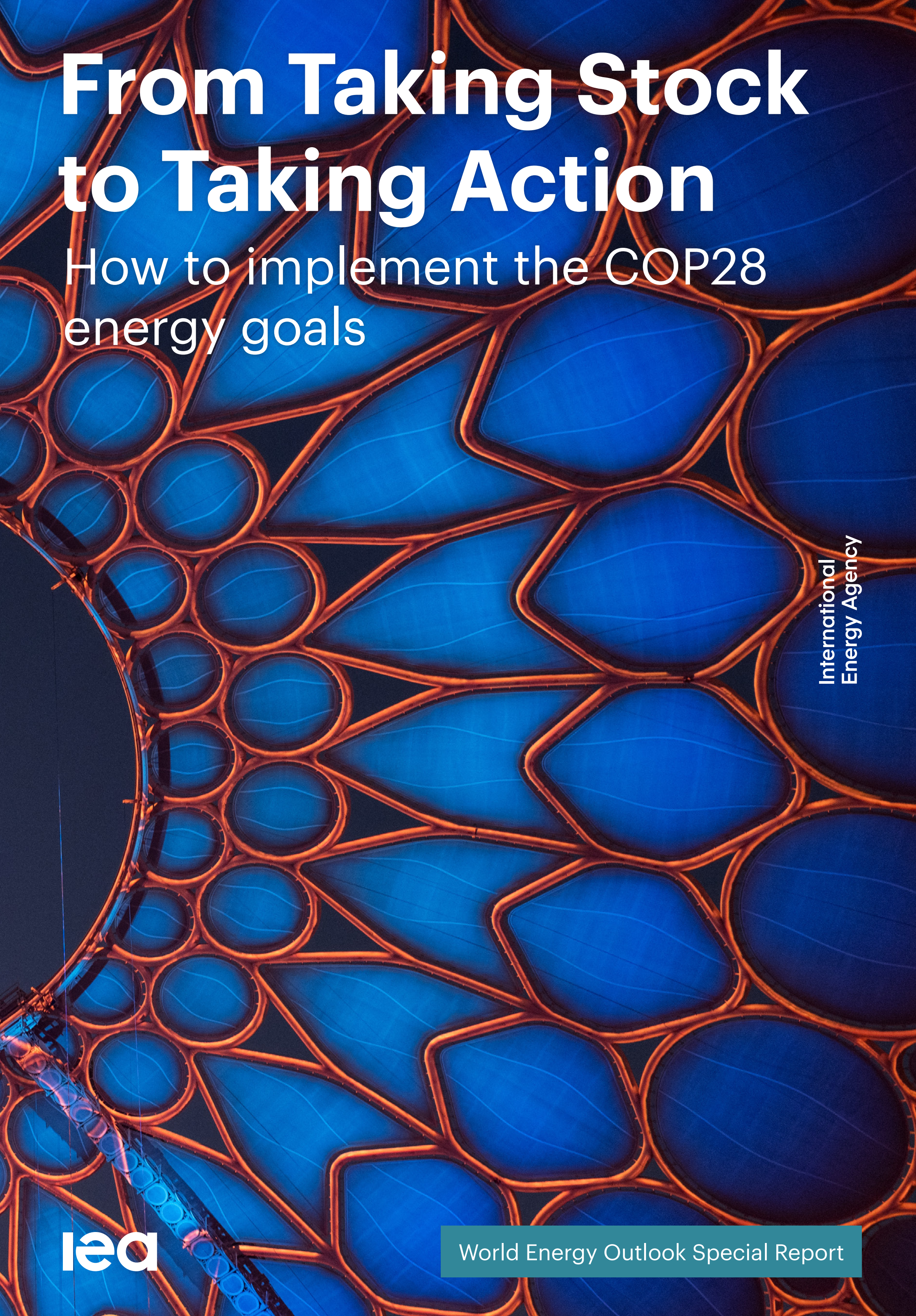
From Taking Stock to Taking Action

How to implement the COP28 energy goals

International Energy Agency



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World Energy Outlook Special Report

INTERNATIONAL ENERGY AGENCY

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Ahead of the COP28 climate change conference hosted by the United Arab Emirates in December 2023, new analysis from the International Energy Agency (IEA) underscored both the high stakes and the major opportunities. Record growth in a number of clean energy technologies was keeping open a path to achieving net zero emissions from the global energy sector by mid-century. But without much stronger international action, emissions would not decline anywhere near fast enough – and the goal of limiting global warming to 1.5 °C, as called for in the Paris Agreement, would be in severe jeopardy.

Drawing on our data and analysis, the IEA developed five pillars for global action in the energy sector by 2030 that could help keep the 1.5 °C goal alive. These included tripling renewable energy capacity, doubling the rate of energy efficiency progress and significantly reducing methane emissions from fossil fuels. And we ramped up efforts to foster broad consensus around 1.5 °C-aligned transition pathways, convening a summit on this topic with the Government of Spain and hosting a series of High-Level Energy Transition Dialogues with the COP28 Presidency.

When nearly 200 countries at COP28 in Dubai agreed on a powerful package of energy commitments – including the tripling and doubling goals, a call to slash methane emissions and a historic pledge to transition away from fossil fuels in a just, orderly and equitable manner – it was a moment to cherish. In a challenging context, the "UAE Consensus" delivered a vision for a net zero energy future that could be transformative.

Yet change is never a given. And with the approach of COP29, which will be hosted in Baku, Azerbaijan, the focus must continue to shift towards implementing the promises made in Dubai.

This report addresses what that means in practice, providing timely and constructive guidance for decision makers around the world. It will play an important role as the IEA continues to drive forward the international discussion on energy and climate goals, including through a new series of High-Level Energy Transition Dialogues in partnership with the COP29 Presidency.

One priority the report makes clear is that countries need to quickly translate the COP28 pledges into domestic energy policies. The next round of Nationally Determined Contributions, or NDCs, due in 2025, presents an unmissable opportunity. These new national climate plans will collectively form the backbone of international climate progress and cooperation for the next decade and beyond. While every country will have its own pathway to achieve its energy and climate goals, all can – and should – determine how they can help turn the COP28 outcomes into reality.

The report also finds that the world is on track to produce enough solar panels and related materials to meet the goal of tripling renewable capacity this decade. But we need to transform this capacity into electricity. This will require a significant pick-up in investment in grids and storage. If this does not happen, the use of coal will not decline – and neither will global emissions.

Another important takeaway is on energy efficiency, which has been central to the IEA's work since its founding 50 years ago. This report sets out with great clarity how to reach the critical goal of doubling efficiency progress this decade, looking at what is needed across economies at all stages of development. What it finds is that even though the world is not on track based on today's policies, a course correction is still possible with a concerted global push.

The IEA will continue to provide the data and analysis to develop unbiased advice for clean, secure and affordable energy transitions around the world. Our landmark Net Zero Roadmap, first published in 2021, helped set the original vision. Now, as countries seek to move forwards, the IEA will keep mapping out practical pathways to reach the goals that have been set, while bringing leaders together to catalyse further bold action.

I would like to thank the team of IEA colleagues who worked on this important analysis, led by Laura Cozzi and Thomas Spencer. I'm confident that this report will provide a strong foundation for further progress towards a better energy future for all.

Dr Fatih Birol
Executive Director
International Energy Agency

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Marina Dos Santos and Eleni Tsoukala provided essential support.

Edmund Hosker carried editorial responsibility. **Julia Horowitz** contributed to editing. **Debra Justus** was the copy-editor.

Valuable comments and feedback were provided by other senior management and colleagues within the IEA, in particular Dan Dorner, Tim Gould, Timur Gül, Dennis Hesseling, Pablo Hevia-Koch, Brian Motherway and Keisuke Sadamori.

Thanks to the IEA Communications and Digital Office for their help in producing the report and website materials, particularly Jethro Mullen, Poeli Bojorquez, Curtis Brainard, Astrid Dumond, Grace Gordon, Isabelle Nonain-Semelin and Wonjik Yang. The IEA Office of the Legal Counsel, Office of Management and Administration and Energy Data Centre provided assistance throughout the preparation of the report.

The IEA Clean Energy Transitions Programme, the flagship initiative to transform the world's energy system to achieve a secure and sustainable future for all, supported this work.

Peer reviewers

Many senior government officials and international experts provided input and reviewed preliminary drafts of the report. Their comments and suggestions were of great value. They include:

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Abdullah Malek	COP28 United Arab Emirates
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COP28 set an ambitious course correction for the global energy sector

The 28th Conference of the Parties (COP28) delivered both a vision for creating a net zero energy system and a pledge by almost 200 countries to take actions to achieve it. Long due, it arrived at a time when the world continues to break records for energy-related emissions and global temperatures, as well as records for clean energy investment and deployment. Without the surge of clean energy technologies, emissions growth since the Covid-19 pandemic would have been three times larger. Yet the world is still falling far short of its Paris Agreement goals to limit global warming.

Despite a challenging geopolitical, economic and climate backdrop, countries came together at COP28 and agreed on the "UAE Consensus," setting ambitious global energy transition goals. These include, among others, reaching global net zero emissions in the energy sector by 2050; transitioning away from fossil fuels in line with net zero emissions by 2050; tripling the global installed capacity of renewable energy by 2030; doubling of the rate of energy efficiency improvement by 2030; and accelerating the deployment of other critical low-emissions technologies.

This report analyses what full implementation of the COP28 goals would mean for the energy system and its emissions, assesses the risks and pitfalls of partial implementation, and discusses how countries can integrate the COP28 outcome into the next round of their targets under the Paris Agreement. These Nationally Determined Contributions, or NDCs, extend until 2035.

The COP28 goals build on growing clean energy momentum and could keep the path to net zero by 2050 open

The tripling renewables and doubling efficiency targets could, on their own, get the world fully two-thirds of the way to a Paris-aligned energy system by 2030. If done correctly, their achievement would reduce the world's GHG emissions by 10 billion tonnes by the end of the decade compared with what is otherwise expected. If achieved as part of a comprehensive implementation of the COP28 outcome – balanced across countries, sectors and technologies, and with the necessary enabling infrastructure – this would keep open the path to net zero emissions by 2050 and give a chance – albeit still slim and difficult – of holding warming to 1.5 °C. In contrast, if countries only focus on a subset of the COP28 outcomes, fail to translate them into comprehensive plans and policies, or are slow to develop the necessary enabling infrastructure such as storage and grids, then most of the huge positive potential promised at COP28 will remain unrealised.

Countries need to translate the COP28 goals into domestic energy policies

Country pathways and enabling conditions differ, but all countries can and must strengthen work on contributing to the COP28 goals in national policies and new NDCs due in 2025. Not all goals in the COP28 vision are given equal detail; how they are translated into national plans and policies will be key. Where there is ambiguity, the overarching goal of net zero emissions by 2050 should shape responses. Individual countries' contributions to achieving the COP28 goals will and should vary. At the same time, the COP28 goals are not a menu from which countries can pick and choose: together they form a high-level, multilateral roadmap the energy sector has long been lacking.

Energy efficiency should lead, but it is far from achieving its full potential

The goal of doubling the rate of energy efficiency improvements globally could provide larger emissions reductions by 2030 than anything else, but it looks far out of reach under today's policy settings. As a result, energy costs for consumers are set to be 8% higher in 2030 under today's policies than they would be with full implementation of the goal of doubling efficiency, and annual emissions 6.5 gigatonnes (Gt) higher.

Focussing on the doubling of technical efficiency is critical but will not be enough on its own. Stronger efficiency policies for new equipment can boost the global rate of efficiency improvement to 2.4% per year on average to 2030. While better than the improvement rate under today's policies, it falls short of the 4% needed annually for the doubling goal.

Achieving the doubling goal requires countries to expand the focus of energy efficiency policies. Reaping the efficiency benefits of electrification, reducing the energy footprint of transport and industrial systems through greater use of public transportation and improved material efficiency, and supporting energy-saving among consumers are important everywhere. Different countries will have different starting points and priorities, but in broad terms:

- **In advanced economies, electrification is the key lever to improve efficiency,** with electricity set to power 30% of total consumption by 2030 and 40% by 2035 if the COP28 goals are achieved. The rising use of electric vehicles and heat pumps are at the heart of this: they are two- to five-times more efficient than their fossil fuel equivalents. Energy efficient retrofits of old buildings are also critical.
- **In emerging markets, strengthening and enforcing efficiency standards for new buildings, factories and appliances is key**, with these countries set to add half a billion new air conditioners and 35 billion square metres in floor space for new buildings by 2030. By 2030, achieving COP28 goals in full would reduce the heating and cooling energy consumption of new buildings in emerging markets by 50%.
- **In countries without full access to clean cooking, particularly in sub-Saharan Africa, achieving full access to clean cooking delivers the largest energy savings**. Switching from traditional cookstoves would save more energy annually than the current energy demand of Brazil. Alternatives are well-understood and scalable, and the clean cooking benefits for lives and livelihoods are huge.

Without grids and storage, the tripling of renewables will not succeed

With today's policy settings and technology trends, the world is on course to achieve more than three-quarters of the growth needed for the goal of tripling global renewables capacity by 2030. Achieving the tripling goal is possible with faster capacity expansion. To reap the economic and emissions benefits of the tripling of renewables, while ensuring reliable and affordable access to electricity, countries need to focus on a range of measures to ensure that the renewables coming online are securely integrated and displace fossil fuel generation.

This requires faster but responsible permitting processes, more than 25 million kilometres of electricity grids to be built or upgraded by 2030, and global energy storage capacity to grow to 1 500 GW by 2030. Slow permitting for new grid expansions, a lack of investment in many (often state-owned) grid companies in emerging market and developing economies, and old and outdated grids in advanced economies are key bottlenecks. Integrating the large increase in variable renewable generation implied by the tripling goal also requires a range of measures, including around 1 500 GW of storage capacity to be installed by 2030, of which 1 200 GW is battery storage – a nearly fifteen-fold increase on today's level.

Failure to take the necessary action would result in higher electricity prices, more coal and gas generation, higher curtailment of renewables and higher emissions. Our modelling of a partial implementation of the tripling goal, in which grids and storage lag behind the expansion of capacity, results in almost 40% more coal generation and higher curtailment.

Key benchmarks for energy system transitions aligned with the COP28 outcome

By 2030, to support the full implementation of the COP28 outcome, the world needs to:

- Achieve a **global storage capacity of 1 500 GW** and build or modernise **25 million kilometres of grids**
- Achieve a share of **electricity in final energy consumption of 30%**
- Achieve the Sustainable Development Goal of **universal access to clean cooking**
- Increase the **efficiency of new air conditioners sold by 50%**

By 2035, to guide energy sector ambitions for the timeframe of the next NDCs:

- **Quintuple renewables capacity,** maintain the **rate of efficiency improvements at 4%**, and **build or modernise another 30 million kilometres of grids,** bringing the total to 55 million kilometres built or modernised from today
- Achieve a share of **electricity in final consumption of 35%** globally
- Scale up **nuclear power capacity by 1.8 times** and sustainable **low-emissions fuels by 2.8 times**, including carbon capture, utilisation and storage (CCUS), low-emissions hydrogen and sustainable bioenergy

Clean energy policies alone are not enough to drive a secure transition away from fossil fuels

The COP28 outcome broke new ground in highlighting the importance of transitioning away from fossil fuels in a just, orderly and equitable manner, accelerating action in this critical decade, to achieve net zero by 2050. It also included specific fossil fuel-related goals on phasing down unabated coal power, reforming fossil fuel subsidies and reducing methane emissions.

The growth of clean energy is critical to driving down demand for fossil fuels, but a singular focus on clean energy policies alone is not enough. Methane emissions are an example of an area in which additional action is needed. Fossil fuel production is responsible for around 15% of global energy-related greenhouse gas emissions – most of which are methane emissions. Many of the ways to reduce these emissions are well-known and cost-effective. Full implementation of the COP28 goals would cut emissions from oil and gas supply activities by more than 60% from today's levels by 2030, led by declines in methane and building on initiatives such as the Global Methane Pledge and the Oil and Gas Decarbonization Charter. Phasing out inefficient fossil fuel subsidies and ensuring the safe and responsible decommissioning or repurposing of fossil fuel infrastructure when it is no longer needed are also crucial.

In a world characterised by uncertainty, clear fossil fuel transition policies are needed alongside robust clean energy policies to accelerate transitions. Such policies can help to set market expectations and ensure that clean energy grows at the pace and scale needed. They might include regulations that set phase-out dates for certain assets or equipment such as coal-fired power plants, measures that bring about the early retirement or repurposing of fossil fuel infrastructure, and national plans to synchronise reductions in investment in fossil fuels with the scaling up in clean energy investment in a way that protects energy security.

If unchecked, emissions from existing coal-fired capacity alone would be enough to push the world across the 1.5 °C threshold. A key first step is to end the approval of new unabated coal plants, but the scale of existing coal capacity means that this is not enough alone. Existing plants must also be run much less and more flexibly as clean generation scales up, and a significant number of coal plants must be retired early. Maintaining electricity security will require investment in storage and grids alongside a careful sequencing of retirements.

Achieving a transition away from fossil fuels that is just, orderly and equitable requires dialogue and cooperation among a broad range of stakeholders, including between producer and consumer countries. Inclusive dialogue that includes industry, labour, communities and governments is essential to inform coherent energy investment planning, maximise opportunities for socio-economic development from the transition, and minimise negative impacts on communities, workers, companies and vulnerable social groups. Consumer economies can send important market signals to producers and support their economic diversification and growing role in the clean energy economy through technology collaboration and investment.

Clean energy investment is skewed in two glaring ways

Advanced economies and China account for more than four out of every five dollars invested in clean energy since the Paris Agreement was signed. The scale up of clean energy investment in other regions will require stronger and more stable policies to attract private investment, and more sizable, more targeted and more catalytic international support, spurred by the new global goal for climate finance and the Paris Agreement's goal to align financial flows with low-emissions development. **More must be done in all countries to make sure that consumers, particularly those with low incomes, can access clean energy.** At a time when governments are concerned about the social acceptance of transitions, the fact that globally they spend nine times more making fossil fuels cheaper than they do on clean energy subsidies for consumers is a striking discrepancy.

The next round of national emissions targets is critical

If fully implemented, the COP28 goals would set the foundation for achieving ambitious NDCs, reducing global energy-related emissions by over 60% by 2035. NDCs aligned with the COP28 outcome or national net zero pledges would see emissions reductions by 2035 relative to the 2022 level within the following ranges. The higher end of the ranges is aligned with the COP28 call for global net zero emissions by 2050 and pathways to limit warming to 1.5 °C, and the lower end with national net zero pledges. National net zero pledges are less ambitious than the COP28 goals, falling short of a pathway to global net zero emissions by 2050 and limiting warming to 1.5 °C.

- **Advanced economies** and other high-income countries reduce emissions by 60% to 80% as a group.
- **Emerging markets,** such as those including China with net zero pledges by or before 2060, reduce emissions by 35% to 65%.
- And **developing economies reduce emissions** by 5-50%.

The next round of NDCs is a critical test for COP28 implementation. These new NDCs must be economy-wide and entail absolute reduction targets, especially for all major economies. All countries should consider in the design of their NDCs how they intend to implement the COP28 goals, not least to send clear signals to investors.

COP29 and multilateral cooperation must drive implementation

After a high point at COP28, climate action and the energy transition must remain in focus. The upcoming COP29 and related multilateral processes, notably the G20 and G7, have a critical role to play in refining and reinforcing the consensus reached at COP28. Any backsliding will put at grave risk the chances of achieving the objectives of the Paris Agreement. Countries should also use the opportunity provided by the COP29 and G20 summits this autumn to advance the enabling measures necessary to reach the COP28 goals and do even more to set the stage for ambitious NDCs.

From taking stock to taking action

How to implement the COP28 energy goals

1 Introduction

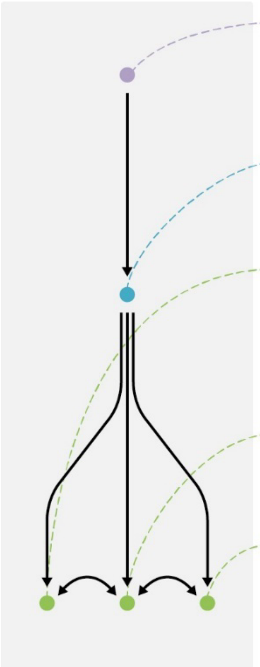
The first Global Stocktake of the Paris Agreement at COP28 in Dubai in December 2023 concluded that the world is currently not on track to meet its goal of limiting global warming to 1.5 °Celsius (C).[1] To get back on track, nearly 200 governments at COP28 set out a series of ambitious global goals, in particular for the energy sector. Flowing from the overarching goal of net zero emissions from the energy sector by 2050, the collective goals set out for the global energy sector in paragraph 28 of the COP28 outcome provide robust, high-level priorities for the clean energy transition (IEA, 2024a). Countries are called upon to contribute to implementing these goals with supportive national policies and to integrate them into the next round of Nationally Determined Contributions (NDCs), which will be crucial to determine the pace at which greenhouse gas (GHG) emissions decline over the next decade.

This represents a landmark agreement in several aspects. It was the first time that countries agreed that it is necessary to achieve net zero emissions from the energy sector by 2050 to limit global warming to 1.5 °C. Also, for the first time, countries formally recognised the need to rapidly transition away from fossil fuels in order to achieve the temperature goals of the Paris Agreement (IEA, 2024a). Plus, countries set out clear ambitions to curb energy-related emissions and to keep the 1.5 °C target viable. Efforts in this regard include:

- **Triple renewable energy capacity** and **double the global average annual rate of energy efficiency improvements** by 2030.
- Accelerate efforts to **phase down unabated coal-fired power generation.**
- Accelerate efforts towards **net zero emissions energy systems** well before or by around mid-century.
- **Transition away from fossil fuels in energy systems,** in a just, orderly and equitable manner, accelerating action in this critical decade, in order to achieve net zero emissions by 2050.
- **Accelerate zero- and low-emissions technologies.**
- Accelerate and substantially reduce **non-carbon dioxide emissions worldwide,** particularly **methane emissions by 2030.**
- **Accelerate the reduction of emissions from road transport.**
- **Phase out inefficient fossil fuel subsidies** that do not address energy poverty or just energy transitions.

[1] The first Global Stocktake outcome is part of the "UAE Consensus". For simplicity, we refer it to as the "COP28 outcome" in this report.

Figure 1.1 ▷ Energy goals adopted at COP28



Paragraph 28
- Reduce GHG emissions in line with 1.5 °C pathways
- Global, nationally determined efforts
- Taking into account the Paris Agreement

Paragraph 28c
- Net zero energy systems
- Well before or by around mid-century

Immediate emissions reductions
- Tripling renewable capacity by 2030 (28a)
- Doubling energy efficiency by 2030 (28a)
- Reduce non-CO_2 emissions, especially methane by 2030 (28f)
- Reduce emissions from road transport (28g)

Accelerate clean energy innovation
- Accelerating zero- and low-emisisons technologies (28e)
- Including nuclear, CCUS and low-carbon hydrogen production (28e)

Transition away from fossil fuels
- Transition away from fossil fuels in energy systems... (28d)
- ... in a just, orderly and equitable manner (28d)
- Accelerate the phase-down of unabated coal power (28b)
- Phase out inefficient fossil fuel subsidies (28h)

COP28 energy goals form a much-needed multilateral roadmap for the clean energy transition

The extent to which the COP28 outcome is a success depends ultimately on actions to meet its goals. These aims require a holistic package of complementary actions and alignment with a 1.5 °C pathway to realise all of them comprehensively. If achieved in full, the COP28 energy goals would have profound impacts on the energy sector. The level of ambition in the next round of NDCs should be consistent with the decisions taken at COP28, and those NDCs will show whether or not the goals agreed at COP28 are likely to be achieved.

Building on the International Energy Agency's (IEA) support for the COP process and analysis of pathways to limit warming to 1.5 °C (IEA, 2023a), this special report aims to:

- Show that the extent to which the COP28 outcome is comprehensively implemented will determine whether the world is able to get on track for 1.5 °C pathways and a transition away from fossil fuels.
- Identify key milestones and targets for national actions and multilateral co-operation to implement the COP28 outcome.
- Offer ideas on how to integrate the COP28 outcome into the next round of NDCs.

Box 1.1 ▷ Scenarios used in this report

A scenario approach is employed in this report to explore potential developments for the energy sector and energy-related emissions. Each scenario has the same starting point and incorporates the most recent data for markets, technology costs and policies. From the starting point, each scenario diverges over time. The scenarios are not forecast. Rather they are designed to explore various courses of action and their implications for the energy sector and related emissions.

- **Stated Policies Scenario** (STEPS): This scenario is designed to provide a sense of the prevailing direction of the evolutions of the energy system, based on detailed analyses of the policies that are in place in countries around the world, including energy, climate and related industrial policies. The aims of these policies are not automatically assumed to be met; they are incorporated in the STEPS to the extent that they are underpinned by adequate provisions for their implementation.
- **COP28 Full Implementation Case**: This case shows a pathway for the global energy sector that implements the COP28 outcome fully and on-time. It puts the world on a trajectory by 2030 consistent with achieving the goal of global net zero energy-related carbon dioxide (CO_2) emissions by 2050, as set out in paragraph 28c of the COP28 outcome. It assumes that quantified COP28 goals such as tripling renewable energy capacity and doubling the rate of energy efficiency improvements are met in full and on-time. Further, it sets ambitions for the qualitative goals of the COP28 outcome in line with the overarching objective of net zero emissions by 2050. The COP28 Full Implementation Case is consistent with the IEA Net Zero Emissions by 2050 Scenario, which represents a global pathway, but not the only one, towards the goal of reaching net zero energy-related emissions by 2050 and limiting warming to 1.5 °C.
- **COP28 Partial Implementation Case**: This case shows the implications if countries implement the COP28 outcome without the necessary enabling conditions and without comprehensive approaches to integrate its goals into national policies. In particular, it highlights the difficulties that are likely to arise if countries seek to deliver the headline goals of COP28 on renewables and energy efficiency in a way that is too narrow. This case is described further in Section 3.

The analysis is presented in Sections 2 through 6:

- Section 2 presents the current outlook for the energy sector.
- Section 3 analyses pathways to implement the COP28 outcome and shows that success depends on comprehensive implementation of each its elements.
- Section 4 provides an implementation guide for the COP28 energy goals.

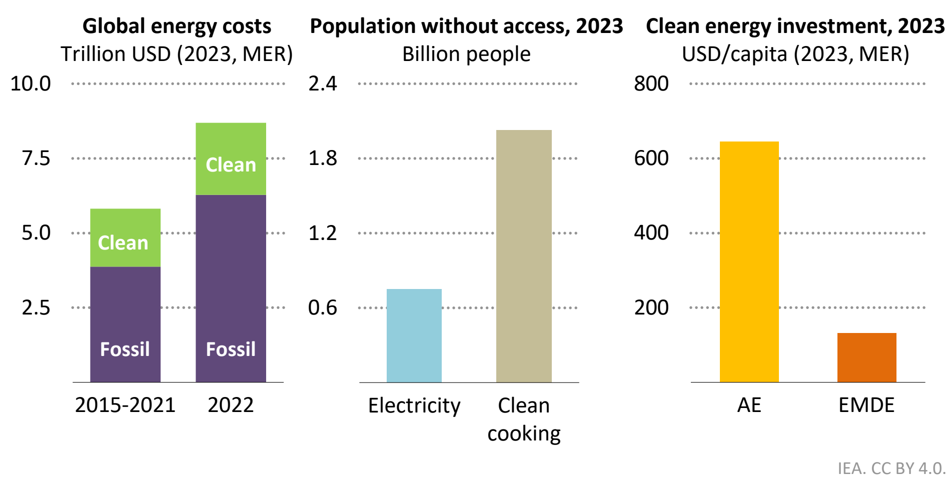
- Section 5 highlights the importance of just, orderly and equitable transitions, exploring the issues of investment in clean energy and subsidy reform to ensure affordable access to clean energy for all.
- Section 6 discusses how the outcome of the COP28 can be integrated into the next round of Nationally Determined Contributions and national low-emissions strategies.

2 Where do we stand today?

The Global Stocktake at the COP28 acknowledged that the world is not currently on a path to meet the temperature goals set out in the Paris Agreement. Global energy-related CO_2 emissions increased by around 1% in 2023, reaching a new record high of around 38 gigatonnes (Gt). But today clean energy technologies are being deployed rapidly, limiting both GHG emissions and growth in fossil fuel consumption. Absent the increased uptake of clean energy technologies, the rise in emissions seen over the last few years would have been much higher (IEA, 2024b). However, the energy sector is not progressing fast enough.

Furthermore, clean energy transitions are not advancing with equal speed in all regions, with advanced economies and the People's Republic of China (hereinafter China) accounting for 90% of the capacity additions for wind and solar photovoltaics (PV), and more than 95% of global sales of electric cars in 2023. On a per capita basis, clean energy investment in advanced economies was nearly five-times higher in 2023 than in emerging market and developing economies. These differences risk acting as a drag on the global transition to clean energy. They also threaten the goal of achieving a just, orderly and equitable transition.

Figure 2.1 ⊳ Key indicators for a just, orderly and equitable energy system



Today's global energy system falls short in providing affordable, secure and sustainable energy for all

Notes: MER = market exchange rate; AE = advanced economies; EMDE = emerging market and developing economies. Global energy costs are the costs of delivering energy to consumers, and include repayments on capital, financing costs, operating costs and fossil fuel rent; data for the 2015-2021 period are the average annual costs.

Today's energy system also faces other problems (Figure 2.1). Recent extreme price volatility in fossil fuel markets – triggered by the Russian Federation's (hereinafter Russia) invasion of Ukraine – has highlighted the ever-present risks of volatility and price spikes and has underscored the importance of energy security. Compared to the pre-2022 average, global annual energy delivery costs increased by almost USD 3 trillion in 2022, or around 3% of global gross domestic product (GDP), burdening consumers and fuelling inflation. Furthermore, progress on delivering energy access for all has slowed or even reversed in some countries as a result of this cost increase, coming on top of the effects of the Covid-19 pandemic. Today, over 2 billion people worldwide still cook with wood and charcoal, polluting their homes, reducing their productivity and shortening their lives.

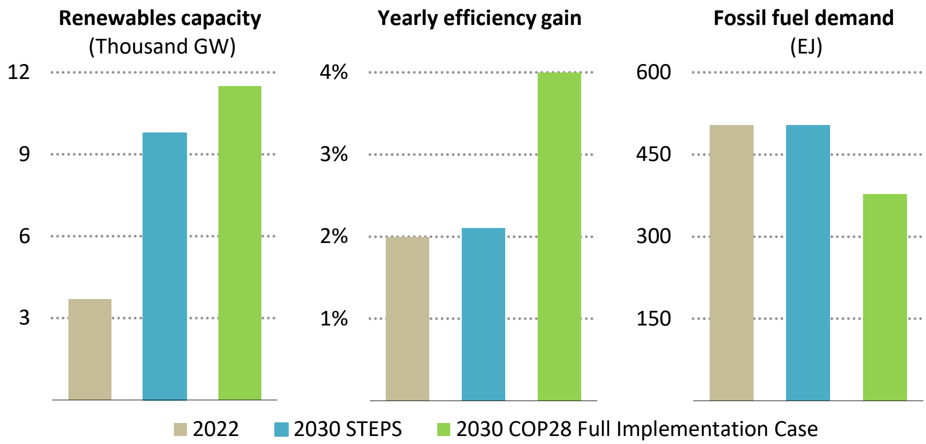
The Stated Policies Scenario (STEPS) provides an understanding of where current policy settings and market trends are likely to lead. It is instructive to measure this scenario against the goals set out in the COP28 outcome (Figure 2.2).

- Tripling the global installed capacity of renewables requires capacity to increase from around 3 680 gigawatts (GW) in 2022 to over 11 000 GW in 2030. In the STEPS, global renewable energy capacity rises to around 9 770 GW by 2030, an increase of around 2.7-times on the 2022 level. Under current policy settings, the world would therefore achieve around three-quarters of the growth needed for the goal of tripling renewables capacity by 2030.
- Doubling the rate of energy efficiency improvements means increasing the 2% improvement in the energy intensity of GDP seen in 2022 to around 4% per year on average by 2030. In the STEPS, the average rate of energy intensity improvements remains around 2% per year to 2030, barely improving from the level seen in 2022 and remaining well below the COP28 outcome goal of 4%.
- The aim to "transition away from fossil fuels in energy systems … so as to achieve net zero by 2050" means reducing demand for fossil fuels fast enough to put the world on a path to net zero emissions by 2050. In 2022, worldwide fossil fuel demand was around 500 exajoules (EJ). Current policy settings in the STEPS lead to a peak in global fossil fuel demand before 2030. By 2030, global fossil fuel demand falls back to the 2022 level. This is far from the 130 EJ drop seen in the COP28 Full Implementation Case, which marks a decline of around 25% on the 2022 level.

In the STEPS, global energy-related CO_2 emissions are not on a path consistent with the COP28 outcome: they peak before 2030 but are only 4% below 2023 levels by 2030 and around 10% lower by 2035. In the COP28 Full Implementation Case, they fall by around 30% by 2030. Therefore, the need for enhanced action and an accelerated transition is clear.

Many countries have announced new goals and targets that would help to close the gap. These are taken into account in the IEA **Announced Pledges Scenario** (APS), but they are not reflected in the STEPS because they are not underpinned by specific implementation policies. Moreover, the APS still falls short of what is necessary to deliver net zero emissions globally by 2050. While announced goals and targets that go beyond the STEPS therefore give cause for hope that countries will come up with more ambitious NDCs in the future, they do not alter the need for enhanced action and an accelerated transition.

Figure 2.2 ▷ Selected key energy goals in the COP28 outcome in the STEPS and COP28 Full Implementation Case



Stated policies put the world close to the goal of tripling renewables capacity, but fall far short on energy efficiency and the transition away from fossil fuels

Notes: GW = gigawatt; EJ = exajoule; STEPS = Stated Policies Scenario. Efficiency gain refers to the annual improvement of the primary energy intensity of the economy measured as the ratio of total energy supply to GDP.

SPOTLIGHT

Tracking progress towards the COP28 goals

The IEA, in collaboration with the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat, is tracking progress towards the energy objectives established at COP28 to support their full and timely implementation. This is not a straightforward task. Some of the energy goals outlined in paragraph 28 of the COP28 outcome are clearly defined, yet not all of them are. For this reason, it is difficult in most cases to choose metrics to measure progress. It is also worth noting that the COP28 goals are not exhaustive, even though they capture many important dimensions of the global energy transition.

Given the importance of trying to establish what progress is being made, and how far it is succeeding to put the world on course for the Paris Agreement goals in 2050, the IEA has nevertheless drawn up a set of metrics that is intended to capture many of the dimensions of the objectives agreed at COP28 (Table 2.1). For example, to assess progress in achieving a just and equitable energy transition, the IEA tracks clean energy investment in emerging market and developing economies, energy access goals and growth in clean energy jobs. These are important indicators, though they clearly do not reflect the full complexity of the issues. The IEA's first Global Commission on People-

Centred Clean Energy Transitions in 2021 set out 12 recommendations for just and equitable transitions. The second Global Commission is currently examining how to enact the principles through good policy.

The Global Stocktake concluded at the COP28 highlighted that the world is off track to limit warming to 1.5 °C, and therefore set out goals for an ambitious course correction. There are significant gaps between these goals and the trajectory implied by current policies, as shown in the STEPS, which highlights the scale of the task at hand. For some global goals, notably for renewables, the world is not far off course from doing what is needed under current policy settings, although the picture is more mixed at regional levels. The gaps are particularly significant for energy efficiency, unabated coal power, clean energy investment in emerging market and developing economies, and GHG emissions reductions. (Section 3 looks at how to get the global energy sector onto a path to meeting the COP28 outcome goals.)

Table 2.1 ▷ Global COP28 outcome energy goals in the STEPS and COP28 Full Implementation Case

	2022	2030		
		STEPS	COP28 Full	COP28 Implement-ation gap
§28 (a) tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030				
Renewable energy capacity (GW)	3 680	9 770	11 500	↑ 1 730
Improvement in global energy efficiency	2.0%	2.1%	4.0%	↑ 1.9 pp
§28 (b) accelerating efforts towards the phase-down of unabated coal power				
Electricity generation from unabated coal (TWh)	10 450	9 210	5 360	↓ 3 850
§28 (c) accelerating efforts globally towards net zero emissions energy systems, utilising zero- and low-carbon fuels, well before or by around mid-century				
Energy sector CO_2 emissions (Gt)	37.2	36.2	25.1	↓ 11.1
§28 (d) transitioning away from fossil fuels in energy systems…				
Fossil fuel demand (EJ)	505	505	375	↓ 130
Investment in fossil fuels (trillion USD)	1.0	0.9	0.4	↓ 0.5
…in a just…				
Clean energy investment in EMDE (trillion USD)	0.8	1.3	2.5	↑ 1.2
…of which EMDE outside China	0.2	0.5	1.4	↑ 0.9
…orderly…				
Ratio between fossil fuels and investment in clean energy	1:2	1:3	1:10	-
…and equitable manner…				
Share of global population with access to:				
clean cooking	74%	81%	100%	↑ 19 pp
access to electricity	90%	92%	100%	↑ 8 pp
Energy employment (million)	65	73	82	↑ 9

	2022	2030		
		STEPS	COP28 Full	COP28 Implement-ation gap
§28 (e) accelerating zero- and low-emissions technologies, including, *inter alia*, renewables, nuclear, abatement and removal technologies such as carbon capture, utilisation and storage, particularly in hard-to-abate sectors, and low-emissions hydrogen production				
CO_2 emissions captured (Mt)	40	120	1 020	↑ 900
Low-emissions hydrogen production (PJ)	70	820	7 930	↑ 7 110
Nuclear installed capacity (GW)	420	480	550	↑ 70
Liquid biofuel production (EJ)	4.3	5.8	11.7	↑ 5.9
§28 (f) substantially reducing non-carbon dioxide emissions globally, including in particular methane emissions by 2030				
Energy sector methane emissions (Mt CO_2-eq)	3 690	2 840	1 040	↓ 1 800
§28 (g) accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero and low-emissions vehicles				
Road transport CO_2 emissions (Gt)	6.0	6.2	4.6	↓ 1.6
Electric cars share in sales	14%	43%	67%	↑ 24 pp
§28 (h) phasing out inefficient fossil fuel subsidies that do not address energy poverty or just transitions, as soon as possible				
Over the past five years, USD 600 billion has been spent annually to subsidise fossil fuel consumption, compared to USD 70 billion spent in 2023 on support to consumers for clean energy. Only 14% of fossil consumption subsidies are currently aimed at agriculture and household use of liquefied petroleum gas and kerosene. Worldwide, the poorest 20% of households receive or benefit from only 10% of fossil fuel consumption subsides. Most of these subsidies could be phased out in tandem with the provision of targeted support for vulnerable consumers.				

Notes: § = paragraph – here related to the COP28 outcome; GW = gigawatt; TWh = terawatt-hour; Gt = gigatonne; EJ = exajoule; EMDE = emerging market and developing economies; Mt = million tonne; PJ = petajoule; Mt CO_2-eq = million tonnes of carbon-dioxide equivalent; pp = percentage point.

3 Pathways to meet the COP28 outcome energy goals

The IEA has constructed two sets of ways in which the COP28 outcome energy goals might be pursued. They are the COP28 Full Implementation Case and the COP28 Partial Implementation Case. The COP28 outcome did not set out a detailed blueprint that stipulates which country should do what or by when. Moreover, what works in one country may not be appropriate for another. We set out the COP28 Full Implementation Case and the COP28 Partial Implementation Case to inform debates and decisions about the way forward both in individual countries and collectively.

The essential difference between the two cases is the difference between focussing in a narrow way on the measurable targets of tripling renewable energy globally and doubling the global average annual rate of energy efficiency improvements, i.e. the COP28 Partial Implementation Case, and taking a more comprehensive and holistic approach, i.e. the COP28 Full Implementation Case. They lead to very different outcomes.

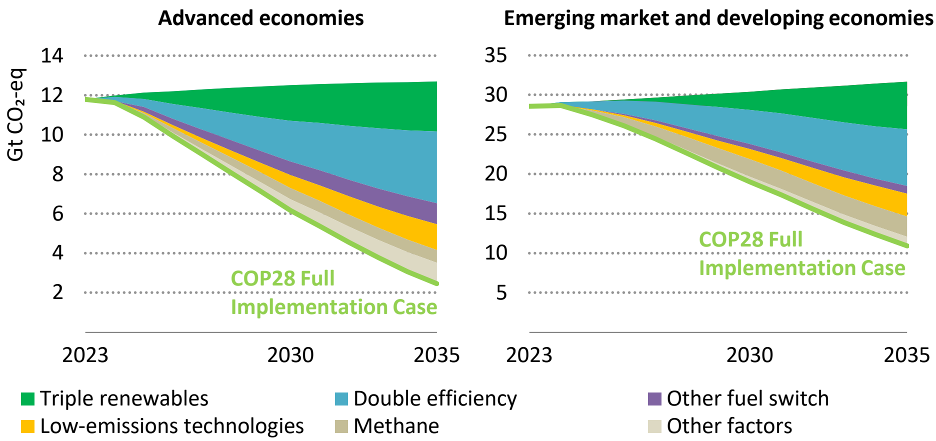
3.1 Full implementation of the COP28 outcome

The COP28 Full Implementation Case describes a world in which governments implement the COP28 energy goals in an immediate, comprehensive and robust manner, designing policies and setting ambitions in line with the overarching goal of 1.5 °C pathways and net zero emissions by 2050.

The quantified COP28 goals to triple renewables capacity and double the rate of energy efficiency improvements are in line with a pathway to net zero emissions by 2050 (IEA, 2024a). Because doubling the rate of energy efficiency improvements requires, among other measures, the deep electrification of energy consumption, the COP28 Full Implementation Case also sees very rapid growth of efficient electric technologies such as electric vehicles (EVs) and heat pumps. Where the COP28 goals are not precisely quantified, the COP28 Full Implementation Case is guided by the overall goal of reaching net zero emissions by 2050 (paragraph 28c of the COP28 outcome). It accordingly sets ambitions for technologies such as nuclear, carbon capture, utilisation and storage (CCUS), and hydrogen and other low-emissions fuels as part of a pathway to reach net zero emissions by 2050. These various measures together put energy-related emissions into a steep decline already by 2030 and set the stage for ambitious NDCs by 2035 (Figure 3.1).

In the COP28 Full Implementation Case, the growth of clean energy technologies is sufficiently rapid to initiate and accelerate the transition away from fossil fuels this decade. Tripling renewables capacity provides around 14 000 terawatt-hours (TWh) of additional clean electricity by 2030, which is more than 80% of the combined generation from coal and natural gas today (17 000 TWh). Meanwhile a rapid increase in the use of EVs – critical to achieve the doubling of energy efficiency and reducing transport emissions – displaces around 10 million barrels per day (mb/d) of oil demand by 2030, or around 10% of current total oil consumption.

Figure 3.1 ▷ Contribution of key elements to reduce energy-related emissions in the COP28 Full Implementation Case, 2023-2035



IEA. CC BY 4.0.

Implemented fully, the COP28 outcome energy goals put emissions into a steep decline, setting the stage for ambitious NDCs for 2035

Notes: Gt CO_2-eq = gigatonnes of carbon-dioxide equivalent. Energy-related GHG emissions include CO_2 and methane.

3.2 Partial implementation of the COP28 outcome

A failure to implement the COP28 outcome in a comprehensive and coherent manner brings the risk that the targets of doubling energy efficiency improvements and tripling renewables are achieved without bringing about the transition away from fossil fuels needed to be on track for net zero emissions by 2050. To explore this possibility, we have developed the COP28 Partial Implementation Case.

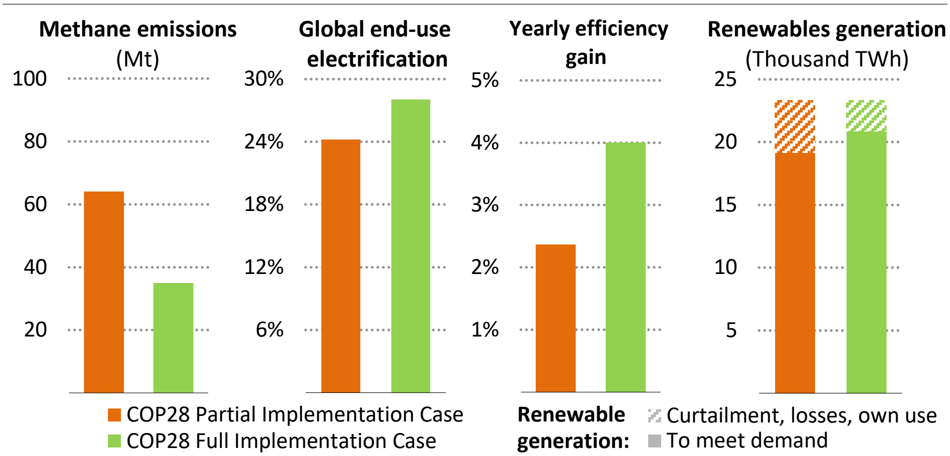
The COP28 Partial Implementation Case depicts a narrow approach to improving energy efficiency, focussed on improving the technical efficiency of new energy equipment such as boilers, cement kilns and internal combustion engine vehicles. The narrow approach taken means that little attention is paid to other important ways to improve efficiency, such as electrification, switching to clean cooking fuels, or making gains in the efficiency of materials, which accordingly advance much more slowly than in the COP28 Full Implementation Case. As a result, the overall rate of energy efficiency improvement is well below what is needed in the COP28 Full Implementation Case.

The COP28 Partial Implementation Case achieves global tripling of installed capacity of renewables, but without the necessary supporting measures – including investment in grids and storage – to allow this additional capacity to displace fossil fuels in electricity systems to the full extent possible. In addition, capacity additions are skewed towards solar PV over wind power, which has recently struggled in an environment of higher interest rates and supply chain tensions, but which produces more clean electricity per unit of capacity than solar PV. As a result, less clean electricity is produced than in the COP28 Full Implementation Case.

Where the COP28 goals are not well quantified, the COP28 Partial Implementation Case assumes a slower and less comprehensive adoption of clean energy technologies than in the COP28 Full Implementation Case. In road transport, the sales of battery electric cars and heavy-duty trucks, although accelerated compared to current trends, are about one-quarter lower than in the COP28 Full Implementation Case. In industry, the use of solid bioenergy and low-emissions hydrogen for heat in steel production increases but remains around 10% lower than in the COP28 Full Implementation Case. In buildings, sales of heat pumps improve compared to current trendlines, but the stock of heat pumps remains around 10% lower than in the COP28 Full Implementation Case in 2030.

The COP28 Partial Implementation Case also assumes the achievement of two recent quantitative targets on methane, with the Oil and Gas Decarbonisation Charter (from COP28) leading to near zero methane emissions upstream from oil and gas production, and the Global Methane Pledge (from COP26) leading to a 30% reduction in economy-wide sources of methane in 2030. This represents an improvement on current trends but falls well short of the COP28 Full Implementation Case, in which all fossil fuel producers reduce their methane emissions intensities by 2030 to levels similar to those achieved by the world's best operators today.

Figure 3.2 ▷ Key indicators in the COP28 Full Implementation and Partial Implementation cases, 2030



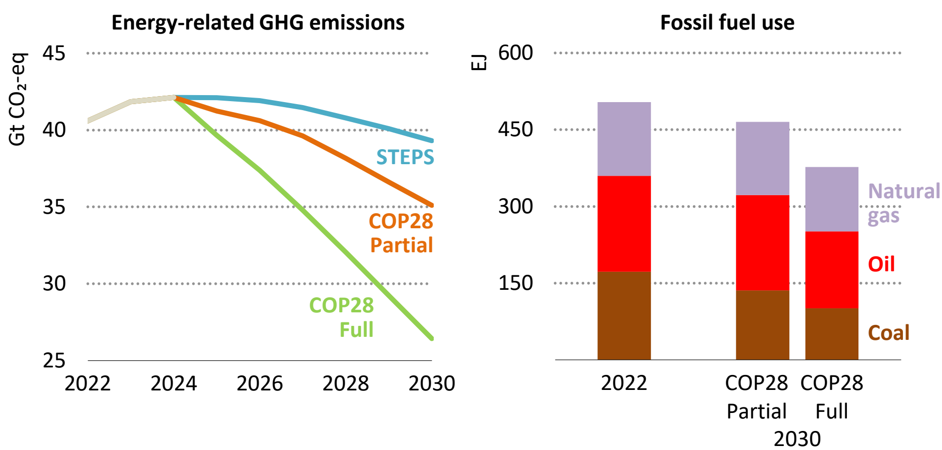
COP28 Partial Implementation Case achieves less than the COP28 Full Implementation Case across a range of interdependent indicators

Notes: Mt = million tonne; TWh= terawatt-hour. End-use electrification refers to the share of electricity in total final consumption.

The COP28 Partial Implementation Case falls well short of what is achieved in the COP28 Full Implementation Case (Figure 3.2). In so doing, it highlights the disadvantages of taking a piecemeal approach. For example, the average rate of improvement of energy efficiency between 2023 and 2030 is around 2.4% per year in the COP28 Partial Implementation Case – an improvement from recent years – but significantly lower than the 4% achieved in the COP28 Full Implementation Case that doubles the energy efficiency rate. In part, this reflects a narrow focus on technical energy efficiency improvements. But the slower improvement in energy intensity is also a consequence of lagging behind the Full Implementation Case in the pace of electrification of end-uses – a key enabler of energy efficiency improvements. A lower level of electrification also implies higher fossil fuel use, making it harder to reduce methane emissions from oil and gas supply, which are about two-thirds higher in the Partial Implementation Case compared to the Full Implementation Case in 2030.

Electricity capacity from renewables is the same in both cases, but the level of curtailment, losses and own use is around 70% higher in 2030 in the COP28 Partial Implementation Case. This reflects slower expansion and modernisation of grids, interconnections, storage and demand management solutions that are necessary to ensure that new renewables capacity translates into useful generation to meet electricity demand and displace fossil fuel generation (see Section 4.1). As a result, the carbon intensity of electricity in the COP28 Partial Implementation Case is around 25% higher than in the Full Implementation Case.

Figure 3.3 ▷ Energy-related GHG emissions and fossil fuel use by scenario and case, 2022-2030



Fossil fuel use drops significantly less quickly in the Partial Implementation Case than in the Full Implementation Case

Note: Gt CO_2-eq = gigatonnes of carbon-dioxide equivalent; COP28 Full = COP28 Full Implementation Case; COP28 Partial = COP28 Partial Implementation Case; STEPS = Stated Policies Scenario.

The COP28 Partial Implementation Case sees a slower transition away from fossil fuels than the Full Implementation Case (Figure 3.3). In 2030, coal use is 35% higher in the Partial Implementation Case, oil use is 25% higher and natural gas use is about 15% higher. About one-fifth of the difference in total fossil fuel use between the two cases results from the higher level of fossil fuel-based electricity generation in the Partial Implementation Case, and the remainder from a slower shift away from fossil fuels in end-use sectors in that same case. GHG emissions in the COP28 Partial Implementation Case fall at around 40% of the rate in the Full Implementation Case to 2030 and close only one-third of the emissions gap between STEPS and the Full Implementation Case in that year. This emissions trajectory would put the 1.5 °C target of the Paris Agreement out of reach.

4 Guidebook to implement the COP28 energy goals

This section looks at how the world can achieve each of the energy goals set out in the COP28 outcome. It uses the results of the COP28 Full Implementation Case to detail what these goals mean in the context of the overarching target of achieving net zero emissions by 2050. It highlights the results of the COP28 Partial Implementation Case to discuss potential pitfalls on the road to implementation.

4.1 Triple renewables capacity

Tripling renewables capacity globally translates into boosting total installed capacity of all renewable energy technologies in the electricity sector from 3 680 gigawatts (GW) in 2022 to around 11 500 GW in 2030. To achieve this goal, almost 1 000 GW of new renewables capacity must be added on average per year from 2023 to 2030. To put this in context, 560 GW of renewables capacity was added globally in 2023, a record high. The portfolio of renewable energy technologies includes conventional dispatchable power sources such as hydro, bioenergy and geothermal as well as variable renewables like wind and solar PV. In 2023, solar PV alone accounted for three-quarters of all new renewables capacity.

Each technology has specific characteristics, including patterns of operation, and each generates a different amount of electricity each year for each unit of capacity. For example, solar PV produces electricity only during the day and, over the course of the year, generates only about half as much electricity as wind power per unit of capacity. A portfolio of various renewable energy technologies will often help countries to meet electricity demand in a secure and affordable way.

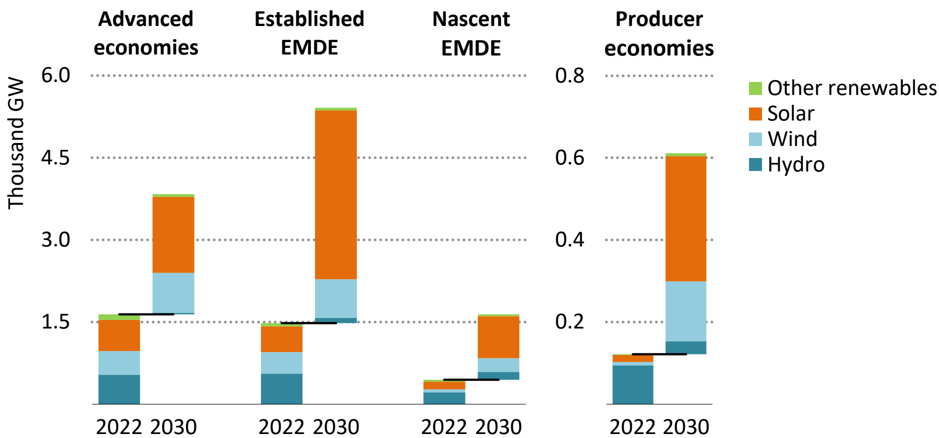
Advanced economies currently have a higher share of renewables in electricity generation than other categories of economies. In our analysis, advanced economies increase total renewables capacity by more than 2.3 times to 2030 (Figure 4.1). This relatively low level of increase reflects their relatively high share of renewables today and their lower electricity demand growth expected to 2030.

Emerging market and developing economies in general increase capacity by more than this to 2030 because of their lower share of renewables in electricity generation today and because their electricity demand growth is projected to be more significant:

- Emerging market and developing economies where renewables form a major part of the electricity system and operate in well-established markets, including China and Brazil, see their collective renewables capacity increase by more than 3.5 times by 2030, building on recent momentum.
- Less developed or nascent markets for renewables increase their renewable energy capacity by 3.7 times, but from a lower base. Nascent markets for renewables include several countries in Southeast Asia, other developing Asia and Latin America together with many countries in Africa. Despite this stronger growth, variable renewables still account for only around 30% of electricity generation in these economies collectively in 2030, compared to around 45% in 2030 in advanced economies.

- Producer economies, i.e. those that rely heavily on the revenues from producing and selling fossil fuels, most notably oil and natural gas, collectively multiply renewables by around five-times by 2030, again from a relatively low base.

Figure 4.1 ▷ Installed renewables capacity by type of economy in the COP28 Full Implementation Case, 2022 and 2030



To triple global renewables capacity to over 11 000 GW requires action in all countries, but some countries are starting from a lower base and see higher relative increases in capacity

Notes: GW = gigawatt; EMDE = emerging market and developing economies. Established EMDE refers to those emerging market and developing economies in which the recent increase in wind and solar capacity was above the world average. Nascent EMDE refers to those in which it was below. Producer economies refer to economies that are heavily dependent on the sale of fossil fuels.

The case for renewables in the electricity sector has strengthened in recent years. Solar PV and wind are now the cheapest new sources of electricity in most markets, with the average generation cost of solar PV falling by 90% over the past decade, and the average cost of onshore wind power projects by two-thirds. Government support for the expansion of renewables in over 150 countries around the world underlines the widespread availability of these resources. In most countries the potential for renewable energy is larger than total electricity demand, and in many instances, it is far higher. By tapping local resources, renewable energy can also provide energy security benefits, not least by helping economies to reduce their reliance on imported fuels.

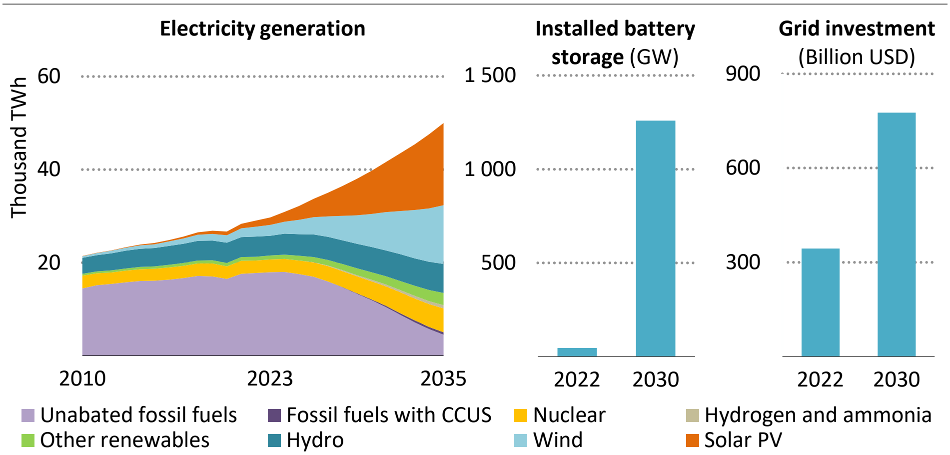
In part due to these factors, there is strong interest from investors in renewable energy where policy frameworks and market designs are clear and stable. As a result, the Stated Policies Scenario sees renewables capacity increasing 2.7-times from 2022 to 2030. This would be a major advance, but still well short of the tripling called for at COP28. Achieving that tripling is likely to depend on taking action to address several issues that are currently restraining renewables deployment.

Permitting and licensing: It often takes as long or longer to obtain permits and licences for large-scale renewable energy projects as it does to build them. Speeding up administrative processes is essential to deliver the rapid scale up needed. Among others, improvements in siting practices, such as establishing renewable energy zones rather than requiring site-specific evaluations, would help. Distributed renewables, such as rooftop solar PV, usually have much shorter permitting and construction periods, allowing them to scale up rapidly. They show the gains that speeding up processes could bring.

Grid planning: By the end of 2023, more than 3 000 GW of renewable energy projects were in queues for grid connections. This is roughly equal to the total amount of renewables capacity added over the past 15 years. Scaling up grid development and investment in parallel with growth in renewables capacity is critical to the development and effective deployment of that capacity.

Policy frameworks: Committing to policy frameworks that limit risks for renewables is essential to unlock the additional investment needed. This particularly holds in emerging market and developing economies, where financing can be more challenging for renewables (IEA, 2023b). Improving the conditions for growth in renewables gives project developers more confidence and also motivates industry to scale up supply chains. While solar PV manufacturing is fast approaching the levels needed in the COP28 Full Implementation Case, other renewable energy technologies such as wind power are not yet on course to deliver enough new capacity by 2030 (IEA, 2024c).

Figure 4.2 ▷ Electricity generation by source in the COP28 Full Implementation Case and growth of key enablers



Tripling renewables capacity to 2030 could dramatically reshape electricity systems when paired with enhanced system flexibility including battery storage and modernised grids

Note: TWh= terawatt-hour; GW = gigawatt; CCUS = carbon capture, utilisation and storage.

In addition to what is needed to ensure sufficient deployment of renewables, measures also need to be taken to make the best use of the installed renewables capacity to displace fossil fuels, reduce emissions and boost energy security. Enhanced system flexibility – notably through the provision of energy storage – and well-developed electricity grids are crucially important in this context (Figure 4.2). While markets with limited amounts of variable sources like solar PV and wind today can expand their use without extensive changes in the system, enhancing power system flexibility and grids is essential to integrate significant shares of solar PV and wind and to maintain electricity security (IEA, 2024d).

In several leading solar PV markets, e.g. Australia, Germany, Spain and California, there have been increasing numbers of hours with negative wholesale electricity prices linked to a lack of system flexibility. To improve flexibility on short time scales, measured in minutes or hours, a range of measures are needed to enhance thermal power plant flexibility through technical or contractual changes and to expand demand response and energy storage. In the COP28 Full Implementation Case, total energy storage capacity increases to over 1 500 GW by 2030, in line with the commitment by G7 Members in April 2024. Battery storage has a major role to play in delivering this growth, with investment scaling up to about USD 140 billion by 2030, seven-times the level in recent years and more than 50% more than in the Stated Policies Scenario (IEA, 2024e). Managing the seasonal variability of renewables and electricity demand relies more heavily on fossil fuel power plants and hydropower in the near term, and on grid development and long-duration storage technologies, including low-emissions hydrogen, in the longer term (IEA, 2024f).

Timely electricity grid development is also critical to make the most of renewable energy capacity. Scaling up grid investment from an annual average of USD 330 billion in recent years to over USD 700 billion by 2030 will be critical to expand transmission and distribution, strengthen interconnections, alleviate congestion throughout the system and modernise grids, particularly with the use of digitalised distribution systems to enhance operational efficiencies. Grid development also has an important part to play in the provision of longer-term seasonal system flexibility. In the COP28 Full Implementation Case, more than 25 million kilometres (km) of electricity grids are built or modernised by 2030, rising to around 55 million km by 2035, as projects initiated in the next few years come to fruition.

The diversity of renewable energy technologies is also an important issue. If there is too much reliance on solar PV because it is currently the renewables technology most readily deployed at scale, the output from tripling renewables capacity will be less than it would be with a more diverse renewables technology mix. This is because solar PV produces less average output per unit of capacity than other renewables technologies.

With the enabling conditions in place and a diverse set of renewable energy technologies, electricity generation from renewables could increase from 8 570 TWh in 2022 to over 23 300 TWh in 2030. This would be enough to meet all electricity demand growth and displace a significant amount of fossil fuels. This is what happens in the COP28 Full Implementation Case, causing emissions from the electricity sector to fall by more than 40%, making a significant contribution to overall clean energy transitions and setting a course to net zero emissions by 2050.

Where the enabling conditions are underdeveloped and there is a lack of diversity in renewable energy technologies, there is a risk that, even if renewables capacity triples to 2030, the impact on emissions could be less than envisioned in the Full Implementation Case. If power system flexibility is underdeveloped and grids perform poorly, we estimate that curtailment and technical losses of renewables could reach around 10% of total renewables generation by 2030 in the COP28 Partial Implementation Case. This means that over 3 000 TWh of available renewables output would be lost, needing to be replaced by fossil fuels that would result in an additional 2.3 Gt CO_2 emissions in 2030. If other renewables remained at the level in the Stated Policies Scenario and solar PV alone scaled up to meet the tripling renewables goal, then total renewable output in 2030 would be about 3 000 TWh less than in the COP28 Full Implementation Case, because the average annual output of solar PV per unit of capacity is less than half that of wind, one-third that of hydropower and about one-quarter that of bioenergy.

Key policy recommendations:

- Simplify permitting and licensing processes to reduce development lead times for renewables projects.
- Prioritise investment in grid infrastructure to expand and modernise grids and improve grid connection planning.
- Make full use of distributed renewable energy resources and deploy a portfolio of renewable energy technologies in order to maximise output and cost effectiveness.
- Encourage investment in renewables through policies that provide longer term certainty and limit risks for investors. Such policies could, for example, take the form of renewables targets in national energy plans, support for renewables projects in the pre-development phase and measures to reduce off-taker risk.
- Invest in power system flexibility – such as demand response and energy storage – to support the effective integration of renewables.
- Encourage the establishment of resilient supply chains for renewable energy technologies.

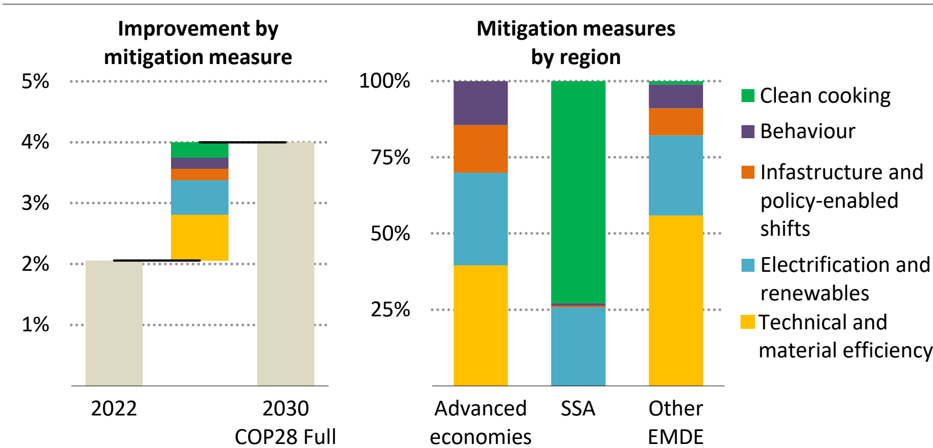
4.2 Double energy efficiency

What is it and how to achieve it?

Actions that lead to a doubling of the rate of energy efficiency account for a larger share of emissions reductions than anything else by 2030 in the COP28 Full Implementation Case (see Figure 3.1). Achieving this requires mobilising all possible levers to mitigate energy consumption while maximising welfare (Figure 4.3). These actions include technical efficiency improvements in new equipment like household appliances, boilers, cars, industrial facilities and improvements in the efficiency of building envelopes. They also include:

- Switching to more efficient fuels, in particular electricity through the deployment of technologies such as EVs and heat pumps.
- Moving away from highly inefficient and polluting cooking fuels to clean cooking in countries that currently lack full access.
- Infrastructure-enabled and technology-enabled changes such as modal shifts in transport, enhanced recycling and material efficiency.
- Behavioural change to reduce energy consumption such as lowering thermostats in cold climates.

Figure 4.3 ▷ How to double the global rate of energy efficiency improvements by measure and country grouping



Doubling the rate of energy efficiency gains requires a comprehensive approach, though the mix of measures will differ among economies

Note: COP28 Full = COP28 Full Implementation Case; EMDE = emerging market and developing economies; SSA = sub-Saharan Africa. Other EMDE refers to emerging market and developing economies outside of sub-Saharan Africa.

The most comprehensive measure of energy efficiency at the level of the global economy is economic output per unit of energy input.[2] This encompasses all changes that improve the ratio of economic activity to energy input. In 2022, the global economy produced 2% more

[2] This is referred to as energy intensity, although the COP28 outcome referred to energy efficiency and we therefore use that term in this report.

GDP for every unit of energy consumed compared with 2021. This forms the baseline for the doubling goal agreed at COP28.

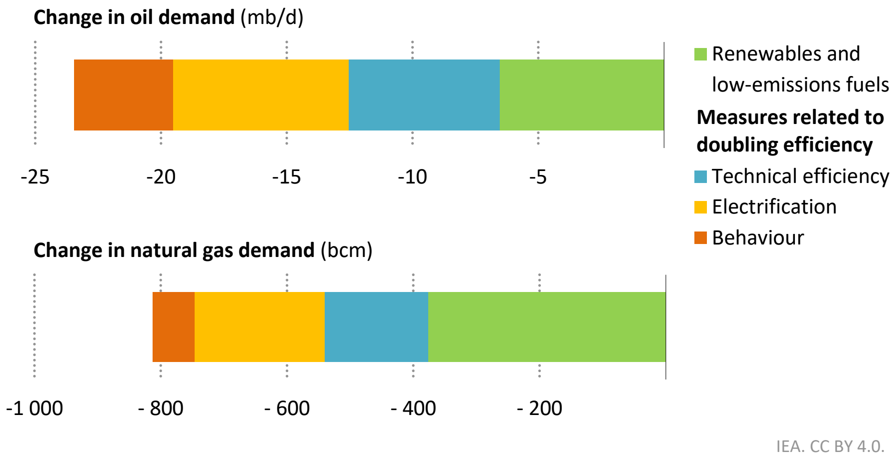
In the COP28 Full Implementation Case, a comprehensive approach leads to a doubling of the current rate of improvement to 4% per year on average to 2030. As a result, global energy demand is 10% lower in 2030 than it is today, despite GDP being around 25% higher. In the COP28 Partial Implementation Case, governments enact policies to bring about incremental improvements in the rate of efficiency of new appliances, industrial motors and buildings. However, they focus narrowly on improving technical efficiency and do not seek to make use of additional levers such as electrification, material efficiency gains and switching to clean cooking. In the absence of more comprehensive policies to facilitate the scale up of clean energy technologies and transition away from fossil fuels, this narrow focus locks in more fossil fuel consuming equipment. As a result, the rate of improvement of GDP per unit of energy consumed is around 2.4% per year to 2030 in this case.

Different economies have different priorities when it comes to achieving the doubling of the improvement in energy efficiency. In advanced economies, a large share of the improvements in energy efficiency are delivered by electrification through technologies such as EVs and heat pumps. In emerging market and developing economies, huge numbers of new buildings, including factories, are added in the coming years, and the purchase of new household goods increases dramatically: this makes robust energy performance standards for the technical efficiency of new buildings and equipment particularly important. In areas currently lacking full access to clean cooking, notably sub-Saharan Africa, the key action is to achieve the shift to more efficient cooking fuels.

Box 4.1 ▷ Achieving the goal of doubling energy efficiency is critical to accelerate an orderly transition away from fossil fuels

Speeding up energy efficiency improvements plays a crucial role in bringing about a secure and affordable transition away from fossil fuels by helping to lower demand (Figure 4.4). Many highly efficient energy technologies, such as EVs and heat pumps, are powered by electricity, which is increasingly generated from clean sources. They also require less overall energy than traditional vehicles or natural gas boilers. In the COP28 Full Implementation Case, nearly three-quarters of the reduction in oil demand by 2030 comes from measures related to the doubling of energy efficiency. Energy efficiency measures are similarly responsible for half of the reduction in natural gas demand. Efficiency policies also limit the need for investment in additional infrastructure such as electricity grids, and give time for the development of market rules, supply chains and the workforce skills necessary for the transition away from fossil fuels.

Figure 4.4 ▷ Oil and gas demand in the COP28 Full Implementation Case relative to the STEPS, 2030



Doubling the rate of energy efficiency improvements is crucial for an orderly transition away from fossil fuels

Note: mb/d = million barrels per day; bcm = billion cubic metres.

Drive electrification in buildings, transport and industry

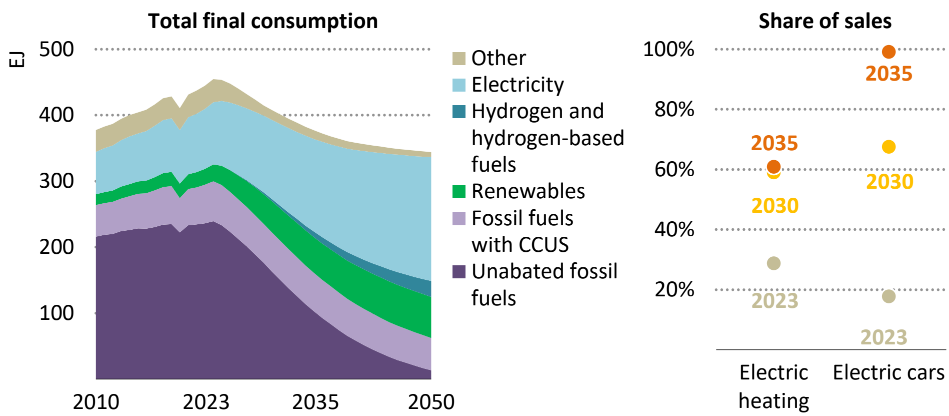
Electricity is efficient: an electric car is about two-to-four-times more efficient than an internal combustion engine car, and a heat pump around three-to-five-times more efficient than a natural gas boiler. Electrifying energy consumption can lower total energy use while preserving the same level of energy service (Figure 4.5).

In the COP28 Full Implementation Case, the share of electricity in total final consumption[3] rises from around 20% today to nearly 30% by 2030, and to over 35% by 2035 (Figure 4.5). The relative efficiency of electricity compared to other fuels means that the increase in its share contributes to total final consumption peaking and then starting to decline, even as GDP continues to rise. By 2035, total final consumption falls by around 15% in the COP28 Full Implementation Case, while GDP rises by more than 40%. The increasing use of electricity is accompanied by a dramatic scaling up of electric technologies such as electric cars, buses and motorbikes, heat pumps in buildings and industry, and electric cooking stoves. The share of electric cars in total car sales rises from slightly less than 20% in 2023 to around 70% by 2030 and nearly 100% by 2035. In the buildings sector, the share of electric technologies in total space heating equipment sales increases from around 30% in 2023 to 60% in 2035, with most other sales coming from other viable low-emissions technologies such as bioenergy.

[3] Total final consumption is the sum of consumption by the various end-use sectors, and includes non-energy uses such as petrochemicals. Total final energy consumption is the sum of consumption of end-use sectors, excluding non-energy uses.

In the COP28 Partial Implementation Case, policies to support electric technologies in new sales are not sufficiently robust to drive down the share of incumbent fossil fuel technologies. As a result, the rate of electrification increases less rapidly: the share of electricity in total final consumption is 24% in 2030, compared to around 30% in the COP28 Full Implementation Case.

Figure 4.5 ▷ Total final consumption by source and sales share of key electrification technologies in the COP28 Full Implementation Case



Electricity provides over 35% of total final consumption in 2035 in the COP28 Full Implementation Case, helping to save energy without reducing energy services

Note: EJ = exajoule; CCUS = carbon capture, utilisation and storage.

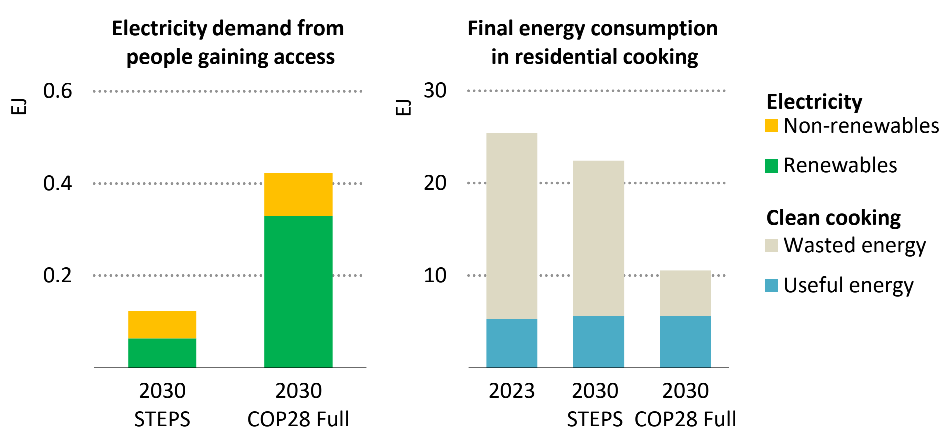
Access to modern energy improves lives and saves energy

Today around 750 million people lack access to electricity and over 2 billion lack access to clean cooking. After years of progress, the Covid-19 pandemic and the 2022 energy crisis triggered setbacks and slow-downs in most countries. A significant acceleration in progress is required to achieve Sustainable Development Goal (SDG) 7.1, which calls for universal energy access by 2030. Energy savings from universal energy access have already been seen in several countries with successful clean cooking and electricity access programmes. For example, Indonesia, which achieved universal access to electricity in 2021/22 and rapid improvements in clean cooking thanks to a series of targeted policies and programmes, saw residential energy demand for cooking decrease by around 20% between 2015 and 2023, even as GDP per capita rose almost 30% in the same period. Similar dynamics have been observed in other countries, including India and Viet Nam.

The IEA estimates that achieving universal clean cooking access could avoid global GHG emissions of up to 1.5 gigatonnes of carbon-dioxide equivalent (Gt CO_2-eq) in 2030, equal to the combined emissions from shipping and aviation today (IEA, 2023c). Most of these savings derive from the shift away from the very inefficient traditional use of solid biomass for cooking to cleaner, more efficient stoves and fuels. Traditional cooking methods waste 85-95% of the input energy. Switching to improved biomass cook stoves can more than halve the energy needed, while modern technologies such as electric cooking, biogas and ethanol would reduce energy needs even more.

In the COP28 Full Implementation Case, there is a strong focus on supporting clean cooking, in which 2.2 billion people gain access to clean cooking by 2030, meeting the SDG goal of providing universal access to clean cooking. The result is that energy demand for cooking in emerging market and developing economies falls by around 60% compared to today (Figure 4.6). In absolute terms, the provision of clean cooking results in a reduction in energy demand of around 15 EJ globally. In the COP28 Partial Implementation Case, progress related to access improves slightly from current policy settings as set out in the STEPS, with an additional 900 million people gaining access to clean cooking by 2030, but this still falls far short of the universal access achieved in the COP28 Full Implementation Case.

Figure 4.6 ▷ Impacts on energy consumption from expanding energy access in emerging market and developing economies in the STEPS and COP28 Full Implementation Case, 2030



Achieving universal energy access by 2030 reduces overall net demand, with around 80% of electricity access and 50% of cooking access met by renewables

Note: EJ = exajoule; COP28 Full = COP28 Full Implementation Case; STEPS = Stated Policies Scenario.

Access to electricity enables households to move away from inefficient, poor quality lighting sources, such as kerosene lamps, to more efficient, reliable sources of lighting and to climb the energy ladder to other essential services.

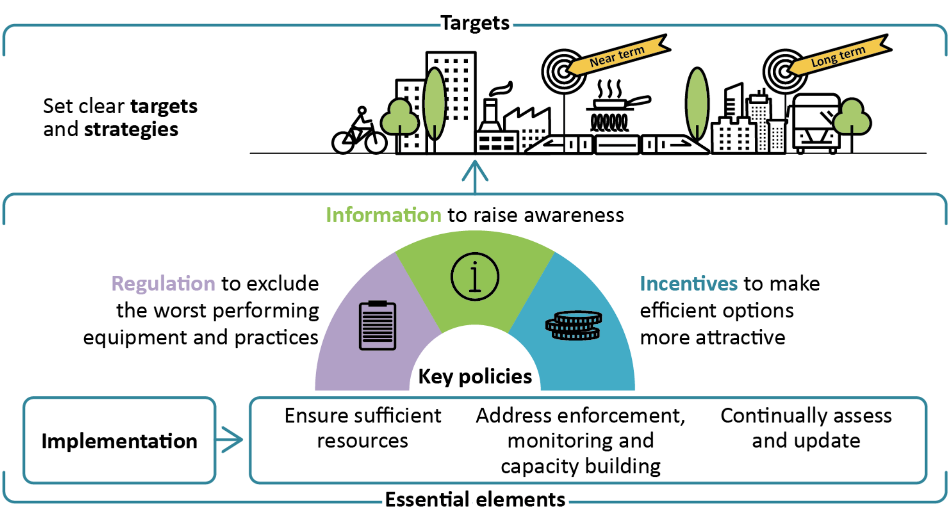
In the COP28 Full Implementation Case, a strong focus on universal access to electricity leads to 840 million around the world, mostly in Africa, gaining access to electricity by 2030. This meets the SDG goal of providing universal access. Renewables account for some 80% of this increase. The increase in energy demand from the population gaining access to electricity is less than 1% of the energy savings from the switch to modern cooking technologies. In the COP28 Partial Implementation Case, the provision of access improves slightly compared to the STEPS, but the SDG target is far from being met.

Policies to deliver technical efficiency

Technical efficiency refers to improvements in the efficiency of energy consuming equipment such as appliances, building envelopes, factories, cars and trucks. To double the rate of energy efficiency gains by 2030, improvements in technical efficiency need to accompany progress on electrification and fuel switching. Making improvements requires an integrated policy approach that combines regulation, information and incentives.

Buildings account for around 30% of final consumption worldwide and more than half of electricity consumption. Building energy codes are an effective policy tool to regulate minimum energy performance. The adoption of building energy codes is increasing worldwide, but more than 100 countries had no mandatory codes in 2023. It is particularly important to improve the energy performance of existing buildings between now and 2030 if the world is to get on track for net zero emissions by 2050, but only around 50 building energy codes today contain provisions for the standing building stock.

Figure 4.7 ▷ IEA policy packages toolkit for energy efficiency



Comprehensive policy packages are required to deliver technical energy efficiency gains in industry, transport and buildings

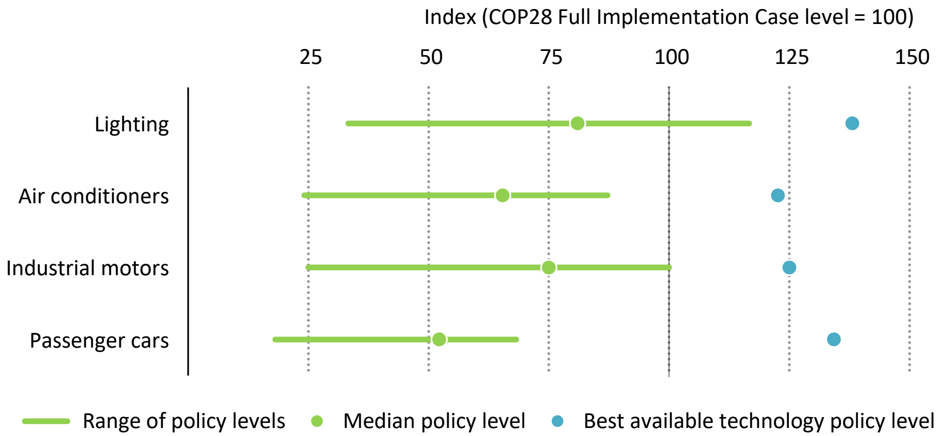
Governments can also improve the energy performance of buildings by promoting energy retrofits with incentives such as grants and loans, and with support for innovative approaches such as using prefabricated construction elements to retrofit in bulk. They can further improve future energy performance by promoting grid-interactive buildings. These can play a vital role in system flexibility, helping to reduce costs for consumers and to integrate variable renewables into electricity systems. Technologies such as smart meters and building energy management systems enable consumers to monitor and reduce their energy use. They also facilitate demand-response measures, for example by enabling the flexible operation of EV chargers, water heaters and other appliances, and can be specifically designed to overcome barriers and maximise benefits for low-income consumers. Such measures have the potential to reduce household electricity bills by 7-12% by 2050 in advanced economies, and by almost 20% in emerging market and developing economies.

Appliances represent 46% of electricity demand in buildings. To double the rate of energy efficiency improvements, appliances need to be between 30% and 40% more efficient by 2030. Minimum energy performance standards specify efficiency requirements for appliances and help to eliminate the worst performing equipment from the market. More efficient appliances often do not cost more than their less efficient counterparts, and in many cases, they offer significant energy and cost savings over their lifetime. Minimum energy performance standards could be accompanied by incentives to lower the upfront cost of more energy-efficient appliances, where there is a case for this, and by market replacement programmes to accelerate the uptake of more efficient appliances and prevent a potential lock-in effect.

Industry accounts for around 40% of final consumption globally. There is scope for significant short-term energy savings in the light industry sectors and in small and medium enterprises, particularly in motors and the electrification of industrial heat. Today, around 65% of electricity in industry is used in motor-driven systems, such as pumps, fans, air compressors and processing systems: efficiency improvements for such systems could be accelerated by strengthening minimum energy performance standards for electric motors and variable speed drives and by market replacement programmes to encourage faster uptake of the most efficient models. Given the long lifetime of motors, there is a case for early action on this front. Governments could also try to accelerate efficiency improvements by encouraging the uptake of energy management and reporting systems, incentivising or mandating regular energy audits and facilitating knowledge exchange though industry networks.

Transport is responsible for around a quarter of total final consumption. Although EVs are crucial to reduce fossil fuel consumption in the transport sector, efficiency gains in conventional vehicles are also important to curb transport energy demand and emissions in the short term. Intensity improvements in heavy-duty vehicles are particularly important, given that electrification is more difficult in this segment of the market. Fuel economy regulations and purchase incentives have a potentially important role to play. Studies suggest that efficiency improvement rates for cars can be 60% faster in countries with such regulations and incentives than in those without them.

Figure 4.8 ▷ Minimum energy performance standards for selected end-uses in force today in a representative sample of countries compared to the level reached in the COP28 Full Implementation Case in 2030



Technologies and policies that can enable doubling energy efficiency rates are available today, yet the potency of efficiency regulations differs considerably among countries

For many technologies, policies exist today that are in line, or close to, the required levels for the global doubling target (Figure 4.8). However, there are large differences between countries, highlighting the potential for international or regional alignment of standards. Furthermore, not all end-uses are regulated to the same extent. For example, while almost 100 countries have minimum energy performance standards in place for air conditioners, refrigerators or lighting equipment, only 40-65 countries have them for cook stoves and heating equipment. Countries with existing standards can accelerate progress by aligning them with the levels required in the COP28 Full Implementation Case, and countries without standards can develop them and establish labelling programmes.

Key policy recommendations:

- Use minimum energy performance standards and other regulatory measures to improve the technical efficiency of energy using equipment and support these measures with incentives and information.
- Deliver access to electricity and clean cooking for all, and thus bring about a switch to more efficient and less polluting fuels.
- Support faster deployment of super-efficient electrical technologies such as EVs and heat pumps.
- Invest in technology and infrastructure to enable efficiency gains to be made from modal shifts in transport, notably with higher use of public transport, and from enhanced

recycling and improved material efficiency at each stage of the life cycle of products and buildings.

- Encourage behaviour change to reduce energy use.

4.3 Accelerate the phase-down of unabated coal-fired power generation

Coal is the largest single source of electricity worldwide, accounting for over one-third of global electricity generation. As the most carbon-intensive fuel, coal-fired power generates around 30% of all energy-related CO_2 emissions. Production of coal for power generation is also a substantial emitter of methane accounting for nearly one-third of all energy-related methane emissions in 2023. The COP28 outcome therefore identifies accelerating the phase-down of unabated coal-fired power as a key goal.[4]

Today, the world is far from achieving this goal. Global unabated coal power generation rose to its highest ever level in 2023, the third consecutive year of record-breaking amounts. Many countries use coal to generate electricity, but the largest five consumers of coal for power – China, India, the United States, Indonesia and Russia – represent over 80% of all coal use for power. Coal is the main source of power generation in several of the fastest growing economies in the world, accounting for roughly three-quarters of generation in India, two-thirds in Indonesia, and 60% in the Philippines and China. In these countries and several others, coal is critical to electricity security, since it provides the largest share of the capacity needed to meet peak demand.

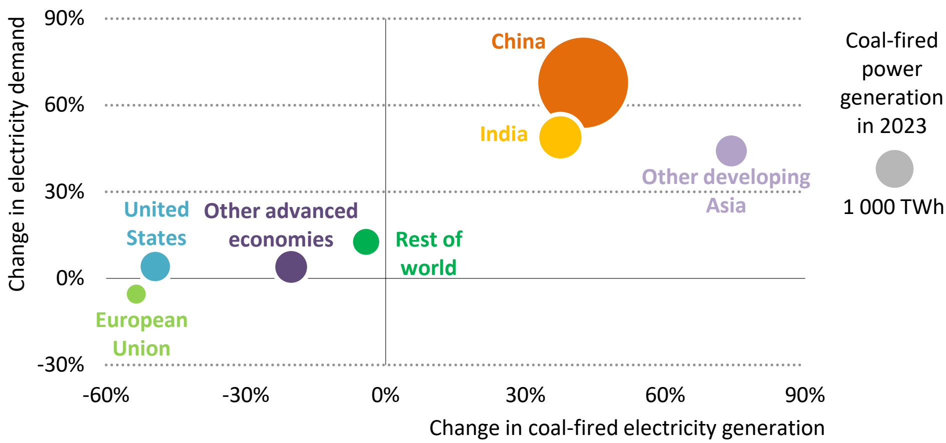
Achieving the transition away from unabated coal power while maintaining energy security, stability and affordability thus hinges critically on a rapid scale up of low-emissions power sources. Historically, rapid transitions away from coal have occurred in countries with stagnant electricity demand (Figure 4.9). A focus on stopping new investment in coal-fired power or retiring existing plants early is unlikely to work without much faster growth of alternative sources of low-emissions generation, especially renewables, than implied by current trends. In the COP28 Full Implementation Case, tripling renewables capacity by 2030, combined with strong growth in nuclear and other low-emissions sources of power, provides sufficiently rapid growth to start displacing coal.

As a result, coal plants increasingly shift their primary operations from bulk electricity generation to providing load balancing services in the near term. By decreasing electricity production but remaining available for use as backup when variable renewables are not generating, coal plants can support the secure integration of renewables into power systems in the near term. In the COP28 Full Implementation Case, the capacity factor of coal plants in emerging market and developing economies falls from 56% in 2023 to 22% in 2035 as more of the fleet is reoriented to provide flexibility. Replacing the contribution of coal to system

[4] Unabated coal is coal used in a facility that is not equipped with CCUS. Co-firing coal with biomass or ammonia reduces emissions by substituting for unabated coal, but the remaining coal that is combusted is considered to be unabated.

adequacy in the longer term will require deployment of a broad suite of technologies, including storage such as batteries and pumped storage hydro, as well as strengthening grids and flexibility incentives.

Figure 4.9 ▷ Coal-fired power generation and electricity demand growth by major economy or region, 2015-2023



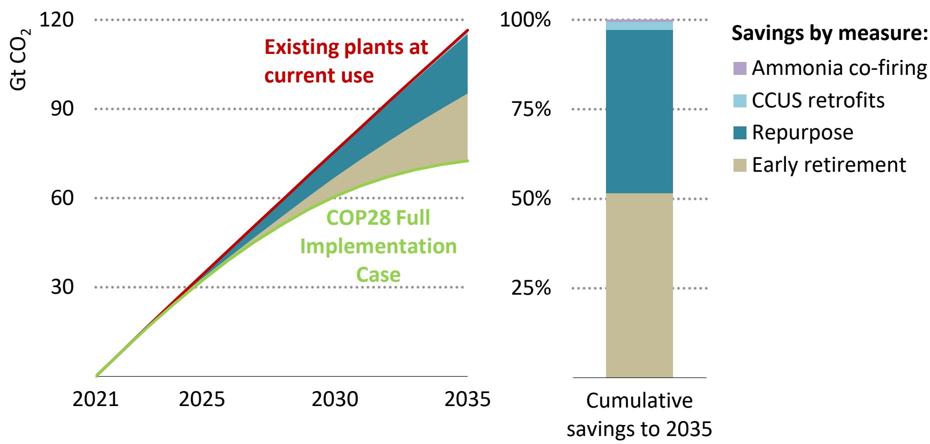
Since the Paris Agreement, power generation from coal has expanded mainly in regions with fast growing total electricity demand, notably in developing Asia

Note: TWh = terawatt-hour.

As of April 2024, over 500 GW of additional coal-fired power plants were under development worldwide, primarily in China, though only one-quarter of this capacity had started construction. Most new coal plants are publicly funded, with private sources accounting for just over a third of coal-fired generation investment in 2023. Ending the approval of new unabated coal-fired plants immediately is a key milestone on the road to net zero emissions by 2050. However, today's global coal fleet is around 2 000 GW. As the average lifespan of a coal-fired power plant is approximately half a century, the implied lifetime emissions from the existing coal fleet seriously endanger the goal of limiting global warming to 1.5 °C.

Repurposing the existing coal fleet to run less and provide capacity and load balancing helps reduce emissions, but it alone is not enough. The COP28 Full Implementation Case also sees early retirement of some coal power plants as clean energy ramps up. This strategy is most feasible in advanced economies where plants are older on average and sunk costs are less. However, the huge size and young age of the coal fleet in emerging market and developing economies means that early retirement also takes place there in the COP28 Full Implementation Case, responsible for over half of the emissions reductions from the existing coal fleet in those economies by 2035 in this scenario (Figure 4.10). Retrofitting coal plants with CCUS and ammonia or biomass co-firing provide additional solutions. However, CCUS and ammonia remain technically challenging and prohibitively expensive options in most cases today, so they make a limited contribution to emissions reductions compared with retiring and repurposing.

Figure 4.10 ▷ Cumulative CO_2 emissions from existing coal-fired power plants in emerging market and developing economies in the COP8 Full Implementation Case



Existing coal power plants in emerging market and developing economies could emit nearly 120 Gt CO_2 by 2035, so repurposing, retiring and retrofitting are necessary to bend the curve

Note: Gt CO_2 = gigatonnes of carbon dioxide; CCUS = carbon capture, utilisation and storage.

Governments have at their disposal a variety of policy options to motivate public and private power sector actors to accelerate investment in clean energy and reduce use of unabated coal while minimising social and economic externalities (see Section 5). These interventions may be used alone or in combination, depending on the regional context. They include:

- **Direct regulation** including requirements to reduce operations, bans on the construction of new coal plants or mines, and regulated closures of plants.
- **Financial incentives** for coal power plant owners to close their assets or limit their operations. The coal plants that are best suited to this approach are those which have not yet been fully depreciated and which could be replaced by renewable energy or other low-emissions alternatives that would bring financial savings for consumers.
- **Market-based measures** that favour competing clean energy sources and thus disincentivise coal power plant owners to continue operating, especially at high levels of utilisation. Examples of market-based measures include: carbon pricing; measures that reduce revenue available beyond a limited number of operating hours via taxes; tenders or market rules; and market reforms that prioritise the use of renewables.

Key policy recommendations:

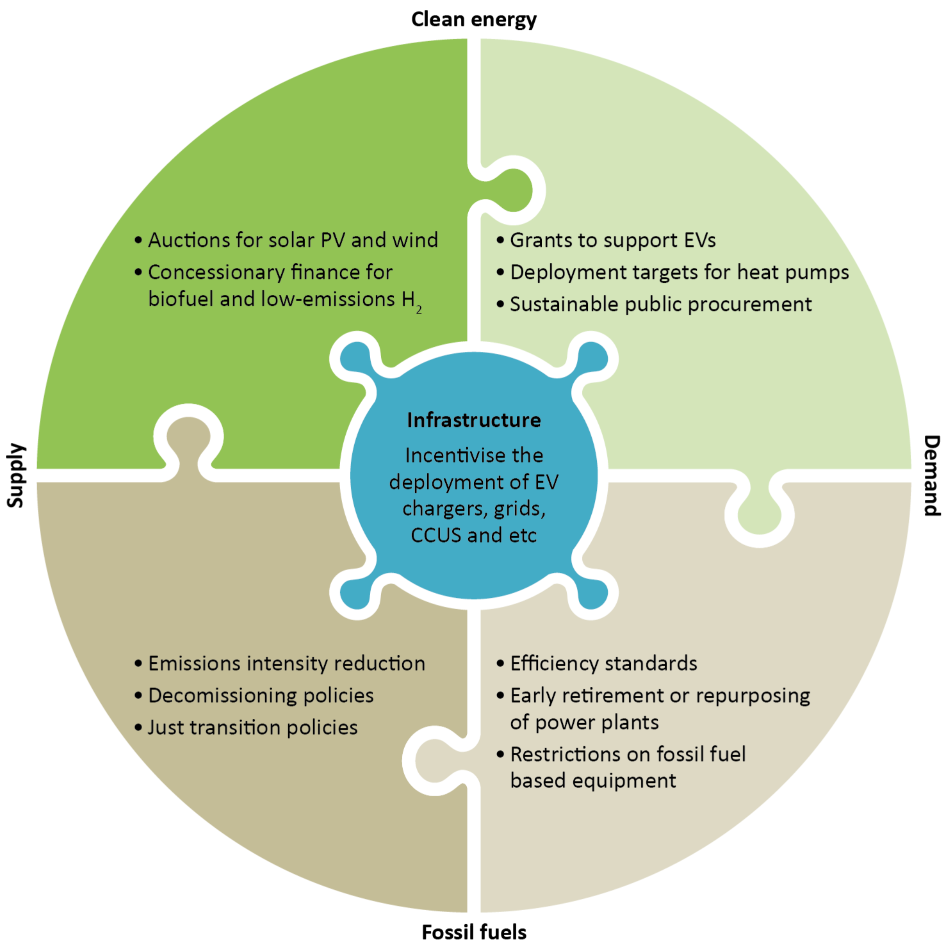
- Support the rapid scale up of alternative sources of low-emissions power generation, principally renewables, but also nuclear power, including through market-based policies like carbon pricing that make coal-fired power less attractive.
- Put an immediate end to approvals of new unabated coal-fired power plants.
- Repurpose existing thermal coal plants through regulation or incentives to provide flexible power generation for load balancing and to support the secure integration of renewables.
- Replace this coal power capacity over time with low-emissions flexibility solutions, including through scaling up energy storage and strengthening grids.
- Prompt the early retirement of coal plants using regulations and financial incentives.

4.4 Transition away from fossil fuels

Total fossil fuel demand was 510 EJ in 2023. Recent decades have seen demand rise rapidly, by 40% in the last twenty years and 10% in the last ten years. The COP28 outcome recognised that achieving emissions reductions in line with 1.5 °C pathways requires "transitioning away from fossil fuels in energy systems in a just, orderly and equitable manner, accelerating action in this critical decade so as to achieve net zero by 2050". The growth in demand in recent decades indicates that this will not be easy.

Transitioning away from fossil fuels means an absolute reduction in fossil fuel demand through the scaling up of clean energy supply and gains in energy efficiency. To achieve this, policies to boost the supply of clean energy and improve energy efficiency are needed to reduce emissions while meeting energy service demands. In parallel, policies targeting the supply and demand of fossil fuels are needed to tackle sources of emissions that would not be addressed through clean energy and efficiency measures alone, to help achieve the energy transition in a just, orderly and equitable way, and to support the scaling up of clean energy (Figure 4.11).

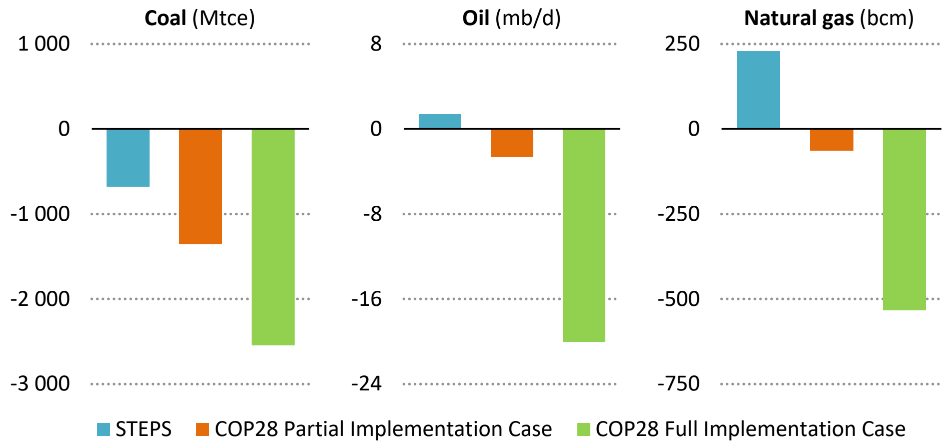
Figure 4.11 ▹ Framework for combining policies focussed on clean energy with policies focussed on fossil fuel transition



Growth of clean energy supply is critical to drive down demand for fossil fuels, but a singular policy focus on clean energy will not be enough

The COP28 Partial Implementation Case assumes that no new policies of this kind are introduced. It shows that, without robust policies for supply and demand of fossil fuels to support the scale up of clean energy, reductions in fossil fuel demand will be much less than those achieved in the COP28 Full Implementation Case, which does include such policies (Figure 4.12).

Figure 4.12 ▷ Fossil fuel fossil demand in the COP28 Full Implementation and Partial Implementation cases, 2023-2030



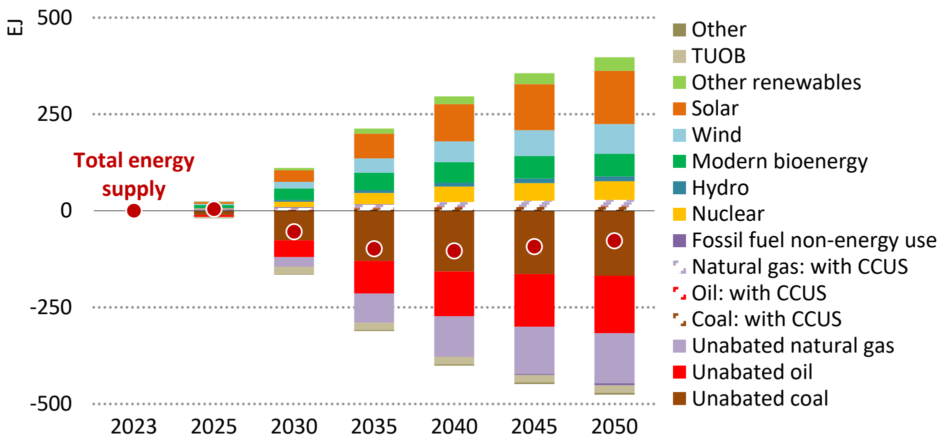
Coal demand falls by 40% to 2030 while oil and gas use decline by around 20% In the COP28 Full Implementation Case, but far less in the Partial Implementation Case

Note: Mtce = million tonnes of coal equivalent; mb/d = million barrels per day; bcm = billion cubic metres; STEPS = Stated Policies Scenario.

In the COP28 Full Implementation Case, governments rapidly adopt policies to scale up investment in clean energy technologies by a factor of 2.5 by 2030. This surge in clean energy investment means that oil and natural gas demand decline by around 20% between 2023 and 2030, and that coal demand falls by 35% over the same period. As a result, total fossil fuel demand declines by around 25% (Figure 4.13). These declines are steep enough to mean that no new long lead-time conventional oil and gas projects are required. Investment in existing oil and gas assets continues, but some oil and gas production gets squeezed out of the market and need to be shut in.

Some producers have argued that levels of oil and gas demand much higher than those seen in the COP28 Full Implementation Case could be consistent with achieving net zero emissions by 2050 if CCUS and direct air capture (DAC) were to be deployed on a sufficiently large scale. Achieving this however would require an almost inconceivable level of spending on CCUS and DAC. For example, if oil and natural gas consumption were to evolve as in the STEPS, achieving net zero emissions in 2050 and limiting the temperature rise to 1.5 °C would require 32 Gt CO_2 of CCUS by 2050, including 23 Gt CO_2 of DAC. This would necessitate around USD 3.7 trillion of annual average investment from 2024 through to 2050, a level of spending similar to the annual revenues from all oil and gas sales in recent years. Reducing emissions by transitioning away from fossil fuel use remains the most technically feasible and cost-effective way to limit the temperature rise to 1.5 °C.

Figure 4.13 ▷ Change in total energy supply by source in the COP28 Full Implementation Case, 2023-2050



Transitioning away from fossil fuels means an absolute reduction in fossil fuel demand via scaling up of clean energy supply and improvements in energy efficiency

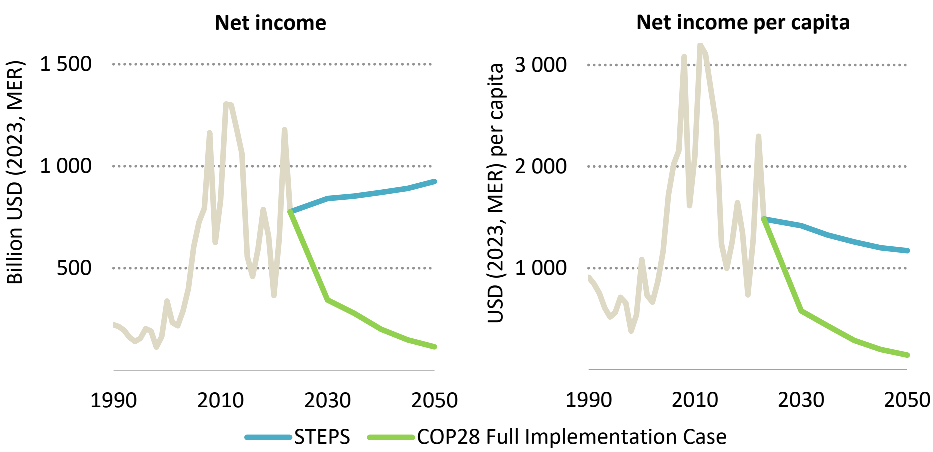
Notes: EJ = exajoule; CCUS = carbon capture, utilisation and storage; TUOB = traditional use of biomass. Other renewables include geothermal, tidal and wave energy.

Policies specifically targeting the supply and demand of fossil fuels play an important role in achieving the changes seen in the COP28 Full Implementation Case. For example, the production, transport and processing of oil and gas results in just under 15% of global energy-related GHGs today. In the COP28 Full Implementation Case, these emissions are cut by more than 60% by 2030, mostly by tackling methane emissions (see Section 4.7). As a result, the emissions intensity of global oil and gas operations is near zero by the early 2040s. In the COP28 Full Implementation Case, policies also help avoid the unplanned, chaotic or premature retirement of existing fossil fuel infrastructure, for example, preventing gas-fired power plants from becoming uneconomic while they continue to provide valuable electricity system flexibility. They also ensure the safe and responsible decommissioning of fossil fuel infrastructure, e.g. pipelines and wells, where they are no longer needed.

Policies are also important in the context of the declines in oil and natural gas demand in the COP28 Full Implementation Case, including signals from consumers to producers that are backed by policy measures. Declines in demand are assumed to be incorporated fully into the resource development plans of companies and countries, implying there is no need for additional policies that restrict resource extraction or centralised efforts to impose production quotas. However, this depends on market signals from consumers to producers that are clear, credible and unambiguous on the demand trend. Ambitious NDCs have a key part to play here, and these need to be underpinned by credible policy measures.

Specific policies are also needed to boost the prospects for a just, orderly and equitable transition. This includes importing countries supporting producer economies to manage sharp reductions in fiscal income from oil and gas sales (Figure 4.14). In a world where demand for energy services is increasing, resource-rich countries will continue to seek value from their domestic resources through exports, and importers will continue to value secure, affordable energy supplies. The task ahead is to make these objectives compatible with net zero emissions energy transitions. Consuming economies can help by sending the right market signals to producers, recognising that producer economies can play a critical role in the development of a number of clean energy technologies, and supporting technology collaboration, and bilateral and multilateral engagement.

Figure 4.14 ▷ Net income from oil and natural gas in producer economies in the STEPS and COP28 Full Implementation Case



Transitions in line with the COP28 outcome present a stark challenge for producer economies, underlining the case for economic diversification

Notes: MER = market exchange rate; STEPS = Stated Policies Scenario. Producer economies here include Algeria, Angola, Iran, Iraq, Nigeria, Oman, Qatar, Saudi Arabia, United Arab Emirates and Venezuela.

Fossil fuel policies can also play an important part in complementing clean energy policies by ensuring the early retirement or conversion of fossil fuel assets such as coal-fired power plants or long-lived industrial facilities, by providing clear signals to markets about the desired path, for example by banning the sale of new fossil fuel equipment, and imposing effective carbon pricing or other market or regulatory measures that disincentivise the use of fossil fuels.

Low-emissions fuels have a particularly important role to play in some sectors. In the COP28 Full Implementation Case, oil, natural gas and coal use all decline sharply as clean energy is scaled up, with low-emissions fuels playing a major role. By 2050, 10 million barrels of oil equivalent per day of modern liquid biofuels and low-emissions hydrogen-based fuels are consumed globally, i.e. slightly over one third of global liquids consumption in 2050, and 747 bcm-equivalent of biogases and low-emissions hydrogen consumption, i.e. about 80% of the demand for natural gas. These fuels play an essential role in helping to satisfy the demand for energy services during the energy transition through to 2050, especially in areas such as heavy industry, aviation and shipping.

Key policy recommendations:

- Scale up clean energy supply and improve energy efficiency rapidly to bring about a significant reduction in fossil fuel demand.
- Support the development and scaling up of sustainable fuels, i.e. modern liquid biofuels and low-emissions hydrogen-based fuels, to displace fossil fuel demand in heavy industry and transport.
- Implement policies to reduce the emissions intensity of oil and gas supply and ensure the safe decommissioning of fossil fuel infrastructure when it is no longer needed.
- Improve prospects for a just, orderly and equitable transition by supporting co-operation and dialogue between consumer and producer countries and ensuring coherence in energy investment planning.
- Implement policies and regulatory measures to reduce fossil fuel demand, for example by requiring or incentivising the early retirement/conversion of fossil fuel assets and the phase-out of fossil fuel equipment such as internal combustion engine vehicles, and by implementing carbon pricing or other market-based policies.

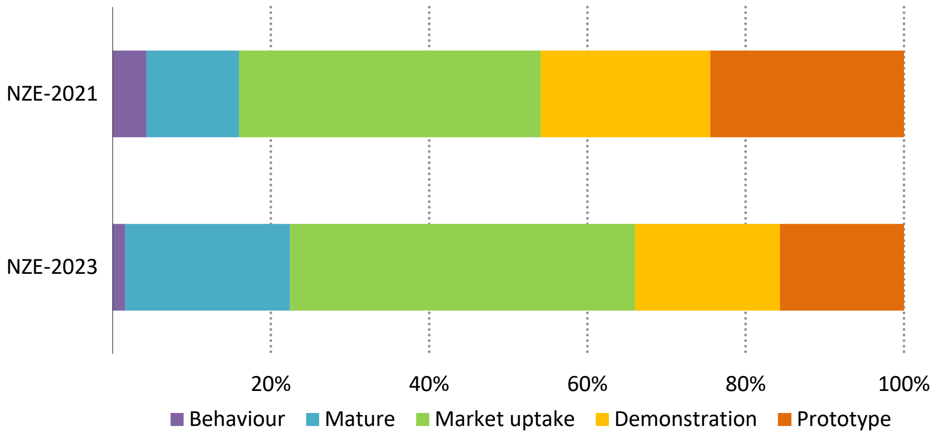
4.5 Accelerate zero- and low-emissions technologies

Role of innovation in the COP8 Full Implementation Scenario

The COP28 outcome calls for accelerating zero- and low-emissions technologies, including renewables, nuclear, abatement and removal technologies such as CCUS and low-emissions hydrogen. According to IEA analysis, the world has the technologies it needs to start making deep emissions cuts, as discussed in the sections on tripling global renewable energy capacity and doubling energy efficiency progress. However, further progress is needed to demonstrate, commercialise and deploy additional low-emissions technologies to reach the goal of a net zero emissions energy system (Figure 4.15).

Innovation is already delivering more technological options and lowering technology costs: between 2021 and 2023, the share of emissions reductions needed to reach net zero emissions by 2050 from technologies currently at demonstration or prototype phase fell from around 50% to around 35%. However, some important technologies that are already commercially available, e.g. CCUS and low-emissions hydrogen, are not yet mature, or are still too expensive to be taken up at a pace that is consistent with the COP28 Full Implementation Case.

Figure 4.15 ▷ Decomposition of emissions reductions by innovation stage



Innovation has brought new technologies to the market, but more needs to be done to reach net zero emissions by 2050

Notes: NZE = Net Zero Emissions by 2050 Scenario. The NZE-2021 and NZE-2023 refer to different editions of the NZE Scenario (IEA, 2023a).

The following sub-sections focus on CCUS, hydrogen and hydrogen-based fuels, and nuclear, as the COP28 outcome explicitly calls for them to be scaled up at a faster pace.

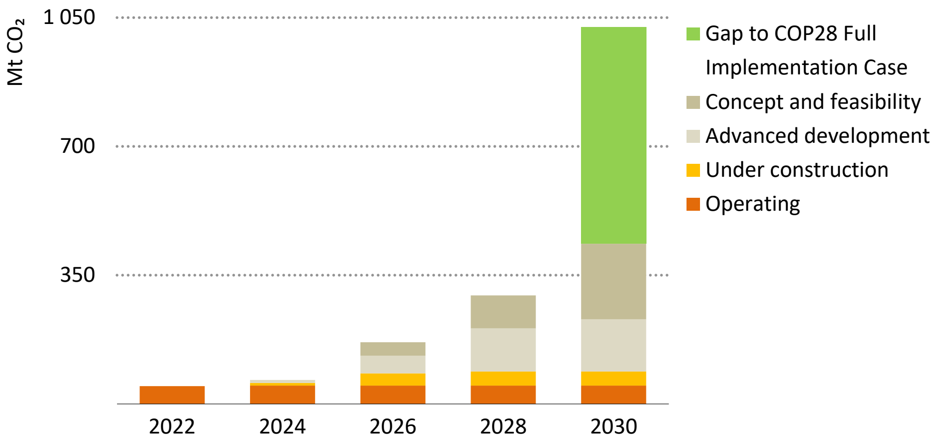
Carbon capture, utilisation and storage

CCUS technologies have an important role to play on a path to net zero emissions, especially given their potential to lower emissions from hard-to-abate sectors, such as cement production and to capture CO_2 from the atmosphere.[5] In the COP28 Full Implementation Case, CCUS accounts for 8% of total emissions reductions by mid-century. High capture rates, i.e. above 90%, are essential to minimise residual emissions to the atmosphere, and for CCUS to play a role in the transition to a net zero energy system.

Around 45 commercial CCUS facilities are currently in operation, collectively with capacity to capture around 50 million tonnes of carbon dioxide (Mt CO_2) emissions annually (Figure 4.16) (IEA, 2024g). Around 65% of operating CO_2 capture capacity is at natural gas processing plants, which is one of the lowest cost applications, but the widespread adoption of economy-wide decarbonisation targets for 2050 is boosting uptake in hard-to-abate industries, the power sector, the production of low-emissions hydrogen and ammonia, and atmospheric carbon dioxide removal.

[5] CCUS refers to the process of capturing carbon dioxide emissions from fuel combustion, industrial processes or directly from the atmosphere. Captured CO_2 emissions can be stored in underground geological formations, onshore or offshore, or used as an input or feedstock in manufacturing.

Figure 4.16 ▷ Capacity of current and planned large-scale CO_2 capture projects versus the COP28 Full Implementation Case, 2020-2030



Current annual CO_2 capture is a fraction of what is needed in the COP28 Full Implementation Case – new projects are emerging, but many are at an early stage

Notes: Mt CO_2 = million tonnes of carbon dioxide. Includes large-scale projects with capture capacity more than 100 000 tonnes per year (1 000 t per year for DAC). Capture projects for CO_2 use are included if the CO_2 is used in fuels, chemicals, polymers, building materials or for yield boosting. Within planned CCUS industrial hubs, only identified CO_2 capture projects are included (not the full potential capture capacity of industrial hubs for which capture sources are not specified).

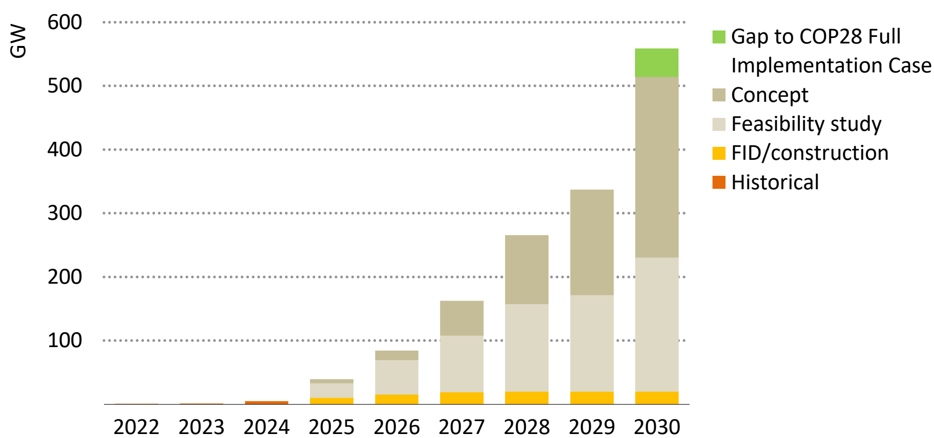
While CCUS deployment has trailed behind expectations in the past, momentum is rising thanks to increasing policy support, with over 700 new projects now in various stages of development. If all are realised as planned, CCUS facilities could capture 435 Mt CO_2 per year in 2030, while annual storage capacity could reach around 615 Mt. Yet, even if all these projects come online, they would represent only around 40% of the roughly 1 Gt CO_2 that needs to be captured and stored in 2030 in the COP28 Full Implementation Case. To meet this target, shorter lead times for constructing and commissioning new projects are essential.

Hydrogen and hydrogen-based fuels

The COP28 outcome also calls for accelerating low-carbon hydrogen production, which similarly plays a major role in reducing emissions on a net zero emissions pathway for sectors in which alternative options are limited or more costly. In the COP28 Full Implementation Case, low-emissions hydrogen or fuels derived from it are increasingly used by the steel, shipping and aviation sub-sectors. Their use accounts for 4% of total global emissions reductions to 2050.

According to the IEA *Global Hydrogen Review*, hydrogen production stood at 97 Mt last year (IEA, forthcoming). However, less than 1 million tonnes (Mt) were produced via low-emissions methods. In the COP28 Full Implementation Case, low-emissions production increases to 65 Mt by 2030. Around three-quarters of which derive from electrolysis, and around one-quarter from natural gas with CCUS. For this to happen, the capacity of installed electrolysers needs to expand from just over 1 GW in 2023 to 560 GW in 2030 (Figure 4.17). IEA analysis indicates that announced projects are nearly sufficient for this level, but more than half of the announced capacity is in early stages of development, and some projects may not be realised. Only 5% of electrolyser projects by total capacity have taken a final investment decision (FID) or are under construction.

Figure 4.17 ▹ Installed electrolyser capacity, project pipeline and deployment needs in the COP28 Full Implementation Case



Alignment with a net zero emissions by 2050 trajectory would require an increase in electrolysis capacity from over 1 GW in 2023 to 560 GW in 2030

Notes: Capacity (GW) expressed in terms of electricity input to the electrolysers; FID/construction = final investment decision and under construction. 2024 is estimated based on projects planned to start operations in 2024 and that have at least reached FID.

Therefore, there is a risk of a large implementation gap. Policy makers need to try to prevent this by putting in place measures to create predictable demand for low-emissions hydrogen, reduce its production costs, support faster build-out of announced projects by expediting permitting and maintaining regulatory clarity, and advance certification efforts, including at the international level.

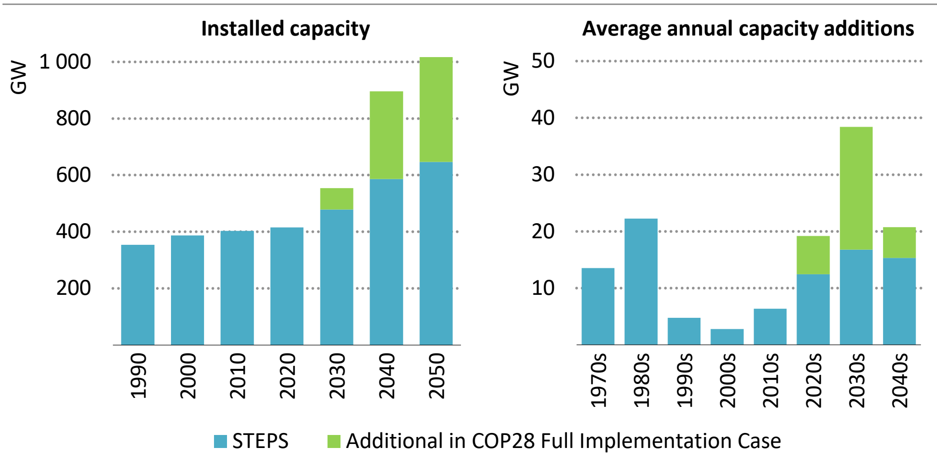
Nuclear power

Nuclear power has an important role to play in secure energy transitions. In the COP28 Full Implementation Case, global nuclear capacity more than doubles by 2050, complementing renewables as a low-emissions source of electricity and heat, while also bolstering electricity security by stabilising the grid. Innovation will play a critical part in scaling up nuclear power and making it available in countries that are open to the technology. Finding ways to drive down the costs of small modular reactors and bring them to the market by the early 2030s will be particularly important, as will innovation for large-scale reactors, not least to overcome recent challenges in the industry related to project cost overruns and delays. It will also be critical to ensure that high-level nuclear waste disposal facilities are constructed.

Nuclear power has been the second-largest low-emissions source of electricity for the past 50 years. With nuclear reactors operating in more than 30 countries, it provides 9% of global electricity supply today and avoids about 1.5 Gt CO_2 emissions per year by reducing the need for fossil fuels in the electricity sector. However, the nuclear share of electricity has declined by half since the 1990s: construction of new plants has slowed, and a wave of retirements followed the accident at the Fukushima Daiichi power station in 2011.

Advanced economies get almost 20% of their electricity from nuclear, though nuclear reactors in these economies are on average more than 30 years old. The United States, France and Japan are long-time leaders in nuclear technology. Emerging market and developing economies as a group generate only 6% of their electricity from nuclear, though the figure for Russia is over 20%. China is now the market leader for nuclear power: it has added 40 GW over the past decade, which is almost 30% more than the rest of the world combined and is set to have the most nuclear capacity in operation of any country before 2030 (IEA, 2022). Several other emerging market and developing economies are expanding use of nuclear power, including India, where the eight reactors under construction at the start of 2024 will nearly double the total nuclear capacity.

Figure 4.18 ▷ Nuclear installed capacity and capacity additions in the STEPS and COP28 Full Implementation Case to 2050



To double global nuclear capacity, the industry would need to scale up to higher levels than ever before

Note: GW = gigawatt; STEPS = Stated Policies Scenario.

At COP28, two steps forward occurred for nuclear power. First, nuclear power was included in the final text of the Global Stocktake as one of the ways to reduce GHG emissions. Second, a coalition of more than 20 countries launched a Declaration to Triple Nuclear Energy Capacity by 2050, citing its key role to achieve net zero emissions as a dispatchable low-emissions source of electricity. This target is more than 20% higher than the level of nuclear capacity envisioned in the COP28 Full Implementation Case, where global nuclear capacity increases to around 1 000 GW by 2050 (up from around 415 GW in 2023) to maintain its global share of electricity generation at just below 10%. In either case, the nuclear industry needs to scale up to record levels in the 2030s and 2040s to deliver what is required, with average annual additions well above those ever seen in the past, and well above those in the STEPS (Figure 4.18). In addition to innovation support for both small and large-scale reactors, this will require market frameworks that minimise and share risk to attract investors and new sources of finance.

Key policy recommendations:

- Develop policy frameworks to support the growth of markets for these technologies and reduce their costs, for example by supporting industrial hubs with shared infrastructure for CCUS and hydrogen, boosting innovation, and implementing market-based measures to make zero- and low-emissions technologies competitive with fossil fuel-based technologies.
- Shorten project development timelines by streamlining permitting.
- Focus innovation and policy support for low-emissions hydrogen and its derivatives on measures that help to create predictable demand.
- Develop harmonised international standards and certification for critical low- and zero-emissions technologies, like sustainable fuels.
- Focus innovation and policy support for nuclear energy on achieving the commercial deployment of small modular nuclear reactors, and on making large-scale nuclear reactors more attractive and easily deployable by addressing costs, planning and construction, and waste disposal.

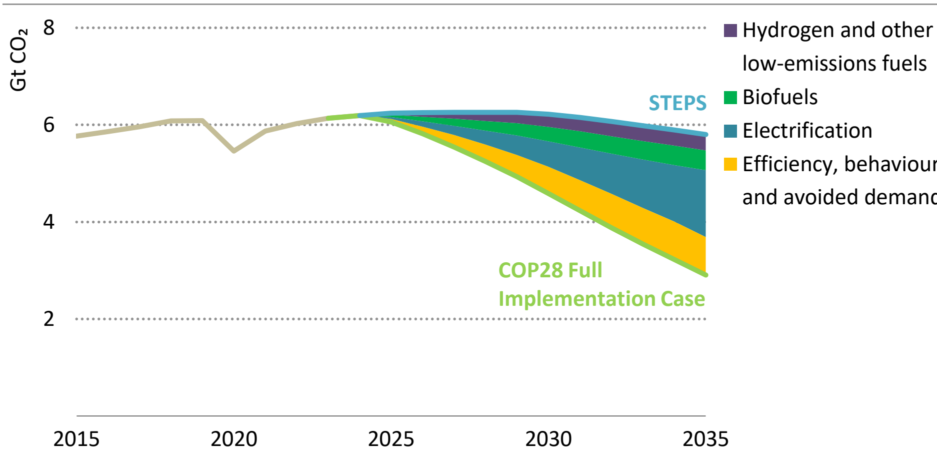
4.6 Reduce emissions from road transportation

The COP28 outcome calls for an acceleration in the reduction of emissions from road transport, which today accounts for over 15% of global energy-related emissions. In the COP28 Full Implementation Case, road transport emissions decline more than 50% by 2035. These rapid emissions reductions are facilitated by the maturity of key technologies, notably EVs. Global sales of electric cars reached a record high of almost 14 million in 2023, accounting for nearly 20% of the global market, and the momentum behind them looks set to remain strong. For this reason, electrification delivers the biggest share of emissions reductions from road transport in the COP28 Full Implementation Case (Figure 4.19). In addition to electrification, low-emissions fuels such as advanced bioenergy and hydrogen play a role, notably in the heavy-duty transport sub-sector.

In the COP28 Full Implementation Case, EVs reach a market share of 70% by 2030, compared with around 45% in the STEPS, and almost 100% by 2035. Over their lifetime, EVs are already cheaper in many cases than vehicles with internal combustion engines, since EVs are more efficient and fuel costs are lower. Upfront costs are increasingly competitive as well, though there is still a higher premium for most electric models and in most markets. This could change in the coming years, as falling battery prices, increased competition, economies of scale and growth in second-hand markets deliver affordability improvements. Nevertheless, continuing policy support for EVs will remain critical this decade as market forces gather steam, particularly in the form of continued investment in charging infrastructure, financial support to enable low-income households to meet the remaining higher upfront cost of EVs, and policies to disincentivise internal combustion engine vehicle sales.

While the COP28 outcome emphasised the need to reduce road transport emissions, including through the development of infrastructure and the rapid deployment of zero- and low-emissions vehicles, it did not lay out specific targets. Setting a quantified global goal for 2030 and beyond could accelerate action to decarbonise the road transport sector.

Figure 4.19 ▷ Emissions reductions by lever in the road transport sector in the COP28 Full Implementation Case, 2015-2035



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Road transport emissions decline by more than 50% by 2035 in the COP28 Full Implementation Case, driven by rapid electrification of vehicles

Notes: Gt CO_2 = gigatonnes of carbon dioxide; STEPS = Stated Policies Scenario. Other low-emissions fuels include hydrogen and hydrogen-based fuels.

Key policy recommendations:

- Disincentivise sales of internal combustion engine vehicles, for example, via taxation, regulation or financial support (particularly for low-income households) to purchase EVs.

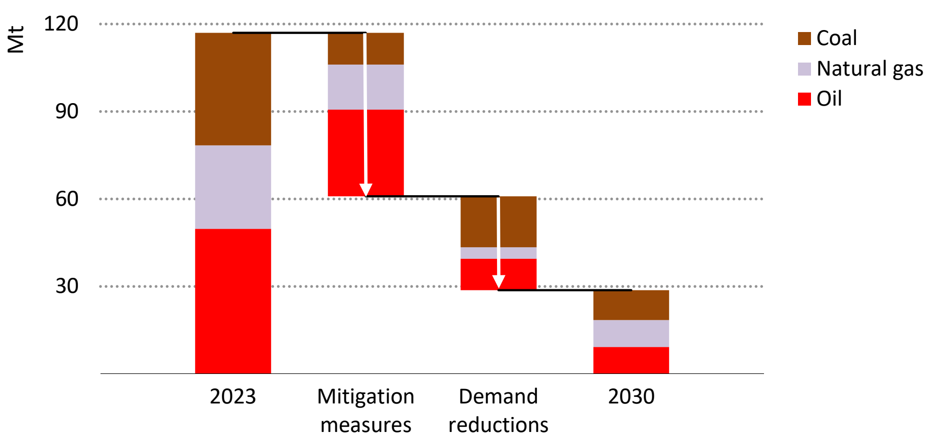
- Invest in charging infrastructure for EVs.
- Support the scaling up of low-emissions fuels like sustainable biofuels and hydrogen for use in heavy-duty transport, including through measures to boost innovation.
- Invest in infrastructure such as public transportation or cycling networks to enable modal shifts.

4.7 Reduce methane emissions

Methane is responsible for around 30% of the rise in global temperature since the Industrial Revolution (IPCC, 2023). Rapid and sustained reductions in methane emissions are key to limit near-term global warming and to improve air quality. The energy sector accounts for over one-third of total methane emissions attributable to human activity, and cutting emissions from fossil fuel operations could reduce this quickly by a significant amount.

The COP28 produced a host of new pledges to accelerate action on methane. The outcome of the first Global Stocktake called for countries to substantially reduce methane emissions by 2030. Additionally, more than 50 oil and gas companies launched the Oil and Gas Decarbonization Charter to accelerate emissions reductions within the industry, new countries joined the Global Methane Pledge, and new finance was mobilised to support the reduction of methane and other short-lived GHG emissions.

Figure 4.20 ▷ Reduction of methane emissions from fossil fuel operations by lever in the COP28 Full Implementation Case, 2023-2030



Better methane management in the fossil fuel industry drives emissions reductions to 2030, with demand reductions playing a more important role thereafter

Note: Mt = million tonnes.

Targeted measures to reduce methane emissions are necessary even as fossil fuel use begins to decline. In the COP28 Full Implementation Case, the scaling up of clean energy technologies cuts oil and natural gas demand by around 20% to 2030 and coal use by around 35%, with further declines through to 2050. These reductions in fossil fuel use to 2030 would cut related methane emissions in aggregate by just over 25% (Figure 4.20). Yet, there is scope to do more as part of efforts to limit warming to 1.5 °C. This case therefore has additional, targeted actions to tackle methane emissions that would lead to even larger reductions. In total, methane emissions from fossil fuel supply are cut by more than 75% from current levels by 2030.

In the COP28 Full Implementation Case, all fossil fuel producers achieve near zero methane emissions intensity by 2030. Operations with high emissions intensities where methane abatement measures cannot be systematically deployed, such as marginal oil and gas wells with emissions-prone equipment, are decommissioned. There is a bigger reduction in coal supply from surface mines that produce steam coal, where there are fewer opportunities to deploy abatement technologies, than from underground coal mines that produce coking coal.

No technological breakthroughs are required to achieve the 75% cut in methane emissions from fossil fuel operations to 2030. The required technologies and measures are well known and have already been deployed in multiple locations around the world. The sustained low methane emissions intensity seen in the operations of some major oil and gas producers for many years, for example, in Norway and the Netherlands, demonstrate what is readily achievable. Moreover, many abatement measures can save money because the outlays required to deploy them are less than the market value of the methane that is captured and can be sold.

These emissions reductions depend on rapid action to address known sources of methane such as flaring and venting, uncover leaks and unknown sources, and develop comprehensive methane reduction management plans. These plans should involve action to close, repair or replace high emissions assets, measures to monitor emissions and avoid leaks, the use of no or low-emissions equipment, and electrification of facilities.

While industry efforts can and should play an important role, government policy and regulation will be critical to remove or mitigate obstacles that prevent companies from getting started and going further. Methane abatement faces several challenges, including information gaps, missing infrastructure and economic barriers. Governments can address these barriers with policy and regulatory tools such as measures to enforce the monitoring, reporting and verification of emissions, initiatives to encourage knowledge sharing and best practices, requirements to put infrastructure in place as necessary in the planning stages of projects, actions to price environmental externalities, remove barriers to investment, and create financial incentives for the capture and use of methane and for spending on abatement technologies.

There are well-established policy and regulatory tools to help countries create the right incentives. These "tried and tested" policies include leak detection and repair requirements, equipment mandates and measures designed to limit non-emergency flaring and venting. Adopting these policies worldwide would reduce methane emissions from oil and gas operations by more than half. Additional policies such as emissions pricing, financing instruments and performance standards could bring about the full adoption of all technically feasible abatement options and lead to a 75% emissions reduction. Such policies would need to be supported by robust measurement-based monitoring regimes.

Key policy recommendations:

- Put in place requirements to detect and repair leaks, replace emissions-prone equipment and limit non-emergency methane flaring and venting.
- Introduce policies to require the monitoring, reporting and verification of methane emissions, and initiatives to encourage knowledge sharing.
- Provide incentives for the capture and use of methane and the use of abatement technologies.

5 Transition in a just, orderly and equitable manner

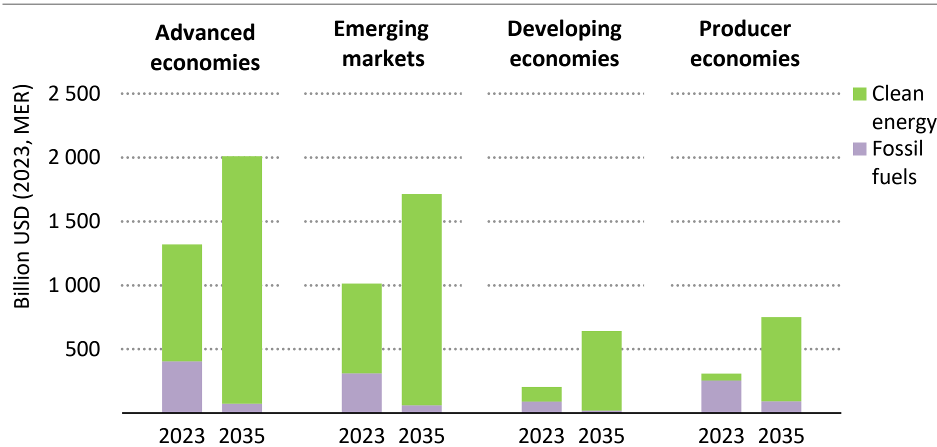
The COP28 called for transitioning away from fossil fuels in a just, orderly and equitable manner. This section deals with several relevant cross-cutting issues, in particular the challenges of scaling up clean energy investment in emerging market and developing economies and reforming incentives for consumers to access clean energy. These are two important aspects of just and equitable transitions, but by no means the only ones. The IEA first Global Commission on People-Centred Clean Energy Transitions in 2021 set out 12 recommendations for just and equitable transitions. The second Global Commission is currently examining how to enact the principles through good policy.

5.1 Clean energy investment

Clean energy investment

Investment in the global energy sector was around USD 2.9 trillion in 2023. The COP28 Full Implementation Case sees an increase to USD 5.2 trillion in 2035, in line with paragraph 68 of the Global Stocktake. The increased spending is focussed on clean energy, while fossil fuel capital expenditure declines across all economic categories (Figure 5.1).

Figure 5.1 ▷ Investment spending today and investment needs in the COP28 Full Implementation Case, 2023 and 2035



Clean energy investment increases in all economies, with a rapid transition in producer economies from 80% unabated fossil fuel to 90% clean energy investment

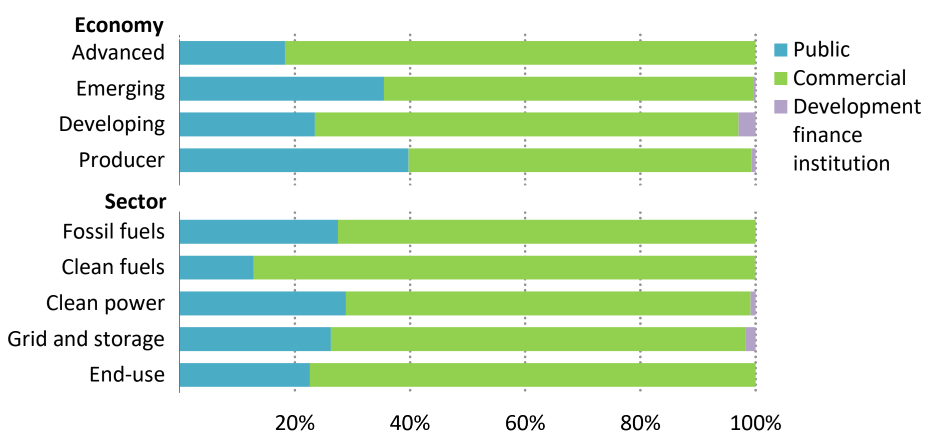
Note: MER = market exchange rate.

Advanced and emerging economies in aggregate, led by China, are the leading economies in term of energy investment today. They already have relatively high levels of clean energy investment, though their total energy investment still increases by 45% and 70% respectively by 2035 in the COP28 Full Implementation Case. Developing economies invest too little in energy today relative to their growth needs and have relatively low levels of clean energy investment. They see a tripling of investment in the COP28 Full Implementation Case compared to the current level. But the most significant transformation is in producer economies, which see a switch from 80% of energy investment for unabated fossil fuels today to almost 90% investment towards clean energy in the COP28 Full Implementation Case in 2035.

This huge increase in clean energy investment means that investment in clean power almost doubles, grid and end-use investment triples, and spending on low-emissions fuels jumps 15-fold between today and 2035 in the COP28 Full Implementation Case. End-use accounts for the largest share of energy sector investment in 2035, driven by EVs and energy efficiency in buildings. Meanwhile, investment in unabated fossil fuel supply and power decreases by almost 80%.

Currently, almost three-quarters of global energy investment is financed by commercial sources (Figure 5.2). Around 25% comes from public finance and 1% from development financial institutions. Despite its small overall share, development finance plays a crucial role in mobilising commercial finance, particularly for clean energy investment in developing economies. Public finance also plays a significant role in emerging economies: it accounted for 32% of spending between 2015 and 2023, compared with 13% in advanced economies.

Figure 5.2 ▷ Current investment by source of finance



Finance from commercial sources supports roughly 73% of overall energy investment, but public finance is also important, particularly in emerging market and producer economies

Public finance is more prominent in some parts of the energy system than others. Almost a quarter of financing for fossil fuel projects comes from public sources, primarily due to the large size of government shareholdings in national oil companies. Public actors also finance 30% of transmission projects globally, compared with 20% for distribution projects, and tend to be involved in financing nuclear power. End-use sectors see much higher shares of commercial financing at 70% for industry, 75% for buildings, and 85% for transport, though public financing in industry is widespread in certain countries where large state-owned enterprises drive industry development, such as China and Saudi Arabia. In emerging market, producer and developing economies, public institutions account for 35% of all financing in the energy sector, underscoring the significant role of state-owned enterprises, and 1% is financed by development financial institutions. In China, a remarkable 40% of financing is attributed to public finance, reflecting large public equity stakes in private corporations and state-owned enterprises.

Many emerging market and developing economies struggle to finance new projects due to rising debt levels and tight fiscal conditions. Some have seen access to external financing closed off. Large emerging economies such as Brazil, India, Indonesia, Mexico and South Africa can raise capital, but it can cost two- or three-times more than in advanced economies. The high cost of capital is one of the most important barriers to the clean energy transition in emerging market and developing economies.

Closing the financing gap will require increased international co-operation between countries and more active engagement with public and private financial stakeholders to better understand the barriers faced by different economies and the impact on the cost of capital of these risks. This would help to better target policy interventions and inform the design and prioritisation of financing instruments that can help mobilise private capital to where it is needed most. The knowledge and experience gained from successful projects could also be shared more widely with the aim of helping other countries, while more standardisation in project structuring and preparation would facilitate the development of new projects and ease due diligence processes. Stronger efforts are also needed to improve the availability and quality of data necessary for financial investors to better assess and manage risks. The provision of support for capacity building by the international community would help with this.

Concessional finance must be increased and strategically deployed to attract private capital in support of emerging market and developing economies development and climate goals. While concessional funds, e.g. guarantees, senior or sub-ordinated debt or equity, performance-based incentives, interest rate or swap cost buydowns, viability gap funding or other investment grants, are not a replacement for necessary policy actions or institutional reforms, they can effectively mobilise private capital for clean energy projects that might otherwise go unfunded. These projects may include those involving newer technologies that are not yet widely used or cost competitive in many markets, such as battery storage, offshore wind, renewables-powered desalination, or low-emissions hydrogen. It also includes projects in frontier markets with higher country and political risks, projects with large capital needs and long timelines, such as grids, or projects with foreign exchange or other macroeconomic risks that increase project costs.

To attract the required private finance for energy transitions in emerging market and developing economies outside China, it is estimated that around USD 80-100 billion of concessional finance per year will be needed by the early 2030s. These estimates account for the varying proportions of public and private financing across different economies and sectors, the specific clean energy technologies that may need concessional finance to be viable, and the differing levels of concessional finance necessary to attract private investment in various projects and country contexts.

Key policy recommendations:

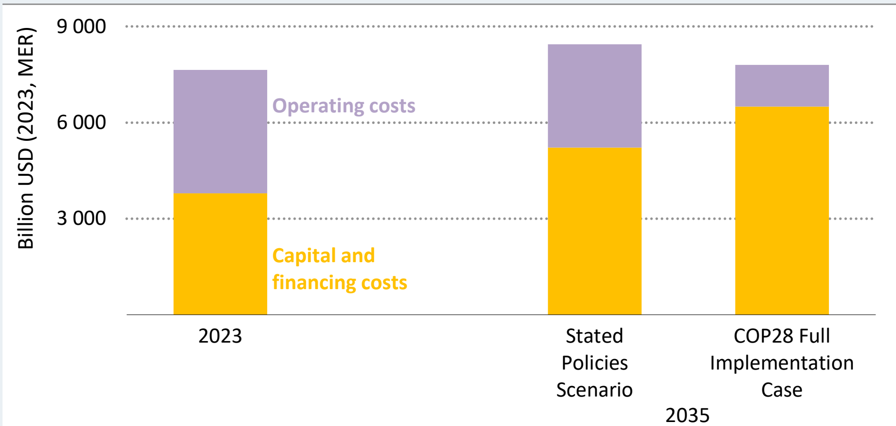
- Work with financial stakeholders to develop a better understanding of the barriers faced by various countries and their impact on the cost of capital in order to help target policy interventions more effectively.
- Support the development of a pipeline of clean energy projects in emerging market and developing economies through collaborative international efforts to standardise project structure and preparation, improve planning and implementation capacity, and provide financial support for project development.
- Improve data reliability and availability to better assess and manage risks for clean energy projects in emerging market and developing economies. Increase the availability of concessional finance and use it effectively to attract private capital to clean energy projects those economies, particularly projects involving newer technologies or taking place in riskier country contexts.
- Increase local currency financing in emerging market and developing economies.

Box 5.1 ⊳ Impact of clean energy transitions on affordability

The affordability of energy remains a key concern for consumers and governments alike. Energy bills represent a significant share of consumer spending, and they are characterised by volatility. Consumer spending on energy makes up nearly 10% of global GDP, and it was 20% higher in 2022 than the average of the preceding five years as a result of the global energy crisis. Oil price fluctuations are a particular concern since oil accounts for around 50% of consumer spending on energy worldwide. Spending on energy is also marked by inequalities. In advanced economies, the poorest decile of households spends over 20% of the disposable income on residential energy and transport fuels, compared to only 5% among the richest decile. In emerging market and developing economies, the poorest households lack access to modern energy, and few own appliances and vehicles. Furthermore, ensuring energy affordability imposes significant fiscal strain on governments. To protect consumers during the global energy crisis, governments around the world spent USD 900 billion from the start of the crisis until April 2023. Global fossil fuel subsidies in 2022 rose to USD 1.2 trillion, which is more than double the level in the preceding five years.

Scaling up clean energy can improve the affordability of energy for consumers. In the COP28 Full Implementation Case, the cost of delivering energy is 8% lower in 2035 than in the STEPS (Figure 5.3). There is a 70% increase in capital recovery and financing costs arising from increased clean energy investment, but this is more than offset by the benefits that increased clean energy use brings in the form of reduced spending on oil, gas and coal, and the lower operating costs associated with clean energy. Despite higher upfront costs, several clean energy technologies are already more cost competitive than comparable emissions-intensive technologies over their lifetime. For example, electric two-wheel vehicles cost less over their lifetime than petrol or diesel two-wheelers in emerging market economies, and thermal efficiency retrofits in buildings in advanced economies often more than pay for themselves through energy savings. The COP28 Full Implementation Case also reduces volatility of consumer energy bills and in the cost of government fossil fuel subsidies as the share of fossil fuels in energy delivery costs is cut 15% by 2035, down from 65% today.

Figure 5.3 ▷ Total energy delivery costs by scenario, 2023 and 2035



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Costs to deliver energy to consumers are lower in the COP28 Full Implementation Case compared with the STEPS in 2035 due to lower operating costs

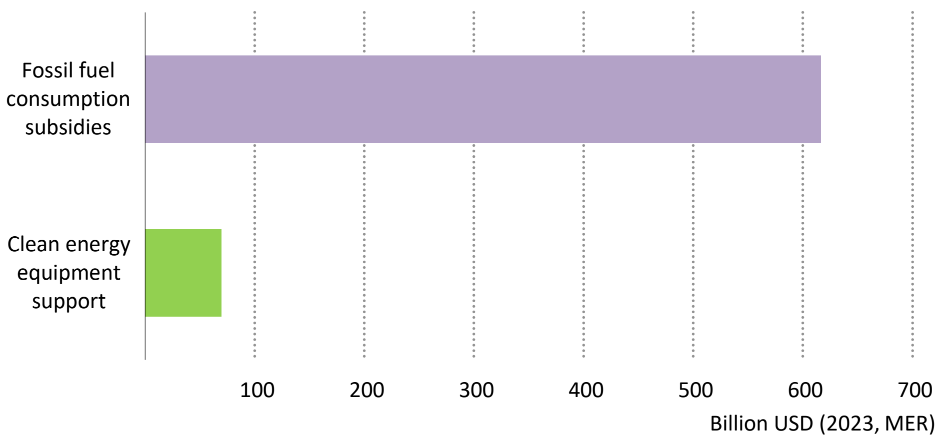
Note: MER = market exchange rate.

While the cost of delivering energy is lower in the COP28 Full Implementation Case than in the STEPS, the benefits depend on putting in place the right measures to support clean energy and spread its impact widely through society. It is vital in this context to ensure that market design, financing and regulation provide a level playing field for clean energy, and that policy interventions help the most vulnerable consumers to overcome the hurdle of higher upfront investment associated with some clean energy technologies. The IEA special report, *Strategies for Affordable and Fair Clean Energy Transitions* (IEA, 2024h), discusses the various dimensions of affordability and provides guidance on ensuring equitable and affordable clean energy transitions.

5.2 Subsidy removal and affordability

In the past five years, governments around the world have spent an average of over USD 600 billion every year on fossil fuel consumption subsidies. As fossil fuels are globally traded commodities susceptible to supply shocks, their prices are inherently volatile, which has led to considerable fluctuations in the cost of subsidies. In 2022, as the global energy crisis unfolded, fossil fuel consumption subsidies approached USD 1.2 trillion, or more than 1% of global GDP, putting acute strains on government budgets.[6] Government support for clean energy consumption is only a fraction of fossil fuel consumption subsidies: in 2023, it was only one-tenth of the latter (Figure 5.4).

Figure 5.4 ▷ Global fossil fuel consumption subsidies and clean energy equipment support to consumers, 2023



Global government support to purchase clean energy equipment in 2023 was only one-tenth of the amount spent on subsidising fossil fuel consumption

Note: MER = market exchange rate.

Fossil fuel subsidies are usually intended to make energy more affordable for households that might otherwise struggle with the cost. However, they come at considerable economic and environmental costs. Such subsidies can encourage wasteful consumption and reduce incentives to invest in technologies that make energy use more efficient. They also make cleaner energy sources less competitive by distorting markets and artificially keeping fossil fuel prices low. Fossil fuel subsidies therefore lock in inefficient technologies that rely on

[6] The IEA uses a price-gap approach to calculate fossil fuel subsidies. It compares average end-user prices paid by consumers with reference prices that correspond to the full cost of supply. Other institutions may have different methodologies. For example, the International Monetary Fund IMF) estimates fossil fuel subsidies of USD 7 trillion in 2022 by including implicit subsides as well, which include external costs such as the contribution to climate change and local health damages through local air pollutants (IMF, 2023).

fossil fuels, leading to higher GHG emissions and air pollutants. Moreover, only a small share of fossil fuel subsidies benefits low-income households, making them an inefficient way of supporting energy affordability. Subsidies also lead to continued fossil fuel import dependence in some consuming countries and strain government budgets.

In this context, the phasing out of fossil fuel subsidies, accompanied by measures in parallel to ensure that vulnerable households receive affordability support for clean energy, would bring multiple benefits. In particular, the Intergovernmental Panel on Climate Change (IPCC) reports that phasing out fossil fuel subsidies would lead to a global GHG emissions reduction of up to 10% by 2030 (IPCC, 2022). However, as of November 2023, only 4% of the NDCs mention the phase-out of fossil fuel subsidies (UNFCCC, 2023).

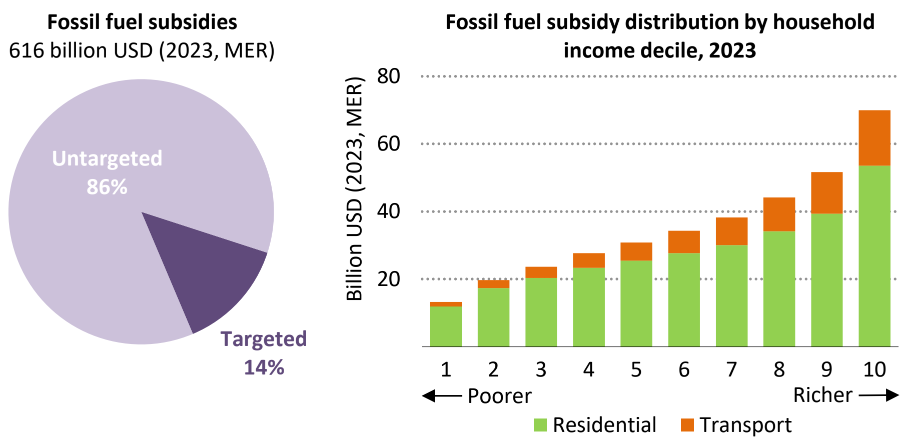
At COP28, parties agreed to the phase-out of "inefficient fossil fuel subsidies that do not address energy poverty or just transitions, as soon as possible". There is no consensus on exactly what "inefficient" means in this context. However, there have been a few attempts to define it elsewhere. For example, the Government of Canada considers energy subsidies inefficient if they do not meet one of six criteria that include, e.g. enabling GHG emissions reductions, supporting clean energy and supporting abated production processes or projects that have a credible plan to achieve net zero emissions by 2030 (Government of Canada, 2023).

Understanding the contours of inefficient fossil fuel subsidies

There are at least two points that indicate that most fossil fuel subsidies are inefficient in the context of the COP28 outcome, which focusses on addressing energy poverty and facilitating just transitions. First, only 14% of the USD 616 billion that was spent to subsidise fossil fuel consumption in 2023 was targeted at uses related to lower income groups, such as agriculture or household LPG use. Second, the poorest 20% of households by income received only around 10% of all residential and transport fossil fuel consumption subsidies globally in 2023, while the richest 30% of households received half of these subsidies (Figure 5.5). This suggests that many fossil fuel consumption subsidies could be phased out while protecting vulnerable households through targeted subsidies for low-income households and specific uses. With better targeting, we estimate that over 85% of current fossil fuel consumption subsidies could be gradually removed while maintaining financial support for agriculture and households consuming liquified petroleum gas (LPG) and kerosene for cooking and lighting.

If energy transitions progress on a path consistent with the full implementation of the CO28 outcome, the share of fossil fuels in energy spending by consumers is set to drop from 60% today to around 30% by 2035. In parallel, the share of electricity in spending is set to rise gradually from nearly 35% today to around 55% by 2035. Ultimately, a clean energy system is more efficient and cheaper to run than a fossil fuel system (Box 5.1). The phase-out of fossil fuel consumption subsidies would help to speed up clean energy transitions, and thus improve energy affordability for consumers, while also reducing fiscal burdens.

Figure 5.5 ⊳ Global fossil fuel consumption subsidies and distribution of subsidies by household income deciles, 2023



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Only 14% of fossil fuel consumption subsidies are targeted, and the poorest two income deciles of households receive only 10% of residential and transport fossil fuel subsidies

Notes: MER = market exchange rate. Targeted subsidies include subsidies to the agricultural sector, and LPG and kerosene subsidies to households. In the analysis of fossil fuel subsidies by household income decile, only residential and passenger transport fuel subsidies are included. Fossil fuel subsidies to industry, freight transport and other sectors are excluded in this distributional analysis.

Key policy recommendations:

- Facilitate the identification of households by the collection of appropriate data to ensure that subsidies are targeted at only those consumers that need them, and only for those fuels that address energy poverty and access concerns. The support could take the form of direct payments to targeted consumers rather than blanket economy-wide fossil fuel subsidies.
- While emergency relief might be needed to help consumers cope with an energy price shock or broader energy crisis, mechanisms should be built in to ensure relief measures are phased out when the crisis has abated.
- Direct spending for structural changes that protect consumers from fossil fuel price spikes and ensure predictable energy bills. Towards this goal, reorient subsidies to support the adoption of clean energy goods and services, including super-efficient appliances, clean mobility and distributed renewables, especially among vulnerable households.

6 Integrate the COP28 outcome into NDCs and net zero emissions strategies

The COP28 outcome recalled previous decisions taken under the Paris Agreement including:

- Parties shall submit their next NDCs at least 9 to 12 months in advance of November 2025 (paragraph 166).
- Parties shall provide information on how the preparation of their NDCs has been informed by the outcomes of the Global Stocktake (paragraph 169).
- Parties are encouraged to come forward in their next NDCs with ambitious, economy-wide emissions reduction targets, covering all greenhouse gases, sectors and categories and aligned with limiting global warming to 1.5 °C (paragraph 38).

If implemented comprehensively along the lines of the COP28 Full Implementation Case, the energy sector goals contained in the COP28 outcome would deliver an ambitious course correction. Doing so would put energy-related emissions into a steep decline by 2030 and set the stage for ambitious NDCs to 2035. The objective of this section is to analyse how countries can build on a robust implementation of the COP28 goals and integrate them into their next round of NDCs.

6.1 Energy-related emissions benchmarks in line with the COP28 outcome

The COP28 outcome called for "accelerating efforts globally towards net zero emissions energy systems well before or by around mid-century". This overarching goal of net zero energy sector emissions by 2050 is a key driver of the COP28 Full Implementation Case presented in this report. The key quantified targets of the COP28 outcome – tripling renewables and doubling energy efficiency – would go a long way to achieving these immediate emissions reductions (see Figure 3.1), if implemented comprehensively with appropriate enabling policies. In the COP28 Full Implementation Case, global energy sector emissions fall by 30% by 2030 and 60% by 2035.

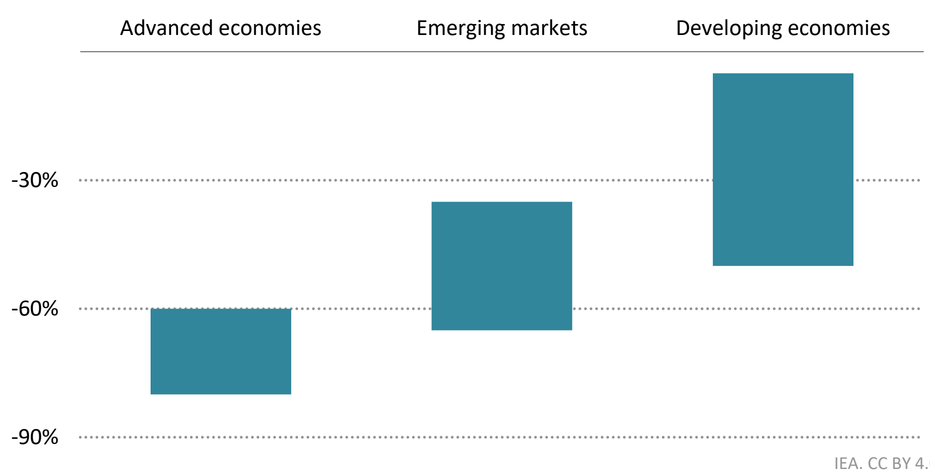
However, equity considerations are important when translating the COP28 global calls into NDCs and long-term strategies. Countries have various starting points and will have different pathways (Figure 6.1). Furthermore, national net zero emissions pledges collectively have a lower level of ambition than the COP28 outcome, leading to global emissions of around 12 Gt in 2050 and warming of around 1.7 °C by 2100. NDCs aligned with the COP28 outcome or national net zero emissions pledges would see emissions reductions by 2035 relative to the 2022 level within the following ranges for various groups of economies, with the higher end of the range aligned with net zero emissions by 2050 and pathways to 1.5 °C:

- Advanced economies as a group have a GDP per capita of around USD 57 000 at 2023 purchasing power parity (PPP) and energy-related GHG emissions per capita of around 8.3 tonnes CO_2 equivalent (CO_2-eq) per capita. They reduce their energy-related GHG emissions by around 80% by 2035 in the COP28 Full Implementation Case and about 60% in pathways aligned with their net zero emissions pledges.

- Emerging market countries as a group have a GDP per capita of around USD 21 000 PPP and energy-related GHG emissions of around 7.0 tonnes CO_2-eq per capita. They reduce their energy-related GHG emissions by 65% by 2035 in the COP28 Full Implementation Case, and 35% in pathways aligned with net zero emissions pledges.
- Developing economies as a group have a GDP per capita of around USD 7 500 PPP per capita and CO_2 emissions that are a fraction of the world average at only 1.4 tonnes CO_2-eq per capita. They reduce their emissions by more than 50% by 2035 in the COP28 Full Implementation, a transition requiring a dramatic scale up of international support including finance (see Section 5.1). Pathways aligned with this group's net zero emissions pledges reduce their emissions by around 5% by 2035.

These COP28 aligned benchmarks imply a dramatic acceleration of mitigation action compared with the level implied by the current round of NDCs for 2030 for each of the main economic groups.

Figure 6.1 ▹ Energy sector GHG emissions pathways relative to 2022 consistent with the COP28 Full Implementation Case to 2035

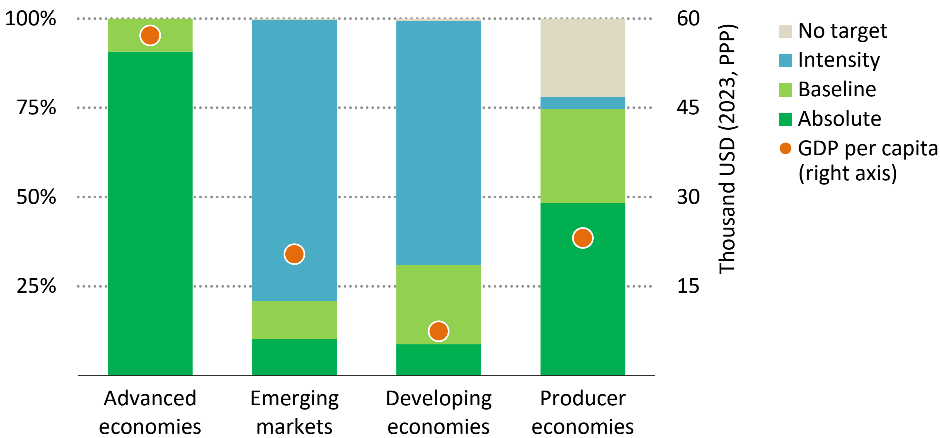


Advanced economies lead the path on overall GHG mitigation, closely followed by emerging markets

6.2 Integrating COP28 goals into NDC design for climate clarity, implementation and investment certainty

The COP28 outcome calls on all countries to adopt economy-wide reduction targets covering all sectors and all GHGs. Such targets are necessary to provide clarity about the level of ambition of NDCs in aggregate, and what those NDCs imply for future emissions. In the first round, a number of countries submitted NDCs with only partial sectoral and GHG coverage and avoided absolute targets (Figure 6.2). For the next round of NDCs, it is critical that major economies submit economy-wide, absolute targets.

Figure 6.2 ▷ Emissions covered by various types of NDCs and GDP per capita by economic grouping



The next round of NDCs should prioritise transparency, comprehensiveness and absolute emissions reduction targets across all GHGs and all sectors

Note: NDCs = Nationally Determined Contributions; GDP = gross domestic product; PPP = purchasing power parity.

Although the primary purpose of NDCs is to provide a clear indication of the overall level of ambition in the countries that provide them and the scale and timing of their contribution to global efforts to reduce emissions, they can also provide important signals on priorities for implementation and investment. These signals have a direct relationship with the actual changes needed in energy systems to achieve a given level of emissions reductions and are therefore valuable for policy makers, investors, technology developers and project planners. They can thus help to orient market expectations, anchor domestic policies and contribute to investor certainty, even if investors are primarily motivated by concrete incentives coming from domestic policy frameworks. NDCs therefore could be designed around headline targets for climate clarity and co-operation, underpinned by a brief description of implementation and investment priorities. For the energy sector, the framework given by the COP28 goals set out in paragraph 28 provide a good starting point.

The COP28 Full Implementation Case is intended to provide guidance on COP28 aligned benchmarks (Table 6.1). The main outlines are clear. By 2035, the electricity sector needs to be well on the way to full decarbonisation, with renewables reaching over three-quarters of global generation. Energy efficiency needs to remain a key priority, with the rate of annual improvement enduring at about 4% per year to 2035. Global energy sector methane emissions need to fall by around 90% by 2035.

Table 6.1 ⊳ Key global energy sector transformations in the COP28 Full Implementation Case, 2035

	2035	Change from 2023
§28 (a) tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030		
Global renewable energy capacity	19 150 GW	× 5
Share of renewables in total generation	78%	+ 48 pp
Share of electricity in total final consumption	36%	+ 15pp
Improvement in global energy efficiency	4.2%	+ 3.2 pp
§28 (b) accelerating efforts towards the phase-down of unabated coal power		
Electricity generation from unabated coal	1 550 TWh	÷ 7
§28 (c) accelerating efforts globally towards net zero emissions energy systems, utilising zero- and low-carbon fuels well before or by around mid-century		
Energy sector CO_2 emissions	13.5 Gt	÷ 3
§28 (d) transitioning away from fossil fuels in energy systems …		
Fossil fuel demand	240 EJ	÷ 2
Investment in fossil fuels	USD 265 billion	÷ 4
…in a just…		
Clean energy investment in EMDE	USD 2.9 trillion	× 3
… of which EMDE outside China	USD 1.8 trillion	× 7
…orderly …		
Ratio between fossil fuels investment and clean energy	1:19	-
…and equitable manner		
Share of global population with access to clean cooking	100%	+ 25 pp
Share of global population with access to electricity	100%	+ 9 pp
§28 (e) accelerating zero- and low-emissions technologies, including, *inter alia*, renewables, nuclear, abatement and removal technologies such as carbon capture, utilisation and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production		
CO_2 emissions captured	2.5 Gt	× 63
Low-emissions hydrogen production	18.2 EJ	× 258
Nuclear installed capacity	750 GW	× 2
Liquid biofuel production	13.4 EJ	× 3
§28 (f) accelerating and substantially reducing non-carbon-dioxide emissions globally, particularly methane emissions by 2030		
Energy sector methane emissions (CO_2-eq)	640 Mt	÷ 6
§28 (g) accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero and low-emissions vehicles		
Road transport CO_2 emissions	2.9 Gt	÷ 2
Electric cars share in sales	99%	+ 81 pp

Note: § = paragraph - here related to the COP28 outcome; GW = gigawatt; pp = percentage point; TWh = terawatt-hour; Gt = gigatonne; EJ = exajoule; EMDE = emerging market and developing economies; CO_2-eq = carbon-dioxide equivalent.

However, much depends on taking a comprehensive and holistic approach, as the COP28 Full Implementation Case shows. Moreover, as the energy transition progresses, the pace of change quickens, and priorities evolve. As they design their NDCs and implementation strategies, governments should consider how to take due account of this. For example, although electrification with technologies like EVs and heat pumps is already an important strategy, its pace accelerates after 2030. Between today and 2030, the share of electricity in total final consumption worldwide increases by 1.1 percentage point per year in the COP28 Full Implementation Case: this accelerates to 1.5 percentage points per year between 2030 and 2035. Achieving this requires further electrification of end-uses such as industrial heat and heavy-duty road transportation. Low-emissions fuels and CCUS increase in importance after 2030, and this is reflected in a jump in the production of low-emissions hydrogen from around 7 EJ in 2030 to around 18 EJ in 2035. Similarly, total CO_2 captured more than doubles at the global level from 2030 to 2035. Direct air capture provides a climate-neutral carbon feedstock for fuels or permanently removes CO_2 from the atmosphere, and this technology increases by around three-times in the period 2030-35.

6.3 Next steps for multilateral engagement

The COP28 energy outcome sets out a series of goals to achieve net zero emissions in the energy sector by mid-century consistent with a 1.5 °C pathway. Through the COP28 Full Implementation Case, this report identifies key milestones along the road to achieving these goals and provides guidance on the actions needed to inform national pathways and spur the international co-operation needed to advance these global goals.

There is a major opportunity for multilateral fora – particularly the COP, but also the G7 and G20 – to drive the policy co-operation and co-ordination necessary to achieve full and timely implementation of the COP28 energy goals. The COP29 meeting in Baku in November 2024 could play a significant part by setting new 1.5 °C aligned targets for key enabling factors to help achieve the COP28 energy goals, such as targets for electricity grids and storage that are crucial to triple renewables capacity by 2030. For emerging market and developing economies to be able to implement the COP28 energy goals, the agreement at COP29 of a New Quantified Collective Goal on climate finance that increases the quantum and quality of financial support available will also be critical. And the road from Canada's G7 Presidency to South Africa's G20 Presidency and Brazil's hosting of COP30 provide key opportunities in 2025 for countries and international partners to work towards strong consensus and action on how to implement the transition away from fossil fuels in a just, orderly and equitable manner.

In addition to setting new targets, international co-operation and multilateral processes can help to ensure that the global targets already agreed are being implemented. The tracking of progress towards the COP28 energy outcome that is being carried out by the IEA, the UNFCCC and other organisations can be used in multilateral fora to take stock of individual country and overall global action, and to identify best practice examples of policy and implementation. Multilateral co-operation can also provide the technical and financial assistance necessary to develop policy and financing packages to facilitate faster implementation of the COP28 energy goals. This could take the form of co-ordinated policies to send clear market signals, building on the work of the Climate Club and the IEA Technology Collaboration Programme network; joint innovation, development and testing of new technologies, building on what Mission Innovation is doing; creation of common standards, where the G7 and the Clean Energy Ministerial have shown the way on specific technologies; and collectively improving the offer of technical and financial assistance to enable a wider deployment of solutions to a wider range of countries.

Box 6.1 ▷ Opportunities for new multilateral commitments and quantified global goals

At COP29 in late 2024, new commitments and quantified global goals for 2030 and beyond could be agreed by Parties on:

Power system flexibility

- Electricity grids: Build and modernise 25 million km of grids by 2030 and around 55 million by 2035, compared to current levels.
- Energy storage: Put in place 1 500 GW of global energy storage capacity in the power sector by 2030 and achieve global annual investment of at least USD 150 billion in energy storage technologies by the same year.

Electrification

- Increase the share of electricity in total final consumption to around 30% by 2030 and around 35% by 2035 ("30 by 30 and 35 by 35").

Clean energy investment

- Triple clean energy investment in emerging market and developing economies to USD 2.7 trillion per year by the early 2030s.
- Agree that development financial institutions should strengthen their focus on de-risking solutions and set higher targets for private capital mobilisation in emerging market and developing economies.

Nationally Determined Contributions

- All countries to commit to include headline targets in line with the COP28 energy goals.
- All major economies to agree to submit economy-wide, absolute emissions reduction targets.
- All G20 countries to agree to submit new NDCs that are aligned with 1.5 °C pathways and contribute to the absolute peaking of global GHGs emissions

Looking ahead to COP30 in 2025, additional opportunities for new commitments and global goals could include:

Transition away from fossil fuels

- Definitions of just, orderly and equitable energy transitions.
- Definition of inefficient fossil fuel subsidies.
- Further elaboration of the objective of transitioning away from fossil fuels, including specifying that it entails an absolute reduction in demand in line with a pathway to net zero emissions by 2050.

Sustainable fuels

- Quantified goals for sustainable fuels (including modern liquid biofuels and low-emissions hydrogen-based fuels) and agreement of sustainability criteria.

Transport

- International co-operation to achieve a share of new sales of electric road passenger light duty vehicles of around 70% by 2030 and almost 100% by 2035.

Government of Canada (2023), Inefficient Fossil Fuel Subsidies: Government of Canada - Self-Review Assessment Framework, https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/inefficient-fossil-fuel-subsidies/assessment-framework.html

IEA (International Energy Agency) (forthcoming), Global Hydrogen Review 2024

IEA (2024a), COP28: Tracking the Energy Outcomes, https://www.iea.org/topics/cop28-tracking-the-energy-outcomes

IEA (2024b), Clean Energy Market Monitor – March 2024, https://www.iea.org/reports/clean-energy-market-monitor-march-2024

IEA (2024c), Advancing Clean Energy Manufacturing, https://www.iea.org/reports/advancing-clean-technology-manufacturing

IEA (2024d), Integrating wind and solar 2024, https://www.iea.org/reports/integrating-solar-and-wind

IEA (2024e), Batteries and Secure Energy Transitions, https://www.iea.org/reports/batteries-and-secure-energy-transitions

IEA (2024f), Managing the Seasonal Variability of Electricity Demand and Supply, https://www.iea.org/reports/managing-the-seasonal-variability-of-electricity-demand-and-supply

IEA (2024g), CCUS Projects Database, accessed September 2024, https://www.iea.org/data-and-statistics/data-product/ccus-projects-database

IEA (2024h), Strategies for Affordable and Fair Clean Energy Transitions, https://www.iea.org/reports/strategies-for-affordable-and-fair-clean-energy-transitions

IEA (2023a), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach

IEA (2023b), Scaling Up Private Finance for Clean Energy in Emerging and Developing Economies, https://www.iea.org/reports/scaling-up-private-finance-for-clean-energy-in-emerging-and-developing-economies

IEA (2023c), A Vision for Clean Cooking Access for All, https://www.iea.org/reports/a-vision-for-clean-cooking-access-for-all

IEA (2022), Nuclear Power and Secure Energy Transitions, https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions

IMF (International Monetary Fund) (2023), Fossil Fuel Subsidies, https://www.imf.org/en/Topics/climate-change/energy-subsidies

IPCC (Intergovernmental Panel on Climate Change) (2023), Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report. Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/sixth-assessment-report-cycle/

IPCC (2022), Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/ar6/wg3/

UNFCCC (United Nations Framework Convention on Climate Change) (2023), Nationally Determined Contributions under the Paris Agreement, Synthesis report by the Secretariat, https://unfccc.int/documents/632334

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Typeset in France by IEA - September 2024
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From Taking Stock to Taking Action

World Energy Outlook Special Report

This paper analyses the outcomes of the COP28 climate conference held in December 2023, where 200 countries agreed on ambitious global energy transition goals. These goals include achieving net zero emissions in the energy sector by 2050, transitioning away from fossil fuels, tripling global renewable energy capacity by 2030, doubling energy efficiency improvement rates, and accelerating the deployment of other low-emissions technologies. The paper examines the potential impact of these goals on the global energy system and emissions, if fully implemented.

The analysis explores the risks of partial implementation and discusses how countries can integrate the COP28 goals into their next round of targets under the Paris Agreement. It emphasises the importance of translating these goals into domestic energy policies. The paper also addresses the challenges in clean energy investment, the critical role of the next round of national emissions targets, and the importance of continued multilateral cooperation in driving implementation of the COP28 goals.