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Renewable-energy development in a net-zero world: Land, permits, and grids

Finding large tracts of land for solar and wind farms is getting harder. Developers will have to strengthen capabilities and enhance their operational effectiveness.

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Achieving the goal of net-zero carbon emissions by 2050 will require staggering increases in the amount of electricity coming from renewable sources. In just the next few years, McKinsey estimates that global renewable electricity capacity will almost triple between 2021 and 2030 to more than 8,800 gigawatts. Of this, the vast majority will come from onshore wind and solar.[1]

Additional solar panels and onshore wind turbines will need land—and a lot of it. Utility-scale solar and wind farms require at least ten times as much space per unit of power as coal- or natural gas–fired power plants, including the land used to produce and transport the fossil fuels.[2] Wind turbines are often placed half a mile apart, while large solar farms span thousands of acres.

The implications of this are daunting. Developers need to continuously identify new sites with increasing speed at a time when the availability of suitable, economically desirable land is getting tighter. Solar farms require flat, dry, sunny locations, while the best sites for onshore wind turbines are the tops of smooth, rounded hills, open plains, and mountain gaps that funnel and intensify wind. Many of the most attractive of these locations are already taken.

In this article, we explore several of the biggest constraints that wind and solar developers face in their search for clean-energy real estate. We also discuss how they can prepare for these intensifying land battles.

Regulatory and sustainability limits

To illustrate how little land is available for renewables development in some countries, we created a model for evaluating potential onshore wind development sites. In Germany, for instance, our analysis shows that of the 51 percent of the country's land potentially suitable for wind farms, only 9 percent remains after factoring in regulatory, environmental, and technical constraints (Exhibit 1). The biggest factor affecting land availability is regulation in some German states related to the distance between wind turbines and human settlements, followed by concerns about biodiversity and animal habitats. Despite recent discussions about loosening distance rules, these and other regulations will likely continue to be the primary constraint for wind development. This 9 percent of available land, which represents a low starting point for renewables developers, could be further reduced by cost considerations and public opposition. With Germany aiming to get 100 percent of its energy from renewable sources by 2035,[3] its capacity targets for onshore wind mean wind turbines must cover 4 to 6 percent of the country's land, giving developers very little room for error.

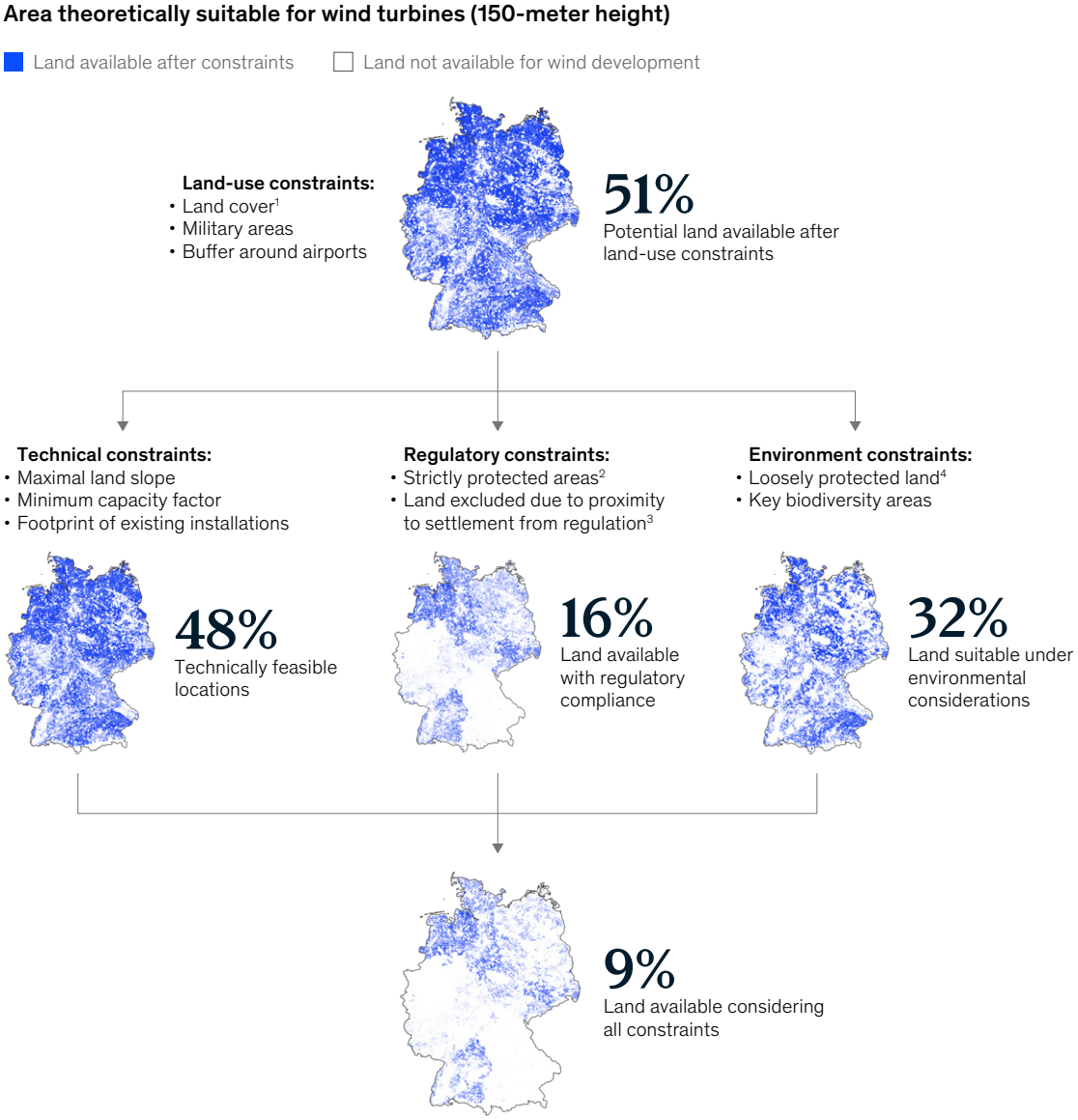
Similar regulatory constraints exist in other countries. For instance, in France, our land-use analysis shows that wind turbines are restricted from about half of France's total land area. This is because of flight paths, historic or protected sites, and radar exclusion zones—areas where wind turbines may interfere with military, civil, and commercial aviation radar systems.

In the United States, solar projects face a different constraint: increasingly contentious land-use protests. In 2021, 10 percent of planned solar capacity was canceled during the permitting stage, largely due to well-organized public opposition.[4] Reasons for this resistance include concerns about the aesthetics of solar farms, the loss of arable land, effects on wildlife habitats, concerns about harm to property values, and fears about health and safety. In China, provincial officials in Hebei also recently banned solar panels on arable land.[5]

[1] *Global Energy Perspective 2022*, McKinsey, April 26, 2022.
[2] Samantha Gross, "Renewables, land use, and local opposition in the United States," Brookings, January 2020.
[3] Markus Wacket and Zuzanna Szymanska, "Germany aims to get 100% of energy from renewable sources by 2035," Reuters, February 28, 2022.
[4] Nichola Groom, "Special report: US solar expansion stalled by rural land-use protests," Reuters, April 7, 2022.
[5] Yuan Ye, "China's solar projects raise land grabbing concerns," *Sixth Tone*, June 17, 2022.

Exhibit 1

Only 9 percent of Germany's land is available for onshore wind development, considering various constraints.



Disclaimer: Our land-use model has a national scope. Considering the necessary simplification, as well as the potential inaccuracies of the data at such a large scale, the results are not intended to represent precise local geographic contexts (such as land rights or planned land use) or recent local developments (political or otherwise). Although our analytics can provide useful directional guidance, drawing any local conclusions will require additional detailed, local studies.

[1]Land not available for solar and wind corresponds to all closed-forests land, urban areas, and bodies of water.
[2]Includes a 200-meter buffer around protected land with protection categories I–IV (strict nature reserve, wilderness area, national park, and natural monument or feature).
[3]Minimum proximity to settlements based on regional-level regulation.
[4]Includes protected land with categories V and VI (protected landscape or seascape and protected area with sustainable use of natural resources) or other.
Source: McKinsey land-use optimization model SpaceFit

Rising land prices

The areas suitable for wind and solar installations have attracted many interested parties, including small and medium-size renewables developers, large utilities, independent power producers, oil and gas majors, and financial players. In addition, other players, such as commercial and residential developers or agricultural companies, may be eyeing the same land. This wide range of interest has had the predictable effect of pushing land prices steadily upward over the past decade. Even though most wind and solar developments involve lease agreements, not land sales, ultimately these deals are driven by land prices. While countries such as France and Spain have experienced moderate price increases of 1 percent annually, land values in Germany and the United States soared nearly 10 percent annually between 2011 and 2020 (Exhibit 2). Furthermore, lease models can be complex: leasing rates can be tied to the surface area, installed capacity, energy generated, or even the revenue or profits generated by a project. This makes it difficult for developers to compare sites and evaluate their financial attractiveness early in the process.

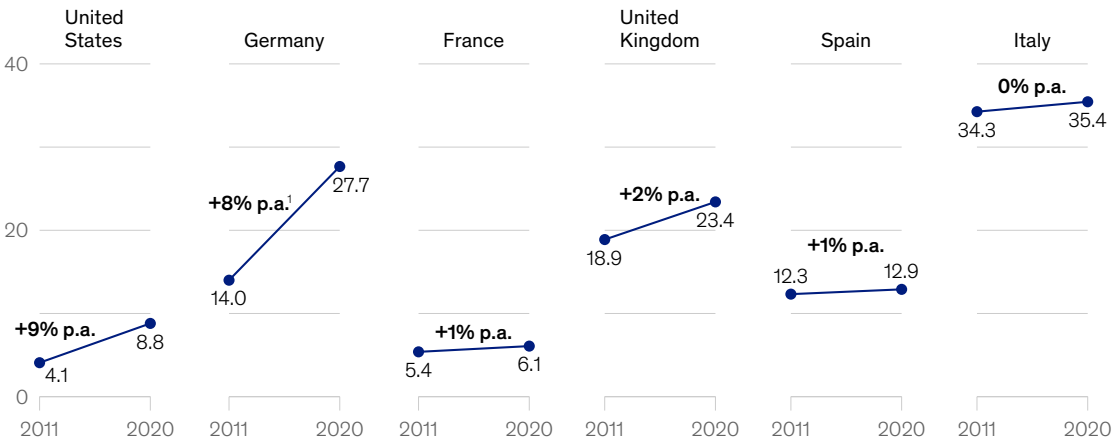
Long, unpredictable development timelines

Finding attractive locations for wind or solar installations often means a consideration not only of the land itself but also of the process and time required to receive the permits to develop it. Many factors in this process are outside of a developer's immediate control. Gaining the required permits, for instance, is usually a slow and decentralized process involving multiple governmental authorities and frequently shifting regulations. Although

Exhibit 2

In nine years, average land prices grew nearly 10 percent per year in Germany and the United States.

Average prices for nonresidential land, € thousands per hectare



[1]Per annum.
Source: Agricultural land prices by region, Eurostat, March 11, 2022; Average value of U.S. farm real estate per acre from 1970 to 2021, Statista, August 19, 2022; Olaf Zinke, "Land prices are on the rise: This is what farmers now have to pay," Agrarheute, October 28, 2021; US Department of Agriculture

regulators' standards for transparency and customer affordability continue to rise, these authorities often lack the staffing, capabilities, and tools to handle the permitting process efficiently. As a result, permitting can span up to ten years, from project start to permits granted. Onshore wind projects take the longest to gain approval, with developers in France and Italy experiencing the longest median duration: eight and seven years, respectively (Exhibit 3).

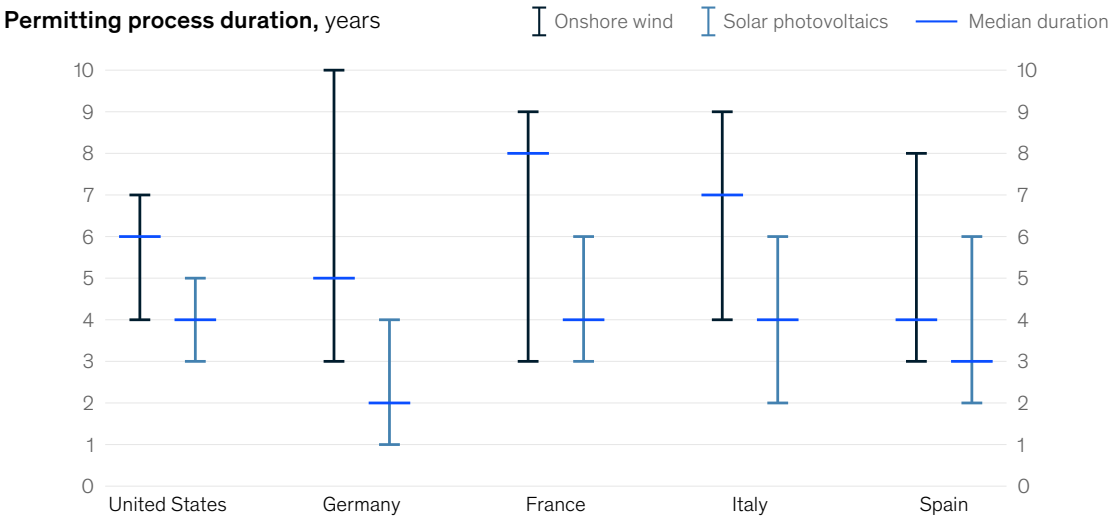
This development and permitting process is also subject to delays that result from public opposition. Even when resistance does not prevent new solar and wind projects, it can cause significant complications. Lawsuits, for example, can delay processes by several years and create unforeseen cost increases. In response, some developers have increased the level of stakeholder engagement they pursue. This can include a range of options, such as active outreach, public hearings, municipal consultations, collaborative decision making with key stakeholders, and even the possibility of giving residents equity or other forms of financial participation in the project.

Increased grid congestion

Utility-scale solar or wind installations need more than land. They also need a large-scale grid infrastructure that will transport clean energy to end users. In many countries, the land most available and suitable for wind and solar development is not located near the dense population, commercial, and industrial centers that need the most electricity. This is particularly true in the United States, where significant power imbalances exist. Densely populated states such as California, Massachusetts, and New York have considerable power deficits (of ten to 40 gigawatt hours), while rural states such

Exhibit 3

The permitting process (from project start to granted permit) for onshore wind projects can take years longer than the process for solar projects.



Source: Wind Europe; Fachagentur Windengerie an Land (Agency for Onshore Wind Energy)

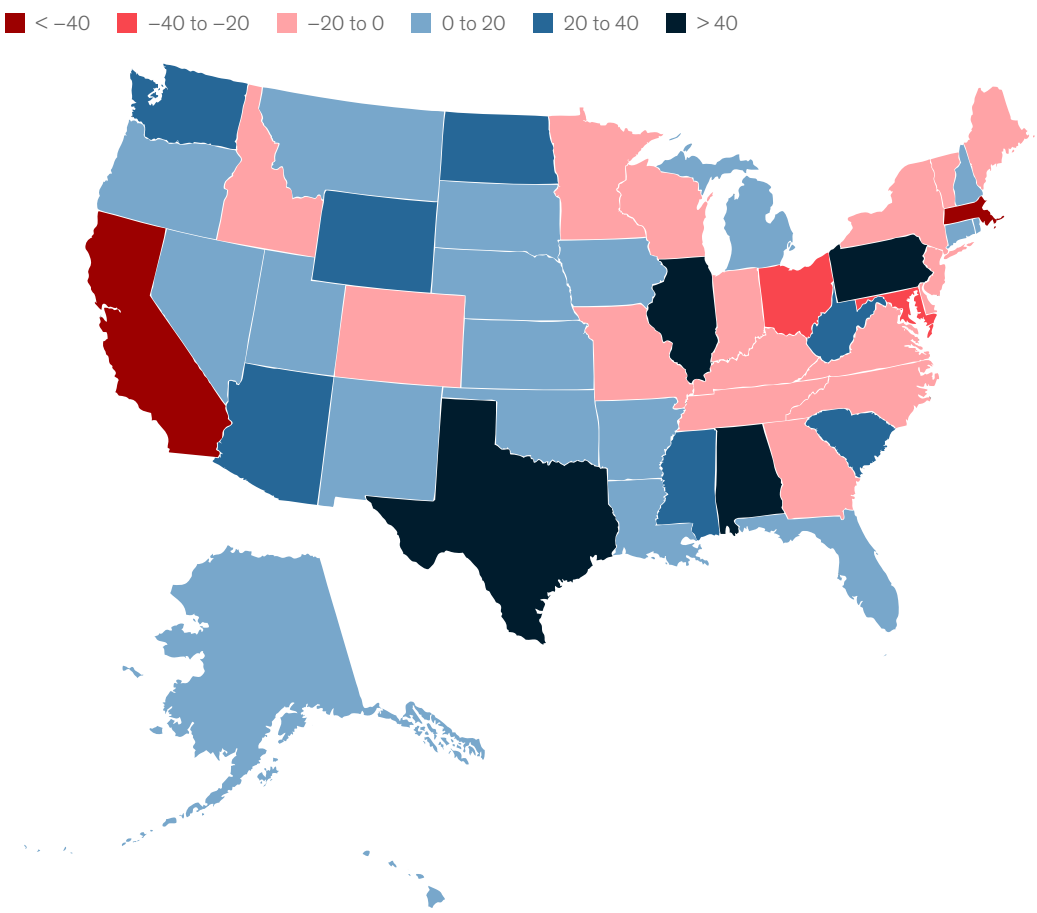
as North Dakota, Texas, and Wyoming have surpluses (of 30 to 40 gigawatt hours) (Exhibit 4). Building new transmission lines to connect rural areas to cities can also be a lengthy and expensive process, subject to its own set of challenges from landowners who don't want power lines they don't benefit from running along their property.

Beyond transmission, grid congestion also arises from a lack of systemwide flexible assets (such as battery storage systems or pumped stored hydroelectricity) that help manage the significantly higher level of variability inherent to wind and solar energy. Because the stability of the power grid depends on predictability and a balance of supply

Exhibit 4

There are significant power imbalances in the United States from region to region and even between neighboring states.

Electricity generation minus consumption, 2020, gigawatt hours



Source: US Energy Information Administration

and demand, the US grid is not always able to immediately integrate all new wind and solar power. Renewable projects can wait for months[6] or even years to be connected to the grid. Projects occasionally have to be shut down, leading to lost investments and missed opportunity for developers, regulators, and society. Although this problem is particularly prevalent in the United States, countries such as Australia, Germany, and Italy face similar issues.[7] If investors and developers determine that unsolved congestion issues are creating unattractive market conditions, they may choose to exit the market. This presents a major risk to a country's renewables expansion targets and net-zero commitments.

Implications for developers

To remain competitive and ensure a smooth and successful development process, renewables players need to proactively address these challenges. We highlight five crucial steps developers may want to take:

Build strengths in early land origination. Finding suitable and financially attractive sites requires thorough and extensive site scouting and relationship building with local leaders, activists, and landowners. Such capabilities are distinctly different from those of project development, which focuses on the permitting processes, technical coordination, and structured public outreach. To ensure the optimal deployment of resources, larger developers may want to adjust their operating model to separate origination from project development. Incentivization mechanisms, such as equity stakes for individuals within an organization who successfully identify wind or solar sites, may also help to build the pipeline of new sites.

Create agile and lean processes across the organization. Succeeding in a challenging and highly competitive environment will mean moving quickly, efficiently, and strategically. For instance, to boost chances of finding suitable land, developers may want to identify as many sites as possible and then quickly narrow them down based upon on a clear, transparent, fast, and digitally enabled process. In addition, as community and stakeholder engagement becomes an increasingly important aspect of renewables development, companies will also need to develop the capability to do effective outreach.

Incorporate a bottom-line view for site identification. Ideal locations for wind and solar installations are those that will not only generate electricity at the lowest possible cost but also create value for shareholders. To make sure sites will become profitable later in their life cycle, site originators and project developers should complement their technical evaluations with an understanding of favorable market conditions, advantageous regulations, auctioning schemes, and grid modeling. These capabilities are often present in other parts of the organization, such as commercial, strategy, and regulatory affairs, or outside of the organization for pure developers. Building them up and leveraging them early in the site identification process can increase a project's future value and reduce the risk of unforeseen cost explosions.

Look to industrial players for additional land and new customer revenue. Industrial manufacturers such as aluminum, steel, cement, and chemical producers are faced with the formidable challenge of decarbonizing their energy-intensive operations. By building renewable-energy-generation assets on the sites of these producers, developers can help them replace fossil-based assets, reduce their dependency on power from the grid, and use clean energy to power their operations. For developers, this direct link to industry can present an attractive opportunity to diversify their revenue sources and bypass challenges related to land scarcity. To be successful, they need to develop new organizational

[6] Gracie Brown, Bernice Chan, Rory Clune, and Zak Cutler, "Upgrade the grid: Speed is of the essence in the energy transition," McKinsey, February 1, 2022.

[7] Christopher Hopson, "Grid congestion choking Australia's massive renewable energy pipeline: WoodMac," *Recharge*, May 1, 2020; Sophie Vorrath, "Grid problems now the biggest turnoff for renewable energy investment in Australia," *Renew Economy*, July 29, 2020; Jason Deign, "Germany's maxed-out grid is causing trouble across Europe," *Greentech Media*, March 31, 2020; "Focus on energy transition: Italy unveils grid development plan 2021," ReGlobal, October 13, 2021; Enza Tedesco, "Italian grid to struggle with fast green growth - experts," *Montel*, April 26, 2022.

capabilities and build strong ties with industry players. Once a customer relationship is established, this can be a basis for further upselling opportunities, such as in energy management services.

Strengthen communication and public advocacy. Throughout the development process, various external stakeholders influence the success or failure of projects. To improve the likelihood of a project's success, developers should enhance their ability to manage the flow of information. When creating new regulations or market frameworks, authorities need the perspective, project experience, and insights of developers. Renewables players should understand the value they can bring and establish strong channels of communication with authorities to ensure that perspectives are being exchanged and aligned regularly. To mitigate the risk of public opposition, developers should actively manage public opinion throughout the process and host forums for public participation early and often.

The renewables sector is at an exciting yet challenging crossroads. Now is the time for developers to use the market's momentum to get their organizations ready for an era of fierce competition for scarce land.

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