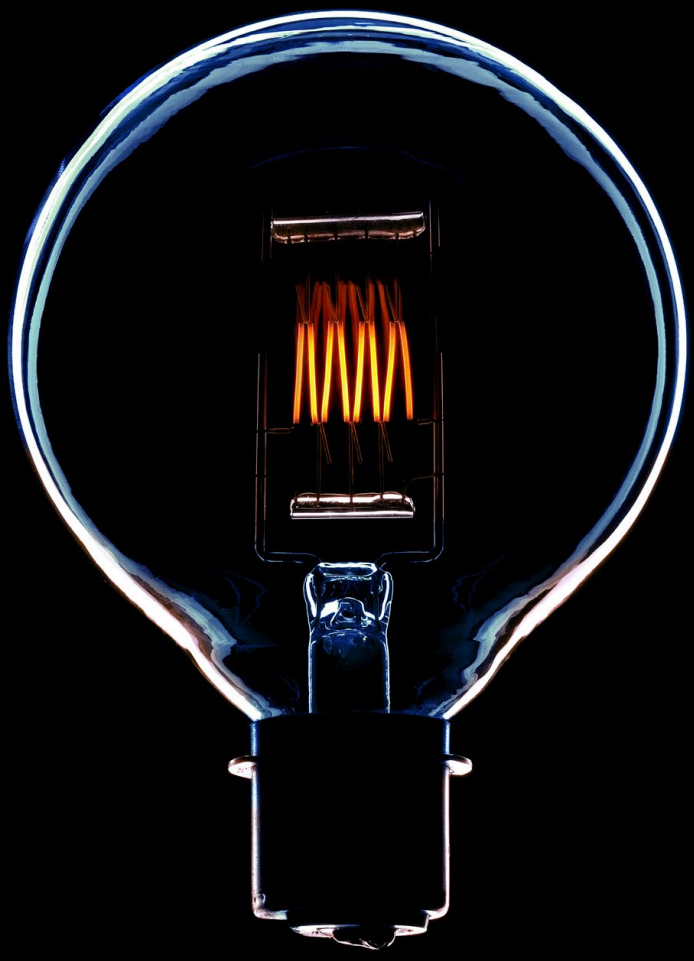
In collaboration
with Accenture

WORLD ECONOMIC FORUM

Fostering Effective Energy Transition
2022 Edition

INSIGHT REPORT

MAY 2022



Images: Getty Images, Unsplash, Pexels

Contents

Foreword 3

Executive summary 4

1 The energy transition under pressure 6

1.1 Economic development and growth 9

1.2 Energy security and access 12

1.3 Environmental sustainability 16

1.4 Transition readiness enablers 19

2 Unlocking the net-zero transformation of industries 23

2.1 No net zero by 2050 without industries 24

2.2 Net-zero choke points: A call for multistakeholder collaboration 29

2.3 Clearing the path to net zero with “next generation” partnerships 33

2.4 Net-zero collaboration between customers and suppliers 35

2.5 Net-zero collaboration between industry and cross-industry peers 38

2.6 Net-zero collaboration between wider ecosystem stakeholders 41

3 Conclusion 43

Appendix 44

Contributors 45

Endnotes 46

Foreword

Roberto Bocca
Head of Shaping the Future of Energy, Materials and Infrastructure, World Economic Forum

Muqsit Ashraf
Senior Managing Director and Lead, Energy Industry Sector, Accenture

The Energy Transition Index (ETI) has benchmarked the progress of countries' energy transition for a decade on the three dimensions of the energy triangle – economic development and growth, energy security and access, and environmental sustainability – and on the enabling environment for transition. In view of the current volatile macroeconomic and geopolitical environment, however, a trend analysis from historical energy data can currently provide only limited insights. Hence, instead of the annual country energy transition benchmarking report, this special 2022 edition builds on the ETI trends observed in recent years to provide a perspective on the current challenges affecting the transition, and highlights priorities to supercharge it.

The urgency for transformative measures to mitigate climate change has intensified. The latest assessments by the Intergovernmental Panel on Climate Change (IPCC) emphasize the need for global greenhouse gas (GHG) emissions to peak by 2025 and for emissions to decline rapidly thereafter. However, a series of systemic shocks over the past three years and their implications on the energy system highlight the challenges in pursuing long-term targets while responding to short-term emergencies. The ETI framework underscores the need to help advance energy affordability, security and access, and sustainability. The current environment poses simultaneous constraints on these three fronts.

Many countries have demonstrated resilience to the pandemic and exceptional economic recovery. However, the faster-than-expected rebound coupled with low investments in parts of the energy system have put stress on the energy supply, leading to very high energy prices and severely impacting households and businesses. Supply-demand imbalances can recur through the transition as energy systems reconfigure, yet the transition cannot progress at pace if it leads to expensive energy or exacerbates inequalities.

The war in Ukraine has led many countries to rethink their energy security paradigm and what it means for their energy transition. A review of the best performing countries in terms of energy security in the past ETI editions reveals the benefits of dual diversification: energy mix diversification and fuel import diversification. The war has forced several countries to consider the trade-offs between energy security and sustainability to secure energy supply in the short term. However, in the long term, we expect the energy transition will offer win-win opportunities, aligning security and sustainability imperatives through investments in renewables and other clean energy sources, as well as demand-side measures like energy efficiency.

We believe this is the time for governments, companies and consumers to intensify efforts to reduce their dependence on fossil fuels. Governments can invest in domestic decarbonized energy systems that will secure affordable and reliable energy, and companies have opportunities to adopt low-carbon technologies and energy-efficient processes. The decrease in GHG emissions observed during the pandemic due to the reduction in energy demand demonstrates the opportunities offered by demand management. Considering the critical role of energy-intensive industries in achieving demand-side emission reductions, this report includes a focus on the energy transition within the industrial sector. As the largest contributor of anthropogenic emissions, industries are regarded as the last frontier of decarbonization. We examine the multiple choke points that industrial firms encounter on their journey to net zero, and show how a new generation of collaboration models, coupled with new levels of ambition at the industry, country and global levels can help these companies break through their bottlenecks and accelerate the transition.

There are glimmers of hope, but also caveats. A few countries, for example, are linking COVID-19 recovery packages with enhanced sustainability solutions to "build back better". But many are not. And several large investment agendas are not yet fully approved. Also, we welcome the additional commitments made at COP26 at the end of 2021. However, action has fallen short in several key areas that will need to be addressed in the future. Overall, we remain cautiously optimistic. But success will depend on countries carefully striking the balance between energy affordability, availability and sustainability, and further strengthening their commitment to climate action.

Executive summary

Navigating the energy transition through a turbulent phase requires a balanced approach.

1. **The effects of macroeconomic turbulence and recent geopolitical developments on the energy system highlight the complexities and trade-offs inherent in the energy transition, calling for a balanced approach that delivers on the imperatives of sustainability, energy affordability, and energy security and access – in essence driving a resilient energy transition.** The pandemic, the steep economic rebound and the war in Ukraine have successively disrupted energy markets, causing significant consequences for people, companies and economies around the world. The conjunction of diverse adverse events has created a perfect storm, creating headwinds on all three imperatives of the energy triangle: economic development and growth, energy security and access, and environmental sustainability. This situation demonstrates that the energy transition is not immune to the impacts of major environmental, economic and geopolitical events, and that the trade-offs between energy affordability, security and sustainability exist and need to be carefully considered. Such an approach is required to establish a resilient energy transition capable of achieving long-term climate ambitions, regardless of the challenges that might impact the journey.

2. **Progress on the economic development and growth dimension of the energy transition has been slow over the past decade. Ensuring affordable access to energy for households and businesses is essential for economic growth and a just transition.** As the energy system reconfigures to a low-carbon future, temporary supply-demand imbalances can be a recurring phenomenon, with consequences for households and businesses, not only in terms of energy prices but also of the cost of living (e.g. food, housing, transportation) and commodities. The effects of energy price volatilities tend to be more severe for vulnerable consumers and small businesses. Measures to address these concerns will rest on a robust framework of data transparency to determine the magnitude and prevalence of the challenge at the national and local levels, define mechanisms to effectively target vulnerable consumers for financial transfers, and design support measures in a manner that does not reduce incentives for efficient consumption.

3. **The diversification of the energy mix with a range of low-carbon energy sources can help strengthen energy security. Countries can engage in dual diversification: diversifying their fuel import partners in the short term and their energy mix in the long term.** A look at over 10 years of energy security analyses through the Energy Transition Index shows that the dual diversification of fuel import partners and of the domestic energy mix generates important benefits. Renewable sources are mature and available for accelerated deployment, allowing countries to build more diversified, reliable and sustainable energy systems. Other low-emission solutions, such as clean hydrogen and nuclear energy in those countries that accept such programmes, may appear as pathways to increase energy independence. Low-carbon energy systems can raise new energy security concerns, for example from disruptions in the supply of transition materials or less flexibility in the power system, which must be mitigated in advance.

4. **Current energy market volatility and security constraints provide an opportunity to supercharge the transition by increasing clean energy investments at record pace and transforming consumers' energy consumption habits.** Renewable energy capacity installations set a record in 2021 with 290 gigawatts (GW)[1] of new wind and solar capacity added worldwide, yet this remains well below the 960 GW needed annually by 2030 to meet the 2050 net-zero target,[2] and the International Energy Agency (IEA) warns clean energy investments would have to triple by 2030.[3] Today, as the risks of high fossil fuel prices and uncertainties about the global energy supply outlook increase, countries can seize the opportunity to strengthen their commitments to clean energy investments.

   Additionally, the demand-side changes will be as critical as the supply-side transformation to achieve the energy transition objectives in the required time frame. The IEA indicates that "energy efficiency improvement will drive more than 40% of the reduction of energy-related GHG emissions over the next 20 years".[4]

5. **Addressing emissions from energy-intensive industries is essential to improve energy efficiency. Industrial activity generates more than 30% of anthropogenic emissions,[5] yet many industries face considerable challenges to decarbonize. Going forward, "clean demand" signals could be a turning point to accelerate "clean supply".** With global demand for industrial products projected to grow significantly by 2050, the decarbonization of industries is fundamental to the global energy transition. Just five industries (cement and concrete, iron and steel, oil and gas, chemicals, and coal mining) together are responsible for 80% of industrial emissions.[6] However, industrial firms face complex challenges that act as choke points.

   Today, technology, financing and policies are at the forefront of companies' and governments' net-zero strategies to decarbonize the supply side. But demand-side initiatives, such as the First Movers Coalition,[7] designed to create a strong "clean demand" pull (e.g. visibility on offtake volumes, acceptance of green premiums, etc.) are still isolated. They must be rapidly replicated to incentivize investments in low-emission technologies and production assets.

6. **The "next generation" of ambitious multistakeholder collaborations between suppliers and customers, between industry and cross-industry peers, and between the wider industrial ecosystem of stakeholders can overcome decarbonization choke points and accelerate the industrial transformation towards net zero.** The remedies to industry choke points are seldom found within a single firm or even industry. New forms of collaboration at the sector, country and global levels are needed. Such multistakeholder partnerships reflect a heightened level of ambition, a clear focus on emission reduction and fresh areas of joint action. Three archetypal partnerships have emerged:

   – Collaboration between customers and suppliers (e.g. low-emission product offtake agreements, circular supply networks, value chain decarbonization projects, etc.)

   – Collaboration between industry and cross-industry peers (e.g. CO_2 infrastructure, low-carbon manufacturing plants, knowledge sharing for decarbonization, etc.)

   – Collaboration between the wider ecosystem of stakeholders, such as governments, policy-makers, financiers, researchers and non-governmental organizations (e.g. emission measurement standards, integrated research for low-carbon technologies, public-private partnerships, etc.).

   Moving the industrial energy transition forward at the required pace will entail replicating, scaling and improving these models of collaboration.

7. **The window of opportunity to prevent the worst consequences of climate change is closing fast. It is essential to make the energy transition robust by building the necessary enablers that will keep the transition going if the economic and energy security context deteriorates.** With the world in the most severe energy crisis since the 1970s, it is critically important to speed up action to put mankind on the path to net-zero emissions while addressing energy security needs. Four key actions can help give impetus and steady long-term momentum to the energy transition and make it more likely to withstand economic disruptions:

   – Anchoring climate commitments in legally binding frameworks that can endure political cycles and enforce the long-term implementation of national transition objectives

   – Taking and holding long-term decisions with regard to the decarbonization of the national energy system structure (energy mix, power generation mix, energy efficiency, fossil fuel dependency)

   – Building an attractive investment landscape for private capital, both foreign and domestic, to finance energy transition projects (policy and legal frameworks, currency and institutional stability, infrastructure quality, technology availability)

   – Promoting consumer participation (awareness of climate change and carbon footprints, individual responsibility for action, incentives for consumer behavioural change) and building the local workforce required for the transition, paying particular attention to the livelihoods of vulnerable populations

The current energy crisis presents a good opportunity to increase the speed of the transition and strengthen its resilience to future challenges. Only by everyone working together will it be possible to advance the collective transition journey to 2050 and achieve the relentless progress the world requires and deserves. The time for action is now.

1 The energy transition under pressure

The challenge is compounded by risks to energy security, sustainability and affordable access.

Key highlights

1. Linked to the energy triangle's three dimensions, high energy prices, the risk of energy supply shortages and climate emergencies jeopardize the energy transition
2. The extreme volatility in energy markets raises concerns about energy security, energy affordability and the energy transition
3. Energy systems' resilience to supply and environmental shocks is essential to maintain energy affordability for economic growth and ensure a just transition
4. Energy mix and import diversification can bring countries greater energy security, affordability and sustainability
5. Now is the time to strengthen commitments to clean energy investments and anchor more efficient energy consumption habits in society
6. The energy transition must be made robust with adequate enablers and support mechanisms to maintain the momentum despite the challenges

The current context highlights trade-offs inherent in the energy transition, which are complicated by the energy sector's structure, socio-economic role and geopolitical significance.

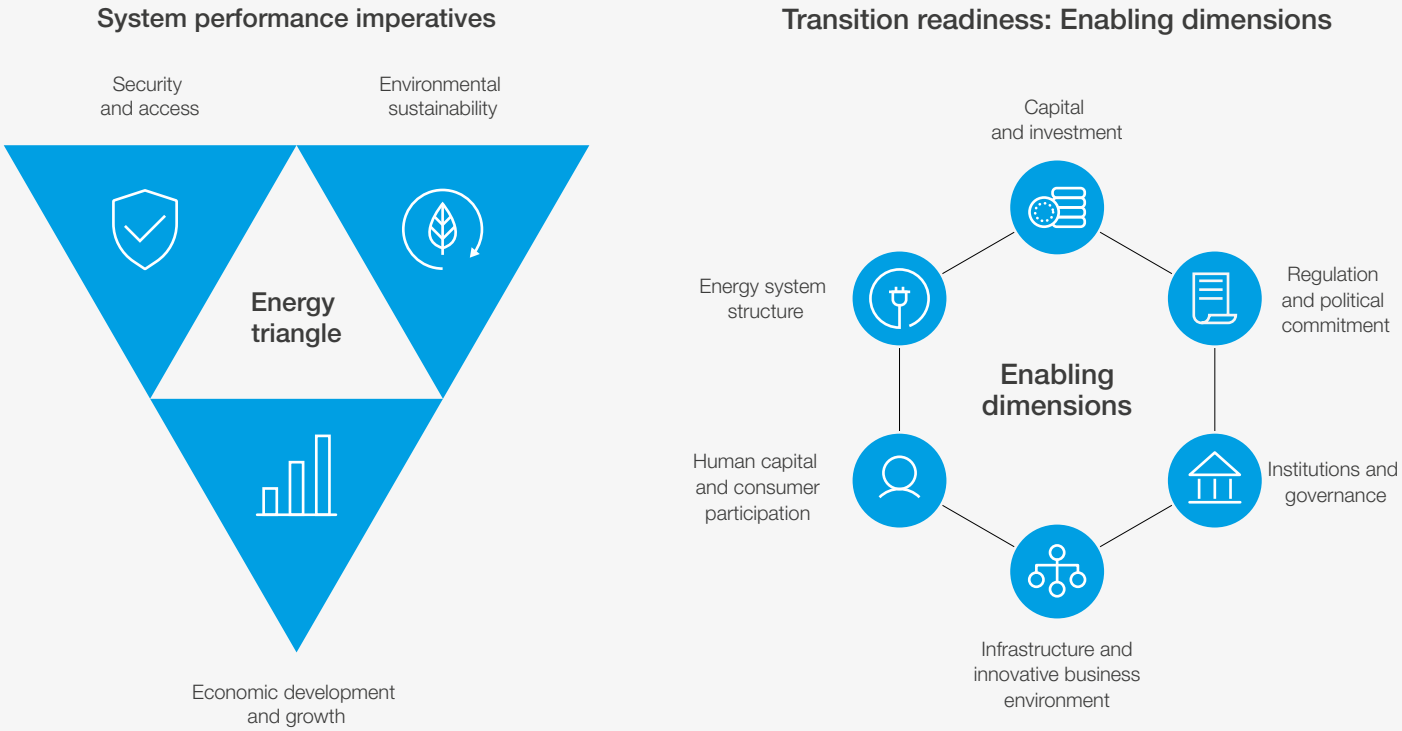
The COVID-19 pandemic, the war in Ukraine and collateral turmoil in the energy markets make clear the need for the global energy transition to simultaneously address the imperatives of economic development and growth, energy security and access, and environmental sustainability. Imbalances will continue to impede efforts to reach the pace required to limit warming to 1.5°C.

The global energy transition, pivotal to climate change mitigation efforts, is well under way. Over the past decade, the world has made progress during nine of the 10 years, as measured by the Energy Transition Index (ETI). However, the narrative's urgency continues to increase. The 2021 United Nations Climate Change Conference (COP26) warned the world that "we have kept 1.5 degrees alive, but its pulse is weak",[8] amid endeavours to turn this decade into one of accelerated climate action and support. The early 2020s have seen a series of systemic shocks that affect the energy system and merit careful examination to support the development of robust energy transition roadmaps. Following the unprecedented pandemic-induced energy demand reduction in 2020, the consumption of energy rebounded strongly in 2021. This rebound resulted in substantial imbalances in energy markets, triggering soaring energy prices as well as significant growth in greenhouse gas (GHG) emissions. The situation was further compounded by Russia's invasion of Ukraine. These events constitute a perfect storm, creating headwinds on all three imperatives of the energy triangle. High energy prices pose risks to economic growth[9] and have raised the cost of living. Progress on energy access has stalled and countries face imminent energy security risks.[10] The consumption of fossil fuels has also increased substantially, driving emissions up to their highest levels in history.[11] The current context highlights some of the trade-offs inherent in the energy transition, which are further complicated by the energy sector's structure, socio-economic role and geopolitical significance.

The same ETI framework published annually for the last 10 years is used to structure the analysis in this special edition. The framework (Figure 1) strives to assess the performance of energy systems across three fundamental imperatives: the ability to support economic development and growth, energy security and access, and environmental sustainability. Balanced progress for a country's energy transition means advancing along all three dimensions of the energy triangle.

Given the interconnectedness of the energy system across the modern economic and social fabric, the drivers and impacts of the energy transition are not restricted to the traditional boundaries of the energy system. Rather, a broad set of social, political, regulatory, macroeconomic and infrastructure-driven parameters enhance a country's transition readiness (Figure 1), enabling an effective energy transition.

FIGURE 1 **The Energy Transition Index framework**

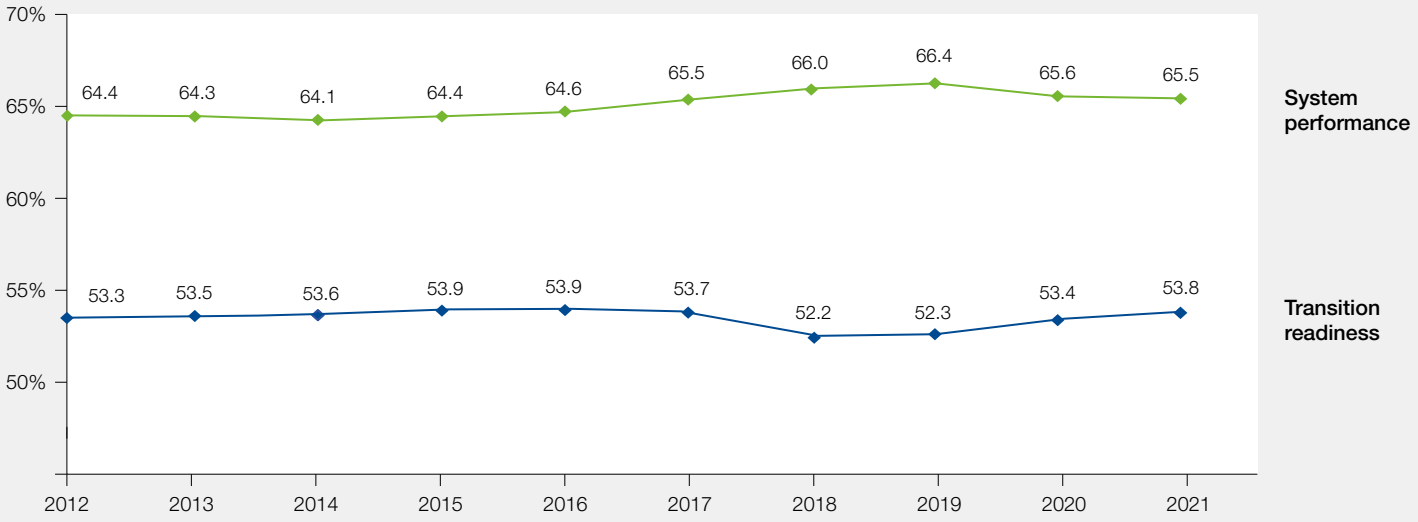


Source: World Economic Forum, *Fostering Effective Energy Transition: A Fact-Based Framework to Support Decision-Making*, 2018

The ETI framework has been used for the past 10 years to reflect on countries' energy system performance and the readiness of their enabling environment for an effective energy transition. Slow but steady progress (Figure 2) was made from 2012 to 2021 on both the system performance and transition readiness dimensions.

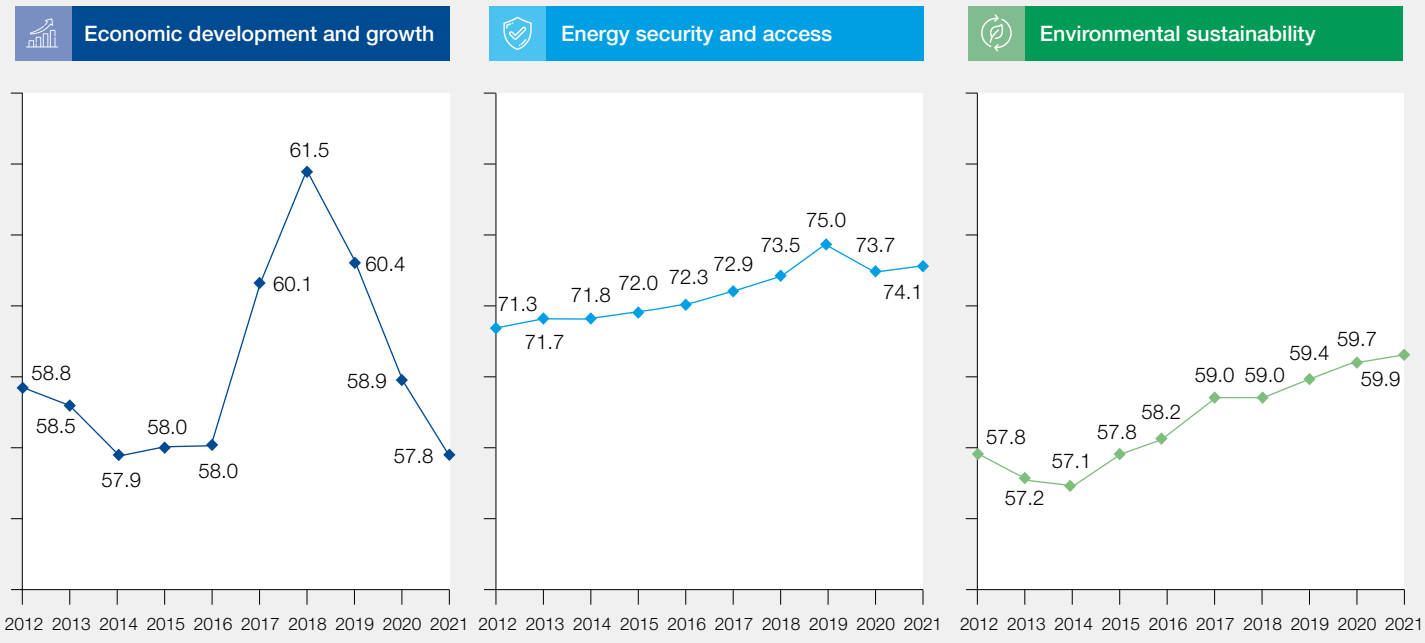
A closer look at the energy triangle (system performance) reveals that countries' progress over the last decade has not been uniform across the three imperatives (Figure 3). Environmental sustainability improved steadily at a deliberate pace, and energy security and access also improved largely consistently over time, although recent developments warrant a fundamental rethink on energy security. The downward trend in economic development and growth since 2018 shows that countries are facing challenges to maintain energy affordability while progressing on their energy transition pathways.

FIGURE 2 **Global average Energy Transition Index system performance and transition readiness scores, 2012-2021**



Sources: World Economic Forum, *Fostering Effective Energy Transition: A Fact-Based Framework to Support Decision-Making*, 2018 ; Accenture analysis

FIGURE 3 **Global average energy triangle sub-index scores, 2012-2021**



Sources: World Economic Forum, *Fostering Effective Energy Transition: A Fact-Based Framework to Support Decision-Making*, 2018 ; Accenture analysis

1.1 Economic development and growth

The risks of high energy prices and economic headwinds are expected to flank the energy transition process, and increased volatility could be a recurring phenomenon.

Energy supply shocks are expected to accompany the energy transition journey, with significant pass-through effects on economic growth and the cost of living. Effective support mechanisms to protect vulnerable populations and businesses are necessary. Steady energy affordability is essential for economic growth and social justice, and both are key to keep the energy transition momentum going.

The past two years have significantly challenged national economies and energy systems. In 2020, pandemic-related restrictions resulted in a steep drop in the demand for energy[12] worldwide and reduced CO_2 emissions, providing a glimpse of the impact demand-side measures could have on climate mitigation.

In contrast, 2021 experienced a fast rebound of demand for products and services and was marked by the global economy's strong and exceptionally rapid recovery with global GDP growth estimated at 5.9%.[13] As economic growth is strongly correlated with energy consumption, the global demand for electricity[14] and oil[15] promptly surpassed pre-pandemic levels, leading to the highest prices experienced in years. Natural gas prices also climbed to their highest in a decade in Europe, the United States and major Asian markets, owing to a combination of both demand-side and supply-side factors,[16] as well as a succession of extreme weather events.[17]

The energy market supply-demand imbalances of 2021 were carried over to 2022 with energy prices sustaining record-high levels even prior to Russia's invasion of Ukraine. The surge in energy prices emerged as an additional factor, fuelling inflation on top of several other factors, such as strong consumer demand,[18] restricted supply chains,[19] rising wages,[20] the increasing cost of housing[21] and food,[22] and low interest rates.[23] In 15 of the 34 economies that the International Monetary Fund (IMF) classifies as advanced, 12-month inflation through December 2021 measured above 5%.[24] A similar trend was observed in emerging markets and developing economies as 78 of 109 countries tackled inflation of above 5%.[25]

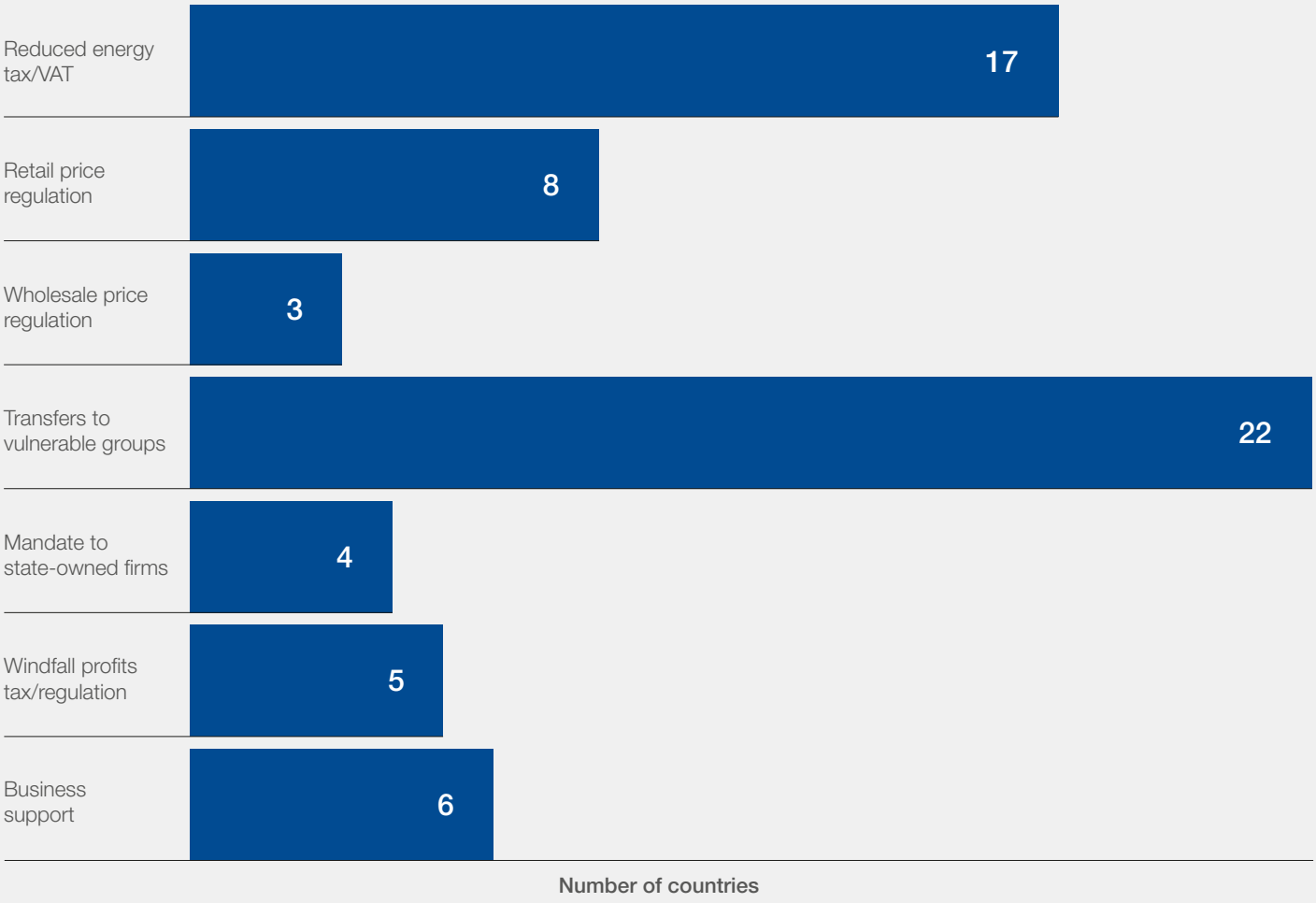
The ability of high oil and gas prices to percolate to other sectors hinges on the relative price inelasticity of its demand. The supply of oil has become more elastic in recent years with the advent of shale oil production in the United States.[26] But oil demand

remains rather inelastic, especially in the short run. Geopolitical events and severe weather events can disrupt supply.[27] **Because energy demand is quite unresponsive due to its lack of elasticity, the risks of high energy prices, inflationary pressure and economic headwinds are expected to flank the energy transition process, and increased volatility is likely to be a recurring phenomenon**.

Emerging and developing economies are disproportionately affected by spiralling inflation. Although the peak pass-through of high retail energy prices in advanced economies is twice that of developing economies,[28] the cumulative impact on consumer price index (CPI) levels in developing economies is higher as prices stay elevated for a longer period of time. Higher energy intensity and lower substitution effects may account for the larger impact on inflation in developing countries.[29] In essence, **the impact of volatility in energy markets is likely to be more pronounced on developing economies, which adds to the concerns of equity and justice of the energy transition.**

With the outlook of potentially recurring periods of supply-demand imbalance of transition fuels such as gas, and rising trends in carbon prices, the contribution of energy prices to CPI could be well above historical norms in the medium term, with potentially far-reaching consequences for households and businesses alike.[30] An increasing number of households, including in advanced economies such as the European Union (EU),[31] United Kingdom[32] and United States,[33] are unable to meet their basic need for heating and lighting at an affordable cost. The energy crisis has also affected companies producing energy-intensive materials like ammonia, steel or aluminium, with significant knock-on effects, such as rising costs of fertilizers, which has compounded food security concerns worldwide.[34] With the price of consumer goods and services already rising due to constrained global supply chains, a sustained increase in energy costs will likely impact the cost of living and consumer spending while adding an additional cost burden to businesses and governments. Countries have taken various emergency response measures (Figure 4) in response to these concerns.

FIGURE 4 **EU+ countermeasures enacted to combat high energy prices**



Note: EU+ includes the United Kingdom and Norway.

Source: Sgaravatti, Giovanni, Simone Tagliapietra and Georg Zachmann, "National policies to shield consumers from rising energy prices", Bruegel Datasets, 21 April 2022 update, https://www.bruegel.org/publications/datasets/national-policies-to-shield-consumers-from-rising-energy-prices

> Developing the necessary support mechanisms to cushion energy supply shocks until the low-carbon energy systems reach the scale and flexibility required will be essential.

In the face of economic headwinds along with the geopolitical uncertainty, governments have also been taking measures to address energy affordability challenges from the supply side. As a last resort to counter recent sky-high gas prices, some countries have increased coal-based power generation. In the United States, where coal-based generation has been in decline since its 2007 peak,[35] it increased by approximately 22%[36] in 2021, with coal production expected to further increase by 4%[37] in 2022. Germany is also investigating extending the life of certain of its coal-powered plants[38] to maintain competitive energy access. In addition, some countries are reconsidering their nuclear power generation policy.

Moreover, strategic petroleum reserves (SPRs) have been leveraged and have proven once again to be a critical tool for emergency response measures[39] to mitigate energy supply shocks. These could be crude reserves, petroleum product reserves or gas caverns. In the face of severe supply disruptions, this countermeasure can help economies mitigate some of the immediate economic impacts of a sudden supply shock. In early March 2022, a coordinated effort was orchestrated by International Energy Agency (IEA) member countries[40] to address significant supply disruptions. At the time of writing, the United States announced the largest release of oil reserves in history, comprising 1 million additional barrels per day for six months.[41] SPRs can lower oil prices in a high-price environment, thereby having a stabilizing effect on the economy during an oil supply disruption scenario.[42] Their major impact is by way of price relief or even alleviating the physical shortage of supply to at-risk and strategic consumers.[43] The system, however, focuses on handling short-term disturbances and has limited impact on medium- to long-term markets.

No universal definition of energy poverty or basic energy needs exists, because of sensitivities related to regional and income-driven differences.[44] Addressing these concerns will rest on a robust framework of data transparency to determine the magnitude and prevalence of the challenge at the national and local levels, mechanisms to effectively target vulnerable consumers for financial transfers, and the design of support measures in a manner that does not reduce incentives for efficient consumption.[45] **However, the systemic nature of the challenge calls for long-term measures to safeguard vulnerable consumers and businesses from volatilities resulting from the transition.**

Building resilience in transitioning energy systems to mitigate the adverse effects of volatility on small and medium-sized enterprises (SMEs),[46] consumers and the most vulnerable households is key to help advance energy affordability and a just and socially accepted transition. In this sense, the pivotal events of the past two years advocate for an energy transition that helps ensure energy affordability while pursuing sustainability goals. Developing the necessary support mechanisms to cushion energy supply shocks until the low-carbon energy systems reach the scale and flexibility required to consign the risks of a major fossil energy crisis to history will be essential.

Building resilience will likely come at a price to countries, companies and consumers, owing to potential inefficiencies, redundancy, extra capacity or green taxation. However, by minimizing the risks of dropouts and delays for economic reasons, it will be the only viable pathway to achieve close to a net-zero[47] society by mid-century.

1.2 Energy security and access

> The prospect of robust progress hinges on the ability to manage short-term shocks.

High energy prices and new risks of energy shortages, resulting from the fast COVID-19 economic recovery and the war in Ukraine, have forced a reprioritization of energy security. Countries can strengthen energy security by diversifying their fuel import partners in the short term and diversifying their energy mix with low-carbon alternatives and improving energy efficiency in the long term.

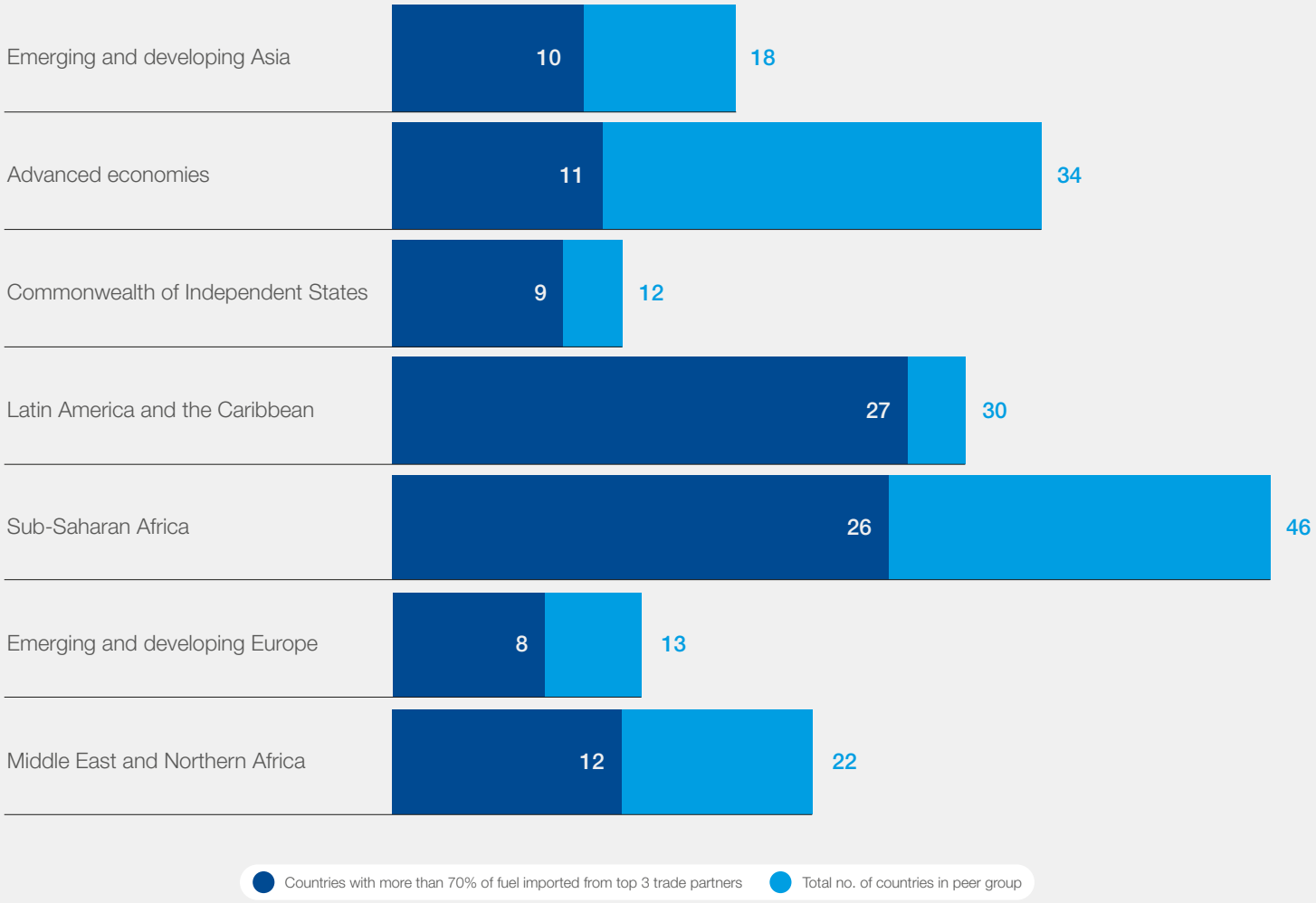
According to the latest evidence from the Intergovernmental Panel on Climate Change (IPCC), global emissions need to peak by 2025 to keep the target of 1.5°C alive. The reconfiguration of the entire energy system, including the underpinning fuels, technologies, markets and geopolitics, may not proceed smoothly.[48] The prospect of robust progress hinges on the ability to manage short-term shocks, especially those that pose risks to the reliability and affordability of energy. The IEA defines energy security as the "uninterrupted availability of energy sources at an affordable price".[49] As measures to combat climate change accelerate, adequate and affordable access to energy will be critical to the continued prioritization of environmental policies. In the long run, energy security means securing the energy supply needed for a country's economic development and growth. In a world aiming to reach net-zero emissions by mid-century, long-term energy security is closely tied, if not constrained, by national sustainability ambitions.

Energy market volatilities and geopolitical events over the past two years have elevated energy security risks. Following a period of low investment in legacy assets,[50] a faster-than-expected economic rebound from the COVID-19 pandemic[51] strained the energy supply chain,[52] leading to concerns about the availability of gas for winter heating,[53] industrial activity slowdown[54] and pressure on the fiscal budgets for energy subsidies.[55] Indeed, the record-high energy prices took countries by surprise and spotlighted their severe reliance on imported fossil fuels as well as the strong interdependence of their domestic electricity prices with global gas markets.[56]

High prices created heavy financial pressure not only on households but also on businesses of all sizes, leading to social protests and industrial production cuts in several countries.[57] Additionally, in 2021, intensifying extreme weather events pushed power grids to the breaking point,[58] which led to severe blackouts affecting 4% of the world's population.[59] And, currently, energy security concerns arising from the war in Ukraine are forcing a fundamental rethink of energy and foreign policy, even in countries not reliant on imported fossil fuels from Russia.

Bilateral energy trade among countries, globally integrated energy markets, and technology standards for mid-stream and downstream infrastructure are among the core building blocks of the current geopolitical landscape. Resource endowments aside, the spatial distribution of reserves vis-à-vis demand centres and infrastructure considerations including pipelines, refinery configurations, etc., necessitate even resource-rich countries to rely on imports, a case in point being Canada.[60] Hence, complete energy independence may not be feasible for countries in the near term. While a decarbonized future energy system can provide energy security dividends due to the localized resource abundance of low-carbon energy sources, ensuring energy security and affordability through the transition will require fossil fuels. Many countries either do not benefit from natural energy resource endowments required to meet their energy needs or are unable to exploit them for their own use due to political, technological or financial reasons. The essence of the energy security challenge in these countries is typically dual: countries' insufficient diversification of their energy mix or insufficient diversification of energy import partners, or both. As an example, Europe relies on natural gas for 19%[61] of its power generation and 38-41%[62] of its residential heating, and 45% of the EU's consumed natural gas is imported from Russia.[63] A majority of countries continue to rely on a handful of trade partners to meet their energy requirements (Figure 5).

FIGURE 5 | **Country fuel import diversification**



Note: See the appendix for the peer group classification.

Source: UNCTAD, World Economic Forum and Accenture analysis

An energy mix, dominated by low-carbon energy systems, is more likely to have a national or regional footprint, implying a convergence of energy security and sustainability.

Eleven of 34 advanced economies are reliant on only three trade partners for over 70% of their economy's fuel imports. Similarly, 10 in emerging Asia, 8 in emerging Europe, 27 in Latin America and the Caribbean and 26 in Sub-Saharan Africa are heavily reliant on just three countries for a majority of their fuel imports. These are all at-risk countries whose energy supply chains could potentially experience disruption in the face of adverse climatic events, supply shortages or geopolitical crises. **The lack of diversity in imports results in the countries' energy system having less cushion to deal with disruptions in supply from a given partner, which eventually could precipitate into a national security concern.**

As nations continue to evolve their energy security priorities in light of the rising uncertainty, governments' role in ensuring energy security is not straightforward, as countries with different energy system structures may follow different pathways. What differentiates today's energy crisis from past crises, though, is the fact that scalable alternative technologies and renewable energy sources are available today, which enables policy-makers to facilitate a more integrated, efficient and flexible energy system. Whenever possible, countries can consider strengthening energy security by diversifying their fuel import partners in the short term as well as diversifying their energy mix with the development of domestic renewable and other low-carbon energy in the long term, driving down both the need for energy imports and strategic geopolitical dependencies.[64] There are reasons to believe that diversification will remain critical in increasingly decarbonized energy systems, where high-carbon energy systems powered by fossil fuels, at least in the coming decades, will continue to cohabit with low-carbon energy sources.

A future energy mix, dominated by low-carbon energy systems, such as solar, wind, hydrogen and biomass, is more likely to have a national or regional footprint, implying that a convergence of energy security and sustainability could be possible. Countries shifting towards more decarbonized domestic energy sources are likely to be more self-reliant and less dependent on the global trade of energy, especially if coupled with efficiency measures that reduce the overall energy needs.

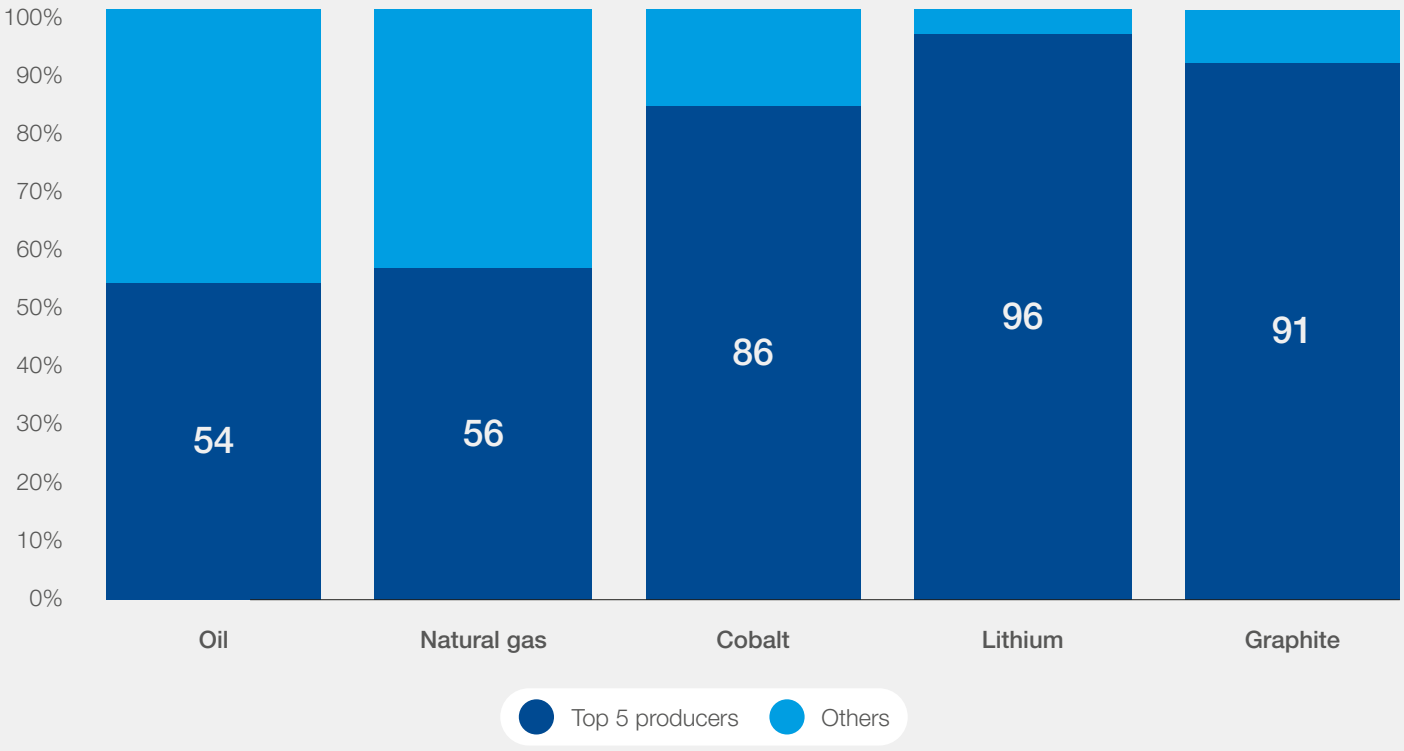
The impending surge of economies' electrification from the rise of renewables is expected to bring in a different set of security-related challenges. Crucial among them would be ensuring the reliability and efficiency of national and cross-border electricity grids. In particular, as the share of wind and solar increases in countries' energy mix, electricity grids will require systemic upgrades to accommodate these variable renewable energy sources. But going forward, countries will also need to think strategically about the technology mix and geographical spread,[65] aside from upgrading and redesigning their grid infrastructure. As a result, grid modernization is also emerging as a key priority for policy-makers and is one of the focus areas of new policy packages, such as in the United States[66] and EU,[67] for both energy security and energy transition imperatives.

The transition to a decarbonized future energy system lowers the security risks from geopolitics of fossil fuels but can also create new potential concerns. Declining fossil fuel demand may further concentrate the remaining supply as higher cost producers exit the market. Additionally, the transition to clean energy depends heavily on access to minerals, such as lithium, cobalt, nickel, copper, etc., to manufacture solar panels, wind turbines and batteries. While the demand of these minerals is expected to grow six-fold for a transition to net zero by 2050 according to the IEA,[68] the production of transition minerals, such as cobalt, lithium and graphite, is more concentrated than that of fossil fuels oil and gas (Figure 6). While a complete phase-out of fossil fuels would reduce countries' energy mix diversification, an increased reliance on renewable power, battery storage and other low-carbon sources could also pose new energy security risks.[69]

Furthermore, as an increasing number of countries, including the United Kingdom,[70] the United States,[71] Japan,[72] India[73] and China,[74] reconsider the role of nuclear energy due to its low emissions and baseload operational profile, security risks from design specifications[75] and nuclear fuel supply chains can arise.[76]

As the transition remakes the energy system, energy security concerns also require upfront risk mitigation measures. Investment in contingency measures, such as strategic reserves for petroleum and storage infrastructure for natural gas, can reduce the impact of disruptions in the supply of these fuels through the transition period. Similarly, considering the criticality of transition minerals' supply to support the manufacturing of the renewable energy components necessary for the energy transition, investing sufficiently in responsible mining, diversifying sources of supply and strategically stockpiling minerals in some cases can ensure a resilient minerals supply chain.[77] **Furthermore, considering the energy security premium, maintaining some legacy assets through market mechanisms that support reserve capacity might be required to address supply demand imbalances during the transition.**

FIGURE 6 **Market share of top five energy commodity producing countries**



Source: bp, *Statistical Review of World Energy 2021*, 70th edition, 2021, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Maintaining some legacy assets through market mechanisms that support reserve capacity might be required to address supply demand imbalances during the transition.

While governments across the globe continue to focus on the critical aspects of their countries' energy security, it is vital that they sustain ongoing efforts to provide energy access to those in need. Even before the pandemic arrived, the world was lagging in providing universal access to electricity and clean cooking fuel.[78] As of 2019, 759 million people do not have access to electricity and over 2.6 billion people do not have access to clean cooking fuels.[79] The rate of progress reveals that the world is not on track to achieve the targets for universal access, and the impact is more acute for the most vulnerable countries that were already lagging.

Emerging and developing economies are likely to suffer longer and more severely from the economic impacts of the Covid-19 pandemic, exacerbating hunger, poverty and inequality worldwide.[80] Early evidence indicates that the pandemic might also have dismantled some of the steady progress towards universal energy access. In 2021, the number of people without access to electricity increased by 2% to 768 million.[81] The lack of access to energy is a constraint in delivering timely and adequate healthcare and vaccination programmes. Only 28% of healthcare facilities in Sub-Saharan Africa have access to reliable electricity,[82] making basic health services in some rural communities inaccessible.

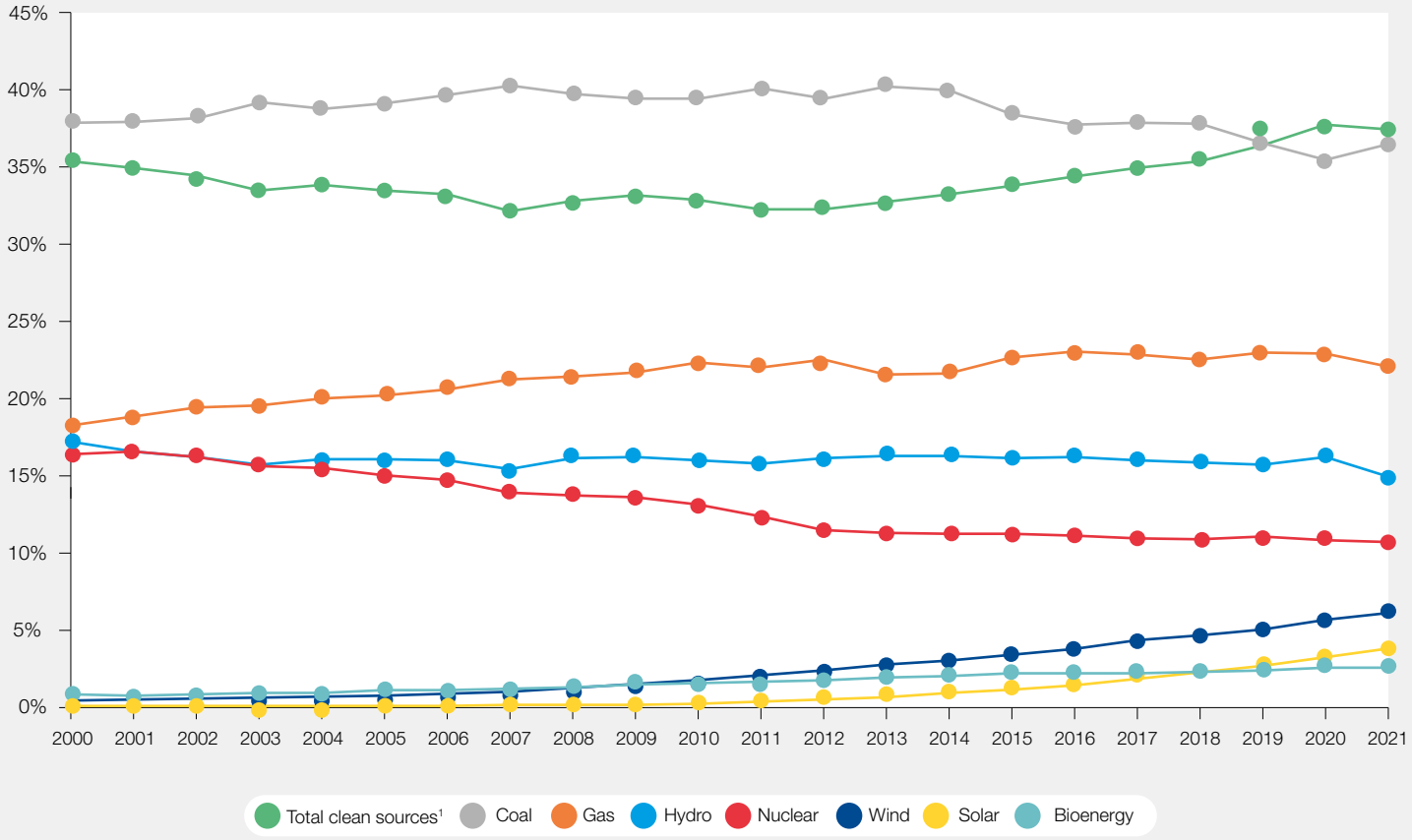
Delivering universal energy access by 2030 remains a key UN Sustainable Development Goal (SDG) with the potential to better the lives of millions. However, the COVID-19 pandemic has significantly damaged ongoing efforts as companies working on providing off-grid solutions continue to suffer from supply chain disruptions.[83] Achieving the UN's seventh SDG also requires large investments, to the tune of $20 billion[84] annually to 2030 in Africa alone, yet fiscal implications of economic recovery programmes tend to indicate that valuable resources are instead being diverted from energy access programmes in the current context.

1.3 Environmental sustainability

Energy affordability and security challenges reinforce the need to supercharge the transition by accelerating investments in the "new" (decarbonized) energy system and embedding more efficient energy consumption habits in post-pandemic societies. The strengthening of governments' and companies' efforts to reduce their reliance on fossil fuels is key, but individuals' "civic duty" towards energy use must also intensify.

The momentum on environmental sustainability has been strong throughout the past decade. Enabled by policies, investments and innovations, renewable energy technologies, such as solar photovoltaics and wind power, are cost competitive with fossil-fuel-based power generation alternatives in countries around the world.[85] Although low at absolute levels, the market share of electric vehicles has steadily increased, doubling in 2021.[86] Costs of energy storage solutions, such as lithium-ion batteries, critical for providing flexibility services to a decarbonized grid, are rapidly approaching cost competitiveness.[87] Despite COVID-19 pandemic restrictions, periods of lockdowns, supply chain bottlenecks and the increasing turmoil on energy markets, the past two years accelerated the global momentum in the transition towards more sustainable energy systems, with record capacity expansion of solar photovoltaics and wind power. Wind and solar energy combined now generate 10% of global electricity for the first time ever (Figure 7).[88] In addition, low-carbon power sources including solar, wind, hydro, nuclear and bioenergy combined generated 38% of the world's electricity in 2021, overtaking coal, with Europe leading the way and China and Japan making over a tenth of their electricity from wind and solar for the first time.[89] An analysis of historical trends from the ETI supports this trend, with the global average score on the environmental sustainability dimension of the index increasing in seven of the past 10 years (Figure 3), with more than 70% of countries showing growth on this dimension. Energy security challenges arising from fossil fuel dependency have intensified due to the ongoing war in Ukraine, strengthening political and popular resolve to accelerate the pace of the clean energy transition.

FIGURE 7 **Share of global electricity generation by source, 2000-2021**



Notes: [1]Total clean sources include solar, wind, hydro, nuclear and bioenergy; The combined solar (3.72%) and wind (6.59%) shares of global electricity generation amount to 10.31%.

Source: Ember, "Global Electricity Review 2022", 30 March 2022, https://ember-climate.org/insights/research/global-electricity-review-2022/#global-trends-1-wind-and-solar-surpass-10

Nevertheless, the ground to cover remains considerable. The latest IPCC assessment indicates that average annual GHG emissions between 2010 and 2019 were higher than in any previous decade.[90] Emission reductions in carbon dioxide from fossil fuels and industrial processes were insufficient to offset the increase from rising global activity in industry, energy supply, transport, agriculture and buildings.[91] While the drop in energy demand in 2020 from COVID-19 pandemic restrictions led to reduced global CO_2 emissions by almost 6%,[92] emissions sharply rebounded in 2021 above pre-pandemic levels to their highest level in history on account of the rapid restoration and rebound of economic and industrial activity levels, and energy market volatilities. To contain the average temperature increase to below 1.5°C, the global GHG emissions must peak before 2025 and be reduced by 43% by 2030.[93] At the same time, methane, the second fastest growing GHG emissions behind CO_2,[94] would also need to be reduced by about a third by 2030. According to IEA's *Net Zero by 2050* report, annual capacity additions of solar and wind need to be higher than 1,000 GW, four times the record installation levels achieved in recent years.[95] Additionally, annual sales of electric vehicles would need to scale up eighteen-fold by 2030. **Achieving a transformation of this magnitude and complexity necessitates long-term and ambitious policies, enabling infrastructure and investments, as well as supporting consumption behaviour changes.**

At COP26, governments and businesses demonstrated strong commitment to address the climate emergency, with 197 countries signing the Glasgow Climate Pact, formalizing their commitments and pledges to net-zero targets.[96] As of the end of 2021, countries responsible for 90% of global emissions have announced or are considering net-zero targets.[97] In addition, over 100 countries have joined the Global Methane Pledge, which aims to cut global methane emissions by 30% by 2030.[98] However, current ambitions still fall short of fulfilling the targets set in the Paris Agreement on climate change in 2015. Despite the momentum at COP26, analyses by the IEA and Climate Action Tracker show that even if all climate pledges are met, the world would still not be on track to limit global warming to 1.5°C by the end of this century.[99,100] Additionally, **pledges must be turned into concrete policies and actions that make a difference on the ground in the few remaining years to 2030; the widening gap between pledges and implementation effort is a growing concern.**

The demand for electricity grew at a record pace[101] in 2021, equivalent to adding the demand of India to the world's grid.[102] Lack of requisite natural gas supply led to a record increase in the use of coal in power generation, including in regions where coal had been in structural decline, such as the United States and the EU. Considering potential energy security implications in the medium term, China, India, Indonesia, Japan and Viet Nam plan to build more than 600 coal power plants, which accounts for 80% of new coal power investment.[103] According to the IPCC, unabated emissions from existing or planned fossil fuel infrastructure until the end of their lifetime is equivalent to the emissions allowance from all sectors in pathways to limit global warming to 1.5°C.[104] **Phasing out coal requires the accelerated capacity expansion of not just proven alternatives like solar and wind, but also of other low-carbon sources of energy, such as hydro, bioenergy, hydrogen-based geothermal technologies and infrastructure to capture and store carbon dioxide.**

Carbon capture and sequestration, while a mature yet costly abatement technology for gas processing and enhanced oil recovery, remains unproven in the power sector, highlighting the need for investment in research and development, and policy measures to support demonstrations and deployment. Additionally, clean energy investments would have to triple by 2030 to meet demand in a sustainable way, according to the IEA.[105] While investments in energy transition have approximately doubled over the last decade, China, the United States and the EU account for more than 80%[106] of the investments.

❝ Pledges must be turned into concrete policies and actions that make a difference on the ground in the few remaining

“ Current paradigms with heightened energy security risks indicate the need to further harness the synergistic potential of energy efficiency.

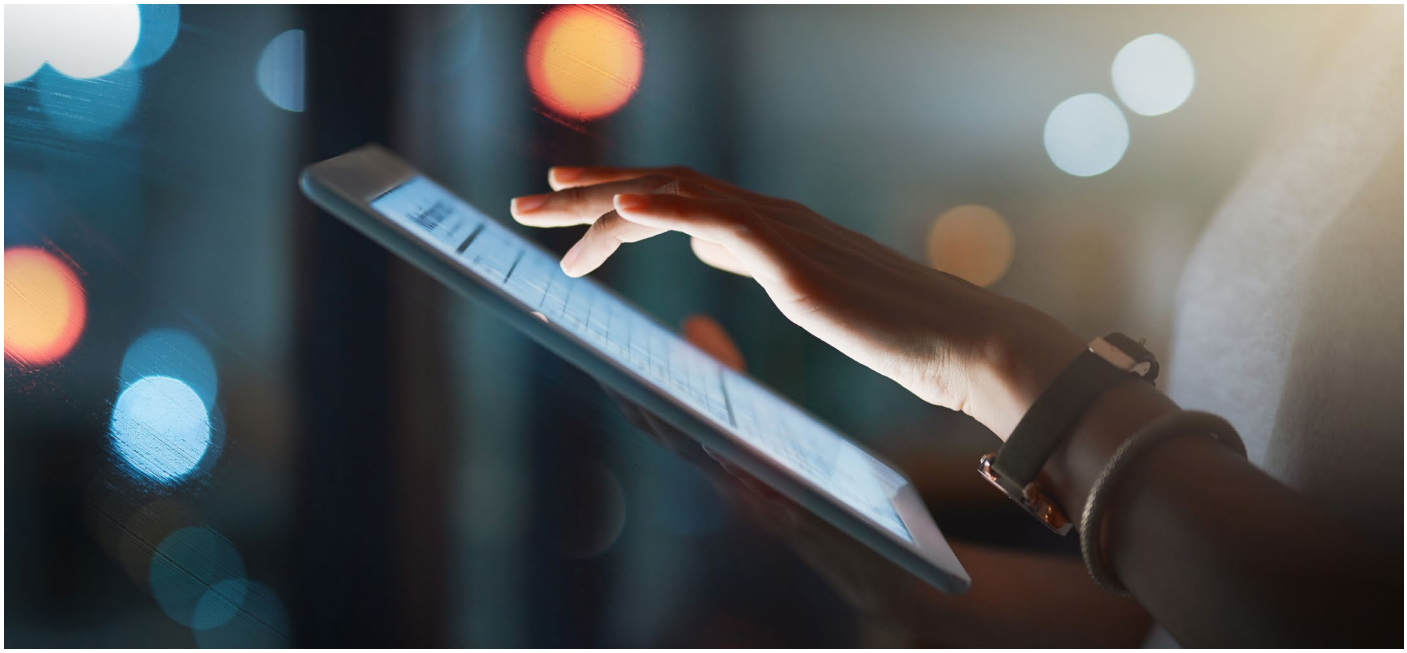
Africa, which has 39%[107] of global renewable energy potential, attracted only 2% of global investment in renewable energy over the last decade.[108] Geographical disparities in global climate finance aside, investments in fossil fuel assets remain higher than low-carbon assets, also reflecting a mismatch between pledges and actions.[109]

Overall, the macroeconomic challenges that came with the 2021 economic recovery as well as the energy affordability and energy security concerns for many countries exacerbated by the Russian invasion of Ukraine reinforce the rationale to supercharge the energy transition.

Apart from supply-side measures, energy efficiency is regarded as the world’s “first fuel” and is the strongest lever in the transition to net zero, according to the IEA.[110] While the energy intensity of GDP has been declining, the rate of decline needs to double to meet the levels for net-zero emissions by 2050. Given the energy footprints across economic sectors, this highlights the importance of improving energy productivity of such end-consuming sectors as industry and transport, as well as economic diversification to decouple growth from energy consumption. An analysis of G20 countries indicates an inverse relationship between their level of national economic output from the industrial sector (including energy-intensive sectors such as manufacturing, mining, construction and energy producing activities) and their scores on the ETI. **Fostering an innovative business environment and human capital development can support the growth of higher value added sectors, enabling necessary economic diversification.**

In addition to supporting sustainability ambitions, integrated demand-side measures to improve energy efficiency can also offer security dividends. For example, Japan, a major energy importer, was able to reduce its import burden of oil and gas by 20% in 2016, as a result of energy efficiency improvements since 2000.[111] Current paradigms with heightened energy security risks indicate the need to further harness the synergistic potential of energy efficiency. Effective demand-side management can offset supply-side additions as well as the need for carbon capture and storage solutions for emissions management. A combination of the right policies, infrastructure and efficient end-use technologies for demand-side mitigation can lead to a 40-70%[112] reduction in GHG emissions by 2050 across the three primary end-use segments: transport, buildings and industry. The expansion of transport electrification infrastructure with incentives to purchase electric vehicles, utilizing remote work arrangements to restrict business air travel, and providing affordable and reliable public transportation where possible can significantly reduce emissions from transportation. Optimizing residential energy consumption through the electrification of heating and cooking, and adopting simple lifestyle changes such as shorter showers or adjusting the setpoint for heating and cooling on thermostats, coupled with sustainable urban design can reduce residential emissions by more than 50%.[113] **Active consumer engagement and participation are pivotal for effective demand-side management.**

While behavioural and cognitive barriers have been persistent in energy efficiency initiatives, the experience from the COVID-19 pandemic demonstrated that social behaviour adaptation is possible in the short term. Lessons from the management of the pandemic highlight the importance of transparent information dissemination campaigns and of the trust in institutions. Additionally, as the pandemic restrictions disproportionately affected low-income households, it also highlights the distributional considerations of lifestyle and behaviour change programmes, emphasizing the need for equity measures to enhance social acceptance.



1.4 Transition readiness enablers

The window of opportunity to prevent the worst consequences of climate change is closing fast. It is essential to make the energy transition robust by building the necessary enablers that will keep the transition going if the economic and energy security context deteriorates. This includes making legally binding commitments, designing long-term visions for domestic energy systems, building an attractive investment landscape for private capital and promoting consumer participation as well as building the local workforce required for the transition.

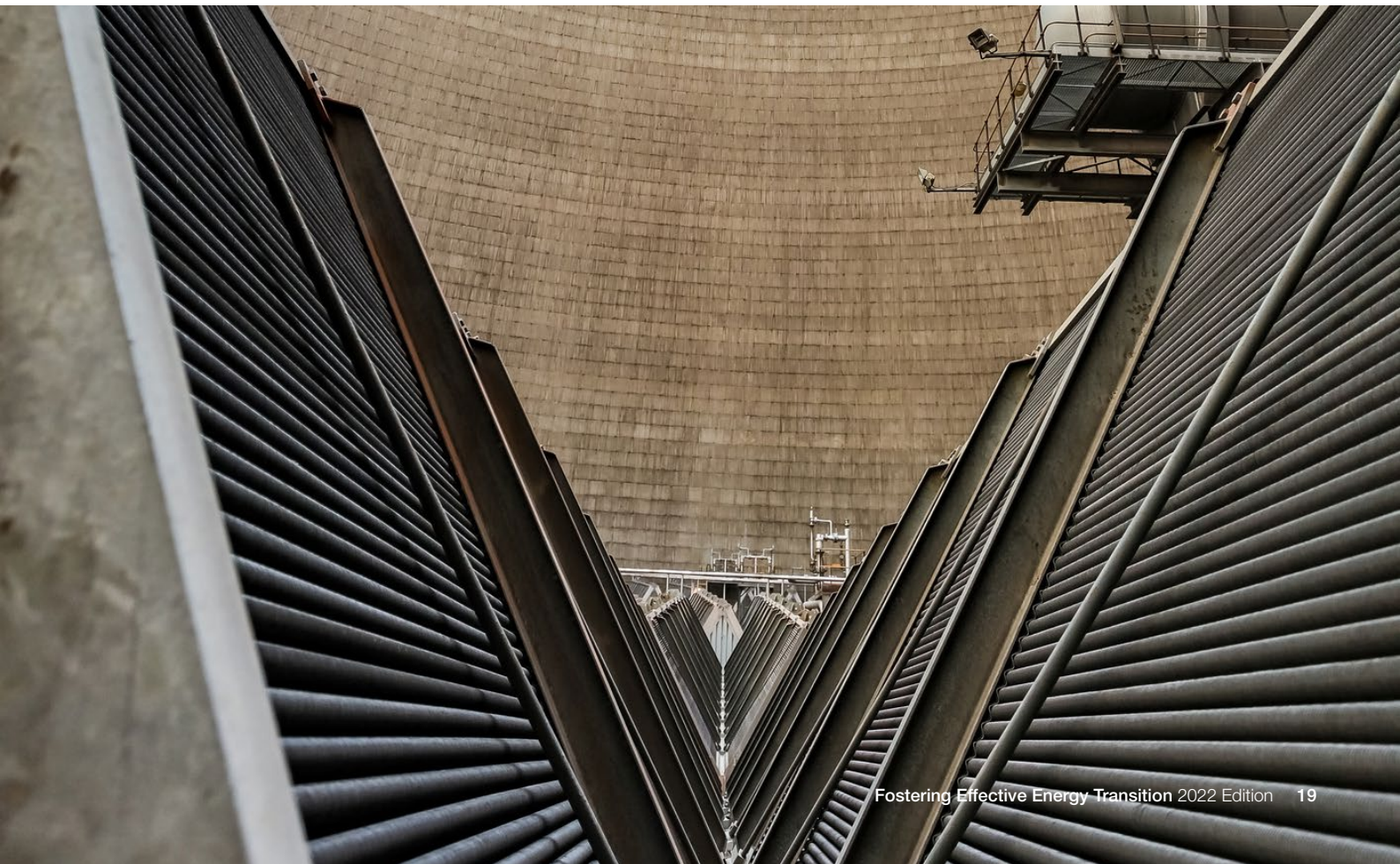
As outlined in the ETI framework, the readiness of a country to transition its current energy system towards one that enables the development of a sustainable low-emission economy depends on a multitude of factors that can be measured and analysed along a country's energy system structure, regulation and political commitment, investment climate, human capital and consumer participation, infrastructure and business environment, and the robustness of institutions (Figure 1). Progress on these dimensions is critical for countries to increase their support of the energy transition and accelerate their efforts.

However, improving these dimensions is gradual as the path to institutional, socio-economic and systemic transformations depends on established processes and systems. Given the disruptive environmental, macroeconomic and geopolitical events of the last two years and their implications for the energy transition, this section outlines four measures that countries can take to support their transition journey.

1) Anchoring climate commitments in legally binding frameworks that can endure political cycles and enforce the long-term implementation of national transition objectives

The long-term structural changes required for the energy transition will take longer than the usual 4- to 5-year political cycles of many countries so they must be made resilient to political changes in the executive, legislative and judicial branches of government. Turning climate commitments into laws (e.g. France attempted a change in constitutional law in 2021[114]) can support the transition effort in the long run. Climate-related laws then overarch the policies to promote energy efficiency, renewable energy and electricity access, the participation in international climate diplomacy, the evolution of GHG reduction targets (both 2030 nationally determined contributions and longer-term net-zero targets), as well as the policy stability required for long-term energy system transformation.

Countries, cities and businesses have vowed to achieve net-zero emissions in the coming decades. In 2021, a wave of pledges were made, raising the number of countries committed to net-zero targets, covering 88%[115] of global emissions. Particularly, prior to COP26, several



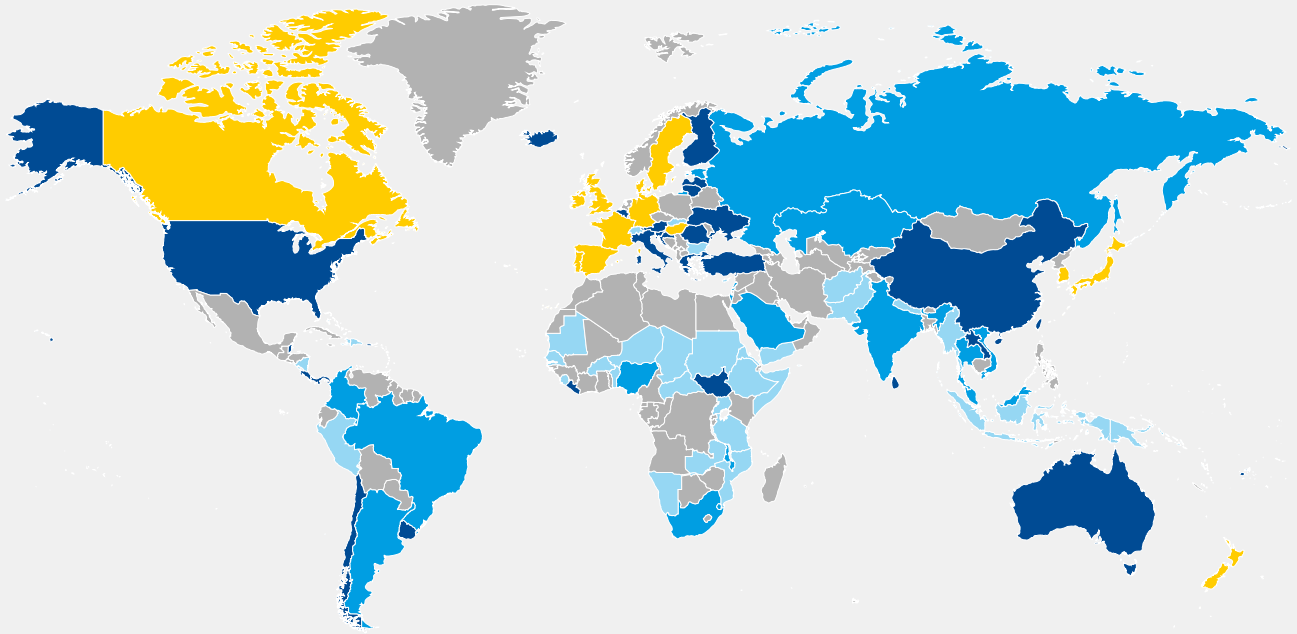
large economies submitted more ambitious 2030 emission reduction targets, notably China, the EU and the United States. But, although these new targets can reduce GHG emissions by 7.5% this decade, 55% is needed by 2030 to align with the Paris Agreement goal of keeping the global temperature rise below 1.5°C.[116]

To help political ambitions translate into on-the-ground action, introducing net-zero commitments into a legal institutional framework and complementing them with binding policies could help strengthen the urge for action of future governments regardless of other existing priorities. To date, 13 countries have made their net-zero targets legally binding and 33 countries have put their net-zero targets in policy documents.[117] Figure 8 shows the status of countries' net-zero targets in 2021. The 2050 climate goals require more countries to transition their commitment into legally binding frameworks to enforce long-term on-the-ground climate action.

2) Taking and holding long-term decisions with regard to the decarbonization of the national energy system structure

A country's existing energy system structure significantly influences transition readiness as the path depends on legacy infrastructure and resource endowments. Technological lock-in, economies of scale, the long lifetimes of current energy infrastructure and end-use behaviour patterns

FIGURE 8 **Status of countries' net-zero targets, 2021**



Net-zero target status	Share (%) of global total energy supply	Share (%) of global CO_2 emissions from fuel combustion	Share (%) of global total nominal GDP
Achieved	0	0	0
In law	14	12	25
In policy document	44	50	50
Declaration/pledge	21	21	12
Purposed/in discussion	5	4	4
Uncovered	16	13	9

Note: The boundaries shown in this map do not imply official acceptance or endorsement by the World Economic Forum.

Sources: Energy and Climate Intelligence Unit; International Energy Agency; World Bank

create barriers to entry for disruptive technologies. Creating a new energy system that can gradually complement and eventually supplant the legacy infrastructure requires enhancing the flexibility of electricity system, improving end-use efficiency and increasing the share of renewable energy in power generation, among other measures.

As an example, coal is generally the most polluting source of power generation today. It emits nearly twice the amount of CO_2 when combusted compared to natural gas at most power plants where it is used,[118] yet it still represents a major share of many countries' energy mix.

Long-term commitments for the future of the national energy system structure can ensure countries make fundamental and irreversible changes in line with their energy transition goals. The emergency returns to coal witnessed in recent months should also make countries rethink how they can build resilience and contingency plans for their energy systems that do not rely on coal.[119] Multinational partnerships can play a crucial role in ensuring long-term visions and structural changes are implemented. For instance, the Just Energy Transition Partnership[120] between South Africa and France, Germany, the United Kingdom, the United States and the EU will provide support to transform South Africa's economy away from coal and towards a low-emission climate resilient economy.

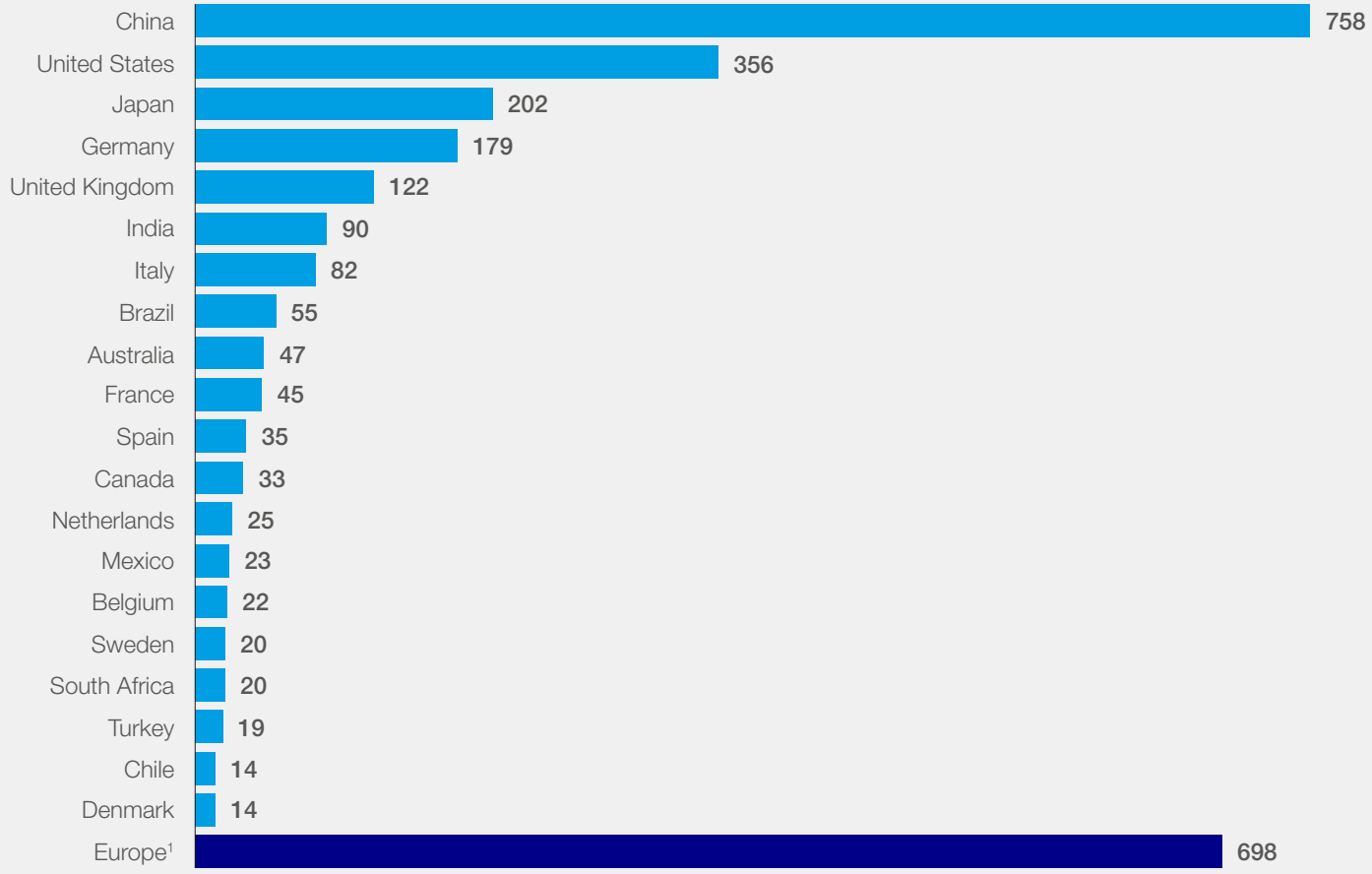
3) Building an attractive investment landscape for private capital, both foreign and domestic, to finance energy transition projects, especially in emerging and developing countries

A country's ability to attract capital depends on a multitude of factors, including supportive policy and legal frameworks, stability of the currency and exchange rates, a secure and safe environment, the quality of infrastructure and the availability of the latest technologies. Adopting and promoting these factors can create strong momentum for capital to flow into the transformation of the energy system.

While advanced economies continue to attract capital under favourable terms, including for higher-risk new low-emission technology industrial projects, developing and emerging countries are still struggling to attract both foreign and domestic private investments essential for the financing of large energy projects and infrastructure. Even though the last decade saw record investment in new renewable power capacity ($2.6 trillion globally[121]), most of these investments were made in countries with stable and favourable investment landscapes, such as China, the United States, Japan and Germany (Figure 9). Additionally, the effects of the COVID-19 pandemic were felt differently across regions, with emerging and developing countries facing acute challenges given the fiscal impacts of the pandemic on their national budgets. Owing to the continued reluctance of a number of financial institutions to fund the transition in emerging and developing countries,[122] it is worth stressing that climate goals cannot be reached without a global transition; solutions must be found to rally the financial sector. Technical and financial support to emerging and developing economies, leveraging a mix of public and private investment instruments, grants, concessional finance and market-based capital could help keep the transition on track. International collaboration, not only on finance flows but also on policies, regulatory practices, best technical practices and new business models is critical.

While governments continue to put in place the necessary enablers to build private investors' confidence, investing entities such as multilateral development banks, philanthropic funds, specialized branches of sovereign wealth funds and commercial banks can play a role in bridging the gap and invest in countries where higher financial risks are involved.

FIGURE 9 | **Renewable energy capacity investment, top 20 countries, from 2010 to first half of 2019 ($ billion)**



Note: [1]All European countries, including those listed beyond the top 20, plus the United Kingdom.

Source: UNEP, *Global Trends in Renewable Energy Investment 2019*, 11 September 2019, https://www.unep.org/resources/report/global-trends-renewable-energy-investment-2019

4) Promoting consumer participation and building the local workforce required for the transition, paying particular attention to the livelihoods of vulnerable populations

Consumer participation involves increasing customer awareness of the stakes of climate change, of carbon footprints and of individual actions that can be taken to support national climate change ambitions. The energy transition will likely create a significant number of new jobs and require a trained workforce with very different skill sets than a country has historically developed (e.g. petrotechnical professionals in oil producing countries). Developing the consumers and workers of the future can be a key enabler of a long-term sustainable energy transition.

When empowered, environmentally conscious consumers can achieve substantial emission reductions, as shown by a recent study[123] that researched household preferences for reducing GHG emissions in cities in France, Germany, Norway and Sweden. These consumers can drive distributed grid networks, apply energy efficiency measures and reduce their overall carbon footprint. Policies raising the awareness of consumers' energy consumption, such as mandating energy labels on products and providing peer-to-peer comparative energy consumption reports to households, or providing monetary incentives like variable power rates and feed-in tariffs can be used to drive long-lasting behavioural changes in consumers.

While moving to clean energy can create new jobs in the clean energy industry, it can also lead to job losses in other industries and can be detrimental to the livelihood of dependent communities. In addition, the transition can negatively affect low-income households, which might struggle to keep up with the rising costs and consumption changes brought about by the transition. Governments can partner with private institutions to reskill, cross-skill or upskill the existing workforce, particularly within jobs at risk, such as those in the fossil fuel industries. They can also adapt the education system to stay abreast of the technologies in the renewables and digital space. Similarly, policies that develop or expand social protection benefits to accompany energy transition reforms can be used to mitigate the negative effects on low-income households.

2 Unlocking the net-zero transformation of industries

A paradigm shift in collaboration is needed to increase progress.

Key highlights

1. Industry-heavy economies may face additional challenges, due to the greater complexity of the industrial net-zero transformation

2. Five industries – cement and concrete, iron and steel, oil and gas, chemicals, and coal mining – represent 80% of all industrial emissions

3. Industries need to overcome difficult choke points whose solutions are seldom found within a single company or even industry

4. A new generation of collaboration models could help overcome the industry decarbonization choke points

5. Industry leaders now favour collaboration and transparency over competition, and view decarbonization as a win-win solution

6. Thanks to industry pioneers, multiple collaboration models have emerged that could be replicated and expanded to help advance the journey to net zero

2.1 No net zero by 2050 without industries

Industries are the backbone of the global economy; their transformation is critical to a net-zero world.

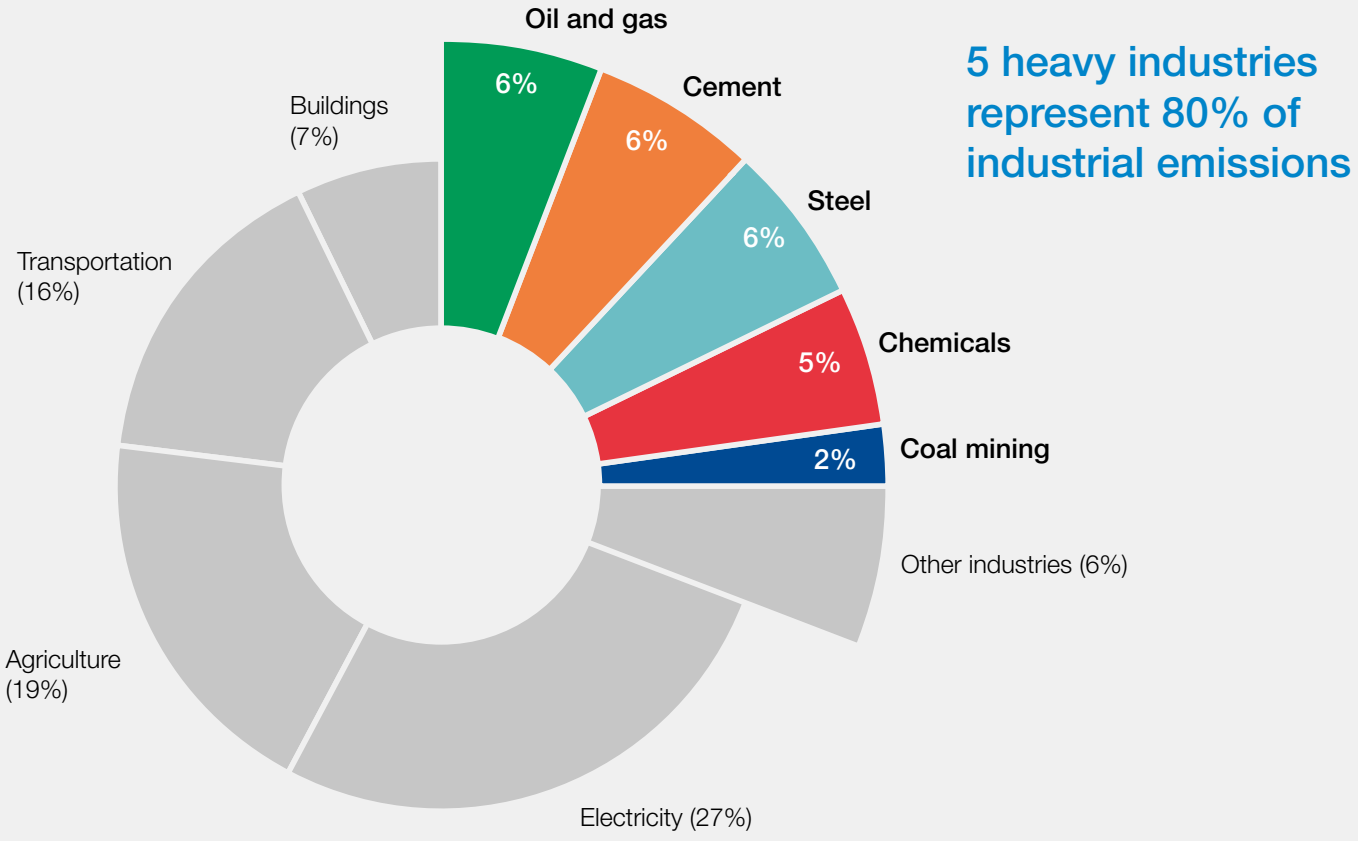
Industries generate more than 30% of anthropogenic emissions[124] – no net-zero economy is possible without them. Yet, industries face considerable challenges to decarbonize, such as the lack of competitive low-emission technology, the limited development of enabling infrastructure or the scarce availability of capital to transform. Going forward, "clean demand" signals could be a turning point to accelerate "clean supply".

Industries are the backbone of the global economy, providing the energy and materials needed to sustain and grow modern society. Emissions from fuel combustion and processes in industries contribute to more than 30% of global GHG emissions[125] (out of a global total of 51 GT of CO_2 equivalent[126]); hence, the transformation of industries is critical to a net-zero world.

While encouraging progress has been made in the past decade to decarbonize power generation (the renewables share in global electricity generation rose from 20% to 29% between 2010 and 2020[127]), many industries are still defining their pathways to a low-carbon future. Particularly, five heavy industries – cement and concrete, iron and steel, oil and gas, chemicals, and coal mining – which together represent 80% of all industrial emissions (Figure 10), need to make a major shift by 2030 to keep the net-zero 2050 objective within reach.[128]

Population and economic growth will likely continue to fuel demand for industrial products beyond 2050, and so will the energy transition itself. For instance, aluminium, steel and many minerals[129] are key elements in the making of solar panels, wind turbines, power grids and electric vehicles. Steel demand is projected to rise by 30%,[130] cement and ammonia by 40%[131,132] and aluminium by 80%[133] in the coming three decades (Figure 11). In addition, all but the most aggressive decarbonization scenarios forecast that oil and gas could continue to play a significant, though diminished, role in the energy mix through 2050 and beyond.[134]

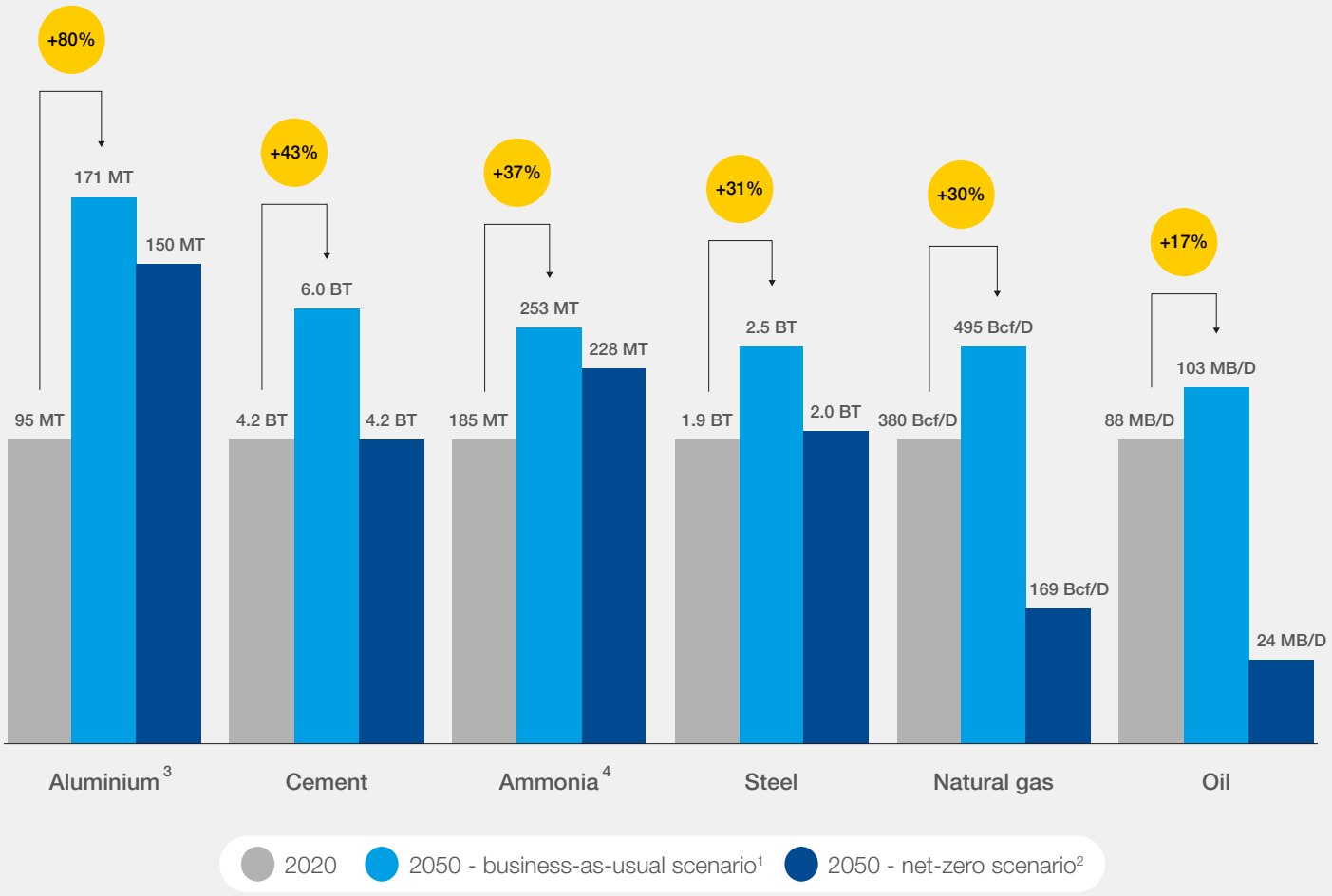
FIGURE 10 **Emissions by sector vs global emissions (51 $GTCO_2e$)**



Notes: Oil and gas also includes refining; Steel includes iron; Cement includes concrete.

Source: Breakthrough Energy, Sectoral Analysis, "Emissions breakdown for Manufacturing, by subsector"

FIGURE 11 | **Global demand projections by industry, 2050**



Notes: [1]Based on IEA Stated Policies Scenario (STEPS) for all except aluminium (International Aluminium Institute (IAI) Business-as-Usual scenario) and cement (Global Cement and Concrete Association (GCCA) Business-as-Usual scenario); [2]Based on IEA Net-Zero 2050 scenario for all except aluminium (IAI 2050 Net-Zero scenario); [3]Demand for aluminium based on 2019 data; [4]Ammonia demand does not include ammonia as an energy carrier; Bcf/D: billion cubic feet per day; BT: billion tonnes; MB/D: million barrels per day; MT: metric tonne.

Sources: IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector*, 2021; IEA, *Iron and Steel Technology Roadmap: Towards more sustainable steelmaking*, 2020; GCCA, *Concrete Future: The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete*, 2021; IEA, *Ammonia Technology Roadmap: Towards more sustainable nitrogen fertiliser production*, 2021; IAI, "Aluminium Sector Greenhouse Gas Pathways to 2050", 2021; IEA, *World Energy Outlook 2021*, 2021

Moreover, viable alternatives to today's heavy industry products remain limited. New cement chemistries could be less carbon-intensive but are likely to substitute only a small share of the global market due to scarcities of resource supply (e.g. fly ashes, calcinated clays) and the differences in the resulting cement properties. While other materials provide alternatives to steel, "its high strength, recyclability and durability, the ease with which it can be used to manufacture goods, and its relatively low cost make its wholesale substitution unlikely" even by 2050.[135] In the absence of scalable substitutes, the only potential way forward would be aggressive decarbonization.

Heavy industries, particularly steel, cement, chemicals and aluminium, are often referred to as "hard-to-abate" sectors, i.e. hard to decarbonize, due to a number of intrinsic characteristics:

- These sectors have energy-intensive complex value chains that sometimes also generate process emissions (e.g. 60% of cement emissions come from the calcination of limestone;[136] 42% of oil and gas emissions come from vented and fugitive methane[137]).
- They are capital-intensive sectors with long investment cycles and low margins, all of which present challenges for the industry to change course; opportunities to significantly cut emissions, such as for major overhaul, relining or plant rebuilding, only appear every 2-3 decades.[138]
- They operate production facilities that are historically located close to natural resources (e.g. a coal mine, quarry) and/or demand centres; these locations can be quite distant from abundant clean energy sources (e.g. solar, hydropower).

– They are critical to domestic economies while supplying into global markets, making emission reduction measures complex to introduce if requirements might lead to a weakened competitive position.

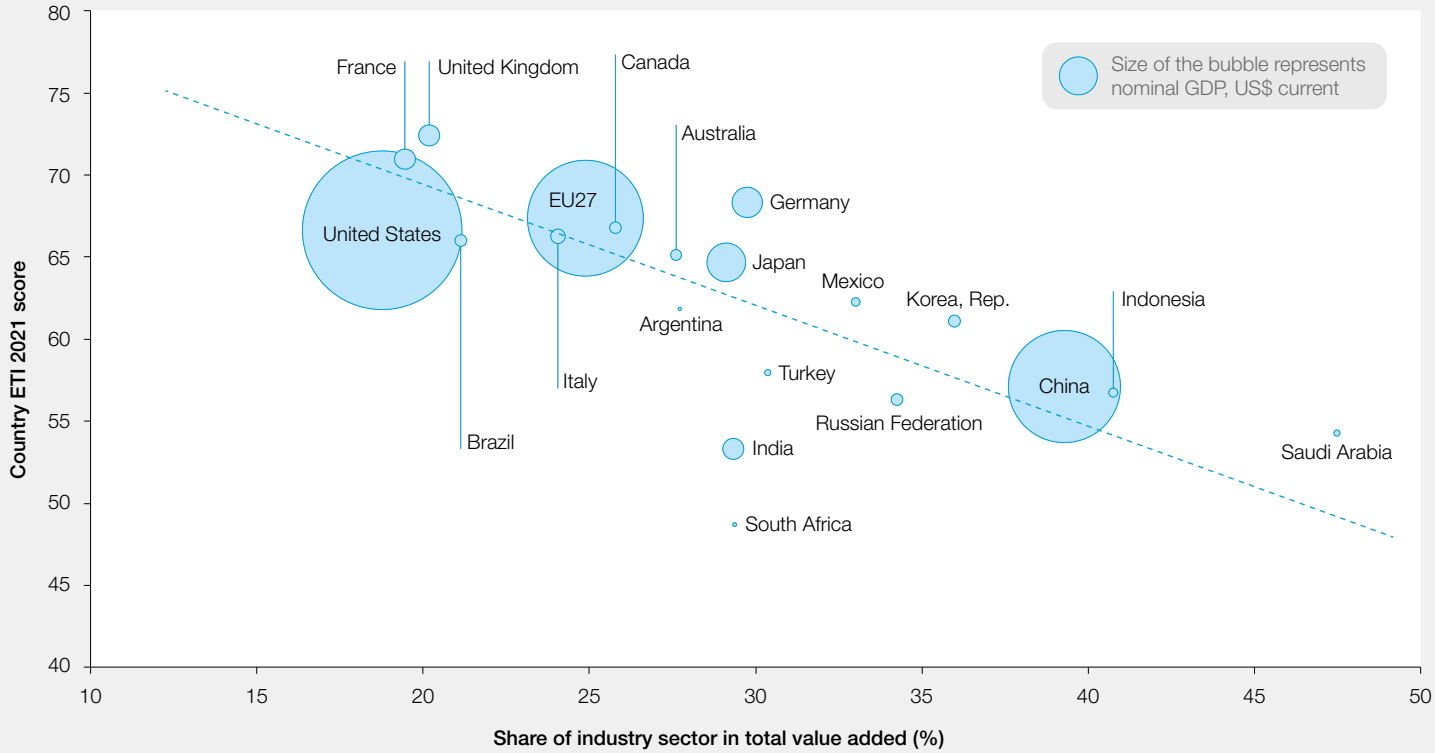
– They often employ a large workforce of specialists and sustain extensive networks of local suppliers and customers. Pacing a just transition for these sectors is a priority for public authorities.[139]

G20 countries, which produce 85% of global industrial output[140] and are responsible for 75% of global GHG emissions,[141] can provide a useful lens to examine the nexus between energy transition and industrial activities.

Despite similar historic development trajectories, the level of present-day industrial activity across G20 economies varies greatly. The industrial sector's contribution to the total economy ranges from 19% to 47% of the total value add of goods and services produced (gross value added, GVA), according to United Nations Conference on Trade and Development (UNCTAD).[142] A country's economic activity is commonly categorized into three sectors: the agriculture sector (consisting of agriculture, livestock, forestry and fishing), the industry sector (made up of manufacturing, mining, construction and utilities providing electricity, gas, water) and the services sector (including a diverse range of services, as distinct from goods). The relative shares of these sectors in total economic activity evolves over time as countries develop and industrialize. Typically, as countries industrialized, the share of the industry sector in output and employment rose, while that of the agricultural sector fell. After industrialization, at an advanced stage of economic development, the share of the industry sector in both output and employment diminished, while that of the services sector rose.[143]

An assessment of energy transition progress in G20 countries, as observed through the ETI (2021), indicates a slower pace of transition in industry-heavy economies, suggesting the greater complexity for countries to decarbonize energy systems tied to industrial performance. Specifically, G20 countries with a larger share of industrial activity (including manufacturing, mining, construction and energy-producing activities) score lower than their G20 counterparts with a lower share of industry (Figure 12).

FIGURE 12 **G20 overall 2021 Energy Transition Index scores vs share of industry**



Sources: World Economic Forum ETI 2021 analysis; UNCTAD statistics; World Bank data

> To enable global industrial decarbonization, international cooperation needs to be strengthened through technological transfers and financing support to economies in need.

The analysis of countries' historical ETI sub-indices, dimension and indicators show a few noteworthy trends. Countries with a larger share of industrial activity tend to suffer from poorer air quality and have higher CO_2 intensity of GDP as a result. These economies also tend to rely more on fuel subsidies to make their industries more competitive. In addition, G20 countries with a larger share of industrial activity are likely to face transition readiness challenges caused by a possible combination of indirect factors. These factors can include the lack of availability of skilled labour and of an innovative environment to foster economic activities with higher value addition and productivity levels. These results are in line with the view that decarbonizing an economy with a large industry sector is likely to be challenging since one must address emissions not only from heat, power and transport but also from complex, energy-intensive, high-emission industrial processes. In this regard, the decarbonization of industry-heavy economies will require large amounts of transformative capital and access to low-emission technologies along with associated infrastructure, such as low emission power, hydrogen and carbon storage.

Ultimately, the path is still long for all industries, and not only the hard-to-abate sectors, as they look to implement decarbonization strategies. In the IEA Net Zero by 2050 roadmap, while global emissions are expected to drop by 81% between 2020 and 2040, industrial emissions are only expected to decrease by 58%, which would account for half of 2040 emissions.[144] G20 countries, which are likely to have considerably more resources at hand than other nations, are often considered to have a greater opportunity to lead in the emergence and diffusion of zero and low-emission solutions for global industries.[145] This aligns with the priorities set during the 16th G20 summit, held in October 2021 in Rome. The summit resulted in a number of agreements on climate change, such as maintaining the "goal of limiting global warming to 1.5°C compared to pre-industrial levels within reach" and to "accelerate actions towards achieving global net-zero GHG emissions or carbon neutrality by or around mid-century".[146]

Nevertheless, a reflection on the challenges ahead for industrial decarbonization and the significant effects of high-impact events such as the COVID-19 pandemic indicates more than ever that international cooperation must be a key factor to accelerate industrial decarbonization. The reference to G20 countries by no means suggests that other countries outside the G20 are not needed to lead transition initiatives around industry. They are in fact essential to positively impact the progress of the transition, especially as emerging markets and developing economies are expected to see the biggest increase in energy growth through 2050.[147]

To enable global industrial decarbonization, international cooperation needs to be strengthened through technological transfers and financing support to economies in need. The G20 countries have focused on the theme, *Recover Together, Recover Stronger*, recognizing the importance of collective action and inclusive collaboration between major developed countries and emerging economies around the world, and encouraging all countries to work together to achieve an accelerated and more sustainable recovery.[148]

Accelerating the energy transition is the only option

by Arifin Tasrif, Minister of Energy and Mineral Resources of Indonesia

The latest Intergovernmental Panel on Climate Change report indicates that global CO_2 emissions continue to rise and have reached an unprecedented level, creating more severe impacts on humanity. As the key factor of enhancing ambitions to confront this situation, the acceleration of energy transitions is a must.

Moreover, in the acceleration towards sustainable energy transitions, we need to embed just transitions. As addressed in the 2030 Agenda for Sustainable Development, particularly Sustainable Development Goal (SDG7), we must ensure universal energy access while implementing energy transitions, in order to *leave no one behind*. In this light, the critical challenges of energy transitions should be revisited.

First, countries have their unique challenges and needs in transitioning their energy systems. The existing energy structures and systems, from infrastructure to the established organizational systems, should be continuously transformed and readjusted to respond to global challenges and support the process of energy transitions.

Second, just energy transitions will require significant financing. This challenge has been exacerbated by the effects of the COVID-19 pandemic, as around 150 million people have been pushed below the poverty line. Countries tend not to disadvantage the socio-economic burdens of their people, and measures are necessary to mitigate the disproportionate impacts on vulnerable communities.

Third, just energy transitions will require changing and shifting technologies, jobs and other economic opportunities. New skills, capacities and expertise should be developed domestically to support the availability, affordability and reliability of sustainable energy, pertaining to the broader public interests. A just energy transition will create new opportunities such as jobs and other prospects and will support global recovery.

In this context, the IEA recommends four clusters for "people-centred energy transitions": decent jobs and workers' protection; social and economic development; equity, social inclusion and fairness; and people as active participants. We must underline these clusters to set a benchmark to prepare towards the current and future challenges of global energy transitions.

In the acceleration of energy transitions, innovations should be continuously explored and financed to support expansion. This scale-up relates to *industrial decarbonization*, which is well addressed in this Forum report. The focus truly reveals the great challenges we are facing in enhancing emission reductions.

Decarbonizing the hard-to-abate industries will require not only new and more reliable technologies but also companies to transform entire production processes. The challenges are more evident in the contexts of emerging economies and developing countries, which need to finance and support industries for socio-economic goals while improving sustainability. Industries and energy transitions involve multi-SDGs goals on industries and infrastructures, sustainable energy, decent jobs, climate actions and other related goals.

Reflecting these significant challenges, international cooperation must become the key factor to enable industrial decarbonization. Highlighting the G20 figures, the G20 countries hold 80% of global industrial output. The landscape of the G20 is divided between the countries of the Global North and Global South. The importance of common but differentiated responsibilities, the principle of international environmental law, will contribute to enhancing just energy transitions. International cooperation needs to be strengthened with technological transfers and financing support to emerging economies.

In this context, the G20 2022 Indonesian Presidency is keen to promote the three pillars that the Presidency considers most relevant to our current global challenges: global health architecture, digital economic transformation and energy transitions. These pillars are expected to actualize the Presidency's main theme, *Recover Together, Recover Stronger*, which international communities are currently working towards. The energy transitions pillar aims to strengthen just energy transitions and accelerate their pace, by collecting initiatives to prepare the pathways towards the acceleration. The forum on energy transitions sets three main priorities: access, technology and financing. In the priority area on technology, we seek to address issues pertinent to industrial decarbonization, such as the integration of renewables, expansion of the widest variety of technologies, energy efficiency, and the development of greener and cleaner industry.

While having no option but to accelerate energy transitions, no single stakeholder can cope with these transformational stages alone. This Presidency year will become the opportunity to attract additional green investments, engaging multistakeholders, international partners and global forums.

2.2 Net-zero choke points: A call for multistakeholder collaboration

Heavy industry companies increasingly face implementation choke points whose solutions are seldom found within a single firm or even industry.

Heavy industries are likely to be the last frontier of decarbonization. In response, an increasing number of heavy industry companies are establishing net-zero targets and strategies. For example, the Global Cement and Concrete Association (GCCA), which represents over 40 leading cement companies, has announced the production of net-zero concrete by 2050.[149]

The momentum is growing across industrial companies and sectoral players such as business alliances, but also across a larger ecosystem of stakeholders, from governments to international organizations and non-governmental organizations (NGOs). For example, the Mission Possible Partnership (MPP) has outlined roadmaps for four hard-to-abate industrial sectors (concrete, steel, aluminium, chemicals) to reach net zero.[150]

While pledges and roadmaps are essential to jump-start the net-zero transformation and to provide a long-term vision, tackling the implementation challenges faced by companies is critical to progress at the necessary pace. Ten challenges have been identified as "choke points", or barriers, that will limit the transition unless solutions are found outside of business-as-usual improvements:

1. **Breakthrough technologies**: Most technologies to decarbonize heavy industry sectors are either yet to be proven at scale or expensive compared to current alternatives (e.g. +15-40% for low-emission steel,[151] +50-85% for low-emission cement,[152] +10-100% for low-emission ammonia[153]). Solutions must be found to accelerate the technology readiness levels (scale and cost) of "clean" production processes.[154]

2. **Infrastructure access**: Many net-zero compatible technologies considered by heavy industries involve low-emission hydrogen (e.g. for direct reduced iron in steelmaking[155]), renewable power (e.g. for mechanical vapour recompression in aluminium-making[156]) or carbon capture, utilization and storage (e.g. cement plants[157]). Solutions must be found to provide the infrastructure required for supplying these energy sources and handling captured CO_2.

3. **Demand for low-emission products**: Today, low-emission products in heavy industries require a high selling price for producers to maintain economic margin structures. Solutions must be found to generate reliable demand-side signals and provide visibility on offtake to reduce risks for first movers.

4. **Policies and regulations enablement**: Public incentives, including direct or indirect carbon pricing, subsidies or tax breaks, product use specifications or technology mandates, strongly influence the business case for low-emission investments in heavy industries. Solutions must be found to align public-private objectives

while also ensuring efficiency and a just transformation; lessons exist from the growth of wind and solar energies.

5. **Scaling capital**: Heavy industries' low-emission pilot projects require significant capital expenditure while offering less certain or immediate returns than other assets. Solutions must be found to attract capital for investments in necessary higher risk, subeconomic projects that could demonstrate commercial scale feasibility – not only in advanced economies but also in emerging and developing economies where capital markets are less developed and the cost of capital is higher.

6. **Transition capability building**: The transformation requires heavy industry firms to integrate new, often very different, capabilities. Just and sustainable solutions must be found to rapidly upskill or reskill companies' management and workforces to align expertise with new strategies and activities.

7. **Carbon measurement and management**: Measuring, monitoring or forecasting emissions different in nature and scope is complex for heavy industry firms with myriad industrial processes. Solutions must be found to help companies establish standardized transparency for effective action.

8. **Supply chain circularity**: Primary production generates many times the emissions of secondary/recycled production (e.g. 4 times for steel,[158] 30 times for aluminium[159]). Solutions must be found to adapt companies' business models and production processes to circularity.

9. **Scope 3 abatement**: Scope 3 emissions[160] (e.g. estimated at around 80% of all oil and gas emissions[161] and 30% of ammonia emissions[162]) are particularly hard to measure and address. Solutions must be found to create end-to-end transparency and effective abatement solutions with suppliers and customers.

10. **Residual emissions offsetting**: For heavy industries, reaching the net-zero end goal will require substantial investments in GHG avoidance or removal projects to address residual emissions. Solutions must be found to accelerate the provision of quality offset solutions at scale in a transparent and impact-driven manner.

Among these choke points, technology, financing and policies are typically already at the forefront of companies' and governments' net-zero strategies. However, in addition, it is critical to boost demand-side initiatives such as the First Movers Coalition[163] and the Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI)[164] to create a strong "clean demand" pull (e.g. visibility on offtake volumes, acceptance of green premiums, etc.) for low-emission products. Demand-side initiatives can be a game changer for sectors where low-emission technologies already exist but investments lag, such as steel and ammonia. Today, such initiatives are scarce, and global, synchronized efforts are needed to replicate and scale them and channel much larger investments into low-emission techologies and production assets.

First Movers Coalition

by John Kerry, US Special Presidential Envoy for Climate

The urgency of the climate crisis and its existential threat to the planet require an all-hands-on-deck approach. In concert with ambitious government policies, private sector leadership that recognizes and seizes the enormous opportunities in this transition is critical for the world to swiftly reach net-zero emissions. The highest-leverage climate action that companies can take is to dramatically accelerate the energy transition in the sectors of the global economy that urgently need clean solutions to reach commercial scale.

That's why last year at the COP26 meeting in Glasgow, President Biden and the World Economic Forum launched the First Movers Coalition. Leading global companies are sending the biggest demand signal in history for technology innovation across the so-called "hard-to-abate" sectors. These sectors, which include heavy industry and long-distance transportation, already represent a third of global carbon emissions today and could produce a majority by mid-century.

These companies recognize that joining the First Movers Coalition represented a dual opportunity to take action on climate and seize competitive advantage at the same time. Thirty-five companies, representing $6 trillion in market value, made ambitious pledges across steel, aviation, trucking and shipping. These are precise purchasing commitments that will help bring emerging clean technologies to market by 2030. By creating early market demand for these technologies, companies can secure access ahead of their competitors to clean supply chains and next generation technology.

The technology successes that shape the modern world inspired the approach of the First Movers Coalition. NASA's commitment to purchase next generation spacecraft fuelled the innovations that made private commercial space flight possible. Similarly, purchasing commitments by governments and non-governmental actors alike accelerated the introduction of life-saving COVID-19 vaccines. The First Movers Coalition is bringing that strategy to the hard-to-abate sectors of the energy transition.

The Founding Members of the First Movers Coalition are already catalysing technology innovation, from announcing purchase orders for new zero-carbon ships to buying electric heavy-duty trucks.

For example, First Movers Coalition steel commitment companies pledged that by 2030, 10% of new purchases will be green steel produced with virtually no carbon emissions. Only one Swedish plant currently produces zero-emissions steel today, using green hydrogen instead of fossil fuels. Now, major automakers and energy developers are ensuring investors and innovators can rely on this demand signal to build additional clean steel plants, knowing they will have ready buyers for their output.

That innovation is badly needed. In aviation, for example, by 2030 the companies that make the First Movers Coalition aviation commitment will displace 5% of their conventional fuel with technologies and fuels that reduce carbon emissions by 85%. This is unprecedented in the aviation sector, encouraging innovators to scale promising approaches spanning clean synthetic fuels, next-generation biofuels and zero-emission propulsion. Bringing these new technologies to market in this decade is absolutely critical to driving down the sector's emissions towards zero.

The companies that have joined the First Movers Coalition recognize that there may initially be a premium cost for these emerging technologies. But they also recognize that creating early markets to scale up breakthrough technologies is by far the most cost-effective way for companies to speed the global energy transition. Companies need only devote a small fraction of their total purchasing power to make a critical First Movers Coalition demand commitment. As these technologies gain a market foothold, their costs will plummet, erasing the green premium and paving the way for massive global technology deployment.

Though they may be first, the companies that join the First Movers Coalition aren't alone. President Biden's administration is committed to helping reach these ambitious technology goals through a whole-of-government strategy. Earlier this year, the President announced that the Departments of State, Energy and Commerce, as well as the U.S. International Development Finance Corporation, are all pursuing initiatives to partner with the First Movers Coalition. President Biden's Bipartisan Infrastructure Law will invest tens of billions of dollars in supplying the clean technologies that companies have committed to buy, and departments such as the Energy Department's Loan Programs Office are looking to invest further billions of dollars in clean technology projects in hard-to-abate sectors. Outside of the government, First Movers Coalition companies benefit from close collaboration with Bill Gates' Breakthrough Energy Catalyst, the primary implementation partner of the First Movers Coalition, as well as the World Economic Forum, the Mission Possible Partnership, and many other organizations.

This is a remarkable period of clean technology innovation. In 2021, climate technologies raised a record $147 billion in funding from venture capitalists, corporations and institutional investors. Public policy and private investment are aligning to speed the development of critical technology solutions. Companies that join the First Movers Coalition can seize the opportunity to ride this wave, demonstrate climate leadership and secure early access to the clean supply chains of the future.

Furthermore, it is worth noting that the transition capability building choke point underpins all other choke points as well as the progress rate of the energy transition across all economic sectors. The transformation of the global economy towards net zero is strongly challenging the boundaries of companies' capability and expertise. This is particularly evident when decarbonization pathways require companies to shift towards completely new production processes (e.g. from steam methane reforming to electrolysis to make ammonia). A scenario from the International Labour Organization estimates that 25 million new jobs will be created from the energy transition by 2030.[165] Preparing the current workforce and the new generation for these jobs essential to the transition will require "education and training strategies; active labour market measures to provide adequate employment services; retraining and recertification together with social protection to assist workers and communities dependent on fossil fuels", among other solutions.[166] This reconfiguration of the workforce also provides a unique opportunity for companies to improve inclusion and diversity, creating a more equal and resilient economy.

GUEST PERSPECTIVE

Enabling the energy transition and reaching net-zero: The talent imperative
by Julie Sweet, Chair and Chief Executive Officer, Accenture

Across industries, every business must be a sustainable business, both because it is the right thing to do and because it is a source of competitive advantage. To become truly sustainable, every part of every business must find solutions to decarbonize. Innovation and digital transformation are essential, but even the best technology will not lead to our ambition without the right people.

As things stand, we risk failing to meet key climate targets due to skills shortages. Globally, the talent shortage exceeded 40 million skilled workers at the end of 2020, according to US Labor Statistics. By 2030, organizations worldwide could lose $8.4 trillion in revenue directly because of the lack of skilled talent. The talent shortage has deep implications for the energy transition and delivering on our net-zero commitments. The skills in short supply are those required to meet the complex challenges of building a circular economy, decarbonizing hard-to-abate industries and scaling sustainable fuels. It is time to close the gap.

As companies, we need to redefine our relationship with talent and move from being talent consumers to talent creators. This requires taking action now to deliver two mindset shifts.

First, we need to focus on skills, not roles. This is something we are doing at Accenture and for our global clients. For example, in early 2020, we knew we needed more people with cloud skills because the pandemic accelerated our clients' need to move to cloud. We used AI algorithms against our skills database to identify the right people and then upskilled 100,000 people in six months, empowering our people with opportunity for growth while also addressing complex client needs.

The second mindset shift is to think about people's potential to lead. The energy transition requires strong leaders who actively embrace net-zero ambitions and act to embed sustainability across every area of the business. When I think about who we will need to meet our sustainability objectives, I think of Accenture's eight leadership essentials; the first is to always do the right thing, and the eighth is to commit to active innovation both inside and outside of Accenture. We are continuously redesigning Accenture to build the leadership behaviours required for the energy transition.

This is incredibly important as we move to deliver on net-zero goals because none of us can make a big enough impact – on carbon reduction, equality and equity, or anything else – working alone. We need to partner across industries, and with governments, non-profits and communities, to create lasting change. We need to move beyond partnering on projects and think about partnering for purpose, sharing everything from data to talent.

It is our responsibility – and our privilege – as leaders to help advance sustainability by partnering with and creating a talented global workforce with the skills and leadership mindset to move at speed and scale.

The answers and emerging solutions to industry net-zero transformation choke points are rarely found within a single firm or even industry. To solve these challenges, heavy industry companies will need to explore new forms of collaboration. The MPP net-zero roadmaps clearly show where industries need to be by 2030 (e.g. over 70 commercial-scale low-emission steel plants producing 240 MT by 2030) and also highlight that closing the gap will require an unprecedented level of collaboration.[167] Thankfully, heavy industry companies, suppliers, customers, peers from other industries, other businesses, governments, civil society and many other stakeholders recognize the need to reduce global emissions, including their own carbon footprint. This shared challenge creates common interests across organizations and establishes a robust platform for multistakeholder collaboration towards net zero.

The following section lays out how a new generation of collaboration models combined with a step change in ambition level can address the net-zero transformation choke points for heavy industries.

2.3 Clearing the path to net zero with "next generation" partnerships

The "next generation" of ambitious multistakeholder collaborations between suppliers and customers, between industry and cross-industry peers, and between the wider industrial ecosystem of stakeholders can overcome decarbonization choke points and accelerate the industrial transformation towards net zero. However, action is needed now to keep the net-zero by 2050 goal within reach.

A new generation of multistakeholder collaborations focused on decarbonization and net-zero objectives has gained momentum since 2015. These "next generation" collaborations differ from past partnerships due to a step change in ambition level, greater focus on emission reductions, new types of partners and new areas of emphasis. The sense of urgency combined with the steepness of the net-zero pathways have led leaders from both the public and private sectors to view collaborations as a key transition catalyst. Leaders now favour collaboration and transparency over competition, and increasingly consider decarbonization as a win-win solution that does not necessarily entail extra costs.

Three archetypes of collaboration have emerged: collaboration between customers and suppliers, collaboration between industry and cross-industry peers, and collaboration between the wider ecosystem of stakeholders (Figure 13). The following section outlines the rationale, benefits and collaboration models under each archetype, and offers more than 35 examples. Such initiatives are critical to pave the way for similar partnerships in other geographies and industries, and to inspire leaders worldwide to move quickly from pilots to a pipeline of commercial-scale projects by 2030.

FIGURE 13 **Three archetypes of collaboration to accelerate the net-zero transformation of industries**

Source: World Economic Forum and Accenture

Cross-sectoral collaboration is essential for industrial decarbonization

by Jan Jenisch, Chief Executive Officer, Holcim

Given the scale of today's net-zero challenges, no single organization or industrial sector can tackle decarbonization alone. We need close collaboration: between government and industry as well as along our entire value chain.

Government and industry must work as partners to make sure the business case of short- and long-term investments in industrial decarbonization is sound.

At Holcim, we are seeing this collaboration take shape in the deployment of next generation technologies, such as carbon capture, use and storage (CCUS). We are exploring the potential use of CCUS technologies in over 30 pilot projects worldwide, from repurposing CO_2 from our plants for use in vertical farming, all the way to alternative fuel for aviation, thereby also creating new growth opportunities for the company.

To help deploy these technologies at scale, a number of our CCUS projects are receiving public support today, from entities such as the US Department of Energy to Germany's Federal Ministry of Economic Affairs and Energy. Further public-private collaboration is essential to ensure abundant and clean energy to power CCUS, the recognition of technologies such as co-processing that significantly eliminate the use of fossil fuels, enabling the circular economy through effective waste management, and efficient carbon pricing mechanisms.

Moreover, actors from all sectors must collaborate to strengthen market demand for low-carbon and circular solutions across the industrial value chain. As a global leader in innovative and sustainable building solutions, Holcim is playing a central role to decarbonize this sector. This includes reducing Scope 3 emissions from the transport of our materials through optimizing routes, loads, moving load from road to waterways and rail, and replacing diesel with eco-friendly fuels in fleets.

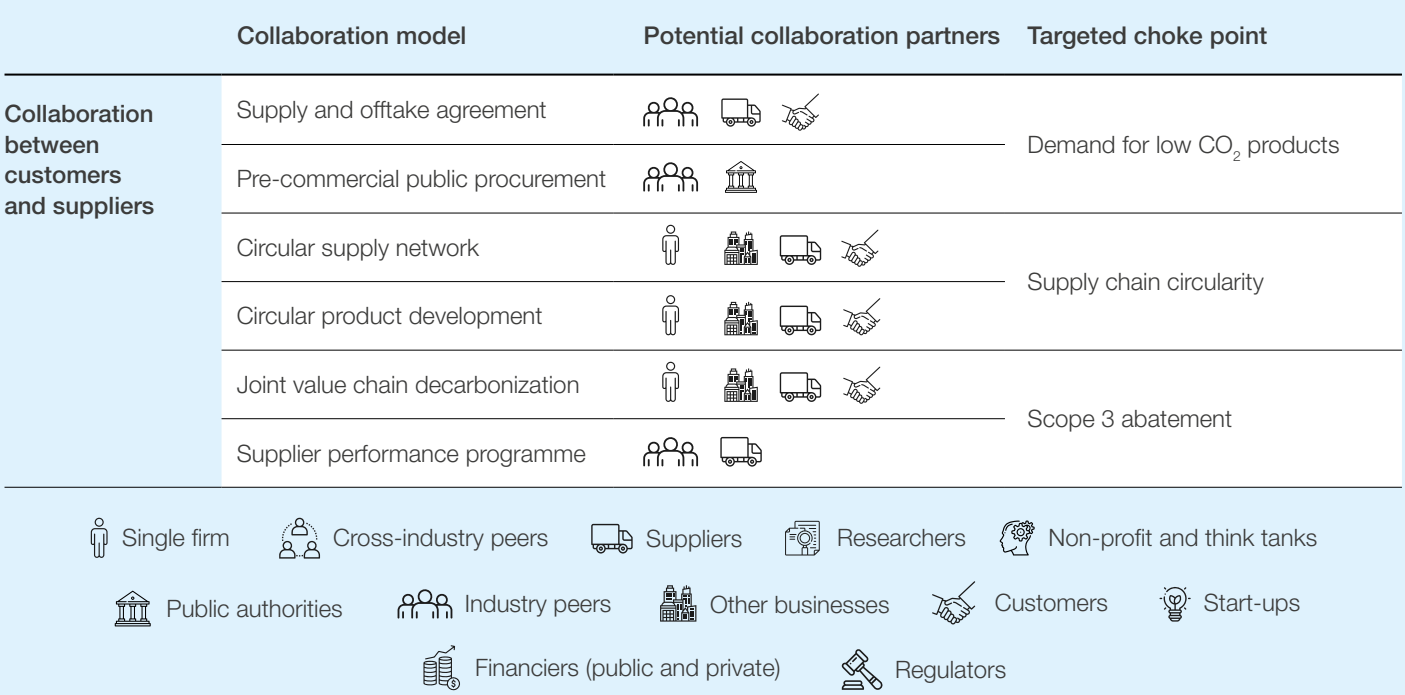
As a founding member of the First Movers Coalition (FMC), we are ambitious to drive more green demand and low-carbon technologies to advance our world's climate goals. On the green procurement side, we commit to FMC's trucking ambition of reaching 30% of zero-emission heavy-duty truck purchases or contracts by 2030. On the supply side, we will continue to scale up our green building solutions and next generation technologies for net-zero construction, building on Holcim's industry-first 2050 net-zero goals, validated by the Science Based Targets initiative.

Leading by example, we hope to inspire the virtuous cycle of collaboration and partnership that is necessary to reach net-zero in our industry. There is no other way forward.

2.4 Net-zero collaboration between customers and suppliers

Value chain emissions are increasingly being scrutinized by progressive climate-conscious end consumers, particularly the younger generations. A recent survey[168] found that 73% of Gen Z consumers (21-25-year-olds) are willing to pay more than every other generation for sustainable products. Reducing direct emissions within an industry will impact the indirect emissions of suppliers and customers (Scope 2 or Scope 3 emissions), and vice versa. This common ground strongly encourages new collaborations between heavy industries and value chain stakeholders.

FIGURE 14 **Collaboration model types between customers and suppliers**



Source: World Economic Forum and Accenture

Collaboration with customers through offtake agreements or pre-commercial public procurement (Figure 14) can provide heavy industry companies with the visibility they need for investments in low-emission solutions (public procurement accounts for 46% of US cement consumption[169]). Customers in return can secure the supply of low-emission products, which will initially be scarce.

In addition, heavy industries can reduce their emissions by increasing the proportion of recycled versus primary feedstock and material – what is now referred to as the "circular economy". Collaboration with suppliers and customers through the development of circular supply networks or circular product development can support that objective. Suppliers can engage in new value-added activities (e.g. high-resolution waste sorting) and customers can benefit from lower emission products.

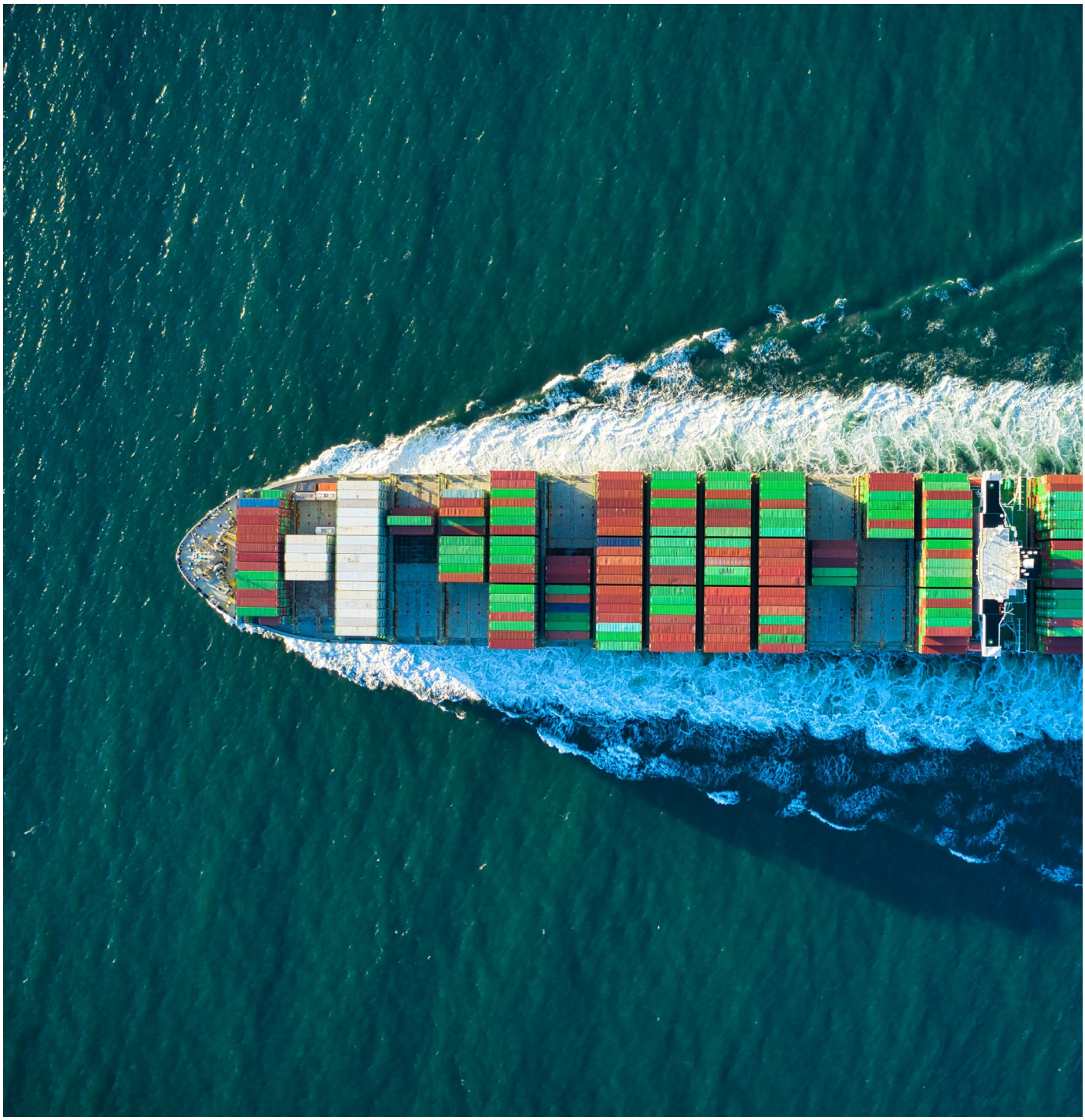
Heavy industries are increasingly engaging to limit their Scope 3 emissions (estimated at 80% of total oil and gas CO_2 equivalent emissions,[170] 20% of steel emissions[171] and 20% of cement emissions[172]), which are driven by companies' upstream and downstream value chain activities. Collaboration with suppliers and customers through shared value chain decarbonization initiatives or supplier performance programmes can help tackle these emissions. Suppliers can benefit from visibility on low-emission procurement standards, and customers from the unique engineering and technology expertise of another industry to decarbonize.

TABLE 1 | **Collaboration model examples between customers and suppliers**

Collaboration model	Short description	Example (collaboration names in bold, when available)
Supply and offtake agreement	Suppliers and customers can create long-term visibility on low-emission product offtake and delivery for each other	The **First Movers Coalition**[173] is a platform of over 35 companies enabled by the US State Department and the World Economic Forum. The Coalition was created through a partnership between the US State Department's US Special Presidential Envoy for Climate and the Office of Global Partnerships, and the World Economic Forum, in collaboration with the US Departments of Commerce and Energy. The coalition advocates for companies to harness their purchasing power and supply chains to commit to long-term demand and supply, creating early markets for clean energy technologies to be accessible and scalable, and to bring down costs.
		SSAB teamed up with Volvo to unveil the world's first truck made from 100% fossil-free steel. More vehicles are expected to follow in 2022 in a drive for Volvo to achieve net-zero value chain GHG emissions by 2040.[174]
Pre-commercial public procurement	Public buyers can pre-purchase low-emission products before they are made to provide the necessary visibility for suppliers to invest	**The Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI)**[175] is a global coalition of public and private organizations committing to the purchase of low-carbon materials, particularly steel and cement. Coordinated by the United Nations Industrial Development Organization, the initiative brings together heavy industries and multilateral organizations, such as the Mission Possible Partnership, LeadIT, IRENA and the World Bank, as well as public entities, such as the Governments of the United Kingdom, India, Germany, Canada and United Arab Emirates.
Circular supply network	Suppliers and customers can establish circular supply networks to maximize the reuse and recycling of materials from one another in a near closed loop	Centro Rottami is supplying recycled aluminium to Indinvest's Italian foundry. Enabled by TOMRA's aluminium scrap sorting technologies, the partnership guarantees a constant supply of high purity aluminium (85% recycled content billet), essential to establishing trust with foundries. This collaboration contributes to Italy's rank of first in Europe for recycled aluminium production, achieving 70% recovery.[176]
		Novelis has implemented closed-loop systems with major automakers, including Volvo, Ford, Jaguar and Land Rover, working together to take back the car manufacturers' aluminium scrap and transforming it into the same high-quality products indefinitely. Novelis increased the amount of overall recycled aluminium in its products from 33% in 2010 to over 61% in 2019.[177]
Circular product development	Suppliers and customers can redesign end products together to maximize recycled content	The **EOCENE industrial research project**,[178] a consortium with Kimitec, Cosentino, Acciona, Omar Coatings, Aerotecnic, Reciclalia and SUEZ, aims to adopt a circular economy in the composites industry by creating a new generation of highly sustainable thermostable composites, procuring all components (resin, fillers, fibres) from renewable sources and developing sustainable technologies for controlled recycling processes and revaluation of waste at the end of its life cycle.
		Tata Steel and Bouwen met Staal (the Netherlands' national organization for the promotion, knowledge transfer and research of steel in construction) have collaborated on a project at Amsterdam's Schiphol Airport to demonstrate the reuse of steel in construction. They adopted building practices that promote high reuse rates of between 20% and 40%, reducing the environmental footprint of the steel used in the airport building by 18% to 36%.[179]
Joint value chain decarbonization	Suppliers and customers can leverage their respective capabilities and expertise to help each other decarbonize	Shell leverages its leading capability in system level modelling (used internally for years to deconstruct Shell plants and processes) to help Dalmia Cement, one of its customers and a leading Indian cement manufacturer, find pathways to decarbonize.[180]
		bp and CEMEX agreed "to develop solutions to decarbonize the cement production process and transportation". These solutions "include low-carbon power, low-carbon transport, energy efficiency, natural carbon offsets, and carbon capture utilization and storage technologies".[181]

TABLE 1 | **Collaboration model examples between customers and suppliers (continued)**

Collaboration model	Short description	Example (collaboration names in bold, when available)
Supplier performance programme	Suppliers and customers can co-design low-emission procurement standards and co-develop roadmaps to achieve new targets over time	Dow is directly engaging with suppliers to request climate-related information via the Carbon Disclosure Project (CDP) supply chain programme's platform.[182] The goal is to support suppliers in environmental reporting to track climate impacts and support the identification of collaborative decarbonization opportunities.
		With building and construction processes in Sweden estimated to generate around 10 MT CO_2e per year, the Swedish Transport Administration has set a target to reach close to net-zero carbon emissions from road construction by 2045. It is reinforcing carbon reduction requirements in the procurement of major project construction, materials used and future maintenance.[183]



2.5 Net-zero collaboration between industry and cross-industry peers

Across heavy industries, companies face increasing pressure from governments, investors and society to decarbonize. This common ground strongly encourages new collaboration between peers within and across industries, particularly to address common needs in terms of capability, energy, infrastructure and capital.

FIGURE 15 **Collaboration model types between industry and cross-industry peers**

	Collaboration model	Potential collaboration partners	Targeted choke point
Collaboration between industry and cross-industry peers	Shared infrastructure development		Infrastructure access
	Industrial cluster infrastructure planning		
	Shared commercial projects		Scaling capital
	Cross-industry funding		
	Knowledge sharing		Transition capability building
	Reskilling the workforce		

Single firm · Cross-industry peers · Suppliers · Researchers · Non-profit and think tanks · Public authorities · Industry peers · Other businesses · Customers · Start-ups · Financiers (public and private) · Regulators

Source: World Economic Forum and Accenture

The transition of heavy industries is a new and fast-changing domain in which deep expertise is scarce but critical. Collaboration with peers through knowledge sharing initiatives, either forward-looking (e.g. net-zero roadmaps) or focused on existing technologies (e.g. methane management), or through upskilling/reskilling programmes for management and employees, can close a number of knowledge gaps while building the workforce of the future (Figure 15).

Heavy industry companies also typically require large amounts of capital to deploy their own or third-parties' promising technology at scale. Collaboration with industry or cross-industry peers through shared commercial projects/ventures or cross-industry funding can bridge capital gaps, reduce risks and overcome financiers' reluctance to invest in subeconomic or lower-return projects that are important to break new ground on the path to net zero.

Many solutions to decarbonize heavy industries involve the adoption of technologies[184] based on electrification, low-emission hydrogen, low-emission power, or carbon capture, utilization and storage, all requiring extensive infrastructure. Collaboration with industry and cross-industry peers through shared infrastructure planning and development can ensure that companies deploying new technologies will not be constrained by the lack of enabling infrastructure.

TABLE 2 | **Collaboration model examples between industry and cross-industry peers**

Collaboration model	Short description	Example (collaboration names in bold, when available)
Shared infrastructure development	Peers within and across industries can join forces to develop shared infrastructure at lower risk and cost	**Longship**,[185] a partnership project between the Norwegian state, Gassnova, HeidelbergCement, Fortum Oslo Varme (waste-to-energy plant) and Northern Lights JV (Equinor, Shell, TotalEnergies) aims to develop the first-ever full-scale cross-border carbon capture and storage value chain for industries to transport CO_2 from capture sites across Europe to a terminal in Norway for storage, before transporting for permanent storage in the North Sea.
Industrial cluster infrastructure planning	Cross-industry peers and public authorities can jointly plan infrastructure development for industrial clusters to realize synergies and ensure all parties' needs are met	The **Kwinana Industrial Area (KIA)**[186] is the largest industrial cluster in Western Australia and exemplifies industrial symbiosis with more than 150 products, by-products and utilities exchanged between facilities in the region. KIA produces industrial, agricultural and mining chemicals and refined materials for national and international markets. bp recently repurposed its Kwinana Refining site as an integrated energy hub that produces and distributes fuel for the future, such as the production of green hydrogen.
		Eight private-sector organizations are working on concrete solutions to achieve carbon neutrality by 2040 in the largest CO_2 emitting industrial cluster in the UK, **the Humber Industrial Cluster**.[187] The plan includes early projects aimed at accelerating industrial carbon capture and green/blue hydrogen production, such as Phillips 66 progressing Gigastack, a green hydrogen project that along with ITM Power, Ørsted and Element Energy seeks to produce green hydrogen and electricity from nearby offshore wind and electrolysis.[188]
Shared commercial projects	By merging a large set of different expertise, joint commercial ventures can create synergies and reduce risks and costs	**HYBRIT**[189] (Hydrogen Breakthrough Ironmaking Technology) is a collaboration between three mining, steel manufacturing and electricity companies – LKAB, SSAB and Vattenfall – to create the world's first fossil-free steel. "The HYBRIT technology involves replacing the blast furnace process, which uses carbon and coke to remove the oxygen from iron ore, with a direct reduction process using fossil-free hydrogen produced from water using electricity from fossil-free energy sources."[190]
		Holcim expands carbon capture projects through a consortium with Svante, Oxy Low Carbon Ventures and TotalEnergies.[191] The partnership has completed a "study to assess the viability and design of a commercial-scale carbon-capture facility at the Holcim Portland Cement Plant" in the United States.[192] With the confirmation of funding from the US Department of Energy, "the partnership has committed to the next project phase to evaluate the feasibility of the facility designed to capture up to two million tons of CO_2 per year".[193] Looking forward, Holcim continues to expand its carbon capture portfolio through new partnerships, such as recently signing an agreement with Eni for the utilization of CO_2.
Cross-industry funding	Collaborative funding can help industries meet the large demand for capital, while allowing them proximity to breakthrough innovation	TotalEnergies, Air Liquide and VINCI "are combining forces with other large international companies to sponsor the creation of the world's largest fund exclusively dedicated to clean hydrogen infrastructure solutions. The **Clean Hydrogen Infrastructure Fund** aims to reach €1.5 billion and has already secured initial commitments of €800 million. Its objective is to accelerate the growth of the clean hydrogen ecosystem by investing in large strategic projects and leveraging the alliance of industrial and financial players" to do so.[194]
		Clean Steel Partnership[195] was established in 2021 by the European Commission and the European Steel Technology Platform on behalf of the entire European steel value chain for the sustainable production of clean steel. The public-private partnership aims to facilitate the reduction of CO_2 emissions from steel production through the funding of research, development and innovation projects. The partnership will invest to develop the technologies necessary for industrial deployment.

Collaboration model	Short description	Example (collaboration names in bold, when available)
Knowledge sharing	Knowledge sharing can be relevant between peers sharing similar strategic or operational decarbonization challenges	The **Mission Possible Partnership (MPP)**[196] is an alliance comprised of the Energy Transitions Commission, Rocky Mountain Institute (RMI), We Mean Business Coalition and the World Economic Forum focused on supporting the decarbonization of the world's highest-emitting industries: the hard-to-abate sectors (steel, cement, chemicals, aluminium, shipping, tracking and aviation). The MPP has released sector-specific net-zero roadmaps, providing powerful and tangible examples of clear targets and strategies to keep the 1.5°C target alive with leading companies and business alliances.
		The **Global Methane Initiative (GMI)**[197] is an "international public-private partnership focused on reducing barriers to the recovery and use of methane as a valuable energy source. GMI provides technical support to deploy methane-to-energy projects around the world … and advances methane mitigation in three key sectors: oil and gas, biogas, and coal mines".[198] GMI partner countries account for approximately 70% of global man-made methane emissions.
		Ten major chemical sector companies around the world – BASF, Dow, DSM, Solvay, Clariant, Covestro, Mitsubishi Chemical, Air Liquide, SABIC and SIBUR – in partnership with the World Economic Forum have established the **Low-Carbon Emitting Technologies (LCET)**[199] initiative, a breakthrough, pre-competitive knowledge sharing development platform and implementation vehicle to accelerate net-zero climate technologies in the chemicals industry.
		The **Carbon Pricing Leadership Coalition**[200] promotes the successful implementation of carbon pricing globally by bringing together leaders from government, business, civil society and academia to strengthen the development and implementation of carbon pricing policies and enhance the sharing of data, expertise and lessons learned through various "readiness" platforms.
Reskilling the workforce	Partnering with peers, NGOs and knowledge institutions can formalize and accelerate capability building, while fostering a just transition for employees	The World Economic Forum launched the **New Generation Industry Leaders (NGIL)**[201] programme in support of designing and driving a responsible industry transformation, while building excitement about its future frontiers and opportunities for younger generations. The community actively engages in the Forum's work and agenda to share new ideas to transform and champion the industry to younger generations.
		Eni, Red Rock Power and the University of Strathclyde have signed a memorandum of understanding to develop and deliver a workforce transition programme to help professionals working in the Scottish oil and gas sector transfer their skills to renewable energy technologies.[202]

2.6 Net-zero collaboration between wider ecosystem stakeholders

In addition to suppliers, customers and peers, heavy industry companies also interact with a wider network of stakeholders, such as public authorities (e.g. central governments, regional and local authorities), regulators (e.g. policy-makers, industry regulatory agency), financiers (e.g. public investment funds, private funds, banks), researchers (e.g. academics, public or private labs) and NGOs (e.g. specialist NGOs, business alliances, think-tanks). These organizations, classified in this report as "wider ecosystem stakeholders", can also play prominent roles in the net-zero transformation of industries. Public authorities and regulators can be incentivized by national net-zero agendas, financiers by investor pressure to decarbonize portfolios, and researchers and NGOs by mandates to find and support new sustainable solutions. This common ground encourages new collaborations between heavy industry firms and wider ecosystem stakeholders, particularly related to technology, policy and regulation, carbon management and emission offsetting challenges.

FIGURE 16 **Collaboration model types between wider ecosystem stakeholders**

	Collaboration model	Potential collaboration partners	Targeted choke point
Collaboration between wider ecosystem stakeholders	Public-private advocacy and collaboration		Policies and regulations enablement
	Intergovernmental action		
	Integrated research and innovation		Breakthrough technology
	Start-up investment and incubation		
	Emission measurement standardization		Carbon measurement and management
	Emission tracking and management		
	Carbon offset supply		Residual emissions offsetting
	Carbon offset quality		

Single firm · Cross-industry peers · Suppliers · Researchers · Non-profit and think tanks · Public authorities · Industry peers · Other businesses · Customers · Start-ups · Financiers (public and private) · Regulators

Source: World Economic Forum and Accenture

In addition to pushing their own R&D effort, heavy industry companies can collaborate with technology start-ups and research labs through private equity investments, incubation, research grants and joint facilities and teams to accelerate the technology readiness[203] of key solutions.

While not a silver bullet, policies and regulations can drastically improve the transformation business case of an industry and reduce first movers' risk by supporting technology adoption, creating demand and enabling access to capital. Collaboration with public authorities and regulators through public-private advocacy groups can help companies co-design the pace and shape of their journey to net zero (Figure 16).

Moreover, significant emission reductions could be achieved today on many industrial sites, provided companies are equipped with adequate standards, processes and tools to manage emissions. Collaboration with specialist NGOs and technology service companies can help heavy industry firms achieve state-of-the-art emission measurement and monitoring and identify impactful actions with today's available technologies.

Some heavy industry companies can reach zero Scope 1 and 2 emissions by fully electrifying their production processes and using renewable power (e.g. aluminium or ammonia industries). However, where structural long-term options are not available, some producers might rely on offsetting residual emissions to achieve net zero by 2050. Collaboration with specialist NGOs and offset providers can help companies secure the required certified offsets in the long run.

TABLE 3 | **Collaboration model examples between wider ecosystem stakeholders**

Collaboration model	Short description	Example (collaboration names in bold, when available)
Public-private advocacy and collaboration	Firms can join forces to ensure that common objectives, roadmaps and needs are adequately communicated to regulators, so the business environment evolves at a pragmatic and just pace	The **European Clean Hydrogen Alliance** "supports the large-scale deployment of clean hydrogen technologies by 2030 by bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. It aims to promote investment and accelerate the roll-out of clean hydrogen production and use" in line with the EU's climate change objectives to build industrial leadership and accelerate the decarbonization of industry.[204]
		The **Clean Energy Demand Initiative (CEDI),** led by the US Department of State's Bureau of Energy Resources, unites companies and governments to jointly achieve their clean energy goals by leveraging corporate commitments and catalysing investment and policy signals. Corporate demand for clean electricity, through corporate power purchase agreements, have the potential to drive significant investment in renewable energy and help the private sector offset its electricity demand. Thirty-nine companies from major sectors, including technology, manufacturing, retail and health, have signed letters of intent to procure renewable energy to offset their electricity demand.[205]
Intergovernmental action	Close collaboration with governmental entities working with foreign counterparts can help companies anticipate and co-shape change	**Mission Innovation**[206] is "a global initiative of 22 countries and the European Commission to catalyse action and investment in research, development and demonstration to make clean energy affordable, attractive and accessible for all" by 2030.[207] It brings together governments, public authorities, corporates, investors and academics and is the main intergovernmental platform addressing clean energy innovation through action-orientated cooperation that seek to create tipping points in the cost and scale of clean energy solutions in select areas.
		Germany and Namibia have signed a Joint Communique of Intent to establish a **Green Hydrogen Technology Partnership.** The Federal Ministry of Education and Research (BMBF) will fund the identification of suitable sites for green hydrogen production in Africa and The Federal Research Ministry will provide up to 40 million euros in funding to accelerate cooperation within the developed framework.[208]
Integrated research and innovation	Integrated R&D and innovation programmes between industry firms and research organizations can affect the net-zero technological race	The **Massachusetts Institute of Technology (MIT) Climate and Sustainability Consortium** convenes influential industry leaders from a broad range of industries (including, cement and chemicals) to work with MIT to accelerate shared solutions to address climate change.[209]
		As part of Institut Polytechnique de Paris's strategic partnership with TotalEnergies, the institute has "approved the creation of a new centre for innovation and research into carbon-free energy solutions". The newly developed innovation park brings together "private and public research centres, thus nourishing the ecosystem of Institut Polytechnique de Paris and more broadly the science and technology cluster of the Paris-Saclay region".[210]
		The Smart Energy Lab[211] is a green "factory" partnership bringing industries, academics and development partners together (e.g. EDP Comercial, Accenture, Instituto Superior Técnico, Faculdade de Ciências da Lisboa, Universidade de Coimbra, INESC TEC and INESC-ID) for "new or improved products, services or processes that contribute to accelerating energy transition, reducing transaction costs, through technology and user adoption".

Collaboration model	Short description	Example (collaboration names in bold, when available)
Start-up investment and incubation	Investing and incubating promising start-ups can help companies secure early access to the technologies and solutions of the future	The **Oil and Gas Climate Initiative (OGCI)**[212] brings competitors (led by CEOs) together to "accelerate the industry response to climate change". It currently includes 12 member companies, including Saudi Aramco, Eni, bp, Equinor and Petrobras. The OGCI Climate Investments team (with a $1 billion fund) brings industry experience and expertise to co-invest, pilot and deploy new technologies and projects that "accelerate decarbonization in oil and gas, industry and commercial transport", and other sectors. OGCI Climate Investments uses the know-how and global footprint of its members and network to support commercial adoption through pilots and global implementation of investments, to achieve scale at an accelerated pace.
Emission measurement standardization	Working jointly with NGOs and peers can accelerate the development of the necessary emissions standards for each industry	**The Carbon Disclosure Project (CDP)**[213] is a not-for-profit organization that "runs the global emissions disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. The world's economy looks to CDP as the gold standard of environmental reporting with the richest and most comprehensive dataset on corporate and city action".[214]
		Pavilion Energy, QatarEnergy and Chevron jointly launched a GHG "quantification and reporting methodology to produce a statement of GHG emissions for delivered liquefied natural gas (LNG) cargoes". This methodology will be applied to sales and purchase agreements for wide adoption. Overall, "it aims to create a common standard for the measurement, reporting and verification of the GHG emissions associated with producing and delivering an LNG cargo to drive greater transparency and enable stronger action on GHG reduction measures".[215]
Emission tracking and management	Partnering with specialized NGOs and technology service companies helps to bring emission transparency to the required level for effective action	**The Climate TRACE** global coalition[216] aims "to make meaningful climate action faster and easier by independently tracking GHG emissions" across the supply chain of various sectors using "satellite imagery and other forms of remote sensing, artificial intelligence and collective data science expertise … The emissions inventory is the world's first comprehensive accounting of GHG emissions based primarily on direct, independent observation". Currently, over 50 organizations are collaborating across 38 industries and 10 sectors, from power plants and oil refineries to rice cultivation, cement production and shipping.[217]
Carbon offset supply	Partnering early-on with offset suppliers can guarantee long-term supply availability (the carbon offset market is expected to grow from $1 billion today to $550 billion by 2050)[218]	Oxy Low Carbon Ventures (OLCV) partnered with Carbon Engineering to produce renewable fuels in British Columbia by capturing CO_2 from the atmosphere using Direct Air Capture (DAC) and Air to Fuels technologies. The DAC to fuels facility is expected to be the first commercial-scale project of its kind. Overall, Oxy is pioneering the ways to leverage quality offsets, delivering the world's first shipment of carbon-neutral oil to India's Reliance Industries.[219]
Carbon offset certification	Partnering with NGOs specialized in carbon offset certification can ensure companies' permanent carbon removal is achieved with their investments	**Verra**[220] is a global non-profit leader developing and managing standards and frameworks to channel finance towards high-impact environment activities, including carbon offsetting projects.
		Gold Standard[221] is a global non-profit leader that was established by WWF and other international NGOs to "ensure that projects that reduce carbon emissions feature the highest levels of environmental integrity and contribute to sustainable development".[222]

The changes required for heavy industry sectors to reach net zero are vast and will be transformative for these industries. These changes will require not only new models of collaboration, like the ones presented in this report, but also a whole new level of collaboration across all stakeholder groups – a step change in collaborative activity.

Companies will have to enter into new collaboration with their suppliers and customers, with their industry peers and with their wider ecosystem. Indeed, when truly disruptive technologies are created, the risk-taking and commitment required are too great for a company to bear alone. Industry companies' innovative power and longstanding expertise will be key to the decarbonization challenge, but they will need their ecosystem to create the enabling environment, to jump-start demand and to create the financial conditions necessary to support private-sector innovation.

In addition, the boundaries of industries do not stop at national borders. International cooperation, including but not limited to groups like the G20, will be essential to pool risks and to create bigger markets for successful innovation and clean new products. International cooperation will also be needed to remove regulatory barriers, provide credible policy support internationally, and create compatible standards or joint investment declarations. This must not only happen in advanced economies; importantly, emerging and developing economies poised to see the biggest increase in energy demand and GHG emissions are in dire need of investments, technological solutions and infrastructure to transition their energy systems. Collaboration across advanced and developing economies will need to play a key role to achieve this.

These changes cannot and will not happen purely "top-down" through governments' orchestrated target setting or through industries' applying the right solutions independently. Public-private partnerships will be crucial, and the public sector will have an important role to play to provide the foundational capital or financial conditions necessary to encourage private-sector innovation.

In recent years, pioneer companies from the heavy industry sectors and their stakeholders have put great effort into exploring solutions to decarbonization choke points. Thanks to them, many inspiring "next generation" collaboration models already exist today. Other industry players can study, learn from, follow, improve, replicate these models in other geographies or industries, and invent more ambitious cooperation to progress the collective journey to net zero.

3 Conclusion

Recent environmental, macroeconomic and geopolitical events have affected the energy system in multiple ways and highlighted the complexities of the energy transition. In particular, energy market disruptions and subsequent volatility and knock-on effects on the global economy have demonstrated the need for the global energy transition to strike the right balance between energy affordability, security and sustainability. In essence, what is needed is to collectively drive a resilient energy transition that can keep the momentum moving forward in challenging times. Trade-offs between energy affordability, security and sustainability exist today and are expected to continue to evolve. Countries must manage them carefully to keep the transition going.

As the gap between climate pledges and implementation continues to widen, it is essential to accelerate the transition and mitigate the risks of a slowdown. Early signs of the transition's implications on equity and justice indicate the need for robust and well-targeted measures to protect vulnerable populations and businesses against the impact of possible future high energy prices. Additionally, as many countries' energy security concerns grow, it is key to note that the energy transition, which can help diversify energy supply with low-carbon energy sources, can be a source of energy security. Countries can engage in the dual energy supply diversification of import partners in the short term and energy mix in the long term. The energy crisis provides an opportunity to supercharge the transition by increasing clean energy investments at record pace and transforming consumers' energy consumption habits. It is too early to tell, however, whether the world will see a tipping point in the transition, which depends on the collective actions of governments, corporations and consumers.

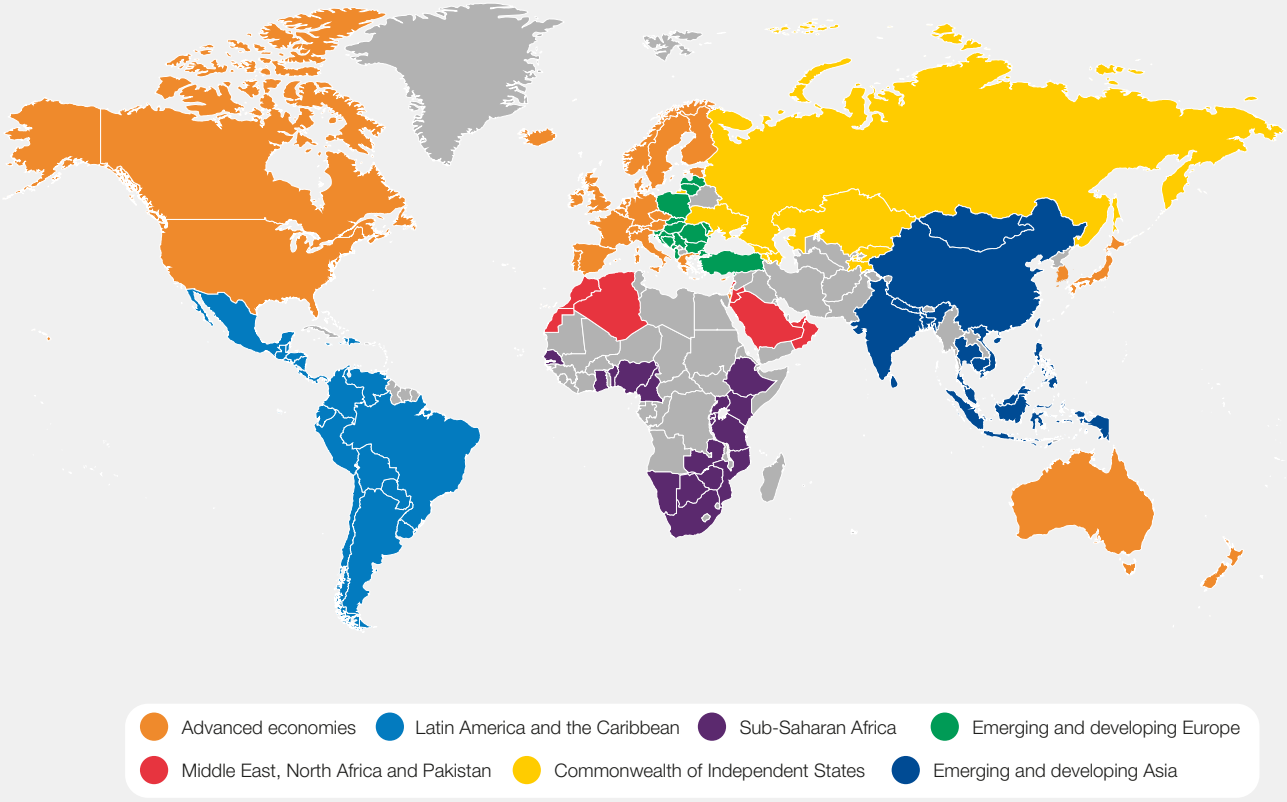
This special 2022 edition stresses the importance of the industrial sector's transformation. This sector represents a significant share of global emissions, faces enormous challenges to decarbonize and is where demand is expected to grow significantly by 2050, partly due to the needs of the transition itself. Stark differences can be observed between countries with largely service-based economies and countries that have maintained relatively large shares of industrial activity. The former typically fare better with their energy transitions as the historical ETI trends reveal. Progress to decarbonize industry will be key in many countries, most notably in the G20 economies, which produce 85% of global industrial output.[223]

However, many industries are still refining their pathways to a low-carbon future and major challenges likely remain, particularly in heavy industries, which face complex decarbonization challenges in multiple areas, including low-emission technology, electrification, access to low-carbon energy infrastructure, demand for low-emission products, enabling policies and regulations, and access to capital, among others. Solutions to industry choke points are seldom found within a single firm or even industry and will require innovative partnerships between customers and suppliers, between industry and cross-industry peers and between the wider ecosystem of industry stakeholders. A step change in collaborative activity could be the key to unlocking the net-zero transformation of industries and keeping the net-zero by 2050 goal within reach.

Advancing the global energy transition at the required pace will depend on the world's ability to intensify, replicate, scale and further improve the collaborative efforts across countries and sectors. Working together will allow us to achieve the structural change necessary to underpin our collective transition journey to 2050 and beyond.

Appendix

Regional peer group classification



Note: The boundaries shown in this map do not imply official acceptance or endorsement by the World Economic Forum.
Source: World Economic Forum

Contributors

ETI data sources

bp Statistical Review of World Energy, Climate Action Tracker, Ember, Enerdata, Energy and Climate Intelligence Unit, Fitch Ratings, Heritage Foundation, International Energy Agency, International Gas Union, International Monetary Fund, International Renewable Energy Agency, Moody's, PBL Netherlands Environmental Assessment Agency, Standard & Poor's, Transparency International, UN SEforALL, UN Statistics Division and UNCTADstat, World Bank Group, World Health Organization, World Trade Organization

Chief expert advisers

The World Economic Forum acknowledges and thanks the individuals and experts without whose support this *Fostering Effective Energy Transition: 2022 edition* would not have been possible:

Morgan Bazilian
Professor of Public Policy, and Director of Payne Institute, Colorado School of Mines, USA

Dominic Emery
Chief of Staff, bp, United Kingdom

Rabia Ferroukhi
Director, Knowledge, Policy and Finance Centre, International Renewable Energy Agency (IRENA), Abu Dhabi

Lin Boqiang
Dean, China Institute for Studies in Energy Policy, Xiamen University, People's Republic of China

Bertrand Magne
Senior Economist and Energy Specialist, International Atomic Energy Agency (IAEA), Vienna

Andrea Mercante
Global Head, Long-Term Strategy, Eni, Italy

Davide Puglielli
Head, Scenario Planning and Group Strategic Positioning, Enel, Italy

John Scott
Head, Sustainability Risk, Zurich Insurance Group, Switzerland

David Victor
Professor, University of California, San Diego (UCSD), USA

Rigoberto Ariel Yepez-Garcia
Chief, Energy Division, Inter-American Development Bank, Washington DC

Project sponsors

Accenture

Muqsit Ashraf
Senior Managing Director and Lead, Energy Industry Sector

Stephanie Jamison
Senior Managing Director and Strategy & Consulting Lead, Europe

World Economic Forum

Roberto Bocca
Head of Shaping the Future of Energy, Materials and Infrastructure; Member of the Executive Committee

Project team

Accenture

Maxime Havard
Senior Manager, Strategy & Consulting, Energy

Ana Luisa Lage
Manager, Strategy & Consulting, Energy

David Rabley
Managing Director and Global Energy Transition Lead, Oil & Gas

Sudipto Sur
Manager, Strategy & Consulting

World Economic Forum

Dominique Hischier
Programme Analyst, Energy, Materials and Infrastructure Platform

Espen Mehlum
Head of Energy, Materials and Infrastructure Platform, Benchmarking and Regional Action

Harsh Vijay Singh
Manager, Energy Transition Benchmarking Programme, Energy, Materials and Infrastructure Platform

Endnotes

1. International Energy Agency (IEA), "Renewable electricity growth is accelerating faster than ever worldwide, supporting the emergence of the new global energy economy", Press Release, 1 December 2021, https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy.
2. Scully, Jules, "Reaching net zero may require 960GW of annual solar and wind additions by 2030, BNEF says", Current News, 22 July 2021, https://www.current-news.co.uk/news/reaching-net-zero-may-require-960gw-of-annual-solar-and-wind-additions-by-2030-bnef-says.
3. International Energy Agency (IEA), *World Energy Outlook 2021*, 2021, https://www.iea.org/reports/world-energy-outlook-2021.
4. Whiting, Kate, "Energy efficiency is the world's 'first fuel' - and the main route to net zero, says IEA chief", World Economic Forum, Agenda, 25 January 2022, https://www.weforum.org/agenda/2022/01/iea-energy-efficiency-worlds-first-fuel-net-zero.
5. Breakthrough Energy, Sectoral Analysis, "Emissions breakdown for Manufacturing, by challenge", https://www.breakthroughenergy.org/go-deeper/sectoral-analysis.
6. Ibid., "Emissions breakdown for Manufacturing, by subsector": adding values from Cement (19%), Iron and Steel (18%), Chemicals (15%), Oil and Gas production (13%), Refining (7.6%) and Coal Mining (6.4%) totals 79%, approximated to 80%, given other measurement uncertainties, https://www.breakthroughenergy.org/go-deeper/sectoral-analysis.
7. World Economic Forum, "First Movers Coalition", https://www.weforum.org/first-movers-coalition.
8. United Nations Climate Change, "COP26: The Glasgow Climate Pact", UN Climate Change Conference UK 2021, 2021, https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf.
9. Sharafedin, Bozorgmehr, Stephanie Kelly and Patricia Vicente Rua, "As fuel prices rise to record highs, governments look for solutions", Reuters, 10 March 2022, https://www.reuters.com/business/energy/fuel-prices-rise-record-highs-governments-look-solutions-2022-03-10.
10. Sustainable Energy for All, "SEforALL Analysis of SDG7 Progress – 2021", 11 August 2021, https://www.seforall.org/data-stories/seforall-analysis-of-sdg7-progress-2021.
11. International Energy Agency (IEA), "Global CO_2 emissions rebounded to their highest level in history in 2021", Press Release, 8 March 2022, https://www.iea.org/news/global-co2-emissions-rebounded-to-their-highest-level-in-history-in-2021.
12. International Energy Agency (IEA), *Global Energy Review 2020*, 2020, https://www.iea.org/reports/global-energy-review-2020.
13. International Monetary Fund (IMF), "World Economic Outlook, Update: Rising Caseloads, A Disrupted Recovery, and Higher Inflation", January 2022, https://www.imf.org/en/Publications/WEO/Issues/2022/01/25/world-economic-outlook-update-january-2022.
14. Newburger, Emma, "Global electric power demand surges above pre-pandemic levels", CNBC, 25 August 2021, https://www.cnbc.com/2021/08/25/global-electric-power-demand-surges-above-pre-pandemic-levels-.html#:~:text=Carbon%20dioxide%20emissions%20from%20the,outbreak%2C%20which%20prompted%20worldwide%20lockdowns.
15. Perkins, Robert, "Global oil demand to surpass pre-pandemic levels in 2022 as omicron fears subside: IEA", S&P Global, 19 January 2022, https://www.spglobal.com/commodity-insights/en/market-insights/latest-news/energy-transition/011922-global-oil-demand-to-surpass-pre-pandemic-levels-in-2022-as-omicron-fears-subside-iea.
16. The Oxford Institute for Energy Studies, "Surging 2021 European Gas Prices – Why and How?", January 2022, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2022/01/Surging-2021-European-Gas-Prices-%E2%80%93-Why-and-How.pdf.
17. International Energy Agency (IEA), *Gas Market Report, Q1 2022*, January 2022, https://iea.blob.core.windows.net/assets/4298ac47-e19d-4ab0-a8b6-d8652446ddd9/GasMarketReport-Q12022.pdf.
18. Harrison, David, "Retail Sales Rise, Showing Strong Consumer Demand, Higher Inflation", *The Wall Street Journal*, 15 October 2021 update, https://www.wsj.com/articles/us-economy-september-2021-retail-sales-11634246791.
19. Morgan Stanley, "Global Supply Chains: Risk, Repair and Restructuring", 17 February 2022, https://www.morganstanley.com/ideas/supply-chain-disruption-outlook.
20. Levanon, Gad, "Why Wages Are Growing Rapidly—Both Now And In The Future", *Forbes*, 26 July 2021, https://www.forbes.com/sites/gadlevanon/2021/07/26/why-wages-are-growing-rapidly-both-now-and-in-the-future/?sh=23791d1bcfe9.
21. Goodman, Laurie, "As Housing Prices Continue to Rise, Who Gets Left Behind?", Barron's, 29 July 2021, https://www.barrons.com/articles/housing-is-becoming-less-accessible-who-rising-prices-affect-most-and-why-51627508785.
22. Marquardt, Andrew, "Up and down the supermarket aisle, food prices are rising in 2022. Here's where you'll pay more", *Fortune*, 29 December 2021, https://fortune.com/2021/12/29/supermarket-food-prices-inflation-2022-kraft-heinz-modelez-general-mills.

23. Abbas, Nassira, and Tobias Adrian, “Low Real Interest Rates Support Asset Prices, But Risks Are Rising”, International Monetary Fund, 27 January 2022, https://blogs.imf.org/2022/01/27/low-real-interest-rates-support-asset-prices-but-risks-are-rising.
24. Reinhart, Carmen, and Clemens Graf Von Luckner, “The Return of Global Inflation”, World Bank, 14 February 2022, https://blogs.worldbank.org/voices/return-global-inflation.
25. Ibid.
26. Arezki, Rabah, and Per Magnus Nysveen, “Ukraine invasion: From oil sanctions to accelerating the energy transition”, VoxEU, 1 April 2022, https://voxeu.org/article/ukraine-invasion-oil-sanctions-accelerating-energy-transition.
27. US Energy Information Administration (EIA), “Oil and petroleum products explained”, 25 February 2022 update, https://www.eia.gov/energyexplained/oil-and-petroleum-products/prices-and-outlook.php.
28. Kpodar, Kangni R., and Boya Liu, “The Distributional Implications of the Impact of Fuel Price Increases on Inflation”, International Monetary Fund, 12 November 2021, https://www.elibrary.imf.org/view/journals/001/2021/271/article-A001-en.xml.
29. Ibid.
30. European Central Bank (ECB), “Looking through higher energy prices? Monetary policy and the green transition”, Remarks by Isabel Schnabel, Member of the Executive Board of the ECB, at a panel on “Climate and the Financial System” at the American Finance Association 2022 Virtual Annual Meeting, 8 January 2022, https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220108~0425a24eb7.en.html.
31. Ibid.
32. Levell, Peter, and Heidi Karjalainen, “The cost of living crisis – who is hit by recent price increases?”, Institute for Fiscal Studies, 17 November 2021, https://ifs.org.uk/publications/15834.
33. BBC, “Rising fuel and food costs push US inflation to 7.9%”, 10 March 2022, https://www.bbc.com/news/business-60696125.
34. Baffes, John, and Wee Chian Koh, “Soaring fertilizer prices add to inflationary pressures and food security concerns”, World Bank, 15 November 2021, https://blogs.worldbank.org/opendata/soaring-fertilizer-prices-add-inflationary-pressures-and-food-security-concerns.
35. US Energy Information Administration (EIA), “Coal Data Browser”, 2021, https://www.eia.gov/coal/data/browser/#/topic/20?agg=0,1&geo=vvvvvvvvvvvo&sec=vs&freq=A&start=2001&end=2020&ctype=map&ltype=pin&rtype=s&pin=&rse=0&maptype=0.
36. US Energy Information Administration (EIA), “Annual U.S. coal-fired electricity generation will increase for the first time since 2014”, 18 October 2021, https://www.eia.gov/todayinenergy/detail.php?id=49996.
37. US Energy Information Administration (EIA), “Short-Term Energy Outlook”, 12 April 2022, https://www.eia.gov/outlooks/steo/report/coal.php.
38. Nasr, Joseph, “Factbox: Can Germany keep warm without Russian gas?”, Reuters, 8 March 2022, https://www.reuters.com/business/energy/can-germany-keep-warm-without-russian-gas-2022-03-08.
39. International Energy Agency (IEA), “Oil security: The global oil market remains vulnerable to a wide range of risk factors”, 24 February 2022 update, https://www.iea.org/areas-of-work/ensuring-energy-security/oil-security.
40. US Department of Energy, “U.S. and 30 Countries Commit to Release 60 Million Barrels of Oil From Strategic Reserves to Stabilize Global Energy Markets”, 1 March 2022, https://www.energy.gov/articles/us-and-30-countries-commit-release-60-million-barrels-oil-strategic-reserves-stabilize.
41. Pilkington, Ed, and Chris Michael, “Biden announces ‘largest release of oil reserves’ in effort to curb gasoline prices”, *The Guardian*, 31 March 2022, https://www.theguardian.com/business/2022/mar/31/us-release-oil-strategic-reserve-gas-price.
42. Stevens, Reid, “The Strategic Petroleum Reserve and Crude Oil Prices”, University of California, Berkeley, 15 November 2014, https://are.berkeley.edu/sites/default/files/job-candidates/paper/The%20Strategic%20Petroleum%20Reserve%20and%20Crude%20Oil%20Prices_0.pdf.
43. Greenley, Heather L., *The Strategic Petroleum Reserve: Background, Authorities, and Considerations*, US Congressional Research Service, CRS Report R46355, 13 May 2020, https://crsreports.congress.gov/product/pdf/R/R46355.
44. Halkos, George E., and Eleni-Christina Gkampoura, “Coping with Energy Poverty: Measurements, Drivers, Impacts, and Solutions”, *Energies*, vol. 14, no. 10: 2807, 13 May 2021, https://www.mdpi.com/1996-1073/14/10/2807.
45. Dobbins, Audrey, Francesco Fuso Nerini and Steve Pye, *Measures to protect the vulnerable consumers in the energy sector*, Insight Energy, Policy Report, 2016, http://insightenergy.org/system/publication_files/files/000/000/065/original/INSIGHT_E_PR_EP2_FINAL.pdf.
46. European Central Bank, “Survey on the Access to Finance of Enterprises: availability of finance improved amid increase in turnover”, Press Release, 24 November 2021, https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr211124~e01183fe90.en.html.

47. The following definition of "net-zero emissions" is from the IPCC (Intergovernmental Panel on Climate Change): "Net-zero emissions are achieved when *anthropogenic emissions of greenhouse gases* to the *atmosphere* are balanced by *anthropogenic removals* over a specified period. Where multiple greenhouse gases are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon)." See IPCC, Annex I: Glossary, in *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Matthews, J.B.R. (ed.), 2018, https://www.ipcc.ch/sr15/chapter/glossary.

48. Bordoff, Jason, and Meghan L. O'Sullivan, "Green Upheaval: The New Geopolitics of Energy", *Foreign Affairs*, January/February 2022, https://www.foreignaffairs.com/articles/world/2021-11-30/geopolitics-energy-green-upheaval.

49. International Energy Agency (IEA), "Energy Security: Reliable, affordable access to all fuels and energy sources", https://www.iea.org/topics/energy-security.

50. Spencer, Starr, "Need for investment is critical for oil, gas industry: World Petroleum Congress panelists", S&P Global, 7 December 2021, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/120721-need-for-investment-is-critical-for-oil-gas-industry-world-petroleum-congress-panelists.

51. World Bank, "The Global Economy: on Track for Strong but Uneven Growth as COVID-19 Still Weighs", 8 June 2021, https://www.worldbank.org/en/news/feature/2021/06/08/the-global-economy-on-track-for-strong-but-uneven-growth-as-covid-19-still-weighs.

52. Attinasi, Maria Grazia, Mirco Balatti, Michele Mancini and Luca Metelli, "Supply chain disruptions and the effects on the global economy", European Central Bank, Part of the ECB Economic Bulletin, Issue 8/2021, https://www.ecb.europa.eu/pub/economic-bulletin/focus/2022/html/ecb.ebbox202108_01~e8ceebe51f.en.html.

53. Sheppard, David, "Why Europe fears a gas crunch even before winter demand begins", *Financial Times*, 15 September 2021, https://www.ft.com/content/7c31ca15-aa4f-4a32-bb90-ebc1341ed374.

54. Cable, Jonathan, and Leika Kihara, "Factories struggling as supply constraints hit, costs rise", Reuters, 1 October 2021, https://www.reuters.com/business/global-economy-asian-factories-stagnate-chinas-slowdown-supply-constraints-hit-2021-10-01.

55. International Energy Agency (IEA), *Financing Clean Energy Transitions in Emerging and Developing Economies*, World Energy Investment 2021 Special Report, Report extract: Executive summary, 2021, https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies/executive-summary.

56. Chestney, Nina, "Explainer: Why Europe faces climbing energy bills", Reuters, 3 February 2022, https://www.reuters.com/business/energy/why-europe-faces-climbing-energy-bills-2022-02-03.

57. Sharafedin, Bozorgmehr, Susanna Twidale and Roslan Khasawneh, "Soaring gas prices ripple through heavy industry, supply chains", Reuters, 22 September 2021, https://www.reuters.com/business/energy/soaring-gas-prices-ripple-through-heavy-industry-supply-chains-2021-09-22.

58. Murtaugh, Dan, Josh Saul and Naureen S. Malik, "Global Power Grids Pushed to Breaking Point", Bloomberg, 16 June 2021, https://www.bloomberg.com/news/articles/2021-06-16/power-prices-rising-temperatures-risk-blackouts.

59. Evans, Morgan, "Global Power Outages, High Prices, Extreme Weather and Supply Chain Issues Arose in 2021", Natural Gas Intelligence, 8 February 2022, https://www.naturalgasintel.com/global-power-outages-high-prices-extreme-weather-and-supply-chain-issues-arose-in-2021.

60. Canada's Oil & Natural Gas Producers (CAPP), "Markets", 2022, https://www.capp.ca/energy/markets.

61. Calculated from the data in Rystad Energy, "Don't call it a comeback: Coal power increased in Europe in 2021 on gas supply concerns and limited alternatives", Press Release, 18 February 2022, https://www.rystadenergy.com/newsevents/news/press-releases/dont-call-it-a-comeback-Coal-power-increased-in-Europe-in-2021-on-gas-supply-concerns-and-limited-alternatives.

62. Eurostat, "Energy consumption in households", June 2021, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households#Use_of_energy_products_in_households_by_purpose.

63. International Energy Agency (IEA), "How Europe can cut natural gas imports from Russia significantly within a year", Press Release, 3 March 2022, https://www.iea.org/news/how-europe-can-cut-natural-gas-imports-from-russia-significantly-within-a-year.

64. International Renewable Energy Agency (IRENA), *A New World: The Geopolitics of the Energy Transformation*, Global Commission of the Geopolitics of Energy Transformation, 2019, http://geopoliticsofrenewables.org/Report.

65. Vithayasrichareon, Peerapat, "Integrating solar PV and wind into the grid", International Energy Agency, 2021, https://iea.blob.core.windows.net/assets/d7e138a1-8c16-42a7-9706-c97d1f6d4de3/IntegratingsolarPVandwindintothegrid.pdf.

66. Cochrane, Emily, "Senate Passes $1 Trillion Infrastructure Bill, Handing Biden a Bipartisan Win", *The New York Times*, 10 August 2021, https://www.nytimes.com/2021/08/10/us/politics/infrastructure-bill-passes.html.

67. European Commission, "Commissioner (2019-2024): Kadri Simson, Responsibilities", https://ec.europa.eu/commission/commissioners/2019-2024/simson_en.

68. International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, Executive summary, 2022, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary.

69. Bordoff and O'Sullivan, "Green Upheaval", op. cit.

70. Twidale, Susanna, "Britain to start approval process for Rolls-Royce mini nuclear reactor", Reuters, 7 March 2022, https://www.reuters.com/business/britain-start-approval-process-rolls-royce-mini-nuclear-reactor-2022-03-07.

71. US Department of Energy, Office of Nuclear Energy, "Advanced Reactor Technologies", https://www.energy.gov/ne/advanced-reactor-technologies.

72. "Majority in Japan backs nuclear power for first time since Fukushima", *The Japan Times*, 28 March 2022, https://www.japantimes.co.jp/news/2022/03/28/national/nuke-power-poll.

73. Government of India, Department of Atomic Energy, Press Information Bureau, "Union Minister Dr. Jitendra Singh says, Government has accorded approval for setting up the largest nuclear power generating site at Jaitapur in Maharashtra with a total capacity of 9900 MW", Press Release, 16 December 2021, https://pib.gov.in/PressReleasePage.aspx?PRID=1782229.

74. Murtaugh, Dan, and Krystal Chia, "China's Climate Goals Hinge on a $440 Billion Nuclear Buildout", Bloomberg, 2 November 2021, https://www.bloomberg.com/news/features/2021-11-02/china-climate-goals-hinge-on-440-billion-nuclear-power-plan-to-rival-u-s.

75. Tirone, Jonathan, Kati Pohjanpalo and Jesper Starn, "Europe's Other Energy Problem: Relying on Russian Nuclear Fuel", Bloomberg, 7 April 2022, https://www.bloomberg.com/news/articles/2022-04-07/europe-s-other-energy-problem-relying-on-russian-nuclear-fuel.

76. Northey, Hannah, "How Russia's invasion is affecting U.S. nuclear", *Energywire*, 14 March 2022, https://www.eenews.net/articles/how-russias-invasion-is-affecting-u-s-nuclear.

77. IEA, *The Role of Critical Minerals in Clean Energy Transitions*, op. cit.

78. Sustainable Energy for All, "SEforALL Analysis of SDG7 Progress – 2021", op. cit.

79. Ibid.

80. Gopinath, Gita, "Managing Divergent Recoveries", International Monetary Fund, 6 April 2021, https://blogs.imf.org/2021/04/06/managing-divergent-recoveries.

81. Cozzi, Laura, Gianluca Tonolo and Daniel Wetzel, "The pandemic continues to slow progress towards universal energy access", International Energy Agency, 24 September 2021, https://www.iea.org/commentaries/the-pandemic-continues-to-slow-progress-towards-universal-energy-access.

82. Brunell, Jacob, Julia Fonteles, Will Putzier and Nicolette Salazar, "Electrifying Rural Healthcare in Sub-Saharan Africa", Climatelinks, 23 September 2021, https://www.climatelinks.org/blog/electrifying-rural-healthcare-sub-saharan-africa.

83. Gordon, Oliver, "How Covid-19 is reversing energy access in the Global South", EnergyMonitor, 22 March 2022, https://www.energymonitor.ai/policy/just-transition/how-covid-19-is-reversing-energy-access-in-the-global-south.

84. Ibid.

85. International Renewable Energy Agency (IRENA), "Majority of New Renewables Undercut Cheapest Fossil Fuel on Cost", Press Release, 22 June 2021, https://www.irena.org/newsroom/pressreleases/2021/Jun/Majority-of-New-Renewables-Undercut-Cheapest-Fossil-Fuel-on-Cost.

86. Lambert, Fred, "Global market share of electric cars more than doubled in 2021 as the EV revolution gains steam", Electrek, 2 February 2022, https://electrek.co/2022/02/02/global-market-share-of-electric-cars-more-than-doubled-2021.

87. "Lithium battery costs have fallen by 98% in three decades", *The Economist*, 31 March 2021, https://www.economist.com/graphic-detail/2021/03/31/lithium-battery-costs-have-fallen-by-98-in-three-decades.

88. McGrath, Matt, "Climate change: Wind and solar reach milestone as demand surges", BBC, 30 March 2022, https://www.bbc.com/news/science-environment-60917445.

89. Ember, "Global Electricity Review 2022", 30 March 2022, https://ember-climate.org/insights/research/global-electricity-review-2022/#global-trends-1-wind-and-solar-surpass-10.

90. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022: Mitigation of Climate Change*, Summary for Policymakers, 2021, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf.

91. Ibid., Section B.2.

92. International Energy Agency (IEA), "Global Energy Review: CO_2 Emissions in 2020", 2 March 2021, https://www.iea.org/articles/global-energy-review-co2-emissions-in-2020.

93. IPCC, *Climate Change 2022*, op. cit.

94. Ibid., Section B.1.2.

95. International Energy Agency (IEA), "Pathway to critical and formidable goal of net-zero emissions by 2050 is narrow but brings huge benefits, according to IEA special report", Press Release, 18 May 2021, https://www.iea.org/news/pathway-to-critical-and-formidable-goal-of-net-zero-emissions-by-2050-is-narrow-but-brings-huge-benefits.

96. As per the IPCC's definition of "net zero", in IPCC, Annex I: Glossary, in *Global Warming of 1.5°C*, op. cit.

97. Climate Action Tracker, "CAT net zero target evaluations", 9 November 2021 update, https://climateactiontracker.org/global/cat-net-zero-target-evaluations.

98. European Commission, "Launch by United States, the European Union, and Partners of the Global Methane Pledge to Keep 1.5C Within Reach", 2 November 2021, https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_21_5766.

99. Climate Action Tracker, "Glasgow's 2030 credibility gap: net zero's lip service to climate action", 9 November 2021, https://climateactiontracker.org/publications/glasgows-2030-credibility-gap-net-zeros-lip-service-to-climate-action.

100. Birol, Fatih, "COP26 climate pledges could help limit global warming to 1.8°C, but implementing them will be the key", International Energy Agency, 4 November 2021, https://www.iea.org/commentaries/cop26-climate-pledges-could-help-limit-global-warming-to-1-8-c-but-implementing-them-will-be-the-key.

101. McGrath, "Climate change: Wind and solar reach milestone as demand surges", op. cit.

102. Ibid.

103. Ambrose, Jillian, "Five Asian countries account for 80% of new coal power investment", *The Guardian*, 30 June 2021, https://www.theguardian.com/environment/2021/jun/30/five-asian-countries-80-percent-new-coal-power-investment.

104. IPCC, *Climate Change 2022*, op. cit., Section B.7.1.

105. IEA, *World Energy Outlook 2021*, op. cit.

106. BloombergNEF, "Energy Transition Investment Trends 2022", Executive summary, January 2022, https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf.

107. Ferris, Nick, "Weekly data: The massive potential for solar energy in the Global South", EnergyMonitor, 10 May 2021, https://www.energymonitor.ai/tech/renewables/weekly-data-the-massive-potential-for-solar-energy-in-the-global-south.

108. International Renewable Energy Agency (IRENA), "Renewable Energy Market Analysis: Africa and its Regions", January 2022, https://www.irena.org/publications/2022/Jan/Renewable-Energy-Market-Analysis-Africa.

109. International Energy Agency (IEA), *World Energy Investment 2021*, 2021, https://iea.blob.core.windows.net/assets/5e6b3821-bb8f-4df4-a88b-e891cd8251e3/WorldEnergyInvestment2021.pdf.

110. Whiting, "Energy efficiency is the world's 'first fuel' - and the main route to net zero, says IEA chief", op. cit.

111. International Energy Agency (IEA), *Multiple Benefits of Energy Efficiency*, 2019, https://www.iea.org/reports/multiple-benefits-of-energy-efficiency/energy-security.

112. United Nations, "UN climate report: It's 'now or never' to limit global warming to 1.5 degrees", UN News, 4 April 2022, https://news.un.org/en/story/2022/04/1115452.

113. See IPCC, *Climate Change 2022*, op. cit., Figure SPM.6: Indicative potential of demand-side mitigation options by 2050.

114. Méheut, Constant, "France Drops Plans to Enshrine Climate Fight in Constitution", *The New York Times*, 6 July 2021, https://www.nytimes.com/2021/07/06/world/europe/france-climate-change-constitution.html.

115. Net Zero Tracker, "Global net zero coverage", https://www.zerotracker.net.

116. UN Environment Programme (UNEP), "Updated climate commitments ahead of COP26 summit fall far short, but net-zero pledges provide hope", Press Release, 26 October 2021, https://www.unep.org/news-and-stories/press-release/updated-climate-commitments-ahead-cop26-summit-fall-far-short-net.

117. Energy & Climate Intelligence Unit, "Net Zero Scorecard", 2022, https://eciu.net/netzerotracker.

118. US Energy Information Administration (EIA), "Frequently Asked Questions (FAQS)", 28 October 2021, https://www.eia.gov/tools/faqs/faq.php?id=73&t=11.

119. Kurmayer, Nikolaus J., "Germany reactivates coal power plants amid Russian gas supply threats", EURACTIV, 9 March 2022, https://www.euractiv.com/section/energy/news/germany-reactivates-coal-power-plants-amid-russian-gas-supply-threats.

120. European Commission, "France, Germany, UK, US and EU launch ground-breaking International Just Energy Transition Partnership with South Africa", Press Release, 2 November 2021, https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5768.

121. Un Environment Programme (UNEP), "A decade of renewable energy investment, led by solar, tops USD 2.5 trillion", Press Release, 5 September 2019, https://www.unep.org/news-and-stories/press-release/decade-renewable-energy-investment-led-solar-tops-usd-25-trillion.

122. Neunuebel, Carolyn, Lauren Sidner and Joe Thwaites, "The Good, the Bad and the Urgent: MDB Climate Finance in 2020", World Resources Institute (WRI), 28 July 2021, https://www.wri.org/insights/mdb-climate-finance-joint-report-2020.

123. Ross, Kelvin, "What if consumers drove the energy transition?", Smart Energy International, 19 June 2020, https://www.smart-energy.com/customer-services-management/what-if-consumers-drove-the-energy-transition.

124. Breakthrough Energy, Sectoral Analysis, "Emissions breakdown for Manufacturing, by challenge", https://www.breakthroughenergy.org/go-deeper/sectoral-analysis.

125. Ibid.

126. Breakthrough Energy, "Getting to Zero", https://www.breakthroughenergy.org/our-challenge/getting-to-zero.

127. International Energy Agency (IEA), *Global Energy Review 2021*, 2021, https://www.iea.org/reports/global-energy-review-2021.

128. Breakthrough Energy, Sectoral Analysis, “Emissions breakdown for Manufacturing, by subsector”.

129. IEA, *The Role of Critical Minerals in Clean Energy Transitions*, op. cit.

130. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, 2021, https://missionpossiblepartnership.org/wp-content/uploads/2021/10/MPP-Steel_Transition-Strategy-Oct19-2021.pdf.

131. Global Cement and Concrete Association (GCCA), *Concrete Future: The CGGA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete*, 2021, https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf.

132. International Energy Agency (IEA), *Chemicals,* 2021, https://www.iea.org/reports/chemicals.

133. International Aluminium Institute, “Aluminium Sector Greenhouse Gas Pathways to 2050”, 2021, https://international-aluminium.org/resource/aluminium-sector-greenhouse-gas-pathways-to-2050-2021.

134. IEA, *World Energy Outlook 2021*, op. cit.

135. Budinis, Sara, Peter Levi, Hana Mandová and Tiffany Vass, *Iron and Steel Technology Roadmap: Towards more sustainable steelmaking*, International Energy Agency, 2020, https://iea.blob.core.windows.net/assets/eb0c8ec1-3665-4959-97d0-187ceca189a8/Iron_and_Steel_Technology_Roadmap.pdf.

136. Markewitz, Peter, et al., “Carbon Capture for CO_2 Emission Reduction in the Cement Industry in Germany”, *Energies*, vol. 12, no. 12, 24 June 2019, https://www.mdpi.com/1996-1073/12/12/2432/pdf-vor.

137. International Energy Agency (IEA), “Tracking Fuel Supply 2021”, 2021, https://www.iea.org/reports/tracking-fuel-supply-2021.

138. Sato, Ichoro, Beth Elliott and Clea Schumer, “What Is Carbon Lock-in and How Can We Avoid It?”, World Resources Institute (WRI), 25 May 2021, https://www.wri.org/insights/carbon-lock-in-definition.

139. United Nations Framework Convention on Climate Change (UNFCCC), “Glasgow Climate Pact, Decision -/CP.26”, November 2021, https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf.

140. United Nations Conference on Trade and Development (UNCTAD), World Economic Forum and Accenture analysis; UNCTAD, UNCTADstat, “Gross domestic product: GDP by type of expenditure, VA by kind of economic activity, total and shares, annual”, https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=95.

141. World Bank, World Economic Forum and Accenture analysis, “Total greenhouse gas emissions (kt of CO_2 equivalent)”, https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE.

142. UNCTAD, World Economic Forum and Accenture analysis; UNCTADstat, “Gross domestic product: GDP by type of expenditure”, op. cit.

143. Yong, Li, “Why industrial development matters now more than ever before”, UNIDO, Industrial Analytics Platform, May 2021, https://iap.unido.org/articles/why-industrial-development-matters-now-more-ever.

144. International Energy Agency (IEA), *Net Zero by 2050: A Roadmap for the Global Energy Sector*, Flagship report, 2021, https://www.iea.org/reports/net-zero-by-2050.

145. Energy Transitions Commission, *Accelerating the Low Carbon Transition*, 2019, https://www.energy-transitions.org/publications/accelerating-the-low-carbon-transition.

146. European Council, “G20 summit, Rome, Italy, 30-31 October 2021, Main results”, 9 February 2022 update, https://www.consilium.europa.eu/en/meetings/international-summit/2021/10/30-31.

147. bp, “Emerging economies to lead energy growth to 2030 and renewables to out-grow oil, says BP analysis”, Press Release, 19 January 2011, https://www.bp.com/en/global/corporate/news-and-insights/press-releases/emerging-economies-to-lead-energy-growth-to-2030-and-renewables-to-out-grow-oil-says-bp-analysis.html.

148. Jessica, Angela, “Education Minister: Make ‘Recover Together, Recover Stronger’ a Meaningful Real Action”, G20 Indonesia 2022, 9 February 2022, https://g20.org/education-minister-make-recover-together-recover-stronger-a-meaningful-real-action.

149. Global Cement and Concrete Association (GCCA), “Global Cement and Concrete Industry Announces Roadmap to Achieve Groundbreaking ‘Net Zero’ CO_2 Emissions by 2050”, 12 October 2021, https://gccassociation.org/news/global-cement-and-concrete-industry-announces-roadmap-to-achieve-groundbreaking-net-zero-co2-emissions-by-2050.

150. Mission Possible Partnership, “About Us”, https://missionpossiblepartnership.org/about.

151. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, op. cit.

152. Gardarsdottir, Stefania Osk, et al., “Comparison of Technologies for CO_2 Capture from Cement Production-Part 2: Cost Analysis”, *Energies*, vol. 12, no. 3, 10 February 2019, https://www.mdpi.com/1996-1073/12/3/542.

153. International Energy Agency (IEA), *Ammonia Technology Roadmap*, https://iea.blob.core.windows.net/assets/6ee41bb9-8e81-4b64-8701-2acc064ff6e4/AmmoniaTechnologyRoadmap.pdf.

154. International Energy Agency (IEA), “ETP Clean Energy Technology Guide”, 4 November 2021, https://www.iea.org/articles/etp-clean-energy-technology-guide.

155. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, op. cit.

156. World Economic Forum, *Aluminium for Climate: Exploring pathways to decarbonize the aluminium industry,* Community Report, 2020, https://www3.weforum.org/docs/WEF_Aluminium_for_Climate_2020.pdf.

157. Global Cement and Concrete Association (GCCA), "Getting to new zero", https://gccassociation.org/concretefuture/getting-to-net-zero.

158. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, op. cit.

159. European Aluminium, *Circular Aluminium Action Plan*, Executive Summary, 2020, https://www.european-aluminium.eu/media/2931/2020-05-13_european-aluminium_circular-aluminium-action-plan_executive-summary.pdf.

160. The following definition of "Scope 3 emissions" is from the US Environmental Protection Agency: "Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain. Scope 3 emissions include all sources not within an organization's scope 1 and 2 boundary. Scope 3 emissions, also referred to as value chain emissions, often represent the majority of an organization's total GHG emissions." See "GHG Inventory Development Process and Guidance", EPA Center for Corporate Climate Leadership, December 2021, https://www.epa.gov/climateleadership/ghg-inventory-development-process-and-guidance.

161. World Economic Forum, "How the oil and gas industry can take a lifecycle approach to reducing emissions", Agenda, 25 August 2021, https://www.weforum.org/agenda/2021/08/oil-gas-industry-lifecycle-approach-reducing-emissions.

162. International Energy Agency (IEA), *Ammonia Technology Roadmap*, op. cit.

163. World Economic Forum, "First Movers Coalition", op. cit.

164. United Nations Industrial Development Organization (UNIDO), "Industrial Deep Decarbonisation Initiative", https://www.unido.org/IDDI.

165. International Renewable Energy Agency (IRENA), "Renewable Energy Jobs Reach 12 Million Globally", Press Release, 21 October 2021, https://www.irena.org/newsroom/pressreleases/2021/Oct/Renewable-Energy-Jobs-Reach-12-Million-Globally.

166. Ibid.

167. Mission Possible Partnership, "Action Sectors", https://missionpossiblepartnership.org/action-sectors.

168. First Insight, *The State of Consumer Spending: Gen Z Shoppers Demand Sustainable Retail*, Survey Report, 2020, https://www.firstinsight.com/white-papers-posts/gen-z-shoppers-demand-sustainability.

169. Clean Energy Ministerial, "Industrial Deep Decarbonisation, Launch of Industrial Deep Decarbonisation Initiative (IDDI)", Press Release, 1 June 2021, https://www.cleanenergyministerial.org/news-clean-energy-ministerial/press-release-launch-industrial-deep-decarbonisation-initiative-iddi.

170. World Economic Forum, "How the oil and gas industry can take a lifecycle approach to reducing emissions", op. cit.

171. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, op. cit.

172. Holcim, "Our CO_2 Footprint", https://www.holcim.com/our-co2-footprint.

173. World Economic Forum, "First Movers Coalition", op. cit.

174. Volvo, "Volvo Launches World's First Vehicle Using Fossil-Free Steel", Press Release, 13 October 2021, https://www.volvoce.com/global/en/news-and-events/press-releases/2021/volvo-launches-worlds-first-vehicle-using-fossil-free-steel.

175. United Nations Industrial Development Organization (UNIDO), "Industrial Deep Decarbonisation Initiative", op. cit.

176. Aluminium Federation, "Collaboration Between Centro Rottami, Indinvest LT and TOMRA Recycling Boosts Aluminium Recycling", 8 September 2021, https://alfed.org.uk/collaboration-between-centro-rottami-indinvest-lt-and-tomra-recycling-boosts-aluminium-recycling.

177. Light Metal Age, "Novelis Creates Automotive Closed-Loop Recycling System with Volvo Cars", 31 January 2020, https://www.lightmetalage.com/news/industry-news/recycling-remelt/novelis-creates-automotive-closed-loop-recycling-system-with-volvo-cars.

178. Kimitec, "Cosentino and Kimitec, Two Giants of the Almerian Industry, Team Up to Promote Circular Economy – EOCENE Project", 26 May 2021, https://kimitec.com/en/eocene-project-cosentino-and-kimitec-join-forces.

179. World Steel Association, "Demonstrating the practicality of reuse in construction", https://worldsteel.org/circulareconomy/case-studies/reuse.

180. Sanyal, Suchismita, "System level modelling to pioneer net-zero carbon emissions in cement manufacturing", Shell, 7 April 2021, https://www.shell.com/energy-and-innovation/digitalisation/news-room/system-level-modelling-to-pioneer-net-zero-carbon-emissions-in-cement-manufacturing.html.

181. bp, "bp and CEMEX team up on net zero emissions", 13 May 2021, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/news-and-insights/press-releases/bp-and-cemex-team-up-on-net-zero-emissions.pdf.

182. Dow, "Dow joins CDP Supply Chain Program to expand supplier engagement on climate", Press Release, 25 May 2021, https://corporate.dow.com/en-us/news/press-releases/dow-joins-cdp-supply-chain-program-to-expand-supplier-engagement.html.

183. Karlsson, Ida, Johan Rootzen and Flip Johnsson, "Reaching net-zero carbon emissions in construction supply chains – Analysis of Swedish road construction project", *Renewables and Sustainable Energy Reviews*, vol. 120, March 2020, https://www.sciencedirect.com/science/article/pii/S1364032119308573.

184. Mission Possible Partnership, *Net-Zero Steel Sector Transition Strategy*, op. cit.

185. OE Digital, "Norway to Launch $2,7B Carbon Capture and Storage Project 'Longship'", 21 September 2020, https://www.oedigital.com/news/481822-norway-to-launch-2-7b-carbon-capture-and-storage-project-longship.

186. Oughton, C., et al., “Water Circular Economy at the Kwinana Industrial Area, Western Australia – the Dimensions and Value of Industrial Symbiosis”, *Circular Economy and Sustainability*, vol. 1, no. 3, July 2021, pp. 995-1018, zhttps://pubmed.ncbi.nlm.nih.gov/34888573.

187. Humber Industrial Cluster Plan, “Together It Is Possible”, https://www.humberindustrialclusterplan.org.

188. Ford, Jason, “Humber Zero: decarbonising an industrial cluster”, The Engineer, 25 November 2021, https://www.theengineer.co.uk/humber-zero-decarbonise-industrial-cluster-vitol-vpi-immingham.

189. Vattenfall, “HYBRIT: SSAB, LKAB and Vattenfall first in the world with hydrogen-reduced sponge iron”, Press Release, 21 June 2021, https://group.vattenfall.com/press-and-media/pressreleases/2021/hybrit-ssab-lkab-and-vattenfall-first-in-the-world-with-hydrogen-reduced-sponge-iron.

190. HYBRIT, “A fossil-free future”, https://www.hybritdevelopment.se/en/a-fossil-free-future.

191. Holcim, “LafargeHolcim Expands Carbon Capture Projects with Government Funding from the US and Germany”, 14 October 2020, https://www.holcim.com/media-release-carbon-capture-projects-USA-germany.

192. Cemnet.com, “Carbon capture project to operate at LafargeHolcim’s Florence plant”, 7 January 2020, https://www.cemnet.com/News/story/168047/carbon-capture-project-to-operate-at-lafargeholcim-s-florence-plant.html.

193. ZKG, “LafargeHolcim expands carbon capture projects with government funding from the US and Germany”, 11 December 2020, https://www.zkg.de/en/artikel/zkg_LafargeHolcim_expands_carbon_capture_projects_with_government_funding_from_3590263.html.

194. GlobeNewswire, “Air Liquide, TotalEnergies, VINCI and a group of international companies launch the world’s largest clean hydrogen infrastructure fund”, 1 October 2021, https://www.globenewswire.com/news-release/2021/10/01/2306763/0/en/Air-Liquide-TotalEnergies-VINCI-and-a-group-of-international-companies-launch-the-world-s-largest-clean-hydrogen-infrastructure-fund.html.

195. Eurofer, “Launch of the Clean Steel Partnership paves the way for further research and deployment of ground-breaking technology”, 23 June 2021, https://www.eurofer.eu/news/launch-of-the-clean-steel-partnership-paves-the-way-for-further-research-and-deployment-of-ground-breaking-technology.

196. World Economic Forum, “Mission Possible Partnership”, https://www.weforum.org/projects/mission-possible-platform.

197. United Nations, “Global Methane Initiative Fact Sheet”, Global Methane Initiative, https://sustainabledevelopment.un.org/content/documents/usa_annex2.pdf.

198. Global Methane Initiative (GMI), https://www.globalmethane.org.

199. World Economic Forum, “Global Chemical Companies Collaborate in Pivotal Move to Net Zero”, Press Release, 13 October 2021, https://www.weforum.org/press/2021/10/global-chemical-companies-collaborate-in-pivotal-move-to-net-zero.

200. Carbon Pricing Leadership Coalition, https://www.carbonpricingleadership.org.

201. World Economic Forum, “New Generation Industry Leaders”, https://www.weforum.org/projects/new-generation-manufacturing-leaders.

202. Eni, “Eni and the University of Strathclyde together to support transition of workforces to the renewable energy sector”, Press Release, 25 March 2021, https://www.eni.com/en-IT/media/news/2021/03/eni-universita-strathclyde-energie-rinnovabili.html.

203. International Energy Agency (IEA), “ETP Clean Energy Technology Guide”, 4 November 2021, https://www.iea.org/articles/etp-clean-energy-technology-guide.

204. European Commission, “European Clean Hydrogen Alliance”, https://ec.europa.eu/growth/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance_en.

205. US Department of State, “State Department’s Clean Energy Demand Initiative Brings Together Companies and Countries to Meet Clean Energy Goals”, Media Note, 4 November 2021, https://www.state.gov/state-departments-clean-energy-demand-initiative-brings-together-companies-and-countries-to-meet-clean-energy-goals.

206. Mission Innovation, http://mission-innovation.net.

207. Government of Canada, “Mission Innovation: Catalysing Clean Energy Solutions for All”, https://www.nrcan.gc.ca/climate-change/canadas-green-future/mission-innovation/18612.

208. Bundesministerium fur Bildung und Forschung, “Karliczek: Germany and Namibia form partnership for green hydrogen”, Press Release, 25 August 2021, https://www.bmbf.de/bmbf/shareddocs/pressemitteilungen/de/2021/08/172_namibia_eng.pdf.

209. Massachusetts Institute of Technology, “MIT convenes influential industry leaders in the fight against climate change”, 28 January 2021, https://news.mit.edu/2021/mit-convenes-influential-industry-leaders-fight-climate-change-0128.

210. Institut Polytechnique de Paris, “Total to be the first R&I center implemented in innovation park”, 26 June 2020, https://www.polytechnique.edu/en/content/total-be-first-ri-center-implemented-innovation-park.

211. Smart Energy Lab, https://www.smartenergylab.pt.

212. Oil and Gas Climate Initiative, “A catalyst for change”, https://www.ogci.com/about-us.

213. Carbon Disclosure Project (CDP), https://www.cdp.net/en.

214. Euronav, “CDP – the Carbon Disclosure Project”, Glossary, https://www.euronav.com/en/glossary.

215. Bloomberg, “Pavilion Energy, QatarEnergy and Chevron Launch GHG Reporting Methodology for Delivered LNG Cargoes”, 17 November 2021, https://www.bloomberg.com/press-releases/2021-11-17/pavilion-energy-qatarenergy-and-chevron-launch-ghg-reporting-methodology-for-delivered-lng-cargoes.

216. Carbon Tracker, “New Global Coalition of Tech, Climate Groups Will Combine AI and Satellites to Monitor GHG Emissions Worldwide in Real Time”, 15 July 2020, https://carbontracker.org/climatetrace.

217. Climate TRACE, “Our Mission”, https://www.climatetrace.org/about.

218. BloombergNEF, “Carbon Offset Prices Could Increase Fifty-Fold by 2050”, 10 January 2022, https://about.bnef.com/blog/carbon-offset-prices-could-increase-fifty-fold-by-2050.

219. Europetrole, “Oxy Low Carbon Ventures Selects Worley for Services Contract on Canadian Direct Air Capture (DAC)-to-Fuels Facility”, 12 November 2021, https://www.euro-petrole.com/oxy-low-carbon-ventures-selects-worley-for-services-contract-on-canadian-direct-air-capture-dac-to-fuels-facility-n-i-22998.

220. Verra, “Standards for a Sustainable Future”, https://verra.org.

221. Gold Standard, https://www.goldstandard.org.

222. Tavares, Cristina, “First Gold Standard-certified Carbon Project registered in Argentina”, Ecosecurities, 18 November 2020, https://www.ecosecurities.com/post/first-gold-standard-certified-carbon-project-argentina.

223. UNCTAD, World Economic Forum and Accenture analysis; UNCTADstat, “Gross domestic product: GDP by type of expenditure”, op. cit.

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

The World Economic Forum, committed to improving the state of the world, is the International Organization for Public-Private Cooperation.

The Forum engages the foremost political, business and other leaders of society to shape global, regional and industry agendas.

World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org