlands announced its plan to make, for new installations, (hybrid) heat pumps mandatory for houses not connected to heat networks from 2026. Austria could ban gas boilers in new buildings as of 2023. France will end subsidies for gas boilers and support installation of heat pumps. Germany may make (hybrid) heat pumps for new installations mandatory from January 2024.

Nuclear energy

Currently 13 of the 27 EU member states are operating nuclear plants; other European countries with capacity are Belarus, Switzerland, Ukraine and the United Kingdom. On 12 March 2022, Finland connected the Olkiluoto-3 nuclear reactor, the first to go online in almost 15 years in Europe. Germany plans to continue phasing out its last three operating reactors by the end of 2022 due to concerns regarding costs, security and legal issues. In contrast, Belgium decided in March 2022 to postpone nuclear phase-out from 2025 to 2035 for two of seven units. Other countries see nuclear energy as an option to secure energy supply in the long term: the UK plans to build up to eight new reactors; in France, President Macron announced, already before the Russian invasion, to build at least six new reactors and extend the lifetime of existing plants.

Russia's state-owned company, Rosatom, is involved in several nuclear construction projects in Europe. Finland cancelled a contract to build the Hanhikivi nuclear power plant, citing delays and increased uncertainties following the Russian invasion. As such, the future of two new reactors planned at the Hungarian PAKS plant remains uncertain. Rosatom's involvement in construction of the Akkuyu nuclear power plant in the Republic of Türkiye (hereafter "Türkiye") raises concern regarding the future of the project. Units 3 and 4 of Slovakia's Mochovce nuclear plant, based on Russian design, are expected to be commissioned by 2023.

To overcome dependency on nuclear fuel imports from Russia, on which the five EU member states (Bulgaria, Czech Republic, Finland, Hungary and Slovakia) with reactors based on Russian design are fully reliant, the European Union is assisting countries in licensing fuel providers outside Russia.

Electricity imports and grid connection

Ukraine and Moldova recently joined the Continental European electricity grid. Following their lead, the Baltic States aim to join by 2025 and are currently in the process of leaving the BRELL ring. Following the installation of an emergency system in 2021, Lithuania states that it could already maintain electricity supply in case of a disconnection from BRELL. In reaction to Russia's invasion of Ukraine, Baltic transmission system operators (TSOs) agreed to limit electricity imports from Russia to 300 MW. Later, trade was stopped completely. Finland reduced its import capacity from Russia to 900 MW (from 1 300 MW) and Norway completely stopped importing electricity from Russia. Following Finland's efforts to join NATO and citing payment issues, Russia stopped exports to Finland in mid-May 2022. Finland expects to be able to compensate missing Russian imports with deliveries from neighbouring countries and domestic generation capacity.

The Agency for the Cooperation of Energy Regulators (ACER) points out, in its assessment of wholesale electricity market design, that cross-border trade provides substantial welfare benefits, reduces price volatility, facilitates the integration of renewable energies and increases security of supply. Initiated already before the conflict in Ukraine, the Trans-European Networks for Energy Regulation was adopted by the European Council in May 2022. This was soon followed by a call for clean energy infrastructure projects, which aims to contribute to the EU target of increasing the resilience of its energy system and to phase out dependency on Russian fossil fuels well before 2030. The strategy includes 67 electricity transmission and storage projects.

Coal-fired power plants

High prices for natural gas created cost advantages for coal-fired plants. However, impact on gas demand was limited: due to limited coal plant capacity, low hydropower generation and poor availability of French nuclear plants, gas-fired generation in Europe declined by only about 2% in the first half of 2022. The increasingly tight gas supply situation (Germany for example triggered in June phase 2 of its emergency gas plan) has led governments to temporarily resort to more coal power plants to reduce the need for gas-fired electricity generation. Also REPowerEU states that “some of the existing coal capacities might also be used longer than initially expected”.

Coal-fired production limits have been relaxed in France and the Netherlands. Phase-out delays and temporary re-opening of idle plants are being discussed and/or have been approved. Greece extended operation of its coal power fleet from 2023 to 2028. Italy is considering to postpone decommissioning of six coal plants due to stop operating in 2025. In the United Kingdom, the West Burton A power station (opened in 1966) is expected to remain in service until March 2023, six months longer than planned; similar decisions could be taken for other units. In June 2022 (and approved by parliament in July), the German government announced plans to restart mothballed coal power plants, bringing up to 10 GW capacity back online for up to 2 years. In Austria, a reserve gas-fired plant will be converted to enable coal use for a possible emergency.

While these developments indicate increased coal use in the short to medium term, the emission cap enforced by the EU Emissions Trading System (EU ETS), should lead to reduced emissions and accelerated coal retirements in later years.

Hydrogen

Low-carbon hydrogen is seen, next to electrification and energy efficiency, as essential in reducing European fossil fuel demand. REPowerEU sets an EU target of 20 Mt of renewable hydrogen use by 2030 (equivalent to 660 TWh energy) – with equal volumes coming from domestic production and imports. According to industry estimates, this would require about 90 to 100 GW of electrolyser capacity. In a bid to reach the domestic production target, the EU and European electrolyser manufacturers signed a joint declaration, with industry commitments to increase electrolyser manufacturing capacity tenfold to 17.5 GW per year by 2025. Assuming a 70% electrolyser efficiency, achieving domestic production of 10 Mt of renewable hydrogen requires around 470 TWh renewable electricity, 44% of the EU’s renewable generation in 2021.

The UK’s British energy security strategy announced a target to double hydrogen production capacity, with at least 5 GW of electrolysis capacity using low-carbon electricity by 2030 and 1 GW being operational or under construction by 2025.

Coupling with Continental Europe provided stability for Ukraine's electricity system

On 16 March 2022, Ukraine and Moldova were synchronised to the Continental European grid, just over three weeks after the Russian invasion of Ukraine. Previously, these grids were part of the unified and integrated power system of Russia and its neighbours.

The TSOs of Ukraine and Moldova, Ukrenergo and Moldelectrica, initiated a co-operation with European TSOs in 2006 and signed in 2017 an agreement specifying the requirements and steps to synchronise with Continental Europe. In 2010 and 2011, respectively, Moldova and Ukraine joined the Energy Community, an institution supporting adoption of European energy law beyond the European Union to create an integrated pan-European energy market. On 26 April 2022, Ukrenergo reinforced its collaboration with the European Network of Transmission System Operators for Electricity (ENTSO-E) by becoming an Observer of the Network.

According to previous plans, the synchronisation was not scheduled to be operationalised before 2023. To demonstrate the ability of their systems to perform load-frequency control – i.e. remain stable and operate reliably during credible contingencies with respect to generation and load – on 24 February 2022, Ukraine and Moldova started isolation mode tests for three days. As Russia invaded Ukraine just a few hours after the test start, the Ukrainian authorities and TSO decided not to reconnect to Russia. On 27 and 28 February 2022, respectively, Ukrenergo and Moldelectrica asked ENTSO-E for emergency synchronisation, which was approved and completed in record time. This short notice synchronisation was possible due to prior preparations of Ukrenergo and Moldelectrica, which fulfilled a large part of the connection requirements, and political support by EU institutions and member states.

Since 16 March, the grids of Ukraine and Moldova have benefitted from connection to the Continental European system. Notably, the synchronisation has been able to provide immediate support in case of disturbances that, due to possible outages of nuclear units in Ukraine (providing 50% of Ukrainian electricity demand in 2021), could be large and destabilising. Despite this support from neighbours, the need to ensure supply during war (including 30% lower electricity demand since the Russian invasion and up until time of publication) requires intense efforts from Ukrenergo, especially to restore damaged lines and substations.

The current coupling with Continental Europe will be formally confirmed as permanent when Ukrenergo and Moldelectrica achieve compliance with technical requirements stemming from EU legislation. On 30 June 2022, electricity trade between Ukraine and the EU started via the interconnector between Ukraine and Romania. Initially, trading was limited to 100 MW with the aim of increasing the limit as power system stability and security allow. Trade between Ukraine and other neighbouring countries (e.g. Slovakia and Hungary), as well as between Moldova and Romania, is expected to follow.

End-user prices and price interventions

European countries taking measures to contain electricity prices and protect consumers

The rapid surge of global wholesale electricity prices seen since the second quarter of 2021 continued in 2022, particularly in Europe, resulting in significantly increasing consumer prices. For the next few years, electricity future prices (at time of publication) indicate that although prices decline from the current level, they could remain high compared to before 2021.

In October 2021, the European Commission published a toolbox designed to help member states mitigate the burden of rising prices. Central to the recommendations are support schemes for final consumers and industries as well as mechanisms to enhance electricity market competition. In parallel, the Commission asked ACER to assess the status of EU electricity market design.

Leading up to mid-2022, many European governments implemented a variety of measures to protect consumers. The most common actions include direct transfers to vulnerable consumers (e.g. in the form of checks or vouchers), reduced taxes and charges, retail price regulation, and direct support for businesses.

Wholesale electricity markets

In April 2022, ACER published its assessment of the EU wholesale market design. While the report concludes that the current market design "ensures efficient and secure electricity supply under relatively 'normal' market conditions" and therefore is "worth keeping", it recommends various improvements. In particular, it stresses that the current design is not to blame for the ongoing crisis and that "ill-designed emergency measures could endanger hard-earned benefits of electricity market integration". In May 2022, the European Commission published a communication on energy markets, confirming the view regarding the benefits of the current electricity market design and outlining areas for improvement. To protect vulnerable consumers, the report refers to actions mentioned in the EC toolbox, emphasising compensation and direct support measures as the "first and most fundamental line of action […] to address the crisis".

To dampen electricity wholesale prices and/or raise funds to support vulnerable consumers, several countries discussed and/or established exceptional taxation and market regulation schemes. The Commission gave an exceptional permit to Spain and Portugal to cap wholesale market bids made by fossil fuel power producers. Greece, Italy and others introduced a tax on so-called "windfall" profits for power generators.

End-user electricity prices

The extent to which end-user prices have been affected by soaring wholesale prices depends on the share of electricity procurement costs on final prices, the existing tariff structure and regulatory price limits (if any). Residential prices in the fourth quarter of 2021 exhibited year-on-year growth between 6.5% (Germany) and 175% (Norway), while industry prices grew from 16.7% (France) to more than five times (Norway). While Europe was particularly affected, soaring fossil fuel prices have had impacts on other countries as well. In the United States, residential prices in the fourth quarter rose by 5% year on year while industry prices increased by 12%.

Residential electricity prices continued to rise steeply in the first half of 2022. Over May 2021 to May 2022, in capital cities, prices rose an average of 41% in the European Union and 91% in Great Britain.

To avoid the impact of soaring wholesale prices during 2021, around 4% of all electricity customers in Spain left the regulated tariff (PVPC) in favour of the free market, where they could secure a fixed-price contract. Companies in electricity-intensive industries, such as steelmaking and chemicals, decided to either temporarily stop production or shift their daily production patterns. This behaviour was seen in both Spain and the United Kingdom.

Since the second half of 2021, in line with proposals in the EC toolbox, many European countries implemented measures to mitigate increases in end-user electricity prices. Between September 2021 and June 2022, funding of measures to shield households and businesses from high prices reached up to EUR 43 billion (Germany) in individual countries, representing more than 3.5% of national GDP in some cases (Greece and Lithuania). While many actions target typical consumers, some support particular groups. For example, more than ten countries regulated retail prices, at least ten provided business support and at least 25 approved subsidies for low-income customers. To mitigate negative impacts on production costs of electricity-intensive industries, the United Kingdom announced in April 2022 it would extend its Energy Intensive Industries compensation scheme by another three years.

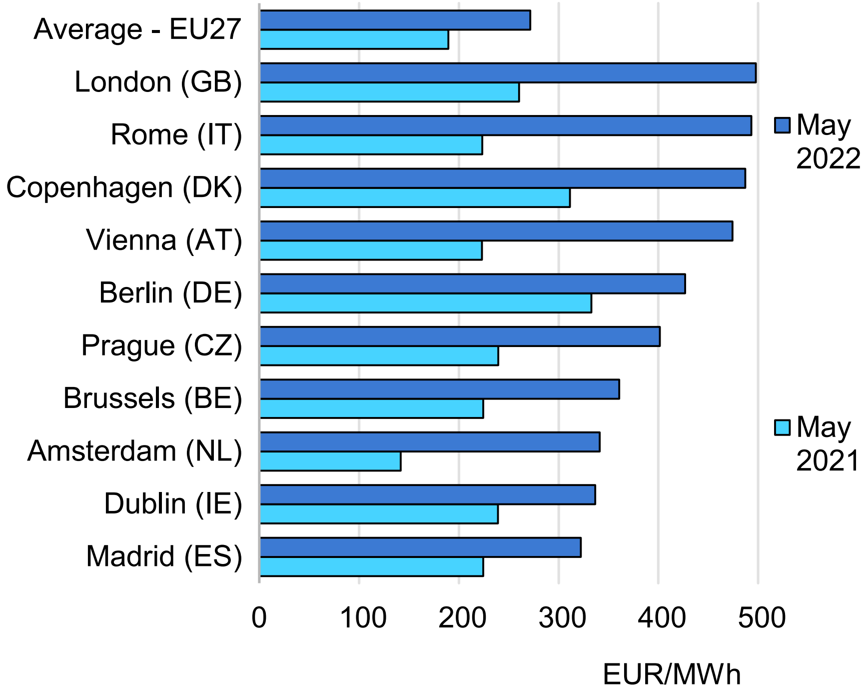
Policies by many European governments had noticeable effects on prices. Based on VaasaETT analysis for selected European capital cities, government interventions prevented a further 20% rise of average household electricity prices in May 2022. Prices would have been over 50% higher that month in absence of subsidies (in Oslo and Athens) and price caps (in Bucharest).

Electricity suppliers

Soaring wholesale prices in 2021 and 2022 also negatively affected suppliers, with at least 20 retailers going bankrupt in the United Kingdom and over 30 in Germany. Similar situations arose in non-European countries such as Japan. This has also affected consumers via reduced supply options. In London, for example, offers for new customers in December 2021 are estimated to have dropped by over three-quarters compared with December 2020. Some retailers suffered from having contracts that did not cover surging procurement costs (and were insufficiently hedged), but regulated price caps also played a role and were consequently increased. Ofgem, the UK energy regulator, raised the default-tariff price cap by over 50% in April 2022 to ensure electricity and gas prices better reflect supply costs. Ofgem also proposed to review their price cap quarterly instead of every six months, starting from October 2022.

Consumer electricity prices increased significantly – and would have shot up even more without government intervention

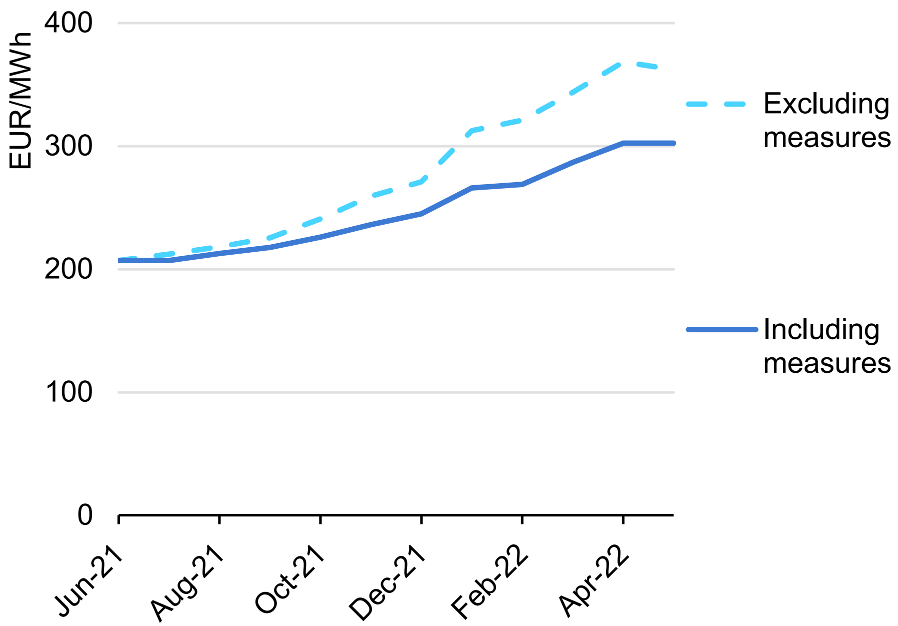
Year-on-year residential electricity price comparison in selected European capital cities, May 2021 and 2022



Notes: GB = Great Britain. IT = Italy. DK = Denmark. AT = Austria. DE = Germany. CZ = Czech Republic. BE = Belgium. NL = Netherlands. IE = Ireland. ES = Spain. Cities shown correspond to those with the highest prices in May 2022, within those included in the Household Energy Price Index (HEPI) analysis.

Source: Energie-Control Austria, MEKH and VaasaETT (2022), Household Energy Price Index (HEPI), © 2022 VaasaETT Ltd.

Estimated impact of mitigation measures on typical residential electricity prices in selected European capitals cities, June 2021 to May 2022



Notes: The analysis focuses on general measures affecting typical consumers and selected capital cities which have applied such measures during the period analysed. Countries included: Austria, Belgium, Cyprus, Czech Republic, Estonia, France, Greece, Ireland, Italy, Latvia, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovenia and Spain. Prices reflect population-weighted averages.

Source: Based on data and analysis provided by VaasaETT (2022), © 2022 VaasaETT Ltd.

Flexibility for decarbonised energy systems

Electrification of space heating could reduce fossil fuel use and provide flexibility

Significantly reducing Europe's reliance on fossil fuels will need a deep transformation of the energy system, including greater use of renewable energy and electrification of more energy end uses. Developing flexibility options will be key to a successful transition. Depending on how it is done, decarbonising the space heating sector could turn out to be a blessing or a curse.

Space heating accounts for a large share of total energy demand in Europe, at over 60% of total residential and almost one-third of total services sector energy use in 2020. In turn, space heating accounted for over half of CO_2 emissions in the residential and more than one-quarter in the services sector.

Fossil fuels are the dominant energy source for space heating (in sharp contrast to space-cooling appliances, which are almost exclusively electricity-based). In the European residential sector in 2020, the estimated share of electricity in space heating energy use was only 6%, while over 60% was served by fossil fuels, in particular gas (44%), oil (12%) and coal (below 5%). In the services sector, electricity provided around 10% of total energy use for space heating and fossil fuels over 70%, with gas at 56% and oil at 16%. The remaining heating energy in both sectors was mostly provided by district heating, biofuels and waste.

To reduce gas use, in its REPowerEU plan the European Commission proposes doubling the current individual heat pump installation rate, leading to "a cumulative 10 million units over the next 5 years" (on top of the 17 million installed by end-2021). We estimate that heat pumps currently account for at least 50 GW of electrical capacity and 7% (200 TWh) of total annual consumption. If all were used at the same time, they would consume the equivalent of over 10% of EU peak demand in 2018.

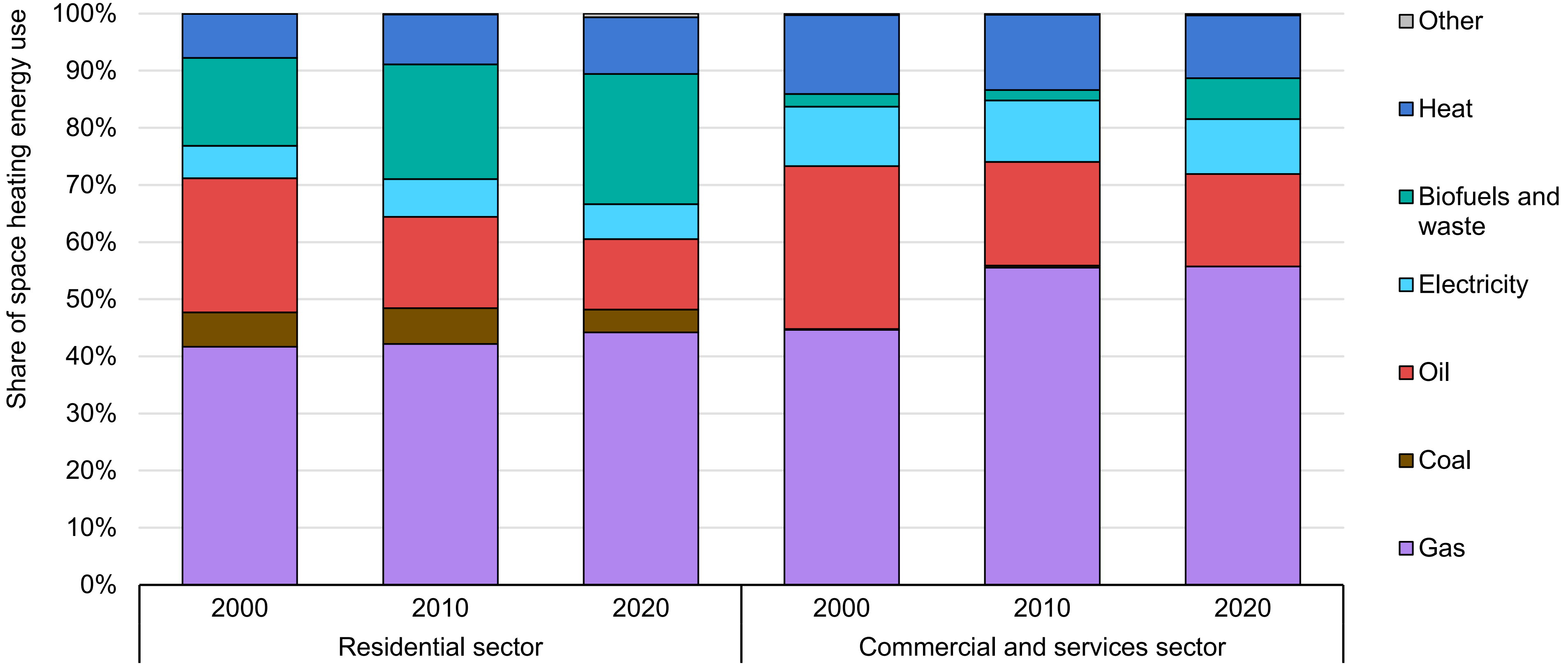
More electric heating or cooling (for which demand is growing) could cause a higher seasonality of electricity demand, raise the need for seasonal electricity storage, and trigger higher demand peaks. This could pose operational challenges for power systems by raising flexibility needs, especially during extreme weather events.

However, electric heating and cooling can also be a large source of flexibility: insulated buildings enable flexible use of heating and cooling appliances due to their high thermal mass and thereby facilitate the alignment of electricity demand with variable renewables generation, particularly in combination with distributed storage. Large heat storage resources could potentially serve as seasonal storage for renewables electricity in district heating or cooling systems.

Digitalisation of the energy system and of heating appliances – which remains in a nascent state in many countries – is a prerequisite for harvesting the flexibility potential of space conditioning.

Despite a minor drop in coal and increased use of biofuels and waste in the last two decades, space heating in Europe remains largely dominated by fossil fuels

Breakdown of estimated space heating energy use by sector, Europe, 2010-2020



Sources: IEA analysis based on data from IEA (2022), Data and statistics.

Digitalisation is a key enabler for clean energy transitions

Digitalisation is crucial for executing clean energy transitions at the speed and scale needed to meet short-term emergency needs and long-term net zero goals. Digital technologies provide granular and diverse data in real time, which can be leveraged to balance energy supply and demand, supporting sustainability, efficiency and resilience of electricity systems. In Tracking Clean Energy Progress, IEA analysis of demand response shows that digitalisation will be key to leverage small-scale flexibility resources, which will be much-needed in a context of higher renewable penetration and flexibility needs. More advanced real-time visualisation and analytics of energy demand, as well as smart controls, are among the main technological enablers. In the IEA's Net Zero Emissions by 2050 Scenario, 500 GW of demand response worldwide are brought into the market by 2030 (up from around 40 GW in 2020) such that it makes up more than 20% of flexibility sources in advanced economies.

In addition to the need to digitalise to reach net zero emissions, the energy crisis following Russia's invasion of Ukraine raises a new level of urgency. In March 2022, the IEA released a 10-point plan showing options to reduce Europe's reliance on Russian gas. Increased digitalisation can support two of the ten points: First, digitalisation can contribute to the acceleration of energy efficiency improvements in buildings and industry. Second, connected thermostats or well-designed automation can facilitate temporary thermostat adjustments by consumers. To achieve the potential of this plan, effort will be needed to accelerate deployment of digital technologies and enforcement of measures enabling distributed flexibility.

IEA analysis based on Guidehouse data shows that the installed base of smart meters in Europe reached 165 million in 2021, or 56% of all meters. It is expected to grow to 180 million units in 2022 and continue an upward trend to reach 272 million in 2030. However, the advancement of roll-outs varies: countries such as Italy, France, Finland and Spain have completed deployment. In fact, Italy is deploying its second generation of smart meters to allow for consumption and power data to be read and available for customers and operators with a granularity of 15 minutes. This will open opportunities for more active participation by customers, including in response to dynamic tariffs, and more accurate grid monitoring. In sharp contrast, roll-out has barely started in Germany and Romania.

While smart meter roll-out is well underway in Europe, other types of smart appliances have smaller market shares. To date, about 20.6 million units of connected and smart thermostats, and energy management systems as a whole, have been installed across Europe (for comparison, there are around 292 million power meters, more than half of which are smart). These devices are also on a steadily upward trend and are expected to reach between 78 million and 90 million in 2030, based on Guidehouse analysis.

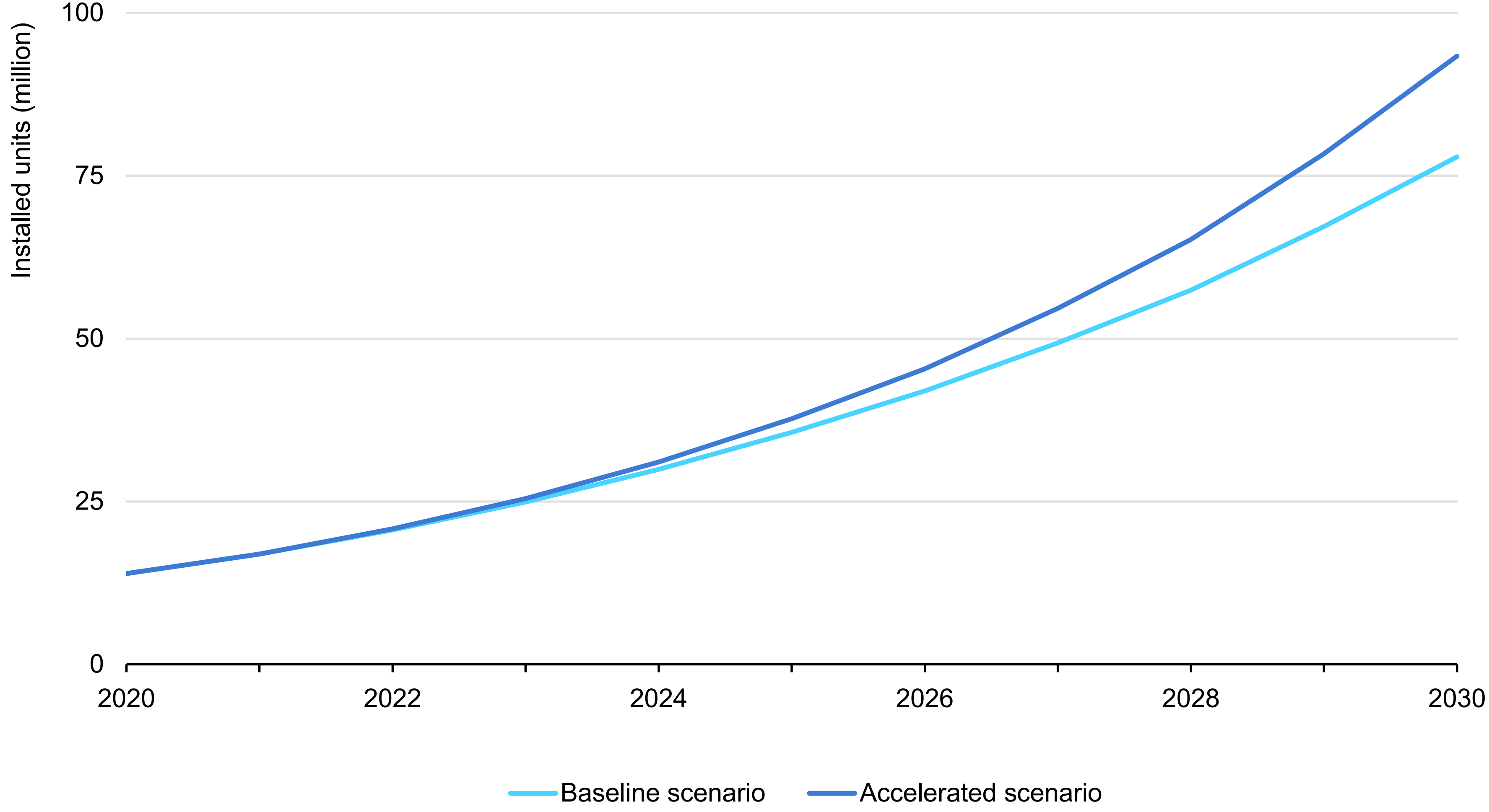
Advanced thermostats and energy management systems could save significant amounts of energy. A study by ADEME, the French Agency for Ecological Transition, found that programmable thermostats could reduce heating energy demand by 5-15%. The US Department of Energy found that lowering the temperature by 4-5.5°C for eight hours per day (e.g. overnight or during hours away from home while at the office) reduces heating and cooling consumption by up to 10%. Some countries have already introduced programmes to provide incentives for smart thermostats, for example France's Coup de Pouce (2020), Belgium's Eco Vouchers, or the SEEH scheme in the Netherlands (2019). These could be continued, scaled up and replicated across other jurisdictions.

Investing in smart meters and thermostats is not enough, however. While they constitute the basic layer for smart grids and distributed flexibility, proper legal frameworks are needed to optimise their capabilities. Analysis under the 3DEN project shows that efficient data systems, guaranteeing higher availability of granular data, are key to unlocking investment in new clean energy business models. The EU Clean Energy Package adopted in 2019 took measures to favour decentralised flexibility and seamless data exchange. These include the right for consumers to access their data and have it transferred to third parties; access for distributed flexibility resources to all markets; and incentives for all network operators to procure flexibility through market-based schemes. In its forthcoming action plan to support digitalisation in the energy system, the European Commission is expected to progress further and address other barriers. For example, the action plan aims to develop a competitive market for digital energy services, thereby supporting energy system integration, facilitating participation of "prosumers" in the energy transition, and ensuring interoperability of energy data, platforms and services.

Progress in translating directives set by the European Commission into national legislation has been uneven, however. Countries such as France and Finland have included provisions to incentivise investments in digitalisation and flexibility. Were others to follow, realising the possibilities of the Clean Energy Package could unlock a large share of the distributed flexibility potential in the coming years.

Distribution of smart thermostats and energy management systems is expected to accelerate

Baseline and accelerated deployment of advanced thermostats and home energy management systems in Europe, 2020-2030



Source: IEA analysis based on Guidehouse data in context of the IEA 3DEN project.

Annex

Demand

Regional breakdown of electricity demand, 2020-2023

TWh	2020	2021	2022	2023	Growth rate 2020-2021	Growth rate 2021-2022	Growth rate 2022-2023
Africa	709	754	783	805	6.4%	3.9%	2.9%
Americas	6 036	6 180	6 295	6 325	2.4%	1.9%	0.5%
of which United States	4 109	4 167	4 254	4 247	1.4%	2.1%	-0.2%
Asia Pacific	12 137	13 115	13 558	14 077	8.1%	3.4%	3.8%
of which China	7 471	8 222	8 479	8 846	10.1%	3.1%	4.3%
Eurasia	1 224	1 297	1 282	1 269	5.9%	-1.1%	-1.1%
Europe	3 648	3 805	3 827	3 866	4.3%	0.6%	1.0%
of which European Union	2 625	2 740	2 762	2 774	4.4%	0.8%	0.4%
Middle East	1 120	1 162	1 187	1 211	3.7%	2.2%	2.0%
World	24 874	26 313	26 933	27 554	5.8%	2.4%	2.3%

Note: For the entire period, the European Union reflects the current 27 member states.
Source: IEA analysis based on data from IEA (2022), Data and statistics.

Global supply and emissions

Breakdown of electricity sector supply and emissions, world, 2020-2023

TWh	2020	2021	2022	2023	Growth rate 2020-2021	Growth rate 2021-2022	Growth rate 2022-2023
Nuclear	2 673	2 784	2 698	2 791	4.1%	-3.1%	3.4%
Coal	9 444	10 203	10 238	10 134	8.0%	0.3%	-1.0%
Gas	6 354	6 521	6 399	6 374	2.6%	-1.9%	-0.4%
Other non-renewables	772	810	768	742	4.9%	-5.2%	-3.3%
Total renewables	7 453	7 899	8 744	9 416	6.0%	10.7%	7.7%
Total generation	26 697	28 217	28 847	29 457	5.7%	2.2%	2.1%
Mt CO_2	**2020**	**2021**	**2022**	**2023**	**Growth rate 2020-2021**	**Growth rate 2021-2022**	**Growth rate 2022-2023**
Total emissions	12 543	13 131	13 091	12 959	4.7%	-0.3%	-1.0%

Note: Other non-renewables includes oil, waste and other non-renewable energy sources.
Source: IEA analysis based on data from IEA (2022), Data and statistics.

Regional and country groupings

Africa – Algeria, Angola, Benin, Botswana, Cameroon, Congo, Democratic Republic of the Congo, Côte d'Ivoire, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania, Togo, Tunisia, Zambia, Zimbabwe and other African countries and territories.[1]

Asia Pacific – Australia, Bangladesh, Brunei Darussalam, Cambodia, Chinese Taipei, India, Indonesia, Japan, Korea, Democratic People's Republic of Korea, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, People's Republic of China,[2] Philippines, Singapore, Sri Lanka, Thailand, Viet Nam and other Asian countries, territories and economies.[3]

Central and South America – Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Venezuela and other Latin American countries and territories.[4]

Eurasia – Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.

Europe – Albania, Austria, Belgium, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus,[5,6] Czech Republic, Denmark, Estonia, Finland, France, Germany, Gibraltar, Greece, Hungary, Iceland, Ireland, Italy, Kosovo,[7] Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Republic of Moldova, Romania, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Republic of Türkiye, Ukraine and United Kingdom.

European Union – Austria, Belgium, Bulgaria, Croatia, Cyprus,[5,6] Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.

Middle East – Bahrain, Islamic Republic of Iran, Iraq, Israel, [8] Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates and Yemen.

North Africa – Algeria, Egypt, Libya, Morocco and Tunisia.

North America – Canada, Mexico and United States.

Southeast Asia – Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN).

Advanced economies – OECD member nations, plus Bulgaria, Croatia, Cyprus, Malta and Romania.

Emerging markets and developing economies – All other countries not included in the advanced economies regional grouping.

[1] Individual data are not available and are estimated in aggregate for: Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Djibouti, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Reunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, Eswatini and Uganda.
[2] Including Hong Kong.
[3] Individual data are not available and are estimated in aggregate for: Afghanistan, Bhutan, Cook Islands, Fiji, French Polynesia, Kiribati, Macau (China), Maldives, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga and Vanuatu.
[4] Individual data are not available and are estimated in aggregate for: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), Grenada, Guyana, Montserrat, Saba, Saint Eustatius, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Sint Maarten, and the Turks and Caicos Islands.
[5] Note by Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".
[6] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
[7] The designation is without prejudice to positions on status and is in line with the United Nations Security Council Resolution 1244/99 and the Advisory Opinion of the International Court of Justice on Kosovo's declaration of Independence.
[8] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD and/or the IEA is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Abbreviations and acronyms

3DEN	Digital Demand-Driven Electricity Networks
ACER	Agency for the Cooperation of Energy Regulators
ADEME	Agence de la transition écologique (French Agency for Ecological Transition)
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BEV	battery electric vehicle
BRELL	Belarus, Russia, Estonia, Latvia and Lithuania
CFE	Federal Electricity Commission (Mexico)
CO_2	carbon dioxide
EC	European Commission
EIA	Energy Information Administration (United States)
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ETS	emissions trading scheme
EU	European Union
EU ETS	European Union Emissions Trading System
Euratom	European Atomic Energy Community
EV	electric vehicle
FYP-E	Five-Year Plan for Energy (China)
GB	Great Britain
GDP	gross domestic product
GRED	Grand Ethiopian Renaissance Dam
HEPI	Household Energy Price Index
ICEV	internal combustion engine vehicle
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	Independent power producer
LNG	liquefied natural gas
NZE	Net Zero Emissions
OECD	Organisation for Economic Co-operation and Development
PHEV	plug-in hybrid electric vehicle
PV	photovoltaic (solar)
PVPC	Precio Voluntario para el Pequeño Consumidor (Voluntary Price for Small Consumers, Spain)
SEEH	Subsidie energiebesparing eigen huis (energy-saving at home subsidy, The Netherlands)
STEO	Short-Term Energy Outlook (United States)
TSO	transmission system operator
TTF	Title Transfer Facility
UAE	United Arab Emirates
UK	United Kingdom
US	United States

Units of measurement

Gt CO_2	gigatonne of carbon dioxide
GW	gigawatt
kWh	kilowatt hour
MBtu	million British thermal units
Mt CO_2	million tonnes of carbon dioxide
MW	megawatt
MWh	megawatt hour
g CO_2	gramme of carbon dioxide
t CO_2-eq	tonne of carbon dioxide equivalent
TWh	terawatt hour

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