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Energy crisis supports green transition

Atradius Economic Research

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Executive summary

1 Energy crisis shakes energy mix

- The fallout from the Russian invasion of Ukraine has triggered an energy crisis. Perhaps paradoxically, this is also acting as a catalyst to accelerate underlying trends in the energy mix towards cleaner energy provisioning.
- The short-term impact of the crisis is increased use of fossil fuels; the long-term impact is the opposite. Higher energy prices as well as the need for energy security are pushing countries, especially in Europe, to an acceleration towards renewables while reducing fossil fuels, especially gas.
- This is reflected in our updated benchmark outlook, based on the Announced Policies Scenario (APS) of the International Energy Agency (IEA), in which fossil fuel prices are higher and global energy demand is lower and cleaner by 2050. The temperature rise is limited to 1.7 degrees Celsius.
- With an improved APS, steps are arguably being taken towards the Net Zero Emissions 2050 scenario (NZE), in which net emissions of CO2 are zero and the temperature rise is limited to 1.5 degrees. To achieve net zero, and even the APS, daunting investments (and efforts) are needed.

2 Renewable energy outlook

- The energy crisis is providing momentum for renewables. Energy security concerns, especially in Europe, are accelerating the energy transition.
- Climate pledges support strong growth in renewables. Around the globe, countries are increasingly committing to NetZero 2050 and announcing ambitious targets and policy incentives. Most visible are those in the US and the European Union, with the Inflation Reduction Act and the REPowerEU strategy respectively.
- China is leading in installed wind and solar capacity and will add most capacity in the medium and long term. India and the US will follow, at a distance, adding solar capacity. Regarding wind capacity, the European Union and the US will follow, again at distance.
- Wind and solar capacity additions mainly take place in the electricity sector. Currently, around 28% of global electricity is generated by renewables, with hydropower being the largest renewable source (15%), followed by wind (7%) and solar (4%).
- Electricity demand will increase strongly, in both the APS and NZE scenarios, as we move to an electrified world. This growth will be entirely met by renewables; solar in particular, is becoming the dominant renewable globally. In the APS, renewable electricity will rise to 49% by 2030 and 80% by 2050. In the NZE scenario, a faster growth to 61% in 2030 and 88% in 2050 is on the cards.
- Huge investments are necessary to decarbonize the energy sector. Renewables and the grid account for the lion's share of investment in the power sector. Investments in the grid are key in an electrified world.

3 Oil market outlook

- Peak demand is now in our baseline scenario and will be sooner rather than later, in the mid-2020s. More decisive energy transition policies, especially in Europe and North America, are the key drivers to declining demand. Lower levels of production will be needed to meet demand and OPEC will increase its market share.
- With peak oil now on the cards, the equilibrium price for oil production to meet demand is significantly lower. The price of oil is forecast to fall to USD 64 in 2030 and to USD 60 by 2050. The general downtrend is subject to high volatility and upside risks in the short run, based on how Russia's war in Ukraine develops and how Chinese demand recovers, now that the authorities have scrapped the 'zero-Covid' policy.
- Under the NZE Scenario, demand never recovers to its pre-crisis levels thanks to more aggressive energy transition policies. Oil production is concentrated in resource-rich countries with lower operating costs and OPEC's market share increases to 52%. The oil price falls to USD 24 per barrel by 2050.

4 Gas market outlook

- Globally, gas demand is expected to peak soon and to be 8% lower in 2030 than in the base year 2021, and even 40% lower in 2050. Asia (especially China and India) and the Middle East are still forecast to see demand growth over the next decade. Demand in these regions will increase to 2030; after which demand peaks and starts to decline. The US and Europe are projected to see a decline in gas demand both in the medium and long term.
- Despite a decline in supply, Russia is still expected to be the largest gas supplier in 2050. Its role in the international gas trade is forecast to diminish strongly, as the reduced supplies to Europe cannot be fully compensated by higher exports to other markets.
- Gas prices in all three regions (US, Europe, Asia) are forecast to decline to lower equilibrium levels in 2050. In the near term, however, gas prices are likely to remain high and volatile. This is especially true for Europe as it is taking in less gas from Russia and is forced to rely on more expensive LNG with knock-on effects in other importing regions, especially in Asia. That said, the the effects are somewhat muted by long-term oil indexed contracts that are more common in Asia.

1. Energy crisis shakes energy mix

1.1 An existential threat

There is no denial anymore. Whereas in our Energy Report of June 2021 we reported that energy transition had become a key issue for governments, firms and financiers, we can now observe that this realisation has extended to the rest of society as well. It is no longer only an intensification of awareness among the broader public of the need for energy transition. Climate change has rapidly become a matter of everyday life. No one can deny the significantly warmer winters, heatwaves, calamitous storms and floodings any longer. The media drive this message home. And if this is not enough, activists such as Extinction Rebellion gluing themselves to a major Dutch motorway on a January Saturday cannot be ignored. This is indeed a huge crisis, arguably an existential one for mankind. Something needs to be done, and quickly.

This is, as we will see in this report, easier said than done. The Russian invasion in Ukraine has turned the energy landscape almost upside down and may well have diverted a large number of countries' attention. For the moment, the focus of the international community seems to be on defending core values such as the right to sovereignty, whilst containing the risk of nuclear escalation, another existential threat. In that context, the results of the recent COP27 Summit in Egypt, meagre as they are perceived to be, should be considered a success. At least some results were achieved, including confirmation of the agreement on the limitation of the temperature rise to 1.5 degrees Celsius.[1] Meanwhile, there may even be a silver lining to the war in Ukraine. The economic fallout, especially in the energy markets, is accelerating the badly needed energy transition. Thus, one existential crisis helps resolve the other. It is too early to claim victory, but, as we argue in this report, there is at least a glimmer of hope that the energy transition will be supported.

As opposed to the March 2022 update, which was relatively brief, with this report we return to the more comprehensive overview of developments in the energy sector that the reader may know from previous Outlooks. That means in addition to a discussion of the developments and outlook concerning the energy mix, we include details on developments in the oil, gas and renewables sector. The energy mix is further discussed in this chapter, renewables in chapter 2, followed by oil and gas in chapters 3 and 4 respectively.

1.2 Energy transition scenarios have a lot in common

We elaborate using essentially two scenarios, following the Energy Outlook of the IEA.[2] The normative one to strive for is Net Zero 2050, the state of the world where the average rise in temperature since industrialisation is kept at 1.5 degrees Celsius by that date.[3] This is achieved by, as the name suggests, reducing global net CO2 emissions to zero by 2050.[4] Although we refrain from calling this a 'dream scenario', we are still too far away from being on track to achieve this target to use this as our benchmark scenario. For this reason, we have opted for the Announced Policies scenario (APS). This captures the implemented and announced climate policies by countries as well as all other climate goals, including longer term net zero commitments. This scenario goes one step further than the Stated Policies scenario (STEPS). The latter is more conservative in that it only covers implemented and announced policies. Moving away from this scenario, which we have used in previous Energy Outlooks, is justified by the accelerated sense of urgency for climate change and thus energy transition. Net

1 For a discussion of the outcome of COP27, see COP27- Achievements and Disappointments, the Oxford Institute for Energy Studies, December 2022.

2 Our outlook draws on the IEA publication of October 2022. The reason for choosing this publication is because the IEA simply reflects the best there is in the market, given the size of what is arguably the most powerful international think tank in the energy world.

3 This goal is more ambitious, as well as more focused, than the 2015 Paris Climate Agreement of 'well below 2 degrees'. It was formulated in the run-up to the Glasgow 2021 Cop26 Summit on climate change.

4 Frequent readers of our Energy Outlook may remember that we have used a similar IEA scenario, the Sustainable Development Scenario (SDS), as a scenario to strive for (or to dream about). This scenario, still lurking in the back ground at the IEA, contained less clear emissions targets, and also included other objectives such as those related to air quality and energy access, particularly in rural areas.

Zero 2050 is, at this stage, one step too far, STEPS too conservative.

The scenarios, different as they may be in their outcomes, have a lot in common. They all describe the energy transition that is evolving, with common underlying drivers. The goal is to limit energy demand growth as the global economy grows and, perhaps even more importantly, to switch to cleaner energy. We identify the following three key characteristics of the energy transition, backed by three conditions that play a role in the various scenarios.

The first is energy efficiency. This means a reduction in the use of energy for the purpose of, say heating a house. Improved insulation reduces energy demand without a loss of heat consumption. Second, electrification. The use of electric rather than gas driven heating may help further reduce energy demand, and with electricity likely provided by cleaner energy (wind, solar PV, hydropower), will also contribute to a cleaner energy mix. Electric vehicles (EVs) are another example. The third characteristic is a move away from fossil fuels where electrification is not feasible. This is the case in sea transport and aviation. Here there is a move towards cleaner fuels, by mixing these with fossil if needed. For these characteristics of the transition to develop, at least three conditions need to be fulfilled. First, government intervention is required, providing clear plans for the transition backed up by information, legislation and money such as subsidies. Second, funding, not only by governments, but also by the private sector, to finance investment for the energy transition. Third, technological progress, allowing new technology to become available for the transition at commercially viable costs. All these factors play a role in the scenarios, with the best outcome in the Net Zero 2050 scenario, where they lead to a job done in terms of (net) zero emissions in 2050.

1.3 The picture of an energy crisis unfolding

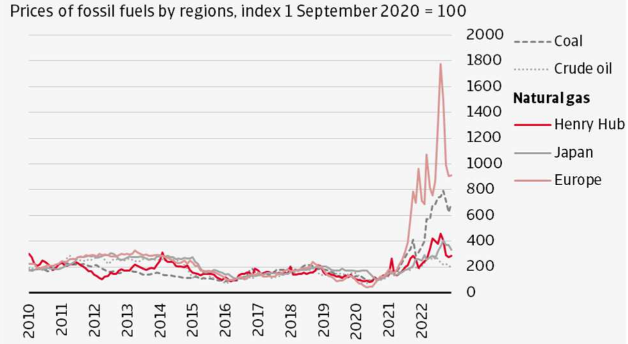
The global economy advanced on the path to recovery from the pandemic during 2022. In line with this, energy demand grew by an estimated 2%, bringing it back up to pre-crisis levels. CO_2 emissions likewise rebounded, though the rise was muted at an estimated 1%.

Underlying this seemingly quiet overall picture, the state of play in the energy markets changed dramatically as a result of the Russian invasion of Ukraine in February. With Russia the largest fossil fuel producer in the world, especially for oil and gas, this was bound to happen. What we now have is an energy crisis, deeper and broader than those back in the 1970s. Just like the current situation, these crises had a geopolitical background and also led to high inflation. But the shocks in the 70s were centred in the oil market. Now, the disruption is far more widespread, encompassing gas, coal and electricity prices, and affecting the economy via a range of energy channels. We distinguish four developments characterising the current crisis.

First, the energy price explosion. What we have seen during the past year is an explosion of prices in these energy markets (figure 1.1). While oil reaching above USD 100 per barrel Brent may not be uncommon, natural gas prices at the European Title Transfer Facility reaching the oil price equivalent of more than USD 100 per barrel was unprecedented. The gas price rise was the major cause of the spike in electricity prices, with some contribution coming from the rising cost of capital as monetary tightening kicked in, reflected in higher interest rates (and lower share prices). Meanwhile markets have calmed down somewhat, with prices remaining relatively high and volatile.

Europe was particularly badly hit as Russia cut its gas supply by more than 80% over the year in response to economic sanctions and support for Ukraine: electricity prices tripled in the first half of 2022. The impact on the gas price was compounded by higher coal prices, biting CO_2 prices, lower nuclear availability and hydropower in short supply as a result of drought. Ripple effects were felt across the globe as Europe sought to fill the gas tanks by LNG purchases worldwide. These have consequently risen almost twofold in 2022. As Russia cut back deliveries to the EU, the US ramped up its exports. The remainder came from the Asian market, at the expense of some developing countries (such as Pakistan) and helped by lower Chinese demand. This is clearly seen in the value of gas traded: as a percentage of oil and gas it doubled in 2022 (to 40%).

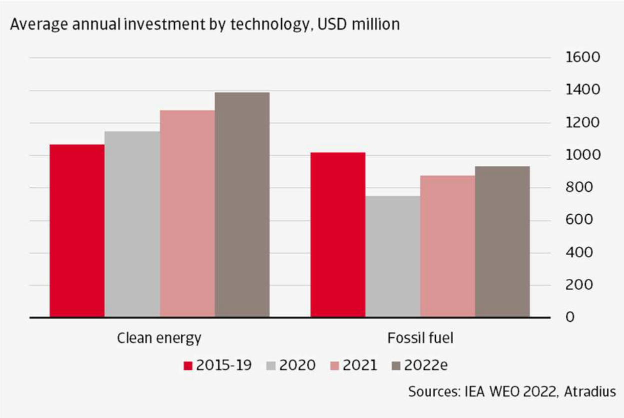
Figure 1.1 Energy price explosion



Sources: World Bank, Atradius

Second, lack of investment and neglect of energy security. Whereas the Russian invasion acted as a catalyst for these developments, we should be aware of major underlying issues contributing to the crisis as well. These include what we have repeatedly mentioned in previous outlooks: the lack of sufficient investment, especially in fossil fuels (see figure 1.2). These reached a level of USD 2.1 trillion per annum on average over the 2015-2019 period, sank in 2020 by more than 25% and have only partially recovered since. It may seem contradictory to call for fossil investments, as precisely fossil energy should be abandoned for its CO_2 footprint. At the same time, the under-investment that we have seen in recent years can lead to supply-demand mismatches and large swings in prices, even without a war. The silver lining is that investments in renewables have embarked on an upward track, due to the decline in cost and an additional effect of 'getting more bang for your buck'. Unfortunately, the current level of USD 1.4 trillion per annum investment in renewables is as yet insufficient to support a robust energy transition. Another underlying issue is Europe's reliance on Russian energy prior to the war. This had long been identified as a structural weakness, especially after the annexation of the Crimea in 2014, which - with the benefit of hindsight - should have rung the alarm bells far more loudly. There was some diversification to alternative import sources but the reliance on Russian energy remained high, especially in countries such as Germany and Italy. Worse, in the period 2015-2020 Russia provided 40% of the European gas demand, up from 30% over the previous period. Earlier diversification could have prevented, or at least softened, the turmoil in the gas market we saw in 2022. Now, energy security has become a major issue.

Figure 1.2 Meagre investment growth



The third significant development in the current crisis is government intervention. Governments have stepped in again to soften the impact of energy price rises on households and firms. The IEA tracked USD 550 billion worth of interventions, mostly in Europe, until September 2022 only. Greater coal-fired electricity generation was allowed, the lifetime of nuclear power plants extended and - importantly - the flow of new renewables projects accelerated. There were incentives to encourage and incentivise cuts in energy use, with an eye-catching 15% voluntary reduction in gas use and a mandatory 5% reduction of electricity in peak hours. There were also interventions against those benefiting from the crisis, such as power plants sourced by cheaper sources (but with price setting based on gas) and oil and gas companies. Temporary additional taxes for these firms have been imposed to fund crisis packages.

Longer term interventions include incentives for increasing fossil fuel production and new infrastructure such as LNG terminals to reduce dependence on Russian gas. Furthermore, and perhaps critically, we have seen large policy initiatives aimed at accelerating the energy transition. The EU is raising renewables and energy efficiency targets, backed with funding. In the US the Inflation Reduction Act gives a USD 370 billion public money boost to a range of clean energy technology initiatives, potentially leveraged by the private sector. The EU has now launched a Green Deal Industry Plan to answer this initiative, fearing a large exodus of firms to the US that want to benefit from the subsidies related to climate change. China continues with investment in renewables and electric vehicles (EVs) and India has taken steps towards carbon market and energy efficiency. Encouraging as this may be, the question is how this will all play out for the energy transition.

Fourth, CO2 emissions growth is flat. That said, they have stabilised at a high level. There is a glimmer of hope though. True, the CO2 emissions by the energy sector, after a decline of almost 4% in 2020 rebounded unprecedentedly by the same figure in 2021 to 36.2 billion tonnes. This increase reflects the recovery from the Covid-19 pandemic and related energy demand (+4% likewise) and can be attributed more specifically to the higher use of electricity coupled with the use of coal, as well as an increase in transport. The latter had been restrained by the pandemic. Growth in renewables accelerated but was not sufficient to outweigh the boost from fossil fuels. Still, 2021 was a recovery year. In 2022, a relatively small increase of 0.5% emissions growth is estimated. The implication is that over the period 2019-2022 CO2 emissions have remained relatively flat. There is a long way to go to (net) zero emissions, but it is a start.

1.4 APS reset

With these developments in mind, we turn to our benchmark scenario, the Announced Policies Scenario (APS). As mentioned, this is the scenario that assumes all climate commitments, including the rather vague policy statements, made by governments will be met in full and in time. We think the urgency of the need for energy transition triggered by the visible climate change that is now felt across the globe will force governments to meet their self-imposed targets.[5] Moreover, the need for energy security is now also generating momentum for the energy transition, especially in Europe.

That said, we emphasise that there is a risk embedded in this approach, because detailed implementation measures need to follow up these commitments. As long as that has not taken place, we have an implementation gap. We return to the implementation gap in the next section.

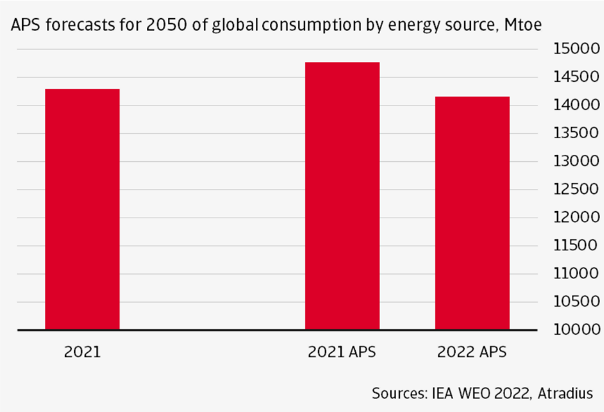
The main development of 2022 for our benchmark scenario relative to the Energy Update of March last year concerns the much higher energy prices we are currently facing, especially for gas. Europe is shifting permanently from Russian energy provisioning, necessitating more energy imports from other regions such as the US and the Middle East. Gas prices, due to more expensive LNG, will remain high until at least the middle of the decade.

This is leading to two major scenario shifts. The first is that higher energy prices put a brake on energy demand, diverting global demand away from energy, creating a feedback effect into the economy, restraining overall

5 Targets are self-imposed, but there is a lot of peer pressure from other countries to deliver these. See Section on COP27.

demand in the economy, including energy. These so-called price and income effects of the energy price rise cause a double whammy for energy demand: it is unambiguously reduced (see figure 1.3).

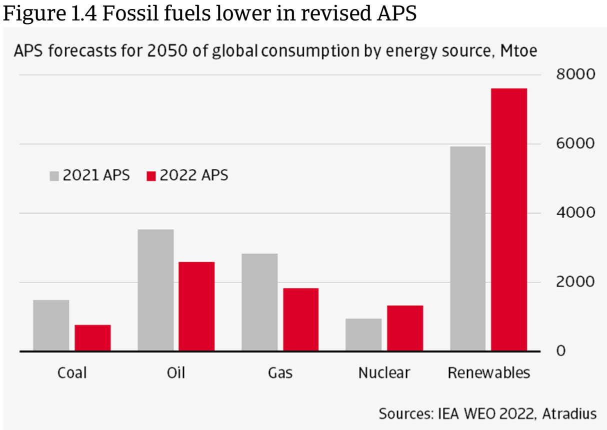
Figure 1.3 Lower energy consumption in revised APS



In a second shift, a change in the energy mix is triggered. Gas in particular loses ground in the electricity supply until 2030. Governments opt for other sources, such as nuclear and - temporarily - even coal, to allow for flexibility and thus strengthen energy security. Moreover, and this is the effect of government intervention discussed above, the speed of employing renewables is accelerated.

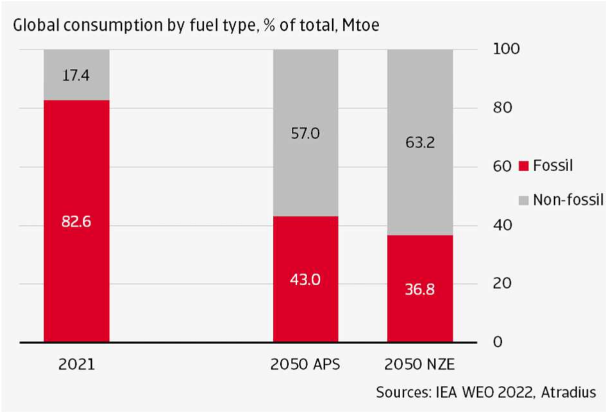
Relative to our latest Energy Update we see higher levels of fossil fuels (not gas) in the energy supply. But that is temporary and will be outweighed by the growth of clean energy. Indeed, nuclear and, especially, renewables, become gradually more prevalent than in the March Energy Update (see figure 1.4).

Figure 1.4 Fossil fuels lower in revised APS



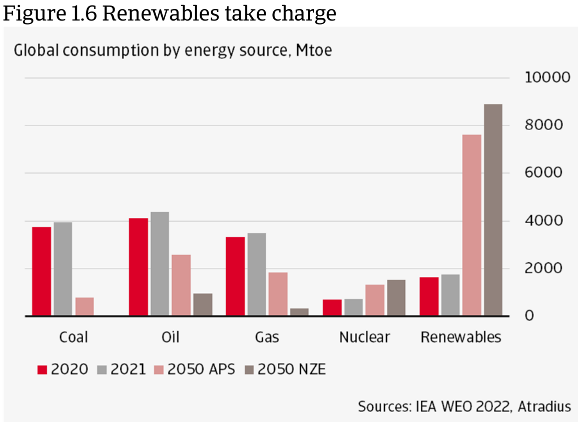
In the APS, total energy demand is expected to grow only marginally over the decade, with the level in 2030 2.7% higher than in 2021. In 2050, as pledges for net zero emissions kick in further, the level is even 1.4% lower than in 2021. To understand the relevance of these pledges,[6] without these, energy demand would be 10.5% higher in 2030, and in 2050 it would be 24% higher. This is also reflected in the share of fossil fuels in the energy mix (figure 1.5): in the APS it drops from 66% in 2021 to 36% in 2050, without pledges only to 57%.

Figure 1.5 Fossil fuel down but not out



Now consider the main energy sources in more detail (figure 1.6). Oil demand peaks in the mid-20s as sales for passenger EVs rise, reflecting national and corporate targets. This is supported by the higher oil price and targeted policy measures. EVs go from 9% of total new car sales today to 20% in 2025. Gas demand declines during this decade as well, reaching an 8% lower level in 2030 from current levels. In the power sector, high gas prices and security concerns trigger a further push to renewables. Coal demand rises with economic growth in China and India as well as the need for short-term energy sourcing in the power sector in the advanced economies. As the latter falls away and new renewable projects come on stream, coal is in decline again from 2025. Renewables deliver 50% of the power for electricity generation, compared to 28% now. Wind and solar PV account for 90% of the increase, with hydropower, bioenergy and geothermal providing complements. Nuclear power generation increases by 2030.

Figure 1.6 Renewables take charge



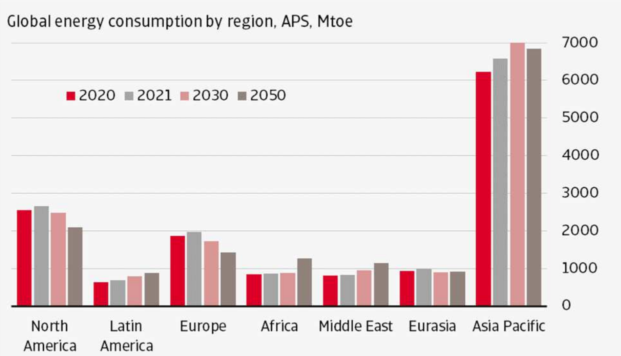
Energy demand is expected to reduce in the advanced economies. Strong policy support kicks in in both the APS and STEPS to achieve this as well as a cleaner energy mix. In the United States, the Inflation Reduction Act and the Bipartisan Infrastructure Act together provide USD 560

6 Which is essentially going back to the STEPS scenario as the reader may have noticed.

billion in public support for clean energy. Rising EV sales will account for 50% of total new car sales in 2030, bringing down oil demand from current levels. Gas and coal demand will fall as well, while wind and solar PV become dominant. In the EU, various governments have lined up USD 389 billion in clean energy support up to 2030, boosting the energy transition. The increase in the use of coal is temporary. Gas is reduced as buildings and the industry contribute significantly to reductions. Wind and solar PV expand rapidly, pushing renewable power generation to 50%, helping to reduce the use of gas as well. EVs also grow fast, reducing oil demand. In STEPS a similar pattern of transmission is followed, but at a lower speed.

In the emerging economies the picture is one of still strong energy demand growth, only met to some extent by clean energy (figure 1.7). China National Determined Contributions and national targets, such as in the Five-Year Plan (2021-2025), are in place to weaken the dominance of coal in the energy supply. Energy demand is projected to peak just before 2030. Renewables growth is planned so that the country is carbon neutral by 2060. Under STEPS, 45% of electricity supply should be carbon neutral by 2030. Oil demand already peaks in the middle of this decade. In the APS the process is slightly accelerated. In India energy demand grows. Progress with the energy transition is made as well: energy demand grows at less than half the pace of the growth in population. Programmes are in place such as the Self-Reliant India scheme and Gati Shakti National Master Plan to increase the use of renewables, especially solar PV, and sales of EVs. This helps to cover demand growth by one third by 2030. Coal contributes similarly, peaking in the early 30s, oil contributes 25%. In the APS India reaches net zero by 2070. Relatively high energy demand growth is visible in the other countries of Emerging Asia as well.

Figure 1.7 Energy demand rise in emerging economies



Sources: IEA WEO 2022, Atradius

1.5 CO_2 emissions highlight call for further action

We have already observed CO_2 emissions growth was marginal in 2022 ending at 36.6gt. In the APS, CO_2 emissions peak in the mid-2020s and fall to 12gt by 2050. This is a bigger reduction than in our March Outlook, reflecting newly updated National Determined Contributions (NDCs) and newly announced zero pledges, including India's. It is predominantly in the advanced economies that these CO_2 emission reductions are expected to take place - 40% decline by 2030 whereas the emerging economies reduce by only 5%. A reduction of this scale brings us into the realm of the Paris Agreement of 'well below 2 degrees C' with about 1.7 degrees C temperature rise.

This is progress, but still not enough. A 2022 IPCC report has emphasised that warming close to 2 degrees C still entails a strongly negative impact for societies. In that context, the currently perceived impact of climate change at a temperature rise of 1.1 degrees C is a case in point. Moreover, we are not there yet with announced zero pledges. They need to be backed up by policy measures and these need to be implemented as well. If not, we fall back to STEPS. The difference is stark. In that scenario, 32gt CO_2 will be emitted in 2050, leading to a 2 degree C temperature rise.

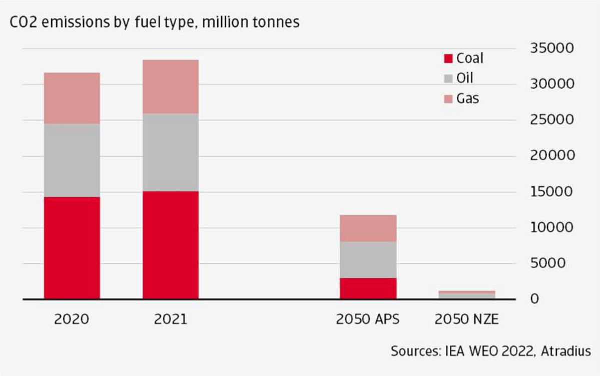
What kind of measures are we looking at to reduce this so-called implementation gap? These revolve around the themes mentioned in section 2. First, scaling up technologies with the aim to decarbonise. Enhance the use of renewables, EVs, retrofits for existing power stations and efficient motors for industry. This mainly involves tried and trusted technologies. But that is not enough. Long haul road transport and industry sectors need technology that is so far less developed. Second, further boosting electrification, including for freight transport, industrial processes and heating in buildings. Third, besides decarbonisation and electrification, further enhance energy efficiency. Fourth, develop bio-energy, solar thermal and geothermal sources to supplement the existing set of renewables. Finally, remaining CO_2 emissions can be neutralised by carbon capture, utilisation and storage (CCUS).

1.6 Towards Net Zero 2050

If one takes APS seriously, as we do, we are making progress towards the Net Zero 2050 world. In such a world CO_2 emissions decline to 23 gt in 2030 and, unsurprisingly, to (net) zero by 2050. The temperature rise is 1.5 degrees C in 2050. This is not a huge reduction compared to the 1.7 degrees of the APS, but still worth pursuing. This is because it is in line with what IPCC calls a 'no or low overshoot scenario' and, more formally, it is in line with the Paris Climate Agreement. Perhaps even more importantly, as mentioned above, every tenth of a degree C less warming is worth pursuing in view of what we are currently experiencing at 1.1 degree global warming.

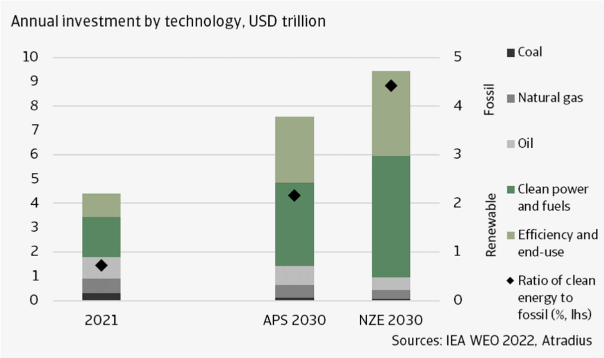
Closing the gap between Net Zero 2050 (NZE) and APS, the ambition gap (see graph 8), is somewhat different to closing the implementation gap (between APS and STEPS). This latter involves simply fulfilling policy commitments, not necessarily net zero commitments and if so, not net zero commitments by 2050. Indeed, China (2060) and India (2070) have delayed net zero commitments as we saw. The ambition gap closure concerns the elimination of all (net) zero CO_2 emissions. In that sense the NZE scenario is normative: it tells what needs to be done to achieve the (net) zero target.

Figure 1.8 The ambition gap



Still, closing the ambition gap develops around comparable themes. First, clean electricity generation and more particularly a strong decline in the use of coal in the NZE compared to the APS. Especially in the emerging economies, where coal is still dominant in the power sector, a lot more is done in the NZE. This requires the employment of low emission sources, mainly renewables as well as measures to expand and modernise power grids. There is greater investment in flexibility of the electricity grid, including energy storage. Second, in the NZE, efficiency improvements are combined with more robust materials efficiency and behavioural change such as working from home and less (business) aviation travel. As a result, energy consumption is 10% lower in 2030, even while the global economy continues to grow. This contrasts with a 2% rise in the APS scenario. Third, electrification of end-uses in all sectors of the economy. While fossil fuels do not disappear from the energy mix (30% remains), their dominance wanes. Electricity is the 'new oil'. In buildings, electricity becomes the principal source of energy, with highly efficient heat pumps the primary technology choice. In transport, oil is displaced by electricity. In the NZE 60% of all new car sales are EVs as opposed to 35% in the APS in 2030. In the emerging economies electrification focusses on two/three-wheelers and urban buses. Biofuels, hydrogen and hydrogen-based fuels increase significantly, especially in aviation and shipping and for long haul freight. In industry there is continued demand for industrial materials, such as steel and cement, as urbanisation and industrialisation in Africa and India continue. In the NZE stringent emission standards and policies help support the transition for efficient use of these, as does enhanced support for new and sometimes even untested technologies. Fourth, the NZE entails a steep fall in other greenhouse gases. For example, energy-related methane emissions drop 75%. This comes partly in conjunction with the lower fossil fuel demand. But the largest part comes from the deployment of emission reducing technologies across the oil, gas and coal sectors. Technically avoidable methane leaks have disappeared by 2030. Fifth, low emissions technology application is ramped up sufficiently fast. This involves sufficient battery capacity for the expansion of EVs, with battery metals availability such as lithium critical. In industry, hydrogen production from fossil fuels is to be largely replaced by electrolyse - 70% by 2050 in the NZE. Minerals such as nickel and platinum are needed. This is also the case for further solar PV development. CCUS technologies in the NZE deliver deep reductions across the industry, power and fuel transformation sector by taking CO2 from the atmosphere. In the NZE capacity goes up to 1200 Mt in 2050; the current level is 45 Mt.

Figure 1.9 Daunting investment required



Closing the ambition gap also requires daunting investment (see figure 1.9). By 2030 the investment level as a percentage of GDP should be doubled to 4% per annum. Especially investment clean energy is to be ramped up. This stood at USD 1.3 trillion per annum in 2021 and is to triple in the NZE by 2030 to USD 4.2 trillion, as opposed to the APS where it doubles. In the NZE, but also in the APS, investment in fossil fuel falls. In the NZE it declines by a larger amount: from USD 830 billion to USD 455 billion per annum in 2030. Investment in low-emission fuels such as biofuels, low emission hydrogen and hydrogen-based fuels go from USD 18 billion to USD 235 billion. End-use investment includes the cost of energy efficiency upgrades and fuel switching in buildings, appliances as well as industry and transport. This represents a major part of clean energy investment, requiring about USD 900 billion per annum in both the NZE and APS, more than double the level in 2021. This is a deflated figure as the underlying cost of technologies declines (more bang for the buck). In the NZE, renewables form the foundation of an electricity sector that is four times larger in 2050 than is currently the case. Clean power spending is three times higher in the NZE than now, directed at wind, solar, nuclear, CCUS, storage and networks. It rises to USD 1.3 trillion per annum in 2030. Financing of these intimidating figures comes from the private sector to the amount of USD 3 trillion in 2030 in the NZE. Public spending plays a larger role in emerging economies than in the advanced economies: 40% versus 15%.

The financing in the NZE (and APS) versus what is currently being done provides a sobering picture of progress with the energy transition. Indeed, massive investment is needed to get the world on track to approach the Paris Agreement goal of a temperature rise of well below 2 degrees C by 2050. The stepped up commitments towards NZE as reflected in the APS provide a glimmer of hope, but no more than that. An incredible lot of work still needs to be done before the rise in temperature is brought under control.

2. Renewable energy outlook

The Russian invasion in Ukraine and the subsequent sharp increase in fuel prices are providing momentum for the use of renewables. Although the high gas prices resulted in a shift towards the use of coal for generating electricity, at the same time the demand for renewables has increased. The energy crisis will accelerate the energy transition towards low-emissions renewables. Many governments, as in the EU and the US, have announced new policies since the Russian invasion that will provide a boost to investment in clean energy and efficiency. In the Announced Pledges Scenario (APS), it is assumed that all targets announced by governments are met, including their long-term net zero and energy access goals. In this scenario, renewables will increase strongly towards 2050. In the Net Zero Emissions by 2050 Scenario (NZE) the increase will be even more marked, as in a Net-zero world electrification will be key. In such a world, the global energy sector will have changed dramatically. In an electrified world, the power sector will become more important. Because of the widespread use of renewables in the power sector and the rapidly growing importance of solar and wind in this sector in both the APS and NZE, we will focus on this sector in this report.

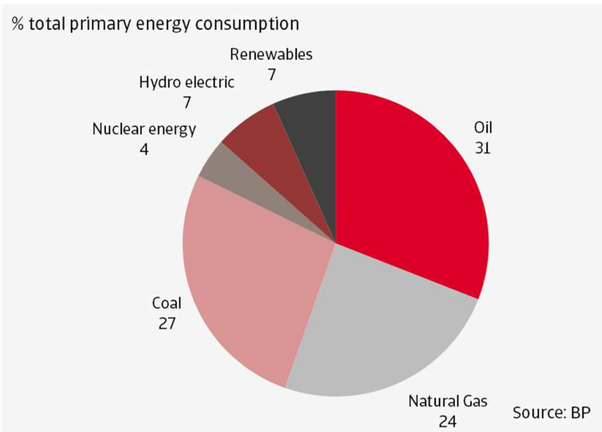
2.1 Key developments

The energy crisis is fuelling the use of renewables. The high fuel and electricity prices have improved the competitiveness of solar and wind generation versus other fuels. Moreover, due to energy security, renewables are increasingly attractive. Compared to a year ago, the IEA has increased its renewable capacity projections for 2022-2027 in its Renewables 2022 report. The IEA estimates that renewables capacity will be almost 30% higher than was forecast a year ago. This increase is mainly driven by China, the European Union, the US and India. It is assumed that these countries will implement all existing policies and regulatory and market reforms and will introduce new policies in response to the energy crisis. Especially in Europe, the energy transition will accelerate due to energy security concerns. In May 2022, the European Commission released its REPowerEU plan in which it proposes to end the reliance on Russian fossil fuels by 2027. The plan also aims to increase the share of renewables in final energy consumption to 45% by 2030.

Both solar and wind capacity have increased sharply over the years; China is leading investment in solar and wind. In 2021 China had a market share of around 40% of global installed wind capacity, with the United States (16.1%), Germany (7.7%) and Spain (3.3%) following at distance. China also has by far the most installed solar capacity. It has a share of 36.3% of global solar capacity. Other countries with relatively high shares in global solar capacity are the US (11.1%), Japan (8.8%) and Germany (6.9%). China's support for clean energy technologies is not only driven by environmental and industrial strategy considerations, its policy to reduce import dependency of fuels is also responsible for this. Although a leading global investor in renewables, China is still highly reliant on coal for generating electricity.

Despite increasing use, renewables still have only a minor share in global primary energy consumption. According to BP statistics, renewables, i.e.,solar and wind, have a share of 7%. For the first time they have the same level as hydropower in global energy consumption. Whereas renewables continued their growth, the consumption of hydropower actually dropped in 2021. Severe droughts in countries where hydropower is the main energy source resulted in sharp declines in these countries. In particular, Brazil, Chile, Argentina and Turkey had lower than usual hydro capacity utilisation in that year. According to the IEA, hydropower generation in Brazil, US and China will be higher in 2022 because drought conditions have eased.

2.1 Renewables (solar and wind) on a par with hydropower in 2021



2.1.1 Climate pledges will boost renewables

Around the world, countries are increasingly committing to NetZero 2050 and announcing Nationally Determined Contributions (NDCs). Ambitious targets and policy incentives will boost renewables.

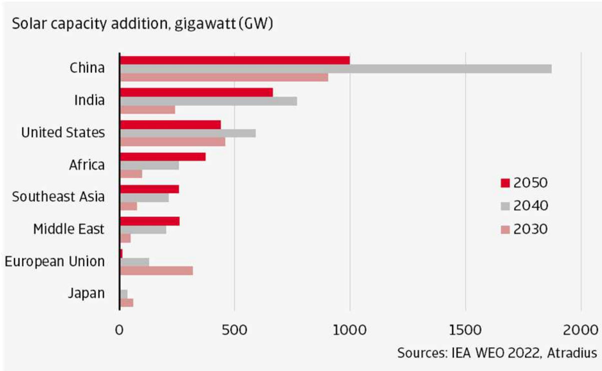
China will remain the leader in renewable capacity growth for the coming years. Despite the phasing out of wind and solar subsidies, China will add the most capacity, both solar and wind, in the short and long term. Support is coming from the 14th Five-Year Plan, in which China has ambitious renewable energy targets. In this plan, China has changed its policy focus from installed capacity to share of renewable energy sources in electricity generation. It aims for 33% renewables and 18% wind and solar in electricity generation by 2025. In addition, market reforms and strong provincial government support provide long-term revenue certainty for renewables. For the longer term, the ambition of the Chinese government to reach net-zero emissions by 2060 will underpin growth in renewables.

In the **US,** the Inflation Reduction Act, announced in August 2022, will result in a strong rise in renewables. The energy transition will accelerate in the US and have a major impact in the power sector. Due to the legislation extending tax credits for renewables until 2032, the deployment of solar PV and wind will increase sharply. In addition, many states have renewable portfolio standards and goals supporting expansion. In APS, the US could actually reach net zero emissions in the electricity sector around 2035. Not only will a faster deployment of renewables contribute to this, but also the increased use of CCUS, hydrogen and ammonia and an expansion of nuclear power.

In the **EU,** even before the war in Ukraine, several member states had already introduced ambitious targets and policies to accelerate the deployment of renewables. In 2022, the European Commission announced its *Fit for 55* package and proposed raising the targeted EU renewable energy share in final energy consumption from 32% to at least 40% by 2030. Since then, the European Union has even proposed more aggressive goals under the REPowerEU strategy (a 45% renewables share by 2030). In particular, the elimination of Russian fossil fuel imports by 2027 will accelerate the deployment in the short term. The IEA classifies policy actions in the EU into three categories. The first is increasing renewable energy ambitions. Several EU countries have raised their renewable electricity targets. For instance, Germany has increased its target from 65% to 80% in 2030. Second is increasing policy support. Actions include raising remuneration levels and introducing new financial support. The Netherlands eliminated the VAT for residential PV systems and Germany increased feed-in tariffs for distributed PV. Third is addressing non-financial challenges. Governments are passing regulatory reforms to streamline permissions, make grid connection easier and improve network congestion. These are the three main barriers that have delayed project development. For instance, Spain has introduced a simplified licensing procedure and made grid capacity available for renewable energy projects.

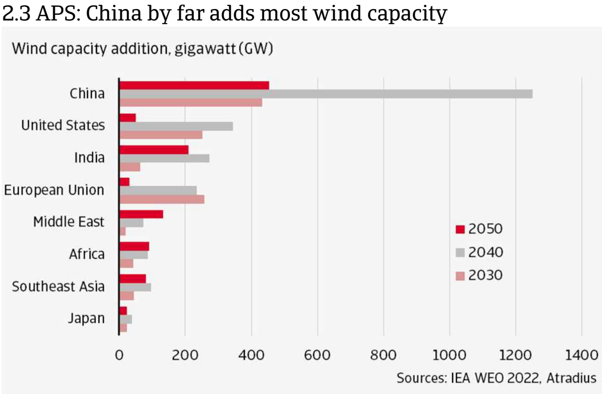
In the APS, China will add the most solar capacity, followed by India and the US. India is expected to increase its solar capacity especially between 2030 and 2040 when it is progressing towards NetZero in 2070. India's energy system is highly dependent on coal (75% of the electricity mix), which is gradually being replaced by renewables. Coal demand is expected to peak late this decade in the APS, and will then steeply decline. India has implemented competitive auctions to achieve the target of 500 GW of renewable power in 2030.

2.2 APS: China leads solar PV capacity addition



Wind capacity will also increase strongly, but much less than solar. Particularly in China, wind capacity will increase greatly. Towards 2030, the European Union and the US will follow second and third. In the period 2030 towards 2040 wind capacity will grow faster in the US, supported by the Inflation Reduction Act. In Europe, licensing delays are a key barrier for faster renewables growth. IEA mentioned that in Q3 2022 wind turbine orders fell by 36% compared to a year ago. In 2021, onshore wind auctions held in Germany, France and the United Kingdom were undersubscribed because projects could not obtain permits due to authorisation complexity, siting restrictions or social opposition. Therefore, the IEA has revised downward the onshore wind forecasts for these markets. Other constraints are grid congestion, coupled with a lack of investment and long lead times for upgrading the network.

2.3 APS: China by far adds most wind capacity



2.1.2 Hydrogen still in early stages

The energy crisis, especially the gas security crisis, has also boosted momentum for hydrogen, which is mainly produced from unabated fossil fuels. Hydrogen can play an important role in sectors where emissions are hard to abate and alternatives are either unavailable or difficult to implement.

For example in heavy industry, shipping, aviation and heavy-duty transport, as an alternative for oil.

There is growing interest in international trade in hydrogen and hydrogen-based fuels, especially in the US and Europe where respectively the Inflation Reduction Act and the push for clean energy will boost hydrogen. But there are challenges. High costs of production and limited enabling infrastructure hinder this substitution currently.

Production is currently at a very low level. Development and deployment over the next decade will be essential to lower costs and improve performance so that these fuels can become important. A significant amount of investments is necessary to set up an international value chain. The IEA mentions that only for the European Union investments would amount around 1.4-1.7 trillion (including financing cost) to reach that assets could deliver 10 MT H_2 per year to the European Union. Moreover, planned projects reveal a significant imbalance, export projects are more numerous and more advanced than those for the corresponding import infrastructure.

In APS, the share of hydrogen in total final consumption will increase from 0% in 2021 to 2% in 2050. In the NZE scenario, hydrogen will grow in importance due to its low emissions. It will be mainly deployed in the heavy industry and long distance transport. The share of hydrogen in total final consumption in the NZE scenario will reach 6% in 2050.

2.2 Moving to an electrified world

Solar and wind capacity additions are mainly taking place in the electricity sector. On a global level, renewables already have a major share in generating electricity. In 2021, renewables had a share of 28% in global electricity generation. Hydropower is still by far the largest renewable electricity source, contributing around 15% of electricity generation. Although wind (7%) and solar (4%) follow at some distance, their share is growing strongly, unlike hydropower. In 2010, the share of wind and solar was respectively around 2% and 0.1%, whereas hydropower had a share of 16% back then. In some countries, the share of renewables in electricity generation is much higher. For example in Brazil, renewables have a share of almost 80% in the electricity mix, with hydropower being the major contributor (57%). Some countries that are so dependent on hydropower are quite vulnerable to climate change, as was clearly visible in 2021. Countries where solar and wind together have large shares in generating electricity are in Europe, with the United Kingdom leading with a share of 38%, followed by Germany (32%), Spain (35%) and the Netherlands (33%). A region where renewables have only a minor share in generating electricity is the Middle East (4%).

Other main end-use sectors are heating and transport. Renewable sources are limited in both heating and the transport sector. Heating is concentrated in industrial processes and in buildings, space and water heating and cooking. This sector is largely dominated by fossil fuels, with renewable energy sources accounting for around 11% in 2021. The IEA expects this share to increase to 14% in 2027. Due to environmental and energy security concerns, renewable heat will increase. The move away from gas results in a push to retrofit buildings and install heat pumps that are fuelled by electricity. The increasing use of renewables in electricity for heating contributes to the increase in this sector. For industry, decarbonisation will take place via electrification, the use of large-scale heat pumps and renewables-based hydrogen. This will especially be the case in the EU where the REPowerEUplan contains plans for industry.

In transport, electrification will accelerate over the coming years. Oil is still dominating in transport, accounting for 90% of consumption. This will change in both scenarios, but most significantly in the NZE scenario. In 2021, electricity accounted for just 1% of the fuels consumed in transport. In APS, this is expected to increase to 5% in 2030 and 25% in 2050. In this scenario, oil will remain the leading fuel in transport. This is in contrast to the NZE scenario, where electrification will accelerate and the use of oil declines sharply. In the NZE scenario, electricity will account for 48% of the energy consumption and oil drops to 9% in 2050. In this scenario, the use of hydrogen will also rise rapidly and account for 18% of energy consumption in 2050. Particularly in aviation and shipping, the use of biofuels, hydrogen and hydrogen-based fuels will increase.

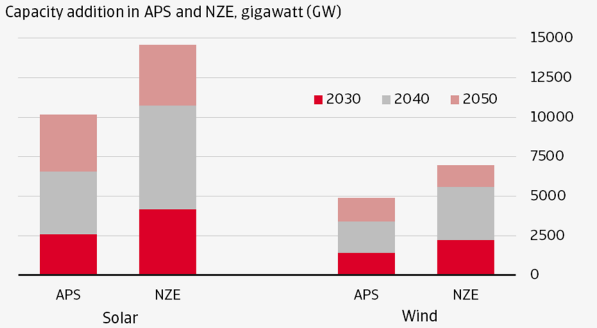
This electrification in transport is the result of the faster adoption of electric vehicles. In 2021, around 10% of new cars sold were electric. In APS, by 2030 around 35% of global new car sales are electric, compared to 60% in the NZE Scenario. The IEA expects that the electric car markets will be six times bigger than in 2021. Especially in China, the European Union and the United States EV sales will increase. In around 36 countries, for example in the United Kingdom, there are targets to phase out internal combustion engine vehicles as well as plans by major manufactures to pivot to EV production. In 2050 70% of passenger cars are electric or fuel cell vehicles, and 40% of heavy trucks. Especially in the NZE scenario, it is assumed that policy makers will demand a strong push towards cleaner alternatives. In this scenario it is assumed that no new cars with internal combustion engines are sold after 2035 and nearly all trucks sold from 2040 use electricity or hydrogen. In this scenario, the road transport sector is almost fully decarbonised.

2.2.1 Renewables will reshape the power sector

Global electricity demand showed its largest increase in 2021 since 2010 due to the rebound in many economies after the Covid19 pandemic. Electricity demand will increase strongly in the coming years and decades. In the APS, announced pledges lead to more rapid deployment of electric vehicles and of heat pumps in buildings and for industrial processes. In the APS, total electricity demand will be 120% higher in 2050 than nowadays. In the NZE scenario, where the electrification of end-users will be faster, total electricity demand will be 150% higher in 2050. Growth in electricity demand differs per region. Strong growth will take place in China, India, the Middle East and Africa due to growing demand in industry and buildings. High economic growth and rising living standards will boost demand in emerging markets, especially in India. Increasing consumption of household appliances, specifically air conditioners, will account for this growth. Climate change is largely responsible for the strong rise in demand for cooling. In Africa, increasing access to electricity and rising ownership of household appliances are responsible for the strong growth. In advanced economies, the efficiency gains in modern appliances and heating and cooling systems will temper electricity demand. In these economies, the transport sector is mainly responsible for the robust growth in electricity demand. It is expected that the number of electric vehicles will grow rapidly. For instance in the US, thanks to the Inflation Reduction Act and state level targets, the share of electric cars will increase from less than 5% in 2021 to 50% in the APS in 2030.

To keep up with faster growth in electricity demand, in both the APS and the NZE scenario, electricity generation needs to accelerate significantly. This will be entirely met by renewables, making renewables the dominant energy source in the power sector. Solar is becoming the dominant renewable at global level. Deployment of solar or wind varies by region or country. For instance in the US and India solar will become the leading technology. This is in contrast to the European Union, which is moving to an energy system fuelled by onshore and offshore wind.

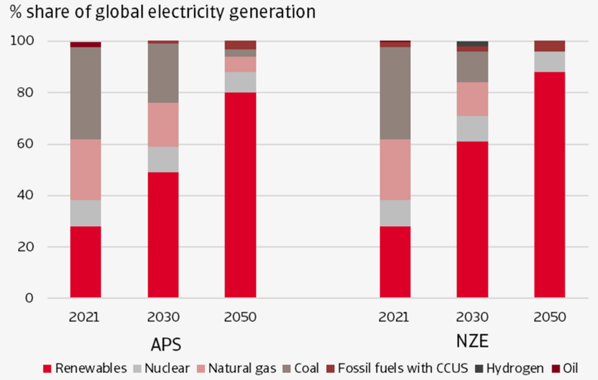
2.4 Solar leads added capacities in both scenarios



Sources: IEA WEO 2022, Atradius

Although the electricity supply mix differs per region, depending on available resources, policy choices and the relative economic competitive position of various power generation technologies, a common trend across regions is the expanding contribution of wind and solar power. The share of renewables in electricity generation is currently around 28%. In APS, this share will rise to 49% in 2030 and 80% in 2050. In the NZE scenario, renewables will grow faster and have a share of 61% in 2030 and 88% in 2050. Currently, there is a strong momentum for renewables because of the rising fuel prices and concerns about energy security. Although the high fuel prices increased the use of coal in 2022, they have also boosted the commitments for reaching net zero emissions by 2050. Many countries have pledged to reach net zero emissions, albeit Indonesia in 2060 and India by 2070. G7 members have even committed to ensure that their power sectors are fully or predominantly decarbonised by 2035. Technology innovation and progress, including declining costs for solar, wind and batteries, facilitate the strong growth in renewables. Renewable sources like geothermal and bioenergy will have limited shares in electricity generation.

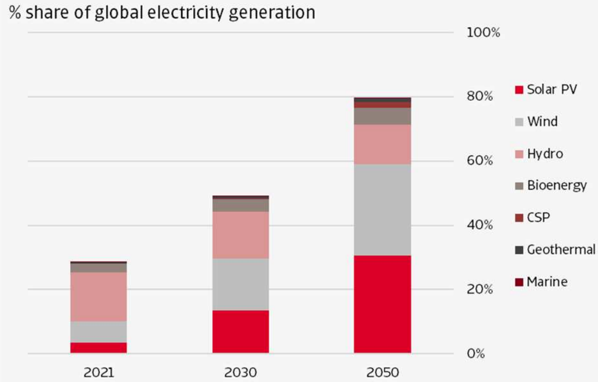
2.5 Renewables becoming the dominant source in power sector



Sources: IEA WEO 2022, Atradius

In APS, solar will be the fastest growing renewable. In 2021, solar had a share of 4% in total electricity generation and this will grow strongly to 13% in 2030 and accelerate further to 28% in 2050. Solar will thereby surpass wind and leave hydropower far behind by 2050. Wind will also increase sharply, from 7% in 2021 to 16% in 2030 and 28% in 2050. Both are benefitting from government policies and declining costs, but solar is set to be favourable because of its short construction times, very low costs and ready availability of manufacturing capacity. In the NZE scenario solar and wind are expected to increase even faster, supported by policies. The share of solar in electricity generation will be 20% in 2030 and increase to 37% in 2050. Wind will increase to 21% and 32% respectively.

2.6 APS: solar to expand rapidly in electricity



Sources: IEA WEO 2022, Atradius

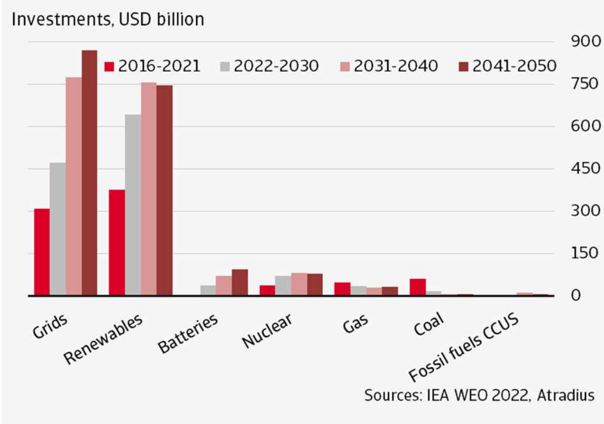
Hydropower will remain an important source for electricity generation. Although it will increase because of its low emissions and its role as a stable energy source in the power sector, its share in electricity generation will decline towards 2050. Hydropower is already a mature technology and therefore has limited room to grow.

A challenge with such an increase of solar and wind in generating electricity is ensuring a reliable, stable electricity supply and flexibility. Power system flexibility[7] is required to continuously balance the supply and demand of electricity and maintain a stable grid. As both solar and wind are dependent on weather conditions, this will increase the variability of the net load. This is especially true in the NZE scenario, in which renewables rise fast and electricity security is key because the global economy will become increasingly dependent on a reliable electricity supply. Traditionally, coal and natural gas power plants and hydropower were providing the flexibility to power systems, but when the world decarbonizes this will change dramatically. The IEA sees four mains sources of flexibility: power plants, grids, demand-side response and energy storage. Batteries and demand-side response will meet more than half of the flexibility needs in 2050.

2.2.3 Investments in grid crucial

To decarbonize the energy sector, huge investments are necessary. In previous years investment in the electricity sector was biased towards renewables and the grid. This will only increase in the coming years to meet the ambitious targets around the world. With the growing importance of electricity in energy consumption, and the increasing share of solar and wind in generating electricity, it is important to have a reliable electricity network. To ensure this, a major increase of investments in the grid is necessary and expected.

2.7 APS: Investments in power sector increasingly to grid



Investments in the grid support the expansion, modernisation and digitisation of transmission and distribution networks. Total world investments in the power sector increase to an estimated annual average USD 1.2 trillion in 2022-2030, much higher than USD 858 billion per year in 2016-2021. In the APS, world investments will increase to an annual average of USD 1.7 trillion in 2031-2040 and increase further to USD 1.8 trillion in 2041-2050. In the NZE scenario, investments will rise to USD 1.7 trillion in the next decade. Investments in renewables and the grid account for the lion's share. Most investments will take place in advanced economies and China where the energy transition is at an early stage.

7 Flexibility is defined as the ability of a power system to reliably and cost effectively manage the instantaneous, hourly, daily, weekly and seasonal variability of demand and supply. It ranges from ensuring the instantaneous stability of the power system to supporting long-term security of supply. IEA WEO 2022

3. Oil market outlook

Policymakers' efforts and investors' capital are increasingly being directed away from oil and other fossil fuels towards renewable energy resources to slow the rate of climate change. The collapse in demand for oil spurred by the pandemic dealt another blow to the sector. Then Russia, the world's second largest oil producer, invaded Ukraine in February 2022, severing major supply chains and rerouting trade flows as a result of Western sanctions. Supply concerns exacerbated by the Russia-Ukraine war put upward pressure on prices and have contributed to the global economic slump, particularly in advanced economies.

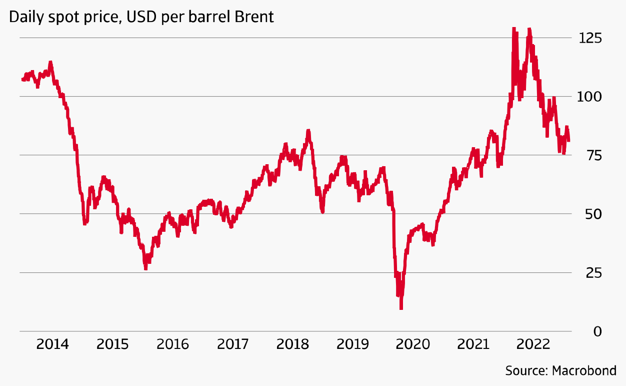
The energy transition, supply uncertainties and geopolitical risks have all combined to expedite the decline of global oil consumption. For the first time ever, we anticipate peak demand in our baseline scenario, the Announced Policies Scenario of the International Energy Agency (IEA). From the mid-2020s on, oil demand will steadily decline, driving down prices almost 20% by 2050 compared to today. Should governments act more decisively to pursue sustainable development goals, as modelled by the IEA in the Net Zero Emissions (NZE) scenario that we use as an alternative benchmark, the price of oil will fall by up to 60%. While the long-term outlook is even more decidedly downwards, short-run volatility will likely be even more severe than previously expected, given years of under-investment and uncertainty surrounding the Russia-Ukraine war.

3.1 Key developments

Price volatility is a common feature of the oil market but the price swings observed in 2022 are exceptionally large. Prices rose steadily through 2021 as global economic activity picked up after the worst of the Covid-19 pandemic; but Russia's invasion of Ukraine in February 2022 caused the price to spike above USD 130 per barrel. Since then, the price trend has been generally downward due to demand-side weakness with sharp upward surges resulting from less flexible supply.

Supply side developments are the main culprit behind elevated volatility. These include Russia's invasion of Ukraine, OPEC+ strategy and US oil production. First of all, the invasion of Ukraine worsened post-pandemic supply chain issues, especially in Europe. This reduced the capacity to trade oil while eventual EU import bans on Russian oil further restricted supply – either outright or by increasing paperwork and complications associated with trade. This has proved one of the most acute shocks to global oil markets in recent years, but Russian oil output has thus far proven rather resilient. In December 2022, Russia produced 9.8 million barrels of oil per day (mb/d) compared to 10.1 mb/d in the previous February. Russian producers continue to benefit from elevated global prices which allow profits to be made per barrel even at steep discounts to the global Brent benchmark price. This is even despite the introduction of bans on oil imports to the EU and a G7-imposed price cap of USD 60 per barrel, as third countries like India, China and Turkey have increased their imports of cheaper Russian oil.

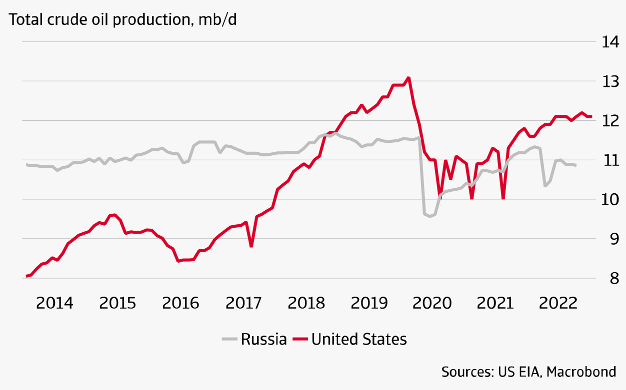
Figure 3.1 Oil prices subject to high volatility



OPEC+, the alliance of OPEC countries and other major oil producers like Russia and Mexico, has continued its policy of limiting output through 2022 as well. The group's priority is tailoring supply to influence prices, especially in low-demand environments, as they've done since 2016 in response to the US shale boom. Accordingly, the group agreed to reduce production by 2 mb/d, or about 2% of total supply, in its October meeting. Thus far, the impact on prices has been limited though, since most members are actually producing below quota as is. It is clear that OPEC+ will continue to prioritise supply management to keep prices elevated, even against loud calls from the US to increase supply to ease the energy crisis spurred by the Russian war in Ukraine.

The world's largest oil producer, the US, may never fully recover from the pandemic, but it has seen production pick up in the face of the Russia-Ukraine war. The US oil sector has struggled to recover from the pandemic as producers' focus has shifted to strengthening balance sheets and investor returns. Prior to the pandemic, the US shale revolution elevated the US to the world's largest single producer. Given the relative flexibility and short upstart times for shale projects compared to conventional production in OPEC, the US also became the world's swing producer. This allowed it to ramp up or down production in response to global developments to ensure relative stability in the market. But the sector was highly leveraged, leading to a wave of bankruptcies during the pandemic and difficulties recovering now that credit is significantly more restricted and labour costs have exploded. Even in the face of sky-rocketing prices, shale operators prioritised capital restraint. Sticking to lower growth has still allowed steady recovery in the sector and brought US exports to a record high in 2022 as global trade flows shift as a result of the war. In the first weeks of 2023, US production averaged just above 12 mb/d, compared to 13 mb/d just before the crisis. But the annual growth rate was only 7%, half of that during the shale boom.

Figure 3.2 US production growth offsetting lower Russian output



On the demand side, slowing global GDP growth and rising prices put a ceiling on oil prices. Rising concerns that 'stagflation' could become entrenched motivated central banks to hike rates aggressively. Higher consumer prices compounded by rising interest rates put some brakes on consumer spending and consequently demand for oil. Monetary tightening was led by the Federal Reserve, which also resulted in a significant appreciation of the US dollar. Given that global oil sales are denominated in US dollars, oil imports became more expensive for other countries, especially emerging market economies, further weighing on demand. On top of that, China, the world's largest oil importer, continued to pursue its 'zero Covid' policy including strict lockdowns until December 2022, which further capped global demand. The effect of the global economic slump on demand helped prevent additional oil price surges past H1 despite ongoing supply constraints.

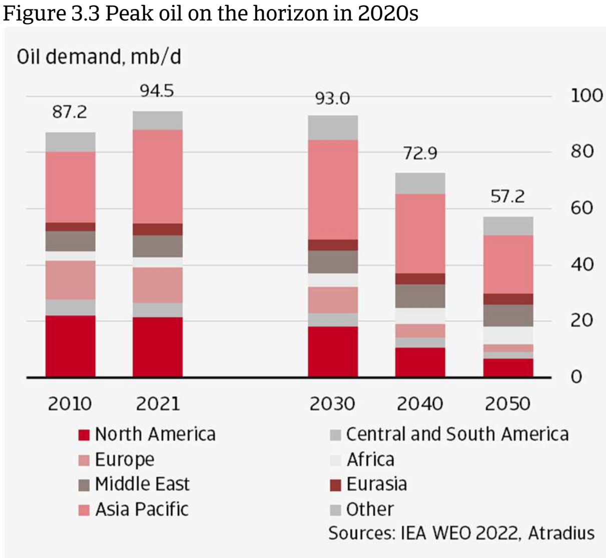
Global investment in the oil sector has been weak since the price collapse in 2014 and the Paris Climate Accord in 2015, which has increased concerns that the oil supply may not be able to keep up with demand to ensure a smooth energy transition. Investment did pick up in 2022 in response to higher prices and energy insecurity but remains well below pre-crisis levels. The IEA estimates a USD 417 billion investment in upstream oil and gas in 2022, 16% lower than the USD 499 billion recorded in 2019. The Middle East is the only region with spending now well above pre-crisis levels. Overall costs for input, transport and labour increased significantly, dampening the attractiveness for investors. Tighter capital conditions and general uncertainty also temper investment.

3.2 Oil demand outlook

Under the Announced Pledges Scenario, demand for oil is expected to peak at 98.1 mb/d, just above its pre-crisis level of 97.9 mb/d, in 2024. This is in contrast to our last Energy Outlook, when we expected demand to surpass its pre-crisis level in 2023 and stabilise around 104 mb/d in the 2030s. The main reason behind this sharp downward revision is more aggressive policies to support the energy transition which particularly target demand reduction through increasing renewable energy resources.

After peaking in 2024, global oil demand is predicted to cool to 93.0 mb/d in 2030. From 2030 to 2050, oil demand is expected to decline by 40% to 57.2 mb/d. The reduction in demand is led by the transport sector, including passenger cars and road freight, followed by industry. Electrification in the transport and buildings sectors is key to governments reaching their current climate goals and ensuring this decline. Aviation and shipping may also see a 25% reduction in oil use by 2050 thanks to pledges from the International Civil Aviation Organization to offset emissions growth above 2019 levels, and from the International Maritime Organisation to cut emissions from maritime transit by half by 2050 relative to 2008.

Figure 3.3 Peak oil on the horizon in 2020s

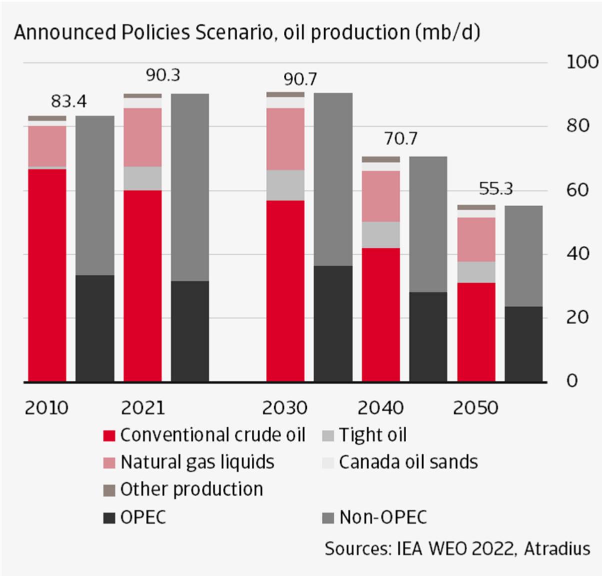


The global decline in oil demand is concentrated in advanced economies, which lead the electrification of car fleets. Demand there is expected to fall by nearly 15 mb/d to 2030. Oil demand in emerging market and developing economies will also decline but to a lesser extent - 5 mb/d, as more rapid economic development, population growth, and urbanisation partially offset the shift to more efficient energy sources. Asia-Pacific will remain the largest oil-consuming region, but even there, demand is expected to decrease to 20.6 mb/d in 2050. The magnitude of decline is just below the 14.5 mb/d decline forecast in North America to 6.9 mb/d consumption in 2050.

3.3 Oil supply outlook

The largest uncertainty in the short term for supply of oil is how Russia's producers react to sanctions. Thus far, the sector has been relatively resilient as high global prices have allowed production to continue above break-even prices and trade has largely been rerouted to emerging market economies in Asia. Given the outlook for rising demand in China especially and the price cap's goal of ensuring global price stability, we expect Russian oil to continue pumping – but with high downside risks. Additionally, the increasingly heavy sanctions against Russia limit access to technologies and oil field equipment, which will drag on productivity in the long run. The IEA estimates this to trim just over 2 mb/d off Russia's production in 2030 and for that country to further lose its slice of the pie to only 3.9 mb/d total in 2050 – from 12% of global production in 2021 to 7%.

Figure 3.4 Conventional crude from OPEC remains most important source of production



It is clear that the US shale sector is no longer the dynamic, swing producer it was a decade ago, but it is still a central producer to meeting demand to 2030. US tight oil supply is forecast to still be 8.8 mb/d in 2030 from over 10 mb/d at end-2022. We expect that producers will continue to prioritise returns over production growth but the high near-term prices ensure some boosts to drilling. From 2030 to 2050, overall US production will fall 8.1 mb/d to 10.7 mb/d as conventional fields mature and lower prices spur less investment in shale plays. Other non-OPEC producers, especially Guyana, which first began producing oil in 2019, will see strong increases in output and development in new non-conventional oil sources.

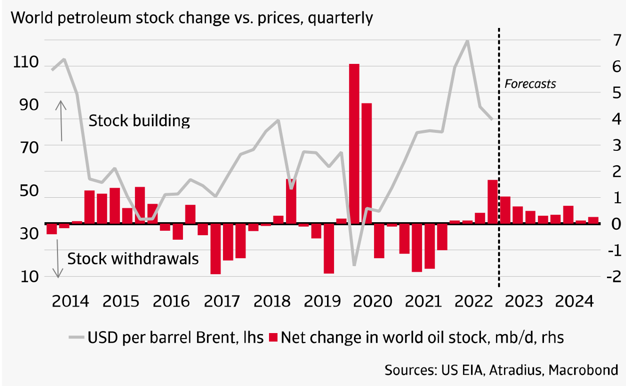
OPEC will increase its influence over the period at the expense of the US. While overall OPEC production is set to decline by 7.8 mb/d to 23.8 mb/d in 2050, its market share increases from 35% in 2021 to 43%.

The supply outlook is vulnerable to investment developments. As discussed in section 3.1, investment in 2022 remains about 20% lower than pre-crisis rates and most extra investment stems from cost inflation instead of increasing activity. Oil companies have been making record profits though in the high oil price environment; and whether they invest these windfall revenues in large-scale production assets or pay back shareholders will have a large impact on supply. Investments averaging USD 378 billion per year to 2030 then USD 227 billion per year to 2050, will be needed in both new and existing fields to compensate for declining production from existing supply sources.

3.4 Oil price outlook

Our baseline scenario projects prices to decline gradually in the near term, continuing the downward trend from a peak above USD 130 in March 2022 following Russia's invasion of Ukraine. This is based on the assumptions that short-term production growth, concentrated in non-conventional non-OPEC producers, will outpace demand growth, tempered by weak economic activity and strong policy initiatives in advanced economies to accelerate the energy transition. This is supported by an anticipated continuation of building of oil inventories in 2023 and 2024 which generally corresponds with declining prices (see figure 3.5).

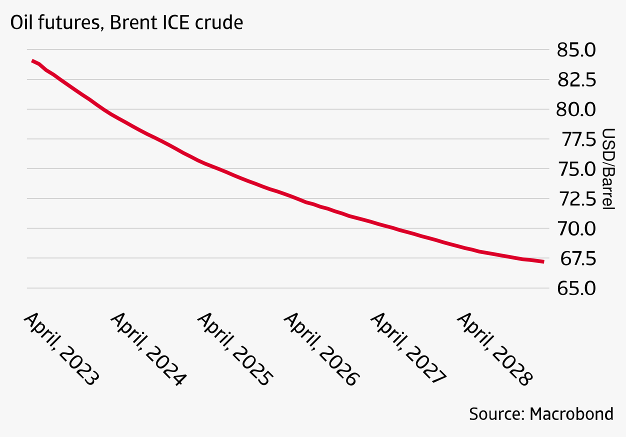
Figure 3.5 Net oil stock-building exerts downward price pressure



The oil futures market is also in backwardation again, which suggests investors expect the price of oil to decline from current levels over the coming period (see figure 3.6). The curve has narrowed significantly from the last Energy Outlook, showing the short-term decline will be more gradual.

The slower decline is due to two key risks to the outlook: Russia on the supply side and China on the demand side. As such, we see the risks for short-run volatility to lean heavily to the upside for prices. Global demand is set to reach a record high around 98 mb/d in the mid-2020s, led by China's scrapping of its zero-Covid policy in December 2022. With years of low investment and high risks to production, especially from Russia, the production outlook ensures a floor on prices of around USD 70 in the coming years.

Figure 3.6 Oil market in backwardation

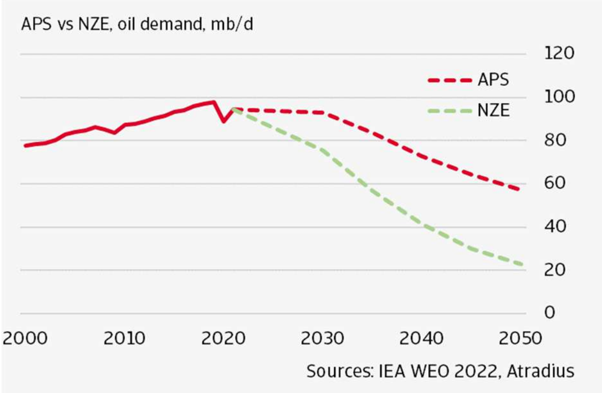


With peak oil on the horizon, the long-run equilibrium price for production to meet demand is now lower. We now expect a barrel of Brent crude oil to fetch USD 64 (in real 2021 terms) in 2030 and USD 60 in 2050 (see figure 3.7). US oil production will continue to grow but at an increasingly slow pace, continuing to lose its strength in smoothing global oil markets. The ongoing reliance on tight oil and increasingly costly environmental regulations will prevent the price from falling more quickly in the long run, as the break-even cost of the marginal producer in this instance is around USD 55. In this environment, OPEC will continue to grow its influence and maintain its market management strategy to keep prices elevated.

3.5 Net Zero Emissions

Under the Net Zero Emissions scenario, peak demand is no longer in our forecast period, but instead it's already been reached. Oil demand never recovers to its 2019 level and falls an average of 2.5% per year to 2030. From 2030 to 2050, the pace of decline picks up to 6% per year. The NZE world is characterised by very significant policy mandates to boost the clean energy transition. Most notable is the shift in demand to electrification for road transport, as discussed in section 2.2. 75% of the demand for oil that persists in 2050 will be from petrochemicals where the oil is not combusted, such as lubricants and asphalt.

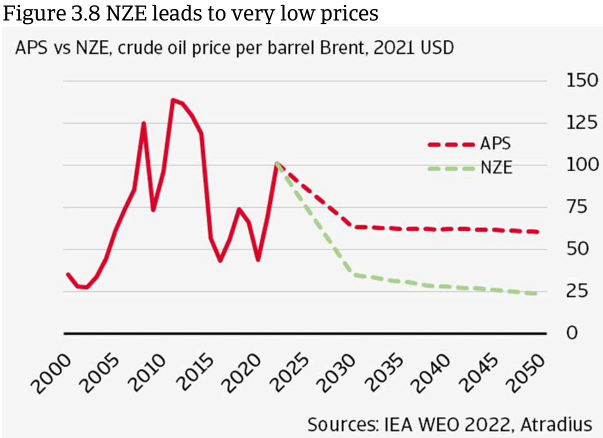
Figure 3.7 Peak demand has passed in NZE scenario



Under the NZE scenario, even with rapidly declining demand, investment in existing oil production assets is still needed to ensure an orderly transition. This entails in-fill drilling, enhanced oil recovery and tight oil drilling, but no further investment in new conventional oil fields will be required. The IEA estimates the required annual investment to be about USD 350 billion to 2030 - USD 130 billion per year less than in the APS. This reduction in investment must be taken in tandem with redirecting investment to clean energy and reducing oil demand to prevent painful market volatility. In a smooth transition, this would bring the price of oil further down in line with the operating cost of the marginal project. In 2021 real USD, this would bring oil prices to about USD 26 per barrel of Brent in 2030 and USD 24 per barrel in 2050.

Production falls across all regions, but OPEC's market share increases even further to 52% in 2050 – its highest level ever. This is due to the large size and slow decline rates of their existing fields allowing minimal investments to continue to garner output gains. With such low oil prices and policy commitments to reaching net zero, we do not foresee OPEC members developing new fields.

Figure 3.8 NZE leads to very low prices



4. Gas market outlook

Under our two main scenarios – Announced Pledges and Net Zero Emissions – gas demand falls between now and 2050. Under the APS scenario, it flattens up to 2030, before declining to below present levels in 2050. In the alternative Net Zero Emissions (NZE) scenario, demand starts to decline sooner and the level drops even lower in 2050 compared to APS. Globally, the share of gas in the energy mix is expected to decline from 16% today to 10% in 2050. Europe is expected to see a severe drop in gas demand in the medium term (up to 2030), while Asia and the Middle East still have the potential for demand growth in the same period (though not in the longer term). China and India are important catalysers of demand growth in Asia. On the supply side, the increases that are still needed in the medium term are mainly coming from the Middle East. In all the other major gas producing regions, supply is expected to decline in both the medium (up to 2030) and long term (up to 2050).

4.1 Key developments

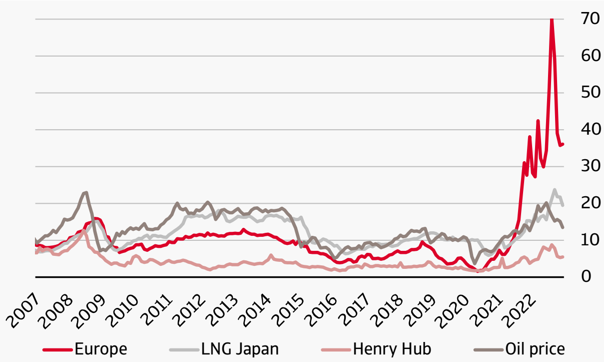
The world is facing a global energy crisis of unprecedented depth and complexity. Europe is the main theatre in which it is playing out, and natural gas is centre stage. Gas markets are traditionally separated into three markets - North America, Asia and Europe - each with its own pricing mechanism. In North America, gas prices are dictated by the fundamentals of supply and demand as a result of competition between multiple sellers and buyers interacting in a spot market (gas-on-gas competition). The reference price is that of Henry Hub, a distribution hub in the US pipeline system in Louisiana. The dominant pricing mechanism in Asia remains oil indexation. European prices are determined by a mixture of gas-on-gas competition and oil indexation, with the former getting more prominence, catalysed by new EU rules on market liberalisation. The European gas price can be measured in various ways, though for the purpose of this report we follow the World Bank in using the Netherlands Title Transfer Facility (TTF), which is Europe's biggest (market-based) gas benchmark. In most of recent history, the European gas price was positioned between that of the US and Asia. In the past 1.5 years, however, it rose far above Asian prices due to the European gas crisis.

Gas prices have been rising quickly since mid-2021. There was no single cause behind the initial price rise in 2021, prior to Russia's invasion of Ukraine. Many factors played a part, the most important being: (1) the rapidity of the economic recovery from the pandemic-induced recession, (2), the impact of weather-related events on demand and electricity generation trends, (3) unplanned outages at LNG liquefaction plants and (4) reduced short-term sales by Russia's Gazprom.

Russia's invasion of Ukraine in February 2022 greatly exacerbated the strains in the gas sector. Russia has cut pipeline gas supplies to the European Union by 80% since the invasion of Ukraine. This drove European gas prices – and indirectly Asian spot LNG prices – to record highs in 2022. The European gas price spiked at USD 70 per million btu in August 2022 (more than 350% year-on-year). Besides lower Russian pipeline supplies, higher gas burn in the power sector amid lower nuclear and hydro output, and strong gas storage injections, provided upward pressure on European hub prices.

In recent months, mild winter conditions and lower storage injections have lowered the European gas price. In December 2022, the TTF gas price was USD 36 per million btu on average, compared to USD 28 at the start of 2022, and USD 7 in January 2021. The Henry Hub price has been relatively stable through 2022. In December 2022, it was USD 5.50 per million btu, compared to USD 4.30 at the start of the year. The price of LNG gas in Japan reached USD 20 per million btu in December 2022, compared to USD 15 at the start of the year (Figure 4.1).

4.1 Global gas prices, USD per million btu



Source: World Bank

To fill the gap left by lower Russian gas supplies, Europe increased its LNG imports by 65% (or 43 bcm) in the first eight months of 2022. However, increased LNG imports covered only a small part of the reduction in Russian deliveries, putting a large part of the burden on European gas demand. Gas demand in OECD Europe declined by about 10% year-on-year in the period January-August 2022, largely driven by demand destruction in the industrial sector. In response to limited supply, energy shortages also emerged in several parts of the developing world that rely on imported gas, notably Pakistan and Bangladesh. Major growth markets for gas such as China and India meanwhile sharply reduced their LNG imports in 2022. In the US, demand increased by over 4%, supported by demand from power generation. The demand increase was mostly driven by weather-related events, with colder than average temperatures in the first half of 2022, followed in the summer by successive heatwaves resulting in an increase in gas-fired power generation for cooling.

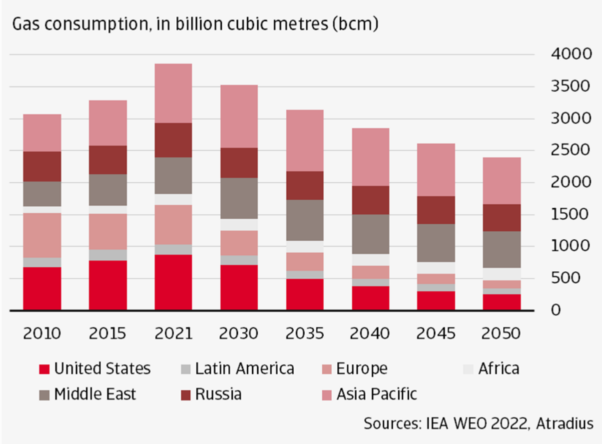
On the supply side, global LNG trade expanded by 6% in the first eight months of 2022, a slight increase on the 5.5% growth rate in 2021 (but less than the 2018-2021 average of 8%). More than half of the increase in global LNG output came from the United States. US LNG exports expanded by 14% year-on-year in the period January-August 2022, thanks to the ramp-up of Sabine Pass train 6 (the sixth liquefaction unit of the Sabine Pass LNG facility in Louisiana) and the Calcasieu Pass terminal (notwithstanding the prolonged outage at the Freeport facility since June 2022). The second biggest contribution came from Russia, where LNG outflows jumped also by 14% year-on-year due to record production at the Yamal LNG facility. Other sizable contributions came from the restart of Norway's Hammerfest terminal and higher LNG output from producers in the Middle East (Qatar and Oman) and South America (Trinidad & Tobago and Peru).

4.2 Gas demand outlook

The recovery in global gas consumption that followed the pandemic-induced drop in 2020 ended prematurely with Russia's invasion of Ukraine in early 2022. The International Energy Agency (IEA) estimates that gas demand in OECD Europe declined by 10% in 2022 and it forecasts a 4% decline in 2023 amid high prices. Europe successfully increased its gas storage levels for the heating season 2022/2023, with EU storage levels at 88% in December 2022. The market dynamics in the coming months will determine how much gas needs to be injected into storage in the summer of 2023, in preparation for the winter of 2023/2024. The IEA expects that demand in Asia could see a modest recovery to 3% growth in 2023 on the assumption of a reopening of the Chinese economy. Gas consumption in North America (US plus Canada) is expected to flatten and then slightly contract in 2023 with a close to 1% decline, led by lower gas use for power generation and assuming average weather conditions.

We use the Announced Pledges Scenario (APS) from the IEA as a baseline for the outlook in the coming decades. In the APS scenario, global gas demand soon peaks and by 2030 is 8% lower than in 2021 (Figure 4.2). The decline continues in the years after 2030, until gas demand in 2050 is almost 40% lower than in 2021. The decline is driven by the push for renewables, but also by the supply squeeze on the gas market that is not expected to ease until the mid-2020s. The path provided by APS is surrounded by high uncertainty as the assumption is that governments will meet, in full and on time, all of the climate-related commitments that they have announced, including longer term net zero emissions targets and pledges in Nationally Determined Contributions (NDCs).

4.2 Gas consumption per region in billion cubic metres (bcm)



Three regions are still expected to see growing gas demand between 2021 and 2030: Asia-Pacific, Middle East and Africa. In Asia, gas demand continues to grow by 60 bcm in the next decade, with growth concentrated in China and India. In China, it slows considerably: growth drops to 1% per annum between 2021 and 2030 compared to 12% in the previous decade. The coal-to-gas switching which started in the 2010s continues into the 2020s, but at a more moderate pace. We expect gas demand in China to peak in 2030. After this, it starts to decline at almost 3% annually between 2030 and 2050. In 2050, Chinese demand is forecast to be 130 bcm lower than in 2021. In India, gas demand is ramped up in the next decade, with almost 6% annual growth. Most of the growth comes from manufacturing and other industry, helped by the expansion of city gas distribution networks. Around 2040, demand in India peaks. It declines by an annual 2% per year between 2040 and 2050.

Besides Asia, the Middle East is an important source of demand, accounting for an additional 70 bcm in the next decade. This translates to an annual growth rate of 1.3%. After 2035, it starts to decline, but at a very moderate pace. In the coming decade, growth is mainly concentrated in the power and industry sectors.

North America (particularly the US), Japan, Europe and Central and South America are projected to see a decline in gas demand both in the medium and long term. In the US – the world's largest natural gas consumer - gas demand falls by 2.2% annually between 2021 and 2030. The Inflation Reduction Act spurs increased deployment of renewables, improved energy efficiency measures and cost declines for heat pumps, significantly reducing gas demand in the power and buildings sectors. In the more distant future, after 2030, US gas demand starts to decline at an accelerated pace. Between 2030 and 2050, gas demand is expected to decline at an annual rate of 4.2%.

Europe is forecast to reduce gas demand by 230 bcm between 2021 and 2030, a total decline of 37% (corresponding to an annual decline of 5.0%). In the baseline scenario, APS, in the EU there is a strong surge in wind and solar capacity additions and a bigger push to retrofit buildings and install heat pumps. These help to bring EU gas demand down by 180 bcm by 2030, which corresponds to a

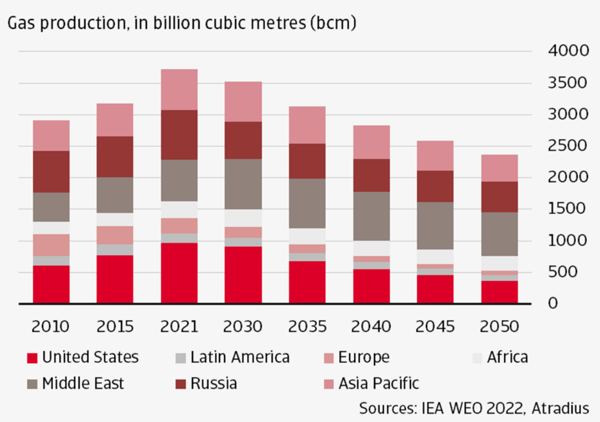
6.0% annual decline. Between 2030 and 2050, EU gas demand declines at a higher speed of 7.4% annually.

4.3 Gas supply outlook

Russia has cut its natural gas pipeline flows to the European Union by 80% since invading Ukraine. This has led to a profound reshuffling of trade flows around the world. Europe is importing more LNG, whereas other importing regions such as Asia are importing less. The procurement of more LNG is not shielding Europe completely from the effects of reduced Russian supplies. It will need to import more LNG and also diversify gas imports from non-Russian pipeline suppliers. The US has the capacity to step up LNG deliveries, but it will take time to establish other major new sources of LNG: for example, large new export facilities in Qatar are not expected to start operations until the middle of the decade. There are considerable uncertainties surrounding the future of LNG. While LNG demand is expected to grow until the mid-2020s in all IEA scenarios, there are sharp divergences thereafter. In the APS scenario, only projects currently under construction are required.

In the APS, global gas supply declines by about 7% between now and 2030 and by almost 40% between now and 2050 (Figure 4.3).[8] Russia is projected to remain the largest gas supplier in 2050, though it will supply 310 bcm less gas compared to 2021 (an almost 40% reduction). We project the US to remain the second-largest supplier, though it delivers 600 bcm less gas in 2050 than now. Qatar is forecast to move to third place among the largest suppliers (currently Iran is third).

4.3 Gas production per region in billion cubic metres (bcm)



We now turn to each region in more detail. In the United States, gas production is reduced by about 55 bcm between 2021 and 2030. This translates to an annual production decline of 1% between 2021 and 2030. The production decline is in stark contrast to the 4.5% growth rate in the previous decade (when the US increased its production by 365 bcm). Even as US gas production falls 7% below current levels by 2030 due to declining domestic demand, LNG exports increase by 45 bcm from today. In the more distant future, after 2030, US gas production starts to decline at an accelerated pace of more than 3% per year.

We expect gas production in Russia to fall significantly by 210 bcm between 2021 and 2030. This represents an annual production decline of 3.3%. The APS scenario assumes Russian gas deliveries to Europe fall to zero before 2030. The upstream projects designed to serve Nord Stream II – Kharasavey and the Bovanenkovo expansion – struggle in the near term to find alternative outlets. The Tambey field expansion to underpin new LNG projects is unlikely to ramp up to its original capacity. The flaring of associated gas[9] has recently increased, and there is a short-term risk of large-scale flaring or venting to ease system pipeline pressures.

Russia's efforts to diversify its export markets have mixed success. Deliveries to China are expected to increase, which is largely achieved through the ramping up of the Power of Siberia pipeline, and to a lesser extent by a new pipeline from Sakhalin into northeast China. Overall, however, Russia's increased pipeline natural gas deliveries to China cover less than half of the drop in exports to Europe by 2030. There are no easy options for Russia in its search for new markets. Sanctions undercut the prospects for large new LNG projects, and long distances to alternative markets make new pipeline links difficult. In the APS, Russia's share of internationally traded gas, which stood at 30% in 2021, falls by 2030 to less than 15%.

The Middle East remains the largest near-term source of supply growth. The entire Middle East region is projected to add about 140 bcm in additional supply up to 2030. Qatar is expected to step up its gas production by around 70 bcm up to 2030. This forecast is underpinned by rising LNG trade as Europe has significantly higher import needs after the Russian invasion of Ukraine. New supplies are made possible by expansion of the North Field in Qatar.[10] Saudi Arabia adds about 50 bcm in production up to 2030, but this is solely used for domestic needs. The country with the largest gas reserves in the region, Iran, adds only about 20 bcm in production, which is also mainly used to meet domestic demand.

The other gas producing regions – Europe, Africa, Asia and Latin America – all see production declines as well. In Asia, the decrease mainly takes place in Southeast Asia. China and India are still ramping up production until 2030; and India even up to 2050. China emerges in each scenario in the top five largest natural gas producers, along with the US, Russia, Iran and Qatar. India increases gas production by 4.4% per year between now and 2030 (for a total of 15 bcm); its government has recently announced a doubling of its licence area for oil and gas exploration. In Latin America, the APS scenario foresees a 1.4% production decline between 2021 and 2030 (in total 18 bcm). In Africa, most of the increased production in the next decade comes from Mozambique, which increases its production by 10 bcm until 2030. Finally,

8 By definition, in the long term, global gas supply has to equal global demand.

9 Associated gas is natural gas that is produced along with crude oil, and typically separated from the oil at the wellhead.

10 The world's biggest single non-associated natural gas field, offshore north-east Qatar peninsula. The North Field represents the southern part of the giant natural gas field that is shared between Iran and Qatar.

we forecast that Europe will lower its gas production by about a quarter (65 bcm) in the next decade.

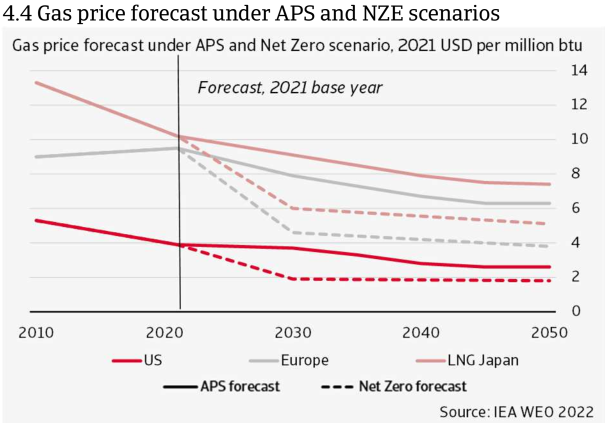
4.4 Gas price outlook

We align our baseline price forecast with the Announced Pledges Scenario (APS) from the IEA, and the alternative scenario with the IEA's Net Zero Emissions (NZE) scenario. The IEA scenarios model an energy system in equilibrium, in which energy prices follow a relatively smooth trajectory to balance supply and demand, and where energy markets, investment, technologies and policies all evolve in a mutually consistent direction. Unlike oil, there is no single global price for natural gas, but instead a set of regional prices that are increasingly interlinked by the ability of LNG tankers to seek out the most advantageous commercial destination. Figure 4.4 shows the gas price forecast under the APS and Net Zero scenarios. The 2022 gas crisis is not visible in this figure as IEA takes 2021 as a base year and makes long-term projections.

Under the APS scenario, the gas price is trending down in all three regions. The gas price stays relatively high in Europe in the near term as Russian exports to the European Union are assumed to fall further in line with the expiry of contracts that have yet to be cut unilaterally. By 2030, however, the EU gas price returns to around USD 8 per million btu as new supply comes online and market conditions ease. The Henry Hub price, the marker for natural gas in the United States, remains more or less flat up to 2030, but declines slightly after this. The Asian LNG price shows a declining trend over the forecast horizon, but remains higher than in Europe or the US (except in the near term, which is not explicitly depicted in the figure). Over the coming decades, LNG trade is expected to take a more prominent role, which reduces the price spread between Asian LNG and Henry Hub.

Under the APS, the EU still needs to attract additional non-Russian gas, keeping near-term gas prices elevated. This has knock-on effects on prices in other importing regions, although the effects in Asia are muted by the link to oil prices in many long-term contracts.

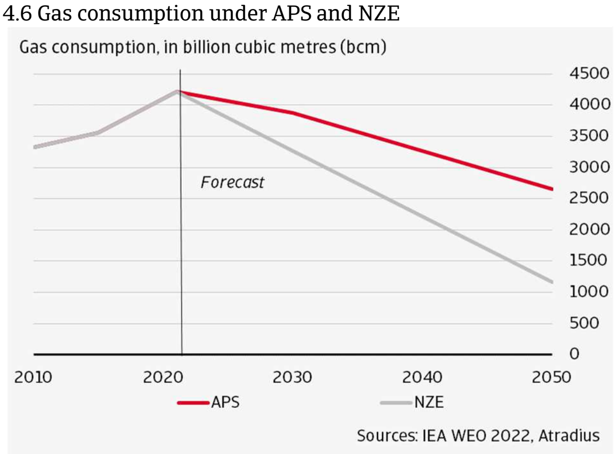
4.4 Gas price forecast under APS and NZE scenarios



4.5 Net Zero Emissions: stronger demand reduction

Given climate change and the increasing speed of energy transition, it is important to look at alternative scenarios. We use the Net Zero Emissions scenario (NZE) as the alternative to APS. NZE is a normative IEA scenario that shows a pathway for the global energy sector to achieve net zero CO2 emissions by 2050, with advanced economies reaching net zero emissions in advance of others. Under the NZE scenario, the decline in gas consumption is stronger than under APS, but some additional investment is needed to compensate for reduced Russian supplies. Gas demand in NZE is over 900 bcm lower in 2030 than in 2021, a drop of around 20%. By 2050, the level of demand is 70% lower than today. Due to the stronger push for renewable energy, the position of gas in the total energy mix declines even more sharply than under APS, from 16% today to 5% in 2050 (compared to 10% in 2050 under APS). By 2050, unabated natural gas meets less than 15% of total demand for gaseous fuels; low-emissions gases account for over 70% of total gaseous fuel demand and natural gas used either for non-combustion purposes or equipped with carbon capture utilisation and storage (CCUS) for the remainder. Around 500 bcm of natural gas is used with CCUS to produce low-emissions hydrogen in 2050, providing around 25% of total hydrogen demand (with most of the rest produced from electrolysis).

4.6 Gas consumption under APS and NZE



The gas price in the NZE scenario clearly gravitates to a lower equilibrium level. Compared to our 2022 Energy Outlook, equilibrium prices in the long term (2050) are all revised upwards, except for the US Henry Hub price under the NZE scenario. These upward price revisions are driven by a permanent loss of Russian gas supplies to Europe, partly due to supply cuts by Russia, but also to a drive within Europe to reduce imports from Russia.

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