Navigating Energy Transitions

Mapping the road to 1.5°C

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Executive Summary

Key Messages:

- **According to a large consensus across multiple modelled climate and energy pathways, developing any new oil and gas fields is incompatible with limiting warming to 1.5°C.** Global oil and gas production and consumption must decrease by at least 65% by 2050.
- **Governments should create enabling environments for redirecting both public and private capital flows toward the clean energy transition, including the deployment of additional solar and wind capacity.** The annual investment gap for the required wind and solar deployment amounts to USD 450 billion until 2030. Forecasts indicate that up to USD 570 billion will be spent every year in new oil and gas development and exploration during the same period.
- **There is no room for new fossil import infrastructure in Europe in 1.5°C-aligned gas phase-out pathways.** Existing import capacity can meet the gas demand for Europe in the medium- and longer-term. In 2022 and 2023, the short-term supply crunch and its potentially dire consequences cannot be alleviated in time by newly added gas capacity.

This report aims to inform policy-makers, investors, and companies on what is required to align their energy decisions with the goals of the Paris Agreement, based on modelled pathways consistent with limiting warming to 1.5°C. We base this analysis on the first-ever comparison of selected climate and energy scenarios across the full body of published global modelled pathways: those reviewed by the Intergovernmental Panel on Climate Change (IPCC), those produced by intergovernmental organizations such as the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), and by the private sector.

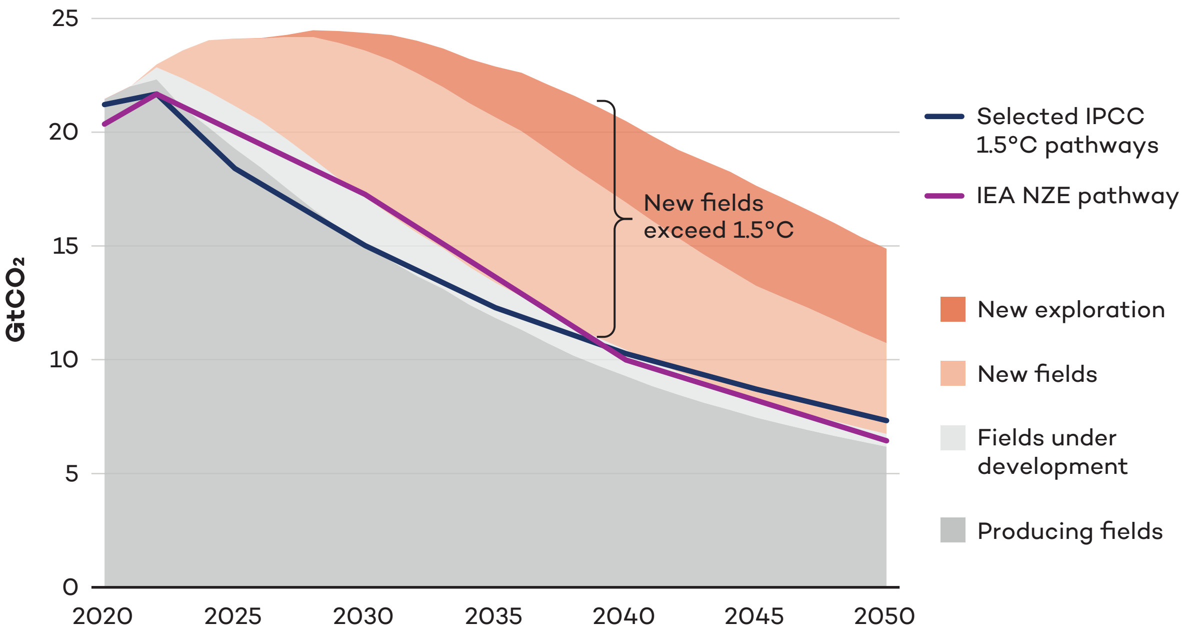
The report focuses on pathways for the phase-out of oil and gas, and for the expansion of wind and solar, required to provide a greater than 50% probability of limiting global temperatures within the 1.5°C limit. We do not address coal, because Paris-aligned pathways for coal phaseout have been extensively reviewed elsewhere (Yanguas Parra et al., 2019). Moreover, we focus on wind and solar energy since they provide the most greenhouse gas mitigation potential at the lowest cost from all currently available options in all sectors (IPCC, 2022). We find a high degree of alignment between scenarios, suggesting that a common set of actions is required. The small variations found across scenarios illustrate that there is still a range of paths to implement this set of actions in line with the 1.5°C target. Now more than ever, understanding how energy decisions by policy-makers, investors, and companies affect our ability to comply with this target is essential. The current energy crisis poses substantial risks to the achievement of a clean energy transition, but also shows the value of shifting our energy systems from fossil fuels to clean energy.

Phase-out Pathways for Oil and Gas Production

Our comparison of multiple climate and energy scenarios finds that, for the world to reach net-zero emissions in line with the 1.5°C target, global oil and gas production needs to decline rapidly.

According to the median of selected IPCC scenarios and the IEA's Net Zero Emissions by 2050 (NZE) scenario, oil and gas production should decline respectively by 15% and 30% by 2030, and by 65% by 2050, compared to 2020 levels. Production volumes from already-operating fields and those currently under development would generate more oil and gas emissions than would be permissible under these pathways (Figure ES1). It implies that no new oil and gas fields should be developed, as they would either generate stranded assets, or push the world beyond the 1.5°C target, unless currently producing fields' operations are significantly curtailed.

Figure ES 1. Global oil and gas production, based on selected IPCC and IEA 1.5°C pathways

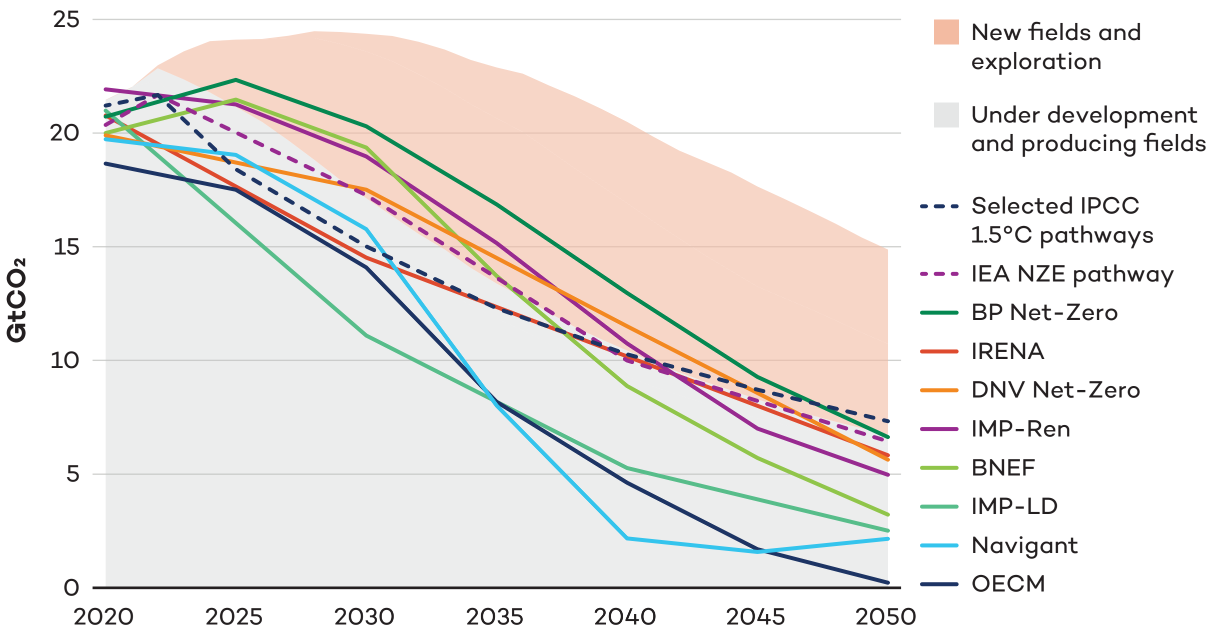


Sources: Byers et al., (2022); IEA (2021); Rystad Energy (2022b).

All other analyzed pathways—the illustrative mitigation pathway high renewables (IMP-Ren) scenario, the Bloomberg New Energy Finance New Energy Outlook pathway, the IPCC IMP low demand (IMP-LD) scenario, the One Earth Climate Model, Navigant, and the IRENA World Energy Transitions Outlook scenario—reinforce the findings of the selected IPCC scenarios and IEA's NZE scenario. They point to the urgent need for production to decline by at least 65% between now and 2050, with small variations in the steepness of production decline rates. Since oil and gas consumption needs to decline at roughly the same pace as forecasted production from existing fields, these scenarios bear similar implications to the

IPCC scenario and IEA's NZE scenario: in order to align with the 1.5°C goal, no new fields should be opened (Figure ES2).

Figure ES 2. Global oil and gas production, based on other selected 1.5°C pathways

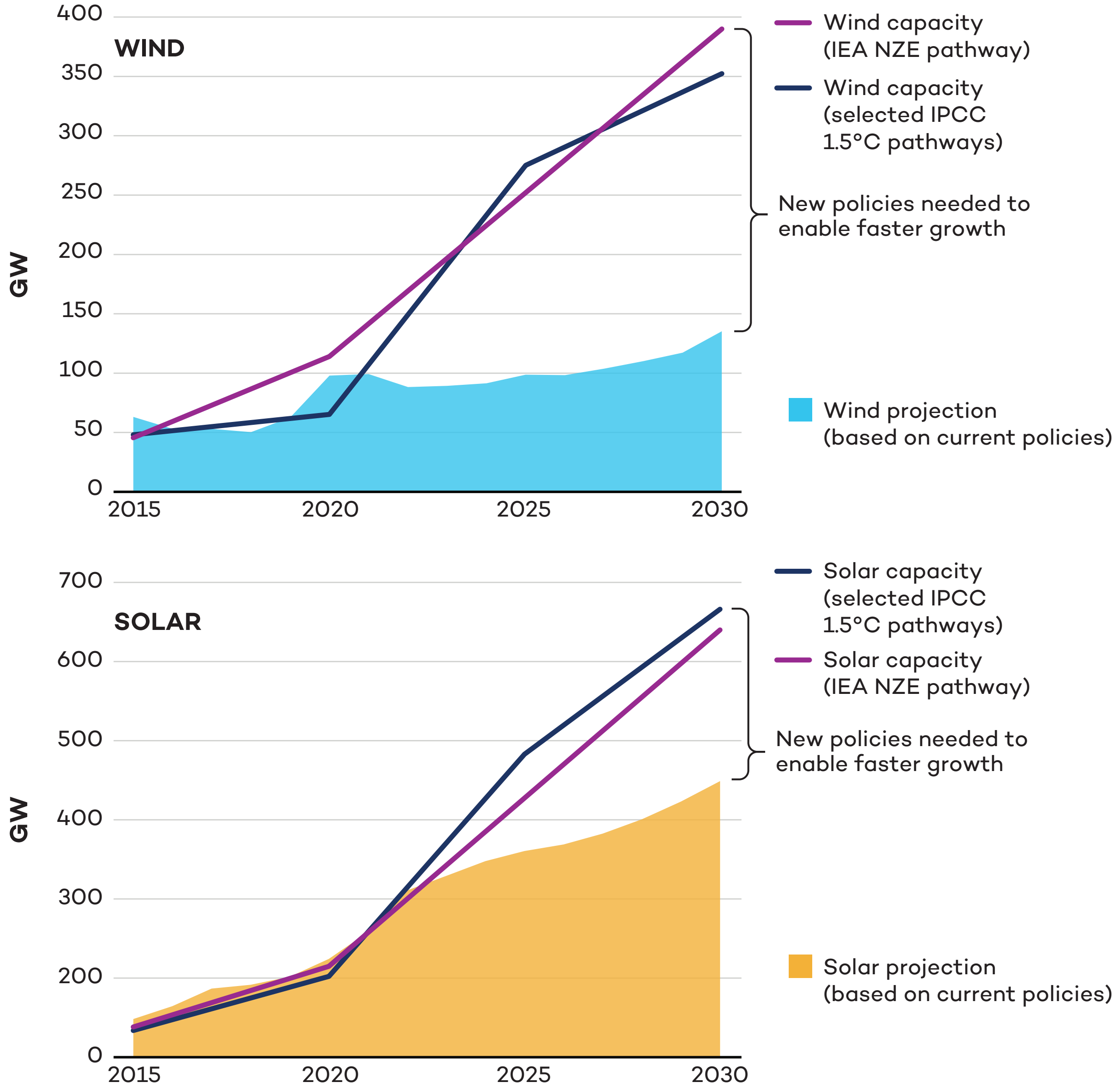


Sources: BNEF (2021); BP (2022); Byers et al., (2022); DNV (2021) ; IRENA (2022); Navigant (2018); Rystad Energy (2022b); Teske et al., (2022).

Development Pathways for Wind and Solar Capacity

Enabling a structural shift in the energy sector in line with 1.5°C pathways will require significantly scaling up the annual rate of renewable technology deployment. Our report finds that policies currently deployed in support of renewable energy fall short of these objectives: according to the selected IPCC scenarios and IEA's NZE scenario, by 2030, annual capacity additions should be at least 2.5 times higher for wind and 1.5 times higher for solar energy compared to current policy forecasts (Figure ES3). All other analyzed scenarios broadly confirm the need to rapidly add far more wind and solar capacity than planned, and generally point to even higher required rates of deployment for the two technologies.

Figure ES 3. Annual wind and solar capacity additions under selected IPCC and IEA 1.5°C pathways



Sources: BNEF (2022); Byers et al., (2022); IEA (2022).

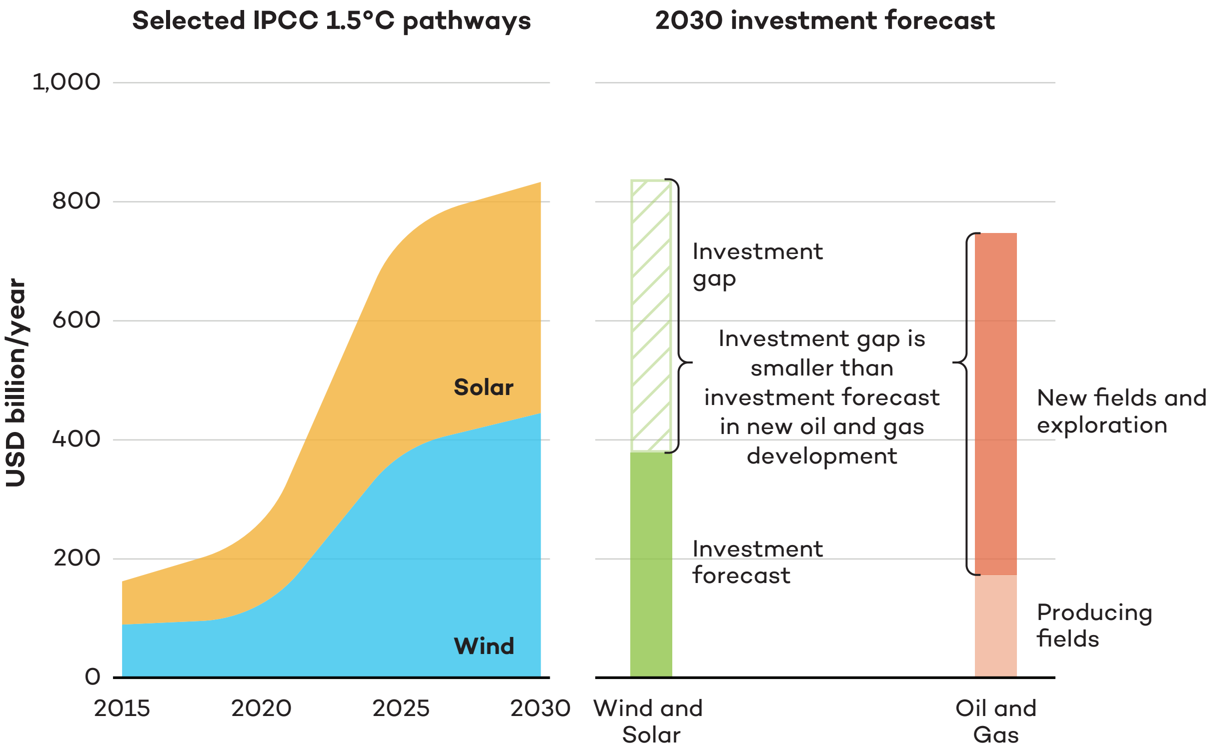
Financing Solar and Wind Deployment: The investment gap

All analyzed scenarios point the need to massively increase wind and solar capacities in order to effectively displace oil and gas production. To achieve this, investments in renewables will need to increase rapidly during the course of this decade.

Our selection of IPCC 1.5°C pathways shows that, between now and 2030, total annual investments in both wind and solar should amount to about USD 830 billion. Current investment plans do not come close to such amounts. Unless new policies are implemented, there will be an annual investment gap of more than USD 450 billion until 2030.

However, estimates show that capital and operational expenditures for the exploration and extraction of oil and gas in new fields—incompatible with IPCC, IEA 1.5°C pathways, and our broader selection of scenarios—are expected to reach USD 570 billion annually by 2030, for a cumulative total of USD 4.2 trillion between 2020 and 2030 (Figure ES4). By themselves, these investments would suffice to bridge the entire investment gap for wind and solar by 2030.

Figure ES 4. Wind and solar investment needs and investment gaps



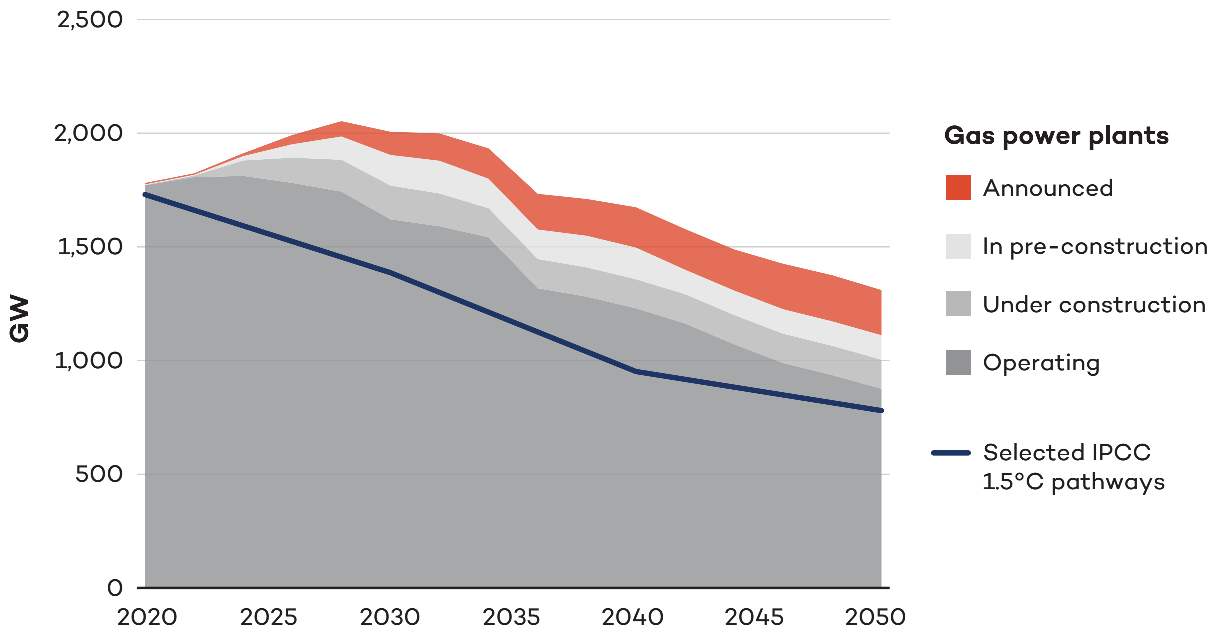
Sources: Byers et al. (2022); Rystad Energy (2022b)

The War in Ukraine and its Implications for Energy Systems

In 2022, the energy market disruptions due to the Russian invasion of Ukraine and the consequent economic sanctions on Russia have strained global gas supplies. They bring questions on the present and future role of gas in energy and power systems to the forefront of policy discussions. Yet the replacement of gas with clean power generation alternatives is an important step in achieving oil and gas production levels that are compatible with a 1.5°C future.

Our report finds that global gas power generation capacity should decrease by more than 55% by 2035 compared to 2020 levels. Currently forecasted generation from gas power plants already in operation, in construction, or being planned, is expected to deliver more generation capacity than would be consistent with the Paris Agreement throughout the forthcoming decades (Figure ES5). Therefore, the construction of new gas-fired power plants risks leading to a dangerously high number of stranded assets.

Figure ES 5. Global gas power capacity

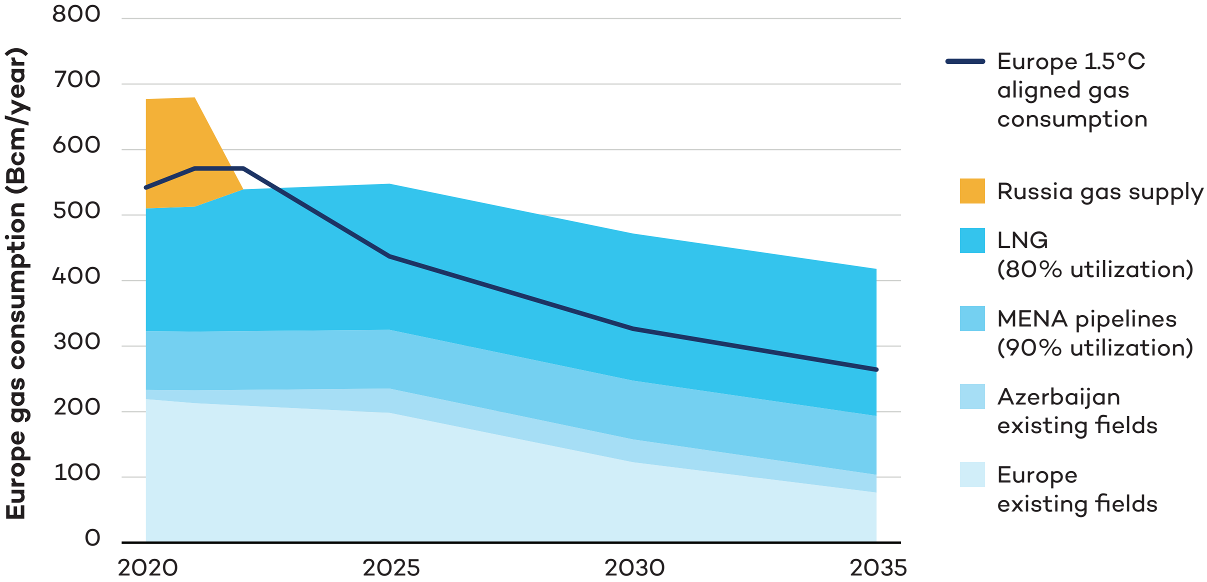


Source: Byers et al. (2022); Global Energy Monitor (2022).

In Europe, the shortage of gas supply has so far pushed policy-makers to accelerate the transition to renewable energies, on the one hand, and to pursue alternative gas supplies, on the other. Based on the selected IPCC pathways, our report finds that existing global import capacity could meet medium- and long-term European demand without Russian imports, if Europe were to reduce gas consumption in line with the 1.5°C target (Figure ES6). The potential supply crunch in 2022 and 2023 could have dire consequences, but new gas supply infrastructure will not come online in time to address it adequately. Not only can Europe meet its energy needs by reducing dependence on Russian gas supply through accelerating renewable energy, energy efficiency and electrification, it must do so to align with 1.5°C pathways.

The European gas crunch has also prompted a global dash for gas, which is incompatible with the timely achievement of an energy transition compatible with the 1.5°C target. As such, the impacts of the energy crisis may also be considerable in developing countries, especially those with exploitable gas reserves. They may face higher risks of stranded assets once the European dash for gas has reached its peak. It is therefore essential that developing countries continue to pursue 1.5°C-compatible transition pathways, and leapfrog from current fossil-based energy paradigms to clean energy sources that can guarantee a more sustainable and secure energy future. It requires dedicated policies to foster capacity building and infrastructure development, and support of donor countries and international financial institutions through adequate streams of climate finance.

Figure ES 6. Europe gas consumption and supply



Source: Author's calculations, based on BP (2022b); Byers et al. (2022); Global Energy Monitor (2022a); Rystad Energy (2022b); European Commission (2022c)

The Private Sector and the Energy Transition

Phasing out oil and gas production and deploying wind and solar capacities in line with the 1.5°C target requires concerted efforts from public and private actors alike. In this report, we have taken a closer look at two key areas where the private sector can positively contribute to the transition, and where governments can play an enabling role.

Governments must act promptly to prevent the licensing of new oil and gas fields. Currently, considerable barriers exist to governments' ability to do so without incurring the risk of legal action. If governments were to cancel all upstream oil and gas projects by 2050 in line with IEA's NZE scenario, our report finds that they might risk an aggregate USD 234 billion claims in so-called investor-state dispute settlements, and a total of USD 340 billion if they additionally cancelled projects in development but not yet producing oil and gas. Possible solutions to this issue range from moratoria on any further licensing or issuing of exploration permits for oil and gas, and the payment of a compensation by governments in return for a waiver of treaty rights, to eventually reforming and terminating investment treaties altogether.

Investors too have an important role to play in the transition to a 1.5°C-compatible future. In the last couple of years, an unprecedented wave of corporate net-zero targets has been announced. However, there currently exists no clear and consistent definition for these targets. This has particularly been the case for net-zero targets in the oil and gas sector, often overestimating companies' actual emissions reductions. To this end, other frameworks and tools are emerging to fill the gaps. These include international climate disclosure reporting frameworks and national-level mandatory disclosure requirements.

Key Recommendations

The selection of modelled pathways analyzed in this report all point to a common set of actions to limit global warming to 1.5°C. Based on these pathways and our analysis of the current opportunities and barriers to policy change, we recommend that:

1. **Governments should prevent the development and licensing of any new oil and gas fields.** Developing any fields beyond those already in operation or under development would pose substantial risks of either not meeting the 1.5°C target or creating stranded assets, because those fields would have to be decommissioned before the end of their lifespan, unless currently producing fields' operations are significantly curtailed.
2. **Governments must provide more and better support to wind and solar deployment.** They need to improve current policies and put in place new ones, to increase solar and wind capacity worldwide. These should include policy frameworks aimed at reducing permitting and licensing delays for renewables' installation, as well as localizing renewable energy value chains to make them more resilient to trade wars, political conflicts, and price volatility.
3. **Governments should create enabling environments for redirecting both public and private capital flows toward the clean energy transition, including the deployment of additional solar and wind capacity.** The forecasted investments in the exploration and development of new oil and gas fields—incompatible with the 1.5°C pathways—are higher than the investment gap for wind and solar deployment.
4. **The current energy crisis, experienced by Europe in particular, should not be tackled by increasing the continent's reliance on gas.** Doing so would risk putting the 1.5°C target even further out of reach, or creating stranded assets for newly built infrastructure both in Europe and in gas-exporting countries, while not solving the short-term crunch. Governments and investors should instead view the crisis as an opportunity to further step up Europe's clean energy ambition, by strengthening existing frameworks such as the EU Fit for 55 package and the European Green Deal.
5. **Investment treaties need to be urgently and radically reformed or repealed to allow governments to enforce 1.5°C-compatible oil and gas phase-out pathways.** Governments can tackle this issue by pursuing one or a combination of existing solutions, namely a moratorium on any further licensing or issuing of exploration permits for oil and gas, setting up systems to pay out compensation in return for a waiver of treaty rights, and eventually reforming and terminating investment treaties.
6. **Governments should better regulate the long-term targets of the corporate sector, at both the global and national levels, to ensure that they support the goals of the Paris Agreement.** Regulative approaches by governments hold critical potential to ensure highly ambitious corporate long-term targets. Such regulation could provide robustly defined concepts that add substantive criteria to ensure Paris Agreement compatibility, and mandate comprehensive and third-party verified disclosure practices.

7. **Governments should set up mandatory requirements for companies' reporting methodologies. Until then, investors can fill the gap by adopting voluntary reporting methodologies.** Corporate climate reporting is instrumental to the ability of the financial sector to channel capital where it is most needed to accelerate the energy transition. Rigorous mandatory standards would enable the production of standardized material information, consistently disclosed within and across countries.

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Abbreviations and Acronyms

AR6	IPCC Sixth Assessment Report
BECCS	bioenergy and carbon capture storage
BIT	bilateral investment treaty
BNEF	Bloomberg New Energy Finance
CCS	carbon capture and storage
CCU	carbon capture and utilization
CCUS	carbon capture, utilization, and sequestration
CDR	carbon dioxide removal
CIF	cost, insurance, and freight
ECT	Energy Charter Treaty
EU	European Union
FF55	Fit for 55
FSRU	floating storage and regasification units
GHG	greenhouse gas
GRI	Global Reporting Initiative
IAM	integrated assessment model
IEA	International Energy Agency
IIGCC	Institutional Investors Group on Climate Change
IMP	illustrative mitigation pathway
IMP-LD	IMP low demand
IMP-Ren	IMP high renewables
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISDS	investor–state dispute settlement
ISSB	International Sustainability Standards Board
LCOE	levelized cost of electricity
LNG	liquefied natural gas
MDB	multilateral development banks
NGFS	Network for Greening the Financial System

NZE	Net Zero Emissions (by 2050)
OECD	Organisation for Economic Co-operation and Development
OECM	One Earth Climate Model
PRI	Principles for Responsible Investment
PV	photovoltaic
SASB	Sustainability Accounting Standards Board
SBTi	Science Based Targets Initiative
SEC	Securities and Exchange Commission
TCFD	Task Force on Climate-related Financial Disclosures
TPI	Transition Pathways Initiative
TTF	Title Transfer Facility
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change

1.0 Introduction

The world must set itself on a pathway consistent with limiting global warming to 1.5°C to avoid the most disruptive and tragic consequences of climate change on people, ecosystems, and economies. This is extremely urgent and every fraction of a degree matters: at present rates of greenhouse gas (GHG) emissions, the world's remaining carbon budget will be extinguished in approximately 8 years. The world can still achieve the 1.5°C goal, but the window to do so is narrowing quickly. Governments must urgently exceed the ambition of their current Paris Agreement pledges.

Mitigating GHG emissions from fossil fuels will require fossil fuel production to decline rapidly, as well as a fast and sustained establishment of alternative and cleaner modes of energy consumption and production. That requires, among other actions, a major shift of investment flows from fossil toward clean energy sources. The war in Ukraine and the resultant energy crisis have only made more pressing the need to reduce countries' dependencies on fossil fuels and move as fast as possible toward cleaner modes of energy production.

Energy scenarios can play a key role in fostering such a transformation by indicating suitable energy pathways that can be translated into policy frameworks conducive to a clean energy transition. They can also inform the shift of capital flows away from fossil-based energy production and toward renewable energy sources, in line with art. 2.1c of the Paris Agreement, "making finance flows consistent with a pathway toward low GHG emissions and climate-resilient development."

This report aims to inform policy-makers, investors, and companies on what they can do to align their energy decisions with the goals of the Paris Agreement, based on modelled pathways consistent with limiting global warming to 1.5°C. We base this analysis on pathways from a selection of the most authoritative energy and climate models, which represent and provide insights about possible ways the future could unfold, based on various technical, economic, societal, and policy assumptions. This report is the first to compare findings across the full body of published energy model pathways: those reviewed by the Intergovernmental Panel on Climate Change, those produced by intergovernmental organizations such as the International Energy Agency and the International Renewable Energy Agency, and by the private sector. The report focuses on pathways for the phase-out of oil and gas, and for the expansion of wind and solar, required for a good chance of global temperatures staying within the 1.5°C limit.

Models rest on a number of assumptions, for example related to the costs, performance, and availability of various energy technologies in the future. Our report begins by discussing these assumptions, outlining the main strengths and limitations of each model, and explaining the choices we made in terms of selection of scenarios (Chapter 2).

We then analyze the selection of scenarios and draw key conclusions on:

- The required phase-out pathways for oil and gas production between now and 2050, at the global level.
- The required levels of solar and wind energy deployment to substitute fossil energy production, at both global and regional levels.

- The investment gaps between current and planned spending and the investment needed to achieve Paris-aligned investment pathways, both globally and regionally (Chapter 3).

The current energy and geopolitical crises triggered by the ongoing war in Ukraine are affecting the strategic energy decisions made by governments and private actors, and may be exacerbating some of the barriers to a clean energy transition. But it is also creating a renewed urgency to move faster with the energy transition than has so far occurred. We analyze the main energy consequences of the war, with a particular focus on Europe's recent dash for gas, and discuss the various options available to move Europe beyond gas. Moreover, we outline the expected impacts of the war on renewable energy development in different regions, and options for developing countries to leapfrog in spite of the dash for gas (Chapter 4).

In order to provide clear and actionable recommendations for policy-makers, financial actors, and investors, the report discusses the role of the private sector in such a transition, and of governments to create an enabling environment for private actors. We highlight some of the main legal and economic barriers faced by governments when trying to phase out oil and gas production, related to the multitude of investment treaties which protect the forecasted revenues that oil and gas companies might generate with their licensed reserves. We also discuss frameworks and tools that could help make corporate net-zero targets more effective and align institutional investors' strategies with a 1.5°C-compatible world (Chapter 5).

Finally, we recommend a number of actions that governments, investors, and financial institutions can take in order to achieve positive change in line with the implications of the energy scenarios (Chapter 6).

2.0
Energy/Climate Models and Energy Pathways

Key Insights

- Energy and climate models represent and provide insights about ways the future may unfold, based on various technical, economic, societal, and policy assumptions. Analysis of such futures ("pathways") plays a key role in informing climate policy decisions.
- This report's core findings are based on two 1.5°C pathways: the median of 26 pathways reviewed in the Intergovernmental Panel on Climate Change's (IPCC's) *Sixth Assessment Report* (AR6), and the Net Zero Emissions by 2050 scenario (NZE), published by the International Energy Agency (IEA) in the 2021 edition of *World Energy Outlook*. We also compare these with several other pathways to identify common features and differences, namely: the IPCC illustrative mitigation pathways (IMPs)—IMP-Ren and IMP-LD—as well as pathways from the International Renewable Energy Agency (IRENA), One Earth Climate Model (OECM), Bloomberg New Energy Finance (BNEF), Navigant, DNV, and BP.
- Two critical assumptions in models regard the availability at scale of methods to remove carbon dioxide (CO_2) from the atmosphere and/or of carbon capture and storage (CCS) technology. Given the uncertainties related to the deployment of these technologies, the scenarios analyzed in this report are selected because they do not exceed IPCC judgements of feasible and sustainable deployment levels.

Energy and climate models[1] represent and provide insights about ways the future may unfold, based on various technical, economic, societal, and policy assumptions (Moss et al., 2010). Analysis of these modelled futures ("pathways")[2] plays a key role in informing climate policy decisions and features centrally in reports of the IPCC.

Pathways limiting warming to 1.5°C (with no or low overshoot of the target) generally see CO_2 emissions reduced by 48% by 2030, compared with 2019 levels, and reaching net-zero by around 2050 (IPCC, 2022).[3] Most pathways see reduced usage of all three fossil fuels by 2030 and major reductions by 2050, with coal declining the fastest (IPCC, 2022, Table 3.6). However, the world remains far off track. In 2022, greenhouse gas emissions are continuing to increase, and while the world can still achieve the 1.5°C goal, the window for this is closing. Governments must urgently exceed the ambitions of their current Paris Agreement pledges (Nationally Determined Contributions) and begin enacting proposed changes before the 1.5°C goal moves out of reach (IPCC, 2022).

[1] This report uses the term "energy/climate models" (or sometimes just "models") to include both integrated assessment models (IAMs), which are generally managed by academic research groups and assessed by the IPCC, and models of the energy system alone, such as those published by intergovernmental and private sector organizations. IAMs represent the energy, climate, and economic systems in an integrated way.

[2] The terms "pathway" and "scenario" are often used interchangeably. In this report, we generally use the term "scenario" when describing the assumptions inputted into the model, and "pathway" when describing the resulting energy systems and emissions outputted from the model.

[3] Specifically, this refers to pathways whose probability of limiting end-of-century warming to 1.5°C or less is greater than 50%, categorized as C1 by Working Group 3 in AR6.

Energy/climate models are used for a wide variety of purposes. For example, IEA's *World Energy Outlook* (2021c, p. 3) aims at "enabling governments to understand what they need to do to put emissions into rapid and sustained decline" to reach net-zero emissions by 2050. OECM, commissioned by the UN-convened Net-Zero Asset Owner Alliance and the European Climate Foundation, "provides very granular sector specific net-zero pathways based on currently available technologies [...] For asset owners committed to net-zero portfolio alignment, sector pathway information is of utmost importance for investment portfolio steering" (Teske et al., 2020, p. 3). Some academic studies aim to better understand how different factors shape possible futures through asking "What if?" questions (Evans and Hausfather, 2018).

These models can shed light on the implications of policy choices or explore the most effective or lowest-cost means to achieve policy goals. Researchers used models to assess the pace at which coal power generation should be phased out to achieve the Paris Agreement's goals (Rocha et al., 2016), which informed the goals of the Powering Past Coal Alliance (2018), whose members have committed to phasing out coal power by 2030 in the countries of the European Union and Organisation of Economic Co-operation and Development, and by 2050 in other countries.

To interpret the implications that model pathways carry for real-world decisions, it is necessary to understand how models work, why they were built, and what their strengths and weaknesses are.

This report aims to inform policy-makers, investors, and companies on what it would take to align their energy decisions with the Paris Agreement's goals, based on global modelled pathways consistent with limiting warming to 1.5°C and showing a probability of 50% or higher. We base this analysis on pathways reviewed by the IPCC as well as those generated by intergovernmental organizations such as the IEA and IRENA and those from the private sector. The report focuses on the phase-out of oil and gas, and expansion of wind and solar. We do not address coal, because other reports have extensively reviewed Paris-aligned pathways for coal phase-out (Yanguas Parra et al., 2019).

2.1 Strengths and Limitations of Energy/Climate Models

Models are powerful tools for revealing the interactions between different elements of complex systems, including dramatically changing systems (DeCarolis et al., 2017; Taylor et al., 2014). They help explore the range of futures that are technically and economically viable. For example, models helped enable policy discussions on the 1.5°C goal in the Paris Agreement, by describing a technically and economically viable energy system to limit emissions (van Beek et al., 2022).

As simplified mathematical depictions of the world, models necessarily rest on many assumptions, and the further they look into the future, the more uncertain these assumptions become. These include not only big-picture assumptions about the shape of the world, such as on population size or energy service demands, but also parameters describing the costs, performance, and availability of various energy technologies (Keppo et al., 2021).

Different models display different strengths. For example, models managed by academic researchers are often more transparent in their methodologies and more flexible in their exploration of research questions. Intergovernmental organizations' energy models tend to narrow the range of possibilities they consider, which makes using their pathways simpler for decision-makers but provides less detail for them to prepare for an uncertain future. Energy models managed by commercial organizations often use the most up-to-date cost estimates but can be less transparent in how they work, making it harder to interpret any of their conclusions (Pfenninger et al., 2017; Skea et al., 2021). These models also suffer trade-offs between the level of complexity or detail they provide and the computing power required to operate them. Models variously give more resolution in geography, technological processes, end uses, infrastructure, or actors.

More fundamental assumptions underpin the structural logic by which models bring together these varied factors, either by simulating how future decisions will be made or by identifying some kind of optimum pathway. Whether simulating or optimizing, models commonly rely on a logic based on economic and technical efficiency. As such, most energy/climate models poorly represent human behaviours, social-political factors, or disruptive changes (Li and Strachan, 2016; McCollum et al., 2017; Wilson et al., 2019), though there are nascent efforts to better reflect socio-political factors in models (Cherp et al., 2018; Geels, Berkhout and Van Vuuren, 2016; Mercure et al., 2019; Trutnevyte et al., 2019).

2.2 Equity and Regional/National Targets

Generally, IAMs have not been adopted for the representation of complex value judgments, as the assumptions required for this could be highly contentious. One of the most important of these judgments is how to equitably share mitigation efforts between different countries and actors (Keppo et al., 2021; Pye et al., 2020).[4] It is widely recognized that certain countries have contributed more than others to climate change through past emissions, and that countries vary significantly in the financial and other resources they have available to contribute to solving the problem (IPCC, 2022). This is known as the principle of *common but differentiated responsibilities and respective capabilities,* which is a central tenet of both the UN Framework Convention on Climate Change (United Nations, 1992, art. 3.1) and the Paris Agreement (United Nations Framework Convention on Climate Change, 2015, art. 2.2).

An equitable international approach has several dimensions, two of which tend to recur in equity debates and receive broad acceptance: differentiated mitigation, where Global North countries act sooner and do more to reduce their emissions; and climate finance, which wealthier countries provide to poorer ones (Calverley and Anderson, 2022). Climate negotiations involve serious contestation about how much more and how much sooner Global North countries must act, which wealthier countries should provide finance, which poor countries should receive it, as well as the amount provided. In some analyses, the two dimensions are linked: if developing countries receive more finance, they may be able to

[4] Equity considerations can be incorporated into models if appropriately interpreted (via value judgments and/or assumptions) and codified into a useable form.

mitigate faster, with less difference in pace from developed countries (Holz, Kartha and Athanasiou, 2018).

Therefore, the geographic breakdown of mitigation efforts will depend on the approach to equity. In this report, we discuss fossil fuel phase-out only at the global level. As a general guide, phase-out should be faster in the Global North than the global average suggested here. Conversely, we do provide a basic regional breakdown of growth in wind and solar deployment based on the models, with the caveat that in the Global South these will only be meaningful as targets to the extent that sufficient finance is made available.

2.3 Key Uncertainties: CCS and carbon dioxide removal

Two critical assumptions in energy/climate models regard the availability of methods to remove CO_2 from the atmosphere and/or of CCS technology,[5] neither of which have yet been deployed at a significant scale. Regarding CO_2 removal (CDR), the IPCC has said "CDR deployed at scale is unproven, and reliance on [CDR] is a major risk in the ability to limit warming to 1.5°C" (Rogelj, Shindell and Jiang, 2018, p. 96).

These assumptions are highly consequential for the kind of energy system that may be considered consistent with temperature limits. The more countries undertake CDR in the future, the longer the world can take to decrease near-term emissions (and by extension, the longer it can take to decarbonize energy systems) (IPCC, 2022). Similarly, CCS creates a potential means to decouple fossil fuel use from CO_2 emissions, in theory allowing continued use of fossil fuels even as emissions decline (Budinis et al., 2018).

Many models rely on very large-scale CDR, with removal achieved either by carbon sequestration through reforestation and afforestation, or through bioenergy with CCS (BECCS).[6] This reliance has been highly controversial within the scientific community, where some view major CDR as "essential" to achieving the Paris Agreement's goals, given the difficulty of reducing emissions (Galán-Martín et al., 2021), while others see CDR reliance as "an unjust and high-stakes gamble" (Anderson and Peters, 2016) that is at best highly speculative. Models that aim to minimize total system costs often favour CDR: later removals of CO_2 provide a way to push costs decades into the future, resulting in lower discounted costs (Emmerling et al., 2019; IPCC, 2022; Rosen and Guenther, 2016). Yet that very distance in the future increases the uncertainty of deployment. Reliance on it also creates the danger where, by the time those uncertainties are resolved, the emissions will already have occurred. Therefore, if CDR cannot be deployed to the extent expected, it will be too late to reverse the emissions (Smith et al., 2015).

[5] CCS is sometimes considered alongside carbon capture and utilization (CCU), using the combined term CCUS. In CCU, the captured CO_2 is used, for example by being processed into fuels, or by being pumped into oil fields to increase reservoir pressures and drive enhanced oil recovery (EOR). Use of waste CO_2 to produce fuels is a very early-stage and speculative technology; if successfully deployed, it will not reduce the amount of CO_2 entering the atmosphere, but will rather obtain additional energy services from the carbon before the CO_2 is emitted. In the case of EOR, any emissions benefit from storing the CO_2 is offset by additional emissions arising from the extra oil. For these reasons, in this report we focus only on CCS, not CCU.

[6] Other proposed methods of CDR – including through direct air capture, soil or ocean sequestration, or enhanced weathering – play less of a role in most models.

Major limitations and uncertainties surround future deployment of CDR. Both forests and BECCS require considerable land area. For example, capturing 11.5 Gt of CO_2 per year using BECCS (compared with present annual global emissions of 40 Gt CO_2) would require a land area of 380–700 Mha, which is equivalent to one to two times the size of India, or to 25–46% of the world's arable land. Capturing the same amount with forests would require three times as much land as BECCS would (IPCC, 2022). This land requirement raises concerns regarding competition with food production and biodiversity impacts where wild land is converted. Taking these limits into account, scholars have estimated what could be considered the *maximum sustainable potential* of various CDR approaches (de Coninck et al., 2018; Fuss et al., 2018). There are also feasibility challenges for all energy system changes, related to their timing, disruptiveness, and scale, which other researchers have assessed, including for BECCS and fossil CCS (Brutschin et al., 2021; IPCC, 2022, Annex III, Table II.1).

Even at potentially feasible levels, the uncertainties remain about whether and how CDR or CCS can be delivered. CCS deployment to date has consistently fallen behind expectations. After more than 30 years of efforts to commercialize CCS, today there are only 27 CCS facilities in operation, which have a total nameplate capacity of 36 Mt CO_2 (0.1% of global emissions). Only five of these facilities aim to deliver long-term storage of CO_2, while the others are used in enhanced oil recovery (Global CCS Institute, 2021). Many CCS projects have failed (Robertson and Mousavian, 2022; Wang, Akimoto and Nemet 2021), and costs remain high compared with other low-carbon alternatives. Indeed, the costs of a facility with CCS will always be higher than the costs of the same facility without CCS (Budinis et al., 2018).

For either CCS or CDR, some of the largest challenges relate to governance. Many unanswered questions remain on how these measures can be implemented, monitored, and regulated to ensure their effectiveness, and what institutions are needed to deliver incentives, funding, and penalties at the global level (Greenpeace, 2021).

2.4 The Pathways Used in This Report

This report aims to provide guidance for energy decisions to governments, investors, and companies, especially concerning oil, gas, wind, and solar. Our core findings are based on two 1.5°C pathways:

- The median of 26 pathways reviewed in the IPCC AR6 Working Group 3 (IPCC, 2022), using data hosted on the International Institute for Applied Systems Analysis' Scenario Explorer (Byers et al., 2022).
- The IEA's NZE scenario, published in the 2021 edition of *World Energy Outlook* (IEA, 2021c).

The methodology for selecting the pathways was based on the approach first proposed by Climate Analytics (2018) and employed in the Production Gap Reports to analyze pathways from the IPCC *Special Report on Global Warming of 1.5°C* (Stockholm Environmental Institute et al., 2021). It used the IPCC Scenario Explorer database to select pathways that are consistent with certain criteria. The set of 26 IPCC pathways[7] selected for our analysis consists of the pathways in AR6 that align with the 1.5°C limit, excluding those whose usage of BECCS or fossil CCS is categorized by the IPCC as raising medium to high feasibility concerns. It also excludes those whose forest CDR exceeds the IPCC's estimate of maximum sustainable potential (see appendix for more detail), which is intended to provide a more realistic account of their potential contributions over the coming decades.

The subset of pathways all limit warming to 1.5°C (greater than 50% probability) with either limited or no overshoot. They are generated using three[8] models: MESSAGE-GLOBIOM,[9] REMIND-MAgPIE,[10] and WITCH.[11] All three are optimization models that find solutions with the lowest cost or highest economic welfare, subject to various real-world constraints.

The NZE scenario is generated using the IEA's World Energy Model, a simulation model of the energy system, using exogenous future policy assumptions that are listed in the documentation (IEA, 2021b). It thus relies on the IEA's explicit judgment about which policies are most realistically achievable, rather than embedding policy choices in cost-optimization as an overriding principle.

We focus on these two pathways because the IPCC and IEA are widely used in the current literature, and in the case of the IPCC, the diversity of pathways improves the robustness of our analysis. Moreover, we also compare these with other well-known pathways employed by financial institutions, consultancies, and the private sector to identify common features and differences. Most of these pathways are consistent with limiting warming to 1.5°C with greater than 50% probability, and not relying on CCS or CDR to a greater extent than judged feasible or sustainable, as above.[12] The other scenarios considered in this report are:

- **IPCC IMP-Ren** (illustrative mitigation pathway high renewables): one of the IPCC's 26 pathways, it is also shown separately because the IPCC uses it as an illustrative mitigation pathway (IMP) to represent a future with a high level of renewable energy.
- **IPCC IMP-LD** (IMP low demand): another of the 26 pathways, this IMP represents a future with low energy demand, achieved through changes in societal behaviours.
- **OECM:** developed by the University of Technology Sydney for the Net-Zero Asset Owners Alliance and designed to give a high level of sector granularity to help inform investor decisions (Teske et al., 2020).

[7] The IPCC does not produce these pathways but rather collect and assess quantitative, model-based scenarios related to the mitigation of climate change. The final selection of scenarios considered by the IPCC Working Group 3 was conducted by authors of the AR6 report.

[8] The AR6 also considered 1.5°C pathways generated using seven other models, but all of these pathways exceeded the feasibility/sustainability thresholds on CDR and CCS discussed above.

[9] Managed by the International Institute for Applied Systems Analysis near Vienna, Austria.

[10] Managed by the Potsdam Institute for Climate Impact Research in Potsdam, Germany.

[11] Managed by the European Institute on Economics and the Environment in Milan, Italy.

[12] Based on the CDR/CCS criterion, we do not include scenarios from the Network for Greening the Financial System, from Shell or from Equinor.

- **Bloomberg New Economic Finance (BNEF) green scenario:** one of three net-zero scenarios in BNEF's *New Energy Outlook 2021,* which prioritizes clean electricity and green hydrogen. It uses a carbon budget consistent with a 67% chance of keeping warming below 1.75°C (BNEF, 2021).
- **IRENA World Energy Transitions Outlook 1.5°C Pathway:** uses macroeconometric modelling to assess the socio-economic impact of a diverse policy basket with moderate carbon prices to limit warming to 1.5°C (IRENA, 2022d).
- **Navigant Pathway to Net-Zero:** a 1.5°C scenario for 100% Decarbonization of the Global Energy System by 2050, it was developed to provide maximum feasibility, giving preference to options that have high social and political acceptability (Navigant, 2018).
- **DNV Pathway to Net Zero:** aims to achieve 1.5°C within the bounds of techno-economic and political feasibility. Accordingly, it employs an integrated system dynamics simulation model that reflects relationships between demand and supply in several interconnected modules (DNV, 2021).
- **BP net-zero scenario:** one of three possible energy transition scenarios and the only one that aims to limit warming to 1.5°C, this scenario is based on a subset of scenarios from the IPCC's *Special Report on Global Warming of 1.5°C*, excluding the ones considered to give overly optimistic assumptions about climate policies (BP, 2022a).

While this report has excluded scenarios relying on CDR or CCS beyond feasibility/sustainability thresholds (above), it should be noted that all the scenarios considered in this report rely on CDR to some extent, and most rely on CCS. Given that neither CDR nor CCS have yet been deployed at a significant scale and that they raise formidable challenges of cost, sustainability, and governance, a precautionary approach to judging energy transition pathways should seek to minimize reliance on CDR and CCS. CDR cannot be considered an alternative to real emissions reductions (Dooley, Nicholls and Meinshausen, 2022), and pathways with faster decarbonization should be preferred over those that rely more on CDR. A summary of the scenarios' use of CDR and CCS follows in Table 2.1.

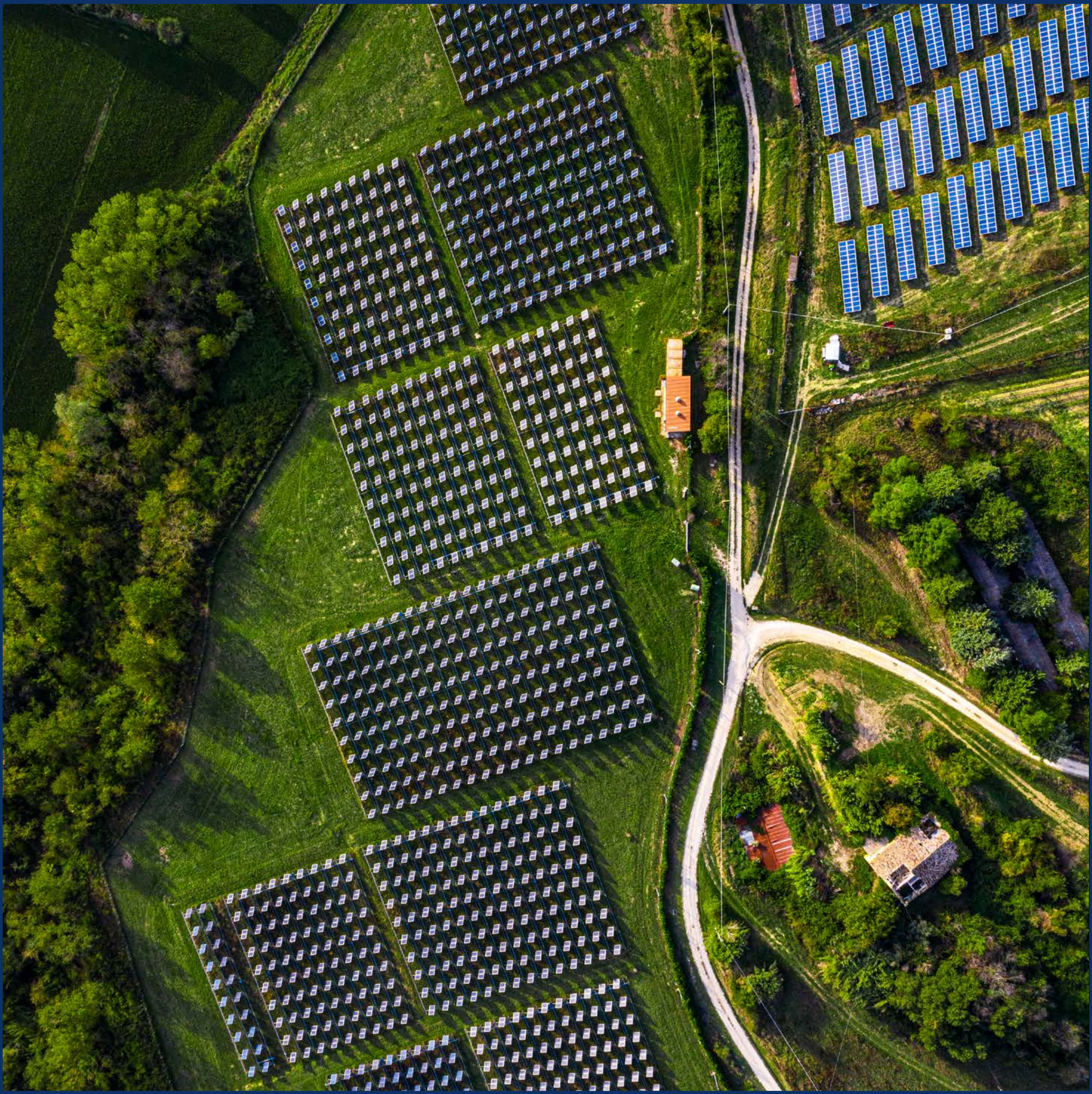
Having discussed the range of pathways consistent with the Paris Agreement and the 1.5°C goal, this report will consider their implications for a range of aspects, beginning with the question of the licensing of new oil and gas fields, and the investments needed in renewable energy technologies.

Table 2.1 Scenarios featured in this report: Use of CDR and CCS

	BECCS		Fossil CCS		Afforestation/ Reforestation	
Mt CO_2	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
IPCC scenarios median	70	1,030	670	2,140	730	2,090
IPCC scenarios first quartile	50	910	400	1,320	360	790
IPCC scenarios third quartile	240	2,460	770	2,710	910	2,160
IEA NZE	260	1,380	1,330	5,250**		1,300
IPCC IMP-Ren	310	2,400	410	560	200	230
IPCC IMP-LD	0	0	-	-	1,340	3,160
IRENA	900	5,000	1,100	2,300		
OECM	0	0	0	0		
BNEF Green Scenario	-	-	-	-		
Navigant	-	-	-	-		
DNV	-	-	3,300*	4,700*		
BP		1,300		3,900		

Notes:
All figures rounded to the nearest 10.
* Includes BECCS
** Includes fossil and industrial process CCS
Sources: BNEF (2021), BP (2022), Byers et al., (2022), DNV (2021a), IRENA (2022), Navigant (2018), Rystad (2022), Teske et al., (2022).

3.0 Energy System Transformation and Infrastructure Needs



Key Insights

- According to a large consensus across multiple modelled energy pathways, developing any new oil and gas fields is incompatible with limiting warming to 1.5°C. Global oil and gas production and consumption must decrease by at least 65% by 2050.
- The investment levels needed for wind and solar technologies in 1.5°C-aligned pathways can be achieved by redirecting finance from new, 1.5°C-incompatible oil and gas fields. The annual investment gap for the required wind and solar deployment amounts to USD 450 billion until 2030. Forecasts indicate that up to USD 570 billion will be spent every year in new oil and gas development and exploration during the same period.
- There is no room for new fossil import infrastructure in Europe in 1.5°C-aligned gas phase-out pathways. Existing import capacity can meet the gas demand for Europe in the medium and longer term. In 2022 and 2023, the short-term supply crunch and its potentially dire consequences cannot be alleviated in time by newly added gas capacity.

This chapter presents a detailed assessment of what an energy transition consistent with limiting temperature rise to 1.5°C would require. It focuses specifically on emissions reduction from oil and gas and on the corresponding levels of wind and solar capacities that need to be installed to deliver a successful transition to a clean energy system. The analysis is based on climate and energy models assessed by the Intergovernmental Panel on Climate Change (IPCC) and published by the International Energy Agency (IEA), and several other scenarios from selected modelling groups.

The assessment of the embodied carbon emissions from licensed oil and gas reserves shows that any extraction beyond fields already in production or under development would unleash significantly more carbon dioxide into the atmosphere than our selection of scenarios deemed consistent with the 1.5°C goal. This points toward the need to prevent the exploration and development of any new oil and gas fields, and to ensure an orderly and managed phase-out of fossil fuel production.

In light of the current energy market turmoil and debates around gas supplies, the chapter will also provide an assessment of the role gas power generation should play in the selected 1.5°C scenarios.

Finally, this chapter presents an overview of the required levels of wind and solar deployment in 1.5°C-aligned pathways, both at global and regional levels, and of the investments needed to enable the deployment of these technologies.

3.1 Paris-aligned Oil and Gas Phase-out Timelines

Despite repeated warnings over a quickly tightening carbon budget, the consultancy firm Rystad Energy estimates that, in the absence of stronger climate policies, oil and gas production forecasts show that extraction volumes are expected to continue to rise above current levels until at least the 2030s (Rystad Energy, 2022b), due to the continued development of new fields and the potential extraction from licensed reserves currently being explored. This continued growth risks pushing the world well beyond the Paris-agreed temperature goal. The *Production Gap Report* estimated that governments still plan to produce more than double the amount of fossil fuels in 2030 than what would be consistent with limiting global warming to 1.5°C (Stockholm Environmental Institute et al., 2021).

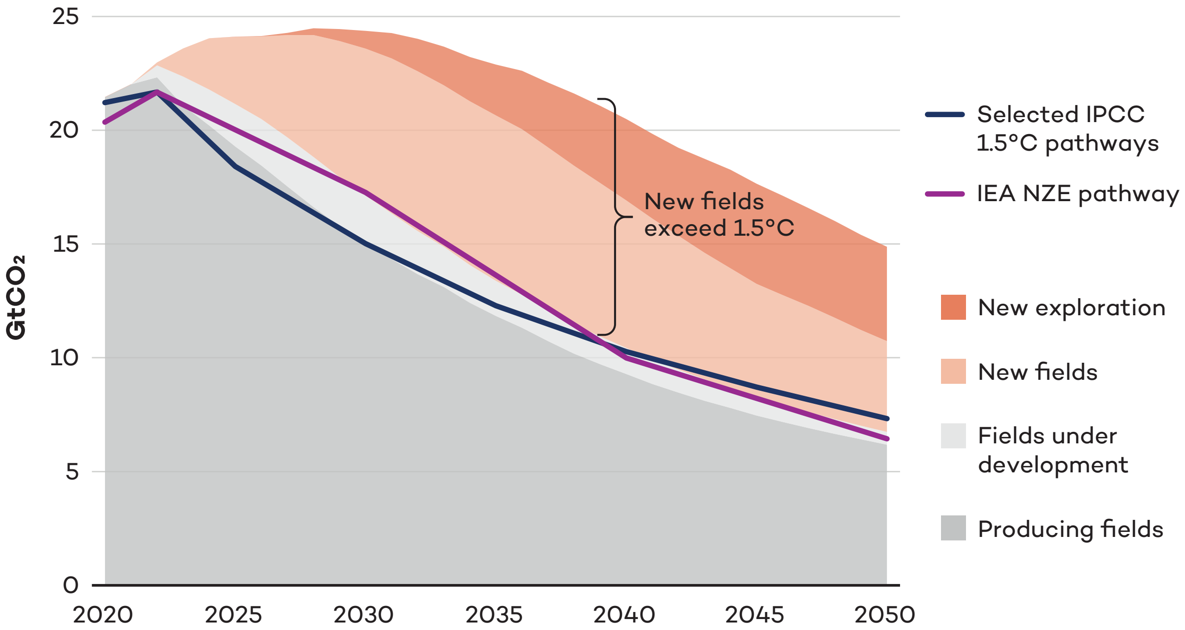
This section compares the forecasted levels of oil and gas joint production with the 1.5°C-consistent volumes from a wide range of selected scenarios. We assess oil and gas volumes jointly, as the extraction of oil and gas is typically conducted by the same companies and financed through the same financial frameworks, and exploration activities are often conducted in such a way that the relative levels of oil and gas production are only known when a discovery is made.

Figure 3.1 below shows the volumes of all licensed oil and gas reserves globally, expressed in terms of their embodied carbon emissions. These reserves are broken down into the different stages of their production lifecycle,[13] to showcase their respective contribution to the 1.5°C-consistent carbon budget for the oil and gas industry. The potential emissions of forecasted oil and gas production from currently licensed reserves assume that no further climate policies are implemented, according to the projections by Rystad Energy's UCube model.

Superimposed on this are two pathways which are consistent with 1.5°C. One represents the median of selected pathways from the IPCC *Sixth Assessment Report* (AR6), while the other is the IEA's Net Zero Emissions by 2050 (NZE) scenario (see chapter 2). These two pathways both show that oil and gas production should decline by at least 65% by 2050 from 2020 levels. Thereafter, most of the remaining emissions would have to be captured and sequestered for the world to reach net-zero carbon emissions by the middle of the century to stabilize the climate to 1.5°C by 2100.

[13] Licensed oil and gas fields that are already in operation or under development are distinguished from those where discovery has been made, and from those where a licence has been awarded but exploration has not yet started.

Figure 3.1 Global oil and gas production, based on selected IPCC and IEA 1.5°C pathways



Sources: Byers et al., (2022); IEA (2021); Rystad Energy (2022b).

In the shorter term, the selected IPCC and IEA pathways showcase a 15% and 30% reduction in oil and gas production by 2030 respectively. This is equivalent to an average annual oil and gas production decline of 2% and 3% for the rest of this decade respectively; in the 2030s, the average production decline accelerates to 4% and 5% respectively.

The implications of this are important for future energy decisions. While energy scenarios do not provide any prescriptive insights on what the production decline rates imply, the production from currently operating fields and those under development would already generate more oil and gas emissions than would be consistent with the 1.5°C goal under both the IEA NZE and selected IPCC 1.5°C pathways.[14] As such, new fields could in theory be developed in alignment with those production levels, as long as existing fields with corresponding production levels were closed.

In practice, however, it is particularly difficult to close existing fields, for economic and political reasons related to jobs, vested interests, and infrastructure lock-in effects, as well as legal reasons related to the costly compensation owed to investors when governments attempt to do so, and the implications of which we discuss in detail in chapter 5 of this report. Therefore, unless these challenges can somehow be overcome, not only is there *no need* for new fields, but most importantly there is *no room* for new fields to be developed if we are to limit warming to 1.5°C. This is aligned with what the IEA concluded in its *World Energy Outlook 2021* report. Any new development of oil and gas fields would ultimately either

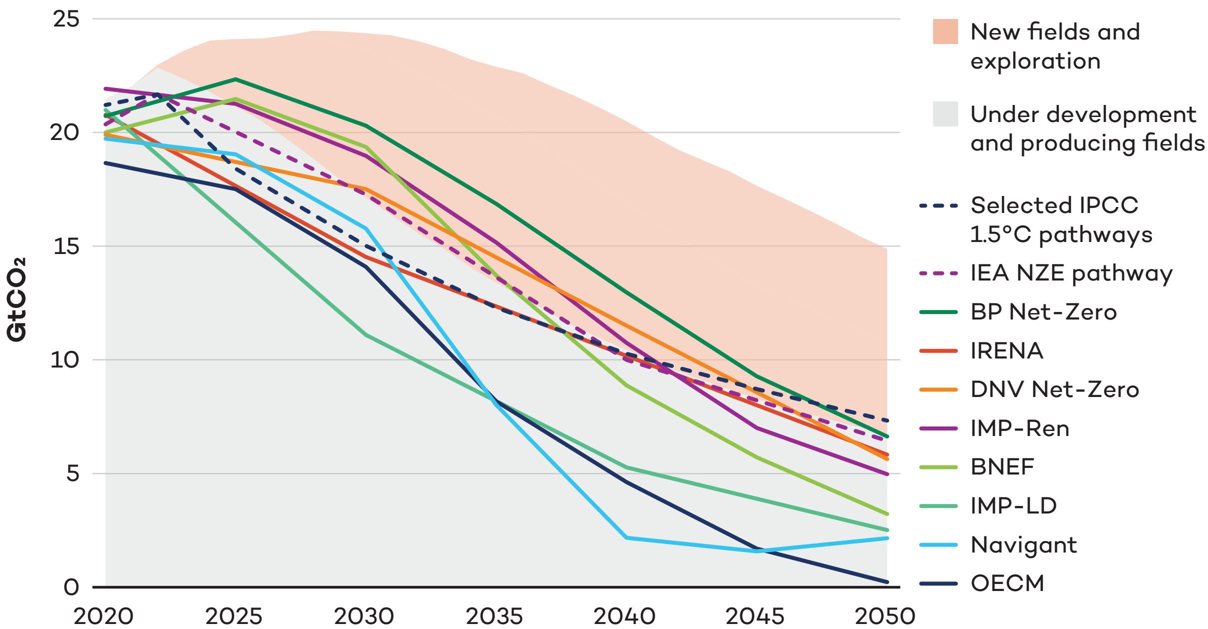
[14] Production from conventional oil and gas fields generally declines by about 4% per year as reservoir pressure decreases, even when ongoing investment is made to improve the fields' productivity, such as drilling additional wells or maintaining infrastructure (Rystad Energy, 2022b).

generate stranded assets[15]—either because they have to shut down early or because existing fields will need to produce significantly less than their anticipated amounts—or push the world beyond the 1.5°C goal.

3.1.1 Sensitivity Analysis of a Broader Set of Scenarios

Besides the selected IPCC 1.5°C pathways and the IEA NZE scenarios, this section analyzes eight additional Paris-aligned oil and gas phase-out pathways (details on these can be found in chapter 2). The analysis of these additional scenarios shows that the conclusions derived from the selected IPCC 1.5°C pathways and the IEA NZE are widely shared among energy models across intergovernmental organizations, academic institutions, and private sector consultancies. As Figure 3.2 shows, these additional pathways follow similar trajectories to the IEA NZE and the median of selected IPCC 1.5°C pathways until the middle of the century, implying the conclusion that there is no room for new oil and gas fields beyond those already in operation or under development is robust across models.

Figure 3.2 Global oil and gas production, based on other selected 1.5°C pathways



Sources: BNEF (2021); BP (2022); Byers et al., (2022); DNV (2021); IRENA (2022); Navigant (2018); Rystad Energy (2022b); Teske et al. (2022).

Although there are some minor variations across scenarios, especially in the 2020s, they all show that oil and gas production needs to decrease by at least 65% by 2050. Short-term differences in the rate of production decline across models are largely due to their varying assumptions on carbon capture and storage (CCS) and carbon dioxide removal (CDR), as well as assumptions on the rate of coal phase-out. Moreover, several pathways shown in Figure 3.2 see oil and gas production decreasing below levels consistent with existing fields

[15] Stranded assets are "assets [that] suffer from unanticipated or premature write-downs, downward revaluations or are converted to liabilities" (Caldecott, Howarth and Mcsharry, 2013).

(International Renewable Energy Agency [IRENA], illustrative mitigation pathway low demand [IMP-LD], Navigant, and the One Earth Climate Model [OECM]); this implies that not only should new field development be stopped, but further measures such as decreased investments in existing fields over time and/or early retirement of those fields should be considered as well. Others exceed existing-field production in the next 10 to 15 years, but then fall below it later on (IMP high renewables [IMP-Ren], Bloomberg New Energy Finance [BNEF], and DNV), indicating a potential risk for some assets of becoming stranded if new fields were developed in the short term. Only in the BP scenario does the 1.5°C pathway remain consistently above production from existing fields, but then oil and gas production declines by nearly 70% by 2050.

As mentioned, the rate of oil and gas production decline in each model is affected by the underlying assumptions each model rests on. Those scenarios with the least reliance on carbon sequestration displayed significantly faster decline in oil and gas production (see chapter 2 for assessment of carbon sequestration in each scenario). This indicates that oil and gas production in energy transition pathways is very sensitive to assumptions made regarding levels of carbon sequestration.

Adopting a precautionary approach to future availability of CDR and CCS technologies—by limiting their deployment levels in line with the IPCC's feasibility and sustainability assessment—implies less carbon sequestration and faster oil and gas phase-out pathways to be consistent with 1.5°C. Therefore, this again points to the need to end new oil and gas development to reflect the current technical capacities and sustainability concerns associated with CDR and CCS methods. Assumption made on the rate of coal phase-out also have a significant impact on the oil and gas decline rates in the short term.

As shown in Table 3.1, there are considerable differences in the percentage reduction of oil and gas, measured separately in 2030, 2040, and 2050, for all the scenarios presented in this chapter. These differences tend to increase with time as the energy mixes change and the deployment of fossil CCS technologies enables greater use of abated gas power generation. Moreover, scenarios with higher levels of CDR and CCS tend to have slower rates of decrease of oil and gas production.

As shown in this section, the analysis of global oil and gas reserves and 1.5°C-consistent production levels shows that governments have granted licences in excess of what the world can afford to produce to comply with the Paris-agreed temperature target. Therefore, licensed reserves beyond the ones already in production or under development should be kept underground if the world is to limit temperature rise to below 1.5°C. Analysis in this chapter shows that this conclusion is shared among a wide range of well-known and highly referenced scenarios in the literature, all supporting the conclusion that there is no room for new oil and gas fields when designing policies to align with limiting warming to 1.5°C.

Table 3.1 Oil and gas production phase-out pace in key model pathways

		2030	2040	2050
IPCC median	Oil	29%	57%	78%
	Gas	29%	42%	42%
IEA NZE	Oil	21%	54%	76%
	Gas	6%	45%	56%
IPCC IMP-Ren	Oil	3%	47%	77%
	Gas	33%	58%	78%
IPCC IMP-LD	Oil	47%	75%	90%
	Gas	47%	75%	85%
IRENA	Oil	37%	-	86%
	Gas	22%	-	48%
OECM	Oil	31%	89%	98%
	Gas	14%	54%	100%
BNEF	Oil	1%	56%	83%
	Gas	7%	56%	85%
DNV	Oil	12%	44%	74%
	Gas	12%	39%	69%
Navigant	Oil	24%	95%	91%
	Gas	36%	75%	85%
BP	Oil	6%	44%	76%
	Gas	0%	30%	55%

Sources: BNEF (2021); BP (2022); Byers et al., (2022); DNV (2021); IEA (2022); IRENA (2022); Navigant (2018); Rystad Energy (2022); Teske et al. (2022)

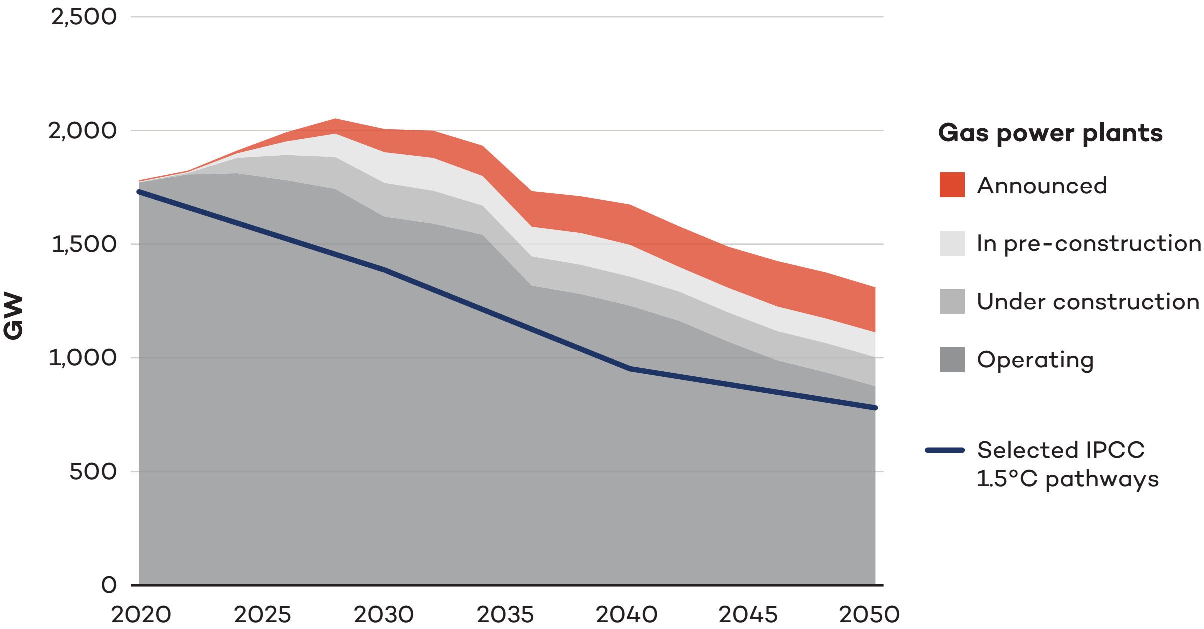
3.2 The Role of Gas Power Generation in the Energy Transition

Many current policy discussions focus on the role of gas in energy systems, with some companies and governments suggesting gas can serve as a "transition fuel", since its emissions intensity is lower than coal or oil at the point of combustion (Deetjen and Azevedo, 2020). Critics argue that, when methane leakage is taken into account, gas power generation can be little or no better than coal, and that accelerating the transition to wind and solar can fulfill the world energy demand at increasingly competitive costs (Fyson et al., 2022; Lazard, 2020). These fugitive methane emissions also spread throughout upstream, midstream, and downstream stages, which makes them harder to abate (Alvarez et al., 2018). Moreover, the extraction of fossil gas from unconventional reservoirs also has a higher overall water footprint and energy demand than conventional fields (Qin et al., 2018).

Furthermore, the record high energy prices triggered by the war in Ukraine and subsequent sanctions have exposed critical risks from reliance on fossil gas in the energy system (see chapter 4). These risks and current disruptions in the energy market call for a thorough assessment of the role gas ought to play in a Paris-aligned future energy system. As power generation is the largest use of gas (Shukla et al., 2022), this section assesses how much room there is for gas power in energy models limiting warming to 1.5°C.

The IPCC database of 1.5°C pathways shows that there is a large range of gas consumption across scenarios (Byers et al., 2022). These differences are largely dependent on the scale of deployment of abated gas power plants equipped with CCS. This section compares the forecasted global capacity of gas power plants with the capacity consistent with the 1.5°C pathways assessed for the IPCC/International Institute for Applied Systems Analysis Scenario Explorer database until 2035.[16]

Figure 3.3 Global gas power generation capacity



Note: The following assumptions are made:

- The total installed capacity from power plants in construction with missing value as start date were distributed evenly over 4 years between 2022–2025.
- The total capacity from proposed power plants with missing value as a start date were distributed evenly over 10 years between 2025–2030.
- Gas power plants have an operational life of 30 years before being decommissioned.
- Operating power plants with a start date prior to 1982 are decommissioned 5 years after 2022.

Source: Byers et al. (2022); Global Energy Monitor (2022b).

[16] The IPCC AR6 Scenario Explorer and Scenarios Database is hosted by the International Institute for Applied Systems Analysis, which collects all the underlying data behind the scenarios assessed by IPCC Working Group 3.

Figure 3.3 shows that global gas power generation capacity need to decrease by about 55% by 2035 compared with 2020 levels. However, current forecast gas power generation from plants already in operation, in construction, or being planned, are expected to deliver more capacity than would be consistent with the Paris Agreement throughout the forthcoming decades. This implies that there is no room for the construction of new plants, which would risk leading to stranded assets if 1.5°C pathways are used as a guide to limit warming to 1.5°C.

Therefore, all new constructions of gas power plants beyond those already in operation or in construction would eventually have to be decommissioned before the end of their economic lifetime, or be retrofitted to include CCS, unless existing plants in operation are eventually to operate at a much lower capacity. Moreover, further analysis of the same subset of selected IPCC 1.5°C pathways shows that the generation of electricity from all unabated gas power plants needs to decrease by about 95% by 2040, in order to limit warming to 1.5°C. Since gas power plants commonly operate for about 30 years, no new unabated gas power plants should be built, to avoid any future stranded assets or significantly underutilized built capacity.

Retrofitting an existing gas power plant to install CCS capabilities is significantly more costly than including sequestration technology from the start (Muttitt et al., 2021). Therefore, it would be ill advised to assume that new unabated plants should be retrofitted in 10 or 15 years. Accordingly, based on the analysis of selected IPCC 1.5°C pathways, and considering the concerns over CCS capabilities, in order to meet the Paris Agreement temperature goal no new gas power generation capacity should be developed.

3.3 Renewable Energy Deployment Needs

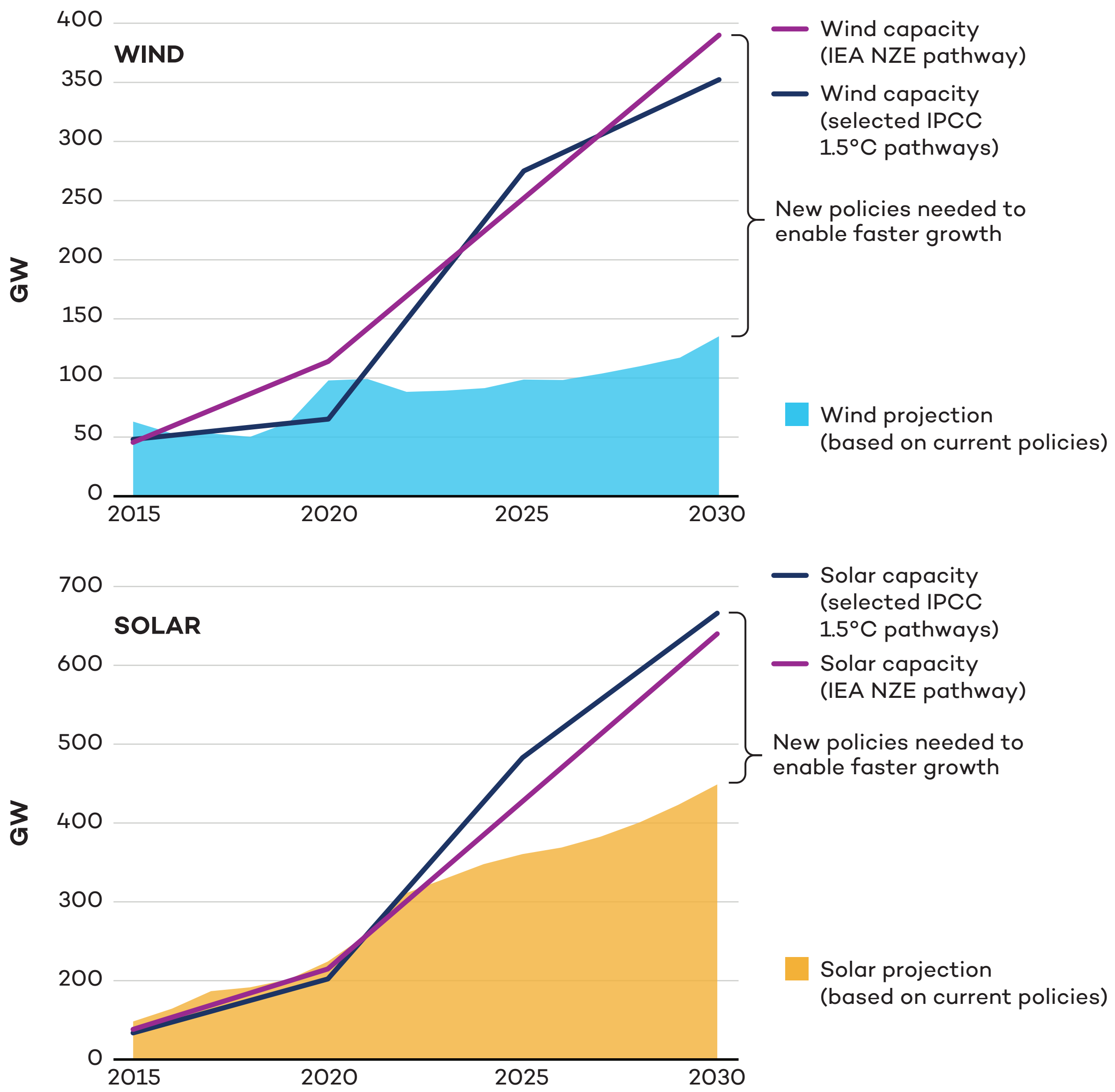
Enabling a structural shift in the energy sector in line with 1.5°C pathways will require significantly scaling up the annual rate of renewable technology deployment as the world moves away from carbon-based energy sources. The IPCC AR6 analysis of available technologies to mitigate greenhouse gas emissions concluded that wind and solar technologies have the biggest mitigation potential at the lowest cost per tonne of CO_2 displaced (IPCC, 2022). Accelerating this transition is of considerable importance not only for climate purposes but also because transitioning to a renewable energy system tends to "support and reduce the costs of key elements of human development, such as education, health, and employment" (IPCC, 2022); this would in turn facilitate the achievement of the UN Sustainable Development Goals.

Moreover, with the current disruptions in the European energy market pushing electricity prices above EUR 350/MWh, and year-ahead contracts reaching up to EUR 1,000/MWh in some countries, wind and solar energies have become increasingly cost competitive (Hancock, 2022). This also increases the imperative to accelerate the energy transition and increase the rate of deployment of these technologies in order to tackle the electricity price hikes and energy security challenges brought on by the war in Ukraine. Further analyses on this are provided in section 4.3 in the next chapter.

This section reviews the pace of wind and solar deployment that is consistent with 1.5°C energy pathways. Figure 3.4 shows how wind and solar 1.5°C-compatible deployment rates compare to the deployment forecasts for these technologies under current policies. The current policies forecast is made by BNEF; it is noteworthy that BNEF estimates are significantly more optimistic than many other forecasters in terms of forecasted wind and solar deployment rates, hence the deployment gap we are estimating is rather conservative.

In the assessed IPCC 1.5°C pathways, wind and solar capacity additions reach 350 gigawatts (GW) and 660 GW respectively by 2030. This represents respectively a fourfold and fivefold increase in annual capacity addition from current levels. The IEA NZE pathway, shown in Figure 3.4, follows an almost identical trajectory and total annual deployment by 2030. Conversely, forecasts of expected deployment of wind and solar capacity based on the current global pipelines of projects and the future implementation of current policies show an increase in capacity addition over the coming decade reaching 135 GW and 400 GW (BNEF, 2022). As also shown in Figure 3.4, this leaves a large deployment gap that needs to be bridged in order to supply enough energy to meet the world's energy demand in 1.5°C pathways.

Figure 3.4 Annual wind and solar capacity additions under selected IPCC and IEA 1.5°C pathways

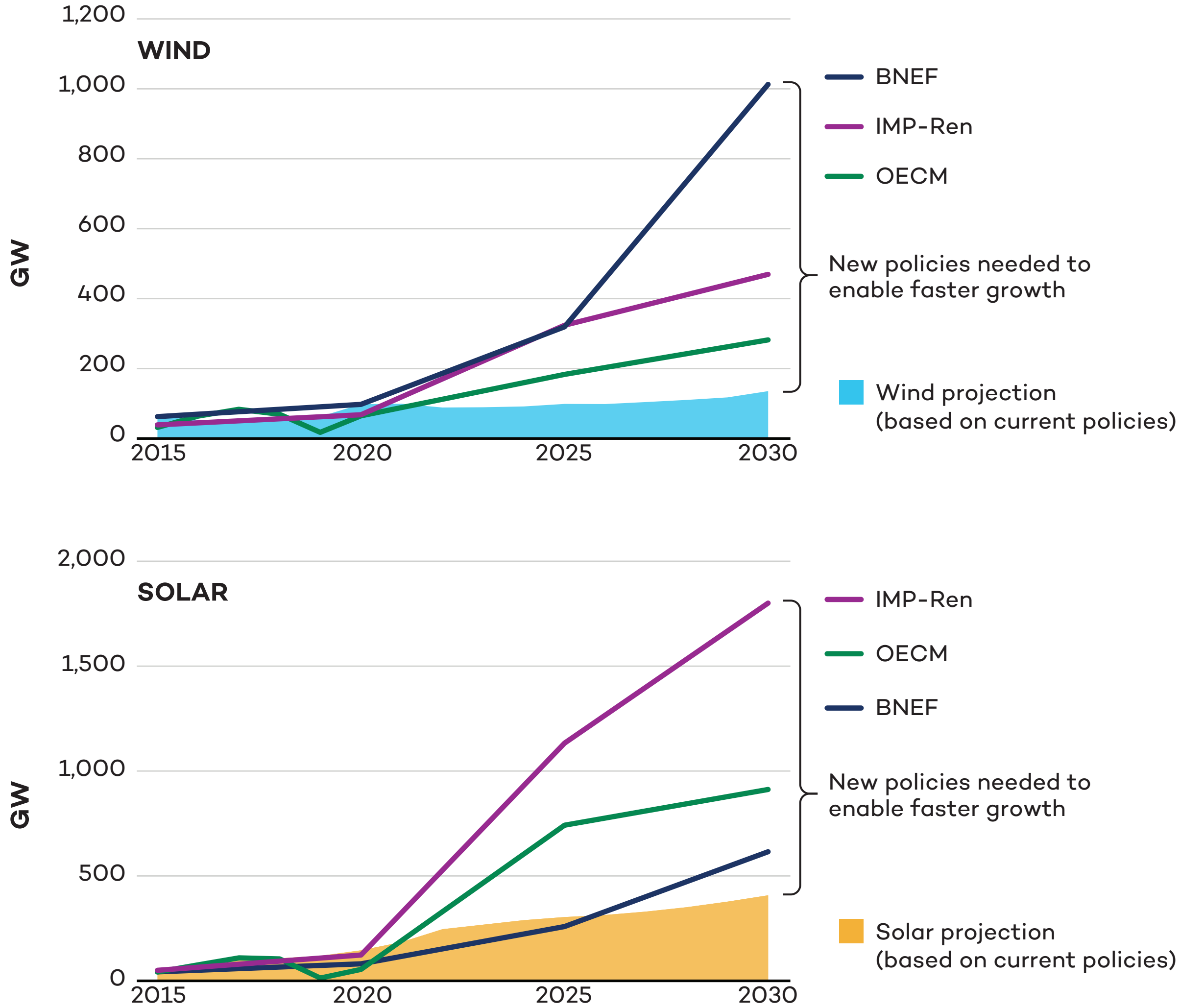


Sources: Byers et al. (2022); IEA (2022).

Both the IPCC and IEA NZE pathways show that by 2030, annual capacity additions should be at least 2.5 times higher for wind energy and 1.5 times higher for solar compared to forecasts based on current policies. This indicates that additional policies are needed to enable growth consistent with 1.5°C.

Figure 3.5 illustrates that even under different assumptions and policies, energy models from BNEF, OECM, and the IPCC IMP-Ren all show a need for significantly higher deployment than is forecast under current policies. These pathways vary considerably in their deployment need. However, they all show that by 2030, wind capacity must be at least 2 times higher and solar must be 1.5 times higher, with a number of scenarios indicating 3.5 times for wind and 4.5 times for solar.

Figure 3.5 Annual wind and solar capacity additions under BNEF, IMP-Ren, and OECM 1.5°C pathways



Sources: BNEF (2022); Byers et al. (2022); Teske et al. (2022).

Accordingly, estimates from BNEF indicate that wind capacity deployment may need to be as high as 1,000 GW annually by 2030, almost 3 times higher than the IPCC and IEA estimates shown in Figure 3.5. Similarly, the IMP-Ren pathway indicates that solar capacity installation would need to reach more than 1,800 GW annually by 2030 to orchestrate an energy transition consistent with the 1.5°C goal.

Global assessments of renewable energy deployment needs are essential to draw a picture of the future of the energy system and of the scale of the interventions required by governments' climate policies. Additionally, the regional dimensions of the transition and the deployment gaps provide necessary insights to inform policy and investment decisions at regional and national levels.

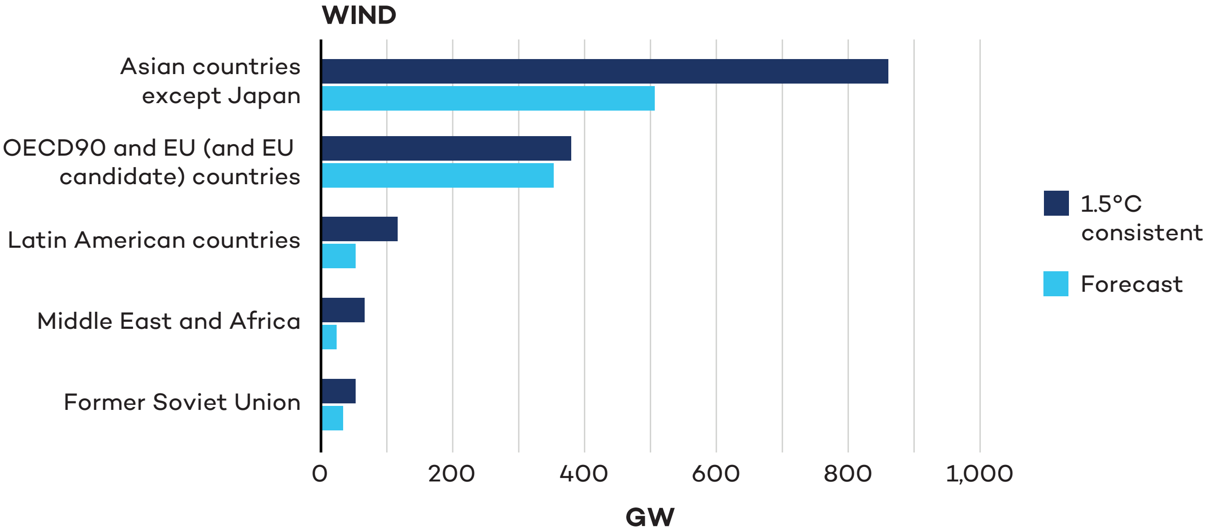
3.4 Regional Dimensions

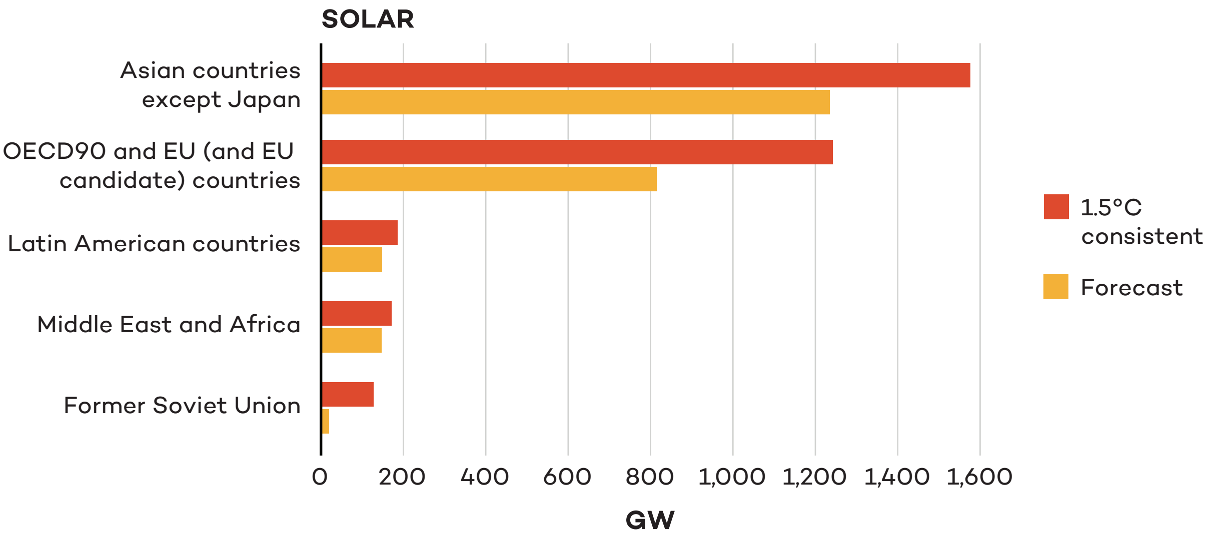
We have matched the regional data available from the same set of IPCC 1.5°C pathways[17] presented above with BNEF country-level forecasts of wind and solar capacity deployment. This way, we estimated the deployment gap for these technologies across the IPCC regions (i.e. the difference between the deployment levels needed to comply with the 1.5°C goal, or *deployment needs*, and the forecasted capacity based on existing policies). By 2030, more than 850 GW of wind capacity must be installed in Asia; this represents half of the global capacity that needs to be deployed between 2022 and 2030, and 70% of the global deployment gap for wind. While the Organisation for Economic Co-operation and Development (OECD) and European countries together account for a quarter of the total deployment needs, their current policies seem to cover such needs to a better extent, hence their corresponding gap in capacity deployment is only about 30 GW between 2022 and 2030.

While the regional picture looks similar for cumulative solar capacity, the OECD and European countries present the largest deployment gap over the course of this decade, with nearly 430 GW of missing capacity by the end of the decade. Asia (except Japan) is the region where most solar capacity additions are needed, with nearly 50% of total capacity needing to be built in this region. Compared to forecasted deployment, significant additional policies and investments will be needed to bridge the 340 GW deployment gap in this region over the coming years.

[17] From the 26 selected IPCC 1.5°C pathways assessed in this report, only 11 included regionally disaggregated data. Accordingly, the analysis of regional deployment of wind and solar capacity is based on the data provided by the REMIND and WITCH models, and excluded the data from MESSAGEix. See appendix for more details on scenarios selection.

Figure 3.6 Cumulative wind and solar capacity deployment needs, 2022–2030





Source: Byers et al. (2022).

As shown in Figure 3.6, the region with the smallest share of cumulative wind and solar deployment is represented by countries of the former Soviet Union. However, this region needs to increase its solar capacity by over 6 times the expected levels projected by current project pipelines and policies in the region. There is also significant catching up required for wind energy in Latin America, as well as in the Middle East and Africa. Capacity deployment needs to be 2 and 3 times larger respectively compared to current forecasts.

It is important to note that the assessment from integrated assessment models of the required capacity additions in each region do not necessarily reflect or incorporate considerations of equity and access. Further considerations to the principle of common but differentiated responsibilities and respective capacities of the Paris Agreement would require an accelerated transition from high-income countries and large historical emitters. Equity concern would likely involve faster oil and gas phase-out pathways for high-income countries less dependent on their fossil industries (Calverley and Anderson, 2022).

Other key system changes are needed to support the transition. Integrating electricity grids, building transmission lines, and storage facilities will also be necessary to deal with the intermittencies of a renewable energy system. Moreover, beyond the supply-side energy system change addressed in this chapter, other energy efficiencies and demand-side measures should be considered to fully implement a successful energy transition compatible with the ambition of limiting warming to 1.5°C.

3.5 Financing the Transition

The economic and legal challenges related to phasing out fossil fuel production and the obstacles posed by the conflict in Ukraine to implementing ambitious energy policies (chapter 4) exposed critical threats to the world's capacity to orchestrate an orderly transition to net-zero emissions by 2050. Moreover, the strained fiscal capacity of governments after historically significant spending packages in response to the COVID-19 pandemic creates an additional risk of underinvestment in the energy transition. This section will provide an assessment of the financing needs that are necessary to deliver the renewable energy capacity aligned with the 1.5°C goal.

Translating the renewable energy capacity consistent with the selected IPCC 1.5°C scenarios into monetary terms will provide a picture of the investment gaps between current and planned spending and the one needed to achieve Paris-aligned investment pathways. The regional disaggregation of investment needs will also provide an assessment of where the largest needs are. Delivering the resources where it matters most will require not only governments but also financial institutions and corporations to redirect their capital away from fossil fuels and toward renewables.

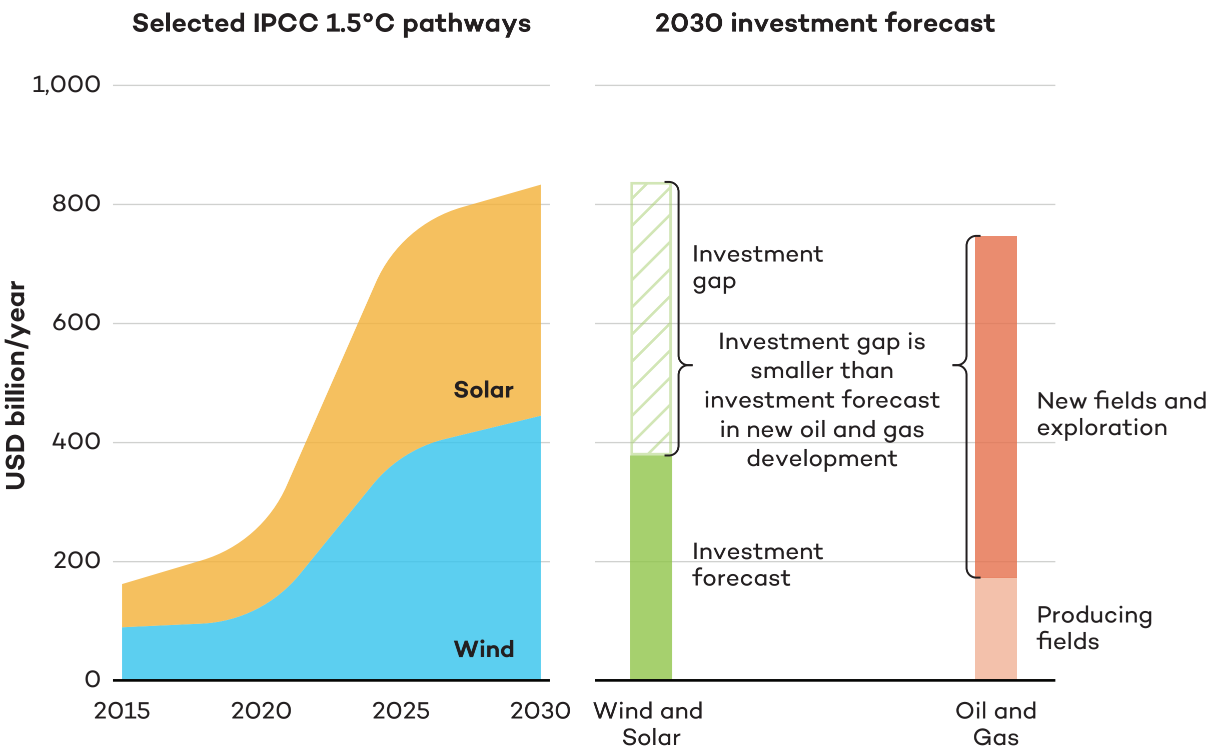
3.5.1 Investment Gaps

Based on the IPCC pathways assessed in this report, this section presents the global investment needs required to deliver the wind and solar capacity consistent with meeting the temperature target of the Paris Agreement. In order to effectively displace fossil fuels, investment in renewables will need to accelerate rapidly during the course of this decade. Selected IPCC 1.5°C pathways show that between now and 2030, annual investment in solar energy needs to increase 3 times over current levels and more than 4.5 times for wind. Together, total annual investments in both wind and solar should amount to about USD 830 billion by 2030.

Figure 3.7 shows this evolution of investment needs by multiplying the required capacity additions shown in this chapter by the capital cost for wind and solar forecasted by IRENA for the coming decade[18] (Asmelash and Prakash, 2019; Prakash and Anuta, 2019). It also illustrates the sizable investment gap in annual investment levels, and shows that unless other new policies are implemented, investment levels are only expected to deliver USD 380 billion of investment in wind and solar energy combined by 2030. This leaves an annual investment gap of more than USD 450 billion by 2030.

[18] See appendix for full methodology on the calculation of investment costs based on IRENA cost curves

Figure 3.7 Wind and solar investment needs and investment gaps



Sources: Byers et al. (2022); Rystad Energy (2022).

However, capital and operational expenditures for the exploration and extraction of oil and gas in new fields—which are incompatible with selected IPCC and IEA 1.5°C pathways—are expected to reach USD 570 billion annually by 2030 (Rystad Energy, 2022). By themselves, these investments would suffice to bridge the entire investment gap for wind and solar in 2030. Between 2020 and 2030, investments in new oil and gas fields are expected to cumulatively reach more than USD 4.2 trillion. Preventing investments in any oil and gas fields beyond those already under development is essential to limiting temperature rise to 1.5°C, and could additionally free up a significant sum of capital required to fill the wind and solar investment gap. In other words, the problem is not a shortage of available capital, but rather that existing energy investment is going to the wrong places.

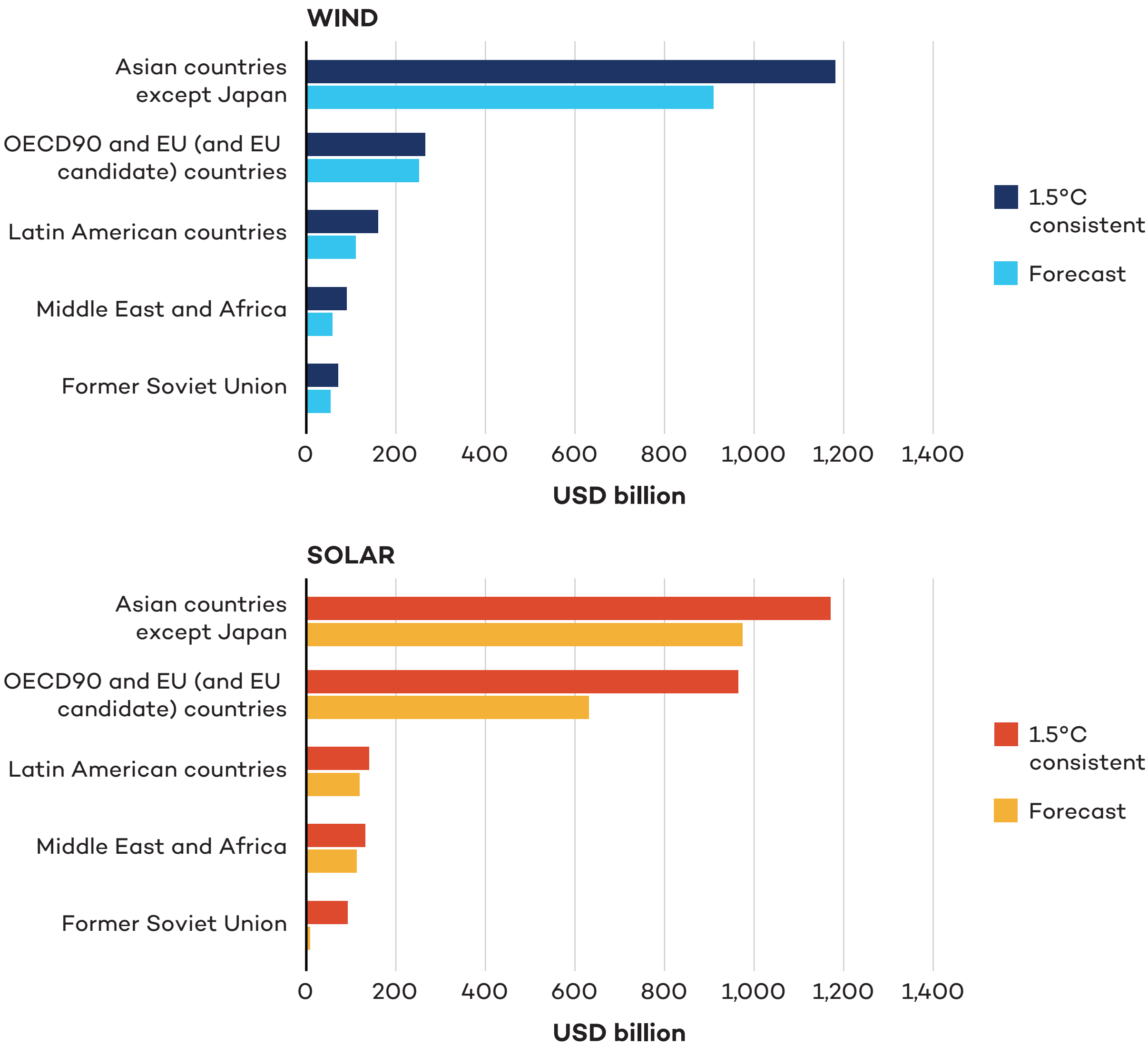
The global investment gap provides useful guidance to assess the scale of measures required to mobilize adequate means to implement the energy transition. However, the enabling investment policies necessary to enable mobile capital flows toward renewables are generally intertwined in national and regional circumstances. It is therefore important to also assess the regional investment needs and gaps to facilitate channelling capital to where it is most useful.

The regional disaggregation of global investment needs reveals crucial insights into the state of the energy transition across different parts of the world. Based on the median of selected IPCC 1.5°C pathways, a regional comparative assessment of the forecasted cumulative and 1.5°C-compatible investments in wind and solar between 2022 and 2030 is shown in Figure 3.8. The figure illustrates the relative investment needs and regional investment gaps for five IPCC regions until the end of the decade.

Notably, it shows that more than two thirds of the total wind energy cumulative investment needs are located in Asian economies (excluding Japan); this accounts for just over 70% of the total USD 385 billion investment gap for wind technologies globally. Accordingly, about USD 1.2 trillion is required just for the installation of wind farms in Asia alone by 2030, based on the 1.5°C-consistent IPCC pathways assessed in this report. However, the highest increase necessary to fill the regional gaps is situated in Latin America and the Middle East and North Africa, with 45% and 55% investment growth respectively required to deploy the wind capacity aligned with 1.5°C pathways.

In terms of investment needs for solar capacity deployment, the OECD and EU countries have the largest gap, with more than USD 330 billion of additional investment needed by 2030. However, the largest share of total investment still needs to occur in Asian countries except Japan. While the countries of the former Soviet Union account for the smallest share of total required investment, this region also has the most growth to achieve over the coming decade, with investment levels expected to be 10 times under the estimated need.

Figure 3.8 Regional cumulative investment needs for wind and solar, 2022–2030



Source: Byers et al. (2022).

Governments have a critical role to play in creating an enabling environment through regulatory frameworks and fiscal reforms for investments to flow away from fossil fuels and toward renewables. Globally, fossil fuels receive subsidies of USD 370 billion per year, while renewable energies receive only USD 100 billion (Bridle et al., 2019). Addressing these imbalances would significantly change the economic and incentive structures in the energy sector.

Moreover, mobilizing the vast amounts of capital presented in this chapter into the energy transition will require redirecting investments by the financial sector. The IPCC's latest assessment report observed that the 60 largest banks have provided USD 3.8 trillion to fossil fuel companies since 2016 (IPCC, 2022). As chapter 5 will show, financial institutions' net-zero strategies are currently inadequate to effectively align with the Paris Agreement targets. This can be partly attributed to corporate net-zero targets' lack of transparency, coverage, and inadequate use of scenarios.

4.0
The War in Ukraine and the Geopolitics of Energy Transitions

Key Insights

- The war in Ukraine has caused a further tightening of global gas markets, forcing Europe to seek new sources of gas provision, both in the form of liquefied natural gas (LNG) and gas pipeline expansion. This "dash for gas" bears medium- to long-term consequences, both for Europe's ambition to reach the 1.5°C goal and for other countries, especially developing ones, where the construction of new gas infrastructures is being planned.
- Four main alternatives to gas in Europe have emerged in recent debates: significant demand reduction and gas savings; fuel switch to alternative energy carriers; a strong uptick in investment in renewables and the energy transition; and a change in the EU gas market model, carrying possible effects for an emerging green hydrogen market.
- New risks of derailing energy transition plans in many parts of the world, at least in the short term, have emerged in the context of the war. However, in the long term, the cost-competitiveness of renewables continues to increase. Key concerns relate to supply chain disruptions, which are putting an unprecedented strain on the renewables industry, especially as policy instruments continue to focus on compressing prices. The design of renewable competitive procurement mechanisms and power markets have now resurfaced as ever-pressing needs.
- Developing countries face great challenges in the context of the global energy transition. To tackle such challenges, these countries need to abandon fossil energy and leapfrog toward renewable energy in an equitable and just manner. This would not only be compatible with tackling the ongoing climate crisis but also unlock the continent's human and economic potential.

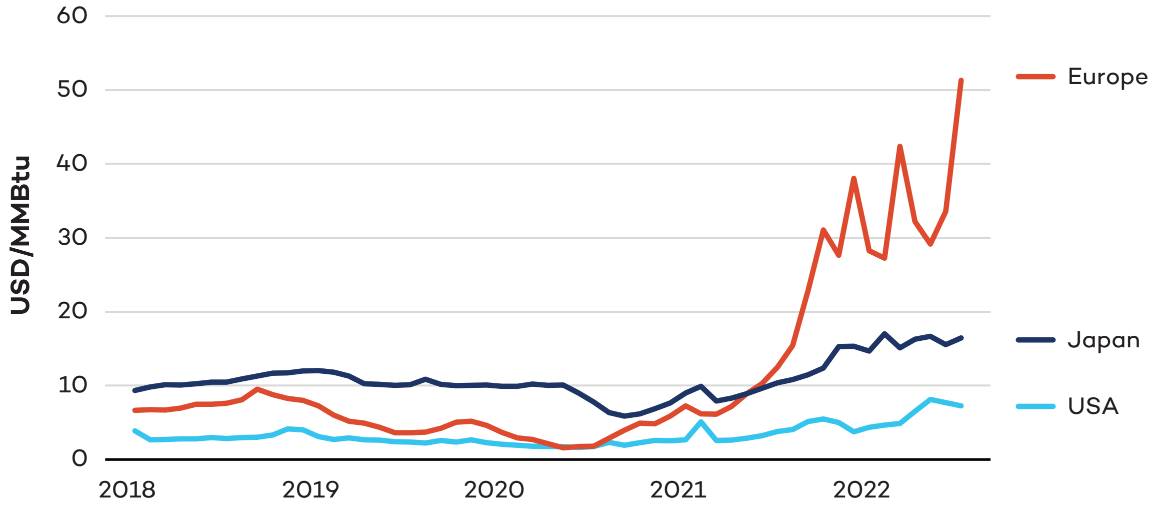
4.1 The War in Ukraine and the Dash for Gas

4.1.1 Current Dynamics in the Global Gas Market

Since the second half of 2021, global gas markets have been tightening due to the combination of a strong post-COVID-19 economic recovery, extreme weather events, and unplanned supply outages. Europe, having fallen at the centre of these considerable market tensions, has entered the 2021/22 heating season with storage inventories well below average, just as Russian pipeline flows have registered a sharp 25% year-on-year drop in the last quarter of 2021 (International Energy Agency [IEA], 2022c).

The Russian Federation's invasion of Ukraine in February 2022 further exacerbated such market uncertainty and price volatility (see Figure 4.1). In many markets, higher gas prices have had significant knock-on effects on fertilizer, food, and electricity prices. In response to the war, the United States, the European Union, and others have imposed economic sanctions against the Russian Federation and have announced plans to phase out their reliance on Russian energy supplies.

Figure 4.1 Wholesale gas prices in key markets since 2018



Notes: Prices are monthly average wholesale prices. Gas price for Europe: Title Transfer Facility (TTF). Gas price for the United States: spot price at Henry Hub. Gas price for Japan: LNG import price, cost, insurance, and freight (CIF); recent two months' averages are estimates.

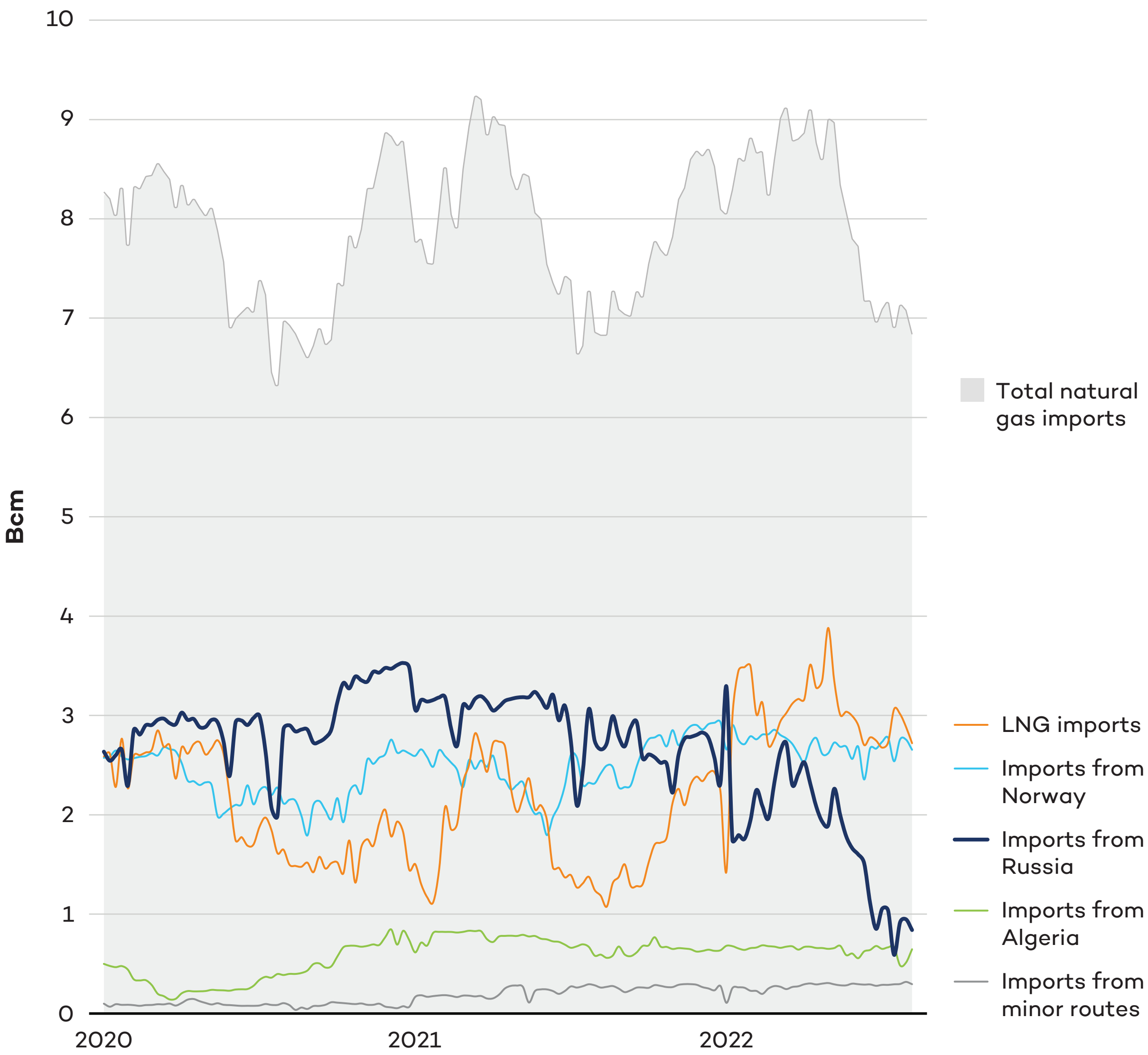
Source: World Bank (2022).

Cutting energy ties with the Russian Federation will be particularly hard for the European Union. In 2020, imports from the Russian Federation satisfied 41.1% of the bloc's natural gas needs, with some member states such as Germany being even more dependent (Eurostat, 2022). The volume of imported fossil gas from the Russian Federation in 2021 was 155 billion cubic metres (bcm). The REPowerEU Plan, adopted on May 18, 2022, aims to curb imports of Russian gas by around two thirds by the end of 2022 and end them by 2027.

Recent sharp cuts in PJSC Gazprom's pipeline gas deliveries to the European Union have raised alarms about winter supplies and the huge economic and human costs they may have on industry and households, especially fuel-poor ones. As a result of the cuts, gas prices have skyrocketed in Europe, leading to demand destruction, fuel switching (gas-to-coal), and record imports of LNG. In the first half of 2022, EU imports of LNG rose by 28 bcm compared with the same period a year earlier (Figure 4.2).

The rapid untangling of the decades-old natural gas trading relationship between the Russian Federation and Europe will impact global supplies. The Russian Federation is still the world's largest gas exporter, (IEA, 2022c) and its scope to divert natural gas exports to other countries is limited by a lack of infrastructure. The Russian Federation supplied just over 30 bcm of gas to Asia in 2021, compared with 155 bcm of gas exports to the European Union. It will take at least a decade for the Russian Federation to scale up its gas exports to Asia to match the pre-war export levels to Europe (see Figure 4.3). Whether it will actually achieve that goal is uncertain as it requires developing new infrastructure while under sanctions as well as forging supply agreements with new customers.

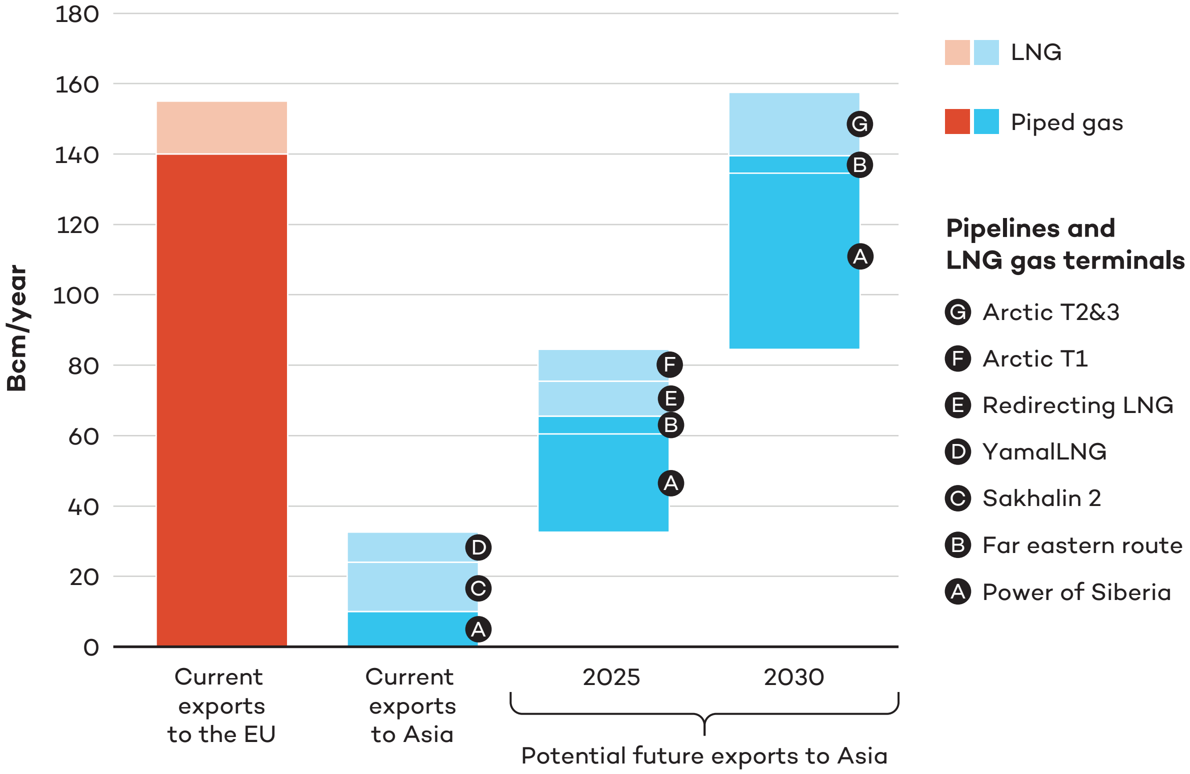
Figure 4.2 EU natural gas imports by source



Notes: Gas imports are weekly data, from January 1, 2020 to August 14, 2022. "Russia", "Norway", and "Algeria" only denote pipeline imports. "Minor routes" includes imports from Azerbaijan and Libya.
Source: McWilliams, Sgaravatti and Zachmann (2021).

Little spare capacity exists in other countries to produce or export natural gas or LNG, and developing new reserves and infrastructure experiences long lead times. It usually takes 3–5 years to build new LNG plants after taking a final investment decision (Rozansky, 2022), while it can take even longer for developing new (conventional) gas reserves (Darko, 2014).

Figure 4.3 Estimated time needed for the Russian Federation to shift its gas exports to Asia



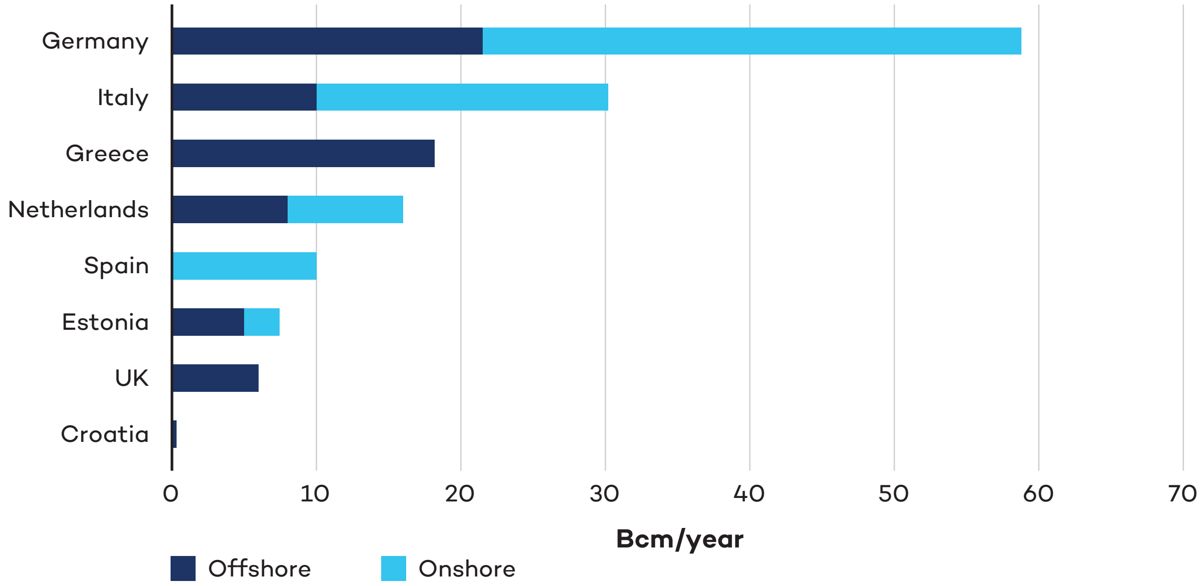
Source: IEA (2022e).

4.1.2 The Dash for Gas

Government reactions to the Russian energy shock of 2022 could determine whether they set themselves on a path toward 1.5°C or lock in carbon-intensive infrastructure. While European governments have reasserted or even accelerated their decarbonization plans in the immediate wake of the Russian invasion, the worsening energy crunch has compelled them to resort to emergency measures that focus on addressing short-term energy supply needs rather than long-term needs to reduce emissions.

This is especially apparent in a wave of new plans to boost LNG import capacity in Europe, including expansions of operating terminals (see Figure 4.4). In the first months since the Russian Federation's invasion, an estimated 150 bcm/year of newly proposed or revived LNG import projects was announced (Aitken, Langenbrunner and Zimmerman, 2022). This equates to a total operational capacity to receive and regasify LNG at 160 bcm/year as of April 2022 (Gas Infrastructure Europe, 2022). Offshore terminals, also known as floating storage and regasification units (FSRUs), have become popular due to the advantages they carry in terms of permit requirements, lead time, and cost.

Figure 4.4 Europe's LNG rush since February 2022



Notes: Breakdown of new planned LNG import capacity additions, including expansions of existing terminals, since February 2022. Offshore capacity covers FSRUs, floating storage units and floating regasification units.
Source: Global Energy Monitor (2022a).

These LNG plans often receive government backing. In Germany, which currently has no LNG terminal, the federal government has adopted the LNG Acceleration Act to fast-track the development of new LNG infrastructure (German Federal Government, 2022). The REPowerEU Plan entails EUR 10 billion of investment in new gas infrastructure by 2030 through the Projects of Common Interest framework (European Commission, 2022a).

The LNG rush is not limited to Europe. Some countries with large gas reserves view the current geopolitical crisis as an opportunity to expand their gas export infrastructure. In the United States, for example, the Federal Energy Regulatory Commission has already picked up the pace in approving projects related to LNG (Shaykevich, Bernhardt and Bird, 2022). Other major LNG exporters such as Qatar are considering boosting export capacity (Foxman and Stapczynski, 2022).

The war and high gas prices have also fuelled renewed momentum to develop and expand LNG terminals in Congo, Mauritania, Tanzania, and Senegal – countries that do not currently export LNG (IEA, 2022b; Ng'wanakilala and Dausen, 2021). Similarly, Canada, which does not have LNG export terminals, is in discussions with European countries about eventually supplying them with LNG and is considering fast-tracking new LNG projects (Tuttle, 2022).

The dash for gas is not limited to LNG but also includes pipelines. In February 2022, Nigeria, Niger, and Algeria signed an agreement to restart the development of the previously dormant Trans-Saharan pipeline. In early June, the Government of Nigeria approved the plan to build an offshore gas pipeline via the West African coast to Morocco (Africa News, 2022). Europe's push to diversify gas supplies has revived plans for the construction of the EastMed gas pipeline, linking the Eastern Mediterranean to Greece and the rest of south-east Europe (Michalopolous, 2022).

There has also been a flurry of new gas import deals. More than 23 million tonnes per year of LNG export deals have been signed in the first half of 2022 (Wood Mackenzie, 2022), with Chinese buyers dominating the market on the demand side (IEA, 2022e, p. 38) and United States companies dominating on the supply side (Paul, 2022). Germany signed a long-term import contract with Qatar, with first shipments estimated for 2024 (Delfs, Nienaber and Ratcliffe, 2022). Italian energy major Eni S.p.A. has signed import deals with Algeria, Angola, the Congo, Egypt, Mozambique, and Qatar (News Wires, 2022; Rossi, 2022a), and Polish oil and gas company PGNiG has signed an LNG deal with U.S. energy firm Sempra Energy (Blake, 2022b).

EU officials have stepped in and concluded a host of political agreements to boost non-Russian gas imports. On March 25, the Biden Administration announced that it would ensure deliveries of an additional 15 bcm of LNG to the European Union in 2022 (White House, 2022a). In mid-June, the European Union signed a memorandum of understanding with Egypt and Israel to boost LNG supplies to Europe (Euractiv, 2022b). On July 19, the European Union also signed a deal to double gas imports from Azerbaijan from 2027 (Euractiv, 2022a).

Some countries cite the European gas crisis as an incentive to develop or grant permits to new gas reserves, including Algeria, Norway (Adomaitis, 2022), and Azerbaijan (Griffin, 2022). In general, total upstream oil and gas investment is set to rebound by 10% in 2022 compared with the previous year (IEA, 2022f). The (announced) exits from the Russian Federation of oil majors such as BP, ExxonMobil, Shell, and Equinor could see them refocus on developing and potentially fast-tracking their natural gas projects in Africa, including LNG projects, which were previously shelved (Table 4.1) (Rystad Energy, 2022a).

Table 4.1 Major African natural gas projects that may accelerate

Project	Country	Operator	Final Investment Decision*	Start-up*	Resources* (MMboe)
Rovuma LNG Phase 1–Mamba South (Area 4 LNG–T1 & T2)	Mozambique	ExxonMobil	2024	2028	2,330
Bir Allah (x-Marsouin) & Orca	Mauritania	BP	2030	2035	2,180
Yakaar–Teranga LNG	Senegal	BP	2030	2034	1,245
Tanzania LNG T1 (Block 1 & 4)	United Republic of Tanzania	Shell Plc	2026	2031	780
Ethiopia-Djibouti LNG T1 (Calub & Hilala Phase 2)	Ethiopia	Poly GCL	2030	2033	500

Project	Country	Operator	Final Investment Decision*	Start-up*	Resources* (MMboe)
Quiluma/Maboqueiro (Northern Gas Complex)	Angola	Eni	2023	2026	425
Coral FLNG Phase 2	Mozambique	Eni	2028	2030	400
Djibouti FLNG (Calub & Hilala Phase 1)	Ethiopia	Poly GCL	2025	2029	355
OML 13 (NLNG Seven Plus)	Nigeria	NPDC	2025–2028	2028–2030	335
OML 18 Redevelopment (NLNG Seven Plus)	Nigeria	Eroton	2024	2025	330
HI-1	Nigeria	Shell Plc	2023	2027	265
Fortuna FLNG	Equatorial Guinea	Lukoil	2024	2028	260
Uzu (NLNG Seven Plus)	Nigeria	Shell Plc	2023	2026	140
Touat Phase 2 (Skikda LNG)	Algeria	Neptune Energy	2023	2026	135
UTM Offshore FLNG	Nigeria	UTM Offshore Ltd.	2024	2027	135
Equatorial Guinea LNG T1	Equatorial Guinea	Marathon Oil	2025–2028	2027–2030	110

Note: *conservative estimates.
Source: Rystad Energy (2022b).

4.1.3 The Geopolitical and Climate Consequences of Europe's Dash for Gas

Europe's hunt for energy carries profound implications for geopolitical allegiances, energy security in developing and emerging economies, as well as the world's ability to meet the Paris Agreement's climate goals. One of the consequences of the war is the renewed geopolitical importance of the Mediterranean and African regions, now perceived as central to the EU's energy security. Europe's hunt for gas supplies could squander its previous efforts to foster green partnerships with its southern neighbours. It could also lead to new equilibria within the European Union as southern member countries such as Italy and Spain try to position themselves as new gas hubs, shifting the balance of Europe's energy security from the East to the South. At the same time, we see closer fossil fuel-based ties between Europe and the United States. Since June 2022, the United States has been sending more gas to Europe than Russia (Shiryaevskaya, 2022a).

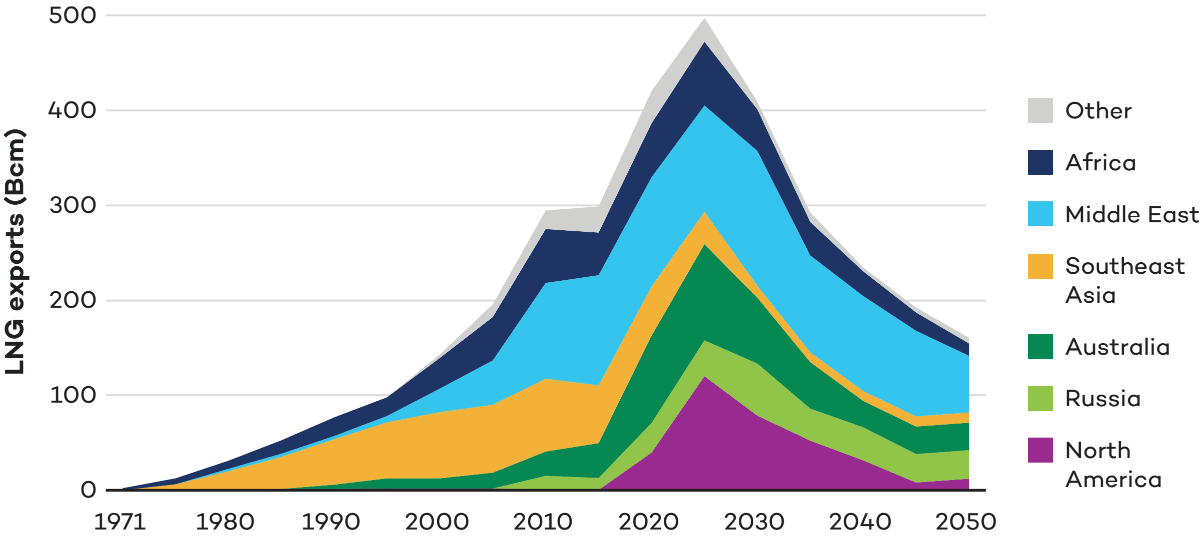
Europe's gas diversification efforts do not eliminate security of supply risks. In late 2021, for instance, the Maghreb–Europe gas pipeline was shut down due to a diplomatic dispute between Algeria and Morocco. A few months later, Algeria threatened to cut gas supplies to Spain if the latter re-exported the gas to Morocco. In September 2022, fighting erupted between Azerbaijan and Armenia, complicating the EU's ambitions to increase its imports of Azerbaijani gas. Several current or prospective gas exporters in Africa are struggling with domestic stability, notably Mozambique where oil major TotalEnergies SE had to withdraw its staff from an LNG project in 2021 due to the deteriorating security situation.

Another clear side effect of the EU's dash for gas and the war in Ukraine is that emerging and developing countries are increasingly being priced out of the LNG market. Since the last quarter of 2021, and continuing in 2022, buyers in emerging nations such as Pakistan, Bangladesh, Thailand, and Argentina have struggled to attract LNG imports (Stapczynski, 2022; Stapczynski and Koh, 2022). In July 2022, a USD 1 billion LNG purchase tender from Pakistan did not receive a single offer (Stapczynski, 2022). While some developing countries such as Bangladesh have resorted to cutting off their electricity supply for parts of the day, others like India have resorted to using more coal. In some cases, LNG cargoes that were due to developing countries have been diverted so as to profit from surging prices in Europe, even if suppliers are forced to pay penalties under contracts with developing nations (Shah and Hirtenstein, 2022). FSRUs that were recently chartered by Senegal (since May 2021) and Ghana (since January 2021) to import LNG have yet to receive their first cargoes. Similar LNG import projects planned in Côte d'Ivoire and Benin have been put on hold (IEA, 2022e, p. 48).

In Asia, gas was long viewed as a bridge fuel between coal and renewables, but due to the current price shock, that bridge may be shorter and narrower than originally thought. The project pipeline shows that demand for LNG from emerging economies in Asia is set to increase by around 22 bcm, including from new entrants into the LNG business such as Vietnam and the Philippines, where new LNG terminals are set to come online in 2022 (Reynolds, 2022). As neither of them has signed long-term contracts, they will need to compete with Europe and north-east Asia for limited spot cargoes in the years ahead (IEA, 2022e, p. 43).

Even though the outlook for LNG demand might have shifted since February 2022, countries that plan to build new LNG terminals face several risks, including delays, cost overruns, outages, and a more competitive and potentially shrinking market in the medium term (Plante and Nace, 2021). In all scenarios analyzed in chapter 3 of this report, gas production needs to decrease sharply between 2025 and 2050 (by 34% according to the selected Intergovernmental Panel on Climate Change [IPCC] 1.5°C pathways assessed in this report; by 85% according to the Bloomberg New Energy Finance net-zero scenario; and by 100% according to the One Earth Climate Model scenario). This equally holds for LNG trade. For the world to have a 50% chance of limiting global warming to 1.5°C (Figure 4.5) (IEA, 2021a), IEA's Net Zero Emissions by 2050 (NZE) scenario projects that there needs to be a 60% decline in natural gas traded as LNG between 2025 and 2050, as well as a 65% decline in trade by pipeline.

Figure 4.5 LNG exports (billion cubic metres) in the IEA's net-zero scenario



Source: IEA (2021a).

New fossil gas infrastructure such as LNG terminals and pipelines can considerably impact climate goals. Burning natural gas eventually generates carbon dioxide, but levels of methane leakage along the entire natural gas value chain have long been underestimated. Moreover, once capital is locked in, the resulting emissions will be locked in as well, or the projects will become stranded assets (Kemfert et al., 2022).

An exception might be FSRUs, which have become very popular in north-western Europe because of the considerably shorter lead times compared with onshore terminals. These units have fewer lock-in risks as they can be chartered for shorter periods. However, there are only 5–10 FSRUs available to Europe in the short term (Dempsey, 2022; European Commission, 2022b).

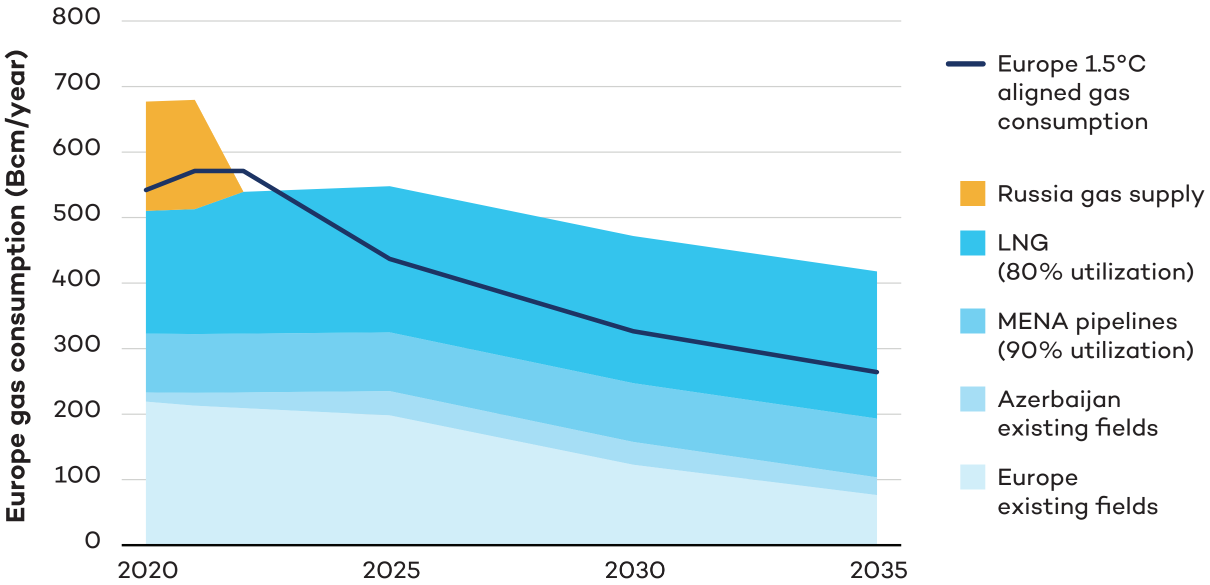
Policy-makers claim that new natural gas infrastructure will be able to handle green fuels such as hydrogen or derivatives (e.g., ammonia) in the future (White House, 2022b). Yet, when it comes to new onshore LNG terminals, major questions remain about the technical feasibility and business case of doing so (except, of course, imports of synthetic methane) (Shiryaevskaya, 2022b). Natural gas pipelines can theoretically be repurposed to hydrogen if they are built using steel that has a low susceptibility to hydrogen embrittlement. However, at this stage, the cost efficiency of transporting hydrogen through pipelines, especially over long distances, remains unclear.

Figure 4.6 shows European gas consumption in the median IPCC 1.5°C pathway and in the IEA's NZE scenario. These lines are superimposed on shaded areas representing the various sources of gas supply, both European production and import infrastructure. Assuming Europe reduces gas demand in line with 1.5°C pathways, the existing supply is sufficient without Russian imports, except for a short-term potential supply crunch in 2022/23.

Research by Artelys (2022) and Brown (2022) has shown that Europe can meet its energy needs while reducing its dependence on Russian supply through accelerating renewable energy, energy efficiency, and electrification, without new gas infrastructure. Our analysis adds that not only *can* Europe do so, but also it *must* do so to align with 1.5°C pathways. Indeed, as with global oil and gas production, building additional supply would lead either to Europe exceeding 1.5°C aligned gas consumption or to stranded assets.

Furthermore, additional production commonly takes 2–3 years from final investment decision, and 5–10 years from the award of new licences, while construction of new pipelines or LNG terminals takes several years even after permits are awarded (which itself can also take years). Therefore, neither additional infrastructure nor production can address the near-term supply crunch, as no meaningful infrastructure can be built in that time, making new production and infrastructure unsuitable solutions.

Figure 4.6 Europe gas consumption and supply, bcm/year



Note: MENA: Middle East and North Africa

Source: Author's calculations, based on BP (2022b); Byers et al. (2022); Global Energy Monitor (2022a); Rystad Energy (2022b); European Commission (2022c).

However, does the current infrastructure exist in the right places in Europe? This is still an open question and one that would require more in-depth investigation, which is outside of the scope of this report.

4.2 Alternatives to Gas in Europe

In policy debates, four elements emerge as central regarding alternatives to gas in Europe: significant demand reduction and gas savings; fuel switch to alternative energy carriers; a strong uptick in investment in renewables and the energy transition; and a change in the EU gas market model, with possible effects for an emerging green hydrogen market.

4.2.1 Gas Savings

Demand reductions have become central in EU policy debates to weather potential gas shortages in the winter of 2022–23, and to avoid rationing. The European Commission estimates that Europe will need to save some 45 bcm of gas over the heating period of fall and winter 2022–23 in case of a Russian supply cut. To that end, and based on a European Commission proposal, the Council agreed in July 2022 on a gas-saving target of 15%, effective between August 1, 2022 and March 31, 2023. Demand reduction is voluntary, and countries are free to choose their respective policy instruments. However, should countries miss their targets – that is, in the event of a "Union alert" (Council of the European Union, 2022) – the European Commission can take coercive measures.

Gas-saving needs will be uneven across the European Union. According to estimates, Germany's reduction needs may be up to 30% compared with its consumption in previous years, whereas the Netherlands could continue without savings. Countries such as Hungary or Bulgaria may even face saving needs of up to 50% (McWilliams and Zachmann, 2022a).

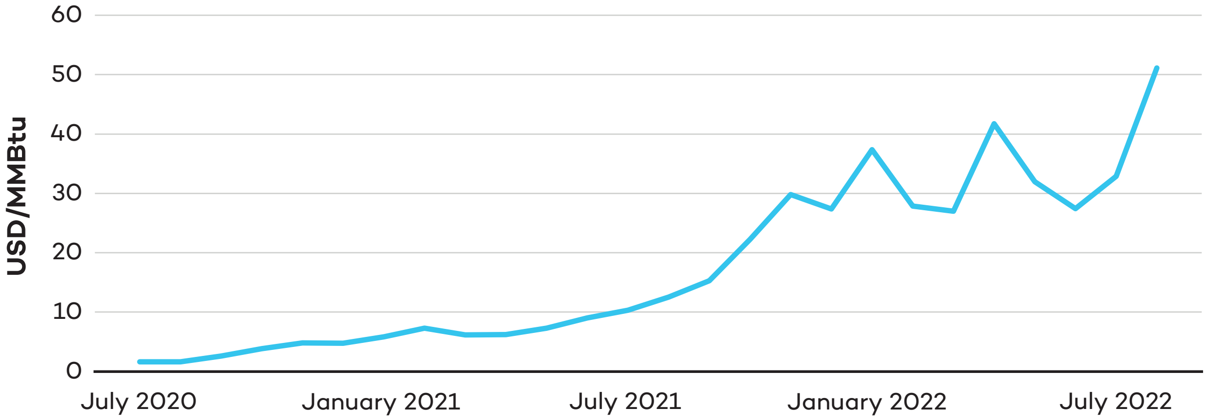
Governments are by and large heeding the call, but many are moving slowly, some are resisting, and others, such as Hungary or Spain, have even rejected the EU's gas-saving plan. Differences in the national policy measures that are in place reflect the realities of a country's respective energy mix and energy systems, but essentially centre around encouraging households, businesses, and industry to enhance savings and conservation. For example, France and Spain reportedly require stores to close entry doors to avoid wasting energy in air conditioning and heating. Efforts also centre on enhancing short-term savings in heating, with discussions in Germany focusing on changes in landlord and tenant law.

Lowering the indoor temperature may, in fact, yield annual energy savings estimated at 10 bcm per degree across Europe (IEA, 2022a), equivalent to one fifteenth of the 2021 Russian gas imports. Because much of the household-level efforts will need to remain voluntary, observers have pointed to the need to using soft policy tools, such as nudging, to achieve gas-saving targets (Neuhoff et al., 2022).

Mid- to long-term efforts include supporting energy efficiency measures in the building stock, installing heat pumps, and fostering district heating systems less dependent on natural gas. For example, the Government of Germany set the target of 500,000 new heat pumps per year from 2024 onward, at which point the new heating systems must rely on at least 65% of renewables. In fact, sales of heat pumps went up by 25% in 2022, signalling an increase in the appeal of non-gas heating infrastructure in housing.

As far as industry is concerned, European corporations had already reacted to a high-price environment prior to the war in Ukraine, and reduced demand by approximately 7% (McWilliams and Zachmann, 2022b). The prices of gas futures at the Dutch virtual trading point TTF suggest that the tight market environment will continue well into 2023, arguably further incentivizing industry-level efficiency measures and conservation/savings. There is room for additional policy measures, such as the auctioning system proposed in Germany (Dezem and Wilkes, 2022). However, there also are limits as to how much companies can save. Unsustainable price levels may eventually mean economic contraction and closure of industrial operation.

Figure 4.7 TTF price development, Natural Gas Forward Day Ahead, USD per metric million British thermal unit



Source: Nasdaq (2022).

4.2.2 Fuel Switch to Alternative Energy Sources and Carriers

Alternatives to gas in Europe include a switch to other fuels, both fossil and renewable. In reaction to tightening gas markets and facing a potential supply shortage, European industry has sought to replace natural gas with coal or oil in industrial processes. For example, the chemical sector has in part turned to steam generators running on oil, as have parts of the glass industry (Blas, 2022). Coal regained prominence in power generation, thanks to its flexibility in production, which holds particular importance in countries with higher shares of (more volatile) renewable electricity. Discussions also emerged around prolonging running plants (Germany) or building new ones (Poland) to replace gas in the power sector.

There are, however, limits to fuel switching. Some industrial processes – notably heating – are not as efficient when compared with alternative fuels or carriers such as electricity. Moreover, both oil and coal markets are strained as well, and when the Western oil embargo against the Russian Federation is fully implemented, crude prices may surge even further. Nuclear power hardly presents a short- to medium-term solution, given its construction times of 10 or more years, in addition to the difficulties of delivery it faces (half of France's nuclear reactors were down in 2022). Climate change places additional limits on alternative fuels. During the summer of 2022, exceptional drought forced a nuclear power plant in France to halt its operations, and in Italy as well as other regions, hydropower proved to be vulnerable to climate impact. Finally, a fuel switch to fossil energy sources bears the risk of delaying the green industrial transformation.

In this context, hydrogen has emerged as a possible solution for European industry, particularly when it comes to process heat. The REPowerEU Plan singles out green hydrogen as a means to replace Russian gas (European Commission, 2022b). Indeed, all leading European economies have put in place hydrogen strategies, although with varying characteristics and targets (Lambert and Schulte, 2021), as has the European Union. Yet, it is fair to assume that home-grown green hydrogen will not suffice to cover the EU's needs, and 10 million tonnes of renewable hydrogen imports may be required by 2030 according to REPowerEU. Green hydrogen partnerships are taking shape, such as Germany's August 2022 agreement with Canada, which is expected to yield 500,000 tonnes of green ammonia by 2025 (Parkes, 2022). The European Union is also enhancing its cooperation with North African countries, such as Morocco and Egypt, with a view to creating a Mediterranean green hydrogen partnership.

However, the question remains open as to whether sufficient partnerships will be in place and operational to cover additional demand as part of a timely fuel switch, as well as the degree to which green hydrogen can decarbonize industrial processes in the short term and at scale. Arguably, green hydrogen will not present a solution to the present crisis, as the volumes needed will not come through within the necessary time frame.

4.2.3 Fostering Investment in Renewables and the Energy Transition

In the wake of the Russian Federation's invasion of Ukraine, European governments as well as the European Commission were quick to stress the need to ramp up renewable energy capacity to replace gas imports from Russia, and fossil fuels more generally. Though the impact of current efforts will not necessarily be immediate (and are more likely to be medium- to long-term), the war in Ukraine indicates that there is the potential to significantly accelerate the EU's energy transition. This is a function of national and EU-level policy efforts to foster renewable energy projects, infrastructure, and related investment.

To that end, European governments have mobilized significant amounts of public funds. Germany, for example, pledged more than EUR 200 billion by 2026 for sustainable industrial transformation (Reuters, 2022c), while France announced incremental spending of EUR 6 billion to the same end (Euractiv, 2022a), in addition to an earlier EUR 30 billion of COVID-19-related green recovery measures. Other European countries also earmarked significant public funds. These national-level spending efforts come in addition to various billion-euro-funding lines set up at the European level, made available as part of the European Green Deal and the EU's Global Gateway initiative. Notably, a EUR 300 billion investment plan in renewables and decarbonization has been announced as part of REPowerEU, which also entails a solar energy strategy aimed at boosting installed capacity.

However, not all of these pledges may materialize, and it remains unclear whether grand policy plans will lead to renewable energy infrastructure within a reasonable time frame. Supply chain bottlenecks may impede rapid renewable energy project implementation and deployment, and though the REPowerEU Plan entails a permitting initiative, notoriously slow processes (particularly in Germany but also other European countries) must be significantly accelerated. Further, not all these pledges represent new money, but rather reshuffled budget positions. Some of the national-level funds may even be diverted to buffer socio-economic hardship, potentially in the form of transfers to households and companies amid soaring energy bills, thus avoiding any changes to the European energy system.

Nevertheless, there are determined policy efforts that presently couple with significant public funds, which may eventually enable the structural breaks needed to put the European energy system onto a sustainable pathway. These measures have emerged against the backdrop of the EU Fit for 55 (FF55) package and the EU Green Deal (see box 1). Some observers have argued that the present crisis and the ensuing policy measures may help achieve the decarbonization targets ahead of schedule. Section 4.3 explores the impacts of the current geopolitical situation and its prospects for renewables deployment in depth.

Box 1. EU FF55 package and European Green Deal

The FF55 package is a comprehensive set of policy measures aimed at cutting European CO_2 emissions by at least 55% by 2030. It includes, among other measures, a revision of the Renewable Energy Directive to increase the share of renewables in the EU energy mix to at least 40%; an envisaged revision of the Energy Efficiency Directive to increase the efficiency targets to 36% and 39% for final and primary energy consumption, respectively; and a Just Transition Fund aimed at alleviating social hardship.

For some industries and sectors, such as the automotive sector, emissions will need to achieve a 100% reduction by 2035. The FF55 package is part of the European Green Deal, which sets a binding target of climate neutrality by 2050. Approved in 2020, the EU Green Deal comprises a set of initiatives aimed at fostering a resource-efficient, circular economy, a clean energy sector, and a sustainable approach to finance, mobility, and agriculture. To that end, the EU Green Deal aims to achieve the circular economy and decarbonize the European economy into a sustainable model based on resource-efficient production.

4.2.4 A Looming Change in the EU Gas Market Model?

The war in Ukraine has triggered debates around the design of the EU gas market, and whether it will stand the test of the new geopolitical realities. Taking a leaf from the liberal playbook, the EU gas sector had been an integrated and (largely) privatized market since the late 1990s (Goldthau and Sitter, 2015). The basic idea of using market competition for enhancing consumer benefit worked well in a market with ample global supply. Once market started tightening, it cast concerns over the EU gas market amounting to a fair-weather phenomenon, and whether it warranted a rethink. Indeed, various policy measures adopted in 2022 already seek to correct some of the incentive problems entailed in the EU gas market model. For example, mandatory EU-wide refilling targets[19] have become better at ensuring sufficient gas storage regardless of other market circumstances (European Parliament and Council of the European Union, 2022).

There also are moves toward a much stronger public ownership of energy infrastructure. Germany has stepped in and seized control of the national retail subsidiary of PJSC Gazprom, the Russian natural gas supplier, and by extension of storage facilities (Moussu, 2022). The Netherlands and the United Kingdom are considering similar steps (Cyrus, 2022; Tan, 2022). When it comes to gas purchase, States are also resuming a stronger role. For example, Berlin

[19] Mandatory EU-wide storage refilling targets have been set to 85% by October 1, 2022 and 95% by November 1, 2022.

mandated the German Trading Hub Europe – an entity set up by network companies – to procure around EUR 1.5 billion worth of LNG for the German market (Reuters, 2022b).

In addition, steps have been taken to facilitate joint gas purchase to "secure the EU's energy supply at affordable prices" (European Commission, 2022d). To that end, European leaders established the EU Energy Purchase Platform. Currently a voluntary mechanism, the platform ties into the European Commission's REPowerEU Plan, seeking to give "support to coordinated gas refilling operations, for example through joint procurement" (European Commission, 2022f). A precedent for these efforts can be found in the early 2000s, when the European Commission explored the option of establishing a joint purchasing vehicle for Caspian gas supplies (IHS Cambridge Energy Research Associates, 2010), but the plan faltered due to a lack of political support and practical impediments.

The debate on reforming the EU gas market model must also be seen in the context of soaring electricity prices, which prompted discussions on revisiting the merit order principle in power markets and would effectively result in delinking electricity prices from gas prices. It remains to be seen whether all the above measures are mere reactions to the tight gas market situation coupled with the economic fallout of the Russian Federation's invasion of Ukraine, or whether they amount to a veritable sea change in EU gas market design. However, it can be argued that the EU's approach to natural gas has stepped over from a liberal to a geo-economic reading of supply matters (Goldthau and Sitter, 2020).

4.3 Implications for Renewables of the War in Ukraine

The war in Ukraine and the subsequent sanctions and gas situation threaten to derail energy transition plans in many parts of the world, at least in the short term. On the one hand, fossil fuel investments have become attractive again, following several years of low oil and gas prices, and are being directed toward new countries to fill the shortage resulting from the sanctions and consequent gas shortages. On the other hand, plans to phase out or phase down coal have been delayed to fill the energy gap in the short term.

However, the long-term impacts favour an energy transition based on renewable energy. This crisis, like the past oil crises in 1973 and 1979, has brought energy security and independence to the forefront of policy priorities, along with the urgency of tackling pollution and climate change, as well as water and food security.

The debate no longer centres on whether renewable energy can fulfill those policy objectives, especially as the cost-competitiveness of renewables has steadily increased compared with fossil fuels, and more so with the recent surge in prices. Instead, as the cost-competitiveness of renewables continues to increase, the debate has shifted toward mounting concerns that higher costs and supply chain disruptions are placing an unprecedented strain on the industry, especially as policy instruments continue to focus on constricting prices. As the crisis looms, some of the most pressing structural changes needed, such as those related to the design of renewable competitive procurement mechanisms and power markets, have resurfaced.

4.3.1 Energy Security and Independence at the Forefront of Policy Priorities

Following the sanctions and consequent increase in global fossil fuel prices, some jurisdictions moved to increase their energy independence and security alongside their reliance on renewables. For instance, the European Commission announced the REPowerEU Plan in March, in which they set the target of reducing gas imports from Russia by two thirds by the end of 2022, and entirely by 2030. The strategy focuses on three key topic areas: securing non-Russian suppliers of oil and gas, improving energy efficiency, and expanding the use of renewable energy. The EU's 2030 target for renewables would increase from the current 40% to 45% in the energy mix. The REPowerEU Plan would bring the total renewable energy generation capacity to 1,236 gigawatts (GW) by 2030 (including 600 GW of solar photovoltaics [PV] and 510 GW of wind), 15% higher than the 1,067 GW envisaged under FF55 (European Commission, 2022a).

Germany has also increased its ambition, aiming to accelerate its shift to renewable power while seeking a 100% renewable electricity supply by 2035. It is targeting 80% renewable share in the power mix by 2030, including more than tripling solar energy capacity to 200 GW (up from 58 GW in 2021), doubling onshore wind energy capacity to 110 GW (from 56 GW in 2021), and more than tripling offshore wind energy capacity to 30 GW (from around 8 GW in 2021) (Renewable Energy Policy Network for the 21st Century, 2022).

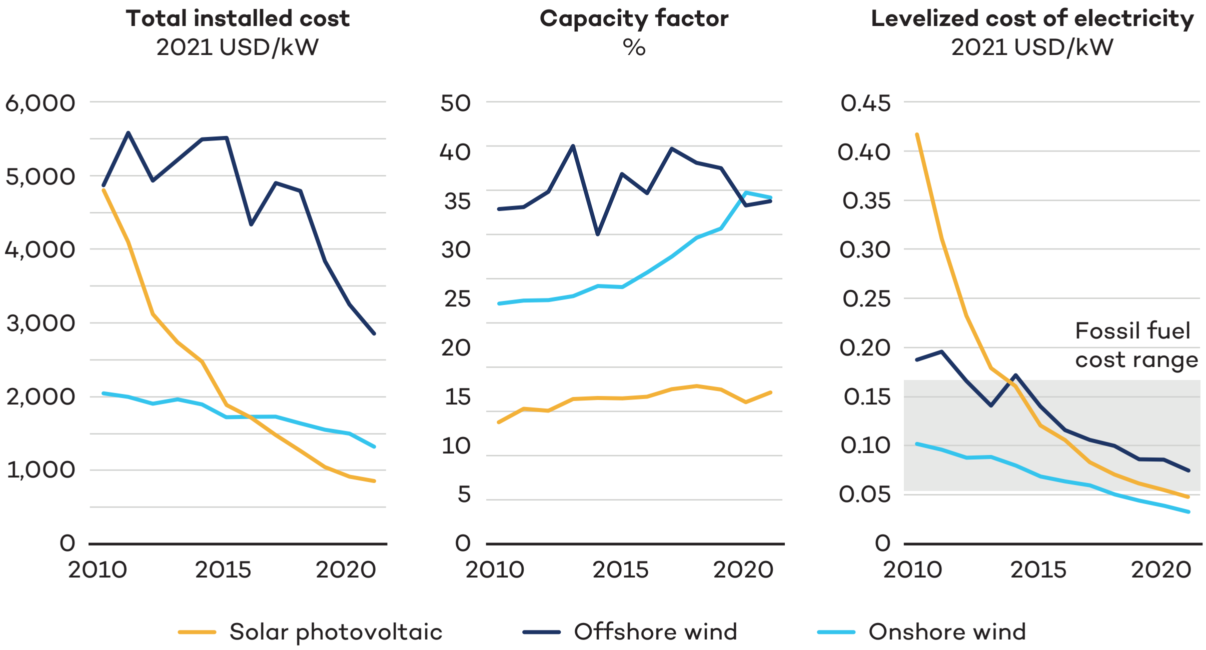
Such ambitions are increasingly achievable with the cost-competitiveness of renewables, especially compared with fossil fuels.

4.3.2 Increased Cost-competitiveness of Renewables Compared to Fossil Fuels

Renewables were already more cost-competitive compared to fossil fuels prior to the 2021 increase in fossil fuel prices. Following the sanctions imposed in 2022, fossil fuel prices increased further, making renewables more competitive, even with the slight increase in costs observed in the past year, as discussed further in this section.

The global weighted average cost of newly commissioned renewable energy projects continued its downward trend in 2021 (Figure 4.8), despite rising materials and equipment costs, primarily due to the delay in these extra costs being passed on to total installation costs. In many cases, the installed costs of projects completed in 2021 were based on prices that had been locked in under contracts signed in previous years. As such, the impact of increasing costs and prices is expected to be felt more strongly in 2022 and beyond. As shown in Figure 4.8, between 2010 and 2021, the global weighted average levelized cost of electricity (LCOE), an indicator of the cost of producing electricity over a power plant's lifetime, declined by 88% for newly commissioned utility-scale solar PV projects, and by 68% and 60% for onshore and offshore wind, respectively.

Figure 4.8 Global weighted average total installed cost, capacity factor, and LCOE of newly commissioned utility-scale solar PV, onshore and offshore wind, 2010–2021



Source: International Renewable Energy Agency (2022a).

Meanwhile, wholesale prices for gas (and electricity) increased substantially in some parts of the world as COVID-19 lockdowns and restrictions were easing and demand was surging.

IRENA estimates that with the rise in gas prices in 2021, the new renewable capacity added in 2021 has the potential to reduce electricity generation costs in 2022 by at least USD 55 billion (IRENA, 2022c).

Cost-competitiveness Increased Further in 2022, Making the Case for Renewables Stronger Than Ever

Following the sanctions and gas shortages, energy prices continued their upward trend. As fossil fuels become more expensive in 2022, the impact on renewables becomes twofold. First, renewables have become even more attractive as a more affordable and reliable source of energy. Second, there is an opportunity to channel windfall profits and additional revenues made in the fossil fuels sector toward investments in renewables.

In August, the United Nations Secretary-General António Guterres urged governments to implement windfall levies and to utilise the revenues to support vulnerable people and fund the energy transition (Taylor, 2022). The United Kingdom's Energy Profits Levy applies a 25% tax to profits that companies make from extracting British oil and gas. It is expected to raise around GBP 5 billion in its first year and increase investments in the energy sector, but it remains unclear how these taxes will support the energy transition (BBC News, 2022).

In the Middle East and North Africa, high oil and gas prices are driving energy investments. The initially forecasted USD 805 billion worth of investments in renewable energy and ESG-related[20] projects are projected to be exceeded. The region is expected to install around 20 GW of solar power over the next 5 years (Energy Connects, 2022). Moreover, higher petrol costs are pushing consumers toward electric vehicles in countries where electrical vehicles and the related infrastructure are already available (and affordable) such as the United Arab Emirates, a major oil-producing country.

Although the increasing cost-competitiveness of renewables has helped advance the case for renewables and other energy transition-related technologies, there is a risk of backfiring. At a time when investments in fossil fuels are marked by high returns, investments in renewable energy technologies are becoming less attractive, and concerns are emerging about the profitability of the industry in some markets.

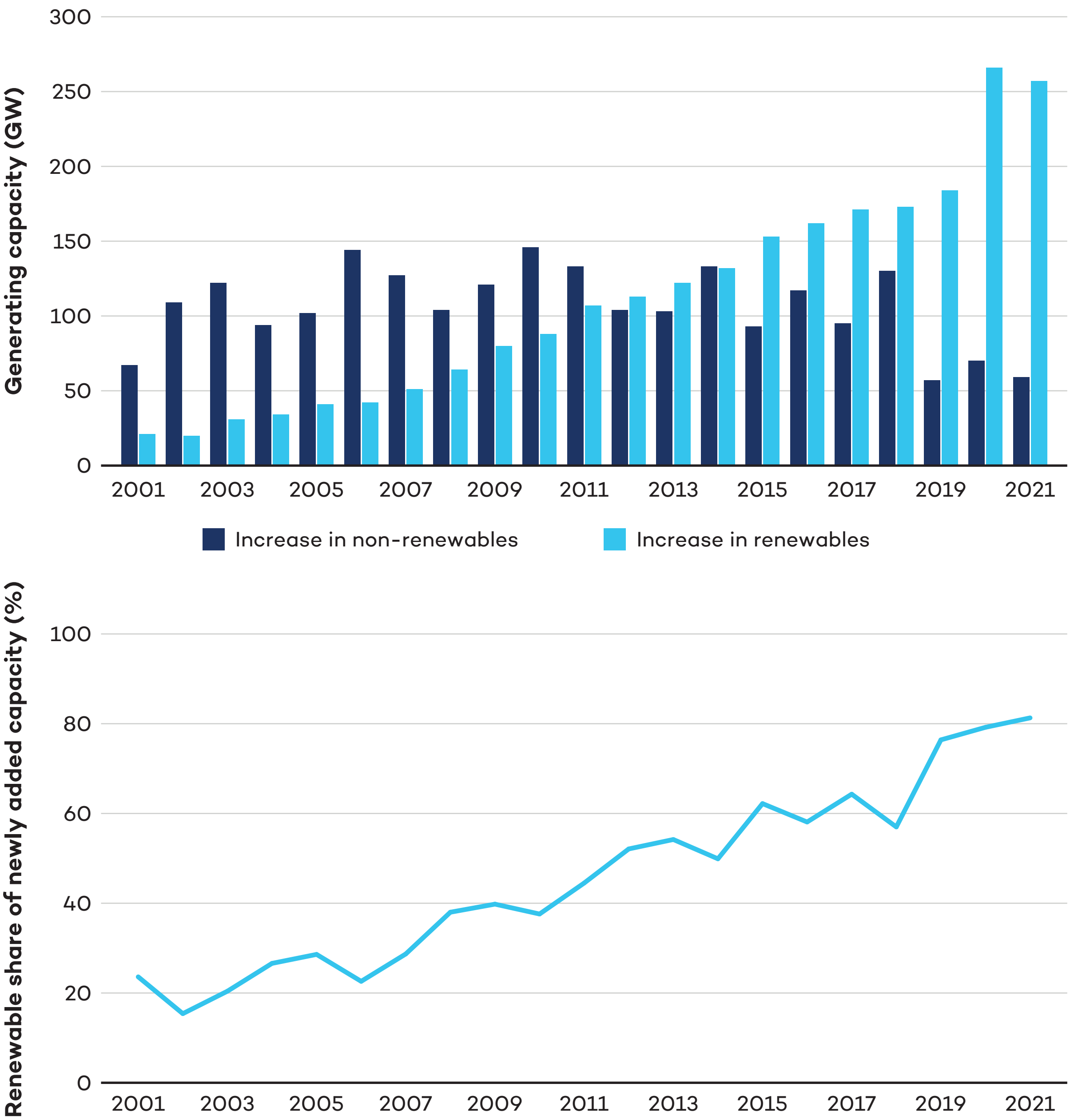
4.3.3 Emerging Concerns Regarding the Profitability of the Wind and Solar Industries in Some Markets

Although renewable energy showed resilience during the market disruption of 2020 and 2021, dominating the capacities added globally in each year (Figure 4.9), the industry is facing the many challenges brought on by pandemic-driven supply chain disruptions, as well as the spike in energy and commodity prices experienced in the past couple of years. The war in Ukraine has only exacerbated this.

More than ever, amid the high commodity and energy prices that are increasing the cost of renewables, while the fossil fuel sector benefits from windfall profits, the renewable energy industry is voicing its concerns regarding the continued focus of policy on reducing prices. This continues to be used as the main metric to measure the success of renewable energy procurement processes such as auctions, which are increasingly being awarded at a negative price. At the same time, as with the COVID-19 crisis, the limitations of the current power market design have resurfaced amid high energy prices.

[20] Environmental, social, and corporate governance.

Figure 4.9 Renewable share of annual power capacity expansion



Source: IRENA (2022b).

Costs Have Increased but Competition Continues to Press for Low Prices

PV and wind supply chains have suffered delays in shipping and delivery of key components, as well as rising prices for energy, shipping, raw material, and labour. The cost of shipping renewable energy equipment and the prices for many of the raw materials used for their production have been on the rise since the beginning of 2021. By March 2022, the price of aluminum had doubled, copper had risen by 70%, steel had increased by 50%, and freight costs rose almost fivefold (IEA, 2022g). The price of polysilicon reached USD 40 per kilogram in the first quarter of 2022, up from USD 6.80 per kilogram in 2020 (Fitch Solutions, 2022). As such, the installation costs of wind and solar have increased for the first time, reversing the long-term trend of decreasing costs seen in the past decades. The IEA estimates the overall investment costs of new utility-scale PV and onshore wind plants to be between 15% and 25% higher in 2022 compared with 2020 (IEA, 2022g).

The costs of developing projects are on the rise, while developers had committed to prices in previously agreed contracts that are no longer feasible. In addition, renewable energy projects are subject to higher financing costs as central banks tighten monetary policy in response to the surging inflation, pushing up interest rates (Indo-Asian News Service, 2022). Meanwhile, bidders in auctions have to continue competing fiercely for projects and shrinking their profit margins to potentially unsustainable levels.

The wind industry has been increasingly struggling, especially in Europe. All five European turbine manufacturers are currently operating at a loss (WindEurope, 2022a). The solar industry has also experienced challenges associated with logistics and trade wars that have caused project delays and even cancellation, with hefty penalties on developers.[21]

Meanwhile, policy instruments for renewable energy deployment still focus on the price. The use of zero-bid auctions, where renewable energy projects do not rely on any support and earn their revenues according to the market price of electricity, started a few years back. But increasingly, even negative bidding is being utilized, whereby the developers are expected to pay the government for the ability to sell electricity to the grid (while passing on these costs to the consumers).[22]

Governments may be enticed to bring in revenues with negative bidding, but this has serious repercussions on the industry as developers pass on additional costs to their suppliers, by further squeezing them for their equipment; and to their consumers, by further increasing electricity bills. This is not helping the sustainability of the industry nor the political buy-in of consumers.

4.3.4 More Actions Needed to Speed Up Renewable Energy Deployment

As the urgency of an energy transition based on renewables has increased, some governments are taking concrete action to speed up deployment on the ground.

Interventions to Reduce Permitting and Licensing Delays

Permitting and licensing delays have long been reported as some of the main challenges to renewable energy deployment, especially in Europe. The REPowerEU Action Plan (European Commission, 2022f) sets out to address permitting hurdles that are impeding the rapid deployment of solar and wind energy. The European Commission has provided

[21] In the United States, Southern Co. announced that almost 1 GW of its planned solar energy projects could be delayed by a year, due to supply chain issues in addition to possible new U.S. tariffs on imports of solar panels from South-East Asia. NextEra recently announced it expected almost 2.8 GW of its solar and energy storage projects to be pushed to 2023.

[22] To address these issues, IRENA has put forward proposals such as the dual market, making long-term power purchase agreements the main pillars of the organizational structure instead of an exception (IRENA, 2022a).

recommendations to tackle slow and complex permitting for renewable projects and has proposed an amendment to the Renewable Energy Directive.

A new law placing renewables as “overriding public interest” – that is, their deployment can be prioritized on a case-by-case basis – has been proposed, together with recommendations and guidance on how permitting processes can be simplified. The proposal includes renewable go-to areas that local governments should designate within a strategic environmental assessment where projects must be permitted within one year. To help countries identify go-to areas, the Commission is making data sets on environmentally sensitive areas available as part of its digital mapping tool for geographic data related to energy, infrastructure, and industry . In addition, existing permitting deadlines of 2 years for new projects and 1 year for repowered projects are kept, with clarifications provided on which procedures and permits must be delivered within these timeframes (WindEurope, 2022b).

More Focus on Localizing Renewable Energy Value Chains

Recognizing the importance of energy security, countries are now making efforts to localize their value chains to be more resilient to trade wars, political conflicts, and price volatility. Deployment policies such as auctions are being tailored to these objectives, and other policies that support the development of local industries are being implemented. Among other strengths, auctions can achieve objectives beyond price. Selecting winning projects based on criteria other than price can support the development and sustainability of local value chains, as in the first rounds in South Africa (IRENA, 2019).

Germany’s Offshore Wind Law (WindSeeG), for example, entails a two-track auction: one for sites that state authorities do not pre-survey (and where uncapped negative bidding is allowed), and another for sites that they do pre-survey. For the latter, two auctions are scheduled for June and August 2023, respectively, where the price criterion will account for 60 out of 100 points, and the remaining 40 will be based on the use of green electricity and green hydrogen in the manufacturing of wind turbines, a quota for training and education, the finalization of a power purchase agreement, and the protection of nature and biodiversity in the installation of wind turbines. The introduction of criteria beyond price was welcomed to account for the added value of wind energy, after having awarded bids solely on the price until recently, which has strained the industry (Dickson, 2022). Discussions between major European turbine manufacturers and the EU Industry Commissioner on how the EU recovery money can support the supply chain and how the EU trade policy can support their competitiveness highlighted how renewable energy auctions should be indexed to inflation, and how they should move away from the price-only approach that has increasingly resulted in negative bidding, hurting revenues and feasibility (WindEurope, 2022a).

For solar PV, the need for localizing supply chains has emerged in key regions. Europe, India, and the United States are all introducing plans and major incentives for vertically integrated manufacturing at scales comparable to those already developed in China (Hutchins, 2022). U.S. senators are proposing schemes, including tax credits for materials used to produce United States-made solar products. One of the European Commission’s industry strategies, the European Solar Initiative, focuses on developing the solar supply chain across the bloc to reach an annual production level of 20 GW by 2025. Around EUR 8 to 10 billion would be needed, reflective of the EUR 8 billion trade deficit for solar energy (predominantly PV) imported into the European Union. Incentives will be required to enable bigger market shares of EU-manufactured solar products (Fitch Solutions, 2022).

While this section highlights some of the challenges for renewables expansion, it also shows how policy design can be tailored to serve specific objectives and priorities and address specific challenges to deployment. As shown in Figure 4.9, renewables have continued their progress in the past 2 years. But IRENA analysis finds that continuing on this path, if all 2030 targets announced to date are achieved, global installed renewable capacity would only reach 5.4 terawatts (TW) in 2030, less than half of what is required to stay in line with the 1.5°C pathway, which is 10.8 TW by 2030 and 27.8 TW by 2050 (IRENA, 2022a). As such, a major increase in ambition will be needed to put the world back on track.

As shown in section 4.3.2, countries and regions have already started raising ambition to increase their energy security and independence. At the same time, there is a growing realization that to achieve those objectives, policy instruments need to change their focus from reducing price to sustaining the industry and supporting local supply chains. This shift in focus would help achieve climate goals while creating value and maximizing socio-economic benefits. Finally, international collaboration in terms of financing and technology exchange will be essential to make the transition universal. In some countries and regions, the energy transition will only materialize and achieve socio-economic benefits if the support and flow of funds from the Global North increase substantially.

4.4 Opportunities for Developing Countries to Leapfrog

Global South energy systems face great challenges within the emerging green global economy. For instance, of the 770 million people that live without access to electricity, most reside in Africa and Asia. The African continent faces the most acute forms of energy poverty in the world. Approximately 630 million people do not have reliable access to electricity, and over 890 million people are forced to rely on solid biomass for cooking. Compounding these challenges is Africa's vulnerability to climate change, which means that traditional pathways to increasing energy supply, which rely on burning fossil fuels, are not feasible and sustainable.

There is a growing need for the Global South to co-create new energy systems for the future. However, the absence of evidence-based research and analysis of the causes of low energy access or the requirements of an energy transition is undermining key political action and investments needed to achieve the much-needed energy transition and enable energy access, especially for the millions of people that lack access. Actions informed by evidence are needed to underpin the energy system of the future that will help the developing countries meet their energy challenges.

Countries in the Global South, and in Africa in particular, need to leapfrog toward renewable energy in an equitable and just manner that abandons fossil energy such as gas, oil, and coal, and embraces clean energy that is not only compatible with tackling the ongoing climate crisis but also capable of unlocking Africa's hidden potential. Africa contains over 39% of the world's renewable energy potential. Shifting to 100% renewable energy sources – that is, ones that are just, affordable, and accessible to most Africans and are in line African values, while providing improved socio-economic conditions for populations living in energy poverty – will help improve livelihoods where sustainability thrives and grows alongside overcoming underdevelopment and energy access.

The ongoing climate emergency is calling on Africa to urgently shift away from its dependence on fossil fuel-based energy generation and transition toward a renewable energy future (African Climate Reality Project, 2021). The just transition to renewable energy has never been more crucial, as Africa needs to immediately move away from further investments that cement energy poverty on the continent and undermine its prosperity, all while exacerbating the current climate emergency. This is even more relevant in the current context, where the dash for gas is spurring new or resumed fossil fuel projects in African countries, as outlined in section 4.1.

Renewable energy provides Africa with a financially cheaper option in comparison to fossil fuel-fired power options: 62% of added capacity in 2019 had lower costs than the cheapest new fossil fuel-powered option (IRENA, 2021), while 56% of the hydropower projects commissioned in 2020 had an LCOE lower than the cheapest new fossil fuel-fired cost option (IRENA, 2022c). In addition, reports indicate that fossil fuel-reliant countries could see a drop in revenue in the coming years as the entire world transitions to low-carbon renewable energy sources. Leapfrogging to renewable energy would be a sustainable and eco-friendly development strategy that may be achieved through adopting a fossil-free future that breaks away from the fossil energy infrastructure that has largely been extractive, exploitative, dominant, and unjust. The success of leapfrogging toward renewable energy could lead to a democratically run and socially owned energy system for Africa and by Africa.

Leapfrogging has several forms, but Gallagher (2006) discusses leapfrogging using a term commonly referred to as path-creating. Path-creating hints toward the idea of late adopters (in this instance, countries in the Global South) exploring a new path of technology that divorces itself from the path of initial adopters (Global North). "For instance, if Africa commits to and succeeds in fulfilling universal energy access by providing the excess market demand with renewable energy, the continent would become the leader in renewable energy access by share of total demand" (Gallagher, 2006). This would fulfill Gallagher's definition of leapfrogging through path-creating. Key opportunities and barriers for leapfrogging are discussed in more detail as follows.

4.4.1 Key Opportunities for Leapfrogging

Over 620 million people living in Africa do not have access to electricity, and over 900 million rely on traditional biomass for cooking (IEA, 2019). The demand for more energy has been increasing and will continue to do so, particularly with the ever-increasing aspirations of developing countries to develop and meet their socio-economic needs. However, many developing countries have the benefit of being latecomers in building foundational infrastructure for development. This makes it easier for them to leapfrog to renewable energy infrastructure and avoid the wasteful and destructive stages that characterized industrialization in the past.

Improving Innovations in Renewable Technologies and Declining Costs

Advances in renewable energy technologies are making renewable energy competitive in price and more attractive. The declining costs of renewable energy and improving renewable energy technology and performance presents developing countries with opportunities to leapfrog fossil fuels. (Deloitte, 2018). For instance, regions such as Africa contain abundant renewable energy resources, and so, with improving technology and reducing prices, it is both technically and economically feasible for Africa to leapfrog to 100% renewable energy by 2030 and thus avoid the mistakes made by richer countries during their development processes.

International Interventions, Partnerships and Cooperation

The existing instruments within the United Nations Framework Convention on Climate Change provide the avenue to help developing countries leapfrog to 100% renewable energy if properly implemented. Its international climate finance provides an entry point for increased investment in initiatives that would help developing countries to enable renewable energy access for much of the population living without access to energy. For instance, initiatives such as Just Energy Transition Partnerships could help developing countries to leapfrog if they consider the element of avoided emissions rather than focus on reducing emissions (UN Climate Change Conference UK 2021, 2022).

Climate Action

The growing concern around climate change, which is disproportionately affecting developing countries, provides an opportunity not only for developing countries to invest in renewable energy to avoid emissions, but also to access affordable and sustainable energy for resilience building. Leapfrogging to 100% renewable energy presents developing countries with an opportunity to avoid carbon-intensive development pathways that are causing the climate crisis, and also enable them to build resilience to the existing climate-induced challenges.

There is a potential to avoid up to 626 million tonnes of CO_2 equivalent emissions over the next decade, approximately equivalent to the annual emissions of 160 coal-fired power plants (Catalyst, 2021). Wind power and solar energy will reduce 97% of water consumption in electricity generation. One drop of oil can contaminate 25 litres of water and make it non-potable (Scott, 2016). To produce 1 megawatt per hour of electricity, wind power uses 1 litre of water, solar power uses 15 litres, and coal uses 1,476 litres (Reve, 2020).

Energy is the backbone of the socio-economic development of any country. By leapfrogging fossil fuels to renewable energy, developing countries especially in Africa will fulfill energy deficiencies without damaging nature. Africa needs alternative energy development pathways. A rapid rollout of renewable energy that is environmentally and socially appropriate as well as people-centred provides African countries with the opportunity to address both the climate crisis and energy access as well as to attain their development aspirations. Leapfrogging to 100% renewable energy will be important in enabling employment opportunities.

Job Creation

Leapfrogging to 100% renewable energy installation, operation, and maintenance offers employment benefits over fossil fuels in Africa. The renewable energy sector has been shown globally to generate much higher employment than that of fossil fuels. The fossil fuel industry creates 2.7 jobs per USD 1 million invested, whereas the clean energy sector (renewable energy and energy efficiency) creates between 7.5 and 15 jobs per USD 1 million invested. Africa's distributed renewable energy industry therefore has the potential to create millions of jobs in the continent, where job creation remains low.

Fostering Energy Access

Nearly half of all Africans still have no access to electricity in their homes. Leapfrogging to renewable energy offers opportunities for African countries to enable universal energy access. Decentralized renewable energy systems offer a faster and more affordable route to increase energy access, thereby further accelerating Africa's economic growth. Mini grids using solar and wind can not only power homes but also local hospitals, schools, businesses, and other critical community resources.

4.4.2 Main Barriers to Leapfrogging

Public Participation

Inadequate public awareness and information barriers may hinder leapfrogging, especially in developing countries. The concerns surrounding public understanding of leapfrogging processes, including information on the benefits of leapfrogging and renewable energy technologies, may delay leapfrogging. Meaningfully engaging the public is very important in leapfrogging fossil fuel, especially in developing countries such as Africa (Karakaya and Sriwannawit, 2015). We need to bridge the growing knowledge gap so that the public can understand the issues around fossil fuels and the need for divestment from them. The main narrative that must be shared includes the dangers of the climate emergency and how the transition and leapfrogging toward renewable energy in a just and equitable manner can solve a significant number of issues that have placed Africa in a precarious position regarding sustainable development. There is a strong need to build an understanding about how development can be achieved in a manner that does not bring harm to the environment and as a result unlocks a just, equitable, and sustainable future.

The public, including multistakeholder participation, is closely linked to enabling stakeholder abilities, building capacity, tapping into local knowledge, and creating spaces for sharing, which includes enabling awareness. An inadequately engaged public creates a barrier to effective participation and hampers leapfrogging. Access to information, especially on issues surrounding leapfrogging, is crucial in enabling ownership of the process and fostering benefits from leapfrogging (Seetharaman et al., 2019).

More instrumentally, social acceptance is important in leapfrogging, without which costs and disruption will increase. However, a key challenge to engagement is that regions where public participation is most needed in developing countries are also where access to civic space to participate in energy decision making, discussion of possible trade-offs, and information sharing is closing down. There is a worsening lack of meaningful engagement grounded in transparency and accountability to participate in decisions, particularly in reference to energy discussions.

Capacity within Developing Countries to Leapfrog

Leapfrogging fossil fuels requires a solid foundation of a skilled labour force, due to the large demand for skilled professionals to design, build, operate, and maintain renewable energy projects. The shortage of trained workers to undertake these projects presents a major obstacle to fast-tracking leapfrogging in developing countries (Karakaya and Sriwannawit, 2015). Inadequate availability of technical professionals and training institutes may slow down leapfrogging, especially in Africa.

Roles of Governments in Developing Countries

Governments have a major role to play in facilitating leapfrogging, which includes putting in place the necessary policies and enabling required investments in the process, including capacity building and infrastructure development. Currently, huge amounts of government subsidies go toward fossil fuel projects (Zhang et al., 2014). This may hinder efforts to leapfrog to 100% renewable energy systems. Studies indicate that subsidies provided by governments to the fossil fuel industry overshadow incentives provided to develop renewable energy systems. For example, it is reported currently that fossil fuel industries received at least USD 130 billion investment and other sectors such as transport received USD 32.5 billion. A total of only USD 100 million was to be used under climate adaptation (Guzmán et al., 2022).

International partners, multilateral development banks (MDBs), and development financial institutions all have a role to play. MDBs and development financial institutions may facilitate or forestall leapfrogging in developing countries by expressing skewed support for fossil fuels, including the technology they promote, projects they finance, and actions in their countries (Oil Change International, 2019). MDBs must prioritize the development and implementation of a fossil fuel finance exclusion policy that states that the MDBs will not fund or provide financial services or capacity support to any coal, gas, or oil project. This will provide a unique opportunity for MDBs to influence national and international frameworks that set ambitious targets with the financial intermediaries (African Climate Reality Project, 2021). This is particularly true for the development of a supportive and enabling regulatory and policy environment, which is crucial to attracting private climate finance.

Climate Finance

Africa needs a robust framework to provide the funding it needs to leapfrog toward renewable energy. National governments should foster and galvanize funding for a bankable pipeline of infrastructure projects that are supported through various actions and support private sector investment in adaptation, including blended finance, fiscal incentives, green bonds, and so on. This is imperative as "Current levels of climate finance in Africa fall far short of needs. Africa's USD 2.5 trillion of climate finance needed between 2020 and 2030 requires, on average, USD 250 billion each year" (Guzmán et al., 2022).

5.0
Fostering Enabling Environments to Accelerate the Transition to Net-Zero

Key Insights

- Enforcing oil and gas phase-out pathways consistent with limiting warming to 1.5°C could cost governments up to USD 340 billion from compensation claims from cancelled projects under development but not yet producing. Investment treaties create moral hazard by insulating investors from stranded asset losses and they push the costs onto the public, diverting resources from the energy transition.
- Regulative approaches by governments at the global and national level hold an enormous potential to ensure highly ambitious corporate long-term targets. Such regulation could provide robustly defined concepts that add substantive criteria to ensure Paris Agreement compatibility, and mandate comprehensive and third-party verified disclosure practices.
- Investors can help accelerate global decarbonization by ensuring companies' capital expenditures align with climate goals. To this end, investors and advocates must reinforce current standards and frameworks to ensure broader use, greater accountability, and a decreased risk of greenwashing.

5.1 Legal and Economic Challenges to the Energy Transition

The transition away from fossil fuel production faces several structural obstacles beyond the current short-term supply crunch and disruptions in the energy markets. Limiting warming to 1.5 °C while avoiding stranded assets implies that a large share of currently licensed oil and gas reserves will have to remain unexploited. As chapter 3 has shown, the development of new fields would generate more carbon emissions than the world can afford to achieve the Paris Agreement temperature goal.

However, oil and gas companies continue to acquire additional licences, explore new resources, and develop new fields (Rystad Energy, 2022b). Moreover, there are a multitude of investment treaties that protect the forecasted revenues that oil and gas companies might generate with their licensed reserves. This creates significant additional legal and economic barriers for governments to implement 1.5°C-consistent climate policies. These legal protections could divert significant sums toward oil and gas companies suing governments for lost revenues (Tienhaara et al., 2022).

Meanwhile, several oil and gas companies are now adopting net-zero targets which tend to be vague and non-committal long-term climate intentions. As this chapter will show, corporate-set net-zero strategies are often disconnected from climate science, with their emissions disclosures not sufficiently comprehensive or transparent. However, emissions-reporting methodologies and net-zero strategies are critical to inform financial institutions' assessment of the carbon intensity of their portfolios.

Accordingly, there is an urgent need to bring more coherence to the corporate net-zero target methodologies, to reorient capital flows toward actors contributing most to the energy transition. This chapter will provide insights on how to overcome existing barriers to implementing 1.5°C-compatible policies, and ways for governments and non-state actors to support and accelerate the transition to net-zero.

5.2 Investment Treaties and Oil and Gas Phase-out

5.2.1 Asset Stranding

The energy transition is creating stranded assets, which are particularly significant in the oil and gas sector. Carbon Tracker (2022) estimates that over USD 1 trillion of oil and gas assets risk becoming stranded. Some assets are stranded as a result of changing market conditions (e.g., drop in cost of renewable energy technologies) and the introduction of market-based policies such as carbon pricing. Governments can also force asset stranding through regulatory measures such as bans on fossil fuel extraction, revocation of permits for the development of fossil fuel infrastructure (e.g., oil and gas pipelines), and early retirement of infrastructure (e.g., coal- or gas-fired power plants). An increasing number of governments are taking or considering these types of measures (Gaulin and Le Billon, 2020).

Research indicates that, when governments force or accelerate asset stranding, many businesses expect to be financially compensated (Sen and von Schickfus, 2020). Whether or not to pay compensation and how much is appropriate are difficult questions, best left to democratic decision-making processes. However, in many instances fossil fuel investors can commence (or threaten to commence) arbitration claims against governments that do not provide what they consider adequate compensation.

5.2.2 Legal Protections for Investors

When a foreign investor engages in the oil and gas sector, it will have up to three layers of legal protection: national law, concession/state contract, and one or more international investment treaties. Each of these sources of law may provide the investor with access to investor–state dispute settlement (ISDS), a form of arbitration where ad hoc arbitral tribunals, usually with three members (one chosen by each party to the dispute and the third agreed on or appointed by an arbitral institution), take a final and binding decision that is internationally enforceable. While national law and contracts can present obstacles to governments, the focus of this report is on treaties.

There are currently more than 2,500 investment treaties in force (United Nations Conference on Trade and Development [UNCTAD], 2022). The vast majority are bilateral investment treaties (BITs), but additionally there several hundred trade agreements with chapters on investment, and one sectoral investment treaty, the Energy Charter Treaty (ECT). These treaties contain provisions that can be interpreted broadly to require that a state compensates investors when they are negatively impacted by changes in policy. The provisions most likely to be employed by investors in cases concerning stranded oil and gas assets are the protection against (indirect) expropriation, the fair and equitable treatment standard, and standards preventing discriminatory treatment (most favoured nation and national treatment) (see further Tienhaara et al., forthcoming). Additionally, many treaties have a sunset clause (sometimes also referred to as a survival clause), that provides for continued treaty protection for a period (typically 10 to 20 years) after a treaty is terminated for investments made prior to termination.

If an investor considers that a state action (or inaction) negatively impacts its investment, it can launch an ISDS claim immediately, without having to exhaust domestic legal remedies. If a tribunal finds that a state has breached the treaty, it will determine—with very little guidance from the text of the treaty—how much compensation should be awarded to the investor. Tribunals increasingly award far more than sunk costs (i.e., what was spent by the investor on the project prior to the treaty breach), preferring to instead base compensation on projections of lost future profits. A recent study found that the average award in a case involving a fossil fuel project was more than USD 600 million (Di Salvatore, 2021), and that 7 out of the 10 largest ISDS awards in history involved oil and gas investments (Bonnitcha and Brewin, 2020; Tienhaara and Cotula, 2020).

Tribunals have demonstrated a willingness to award very large amounts in compensation even in cases when the investment in question has not proceeded past the early stages of planning (Bonnitcha and Brewin, 2020). In the oil and gas sector, this means that companies can launch a claim even if they only have an exploration permit in hand, and potentially win many times their initial investment. An example is United Kingdom-based Rockhopper Exploration, which acquired Mediterranean Oil & Gas, a company with a permit to explore for oil off the Italian coast, for GBP 29.3 million in 2014. After the Italian government banned oil drilling within 12 nautical miles of the coast in response to public concerns about the potential environmental impact, the company launched an ISDS claim on the basis of the ECT. In August 2022, the company announced that the tribunal had awarded it EUR 190 million plus interest.

5.2.3 Treaty Protection of Oil and Gas Assets

In a recent study, Tienhaara et al. (2022) calculated the net present value of upstream oil and gas projects that should be cancelled in line with the International Energy Agency (IEA) Net Zero Emissions by 2050 (NZE) scenario. They found that at an oil price of USD 100/barrel, USD 234 billion could be claimed in ISDSs. If governments went further, as the science now indicates is necessary to stay below 1.5°C (see Trout et al., 2022) and additionally cancelled projects in development but not yet producing, the potential price tag would rise to a total of USD 340 billion.

A second article using the same data set demonstrated that more than two thirds of the net present value of 1.5°C-incompatible and treaty-protected oil and gas assets are found in low- and middle-income countries, including those highly vulnerable to climate change (Tienhaara et al., forthcoming). This demonstrates that the distribution of ISDS risk associated with energy transition is highly unjust. The ECT was identified as the treaty protecting the most 1.5°C-incompatible upstream oil and gas assets.

5.2.4 Solutions

It is increasingly recognized that it is undesirable for countries to provide fossil fuel investors with investment protection during a climate emergency; it may even be considered a violation of art. 2.1 of the Paris Agreement (Gaukrodger, 2022). As a form of free political risk insurance, investment treaties create moral hazard by insulating investors from stranded asset losses. They push the costs of asset stranding onto the public, diverting resources from the energy transition. Most concerningly, the threat of ISDS cases may have a chilling effect on governments, particularly in countries where ISDS risk is high but government capacity to respond to claims and pay awards is low.

There are numerous ways to address the problems posed by investment treaties, some of which can be adopted individually by governments and others which require international coordination. The first and most immediate task is to stop making the problem worse. A moratorium on any further licensing or issuing of exploration permits for oil and gas would achieve this by immediately placing a cap on ISDS liability, limiting claims to those investors that already have permits and licences in place. Such a moratorium is what energy models suggest is consistent with limiting warming to 1.5°C, and yet most fossil fuel-producing countries have yet to commit to one.

To reduce the risk of ISDS claims from existing investors, governments can opt to pay compensation in return for a waiver of treaty rights. This is, admittedly, a very problematic solution. Notably, the prospect of an ISDS claim increases the negotiating power of the investor, which may result in the government having to pay a large sum (Flues, 2022; Tienhaara and Cotula, 2020). As such, governments should, if possible, adopt regulated compensation schemes rather than negotiated ones. However, regulated schemes may be challenged in ISDS if the investors believe they have a chance of getting a bigger payout in arbitration (see the example of the Dutch coal phase-out described in Verbeek, 2021).

One option outlined by Pellegrini et al. (2021) is a reverse auction system where investors voluntarily forgo the right to extract reserves in exchange for compensation. In such a system, the investors would put forward bids for the amount of compensation they would accept in return for relinquishing their licences or curtailing production. Competitive bidding would ensure the lowest possible amount of public funds would be expended to achieve the desired amount of asset stranding. An international fund could support these reverse auctions in countries in the Global South. As participation in a reverse auction is voluntary, it cannot be challenged in ISDS. However, the voluntary nature of the scheme is also a downside—there may not be much interest from investors in participating if oil prices are high and/or if they are aware that they have a chance of obtaining greater compensation in arbitration if the government switches to a mandated phase-out.

Therefore, an additional third strategy, terminating investment treaties, is critical. There are numerous proposals to reform investment treaties to align them with the Paris Agreement (see, e.g., Organisation for Economic Co-operation and Development [OECD], 2022). While many of these proposals have merit (those on capping compensation are particularly worth consideration), it is worth noting that recent experiences with piecemeal reform have demonstrated that it is of limited effect and too slow for the abovementioned scenarios to be met. A recent study concludes that "Changes in investment treaty design have failed to change interpretive outcomes in investment arbitration as new treaties are being interpreted like old ones in practice" (Alschner, 2022).

Investment treaties do not have proven public benefits, such as facilitating foreign investment flows in sectors like renewable energy, that would be lost through termination (Bonnitcha, 2017; Pohl, 2018). Indeed, several countries have unilaterally terminated investment treaties, without experiencing any negative impacts (Public Citizen, 2018). However, given the prevalence of sunset clauses, and the limited time remaining for action to avert catastrophic climate change, investment treaties should be terminated by mutual agreement, which allows the sunset clauses to be invalidated, whenever possible.

European countries have already accomplished this for intra-European Union BITs (European Commission, 2020b). Considering this, as well as international commitments on climate finance, European countries should immediately accept (and even initiate) any BIT termination request from a developing country that is concerned about potential investor claims arising from measures to address climate change. Europe could also take the lead in developing an international treaty that would terminate all BITs between the parties (Johnson et al., 2018).

As this section has shown, the protection of fossil fuel companies' investments and their foregone revenues poses a significant threat to the energy transition. While these companies are suing governments for their plans to reduce fossil fuel production on their territory in line with their commitment to the Paris Agreement, some of them are also adopting net-zero strategies in an attempt to showcase their climate ambition. However, corporate net-zero targets are often disconnected from climate science, while their emissions disclosures are either not sufficiently comprehensive or transparent. Accordingly, the next section will provide an assessment of the current state of the target-setting methodologies and suggest ways forward to improve corporate climate reporting.

5.3 Corporate Net-zero Targets: An inadequate state of play entering a crucial decade

5.3.1 Corporate Net-zero Target Setting in the Context of Missing Regulation

Since the launch of the United Nations Framework Convention on Climate Change (UNFCCC)'s Race to Zero campaign at COP 25 alongside other engagement initiatives, the world has seen a surge in corporate net-zero targets. In the run-up to COP 26 in 2021, the number of businesses that announced net-zero or carbon neutrality targets (hereafter referred to as net-zero targets) increased at an ever-accelerating pace. For instance, over 5,000 businesses had joined the Race to Zero campaign by August 2022 (UNFCCC, 2022).

This unprecedented wave of corporate net-zero target setting, however, has happened against a backdrop of non-standardized definitions and a lack of independent scrutiny to ensure this target setting is in line with the Paris Agreement.

There currently exists no clear and consistent definition of corporate net-zero targets. Several ongoing regulatory and voluntary initiatives aim to better harmonize the concept and set robust criteria. For example, the United Nations Secretary-General António Guterres established a High-Level Expert Group on the Net-Zero Emissions Commitments of Non-State Entities to "develop stronger and clearer standards for net-zero emissions pledges by non-State entities—including businesses, investors, cities and regions" (United Nations Secretary-General, 2022). Other regulatory initiatives, such as the forthcoming European Sustainable Reporting Standards initiated by the European Commission (European Financial Reporting Advisory Group Project Task Force on European Sustainability Reporting Standards, 2022) or the Net-zero Guiding Principles of the International Organization for Standardization (forthcoming), are in the process of developing more binding principles and regulations on corporate long-term target setting. Voluntary initiatives such as the Net-zero Standard by the Science Based Targets Initiative (SBTi) propose their own criteria to verify corporate net-zero targets (SBTi, 2021). It remains to be seen whether and how these regulatory and voluntary initiatives will align their definitions and criteria for corporate net-zero target setting.

5.3.2 Evidence of Shortcomings in Net-zero Target-setting Practice

Existing corporate net-zero targets typically suffer from a lack of ambition and have other severe shortcomings (Day et al., 2022; Mooldijk et al., 2022; NewClimate Institute et al., 2022; Shugar, Myers and Fugere, 2022). An emerging body of literature assessing a range of different company samples emphasizes four common shortcomings in corporate net-zero target setting at present (see Table 5.1 for detailed assessment, including an oil and gas sector deep dive):

1. Incomplete emissions disclosure and emissions coverage across all scopes
2. Inadequate specification of own emission reductions alongside net-zero pledges
3. Insufficient implementation of key emission reduction measures
4. Reliance on contentious offsetting practices to meet net-zero pledges

These recent findings indicate that corporates tend to use their net-zero targets as vehicles for vague and non-committal long-term climate intentions, or even greenwashing. Few corporate net-zero targets at present reflect true climate leadership. Ambitious companies and frontrunners in corporate decarbonization efforts thus struggle to differentiate themselves from those taking limited action while announcing untransparent and non-scrutinized net-zero pledges.

Table 5.1 Shortcomings of existing net-zero pledges across sectors identified in recently published literature, and of net-zero pledges and related transition plans in the oil and gas sector

Incomplete emissions disclosure and emissions coverage across all scopes

Corporate net-zero targets often exclude certain emissions sources within their value chain, especially upstream and downstream scope 3 emissions along their value chain.

Recent analyses on global company samples, and country-specific analyses for the United States and the Netherlands, find that many corporates do not disclose large shares of their value chain emissions from their net-zero targets (Day et al., 2022; Mooldijk et al., 2022; NewClimate Institute et al., 2022; Shugar, Myers and Fugere, 2022). Corporates might only cover certain emissions scopes under their net-zero target, for example exclusively focusing on emissions of their operations and from purchased energy (scope 1 and scope 2 emissions), or simply not communicate at all which emissions are covered by their net-zero targets.

The incomplete disclosure of emissions originating in companies' upstream and downstream supply chains (scope 3 emissions) remains particularly problematic. These emissions oftentimes represent the largest shares of a company's emissions profile (Day et al., 2022; Mooldijk et al., 2022), going well above 80% to 90% for some. Companies in the aviation and shipping industries generally fail to adequately report on non-greenhouse gas (GHG) climate impacts, such as the formation of contrail cirrus clouds (Mooldijk et al., 2022). The exclusion of large emission scopes—either through incomplete disclosure or explicit exclusion from the target's coverage—undermines the ambition and integrity of net-zero pledges.

Oil and gas sector deep dive

Companies in the oil and gas sector typically commit to net-zero targets that exclude large shares of emissions in their value chain.

This becomes particularly problematic if oil and gas companies deliberately exclude upstream scope 3 emissions (e.g., emissions from the extraction of oil and gas purchased from other producers) and downstream scope 3 emissions (e.g., emission from the use of oil and gas by end consumers). For example, ExxonMobil explicitly excludes all of its scope 3 emissions under its net-zero target (Mooldijk et al., 2022). For this reason, Exxon Mobil's target only covers around 20% of their 2019 emissions disclosure, and likely a much smaller share of ExxonMobil's entire emissions footprint.

Inadequate specification of own emission reductions alongside net-zero pledges

Many existing targets lack a specific commitment to reduce a corporation's own emissions across its entire value chain alongside net-zero pledges.

For example, 12 out of 25 assessed multinational corporations do not provide any details on what their headline pledge means in terms of own emissions reductions (Day et al., 2022). Even if companies specify intended emissions reductions across their value chain, these often do not reflect deep decarbonization in line with Paris Agreement objectives. The other 13 companies of this sample of 25 commit to reduce their full value chain emissions from 2019 by only 40% on average in the net-zero target year (Day et al., 2022). Targets aiming for deep decarbonization would, for example, reflect commitments to reduce 90% to 95% of all GHG emissions across the entire value chain (Day et al., 2022; SBTi, 2022). Without explicit and transparent commitments for deep emissions reductions in line with the Paris Agreement, the concept of corporate net-zero become meaningless and can lead to greenwashing and unambitious corporate plans.

Net-zero pledges are inadequately substantiated by transparent, credible, and ambitious interim targets toward 2030 in line with the Paris Agreement.

For example, only around half of the 702 companies in the Forbes Global 2000 with net-zero targets have any type of interim GHG emission reduction target (NewClimate Institute et al., 2022). Even if corporates set interim GHG reduction targets, as for example 19 companies do in an assessment of 20 Dutch corporates, these only represent an average emission reduction commitment of 19% by 2030 across the full value chain (Mooldijk et al., 2022).

These interim targets thus often do not reflect the urgency to decarbonize business activities in the context of global and sector-specific decarbonization milestones in line with limiting global warming to 1.5°C. According to recent findings of the Intergovernmental Panel on Climate Change (IPCC)'s *Sixth Assessment Report,* global CO_2 emissions must be reduced by net 48% by 2030 compared to 2019 levels (range of 36% to 69%) to limit global warming to 1.5°C (IPCC, 2022). The IPCC further concludes that global GHG emissions must decrease by 43% (range of 34% to 60%).

Oil and gas sector deep dive

Oil and gas companies often avoid underpinning their net-zero pledges by specific commitments on how much they plan to reduce their own emissions across their entire value chain alongside the net-zero pledge.

For example, neither ExxonMobil nor BP communicate an emissions reduction target alongside their net-zero pledges by 2050 (Mooldijk et al., 2022). It remains entirely unclear what share of their *own* emissions along the value will be reduced by the target year, leaving the door open for contentious neutralization measures to achieve the targets.

Oil and gas companies' long-term targets—regardless of being a net-zero pledge or another target type—collectively do not meet decarbonization milestones in line with 1.5°C or 2°C of global warming at present. Out of 58 oil and gas companies' 2050 targets assessed by the Transition Pathways Initiative (TPI) as of August 2022, for example, only three companies met TPI's definition of a 1.5°C benchmark, and only one met TPI's definition of a below 2°C benchmark (TPI, 2022).

The use of interim targets focusing on the reduction of emissions intensity (intensity targets) rather than emissions reductions in absolute terms (absolute targets) might further enable companies to prolong the use of oil and gas in the foreseeable future, instead of effectively reducing the exploration and use of fossil fuels.

For this reason, intensity targets inherently face the risk of being decoupled from finite limits of the carbon budget (O'Connor and Coffin, 2022). Oil and gas companies generally fail to explain how their intended emission reductions in the interim relate to decarbonization benchmarks and pathways identified in the literature. For example, the IEA (2021) concludes that governments should not approve any new oil and gas fields for development from 2021 onwards for the global energy sector to align with the 1.5°C temperature limit. UNFCCC (2021) specifies that global oil and gas production levels must decrease by 40% below 2019 levels by 2030.

In this context, The Hague District Court considered Shell's intensity targets by 2030 at the time of the court ruling in 2021 as not sufficiently ambitious to reduce its emissions in absolute terms. The court mandated Shell to reduce CO_2 emissions across all emission scopes in absolute terms by net 45% below a 2019 baseline by 2030, informed by IPCC's *Special Report: Global Warming of 1.5°C* (The Hague District Court, 2021).

Insufficient implementation of key emission reduction measures

While a few companies already implement ambitious and deep emissions reduction measures to achieve their net-zero pledge and interim targets, most others do not publicly announce such measures across all emission scopes or transparently explain their estimated impact and implementation timeline.

The implementation of credible and far-reaching measures constitutes the backbone of ambitious corporate net-zero pledges and fosters transformative change. However, for example, an assessment of 20 Dutch companies shows that none of the net-zero targets included publicly communicated reduction plans considered sufficient to place them on a Paris-compatible trajectory (Mooldijk et al., 2022).

Oil and gas sector deep dive

Oil and gas sector companies show little progress in reducing their emissions along the entire value chain and transitioning their business models away from fossil fuels.

For example, recent analyses of BP, Chevron, ExxonMobil, Shell, Equinor and TotalEnergies conclude that existing decarbonization strategies are not underpinned by concrete actions while the companies' business models continue to rely on fossil fuels (Li, Trencher and Asuka, 2022; Liauw et al., 2022a).

The lack of progress in decarbonizing their emissions along the value chain casts severe doubt on the companies' prospects to achieve deep decarbonization as suggested by their net-zero targets.

For example, both ExxonMobil's and BP's publicly communicated emission reduction measures underpinning their net-zero pledges have been evaluated to have "very low integrity" as they are insufficient to place them on a Paris-compatible trajectory (Mooldijk et al., 2022). Despite its net-zero target for 2050, Shell states that its operating plan, planned portfolio changes and pricing assumptions do not reflect its 2050 commitment (Shell, 2021). Shell instead argues that any fundamental changes of its underlying business operating plans remain conditional on societal progress toward a net-zero society (Shell, 2021; ClientEarth, 2022b). Recent estimates indicate that Shell might only reduce 38% of its emissions below 2019 levels in absolute terms by 2050 (Liauw et al., 2022b).

Reliance on contentious offsetting practices to meet net-zero pledges

Many corporates intend to rely on contentious offsetting practices to achieve their net-zero targets, emphasizing the *net* more than the zero in their corporate pledges.

In the most problematic cases, businesses claim to simply offset large parts of their emissions in the net-zero target year instead of reducing their own emissions along the value chain. This offsetting practice implies that the climate impact is the same as if these emissions were never released in the first place. For example, 19 of the 25 multinational corporations will rely on offsetting for their future pledges, with some corporates offsetting more than 80% of all emissions in the target year (Day et al., 2022).

These offsetting claims are particularly problematic when relying on carbon dioxide removals from forestry and other biological-related carbon sequestration. These carbon dioxide removals are generally neither permanent nor additional, which make them unsuitable for any compensation claim. For example, nature-based solutions can easily be reversed through external events such as forest fires releasing the captured carbon back in the atmosphere. Only a few companies with net-zero pledges intend to only use higher-quality offsets for a limited number of residual emissions or rule out the use of offsets entirely (Day et al., 2022; Mooldijk et al., 2022). Although many corporates rely on offset credits, businesses provide little information on these offsets to allow for independent review. Only 11 out of 55 U.S. corporations with net-zero targets, for example, provide basic information about the type, volume, and third-party verification of offset credits (Shugar, Myers and Fugere, 2022).

Instead of relying on offsets to achieve net-zero emissions, companies could commit to deep and ambitious emission reduction targets across their full value chain. This would be more transparent and constructive, as it highlights the feasible prospect—or the lack thereof—of full decarbonization in a respective industry.

These more transparent reduction targets can be combined with climate contributions beyond the company's own value chain (NewClimate Institute, 2020, 2022; Schallert et al., 2020). Such climate contributions would *not* claim to neutralize a company's own emissions while reflecting responsibility for its unabated emissions today and in the future.

Oil and gas sector deep dive

The use of contentious offsetting practices enables oil and gas companies to claim so-called neutralization of continuous emissions from the use of their marketed fossil fuels.

The use of low-quality offset credits carries the risk of enabling oil and gas companies to continue—or even expand—highly emission-intensive activity while wrongfully covering up how polluting their activities are. This can drive attention away from the fact that oil and gas companies need to rapidly decarbonize toward 2030 and beyond. The practice of offsetting remains particularly dubious if oil and gas sector companies neither limit offsets to a restricted amount of residual emissions (e.g., a maximum of 5% of emissions across the entire value chain below a given base year), nor provide transparency on the volume, type, and quality of offsets used today and in the future. For example, existing net-zero targets by BP and Shell heavily rely on carbon offsets, while neither of them have committed to absolute emissions reduction targets for their scope 3 emissions (Shugar, Myers and Fugere, 2022).

Sources: Day et al. (2022); Li, Trencher and Asuka (2022); Liauw, et al. (2022); Mooldijk et al. (2022); Net Zero Tracker (2022); O'Connor and Coffin (2022); Shugar, Myers and Fugere (2022); Tong and Trout (2022)

5.3.3 The Risk of Misleading Promises in Net-zero Targets in the Oil and Gas Sector

Emerging evidence indicates that larger-scale and publicly visible companies with substantive emission footprints are likely to set net-zero targets (NewClimate Institute et al., 2022). As of May 2022, for example, fossil fuel industry companies had the second highest percentage of net-zero targets (49%) among those industries with more than 10 companies in the Forbes Global 2000.

Among companies operating in the fossil fuel sector, several publicly listed oil and gas companies have announced net-zero targets over the last few years. In-depth assessments of their net-zero pledges and transition plans identify several shortcomings, summarized in Table 5.1, such as the exclusion of emissions from the end use of marketed fossil fuels.

The above findings highlight a key risk of recently announced net-zero targets in the oil and gas sector: unsubstantiated promises with a high potential to mislead consumers, investors, and regulators. Net-zero targets of oil and gas companies predominantly focus on decarbonizing the production of fossil fuels, thus neglecting their actual use by end consumers and associated emissions that constitute the vast amount of emissions across their value chain (Shugar, Myers and Fugere, 2022). Net-zero pledges of such inherently low integrity may give external stakeholders an inaccurate and unjustified impression on the prospects for decarbonizing an emission-intensive industry such as the oil and gas sector from production to final use (Mooldijk et al., 2022, p. 25). This misleading practice can directly lead to continued investments in energy infrastructure not compatible with the Paris Agreement. Unsubstantiated net-zero targets hold the potential to nullify drivers of climate action, for example, as regulators would be more active in introducing regulation that leads to corporate decarbonization, and shareholders would be more active in requiring companies to decarbonize, without them.

Regulative approaches by governments at global and national levels hold an enormous potential to ensure highly ambitious corporate long-term targets. Such regulation could provide robustly defined concepts that add substantive criteria to ensure Paris Agreement compatibility, and mandate comprehensive and third-party verified disclosure practices.

5.3.4 Legal Action on Net-zero Claims

Consumers, investors, and civil society increasingly emphasize the urgent need for independent scrutiny of existing corporate net-zero pledges and their implementation, and have pursued legal action in pursuit of this. Businesses face an increasing number of legal court cases focusing on inadequate corporate climate targets and misleading product claims. For example, charges haven brought forward against Shell in the Netherlands over their insufficient 2030 climate targets (The Hague District Court, 2021), Santos in Australia over their misleading net-zero target by 2040 (Australasian Centre for Corporate Responsibility, 2022), automobile manufactures BMW and Volkswagen in Germany on mandatory phase-out dates for internal combustion engines in newly sold vehicles (Deutsche Umwelthilfe, 2022; Greenpeace Germany, 2022), and on product line-specific net-zero claims such as against Arla in Sweden on their “net-zero climate footprint” claim, and KLM Royal Dutch Airlines in the Netherlands on their “Fly responsible” campaign (ClientEarth, 2022a, Konsumentverket, 2021). This trend might even accelerate further given that more businesses are making net-zero claims, especially if more and more courts agree with the plaintiffs’ concerns.

5.4 Institutional Investor Tools and Strategies: A growing movement, with a need for reliable information

To thrive in the global energy transition, businesses and financial institutions must align their strategies with an equitable, decarbonized economy. A stable climate enables effective risk management and value creation, and institutional investors are increasingly setting climate targets for their own portfolios or assets under management while pushing companies to disclose and mitigate emissions.

Institutional investors’ increased interest in corporate climate action is partially attributable to a substantial and growing share of global equities held by large institutions and in index funds, particularly following the 2008 financial crisis. Such funds hold investments in virtually all major companies and, in the case of passive investors, are required to hold them as long as they remain in the relevant index. This means that engagement, rather than divestment, is the only tool such investors have to manage company-specific risk. It also naturally results in investors becoming less concerned with individual corporate performance and more attentive to systemic risks, such as climate change, that threaten full portfolio value (Condon, 2020). Motivated asset managers, asset owners, and other financial institutions have substantial power to hold companies they own accountable to meaningful climate targets, but need robust information to engage effectively.

Investors are supported by a growing range of climate-focused coalitions, initiatives, ambitious corporate clients, and reporting frameworks. Scenario analysis, a core element of many frameworks, is of particular use to investors seeking to analyze how portfolio companies are positioned to respond to the risks and opportunities of various climate and energy system futures. Investors need standardized disclosures to make direct company comparisons, and are increasingly calling for scenarios discussed in narrative elements of a company's annual report to be integrated into the audited financial statements (Ross, 2021).

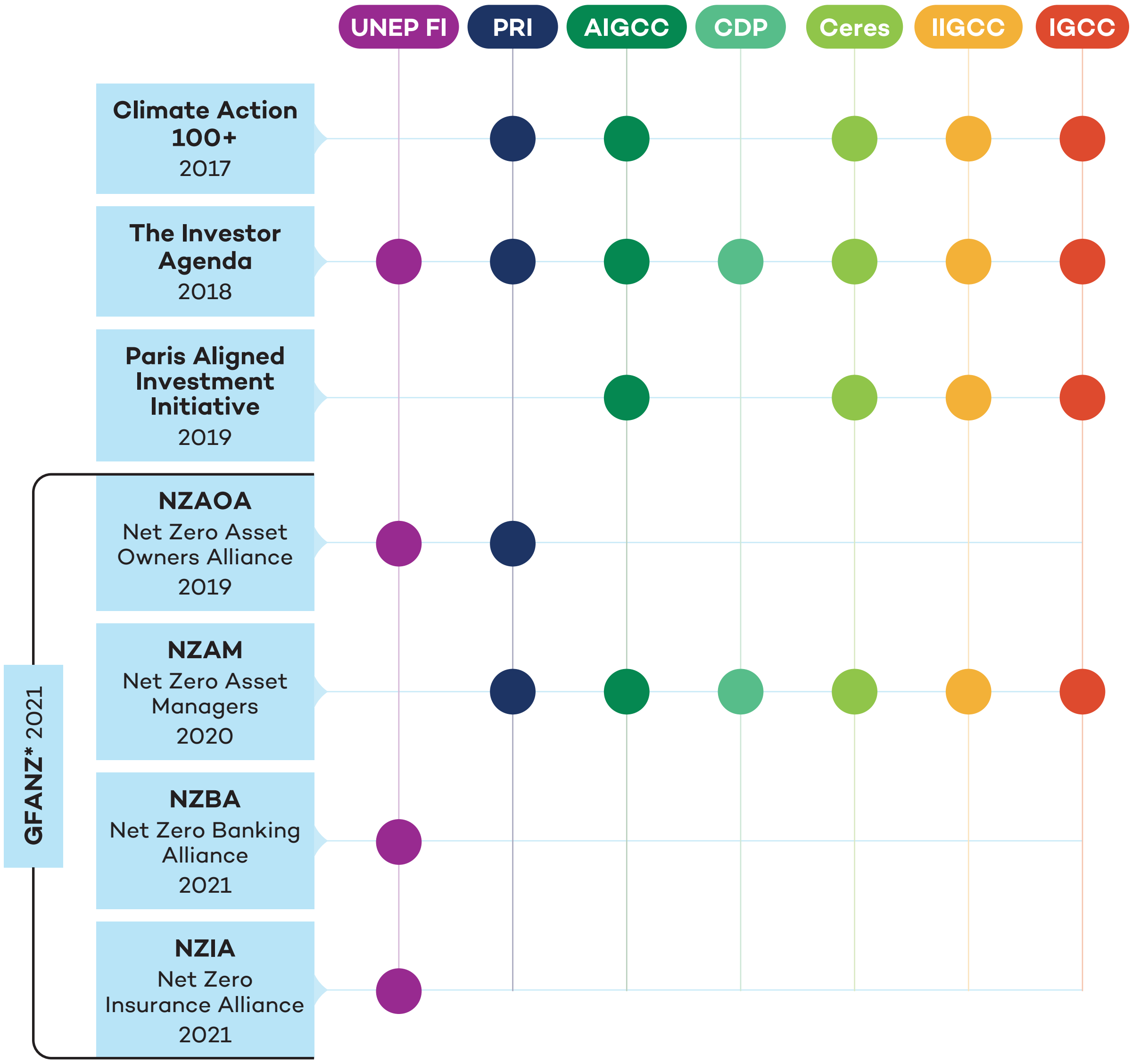
None of the current frameworks alone is sufficient to fully enable investors to assess corporate climate performance, and a lack of mandatory national and international standards limits comparisons (Day et al., 2022). Some countries, including France, New Zealand, and the United Kingdom, have led in mandating corporate climate disclosures, but it will take the broad adoption of national-level regulations to ensure that investors have consistent, necessary access to corporate disclosures that address the full range of material impacts from climate change.

The diversified portfolios of institutional investors, and passive funds in particular, increasingly resemble one another. While this provides investors with common incentives to act, it can also allow inactive asset owners and managers to free ride in the push for corporate emissions reductions. However, collaborative investor initiatives are viewed as a top promising trend for improved shareholder engagement (Ringe, 2021).

In this context, it is encouraging that investor participation in Climate Action 100+, now the world's largest investor initiative on climate, rose 170% over the first four years after the initiative's 2017 launch (Climate Action 100+, 2022a). In the same time frame, the Network for Greening the Financial System (NGFS), a voluntary forum of central banks and supervisors where authorities exchange information related to the risks and opportunities of climate for the financial sector, expanded its founding membership of eight to 116 (NGFS, 2022a). One of six dedicated workstreams at NGFS is dedicated to refining and promoting the use of scenario analysis within the financial system. Still, these collaborative efforts are ultimately only significant if they lead to real changes in corporate behaviour, and so there will continue to be scrutiny both of the overall impact of these programs and of whether all signatories are meaningfully contributing to the overall goals (Majority Action, 2022).

Other initiatives have arisen supporting investors' portfolio goals. The Investor Agenda was founded to accelerate and encourage investor action on corporate engagement, investment in low-carbon assets, policy advocacy, and investor disclosure. Asset managers with targets aligned to 1.5°C came together under the Net Zero Asset Managers initiative, while the Paris Aligned Asset Owners initiative and the Net Zero Asset Owners Alliance emerged to support asset owners. In 2021, these united with other specialized financial groups into a loose coalition known as the Glasgow Financial Alliance for Net Zero, under the umbrella of the UN Race to Zero campaign.

Figure 5.1 Climate initiatives for financial institutions: A landscape



*Glasgow Financial Alliance for Net Zero. As a coalition, GFANZ includes NZAM, NZAOA, NZBA, and NZIA.

Initiative | Founding/supporting organization

Notes: AIGCC: Asia Investor Group on Climate Change; IGCC: Investor Group on Climate Change; IIGCC: Institutional Investors Group on Climate Change.

Source: Author's calculations.

5.4.1 The Landscape of Reporting Frameworks

Investors influence companies using a spectrum of tools including engagements, shareholder proposals, and board votes, either against current directors or for alternative slates, alongside campaigns to pressure companies using tools such as public letters or joint investor statements. Companies do respond—one 2020 analysis found companies fully met the requests of 94% of shareholder proposals that received a majority vote (Blackrock, 2020), though majority votes are still not the norm and are highly dependent on the perceived ambition of the proposal ask. Analysis shows that as the ambition of shareholder resolutions evolves year to year, the number of majority votes changes (Ceres, 2022). In some cases, a company's persistent failure to respond will result in divestment, in line with standards developed by investors (Office of the New York State Comptroller, 2022).

The climate disclosures requested by investors rely upon an evolving and growing series of reporting frameworks—the number of ESG reporting instruments has globally accelerated over the past decade (Woods et al., 2022). In 2021, the International Financial Reporting Standards Foundation launched the International Sustainability Standards Board (ISSB) with the goal of establishing global sustainability reporting standards. ISSB now encompasses several pre-existing initiatives, including the Climate Disclosure Standards Board and the Value Reporting Foundation. It released its first standards for consultation in March 2022.

Investors support the development of strong international standards. In 2021, investors representing more than USD 52 trillion called on global leaders to set mandatory climate risk disclosure requirements (Investor Agenda, 2021). For now, reporting largely remains voluntary, and not all standards include comprehensive metrics analyzing alignment with 1.5°C, although most recommend some form of scenario analysis. Many of these resources and frameworks are connected to or rely upon one another in a web of relationships detailed in Figure 5.2.

Some of the most influential include:

- **Global Reporting Initiative (GRI):** Established in 1997, GRI provides broad global disclosure standards designed to present a comprehensive understanding of economic, environmental, and societal impacts.
- **CDP:** CDP questionnaires are intended to help investors, companies, and regulators measure corporate impacts and risks related to climate change, deforestation, and water security, with questions that facilitate assessment of alignment with the 1.5°C scenario. CDP has released specific guidance aimed at enhancing scenario analysis disclosures (Tucker, 2021). The first round of CDP disclosures in 2002 garnered 245 company responses. By 2020, more than 10,000 companies, cities, states, and regions had disclosed through CDP (CDP, 2022).
- **Sustainability Accounting Standards Board (SASB):** Specialized standards from SASB, established in 2011, specifically focus on the financially material impacts of sustainability-related risks and opportunities, with 77 sector-specific sets of guidelines. SASB standards recommend scenario analysis disclosures for certain industries in which climate impacts are most likely to be material. In 2021, SASB merged with the International Integrated Reporting Council, forming the Value Reporting Foundation.
- **Task Force on Climate-related Financial Disclosures (TCFD):** A voluntary framework developed in 2017 by the Financial Stability Board to standardize corporate climate disclosures and help investors assess whether climate risk is priced into valuations. Scenario analysis is a key recommendation of TCFD, generally referencing disclosures in line with a 2°C scenario, though updated implementation guidelines direct organizations to "consider" analysis aligned with 1.5°C (TCFD, 2021).

- **SBTi:** SBTi defines best practices for corporate climate target-setting, offers resources and guidance, and independently certifies targets against specific, science-based criteria. SBTi provides stakeholders with independent analysis of whether corporate targets are aligned with a 1.5°C or 2°C pathways. In 2021, SBTi launched its net-zero standard, initiating a phase-out of verification for commitments not aligned with 1.5°C scenarios.
- **Climate Action 100+ Net Zero Company Benchmark:** The Benchmark assesses companies against the initiative's high-level goals on indicators material to financial performance, equity, and emissions reductions. Indicator 10 assesses commitments to align disclosures with TCFD recommendations. To fulfill all Indicator 10 criteria, companies must explicitly include a 1.5°C scenario analysis (Climate Action 100+, 2022b).

5.4.2 A Growing Need for Stronger Tools

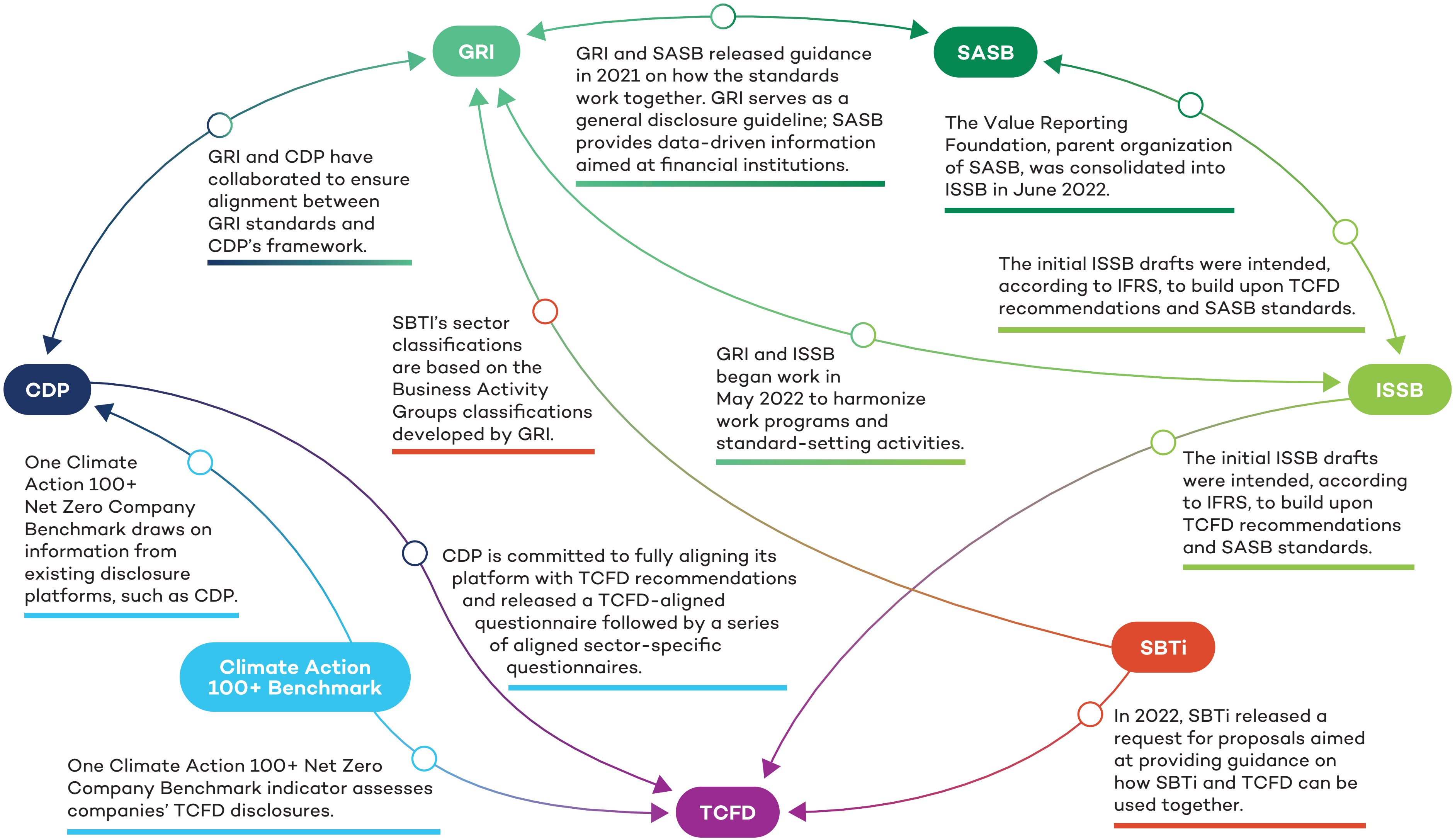
Investors can help accelerate global decarbonization by ensuring companies' capital expenditures align with climate goals. In 2021, IEA found that clean energy investments must triple by the end of the decade in order to attain net-zero by 2050 (IEA, 2021a). Clear corporate alignment of climate commitments with capital expenditures can give investors confidence that targets will be achieved and risks mitigated.

To this end, investors and advocates seek to reinforce current standards and frameworks to ensure broader use, greater accountability, and a decreased risk of greenwashing. One strategy aims to ensure that companies' narrative climate disclosures are consistent with their financial reports, with a focus on third-party audit and expanded assurance (IIGCC, 2020; Principles for Responsible Investment [PRI], 2020). Assumptions, such as future commodity prices, are embedded in cash flow estimates and must be present in financial statements for investors to accurately assess risks and opportunities. Although global standards state that material climate-related risks should not be ignored in accounts or audits, a 2021 report found that 70% of corporate emitters analyzed did not disclose the impacts of climate risk in their financial statements (Davidson and Schuwerk, 2021).

Support for this strategy is accelerating. In 2022, a shareholder proposal at ExxonMobil, filed by Christian Brothers Investment Services, Inc., calling for detailed reports on how applying the assumptions of the IEA NZE scenario would impact company financial statements and positions, earned majority support, in just the second year such a proposal was introduced. Sector-specific analysis and guidance on this issue is also emerging (Ross, 2021).

ExxonMobil had already been the subject of a significant successful campaign in 2021 by impact hedge fund Engine No. 1, in partnership with the United States' second-largest pension fund, California State Teachers' Retirement System, that successfully replaced three members of the company's 12-member director board with candidates with climate and clean energy experience. This campaign is cited as an example of the critical role that hedge funds can play in monitoring companies and initiating campaigns that motivate the pivotal support of the increasingly dominant "Big Three" asset managers, BlackRock, State Street and Vanguard. The campaign at ExxonMobil was well timed, occurring as those funds were increasingly making public commitments to sustainable investing, including pledges to vote against directors who fail to adequately address climate change (Christie, 2021).

Figure 5.2 Map of climate reporting frameworks and resources



Source: Author's calculations.

Institutional investors are also advocating for greater insight into business strategy by demanding time-bound transition plans that detail how climate targets will be achieved. Transition plan recommendations vary across frameworks, and a range of analytical guidance is available to investors (Pinko and Pastor, 2022). For companies, the Climate Action 100+ decarbonization strategy emphasizes that companies should assess and quantify the contribution of each action. However, most transition plans fall short of standard-setter recommendations: in 2021, just 1% of more than 13,000 companies with CDP disclosures met all 24 of the organization's key transition plan indicators (Bartlett et al., 2022).

For investors, the Investor Agenda established the Investor Climate Action Plan self-assessment tool, designed to both help users map out participation in the net-zero transition and provide accountability to stakeholders, governments, and the public. The Investor Climate Action Plan's Expectation Ladder meets investors at their starting point of climate ambition, and highlights specific actions that will strengthen their approach and ensure progress toward short- and medium-term goals.

5.4.3 The Power of National-level Mandatory Disclosure

Investors can effectively wield their influence, through engagements and shareholder votes, to move companies toward improved management of climate risk. This can take the form of setting reliable targets, such as those verified by SBTi, and providing detailed scenario analysis, as recommended by TCFD. The resulting disclosures can help ensure that investors are able to make informed decisions and maximize value, and that companies are held accountable to their climate commitments.

Yet due to the largely voluntary status of today's reporting frameworks, data is not always released publicly and can be treated as proprietary, while disclosures cannot be easily analyzed or compared. Without national-level regulation, even the impending ISSB standards, aimed at creating a unifying framework, will face slow adoption. Rigorous mandatory standards would help ensure material information is consistently disclosed within and across countries.

Some regulations are emerging, many resting on the strength of the TCFD framework. France moved early: art. 173 of the 2016 French Energy Transition Law was the first to enshrine such climate-related rules for investors on a comply-or-explain basis. A 2021 replacement law added requirements for investors, banks, and insurers to report not only on climate-related but also biodiversity-related risks. The European Union's Sustainable Finance Disclosure Regulation was launched in spring 2021. In early 2022, the U.S. Securities and Exchange Commission (SEC) released a draft rule that would require public companies to release climate risk disclosures. For over a decade, the U.S. National Association of Insurance Commissioners has required climate risk disclosure from most insurers, and recently has moved to align its requirements with TCFD (National Association of Insurance Commissioners, 2022). Nonetheless, the SEC's proposed rules have faced some controversy, including suggestions of legal action by Republican Party leaders and trade associations like the American Petroleum Institute, while supporters maintain that the proposed rules fall within the SEC's statutory authority. Letters submitted when the public was invited to comment were broadly supportive of the draft rules, though an analysis from KPMG indicated that general approval should not be interpreted as wholesale support for the specific proposal elements (KPMG, 2022).

A regulatory approach can accelerate action. In 2022, the United Kingdom became the first G20 country to mandate corporate reporting of climate-related risks and opportunities in line with TCFD recommendations; a subsequent analysis found a significant increase in the number of premium-listed companies making disclosures that were either partially or mostly TCFD-consistent (Financial Conduct Authority, 2022). In turn, investors can speed adoption of regulations through advocacy.

5.4.4 A Focus on Oil and Gas

For investors, lack of ambition by many oil and gas companies threatens global progress to reduce emissions, increases the risk of stranded assets, and undermines the industry's social licence to operate. The industry will need to transform, and do so rapidly—no new oil and gas fields are approved for exploration in a net-zero by 2050 scenario according to the IEA, a finding confirmed in chapter 3 of this report (IEA, 2021a). This report follows the 2019 publication of the One Earth Climate Model (OECM), a 1.5°C-aligned scenario model without overshoot. An updated version of the OECM commissioned by the Net Zero Asset Owners Alliance was released in 2022 with detailed sectoral decarbonization pathways (Teske et al., 2022).

The March 2022 Climate Action 100+ Net Zero Company Benchmark shows how far oil and gas companies are from achieving that transformation. Only three of 39 oil and gas companies assessed had transition pathways aligned with 1.5°C, and only one was assessed to have capital expenditures in line with such a scenario. Attaining a net-zero goal requires a comprehensive business model transformation for oil and gas companies. Analyzing their transition plans is complex, and the optimal path will be different for each company (Gardiner, 2021).

The IEA's unequivocal findings challenge financial institutions to evaluate their policies and strategies for the oil and gas industry. In 2022, SBTi released guidance on net-zero target setting for financial institutions, with 19 initial certified targets, including from La Banque Postale, which committed to a complete withdrawal from oil and gas upstream and midstream activities by 2030 (SBTi, 2022). Shareholders and asset owners are now using the IEA Net Zero and OECM pathways as an alignment metric, in engagements and resolutions (Ceres, 2022).

"It is essential that oil and gas company boards know that those with credible independently verified net zero strategies will be supported by their investors", notes the IIGCC Net Zero Standard for Oil and Gas Companies. "Equally important is that those without will be challenged" (Gardiner, 2021).

Chapter 5 has demonstrated the need to bring more coherence to the landscape companies' climate disclosures. Corporate climate reporting is instrumental to the financial sector's ability to channel capital where it is most needed to accelerate the energy transition. Rigorous mandatory standards would enable the production of standardized information, disclosed consistently within and across countries. Governments have an important role to play in setting up mandatory requirements for reporting methodologies. However, until a unified framework emerges, companies can contribute to positively bridging the information gas by adopting some of the voluntary reporting methodologies available.

6.0
Conclusions and Key Policy Recommendations

In this report, we have for the first time analyzed and compared the findings of energy scenarios compatible with the 1.5°C goal, across the full body of published global modelled pathways. We selected scenarios which do not exceed IPCC judgements of feasible and sustainable levels of carbon capture and storage deployment. The report focused on pathways for the phase-out of oil and gas, and for the expansion of wind and solar, required for global temperatures to have a good chance of staying within the 1.5°C limit. For both, we found a high degree of alignment between scenarios, suggesting that a common set of actions is required. Based on these findings, and on an analysis of the current opportunities and barriers to policy change, we have derived a number of policy recommendations, for governments, investors, and financial institutions, to enable concerted efforts aligned with the goals of the Paris Agreement.

1. **Governments should prevent the development and licensing of any new oil and gas fields.** Developing any fields beyond those already in operation or under development would pose substantial risks of either not meeting the 1.5°C target or creating stranded assets, because those fields would have to be decommissioned before the end of their lifespan, unless currently producing fields' operations are significantly curtailed.
2. **Governments must provide more and better support to wind and solar deployment.** They need to improve current policies and put in place new ones, to increase solar and wind capacity worldwide. These should include policy frameworks aimed at reducing permitting and licensing delays for renewables' installation, as well as localizing renewable energy value chains to make them more resilient to trade wars, political conflicts, and price volatility.
3. **Governments should create enabling environments for redirecting both public and private capital flows toward the clean energy transition including the deployment of additional solar and wind capacity.** The forecasted investments in the exploration and development of new oil and gas fields – incompatible with the 1.5°C pathways – are higher than the investment gap for wind and solar deployment.
4. **The current energy crisis, experienced by Europe in particular, should not be tackled by increasing the continent's reliance on gas.** Doing so would risk putting the 1.5°C goal even further out of reach, or creating stranded assets for newly built infrastructure both in Europe and in gas-exporting countries, while not solving the short-term crunch. Governments and investors should instead view the crisis as an opportunity to further step up Europe's clean energy ambition, by strengthening existing frameworks such as the EU Fit for 55 package and the European Green Deal.
5. **Investment treaties need to be urgently and radically reformed or repealed to allow governments to enforce 1.5°C-compatible oil and gas phase-out pathways.** Governments can tackle this issue by pursuing one or a combination of existing solutions, namely a moratorium on any further licensing or issuing of exploration permits for oil and gas, setting up systems to pay out compensation in return for a waiver of treaty rights, and eventually reforming and terminating investment treaties.

6. **Governments should better regulate the long-term targets of the corporate sector, at both the global and national levels, to ensure that they support the goals of the Paris Agreement.** Regulative approaches by governments hold critical potential to ensure highly ambitious corporate long-term targets. Such regulation could provide robustly defined concepts that add substantive criteria to ensure Paris Agreement compatibility, and mandate comprehensive and third-party verified disclosure practices.

7. **Governments should set up mandatory requirements for companies' reporting methodologies. Until then, investors can fill the gap by adopting voluntary reporting methodologies.** Corporate climate reporting is instrumental to the ability of the financial sector to channel capital where it is most needed to accelerate the energy transition. Rigorous mandatory standards would enable the production of standardized material information, consistently disclosed within and across countries.

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Appendix

Scenarios Filtering Methodology

The selection of the 26 1.5°C-consistent scenarios from those published by the Intergovernmental Panel on Climate Change (IPCC) was made through the AR6 Scenarios Explorer hosted by the International Institute for Applied Systems Analysis (IIASA) (Byers et al., 2022). To address concerns over the feasibility and sustainability of the deployment of carbon capture and storage (CCS) and carbon dioxide removal (CDR) technologies, we selected a subset of scenarios that met certain criteria aligned with the IPCC assessment of these technologies. The IPCC Sixth Assessment Report (AR6) Working Group 3 assessment of the scale-up potential of new technologies offered thresholds for the onset of medium concerns over their feasibility (IPCC, 2022, Annex III, Table II.1).

Accordingly, and based on the analysis of potential risks posed by overreliance on fossil CCS and bioenergy and carbon capture storage (BECCS) in energy/climate scenarios (for details, see chapter 2 of this report), we excluded those scenarios that relied on sequestering CO_2 above the thresholds where medium concerns over their feasibility by 2050 were raised. The data on the amount of sequestered carbon was extracted for all the 97 scenarios that limit warming to 1.5°C with no or low overshoot in the AR6 Scenarios Explorer. To prevent irregularities in deployment in the second half of the century, the carbon sequestration by 2050 was measured as the average between 2040 and 2060.

The maximum scale-up potentials were limited to the thresholds of their sequestration potential, which was limited to 3 Gt CO_2/year for BECCS and 3.8 Gt CO_2/year for fossil CCS by 2050. See Table A.1 below for a summary of the filtering criteria used for 1.5°C-compatible scenario selection.

Table A.1 Scenario filtering criteria based on IPCC feasibility and sustainability assessment for CCS and CDR

Carbon sequestration method	Feasibility/sustainability dimension	Sequestration thresholds by 2050
Fossil CCS	New technology	3 Gt CO_2/year
BECCS	New technology	3.8 Gt CO_2/year
Afforestation and reforestation	Sustainable potential	3.6 Gt CO_2/year

Moreover, the selected 1.5°C-compatible scenarios also reflected the IPCC's stated concern regarding the sustainable use of afforestation and reforestation as carbon sinks. Accordingly, the total sequestered carbon through these means was constrained to the maximum estimate of the total sustainable potential. In the IPCC Special Report on 1.5°C, based on the analysis provided by Fuss et al. (2018), the maximum sustainable potential for afforestation and reforestation is estimated as from 0.5 to 3.6 Gt CO_2/year. The upper end of this range was applied to the total sequestered carbon in the agriculture, forestry, and other land use sector in order to ensure greater data availability (there are inconsistencies in how afforestation and reforestation are accounted for in different models) (Warszawski et al., 2021).

This filtering method provided a subset of 26 scenarios from three integrated assessment models and their variations, which were used to extract the data supporting the findings in this analysis. See Table A.2 for the complete list of models and specific scenarios retained for this report. These models are:

1. MESSAGEix-GLOBIOM model, a dynamic systems-optimization modelling framework developed by the IIASA Energy, Climate, and Environment program.
2. REMIND (Regional Model of Investment and Development) model, a numerical model that represents the future evolution of the world economies with a special focus on the development of the energy sector and its implications for global climate. It is developed and maintained by the Potsdam Institute for Climate Impact Research.
3. WITCH model, a global dynamic model integrating the interactions between the economy, technological options, and climate change. It was developed at the RFF-CMCC European Institute on Economics and the Environment.

Table A.2 List of the 26 IPCC 1.5°C pathways limiting CDR and CCS deployment

Model	Scenario
MESSAGEix-GLOBIOM 1.0	LowEnergyDemand_1.3_IPCC
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_450
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_500
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_600_COV
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_600_DR1p
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_600_DR2p
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_600_DR3p
MESSAGEix-GLOBIOM_1.1	EN_NPi2020_600_DR4p
MESSAGEix-GLOBIOM_1.1	NGFS2_Divergent Net Zero Policies
MESSAGEix-GLOBIOM_1.1	NGFS2_Net-Zero 2050
MESSAGEix-GLOBIOM_1.2	COV_GreenPush_550
MESSAGEix-GLOBIOM_1.2	COV_NoPolicyNoCOVID_550
MESSAGEix-GLOBIOM_1.2	COV_Restore_550
MESSAGEix-GLOBIOM_1.2	COV_SelfReliance_550
MESSAGEix-GLOBIOM_1.2	COV_SmartUse_550
REMIND 2.1	LeastTotalCost_LTC_brkLR15_SSP1_P50

Model	Scenario
REMIND-MAgPIE 2.1-4.2	CEMICS_SSP1-1p5C-minCDR
REMIND-MAgPIE 2.1-4.2	CEMICS_SSP2-1p5C-minCDR
REMIND-MAgPIE 2.1-4.2	EN_NPi2020_600f_COV
REMIND-MAgPIE 2.1-4.2	SusDev_SDP-PkBudg1000
REMIND-MAgPIE 2.1-4.3	DeepElec_SSP2_ HighRE_Budg900
WITCH 5.0	EN_NPi2020_400f
WITCH 5.0	EN_NPi2020_450
WITCH 5.0	EN_NPi2020_450f
WITCH 5.0	EN_NPi2020_500
WITCH 5.0	EN_NPi2020_500f

Regional Disaggregation

Regional data on wind and solar annual capacity additions were extracted using the selected IPCC 1.5°C scenarios shown in Table A.2. However, from this subset of 26 selected scenarios, only 11 included regionally disaggregated data. The analysis of the regional deployment of wind and solar capacity is based on the data provided by the REMIND and WITCH models. As the MESSAGEix model does not include regionally disaggregated data for wind and solar capacity addition for the region selected, it was excluded from this part of the analysis.

It should be noted that the estimates from wind and solar deployment in the REMIND and WITCH models are smaller than those in the MESSAGEix model. This skews the regional estimates, such that the sum of all the capacity deployment for the regionally disaggregated data is smaller than the total estimates presented in section 3.3 of chapter 3. For this reason, the regional estimates represent more reliable assessment when it comes to the relative size of the future capacity needs between regions and the indicative scale of the gap in capacity needs over the forthcoming decade, but are likely to be an underestimate of wind and solar capacity deployment needs in absolute terms.

Wind and Solar Capacity Additional Investment Costs

The investment costs shown in chapter 3 for wind capacity addition are estimated based on the International Renewable Energy Agency (IRENA)'s forecasts of the evolution of total capital costs of a wind power plant over the coming decade (IRENA, 2019b). These estimates were then multiplied by the annual capacity addition for wind energy. The capital cost generating a gigawatt of wind power includes an assessment of the cost of four main categories:

1. Wind turbine cost: rotor blades, gearbox, generator, power converter, nacelle, tower, and transformer
2. Civil works: construction works for site preparation and foundations for tower
3. Grid connection costs: transformers, substations, and connection to the local distribution or transmission network
4. Planning and project costs: development cost and fees, licences, financial closing costs, feasibility and development studies, legal fees, owners' insurance, debt service reserve and construction management

The investment costs shown in section 3 for solar capacity addition are estimated based on IRENA's forecasts of the total capital costs of a gigawatt of solar generation capacity (IRENA, 2019a). It includes an assessment of:

1. Cost of non-module hardware: cabling, racking, and mounting; safety and security; grid connection, monitoring, and control
2. Installation: mechanical and electrical installation, inspection
3. Soft costs: incentive application, system design, permitting, customer acquisition, financing costs, and margin

These costs for wind and solar capacity addition reflect a large range of considerations and reflect a realistic estimate of the full deployment costs associated with these technologies. However, there are several additional costs associated with the full integration of renewables into the energy systems. Transmission lines and storage units are also necessary to balance the intermittencies of renewable energies. These later costs are not considered in this report, as they go beyond the scope of our analysis.

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