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Five key action areas to put Europe's energy transition on a more orderly path

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To fulfill its ambitious net-zero agenda, the European Union would need to significantly increase the speed and scale of the transition while ensuring affordability, security, and growth.

The 27-member European Union has long been a leader in the global energy transition, thanks to strong support for clean technologies and an ambitious decarbonization agenda. That agenda includes policy initiatives, such as the European Green Deal (in 2020) and the Fit for 55 plan (in 2021), which aim for a 55 percent cut in CO_2 emissions by 2030 (from 1990 levels) and for net-zero emissions by 2050. Since 2021, however, those goals have encountered headwinds. The Russian invasion of Ukraine, the lingering effects of the pandemic, supply chain disruptions, inflationary pressures, and turmoil in the global economy have threatened energy security and affordability in EU countries. Many of them are net importers of oil and gas and thus particularly exposed to energy reliability and market volatility risks.

Although Russia's natural-gas exports declined after the sanctions against it, the European Union has avoided mandated gas curtailments. One reason was the diversification of gas supply—in particular, liquefied-natural-gas (LNG) imports, which increased by more than 60 percent in 2022 from the previous year.[1] In addition, the European Union reduced gas consumption in industry and buildings by about 15 to 20 percent in 2022 (compared with 2021), thanks to a relatively mild winter and the adoption of behavioral and energy efficiency measures.

Several European nations sought to maintain a steady energy supply by taking steps such as delaying the decommissioning of coal-fired power plants and increasing their utilization, which helped to partially offset reduced generation from nuclear and hydro plants. But by highlighting the European Union's exposure to Russian energy, the crisis gave a fresh impetus to the push for a more orderly energy transition that combines rapid decarbonization with energy security and economic growth (see sidebar "What is a more orderly transition?"). In early 2022, the European Commission announced the REPowerEU plan,[2] which introduced measures "to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition." This sent a signal that the European Union aims to come out of the current crisis with a renewed commitment to climate action (see sidebar "Five interlocking proposals").

The European Union accounts for about 8 percent of global energy-related emissions.[3] While it obviously cannot solve the global climate-change problem on its own, it could position itself as a global leader and serve as an example for other countries and regions if it can come close to achieving its commitments.

Still, fulfilling those commitments would require an unprecedented effort, and the current speed and scale of the transition would need to increase significantly (see sidebar "Europe's starting point"). From 2019 to 2021,[4] EU power sector emissions decreased at less than half the rate necessary to stay on track for a 1.5°C pathway. The European Union would now need to triple its current pace of renewable-energy-source (RES) deployment to avoid a less orderly transition, which would be far more costly and damaging to the economy and the environment than one that balances affordability, reliability, resilience, and security.

Benefits and costs

The energy transition could offer broad economic benefits for the European Union—such as increased energy reliability, economic growth, and job creation—for example, by developing supply chains for renewables such as solar-photovoltaic (PV) manufacturing. McKinsey's net-zero report shows that Europe's cumulative incremental investments toward net zero could reach around €1.7 trillion by 2030, equivalent, in real terms, to 11 times the spending of the post-World War II Marshall Plan. Although the transition could eliminate six million jobs through 2050, it could also create 11 million, for a net gain of five million.[5] As job losses and gains will occur disruptively across the labor spectrum, training and transition support will be required.[6]

In addition to reducing CO_2 emissions, a successful transition would strengthen the region's energy security by reducing dependence on fossil fuels and energy imports. The goal would be to raise the proportion of renewable energy in the final energy mix to 45 percent by 2030, compared with 22 percent today. By 2030, these changes could reduce the European Union's total energy bill by 10 percent.[7]

On the other hand, a less orderly transition—resulting, among other factors, from a lack of coordinated interventions among EU member states—could ultimately raise the cost of energy for households and businesses in coming decades. We estimate, for instance, that producing green hydrogen in Germany would cost 20 percent[8] more than importing it from Spain. A failure to act would have severe negative environmental and economic costs across sectors, infrastructure, human health, and disaster management. These would far exceed the costs of action and adaptation.[9]

EU member states would need to take transformative collective action to meet their goals. Implementing the transition would mean profound change: substantial shifts in both energy supplies and large-scale electrification—two endeavors of tremendous magnitude. On the supply side, for example, our research shows that the rate of installation of renewable-energy sources (RES), such as wind and solar, would have to increase three to five times from the 2018–20 average. On the demand side, substantial and cross-sector electrification would be required to reduce direct demand for fossil fuels. According to McKinsey's 2022 *Global Energy Perspective*, the number of battery electric vehicles (BEVs) on EU roads, for example, would need to increase from 1 percent of the total today to about 20 percent in 2030.

Stakeholders could then begin the lengthy process of scaling up infrastructure, supply chains, and the availability of talent. The public sector could be called upon to play a significant role—for example, by considering institutional reforms if needed. Private-sector efforts could prove equally important. Individual operators could catalyze a more orderly energy transition by focusing on cross-value-chain and cross-industry partnerships to improve the resilience of supply chains. The private sector could also take a leading role investing in automation, innovation, and new capabilities; attracting and reskilling the workforce; and launching initiatives to increase the social acceptance of the measures needed to achieve net zero. Without these—and other—key enablers, Europe will not be able to deploy energy transition technologies at the necessary speed and scale.

Accelerating a more orderly energy transition

In 2021, the EU market was the third-largest source of greenhouse-gas emissions, behind only China and the United States. Within the European Union, emissions were highest in Germany, with 23 percent of the total, followed by Italy and Poland, with 11 percent each. The majority of these emissions come from five sectors: transportation (about 28 percent), heavy industry (about 25 percent), power (about 22 percent), buildings (about 13 percent), and agriculture (about 12 percent). Fossil fuel combustion accounts for 80 percent of EU emissions.[10]

The challenges of reducing them vary from country to country. The Benelux nations, for example, rely on heavy industry and serve as a hub for air freight and shipping—relatively difficult sectors to decarbonize. Other countries, such as Poland, rely on coal-based power generation. Despite these differences, EU member states could act in similar ways to overcome the challenges and help realize the region's climate goals. McKinsey's 2022 report on the transition[11] highlighted nine requirements for reaching net zero. Our research has identified five action areas that EU nations could consider to accelerate the energy transition in an orderly manner:

1. creating resilient, at-scale supply chains for key decarbonization technologies

2. building out the energy grid infrastructure to support resilience and reduce barriers to in-region renewables

3. reexamining land use, societal, and regulatory constraints to accelerate the development of renewables

4. redesigning power markets in line with decarbonization and affordability objectives

5. ensuring the affordability of clean technologies to foster their adoption and accelerate the energy transition

Action area 1: Creating resilient, at-scale supply chains for key decarbonization technologies

The European Union currently imports many of the critical inputs that clean technologies need, including solar panels, wind turbines, and batteries. Supply chains for some of these key technologies are already stretched, and geopolitical tensions have exacerbated the existing problems. Supply chain blockages risk delaying or increasing the cost of the energy transition. A shortage of labor presents a further obstacle.

Potential challenges

The region faces potential challenges for critical decarbonization technologies in three areas of the supply chain:

1. *Raw materials.* Essential materials for decarbonization technologies originate in just a few countries. That makes supply chains vulnerable to geopolitical risks, political instability, and disruptions in trade

relationships. This dependency therefore leaves the European Union at risk for supply shortages, long lead times, and unreliable availability, which could cause sharp price increases and delays for clean technologies. For example, the supply of the rare-earth metals neodymium and praseodymium, used in wind turbines and electric vehicles (EVs), depends considerably on China's refining capacity (Exhibit 1). In some scenarios, there could be shortages of 50 to 60 percent in 2030, and the European Union might not be able to scale up local refining capacity in time to fill these gaps.[12] Other key materials, such as nickel and cobalt, are expected to be in short supply by 2025.

2. *Components.* The European Union faces supply resilience challenges for some components of key decarbonization technologies. China, for example, supplies around 70 percent of solar modules and around 60 percent of lithium battery components.[13] To be competitive in these products, the European Union would need to bridge the current large cost gap: solar modules made in the region are currently 25 to 30 percent more expensive than those made in China.[14]

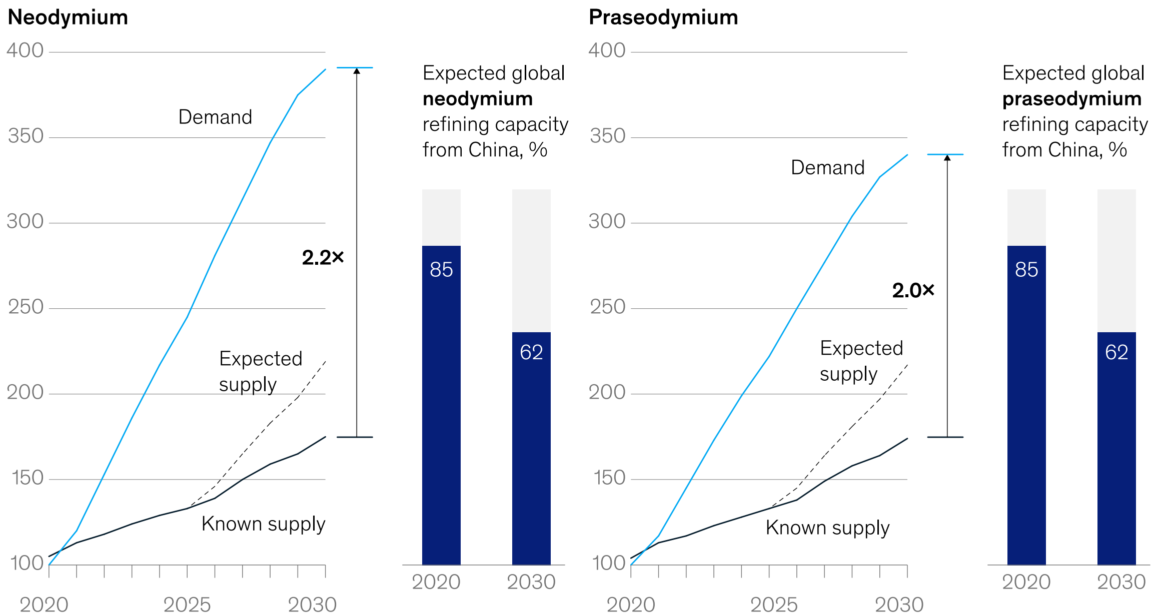
3. *Labor.* A shortage of labor could also hamper a more orderly energy transition in Europe. The expected surge in wind and solar installations, for example, could make them difficult to staff with qualified development and construction employees, as well as operations and maintenance workers. Reaching the Fit for 55 target of a 45 percent share of renewables in the energy mix would require a massive redeployment of labor. Almost one million full-time skilled workers would be needed in 2030 just to develop and construct centralized renewable-energy assets. That is more than triple the number needed today. In addition, though new nuclear plants could be commercially viable for decarbonization in the medium to long

term, the technical skills and capabilities needed to develop them are very scarce.

Exhibit 1

Rare earth metals needed for wind turbines and electric vehicles are highly dependent on China's refining capacity.

Global expected demand and refined supply development, by rare element,[1] indexed to 2020 demand



[1]Based on expected growth of existing capacity and known new projects. Capacity of known new projects based on estimated probability of these projects being active, eg, if a project is still in the exploration phase, the probability of it coming live is lower than if it is in a detailed feasibility study phase. Based on base supply and unknown late-maturity projects or projects not yet developed but that are expected to happen toward 2035.
Source: Company websites for new projects related to supply; Grand View Research; Research and Markets; McKinsey Electric Vehicle Perspective; McKinsey Wind Turbine Perspective; McKinsey Global Energy Perspective, 2022

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Key priorities

To mitigate the effects of supply chain disruptions and bottlenecks, business leaders and policymakers could consider three key priorities:

1. *Building partnerships with raw-material suppliers from a diversified set of exporting countries.* The European Union could create a more resilient supply chain by identifying scarce materials and technologies

produced in geographically concentrated areas and then developing partnerships with suppliers elsewhere. For example, the European Commission, in partnership with the World Resources Forum Association, proposed an EU–Africa collaboration for a sustainable raw-material supply chain. Similar programs may allow countries across Europe to find more resilient and diversified sources of supply.

The European Union could also consider introducing agreements (such as the European Raw Materials Alliance) among its member states to make the sourcing of strategic raw materials more diversified and secure. Meanwhile, the region could consider scaling up both recycling and R&D for raw-material substitution—for example, switching from lithium iron phosphate (LFP) batteries to nickel-manganese-cobalt (NMC) technology.

2. *Scaling up European manufacture of critical technologies.* The European Union could offer incentives to scale up Europe's manufacturing supply chain by introducing local-content requirements, subsidies, better capital access, and European sustainable labels. It could reduce its dependence on interregional relationships, for instance, by encouraging the manufacture of solar modules, batteries, and subcomponents (such as semiconductor products). EU member states would have a natural role in assessing and prioritizing support measures, including grants or subsidies, to increase onshore manufacturing capacity. Initiatives such as the European Solar Photovoltaic Industry Alliance and the EU Innovation Fund, which support large-scale renewables production in the European Union, are first steps in this direction.

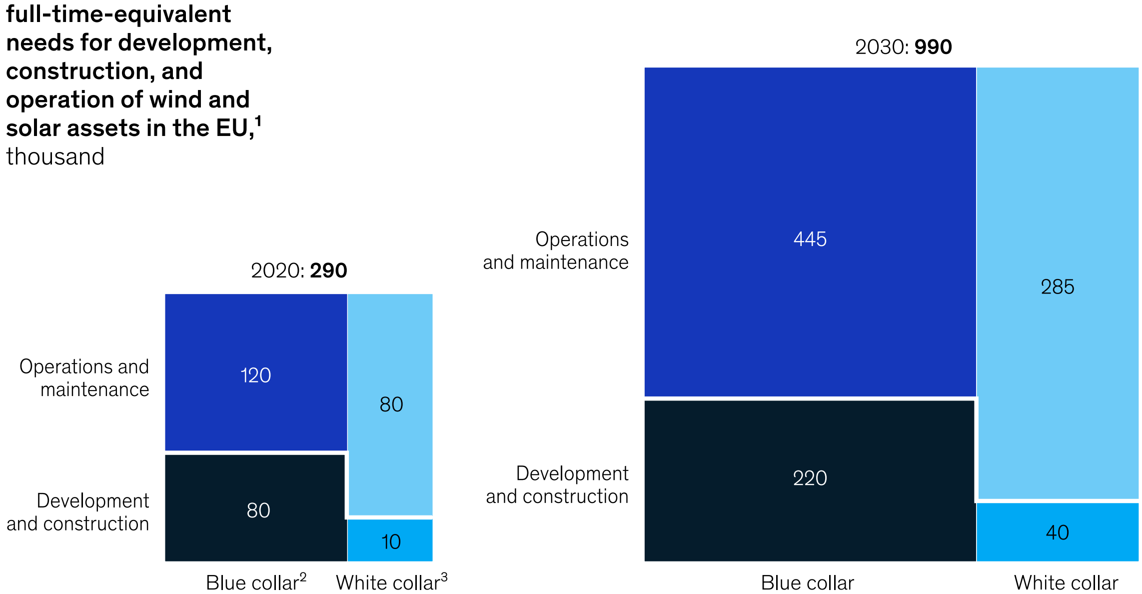
3. *Attracting and training the workforce to ensure adequate labor to scale up clean technologies.* Companies could develop their talent reserves by highlighting the green impact of jobs and by offering

clear professional-development pathways for blue-collar workers. This goal could be achieved through investments in company-, country-, or EU-wide labor programs, such as skilling, reskilling, and enabling international and cross-sector utilization (for example, in the telecommunications, rail, and energy sectors). Furthermore, policymakers could provide incentives to help companies attract talent. Easing certification requirements could permit a faster ramping-up of the needed workforce (Exhibit 2).

Exhibit 2

Demand for workers to develop and construct wind and solar assets in the European Union is set to increase by a factor of three to four by 2030.

Estimated annual full-time-equivalent needs for development, construction, and operation of wind and solar assets in the EU,[1] thousand



[1]Estimate based on current and expected build-out and full-time-equivalent workers per gigawatt estimates, based on different publications from International Renewable Energy Agency (IRENA); learning rates have not been applied.
[2]Practical workers (eg, construction workers, technicians, ship crew, and operators).
[3]Remaining workers (eg, electrical, industrial, mechanical, and telecommunication engineers; and safety and regulation experts, financial analysts, and lawyers).
Source: *Renewable energy benefits: Measuring the economics*, IRENA, Jan 2016; McKinsey Global Energy Perspective, 2022, accelerated transition scenario

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Action area 2: Building out the energy grid infrastructure to support resilience and reduce barriers to in-region renewables

Boosting the share of renewables in the energy mix to 45 percent by 2030 could require a substantial expansion and enhancement of the grid infrastructure to support the integration of new green technologies, such as utility-scale and distributed RES, EVs, and heat pumps. A more up-to-date system could also ensure the security of the gas supply.

Potential challenges

Three areas could prove particularly challenging:

1. *Power.* Annual grid investments of 40 to 70 percent more than the average over the past five years would be needed to support electrification, the integration of renewables and distributed resources, and the digitization of infrastructure. Furthermore, the need for flexibility[15] could triple by 2030 as a result of higher generation by renewables. That could require the development of new flexible capacity, such as energy storage and demand response (Exhibit 3).[16] Connections between wind power generation in northern Germany and the industrial clusters in the south of the country, for instance, remain limited, restricting the ability to balance the grid through interregional connections between generation sites and demand centers.

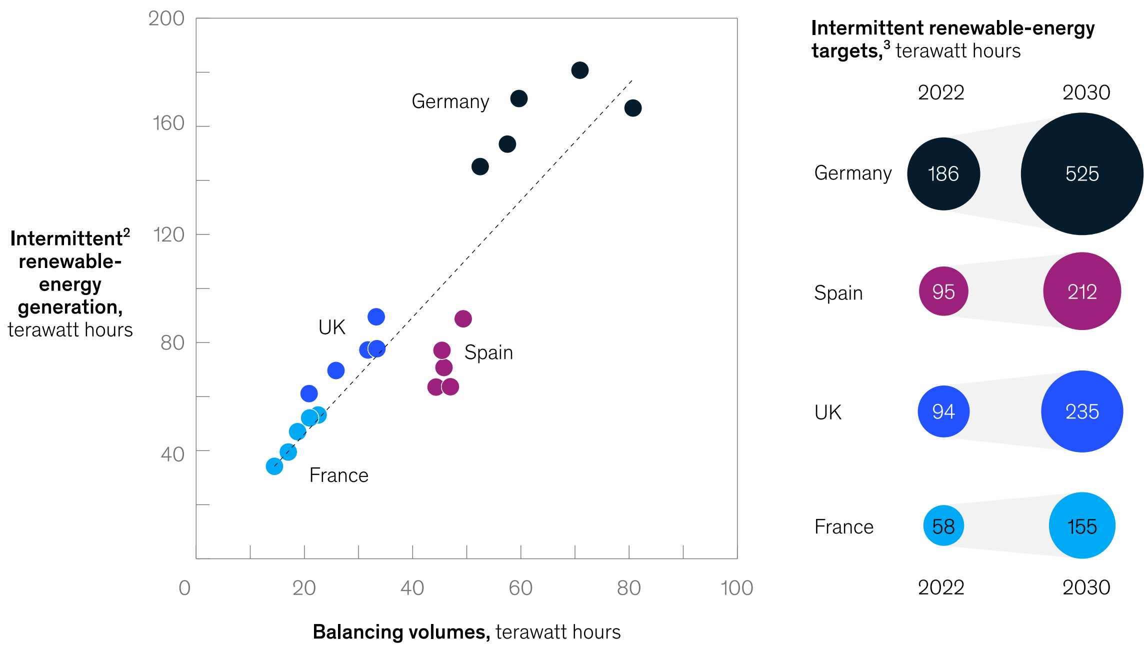
2. *Gas.* The European Union is responding to the energy market disruption that followed the cuts in Russian exports by seeking to increase its liquefied-natural-gas regasification capacity. Russian pipeline gas imports, which accounted for 36 percent of total EU gas consumption in 2021, were down by more than half in 2022.[17] In addition, the limited capacity of gas transport through pipes within Europe hinders the European Union's ability to fully exploit the existing LNG infrastructure. Spain and Portugal, for example, have one-third of the European Union's capacity to process LNG but lack substantial interconnections with the rest of Europe. Furthermore, an estimated 70 percent of the existing EU gas network must be updated to support hydrogen blending.

3. *Integrated planning.* National and cross-national coordination mechanisms could be strengthened to foster integrated planning across value chains, technologies, and countries. A lack of coordination might negatively affect supply resilience and could raise costs.[18]

Exhibit 3

Energy flexibility volumes are likely to increase due to higher renewables generation in European countries.

EU renewables and balancing volumes[1] 2017–21, by country and year, terawatt hours



[1]Balancing refers to intraday market volumes and activated control reserve (secondary and tertiary).
[2]Intermittent is defined as wind and solar.
[3]Germany figures are based on Easter legislation package, July 2022; Spain figures are based on the National Integrated Energy and Climate Plan, 2020; UK calculations based on British energy security strategy, April 2022; France figures are based on multinational energy planning targets, 2020 (targets are for 2028, not for 2030).
Source: *Renewable energy benefits: Measuring the economics*, IRENA, Jan 2016; McKinsey Global Energy Perspective, 2022, accelerated transition scenario

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Key priorities

To enhance the gas infrastructure and improve transmission planning, business leaders and policymakers could consider four key priorities:

1. *Promoting integrated transmission planning and reviewing permitting and siting to accelerate build-out.* Large-scale interconnection projects face long development times. Given the complex issues of siting new large-scale energy transmission projects, stakeholders could identify the most critical projects of integrated plans and review permitting and siting support through regional collaboration and cooperation among EU countries.

National and cross-national coordination mechanisms would foster integrated planning across value chains and technologies—for instance, power, hydrogen, and gas. In the fourth quarter of 2021, the European Network of Transmission System Operators for Electricity (ENTSO-E) and the European Network of Transmission System Operators for Gas (ENTSO-G) took an initial step to implement integrated planning by publishing, for the first time, joint scenarios for the 2022 Ten-Year Network Development Plan. These scenarios capture the interactions between gas and electricity systems to assess the infrastructure of an integrated energy system and optimize overall system efficiencies and flexible use.

2. *Implementing demand-side measures to reduce peak energy loads and defer grid investments.* Grid infrastructure costs are largely fixed, and the deployment of new transmission capacity is slow and costly. Any resource that could improve throughput for these assets at a lower cost and shorten their time to market could increase their overall societal value. The use of demand-side resources has been discussed at length in some markets—for example, the United States—as a way to augment grid capacity.

   Resources may include heating, ventilation, and air-conditioning (HVAC) systems using thermal storage to preheat buildings; the optimized charging of battery electric vehicles; the time (and location) shifting of data center computing loads to areas where the grid is less stressed; traditional industrial load curtailment; and the control of large-scale electricity demand (for instance, to increase green-hydrogen production). The overall loading of the grid infrastructure could be reduced by incentives for flexible demand-side resources to shift loads when grids are most strained to periods of less strain. Flexible demand could help the European Union reduce the need for fossil-based energy generation to ensure energy reliability.

3. *Enabling the development of flexible cross-national gas networks that can carry lower-emission fuels.* Integrating natural gas and hydrogen into European gas networks can help accelerate decarbonization. The enhancement of interregional gas networks could increase energy reliability and enable a more orderly energy transition. Europe could both retrofit its gas infrastructure and build out new capacity to support green hydrogen. As the gas network transitions toward cleaner fuels, policymakers and investors could consider actions that balance reliability and emissions in making investment decisions. For example, could regulatory cost standards for the blended-hydrogen and natural-gas infrastructure be created? Policymakers could also revise the regulations dictating the types of fuels that transmission system operations and distribution network operations may carry.

4. *Raising LNG regasification capacity to support midterm energy security and help alleviate the current energy crisis.* To bolster and diversify domestic natural-gas supply, EU nations could consider coordinated actions, including further work to develop new LNG regasification capacity. Temporary floating storage and regasification units (FSRUs) are already being deployed to increase the European Union's LNG import capacity. Other steps could include building new terminals in Wilhelmshaven, Germany; expanding cross-EU networks, such as the MidCat interconnection between Spain and France, to exploit available capacity; and exploring opportunities to safely exploit indigenous production in areas such as the north Adriatic, the Sicily Channel, and the North Sea. Here too, policymakers and investors could balance cost, reliability, and emissions in making investment decisions, as well as addressing local concerns.

Action area 3: Reexamining land use, societal, permitting, and regulatory constraints

To reach its 2030 climate targets, the European Union would need to shift rapidly to renewable energy. Our research indicates that from 2022 to 2030, the annual number of solar and wind installations would need to increase by two to five times their 2020–22 levels to meet the region's goals.

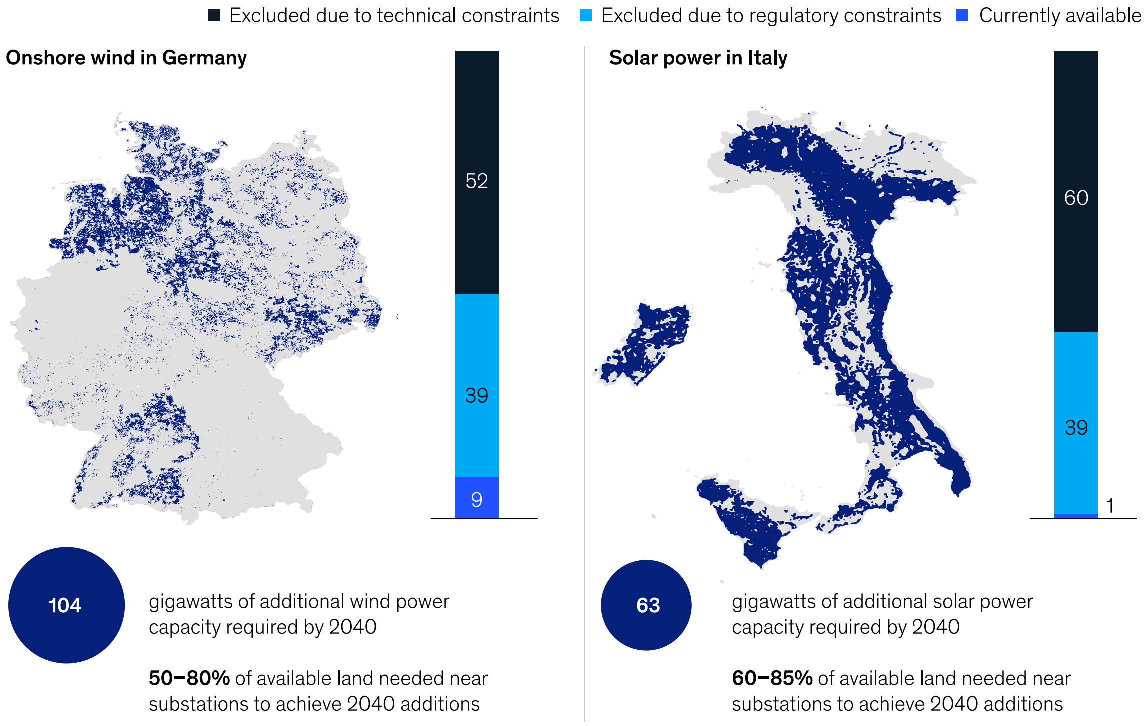
Indeed, REPowerEU targets include a total solar capacity of 600 GW by 2030, up from 209 GW in 2022.[19] Annual additions of PV technology would need to more than double, from 30 GW a year (2020 to 2022) to around 70 GW a year (2022 to 2030). Annual additional onshore wind generation would need to almost quadruple, to 40 GW, from 11 GW, over the same period. Additional offshore wind generation would need to quintuple. What's more, 60 percent of the region's coal capacity might need to be retired.

One critical condition of accelerating the use of renewables is the availability of land. Europe's population density and growing concerns about land use have made it more challenging to find adequate areas for onshore wind and solar power. The land requirements for deploying the target capacity of renewables are significant. The 2040 RES targets in France, Germany, and Italy, for example, would require an additional land area of 23,000 to 35,000 km^2—equivalent to the size of Belgium (Exhibit 4).[20]

Exhibit 4

Available land for renewables development is limited in several countries.

Technically available[1] land for onshore wind in Germany and solar power in Italy, %



Note: For separation of land area, the technical constraints and unsuitable land cover are: Existing wind and solar photovoltaic (PV), urban areas, forests, water, airports, low-wind-potential zones (for wind only), slope, and military zones. Regulatory constraints are distance regulations for onshore wind from settlements, protected land, and, in the case of Italy, regulatory constraints to develop utility-scale solar PV on cropland. General assumption for onshore wind is a density of 5–8 MW/km², not considering additional capacity need if repowering is not possible in former areas, radars, military flight zones, and further country-specific detailed regulation. General assumption for solar PV is a density of 43–60 MW/km²; excluding overlapping wind areas and roof-top solar PV (for Germany: 1:1 split between ground-mounted and roof-top solar PV; and for Italy, 3:1). Germany has official RES targets; Italy only has official 2030 RES targets and France only has official 2050 RES targets that were linearly extrapolated to 2040 for this analysis.
[1]Sites are restricted to a distance of <5 km to substations.

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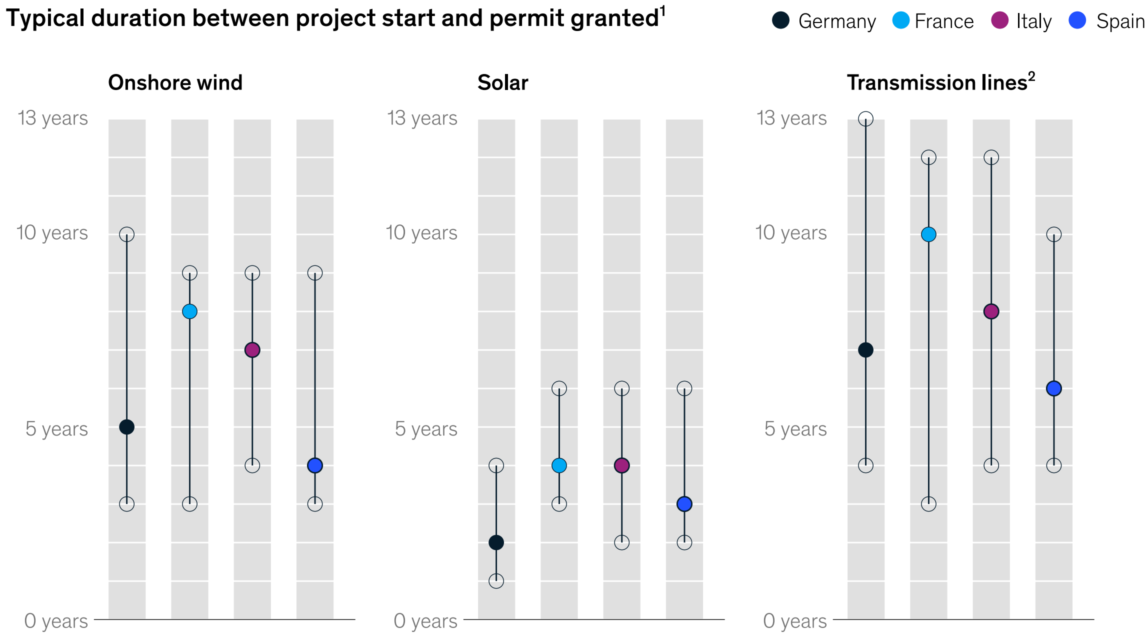
To achieve the necessary deployment of renewables, policymakers could consider accelerating permitting procedures—the part of the RES and transmission-line-development process that typically takes the longest amount of time. In major EU countries, permitting times range from three to ten years for onshore wind installations and from two to six years for solar (Exhibit 5).[21] As a result, recent tenders across the European Union have been largely undersubscribed. Around 80 GW of capacity—some 30 percent of the additions required to achieve the 2030 EU target for onshore wind—is still going through the permitting process.

Exhibit 5

Long permitting lead times delay the build-out of renewable and transmission projects in Europe.

Typical duration between project start and permit granted[1]



[1]Considers only large new-built transmission line projects.
[2]Environmental-impact assessment.
Source: European Wind Energy Association; Fachagentur Windenergie an Land; press searches

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Potential challenges

The expansion of renewables such as wind and solar power could face challenges in six areas:

1. *Timely allocation.* Meeting the European Union's RES build-out targets could require a reconsideration of spatial-planning processes to ensure the timely availability of sufficient land to develop renewables. In Germany, for example, the amount of available land in areas currently designated for onshore renewables would allow the development of only about an additional 5 to 8 GW of onshore wind.

2. *Distance regulation and other constraints.* Today, a significant share of the land that could be used for RES deployment is either not suitable technically or subject to regulatory restrictions.[22] Rules setting a minimum distance to infrastructure such as settlements, airports, water, and railways, for example, exclude 52 percent of the available land in Germany. Although around 9 percent of the country's land is available for onshore wind build-outs, 50 to 80 percent of these areas near substations would be needed to generate 104 GW of onshore wind additions by 2040.

3. *Competing land uses.* Furthermore, RES often must compete for available land with alternative uses, such as agriculture and biomass. In Italy, for example, up to 85 percent of available land would be needed to install the 63 GW of solar PV[23] necessary to meet the 2040 additions.[24] Yet a deployment of RES on that huge scale is unlikely, particularly since Italy limits the use of cropland for RES.

4. *Complex and nonuniform regulations.* Across the European Union, permitting is a complex process that involves multiple authorities. In Italy, for example, more than 30 bodies could be involved.[25] Only a few countries or areas have designated renewable-energy land eligible for fast-track permitting or adopted a fast-track permitting process for repowering projects. As a result, more than 70 GW of onshore wind that reaches its end of life before 2030 must go through the full complex permitting process.

5. *Varying permitting capabilities among authorities, developers, and transmission system operators.* Furthermore, permitting authorities frequently lack the resources, such as digital tools, to track permitting status. Among both developers and transmission system operators, the failure to adopt best practices, such as stakeholder engagement and project planning, slows down the process. Upgrading to best-in-

class tools and processes could reduce permitting times by 20 to 30 percent.

6. *Societal considerations.* Opposition to renewables projects may lead to lawsuits, which can increase permitting time significantly—for example, by around 40 percent in Germany. Some evidence suggests that concerns about renewables projects can be influenced once they become operational. In Germany, for instance, a recent survey showed that more than 70 percent of the people in communities without existing onshore wind have concerns over permitting but that 78 percent of those with wind plants in their communities do not have a problem with this technology.

Key priorities

To help ensure that permitting delays and limited land availability do not become constraints on the energy transition, business leaders and policymakers could weigh six key priorities:

1. *Considering targets for renewables at the national and regional levels to help with land allocation.* Policymakers could address the lack of available land by considering rules, such as those in Germany, that require each state to designate sufficient land for onshore wind to match minimum state-specific targets. If the targets are not met, German law makes it possible to fill the gap by preventing the authorities from denying permits for onshore wind in areas that do not comply with local distance regulations.

2. *Reviewing regulations to safeguard and increase access to land.* Reconsideration of the regulations governing the allowable distance between settlements and onshore wind installations could help increase the area suitable for wind power generation. Relaxing the

distance-to-settlement rules in Bavaria, for example, to match those of Lower Saxony could increase the amount of land suitable for developing renewables 80-fold and permit the generation of 100 GW of additional capacity. Public bodies could attract investment by identifying areas suitable and available for developing renewables and prioritizing these to accelerate permitting and interconnections.

3. *Maximizing the repowering of existing installations to improve land productivity.* The energy production of clean technologies has significantly improved in recent decades. Innovations include tracking and bifacial solar panels, larger wind turbine generators built on taller towers, and blades with the aerodynamic ability to better capture energy at differing windspeeds.

   Existing wind and solar farms are often located on sites with the highest renewables potential—for example, those with high irradiation or wind speeds and with close interconnections. Since these projects often deploy older technologies, they may be producing less than their full renewables potential. As projects age, owners and grid planners could consider seeking out sites that can produce incrementally more energy with the same footprint and repowering where the improved output outweighs the cost of scrapping a generation source. In Germany, for example, repowering could increase capacity by 45 GW by 2030, lowering the overall need for land.

4. *Considering the introduction of a fast-tracking process for certain projects that support transition goals.* Stakeholders could help ensure the timely expansion of infrastructure by reviewing the criteria for fast-tracking large projects critical for the European Union's energy security and decarbonization efforts. As of November 2022, for example, the European Union allows member states to apply for the

fast-tracking of projects focusing on the offshore electricity grid and renewable, low-carbon gas corridors, such as those for hydrogen. These projects, which are designed to help achieve the European Union's overall energy and climate policy objectives, are subject to simplified administrative and judicial procedures. Stakeholders also could consider support for build permitting and siting through regional collaboration and cooperation among EU countries.

5. *Weighing the potential benefits of one-stop shopping and simplifying processes.* To harmonize regulations and establish a central infrastructure authority to oversee permitting timelines, the United Kingdom has undertaken efforts through the Government Major Projects Portfolio (GMPP) from the Infrastructure and Projects Authority (IPA). The new system makes processes more flexible to accommodate changes in technology. Changing a turbine for a more advanced model, for example, would not trigger a restart of the permitting procedure if the change does not increase permitting-relevant risks.

   What's more, permitting organizations, developers, and transmission system operators could improve their ability to manage complex projects. Digital tools, for example, could track the status of permits and potentially create a new action-oriented culture of interaction between developers and permitting organizations.

6. *Launching social-awareness campaigns and implementing incentives to improve public acceptance of solar and wind projects.* Public-opinion concerns about renewables are often best addressed with local solutions that involve the public—not just landowners—in the planning process. Making local communities more aware of the benefits of projects and increasing the transparency of procedures could also ease local concerns.

Projects that aim to foster public acceptance have encouraged local ownership of renewable-energy sources by citizens and businesses. To achieve the target of 6 GW of onshore wind power by 2020, the Netherlands, for example, initiated a goal of 50 percent local ownership of facilities for the production of onshore renewables by 2023. The country gave residents and businesses the opportunity to participate in the decision-making process, from siting to sharing in the revenues. Ultimately, fostering public participation and shared ownership in the development of renewables created widespread acceptance of wind parks across the Dutch provinces.

Action area 4: Redesigning power markets in line with decarbonization and affordability objectives

Power and commodity markets have been designed around energy systems with variable expenditures, so these markets fluctuate according to the cost of commodities. The natural gas burned by a combined-cycle gas plant built in the mid-2000s might have been expected to account for 60 to 70 percent of its lifetime cost. But variable expenses over the life of a solar or wind farm are very low: operations and maintenance costs are just 10 to 20 percent of lifetime costs, according to our analysis.

Potential challenge

Today's market designs factor in operating costs, as prices are based on marginal production costs for power generation units. This system has created an incentive for technological developments such as more efficient combustion turbines. But in the future, more primary energy supply will come from variable intermittent renewable resources with close to zero marginal costs. Current markets do not provide an equivalent operational mechanism to support the transition. Indeed, the current market structure pays for neither the energy produced nor for the changes that would be necessary to create a reliable and resilient system.

Key priorities

To redesign power markets to meet decarbonization and affordability objectives, business leaders and policymakers could consider four key priorities:

1. *Reviewing power markets to strengthen the system in the long term and attract investment.* Wholesale power markets are based mainly on energy markets, reflecting the cost of the power generation technology that produces the incremental (marginal) unit of energy at any given time. Although this system ensures the effective dispatching of resources, it does not provide adequate long term price signals to support investment decisions in new infrastructure, such as renewables or flexible capacity (e.g., battery storage).

   Power markets could be revised to bolster long-term resilience and attract investment while stabilizing the cost of supply for end users. Options for redesigned power markets could include not only centralized competitive auctions (such as contract-for-differences for renewables and long-term auctions for energy storage) but also power purchase agreements (PPAs). Centralized market platforms or green-sourcing obligations for large customers and retailers might also be possible.

One potential design outcome could be balancing longer-term price signals for reliability, resilience, and decarbonization with incentives for short-term resource efficiency, scarcity, and system balancing. In any case, market participants, planners, and policymakers would probably need to go on paying close attention to managing the price and supply volatility that consumers face. Recent energy volatility has caused significant public distress and could diminish confidence in the possibility of a relatively orderly transition. However, volatility may also create a price signal for investments in the system's flexibility and balancing.

2. *Creating more transparency in energy pricing, with more granular bidding zones.* Many national markets have a single clearing price for electricity and little to no accounting for transmission grid constraints. However, these constraints often cause discrepancies between the demand for and supply of power within clearing regions. Complex mechanisms have been introduced to ensure grid balancing but often do not provide clear pricing signals, particularly for demand-side resources.

   Introducing more granular bidding zones—as many markets, including New York, Norway, Sweden, and Texas have done—could create more transparent pricing signals across the energy system. More localized bidding zones enable price clearing to occur at or near the point of generation. The resulting local price reflects transmission constraints. If the basis risk in the market were included, the signals for where to build additional supply or localize demand could enhance efficiency.

3. *Developing financial incentives to minimize energy shortages.* Long-duration gas storage enables seasonal balancing across the EU energy system. To secure an adequate supply of energy—especially during the winter months, when demand peaks—mechanisms and

policies could be developed to minimize shortages. One possibility would be to offer market participants a financial incentive to fill storage. Given more easily contracted offtake, these requirements could support long-term arrangements for additional sources of gas.

4. *Creating compensation mechanisms to reconfigure (rather than strand) assets.* Fossil fuel–fired power plants do not always recover their costs, since their operational expenses are higher than those of renewables. Under the current market design, the early retirement of these assets is sometimes more economically viable than continuing to operate them.

   To ensure that energy supply resilience options exist, capacity markets could be implemented to compensate assets that can reduce volatility of supply by making systems more stable. The gas plants in the European Union could, for example, be gradually transitioned to low-utilization assets that provide power during multiday periods of low renewables production. Instead of classifying such low-utilization assets as stranded, decision-makers could designate those with good operational records as sources of surplus capacity, helping to mitigate the system's volatility and provide reliable supply.

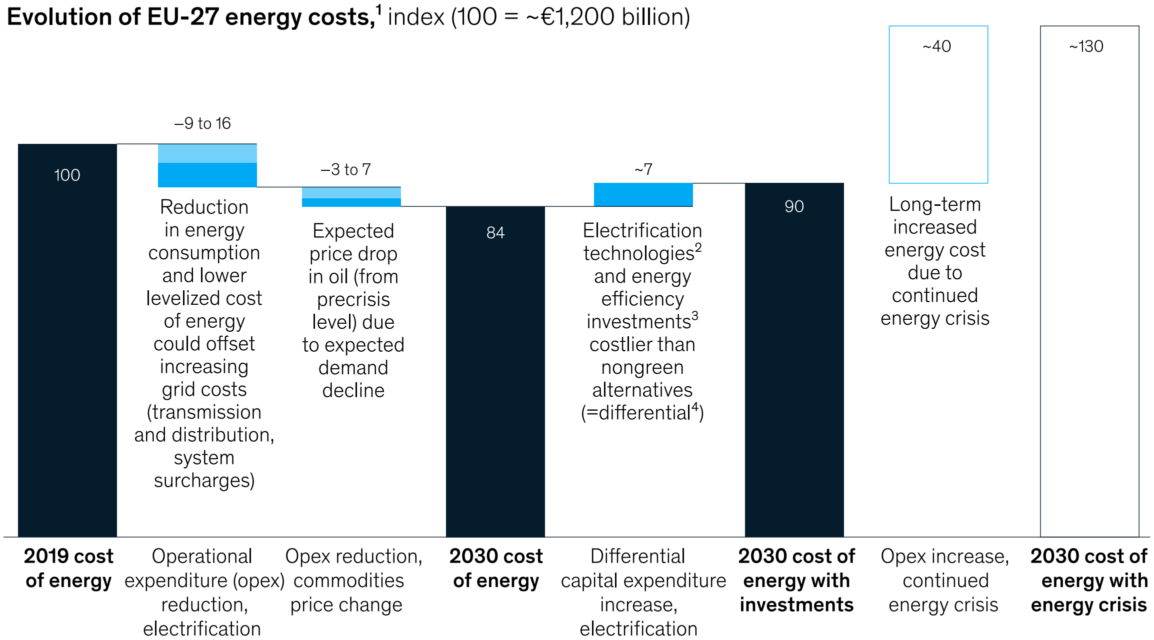
Action area 5: Ensuring the affordability of clean technologies to foster their adoption and accelerate the energy transition

If the energy transition is carried out in a more orderly manner—that is, if renewables account for 45 percent of EU supply by 2030 and the electrification of energy demand meets 2030 targets—it could reduce average EU energy costs by about 10 percent (compared with 2019) by 2030. This reduction could be achieved through a combination of lower energy consumption and the substitution of lower-cost clean energy for carbon-intensive energy (Exhibit 6).

Exhibit 6

Energy consumption and lower levelized cost of energy in Europe could offset increasing grid costs including distribution and system surcharges.

Evolution of EU-27 energy costs,[1] index (100 = ~€1,200 billion)



Note: Total EU-27 energy cost based on detailed analysis on the energy cost of key countries (Germany, France, Italy, and Spain = ~55% of EU-27's energy consumption in 2019). EU-27 cost was estimated proportionally assuming similar average cost of energy in the rest of EU-27. Fuels considered: electricity, hydrogen, natural gas, biogases, motor gasoline, biogasoline, synthetic gasoline, gas/diesel oil, biodiesel, and synthetic diesel.
[1]According to TTF Brent futures (for 2024) as of Sept 2022, assuming gas price of €110/MWh compared with €17/MWh (preinvasion of Ukraine) for 2030.
[2]Eg, electric vehicles, heat pumps.
[3]Eg, building retrofits.
[4]=differential means consideration of delta cost of electrification tech vs nongreen alternative.

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This cost decrease could have two main drivers. First, final energy consumption could fall by 10 to 15 percent through the electrification of final consumption and through energy efficiency (including energy management, HVAC improvements, insulation, and smart lighting, among other things). A fully electric household,[26] for example, consumes around one-third as much energy as an average one.

Second, the unit cost of supplying power can be reduced as renewable-energy support programs expire and the levelized cost of electricity (LCOE) of newly installed renewable energy lowers the average cost of generation. These decreases will probably more than offset the increasing costs of flexibility and of transmission and distribution.

Potential challenge

However, the current energy crisis in Europe presents it with the acute and immediate problem of affordability. This challenge is a major concern to households and businesses across the European Union, prompting government action in many countries. More may be needed in future.

Key priorities

To achieve the necessary reductions, the barriers to the widespread adoption of downstream technologies and energy efficiency measures will have to be overcome. Two of the most challenging obstacles could be high upfront investment costs and the need for subsidies to make technologies such as EVs and heat pumps cost competitive. On average, sustainable cars and heating systems are 7 percent more expensive than conventional ones.

To accelerate the energy transition without adversely affecting affordability, business leaders and policymakers could consider two key priorities:

1. *Lowering financial barriers, such as high upfront investments, by providing incentives and subsidies for the adoption of clean technologies.* The shift to more sustainable energy can require households to pay large sums for clean technologies. The longer-term savings to consumers on items such as air source heat pumps, upgraded building insulation, or electric vehicles may be important. The total cost of ownership of an EV, for example, is in many cases less than that of a vehicle powered by an internal-combustion engine. However, the upfront capital outlay could be a barrier to adoption. To make green technologies cost competitive in the short term, the European Union could consider offering subsidies, tax credits, and additional support while investing to scale up these technologies so they become less expensive.

2. *Enabling active demand participation by removing regulatory and technical constraints for end users and promoting stabilization to mitigate volatility.* Customers could use their own renewable distributed sources to participate in the provision of green energy and flexibility services. In this way, those customers could profit from stable, inexpensive distributed generation and help integrate renewables into the system. Long-term contract options for customers could increase the appeal of active market participation and provide a shelter from volatile commodity prices.

In Europe, demand resources are used to make the grid flexible less frequently than they are in other mature markets, such as the United States. Removing technical constraints (for instance, minimum size or duration) that limit access of demand response could accelerate the uptake of such solutions and increase the system's flexibility.

Finally, to address avoidable future bankruptcies that have raised costs for end users during the recent crisis, stakeholders may need to consider balanced interventions that protect consumers against volatility while avoiding excessive barriers to competition. These interventions could include strengthening the resilience of retailers through capital requirements (similar to those applied in the banking sector) or setting minimum backup levels, such as long-term supply contracts or hedging ratios for sales with fixed prices.

The energy transition can unlock great benefits. These could include a cleaner and healthier environment, more affordable (and less volatile) energy costs for consumers and businesses, increased energy resilience and security, infrastructure investments, and significant job creation. However, realizing these benefits could entail far-reaching change, including institutional reforms, reviews of regulations, behavioral change, and large-scale capital outlays. EU policymakers recently introduced two reform proposals designed to help accelerate the transition.

First, the Green Deal Industrial Plan, announced in February 2023, aims to strengthen local supply chains and to support the affordability and adoption of clean technologies. This plan's ability to help ensure continued EU leadership in the energy transition will depend largely on the amount of financing, the ease of access to funds, and the simplicity of the policy instruments.

Second, a recent proposal aims to ease the weaknesses in the current design of energy markets by strengthening forward markets, developing and supporting liquid PPA markets for renewables, and introducing long-term markets for flexible resources.

Interventions in other areas could also be considered, including changes to the permitting process both for developing renewables and the grid infrastructure. Individual EU member states could consider simplifying administrative procedures and strengthening the capabilities required to comply with the maximum deadlines that the EU Council recently set for granting permits: three months for solar energy, compared with 12 months previously.

For the European Union, a successful energy transition amid geopolitical and macroeconomic turbulence would probably require sustained will, cooperation, and coordination among all stakeholders—including operators, regulators, investors, and society at large.

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