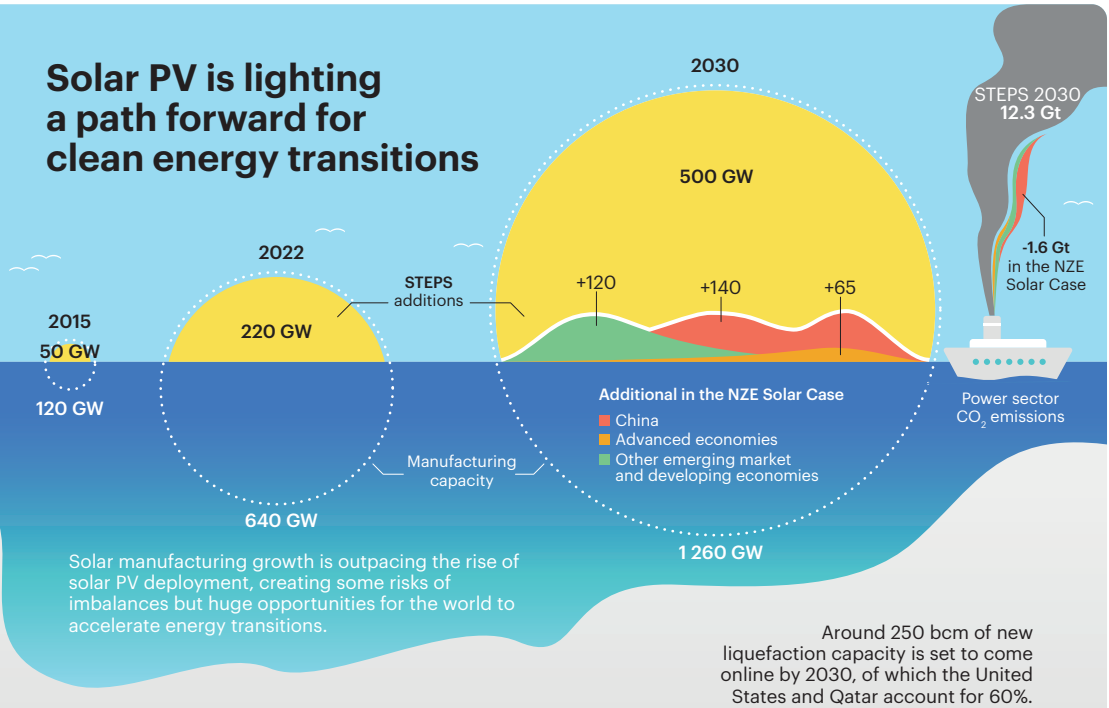
Overview and key findings

Transitions are getting competitive

SUMMARY

- Conflict and uncertainty provide an inauspicious backdrop to the new *World Energy Outlook*. Following Russia's invasion of Ukraine, instability in the Middle East could lead to further disruption to energy markets and prices. This underscores once again the frailties of the fossil fuel age, and the benefits for energy security as well as for emissions of shifting to a more sustainable energy system.
- Clean energy projects are facing headwinds in some markets from cost inflation, supply chain bottlenecks and higher borrowing costs. But clean energy is the most dynamic aspect of global energy investment. How fast it grows in the coming decades in response to policy and market stimuli is key to explain the differences in trajectories and outcomes across our three main scenarios. In all scenarios, the momentum behind the clean energy economy is enough to produce a peak in demand for coal, oil and natural gas this decade, although the rates of post-peak decline vary widely.
- In the Stated Policies Scenario, average annual growth rate of 0.7% in total energy demand to 2030 is around half the rate of energy demand growth of the last decade. Demand continues to increase through to 2050. In the Announced Pledges Scenario, total energy demand flattens, thanks to improved efficiency and the inherent efficiency advantages of technologies powered by electricity – such as electric vehicles and heat pumps – over fossil fuel-based alternatives. In the Net Zero Emissions by 2050 Scenario, electrification and efficiency gains proceed even faster, leading to a decline in primary energy of 1.2% per year to 2030.
- Our analysis explores some key uncertainties, notably regarding the pace of China's economic growth and the possibilities for more rapid solar PV deployment opened by a massive planned expansion in manufacturing capacity (led by China). We highlight the implications of a huge increase in the capacity to export liquefied natural gas starting in the middle of this decade, led by the United States and Qatar. We examine how any deterioration in geopolitical tensions would undermine both the prospects for energy security and for rapid, affordable transitions.
- Extreme volatility in energy markets during the global energy crisis has highlighted the importance of affordable, reliable and resilient supply, especially in price-sensitive developing economies that see the largest increase in demand for energy services. Energy transitions rely on electrification and technologies like wind, solar PV and batteries, and push electricity security and diversified supply for clean technologies and critical minerals up the policy agenda. Emerging market and developing economies account for almost 80% of the global growth in electricity demand in the Stated Policies Scenario, and for over two-thirds in the other scenarios.

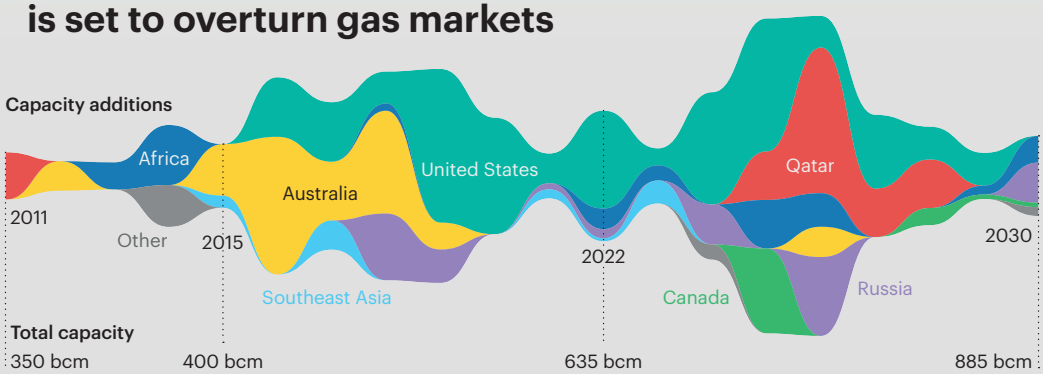
Solar PV is lighting a path forward for clean energy transitions



Solar manufacturing growth is outpacing the rise of solar PV deployment, creating some risks of imbalances but huge opportunities for the world to accelerate energy transitions.

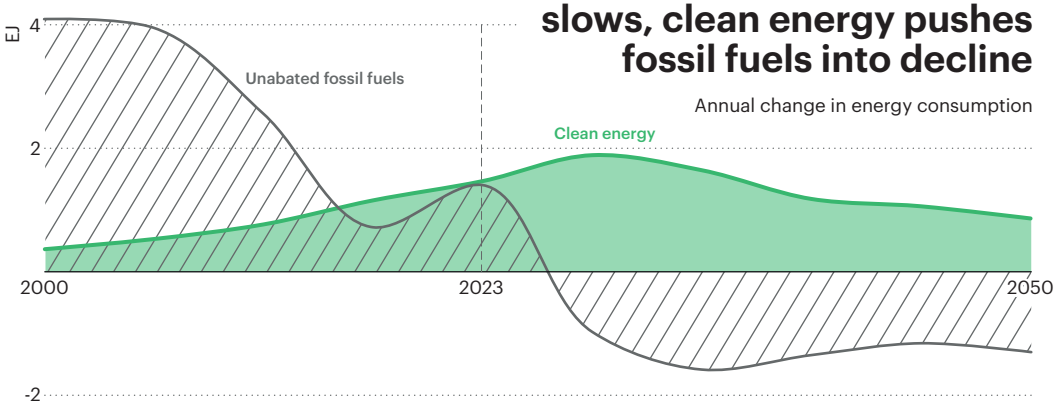
Around 250 bcm of new liquefaction capacity is set to come online by 2030, of which the United States and Qatar account for 60%.

A wave of new LNG export projects is set to overturn gas markets



As China's demand growth slows, clean energy pushes fossil fuels into decline

Annual change in energy consumption



Introduction

Some of the tensions in energy markets receded in 2023 since the extreme volatility of the global energy crisis, but the situation remains fragile. The urgent task of transforming the energy system now takes place in a more challenging macroeconomic and geopolitical context. The frailties of the fossil fuel age and the hazards that it has created for the planet are plain to see, and opportunities in the emerging clean energy economy are growing fast. But many uncertainties remain about the resilience of energy supply chains old and new, about risks to the security and affordability of transitions, and about whether the process of change will be sufficiently rapid to avoid very severe impacts from a changing climate.

Using the latest data for energy markets, policies and technologies, the *World Energy Outlook* (*WEO*) provides insights on all these key issues. It does so by exploring scenarios that reflect different assumptions about the actions taken in the coming years to shape energy systems and reduce energy-related carbon dioxide (CO_2) emissions. The projections in the Stated Policies Scenario (STEPS) give a sense of the current direction of travel for the energy economy, based on the actual state of play in different sectors, countries and regions. The Announced Pledges Scenario (APS) shows how that future would be different if all countries were to hit their aspirational targets, including national and regional net zero emissions pledges, on time and in full. The updated Net Zero Emissions by 2050 (NZE) Scenario illustrates what more is required to limit global warming to 1.5 degree Celsius (°C).

This overview chapter provides ten takeaways from the new analysis. Our projections show that for the first time demand for each of the fossil fuels reach a peak in the STEPS before the end of this decade. We examine how uncertainties over the pace of economic growth in The People's Republic of China (hereinafter China) could affect the near-term outlook, as well as the implications of the extraordinary China-led boom in manufacturing capacity for solar photovoltaic (PV) modules. We highlight areas of hope and areas for caution about the prospects of staying within the 1.5 °C limit, and examine the crucial issue of capital flows for clean energy and fossil fuels.

Against a background of macroeconomic uncertainty, we consider the affordability of the transition for households, industry and governments. As the world comes to rely more and more on electricity, we look at risks affecting technologies that have a key part to play in increasing electrification and decarbonising the power supply. We also ask whether the policy and technology choices facing emerging market and developing economies open the possibility of a new lower carbon pathway for development. In addition, we identify the ways in which geopolitical tensions could affect the *Outlook*, and look back to see how and why our projections have changed over time.

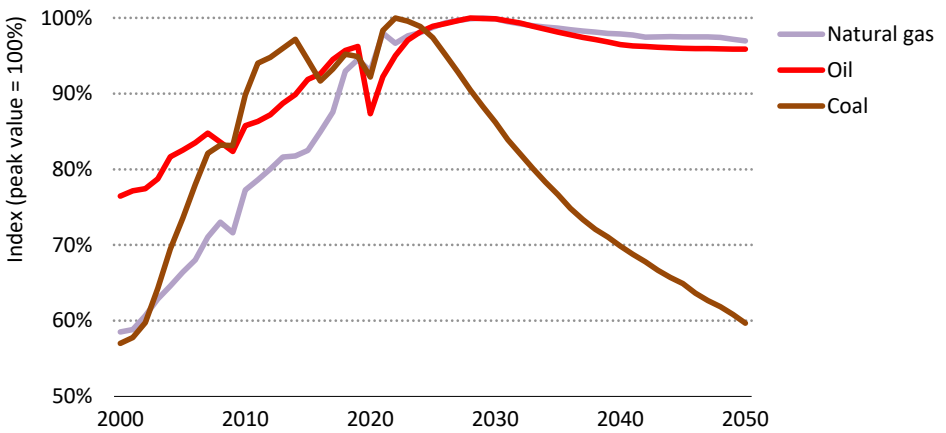
The topics included in this chapter represent key themes of the *World Energy Outlook 2023*. Further information and background on the IEA Net Zero Roadmap is in *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach* published in September 2023. In addition, a range of supply and demand issues for the oil and gas industry and their relation to the *Outlook* are the focus of a forthcoming special report in November 2023.

1.1 A peak by 2030 for each of the fossil fuels

In the *WEO-2023*, the Stated Policies Scenario (STEPS) sees lower demand projections for each of the fossil fuels than in the *WEO-2022*. This reflects current policy settings by governments worldwide, a slight downward revision in the economic outlook, and the continued ramifications of the 2022 global energy crisis. It also reflects longer term trends: fossil fuel technologies have been losing market share to clean energy technologies across various sectors in recent years, and in many cases fossil fuel-powered technologies have already seen a peak in sales or additions.

These shifts mean that each of the three fossil fuel categories are now projected to reach a peak by 2030 (Figure 1.1). This has never previously been seen in the STEPS. The changes in our projections highlight how the energy system is changing as low-emissions electricity and fuels meet an increasing share of the world's rising energy needs, and as energy efficiency improvements help to moderate those needs. Total demand for fossil fuels declines from the mid-2020s by an average of 3 exajoules (EJ) per year to 2050 in the STEPS, and the peak in energy-related CO_2 emissions in the STEPS is brought forward to the mid-2020s.

Figure 1.1 ▷ Fossil fuel consumption by fuel in the STEPS, 2000-2050



All fossil fuels peak before the end of this decade, with declines in advanced economies and China offsetting increasing demand elsewhere

We highlight below some of the key drivers for these changes by fuel, but there are some important issues to bear in mind when considering these trends. First, the projected declines in demand after the peaks are nowhere near steep enough to be consistent with the NZE Scenario – getting on track for this scenario will require much faster clean energy deployment and much more determined policy action by governments (section 1.4). Second, the demand trends for the different fuels vary considerably among regions, with reduced

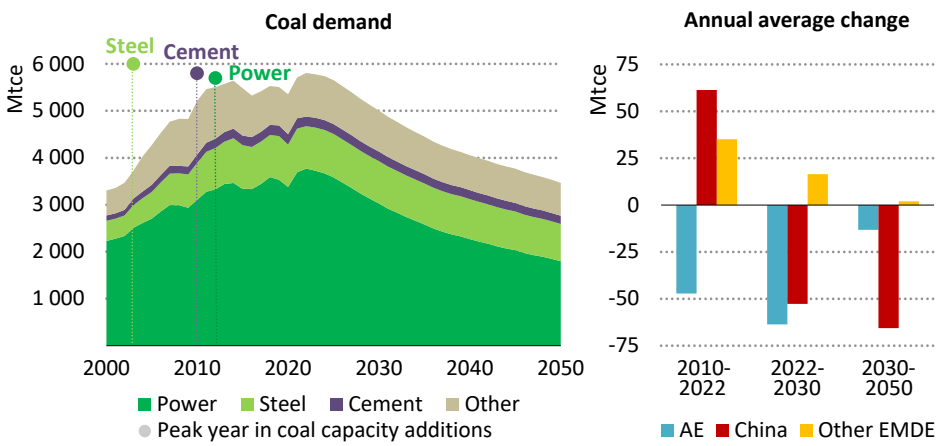
demand in advanced economies partially offset by continued growth in many emerging market and developing economies, particularly for natural gas. Third, while the trajectories in our scenarios reflect underlying structural changes, the demand outlook will not be linear in practice. There will inevitably be spikes, dips and plateaus along the way. For example, heatwaves and droughts could well cause temporary jumps in coal demand by pushing up electricity use at a time when hydropower output may be constrained.

Even as demand for fossil fuels falls, energy security challenges will remain since the process of adjustment to changing demand patterns will not necessarily be easy or smooth. For example, the peaks in demand we see based on today's policies do not remove the need for investment in oil and gas supply, given how steep the natural declines from existing fields often are. At the same time, they underline the economic and financial risks of major new oil and gas projects, on top of their risks for climate change (section 1.5).

1.1.1 Coal: Scaling up clean power hastens the decline

After remaining consistently high over the past decade, global coal demand is now set to fall within the next few years in the STEPS (Figure 1.2). This projected trend reflects declines in recent years of capacity additions of both coal-fired power and coal-fired iron and steel production – the two largest consumers of coal today – which account for 65% and 16% respectively of overall coal consumption.

Figure 1.2 ▷ Global coal demand by sector and annual average change by region in the STEPS, 2000-2050



Peaks in coal capacity additions reached in the power, steel and cement sectors are laying the foundation for global coal demand to peak in the mid-2020s

Note: Mtce = million tonnes of coal equivalent; AE = advanced economies; EMDE = emerging market and developing economies.

The share of coal-fired power in new worldwide capacity additions hit a high point in 2006 at 45% and has since fallen steadily to 11% in 2022. The size of annual coal capacity additions peaked in 2012 at over 100 gigawatts (GW) before dropping to 50 GW in 2022, with big investments in coal falling away rapidly, and solar PV and wind power increasingly dominating the expansion of electricity systems. The role of coal-fired power plants has started to shift towards providing flexibility and system services rather than bulk power. As a result, the average capacity factor of coal power plants was almost ten percentage points lower over the past decade than during the decade before.

Changes in iron and steel production have also contributed to the decline in coal demand. Capacity additions of coal-based steel production plants[1] peaked in 2003 at over 130 million tonnes (Mt), driven in large part by China's rapid industrialisation. Eleven years later, global coal demand for iron and steel production peaked at over 950 million tonnes of coal equivalent (Mtce) before starting to fall, despite a continuing steady increase in the production of iron and steel. The decline in the global coal intensity of steel production since 2015 is the result of growth in the share of scrap-based production in electric arc furnaces, as well as alternatives to blast furnaces for iron production such as natural gas-based direct reduced iron.

In advanced economies, coal demand peaked in 2007. In China – the world's largest coal consumer – the impressive growth of renewables and nuclear alongside macroeconomic shifts point to a decrease in coal use by the mid-2020s. Coal use continues to increase in other emerging market and developing economies as new power plants and industry capacity come online, but this growth is more than offset by projected declines elsewhere.

1.1.2 Oil: End of the "ICE age" turns prospects around

In the past two decades, oil demand has surged by 18 million barrels per day (mb/d). Much of the increase has been driven by rising demand in road transport. The global car fleet expanded by more than 600 million cars over the last 20 years, and road freight activity has increased by almost 65%. Road transport now accounts for around 45% of global oil demand, which is far more than any other sector: the petrochemicals sector, second-largest in oil consumption, accounts for 15% of oil demand.

The astounding rise in electric vehicle (EV) sales is now having an impact on demand for oil in road transport. Sales of gasoline and diesel cars, two/three-wheelers and trucks peaked in 2017, 2018 and 2019 respectively (Figure 1.3). In 2020, EVs accounted for 4% of global car sales. They are on track to reach 18% in 2023 with 14 million EV sales, mostly in China and the advanced economies, and are set to continue to increase rapidly in the future. Sales of internal combustion engine (ICE) buses also peak by the mid-2020s in the STEPS, with the uptake of electric buses rising particularly quickly in emerging market and developing economies. By the end of this decade, road transport is no longer a source of oil demand growth.

[1] Includes blast furnaces-basic oxygen furnaces, smelting reduction-basic oxygen furnace, coal-based direct reduced iron-electric arc furnace, coal-based iron in induction or in open hearth furnaces.