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The global relevance of New York State's clean-power targets

New York State has set ambitious decarbonization goals. What needs to happen to reach them?

by Rory Clune, Jesse Noffsinger, and Humayun Tai

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In the past year, several US states have announced 100 percent clean-power targets—meaning complete reliance on low-carbon sources such as wind and solar—to be achieved over the next 20 to 30 years. The European Union hopes to go even further: it wants to decarbonize almost its whole economy—not just the power sector—by 2050. Meeting these targets will require extensive efforts across sectors (including power, transportation, industry, and building heating), successful bets on technology, and complex policy changes that incorporate market incentives, costs, customer acceptance, and electrical interconnections with adjacent regions.

New York's decarbonization strategy and the power sector

The state of New York provides an interesting case study that could prove relevant to other markets, given its level of ambition, its customer and policy trajectory, and the physical characteristics of its current power system. In 2018, 41 percent of the electricity generated in the state came from fossil fuels, almost all of it gas and dual-fuel (oil and gas) plants; 32 percent from nuclear power, and 21 percent from hydropower. There are long-term issues associated with each of these sources. The Indian Point nuclear plant, which provides 2.1 gigawatts (GW)[1] of power, is scheduled to close in 2021. There are no plans to build new hydroelectric plants, which are unpopular with many environmentalists. New gas pipelines have been restricted, and in most of Westchester County and Long Island, suburbs of New York City, there is a moratorium on new natural-gas service. For context, non-hydro renewables, such as wind, solar, and biomass, together account for a little over 5 percent of New York's electricity generation.

In June 2019, the state legislature passed the Climate and Community Protection Act. Among its specific goals are 70 percent renewable energy production by 2030 (up from 26 percent now, of which more than 80 percent is hydroelectric); 100 percent zero-emissions electricity (including hydropower and nuclear) by 2040; and a reduction in greenhouse-gas (GHG) emissions of 40 percent by 2030 and 85 percent by 2050 (compared to 1990).

As can be seen in the deadlines it has chosen, the state is targeting the power sector first, in a bid to accelerate decarbonization of the larger economy. To do that, it is emphasizing the rapid deployment of specific green-energy technologies, such as the following:

— nine GW of offshore wind by 2035 (compared to none now)

— six GW of distributed solar generation by 2025 (compared to 1.6 GW as of 2018)

— three GW of energy storage by 2030 (compared to very little now)

— a 60 percent increase in energy efficiency by 2030

Experience has demonstrated that market-stimulating policies can accelerate mobilization of an industry and thus improve economies of scale—think of Denmark's long-term support for its wind industry, and the use of renewable standards in Texas that has supported its sizeable deployment of wind. In New York State's case, aggressive targets for clean-power generation mean that, if these are met, the subsequent electrification of other sectors, such as cars and heating, happens on a cleaner grid. To put it another way, decarbonization depends on not only what policies are enacted but in what order.

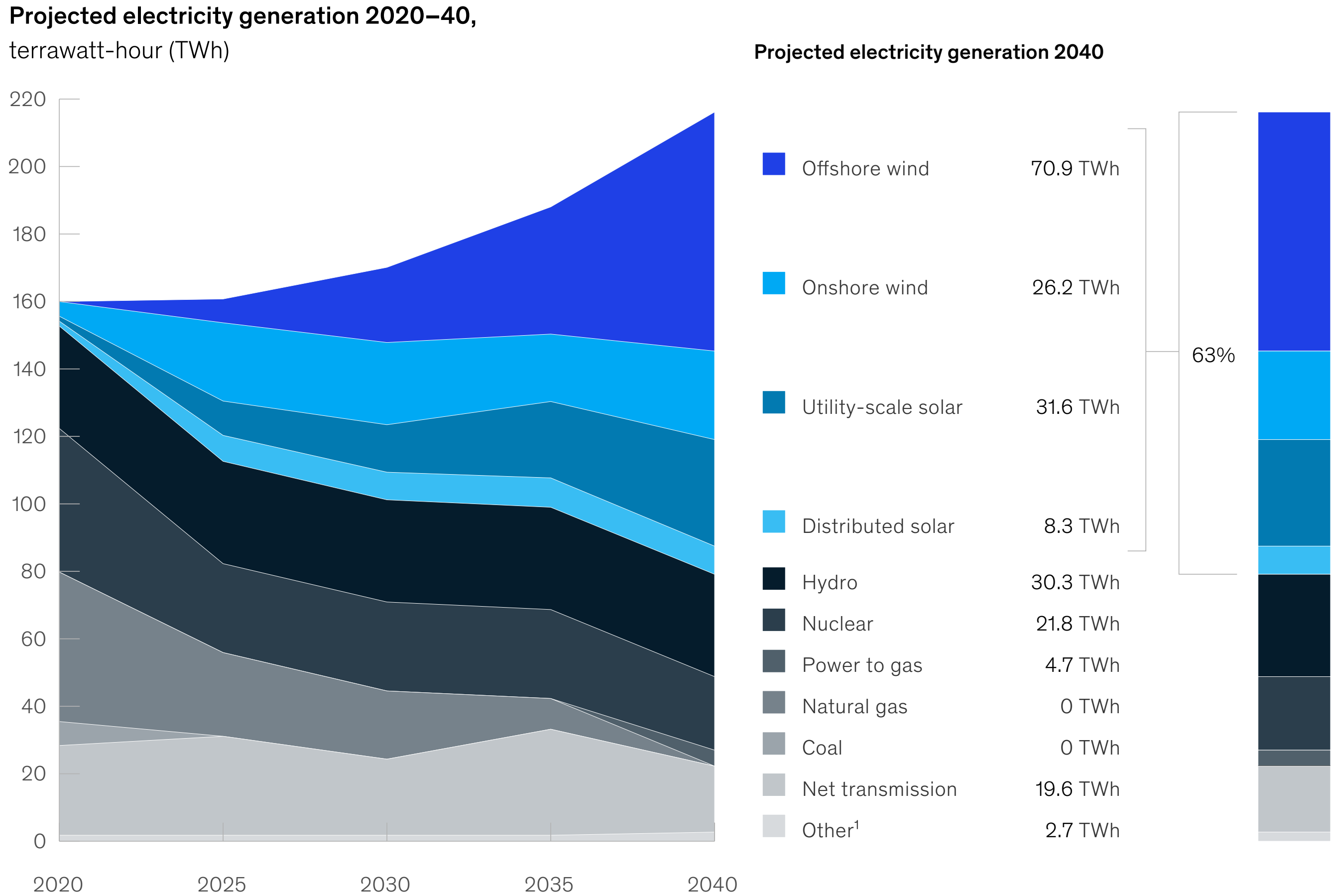
Model insights

To understand the implications of New York State's aspirations on its energy infrastructure, we simulated the performance of the power-generation and -transmission system in hourly intervals to 2040. The goal was to suggest what investment and system changes it would take to meet the state's decarbonization goals for the energy sector cost-effectively and while maintaining grid reliability (Exhibit 1).

[1] One gigawatt is equivalent to 1,000 megawatts (MW); one GW can power about 670,000 homes in New York State. It takes about 3.1 million solar PV panels to produce 1 GW.

Exhibit 1

By 2040, the model projects that more than 60 percent of New York State's electricity will come from wind and solar power.



[1] Includes biofuels, flexible loads, and oil.

The model considered all kinds of generation (both conventional and renewables), the transmission grid, batteries and other forms of storage, and demand-side resources, such as increased energy efficiency, demand-response programs, and vehicle-to-grid technology. It also considered the implications of the retirement of generation assets, the variability in weather and in electricity-demand profiles, and the effects of the electrification of heating and transport.

The model did not consider price to the end consumer. Of course, this is important, but it is also complicated and highly conjectural because it depends on future market structures. We did, however, measure costs, which are more predictable.

We reached ten conclusions:

Decarbonizing power generation will not be enough for New York State to meet its GHG-emission goals. The state's power sector accounts for 17 percent of its GHG emissions; that is why the building and transport sectors will also need to decarbonize, most likely through electrification.

Electrification on this scale will require coordination across multiple sectors of the economy, with effective policy support from the government. As the sales of electric vehicles (EVs) grow, transportation electrification is beginning to occur, albeit on a small scale. But heating electrification is going to be more challenging, given the economics of electric heat pumps and the difficulty of retrofitting existing buildings, particularly in New York City.

Demand for power will rise. In recent years, demand for electricity has been flat or falling. If cars and buildings go electric, though, it will rise. By 2040, we project New York State's electric load will grow by a third, or an additional 51 terawatt-hours.[2]

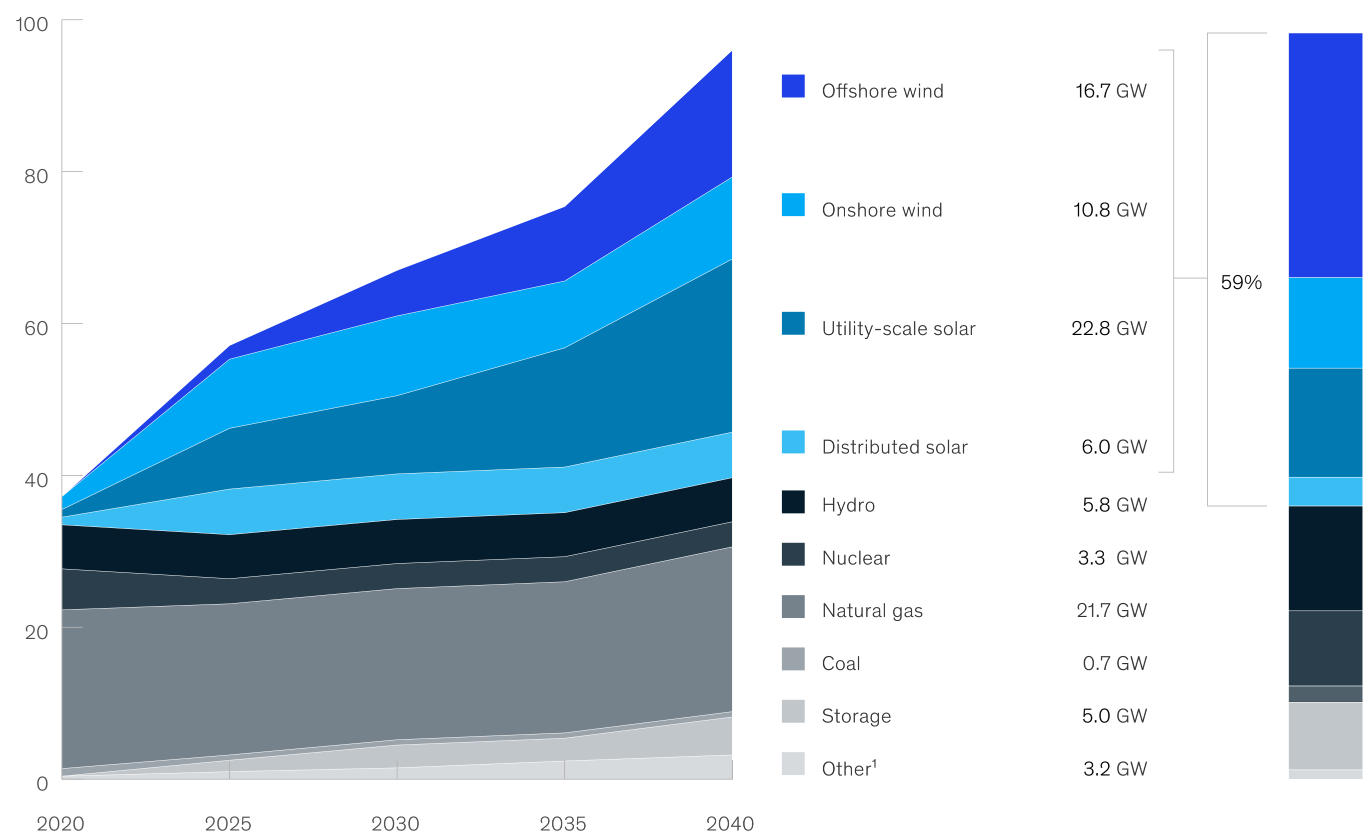
Improving grid flexibility will require using a wide range of options. Our model predicts that green-energy sources such as offshore wind, onshore wind, and solar will largely replace conventional fuels and provide more than 60 percent of New York State's electricity by 2040 (Exhibit 2).

Because wind and solar power cannot run 24/7, however, a range of technologies and practices—everything from batteries to hydro to demand management—that enable the grid to function with intermittent sources of power will therefore need to be deployed, at scale, for a renewables-dominated power system to work well (Exhibit 3).

Exhibit 2

Solar and wind generation are projected to account for most of New York State's new capacity.

Projected generation capacity 2020–40,
gigawatt (GW)



[1] Includes biofuels, flexible loads, and oil.

[2] A terawatt-hour is a unit of energy equal to outputting one trillion watts for one hour.

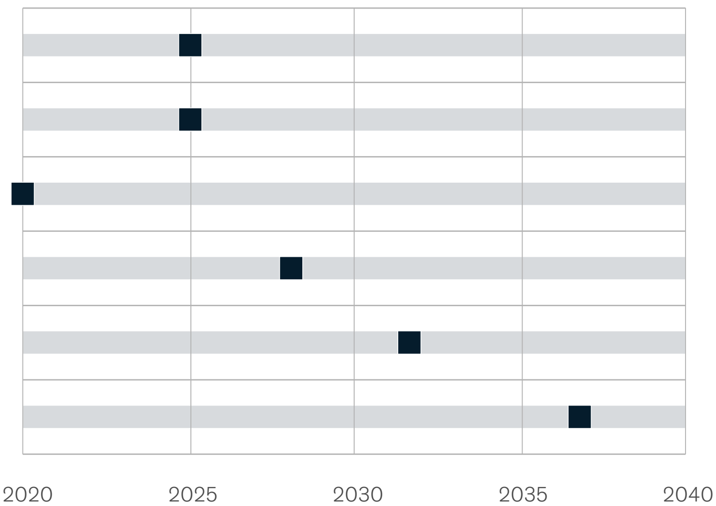
Exhibit 3

By 2040, a variety of resources will be required to manage the intermittency of renewables in New York State.

Estimated average length of operation

Hydro pumped	4–8 hours
Hydro reservoir	2–5 days
Gas peaker plants	6–8 hours
Storage	2–8 hours
Demand management	2–4 hours
Power to gas	2–4 months

Estimated timeline of large-scale deployment



Market structures will need to change. New York State has a variable and sometimes harsh climate; there could be times when the weather creates imbalances between power demand and supply (Exhibit 4). Battery storage could help, particularly as its cost falls and its efficiency rises. There will likely, however, be times where conventional power-generation assets, such as combined-cycle natural-gas plants, are the best solution to fill the gaps. To keep these assets available, the structure of compensation will need to change to ensure that they can serve as backup power, even if their day-to-day utilization is low.

The role of natural gas could be contentious. Our model suggests that natural-gas plants will be an important source of grid flexibility and stability. But investing and regulating to keep them operational could be controversial because of their GHG emissions. One possibility to address the need for natural gas but to deliver it at a net-zero carbon level and provide the final stretch of full decarbonization is power-to-gas technology (or “zero-emissions gas”). In this technology, the excess power that renewables sometimes generate is converted to hydrogen in an electrolysis plant, then combined with CO_2 emissions from existing sources, such as landfills and factories, to create methane, the major component of natural gas. This can then be used to generate electricity. While power-to-gas technology has been proven and a few plants exist, costs will need to drop considerably if it is to be deployed on a large scale.

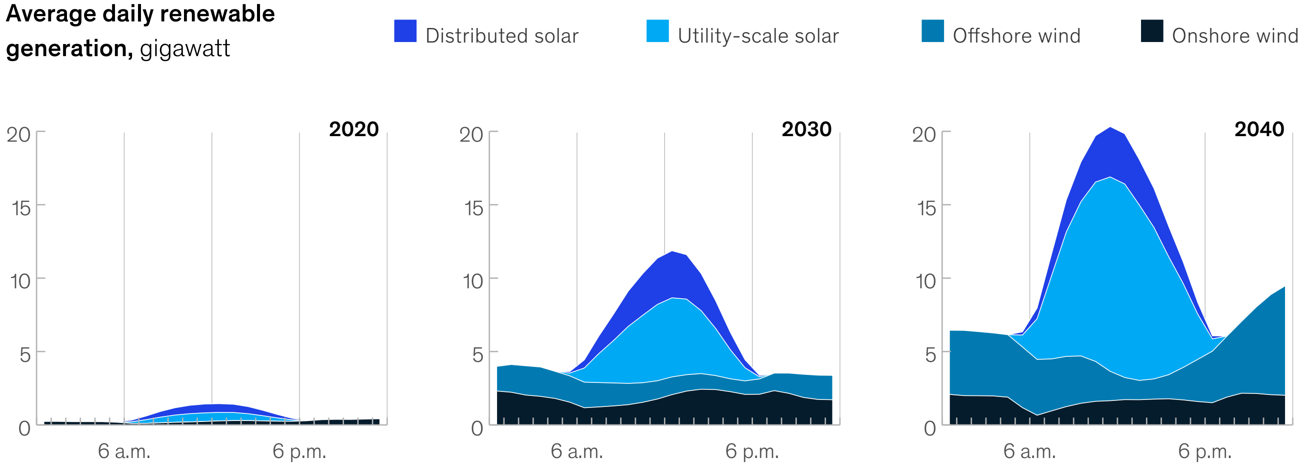
For buildings, converting from natural gas to electric heat pumps could be controversial, too, because the up-front costs are high and the logistics are difficult—doing so would require swapping out boilers in millions of homes and businesses.

Expect a shift in the use of hydropower. New York State’s pumped and reservoir hydro assets are dispatched to balance hour-to-hour imbalances between energy supply and demand. According to

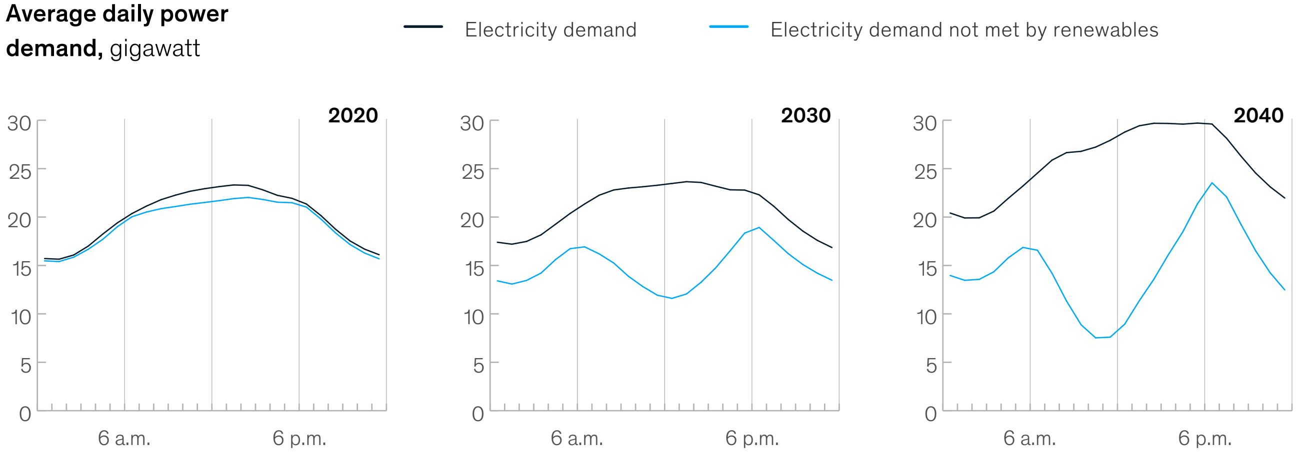
Exhibit 4

As more renewables enter the system, New York State will need to balance the supply of power with the demand for it.

Average daily renewable generation, gigawatt



Average daily power demand, gigawatt



our model, pumped hydro will go from five to ten days of substantial usage a year to more than 250 days. The way in which these assets are operated and maintained will need to change accordingly, allowing for faster ramp-up times and accounting for increased wear on mechanical components.

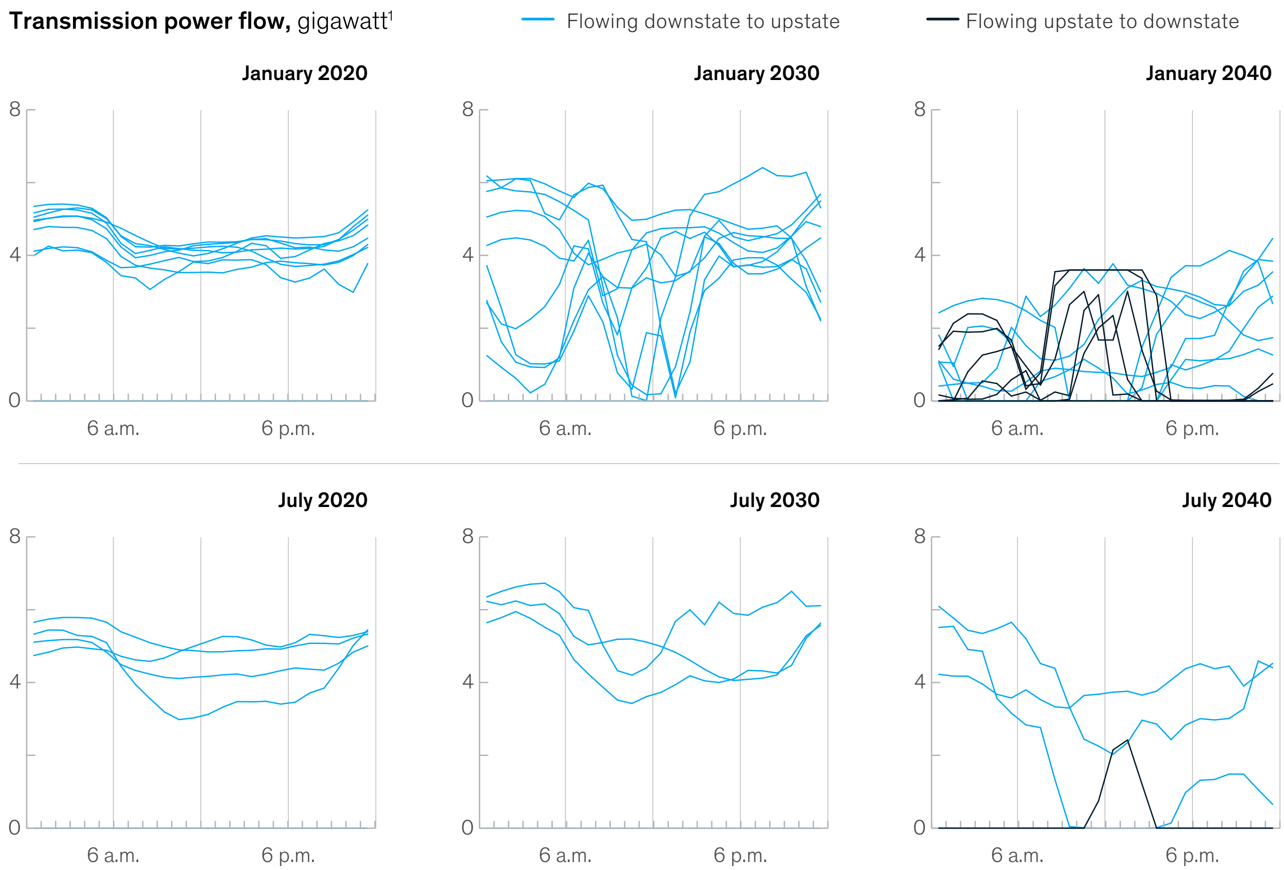
Transmission flows will reverse direction. Today, most hydro and four out of five nuclear plants are upstate,[3] and there is a steady flow south of about five GW. In the future, downstate will likely account for relatively more offshore-wind and distributed-solar generation. By 2030, those north-to-south flows could sometimes be nearer to zero, and eventually, the flow could reverse to reflect the different configuration of the supply (Exhibit 5). If that happens, there will need to be upgrades to the grid, and changes to how the network is operated. This effect will likely be more pronounced in winter, when offshore-wind assets located downstate produce more power and utility-scale-solar assets located upstate produces less.

Transmission and distribution networks will need to adapt. By 2040, our model suggests 17 GW of offshore-wind assets, 11 GW of onshore-wind

[3] New York Independent System Operator defines "upstate" as zones A through E and defines "downstate" as zones F through K. *Reliability and a greener grid: Power trends 2019*, New York Independent System Operator, May 2, 2019, nyiso.com.

Exhibit 5

The flow of power in New York State will become more erratic, or even reverse course, particularly in winter.



[1] Each line represents a single day.

assets, and 23 GW of utility-scale-solar assets will need to be connected to the grid, sometimes over long distances, to meet the state's goals. Those estimates are well above the state's targets. Getting there will require major investments and operational improvements in transmission grids. Distribution grids will also need to be expanded and modernized to absorb the increased demand from electric vehicles and building heat, and to deal with new ways of actively managing that demand.

Managing demand will likely become more important. Building a cost-effective power system requires smoothing out the peaks and valleys of demand. In a future in which the greater use of clean power increases the intermittency of the power supply, that will mean implementing effective demand response and load-shifting programs that incentivize consumers to curb their use of power when needed to balance the grid. As more EVs hit the road, vehicle-to-grid approaches could play an increasingly important role as EV users and charging stations work with utilities to manage demand. For example, when renewables generation is low, a signal could be sent to EV owners to stop charging; they could be paid for cooperation. Moreover, it is possible to sell excess energy stored in EV batteries back to the grid. There are a few vehicle-to-grid projects, but working out the most effective market mechanisms is going to be difficult.

The transition will require investment. The costs of both wind and solar have dropped sharply over the past decade; in fact, they are widely expected to become the cheapest sources of new power generation. Even so, the need for backup capacity to compensate for their intermittency, the build-out of grids, the replacement of existing conventional infrastructure, and the electrification of heat and transport will not come cheap. We estimate that new generation and storage—and associated transmission interconnects—alone could cost an additional $30 billion[4] through 2040, compared with a system without any decarbonization targets. How these costs are borne will have implications for the economy, social equity, and politics.

Conclusion

In broad terms, to achieve its clean-power and decarbonization targets by 2040, New York State is betting on nonhydro renewables to cover all new demand as well as replacing the electricity now generated from the Indian Point nuclear plant and most fossil fuels. This will not be easy, but experience elsewhere suggests it is not impossible. For instance, the United Kingdom has installed about 8 GW of offshore wind over the past decade, not far from what New York State wants to do. (Britain's goal is 30 GW by 2030.) Texas has 22.5 GW of onshore wind, compared to the 11 GW that our model suggests New York State would need to add by 2030. And New York State itself shows the possibilities: installed solar capacity has risen more than tenfold since 2012.

It is fair to say that New York State is generally ahead of the American pack, in the depth and speed of its plans to decarbonize. But it is also fair to say that its clean-power journey has barely begun. The long-term target—100 percent clean power by 2040—is aspirational, not inevitable. Given the degree of cross-sector coordination that will be required, the interim targets that are not far off, and the bets that need to be placed on technology, delay could imperil the state's ability to achieve its goals.

Although our model looks specifically at New York State, we believe the insights could be relevant to other markets looking to decarbonize. The European Union has ambitious decarbonization goals, a large base of hydropower, and a strong reliance on natural gas. Australia plans to continue introducing renewable power and storage, and has proposals for new pumped hydro. However, much of its power sector still relies on coal. China is building more solar, nuclear, and natural-gas generation, diversifying from its legacy base of coal power. None of these markets look much alike. As in New York State, however, all of them will likely face a similar set of challenges as they navigate the changing energy landscape, such as figuring out the role of natural gas, balancing the intermittency of renewables, adapting existing infrastructure, and managing the growth of electrification.

[4] The $30 billion refers to the capital cost to expand and upgrade the power-generation and -transmission system, minus the capital and fuel cost to operate and maintain the system in the absence of decarbonization and clean-power targets. The $30 billion estimate does not include the cost of electric vehicles and charging infrastructure, heat pumps, or upgrades to power-distribution grids.

Rory Clune is a partner in McKinsey's Boston office, **Jesse Noffsinger** is a service line manager of CleanTech in the Seattle office, and **Humayun Tai** is a senior partner in the New York office.

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