Electric Power & Natural Gas Practice

Analytics for grid decision making

The energy transition will make grid planning and operations increasingly challenging for transmission and distribution operators.

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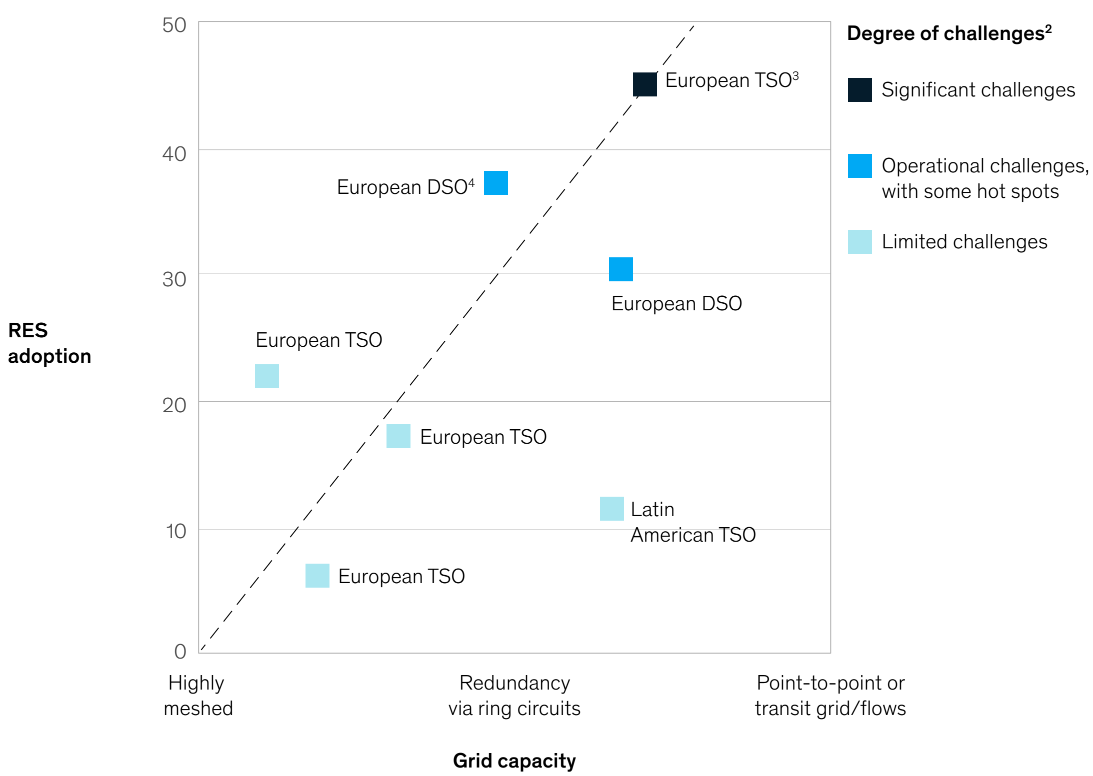
The days of predictable power flows on transmission and distribution grids are now in the past, putting pressure on the planning of grid upgrades (capital expenditures) and outages for maintenance (operating expenditures). The rapid increase in solar and wind feed ins coupled with the shutdown of conventional power plants and changing load patterns (for instance, from electric vehicles) make power flows less predictable. In turn, it is harder for grid operators to determine where grid upgrades (capital expenditures) are necessary and which operational changes are required to secure the necessary outage slots and deliver on their committed preventive-maintenance programs (operating expenditures).

This is a challenge that many transmission and distribution grid operators already face today. In a recent benchmarking exercise with global grid operators, 70 percent of respondents report that they expect an increase in issues, such as the frequent cancellation of outages on short notice and the curtailment of renewable generation. The degree of difficulty that these operators perceive is closely linked to renewable penetration in their markets and the capacity of their grids (Exhibit 1). Highly meshed grids typically have a higher tolerance for accommodating unpredictable renewable feed ins, while in areas with limited grid redundancy, the operators experience challenges at lower adoption levels. Some of the transmission and distribution grid

Exhibit 1

Challenges for grid operators are mainly driven by renewable-energy-source adoption and grid capacity.

Renewable-energy-source (RES) adoption[1] vs grid capacity



[1] % of total annual renewable production of total annual consumption.
[2] Measured in outages canceled and RES-curtailment volume.
[3] Transmission system operator.
[4] Distribution system operator.

Source: McKinsey TSO/DSO Benchmarking Study, 2018 operators at the forefront of the energy transition need to cancel 10 to 20 percent of outages on a short notice, or they run the risk of curtailing renewables and incurring higher operations and maintenance costs than budgeted. The rapid increase in renewable generation is not the only driver that can affect these results. Other contributing factors include aging assets, decentralized production, increase in electric-vehicle penetration, and the trend of electrification, such as power to heat (especially for distribution operators).

There is no universal, one-size-fits-all solution. Problems are local and require tailored approaches.

Many transmission and distribution grid operators are already experimenting with different solutions to overcome these challenges. For example, some grid operators are becoming more agile in outage planning and execution, while others are shortening outage durations by shifting maintenance work to nights and weekends or by investing more in grid upgrades and smart-grid technologies. Most grid operators are applying an assortment of measures based on the challenges and costs that come with mitigation.

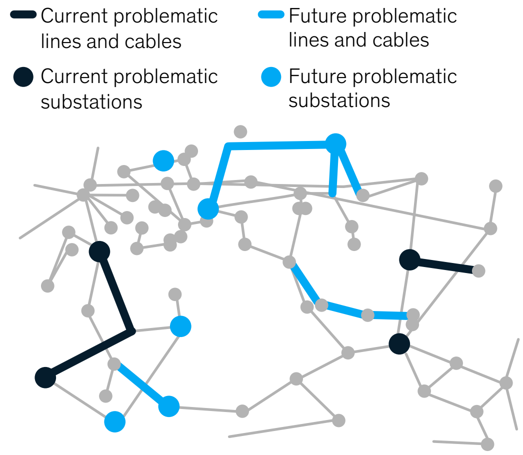
Operators need to find the appropriate nuanced approach by using a set of measures that prevents over- and underinvesting. Overinvesting would be a case in which a grid operator makes grid upgrades instead of using operational measures that might be more efficient. Underinvesting would be a case in which grid operators do not invest capital expenditures and try to solve the problem with low capital-expenditure-intensive solutions, such as agile outage planning—however, these do not achieve enough and pose the risk of not meeting demand or curtailing supply.

Moreover, the problems typically differ in different parts of the grid and are very local (Exhibit 2). In some parts of the grid, it may be necessary to make grid upgrades and shorten the duration of outages by extending working hours. However, other regions might not be affected at all. It is hard to anticipate where the critical assets that will cause problems

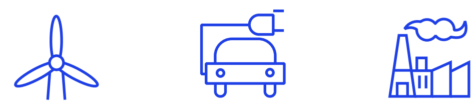
Exhibit 2

Problems typically vary in different parts of the grid and are local.

Transmission system operator, illustrative example



Expected future, illustrative example



Renewable capacity increases by >50%

Number of electric vehicles reaches ≥220,000 units

Conventional capacity is phased out

are located until customers and power producers in these regions of the grid are repeatedly affected and thus protest or take public action.

Implications for grid operators

It is essential for grid operators to answer a few questions before making large investments or changes to their operations:

— What are the future scenarios to prepare for (for example, with respect to renewable penetration, conventional-generation shutdowns, and load-pattern changes)?

— What is the impact of these scenarios on the grid? This can be expressed as the size and

Operators need to find an approach by using a set of measures that prevents over- and underinvesting.

urgency of measures, such as the ability to secure outages, the risk of not meeting local demand, and the risk of curtailing supply.

— What solutions can minimize the impact, and how much do they cost?

— How should we get organized to respond?

Several operators have found it challenging to establish and narrow down the set of possible future scenarios and to test different "stresses" on the grid in an iterative way. It is also important, in an industry undergoing significant change, to be mindful in calibrating the organization so its people and resources are stretched to reach goals but not strained beyond their limits.

How advanced-analytics approaches can help

Advanced-analytics approaches can help evaluate the impact of the energy transition on the grid across several forward-looking market scenarios.

One Western European transmission system operator used advanced analytics to evaluate a medium- to high-voltage grid. Its model considered more than 10,000 variables, including all grid assets, current and future generation capacities and their profiles, expected load distributions and their profiles, and import and export capacities. It ultimately simulated the impact of external events down to the asset level, and clarified risks of possible grid failures, value at stake, and possible solutions.

This approach complements existing grid development models in a few ways. Grid development models are not necessarily set up to link grid development to outage planning. They typically do not test packages of solutions across many scenarios. Finally, the number of future scenarios that can be run is limited by the complexity of these models and the computational power at hand—in this case, 40 million optimizations (Exhibit 3).

The problem can be diagnosed, solutions identified, and a road map created within a few months.

Bringing the organization on board to address the challenges and reaching buy-in typically involve three steps at the outset:

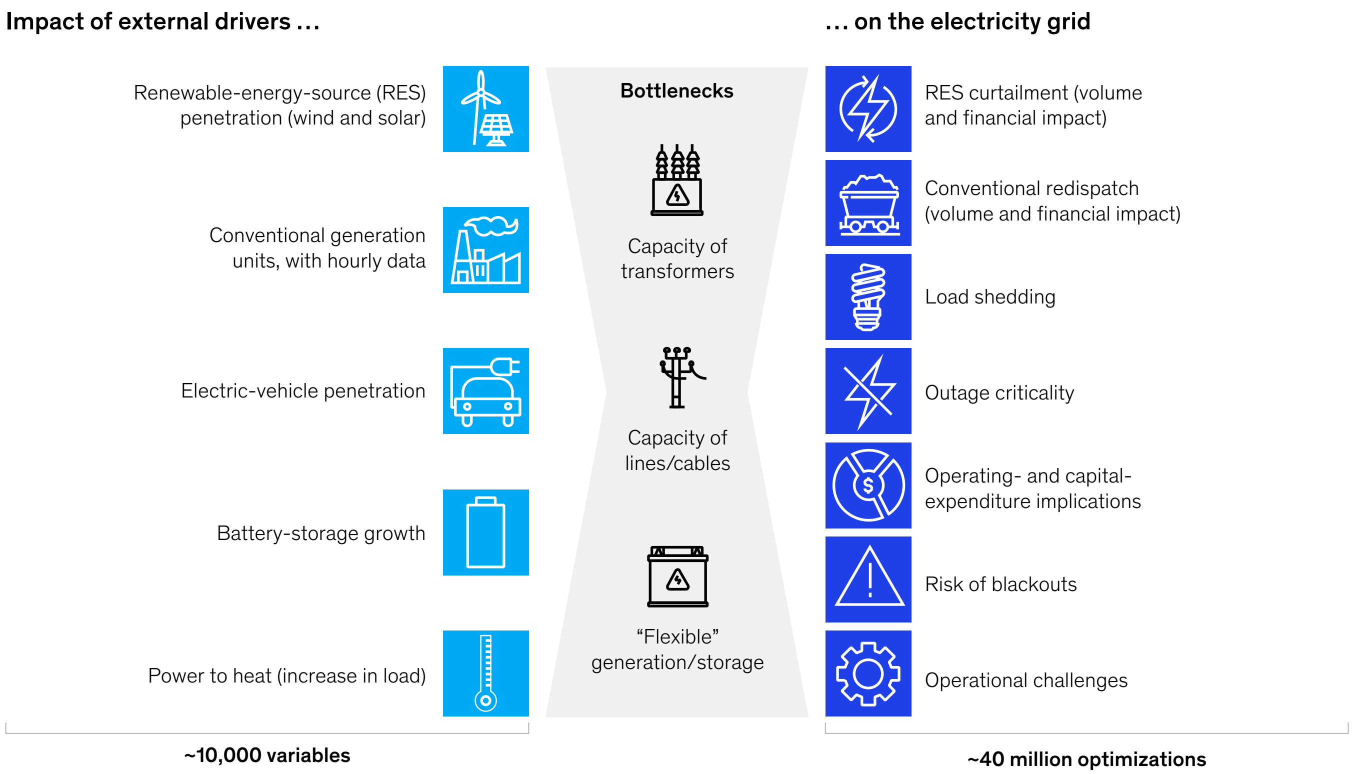
1. Lay out for top management and technical experts (such as system-operations experts and outage-planning engineers) the perspectives on the roots of the problem and potential future scenarios that will be modeled.

2. Once the preparation phase has been signed off on, build and run the model on an analytics platform. Keep experts closely involved to validate the resulting insights and ensure that they fit with the reality of the grid.

3. Define the appropriate solutions based on the challenges discovered in the second step. Such models can be used to define the impact of solutions on parts of the grid and to prioritize a set of solutions to take forward. Finding a simple way to share the findings and to inform internal stakeholders of the possible choices is an essential part of this process.

Exhibit 3

An advanced-analytics model for the power grid can illustrate the potential impact of many future scenarios.



Transmission and distribution grid operators require advanced-analytics capabilities to make effective strategic decisions in a fast-changing energy world. Just as important, they need these capabilities to convince their stakeholders—from the regulator to the public to the operator's own employees—that investments and operational changes are needed to prepare for future challenges.

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