Accenture's Digitally Enabled Grid Research Program

The charge for change

Powering distribution businesses for the energy transition

Begin

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Executive summary

The energy transition is an unstoppable force of disruption. It creates tremendous opportunities for distribution businesses in the utilities industry, but to the poorly prepared, it presents significant existential threats. Decarbonization is driving deep structural changes to how energy is generated and consumed, and significantly increases risks to distribution network management. Renewable energy sources will increasingly connect directly to distribution networks. We will see prosumers switch between dispatching and drawing power, depending on weather and market conditions. And while electric vehicles (EVs) and space heating create new load-growth opportunities, they could put huge strains on existing networks.

This presents unprecedented potential for distribution businesses to generate significant new value, although the opportunities will differ depending on region and regulatory model. They can expand their regulated asset base, in some cases create new products and services—including driving efficiency from the purchase of newly defined flexibility services—and collaborate more closely with other parts of the value chain. They can redefine the nature of network management by using data to drive operations, and create new, innovative roles for employees. But most of all they will be called on to continue their remit of delivering safe, affordable and reliable power to customers as the energy transition unfolds.

Some businesses—particularly in Europe—will reposition themselves as distribution system operators (DSOs). New regulatory and policy frameworks for low-carbon technologies are driving many of these changes, so greater collaboration between distribution businesses and regulators will be critical to help craft the role of distribution during this transformation.

But this change is not linear. Only so much distributed energy resources, or DER, can be deployed before a tipping point triggers significant disruption, resulting in a need for fundamental changes to operations and capital investment. Forecasting when this happens will be difficult. As Accenture analysis shows, uneven and accelerating deployments of low-carbon technologies threaten to rapidly advance such a tipping point.

The energy transition is already here, with tipping points that will be activated in the coming decade. The risks of doing nothing are significant, endangering a distribution business's operations, reputation and ability to comply with regulations. The critical issue: Distribution businesses find themselves ill-equipped to cope. What is needed is a new digital infrastructure that supports truly active grid management as the energy transition moves forward. This means fundamentally increasing visibility and control of the electricity network, connected DER and consumer participation.

Through this year's Digitally Enabled Grid research, including a survey of 250 distribution utility executives worldwide, we have identified four distinct areas underpinning distribution's digital transformation. The first sets the foundation for the rest, taking greatest advantage of existing data and creating a data architecture that supports the evolving response to the energy transition. The second extends core operational visibility and control, targeting grid-connected DER and the solutions needed to integrate it. In the third, IoT devices radically expand the scope of data for even greater visibility of the broader system. The fourth, toward the fully intelligent grid and enabled by cloud, edge computing, 5G, digital twins and platforms, enables near-real-time optimization of local assets, orchestrating grid automation, distributed generation (DG) and demand response.

Action is the imperative. What this looks like for each distribution business around the world will depend on many factors including region, industry structure, regulation and their current point in the energy transition journey. And there will be many lessons to be learned between businesses that will help accelerate the transformation for all.

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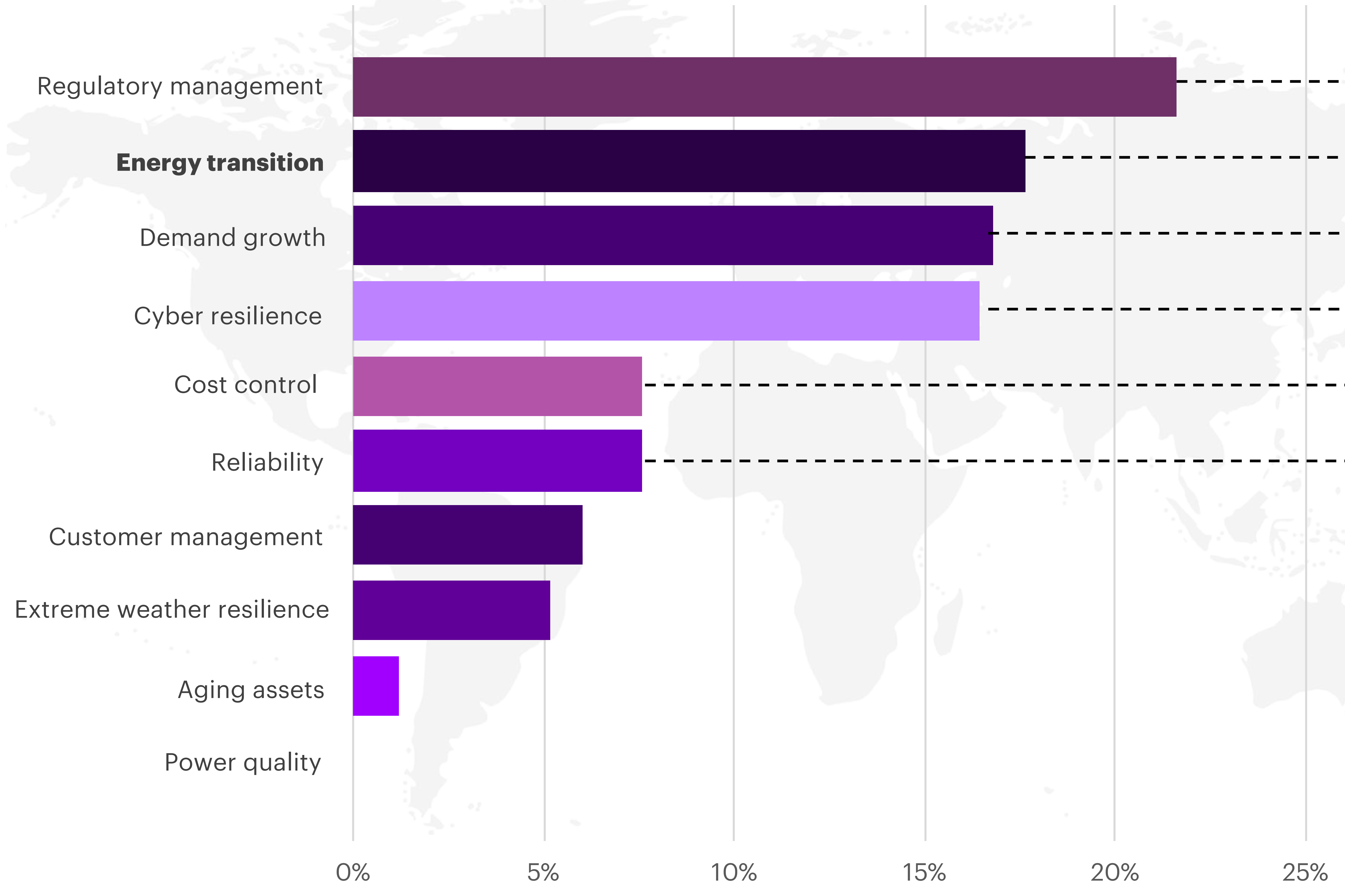
Evolving energy transition: Disruption at the door

Electricity markets are changing dramatically. Large, carbon-emitting, transmission-connected generation is being replaced by renewables, often as smaller, distribution-connected generation. The electrification of transport and building heating will significantly change both peak and total demand. The boundary between supply and demand is also blurring, with new prosumers producing and consuming power at different times of the day. This profound shift—the energy transition—will cause deep structural changes to investment in, and the operation of, distribution networks.

Such a dramatic change in focus redefines the roles of distribution businesses and the regulatory framework under which they operate. Unsurprisingly, these issues—alongside increasing cybersecurity threats—are the primary challenges facing distribution businesses (see Figure 1).

Figure 1. The energy transition ranks among the top challenges for distribution utility executives.

What are the top challenges for your distribution business over the next three years? Top challenge of three, global dataset:



Regional Breakdown

North America	Europe	Asia-Pacific	Latin America
20%	19%	22%	33%
14%	21%	24%	
			33%
19%	11%	22%	
			13%
	11%		

Global, top priority (n=250)

Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

External trends creating an unrelenting force

The energy transition is driven by six, interlinked external trends that will have fundamental, lasting consequences on electricity distribution (see Figure 2).

Energy decarbonization has led to rapid growth in the use of grid-scale renewables, creating major challenges for distribution to connect new sources of variable generation while maintaining system reliability and power quality. Distributed energy resources (DER), including grid-connected storage, have the potential to profoundly change the way distribution grids are designed and operated. The growing wave of small-scale generation and energy storage provide new options for energy customers, generators and grid operators to optimize supply and demand.

The electrification of transport could cause residential customers' annual power demand to double, putting pressure on networks not designed for such loads. The electrification of space heating will also drive huge peak demand, particularly in colder climates. Conversely, ongoing commercial and residential energy-efficiency programs are set to reduce energy intensity, potentially making load curves even peakier.

Consumers' environmental concerns and more active participation are driving demand for cleaner energy and improved energy efficiency. As our 2020 New Energy Consumer report noted, the customer at the end of the value chain has become a cornerstone for energy transition—and the interest to engage is clear.[1] Distribution businesses will be under pressure to support consumers and retail businesses, depending on region, with the capacity to deploy prosumer PV and storage. They may also need to provide access to data to support conservation and new services such as demand response and virtual power plants (VPP) to allow them to optimize their assets.

Figure 2. Six key external trends are driving the energy transition.

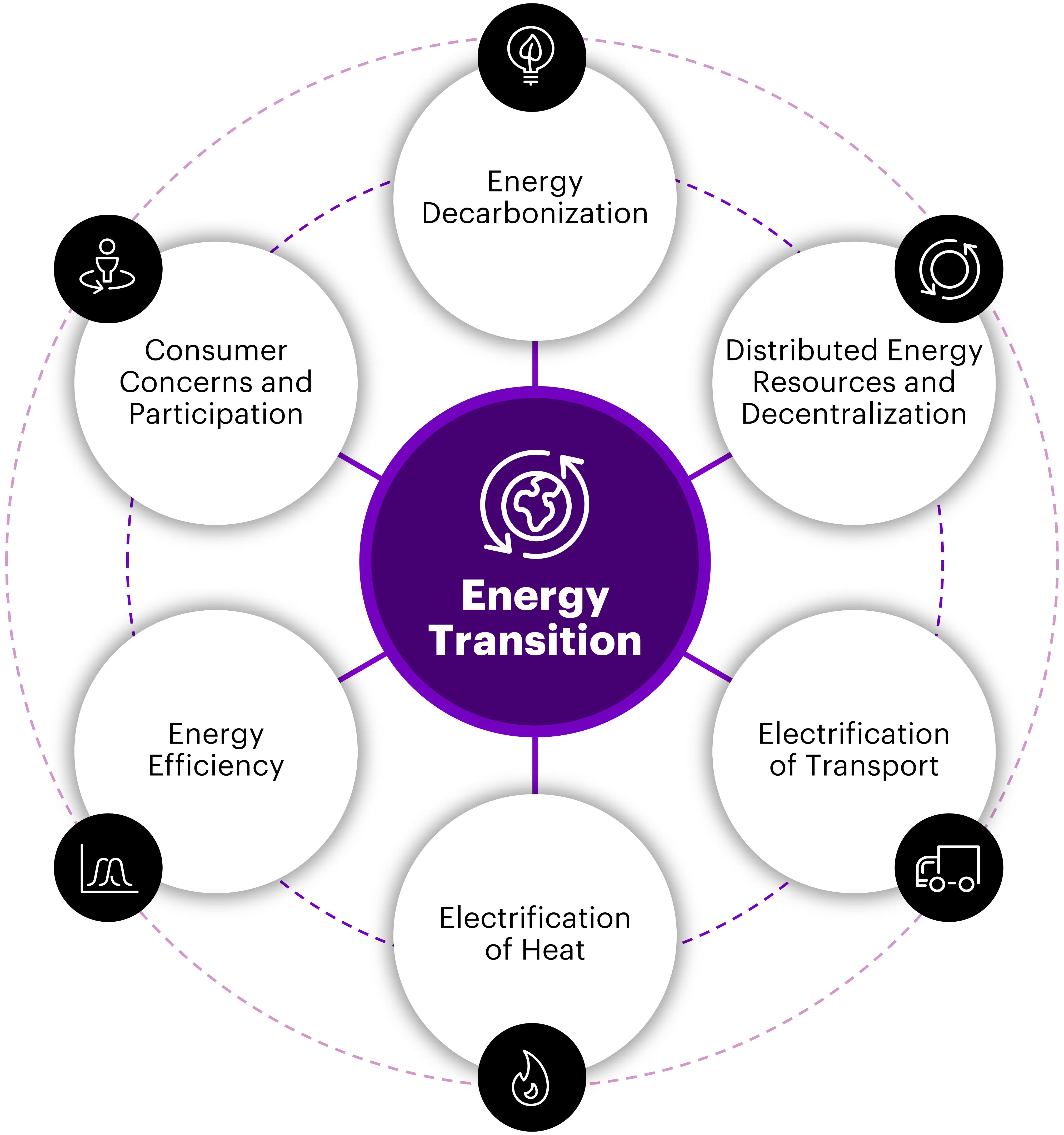
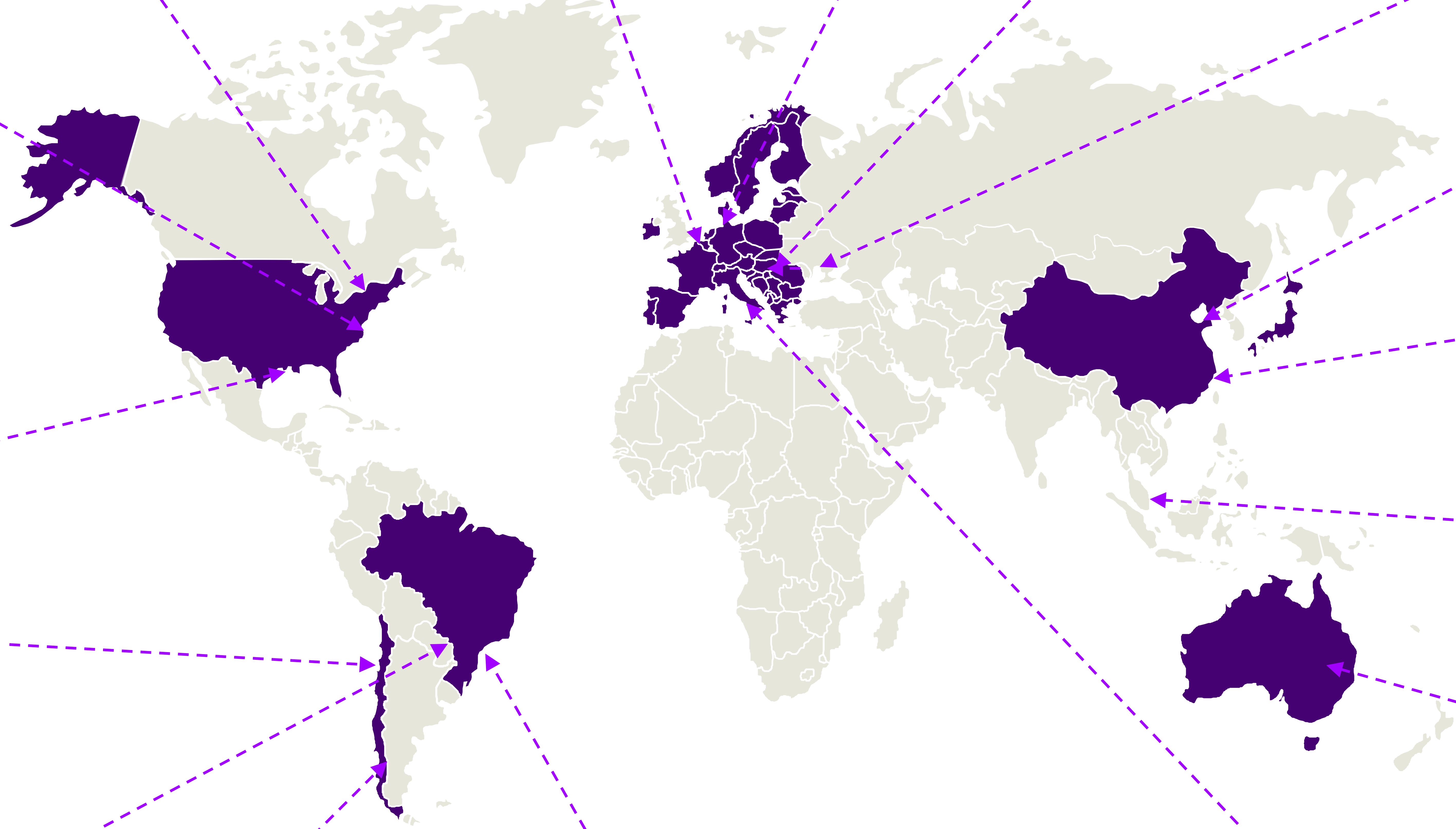


Figure 3. Examples of policy, technology and customer contributions to the tipping point globally.



Renewables acceleration
Additional offshore wind planned along the U.S. East Coast; initial steps in process to approve a wind farm off the N.J. coast as part of an effort to generate electricity for more than 10 million homes by 2030.

Electrification of transport
In January 2021, the New York governor announced initiatives to increase the number of electric buses in the state. Plans include $16.4 million in incentives for transit buses, and $2.5 million for school buses.

Electrification of space and water heating
San Francisco passes an ordinance, effective from June 1, 2021, requiring all-electric new construction of residential and commercial buildings.

Distributed energy resources
In Texas, rooftops solar panels, potentially backed by batteries, may become more common in 2021, as homeowners seek independence from the grid during freak weather events.

Electrification of transport
Chile is encouraging taxi owners to switch to EVs. The program makes financing available toward acquisition of an electric taxi, installation of a home charging station and technical vehicle support for one year.

Renewables acceleration
In 2020, Brazil gave the go-ahead to 2,519 MW of wind and solar farms to commence operations. Wind parks accounted for 1,725.8 MW or 34.9% of that amount and solar plants 793.2 MW.

Distributed energy resources
In January 2021, the EU approved €2.9 billion state aid for a Pan-European R&I project along the entire battery value chain. The project, "European Battery Innovation," is expected to be completed by 2028.

Revolution in energy efficiency
Chile passes the Energy Efficiency Law aimed at a 10% reduction in consumption by 2030, compared to 2019

Renewables acceleration
In December 2020, EU member states agreed to raise the 2030 emission reduction target from 40% to at least 55%, which implies to significantly scale the renewables generation.

Distributed energy resources
Brazil's installed capacity of mini and micro distributed generation is estimated to grow to between 16.8 GW and 24.5 GW by 2030.

Electrification of transport
In March 2021, Germany announced it will provide €5.5 billion of funding for EV charging infrastructure. The funds will be offered until 2024.

Electrification of space and water heating
As of January 1, 2021, no new fossil fuel heating system should be installed in new buildings constructed in the EU.

Consumer lifestyle
In 2020, 60% of energy consumers Accenture surveyed in key European countries are more aware of climate change and its environmental impact since the COVID-19 outbreak. 50% are likely to invest more in energy efficiency today than before the pandemic.

Renewables acceleration
Chinese National Energy Administration announced total wind and solar capacity additions of 120 GW in 2020.

Electrification of transport
China's EV assemblers and battery producers are setting a new goal in their battle for leadership in the world's largest vehicle market—a driving range of up to 1,000 km on a single charge.

Revolution in energy efficiency
In Singapore, all new buildings with a gross floor area of 2,000 sq. meters and above must be 50% more energy efficient than the 2005 baseline. This will apply to new developments submitted for planning approval from Q4 2021.

Distributed energy resources
Australia deployed 2.6 GW of rooftop PV in 2020 and added almost 340,000 installations to the grid.

Sources: "Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs," The White House, March 29, 2021, https://www.whitehouse.gov; "Council agrees on full general approach on European climate law proposal," Council of the EU press release, December 17, 2020, https://www.consilium.europa.eu; "ANEEL ultrapassa em mais de 800 MW a meta de expansão da geração em 2020," ANEEL, January 5, 2021, https://www.aneel.gov.br; "National Energy Administration releases 2020 national power industry statistics," China's National Energy Administration, January 20, 2021, http://www.nea.gov.cn; "Lone Star Solar: Challenges and Opportunities in Post-Blackout Texas," JDSUPRA Business Advisor, April 6, 2021, Factiva, Inc. All Rights Reserved; "Statement by Executive Vice President Vestager on approval of EUR2.9 billion public support by twelve Member States for a second pan-European research and innovation project along the entire battery value chain," ENP Newswire, January 27, 2021, Factiva, Inc. All Rights Reserved; "Generación distribuida de Brasil crecería 50% este año," Business News Americas, February 4, 2021, Factiva, Inc. All Rights Reserved; "Australian Energy Council: New data shows solar shines despite lockdowns," Contify Energy News, February 4, 2021, Factiva, Inc. All Rights Reserved; "NYSERDA: Governor Cuomo Announces Initiatives to Electrify Transit Buses, Boosting Access to Clean Transportation and Building Healthier Communities," Contify Energy News, December 29, 2020, Factiva, Inc. All Rights Reserved; "Scholz: Clear signal for climate action and digitalization – German Recovery and Resilience Plan adopted," Federal Ministry of Finance, April 27, 2021, https://www.bundesfinanzministerium.de; "Energy efficiency law passed in Chile." Arabian-Business.com, January 13, 2021, Factiva, Inc. All Rights Reserved; "Chile launches a taxi electric vehicle exchange programme," The New Dawn, January 21, 2021, Factiva, Inc. All Rights Reserved; "China EV battery race: Tesla's rivals join NIO in efforts to achieve 1,000 km driving range on single charge target," South China Morning Post, January 20, 2021, Factiva, Inc. All Rights Reserved; All-Electric New Construction Ordinance, City and County of San Francisco, Department of Building Inspection, https://sfdbi.org; "Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU," European Commission, November 2019, https://ec.europa.eu; "Tighter energy-efficiency standards for all new buildings seeking planning approval from year-end." The Straits Times. March 4, 2021, Factiva, Inc. All Rights Reserved; New Energy Consumer: Delivering new energy experiences for future growth, Accenture 2020, www.accenture.com. All Factiva articles accessed May 11, 2021.

Avenues for future growth

The energy transition presents a unique opportunity for distribution utilities to refigure their businesses and provide the basis for sustainable growth. There will be significant potential—regulators permitting—to grow the existing regulated asset base (RAB). But the possibilities extend well beyond existing business models. New assets and services are already being developed, in the distribution business and alongside other parts of the value chain. The energy transition creates new demand-driven value pools within retail energy markets, including eMobility-related services, energy efficiency and energy management, and consumer generation and storage,[2] but these cannot be delivered without distribution businesses. The evolving energy consumer is at the heart of this transition, and distribution plays a critical role supporting the development of strategic plays that capture this value.

There are also opportunities for business improvement (see Figure 4). Digitalization required to manage the increasingly decentralized grid will deliver value across distribution businesses. It is the prime accelerator to building the distribution utility of the future and the glue that binds it together. But technology alone will not deliver this vision. A new employee experience is equally vital. Distribution businesses will need to transform their working environment and attract and retain new talent with new skills such as data scientists. However, the industry often struggles to attract such new recruits. According to one Accenture survey, in the United States alone, more than three-quarters of surveyed utilities report difficulty hiring new employees.[3]

The reason: Negative perceptions of the utilities industry, including a lack of room for career growth, a slow-moving culture and a view of the industry as unexciting. The energy transition offers one way to change this perception. The practical involvement in measures to address climate change can be very compelling, particularly for younger candidates.

Most importantly, the shift from centralized generation to distributed generation, or DG, puts distribution networks at the center of the electricity system, with new roles managing the major impacts on wholesale generation portfolios and system ancillary services. For example, some distribution utilities are starting to pilot the sale of balancing services to the transmission system operator (TSO) to support system stability. Indeed, as DG penetration grows, active operation of the distribution system and the connected DER will become vital for stability.

In August 2019 in Great Britain, 1,400 MW of transmission-connected generation was lost due to lightning strikes and near simultaneous technical issues on two large generation stations. In response to the faults, over 1,300 MW of DG also automatically disconnected from the system, making system stabilization by the TSO impossible.[4] This highlights the importance increased visibility and control of DG, as well as enhanced communication between TSOs and distribution, will have as the energy transition forges ahead. According to the World Economic Forum, the path to maximizing system value is about supporting policymakers, businesses and customers to understand where they sit now, and where they need to be next.[5] In the increasingly electrified world, distribution is strategically vital.

Figure 4. Select capability improvements driven from the energy transition.

Grow the existing regulatory asset base	Develop new assets and services in distribution and beyond	Support data-driven performance improvement	Reinvent the employee experience	Deliver system value
• Connection and reinforcement for DG • General reinforcement to support demand growth (such as EVs) • Both of these increase a utility's RAB • There may be an issue if regulators limit RAG growth	• Extend business into grid-connected storage, EV charging infrastucture and flexibility platforms, where applicable • Support development of new retail-focused offerings: energy efficiency, energy management, DG, storage and eMobility	• Grid reliability improvements • More accurately identify technical and non-technical losses • Deliver more effective responses to extreme weather events • Improve cyber resilience	• Transform employees' skillset and attract new recruits • Introduce continuous learning • Improve workforce engagement • Foster innovation • Encourage creative thinking • Improve data analytics skills	• Distribution networks sit at the heart of the future energy system • System value delivers the energy transition's economic, environmental, social and technical value

The critical need for increased flexibility

Distribution utilities are required to deliver sufficient capacity to meet all users' needs, while supporting the system stability actions of TSOs. Traditionally, capacity is delivered through grid reinforcement—increasing the capacity of transformers, cables and overhead lines. In the energy transition, protection systems must also be modified to meet the new operating characteristics forced by pervasive DER. While reinforcement has advantages—it relies on well-understood technology and grows the utility's asset base—DER integration at speed requires a broader approach.

To respond effectively in this new environment, distribution businesses will need to develop a range of tools to forecast and manage capacity, reliability and quality challenges. While traditional reinforcement will be important, 94% of utility executives in our survey said that deploying innovative, lower capital-intensity non-wire solutions will be key in delivering the energy transition at speed.

The deployment of non-wire, flexibility solutions provides tools to help to solve local issues at speed, such as through response, DG output flexing and services from strategically sited grid-connected storage. This will allow distribution businesses to balance the provision of capacity by active management of the grid, DG and user demand, along with capital reinforcement investment directed at key locations on the grid. In particular, such flexible approaches can offer an interim solution, allowing low-carbon technology deployment in the short term, with reinforcement following on some years later when project logistics and economics are most favorable. One distribution model based on applying growing flexibility to deliver a more effective response to the energy transition is the distribution system operator (DSO) model (see sidebar on page 11).

94% of utility executives in our survey said that deploying innovative, lower capital intensity non-wire solutions will be key in delivering the energy transition at speed.

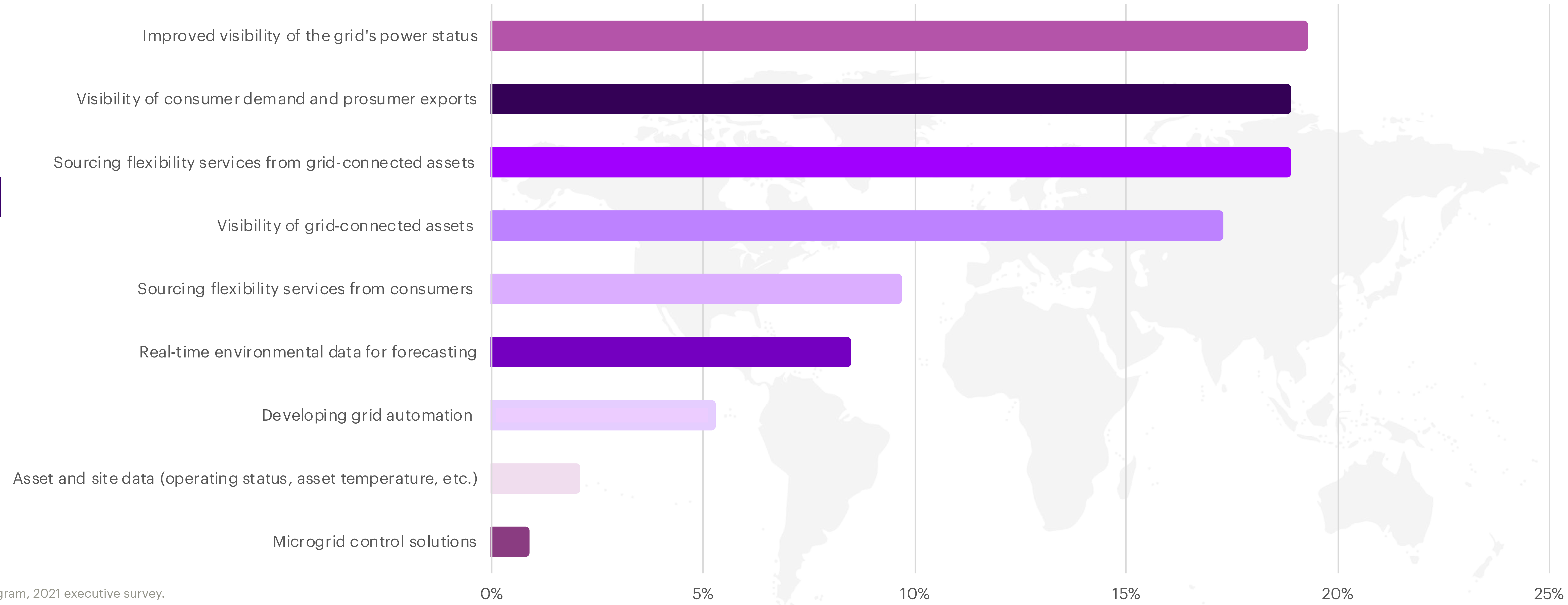
Sidebar: **Flexing the distribution system**

Flexibility includes a range of capabilities to actively modify supply or demand, such as grid reconfiguration control of DG, DER and demand-side response that can be deployed to complement traditional approaches to managing the grid. The development of flexibility is founded on improved visibility of the grid, connected energy assets and demand. When asked about delivering increased flexibility, our survey respondents indicated that three of the top four highest priority areas relate to visibility: the grid's power status, consumer demand and prosumer exports, and grid-connected assets (see Figure 5).

Figure 5. Distribution executives' priority areas for delivering flexibility are focused on improving visibility.

What are the priority area for delivering increased flexibility into distribution operations over the next five years? Global dataset:

Global, top priority (n=250)



Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

Sidebar: **The DSO of the future model**

In some geographies, such as the EU, the United Kingdom and some U.S. states including New York, regulatory changes progressively squeeze value from the traditional asset-ownership distribution business model. The more regulated returns on assets decrease, the more compelling the case to swiftly transition to a different role. One option is to become a DSO focused on enabling flexibility and optimization across the grid, with a reduced focus on the value of asset ownership and in-house delivery of capital programs and maintenance works. Taken even further, the distribution utility could evolve into an energy platform-based business. These could crack open a range of new business models, based on the control of energy flows and acting as the key data facilitator for the electricity system. At some point, there could even be further transformation from being a company enabled by technology to being a true technology company.

Responsibilities of the DSO

The new DSO model focuses on the innovative, cost-effective delivery of the energy transition. Two key principles driving this approach are system-wide efficiency and amplifying choice at speed to all users.

Implications for the DSO of the future

The DSO of the future will represent a significant transformation of the existing model, extending responsibilities and services comprehensively compared to the traditional model. However, this evolution will be progressive, where new capabilities such as flexibility sourcing are developed in conjunction with the enhancement of existing capabilities like asset management and system operations.

The regulator plays a pivotal role in this journey, and developing an overall DSO vision and supporting regulatory model. Key elements include the appropriate support for output-based regulation and non-wire solutions, stimulation of innovation and making sure the regulatory framework incentivizes the investment required to transform the system.

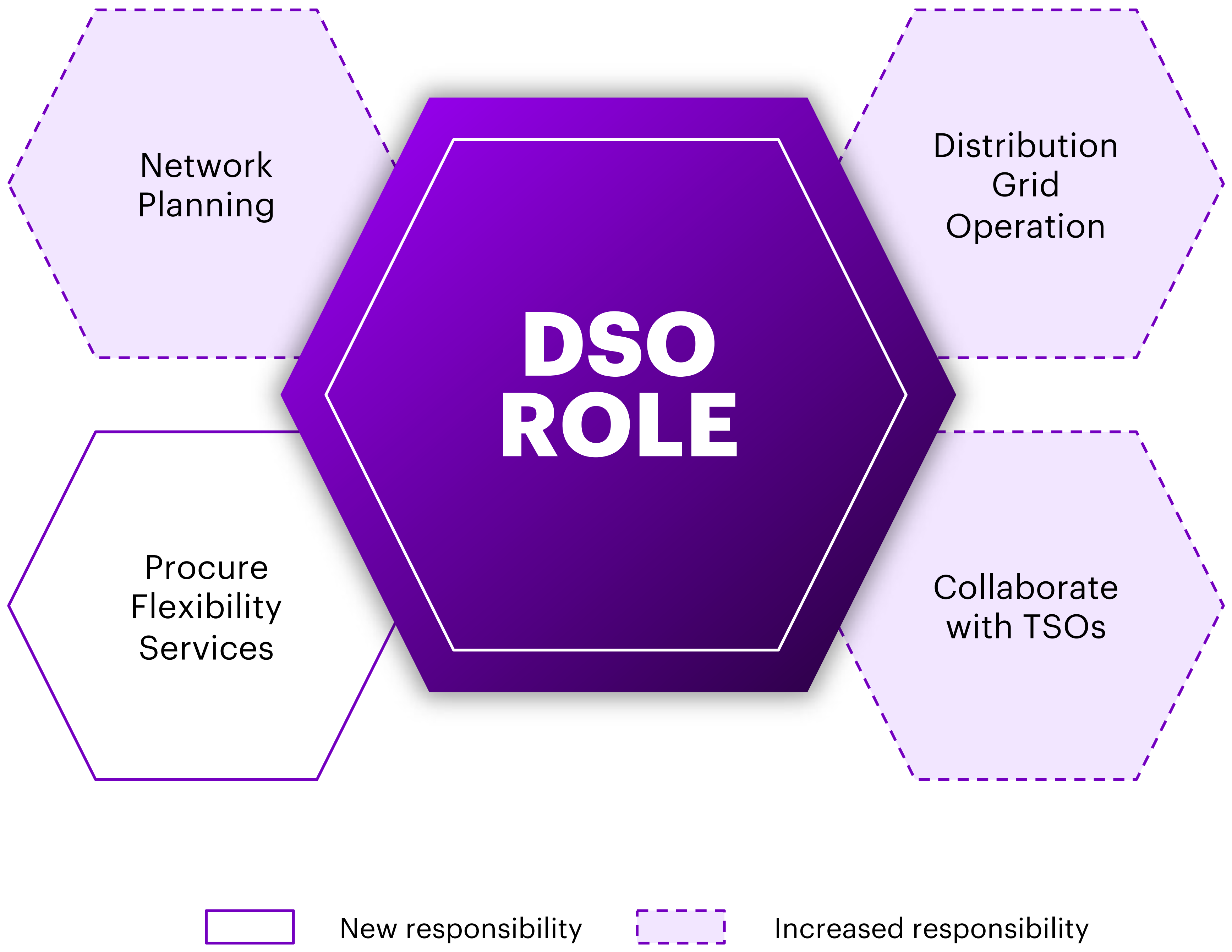
While this DSO model will not be be fully appropriate for all types of distribution utility or region, there are applicable aspects irrespective of industry structure or regulatory model.

Sidebar: **The DSO of the future model**

Figure 6. New and increased responsibilities of the DSO.

- Support the integration of distributed generation, facilitate the development of energy storage facilities and electrification of transport and heating
- Prepare a detailed distribution network development plan regularly (two to three years)
- Collaborate with the relevant system users and TSOs on the development plan definition

- Procure ancillary services with transparent, non-discriminatory and market-based procedures
- Ensure the effective participation of all qualified market participants, including distributed generation, storage and demand response when procuring services



- Include flexibility solutions as an alternative to system expansion
- Define the specifications for the flexibility services procured
- Procure flexibility services, including congestion management through a separate market mechanism

- Cooperate with TSOs to achieve coordinated access to resources such as distributed generation, energy storage or demand response to support distribution and transmission needs
- Exchange all necessary information with TSOs to ensure the optimal usage of resources

02

Energy transition tipping points

Up to a point, the energy transition will progressively strain traditional, passively operated networks but not cause major operational difficulties. However, existing networks can only cope with limited change. Distribution networks were never designed for DG, widespread electrified transport and heating, or highly active consumers and prosumers.

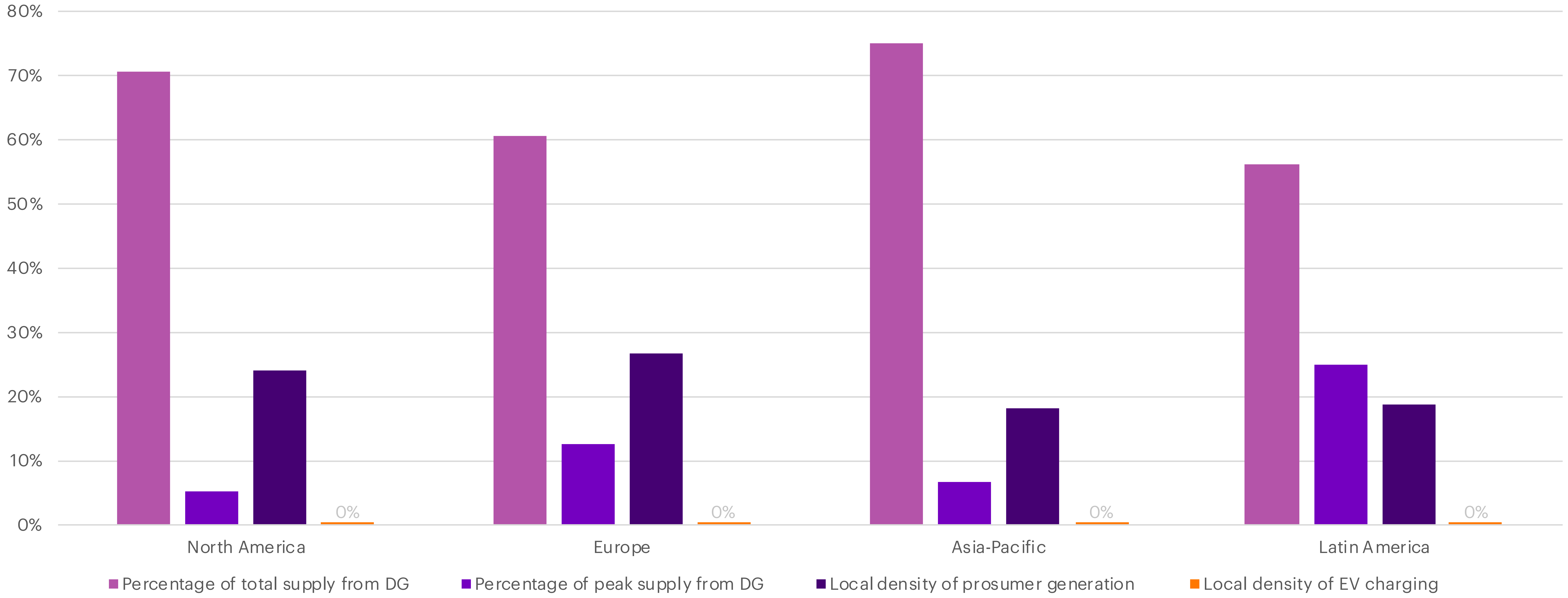
At some point the traditional operating paradigm becomes untenable and major changes are required. More than three-quarters of utility executives (78%) said they expect the energy transition to trigger such a tipping point, after which distribution operations will be significantly impacted and capital investment required.

Globally, the majority of respondents believe this tipping point will be caused by the growth in total supply provided by grid-connected DG (see Figure 7).

The amount of total supply from DG required to trigger the tipping point varies significantly by region (see Figure 8). In Europe and the United States, the majority believe it will be triggered when 30% to 40% of supply comes from DG. In Asia-Pacific and Latin America, it is higher. However, other than in the United States, there is no real consensus over this percentage. The breadth of the results highlights important differences between distribution businesses' expectations of their underlying network hosting capacities for DG.

Figure 7. Globally, executives see the percentage of supply from distributed generation as a clear key trigger for the tipping point.

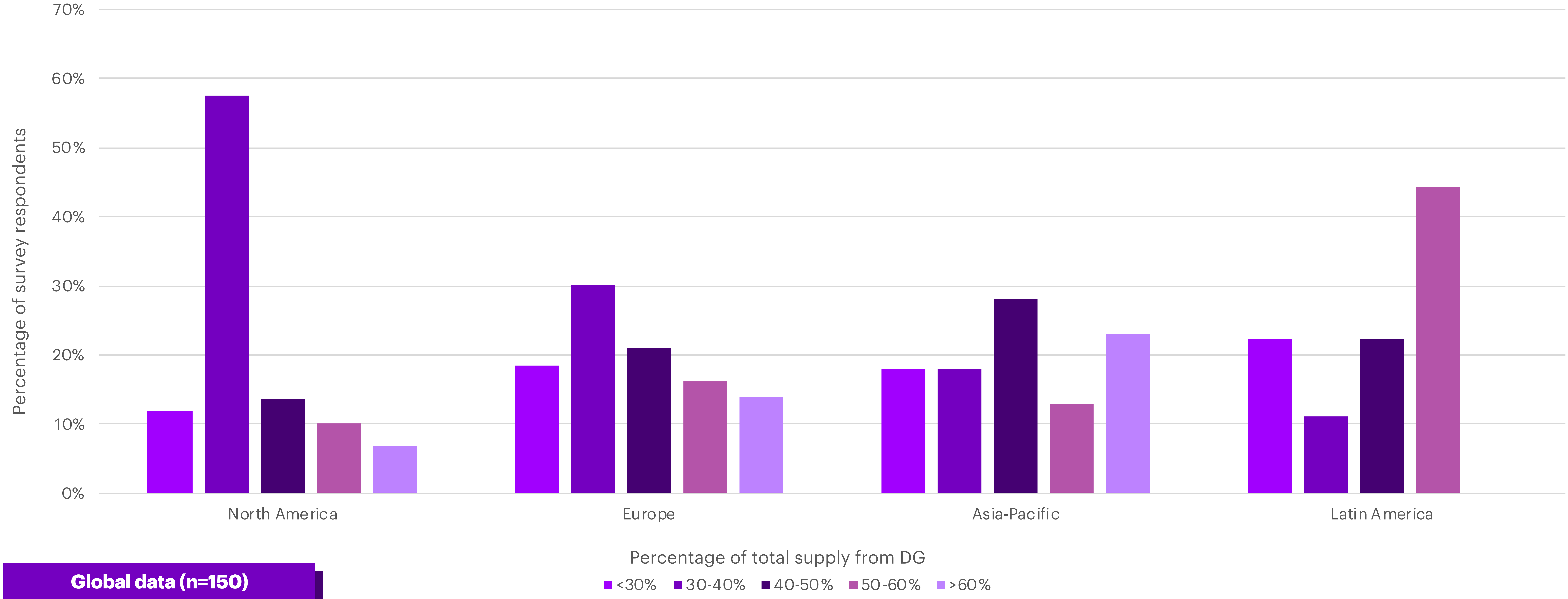
Which of the following areas would you expect to be key triggers for the tipping point in your geography?



Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

Figure 8. The amount of total supply from DG required to trigger the tipping point varies significantly by region.

At what approvimate percentage of total supply from DG would the tipping point be triggered?



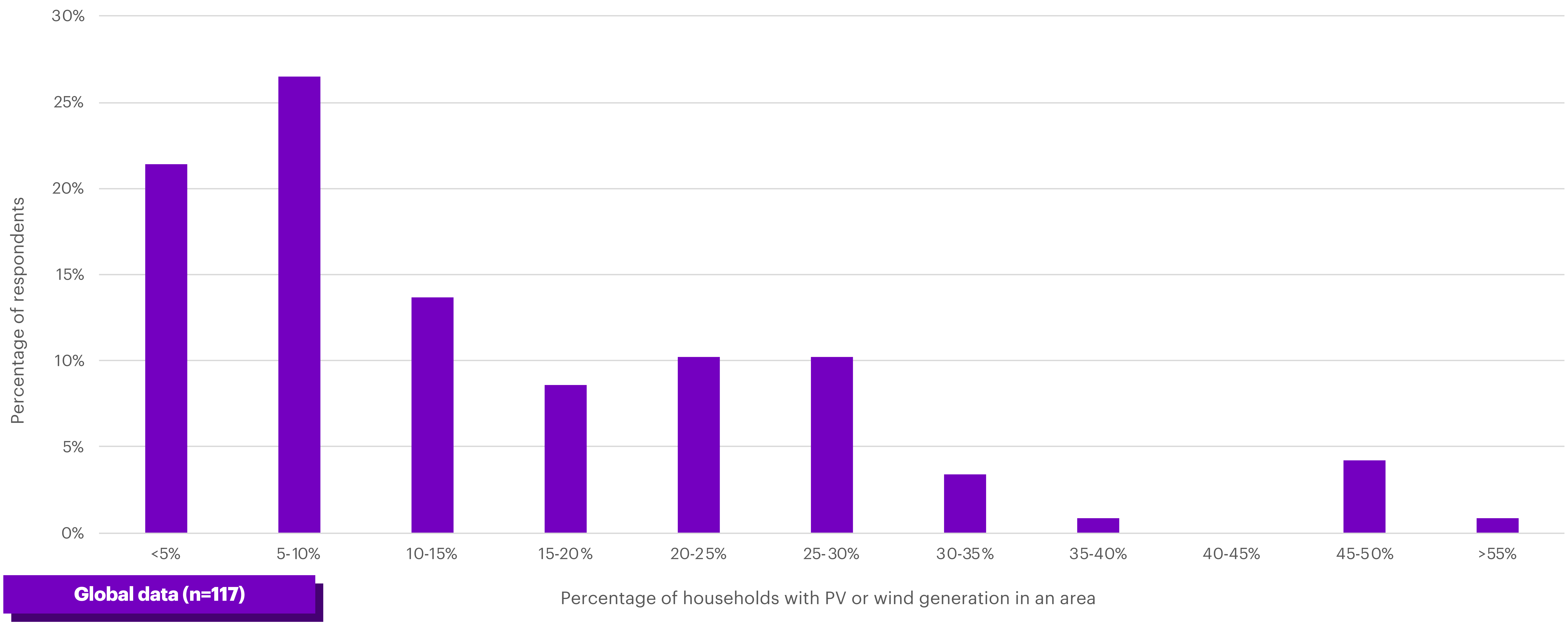
Global data (n=150)

Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

The percentage of households with prosumer DG is the second-most important tipping point trigger. Prosumer DG is noteworthy, as our respondents believe much lower densities of prosumer DG will tip the scales, (see Figure 9). Almost half (48%) of respondents believe the tipping point would be triggered by deployment of 10% or less in a particular area. Experience of countries with high prosumer PV penetration demonstrates that localized deployment of 10% has been easily achieved within a year in the past. Regulatory changes, generous subsidies, further PV cost reductions or the development of new retail products could all accelerate prosumer deployment, and rapidly bring distribution utilities to a dangerous watershed that puts system reliability at risk.

Figure 9. Executives believe that much lower densities of prosumer DG will tip the scales.

What approximate percentage of households with DG in a particular area would trigger the tipping point?



Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

The dynamics of low-carbon technology deployment

Responding to the energy transition means preparing for the imminent arrival of these tipping points. The many unique deployment characteristics for low-carbon technologies mean that localized DG and prosumer PV deployments could rapidly trigger a tipping point in parts of a distribution network.

Clustered, small-scale DER deployments are difficult to manage

Deployment of low-carbon technologies will be uneven across a distribution network. The grid reinforcement requirements caused by high-voltage, connected DG can often be managed through formal planning and connection contracts, although at the risk of slowing down the energy transition. Smaller-scale DG is far more difficult to control and can create unforeseen, localized stress on the network. Significant clustering of low-carbon technologies—particularly prosumer PV and EVs—will occur, driven by the grouping of building types and demographics (see sidebar, Clustering of prosumer PV in Australia, on page 19).

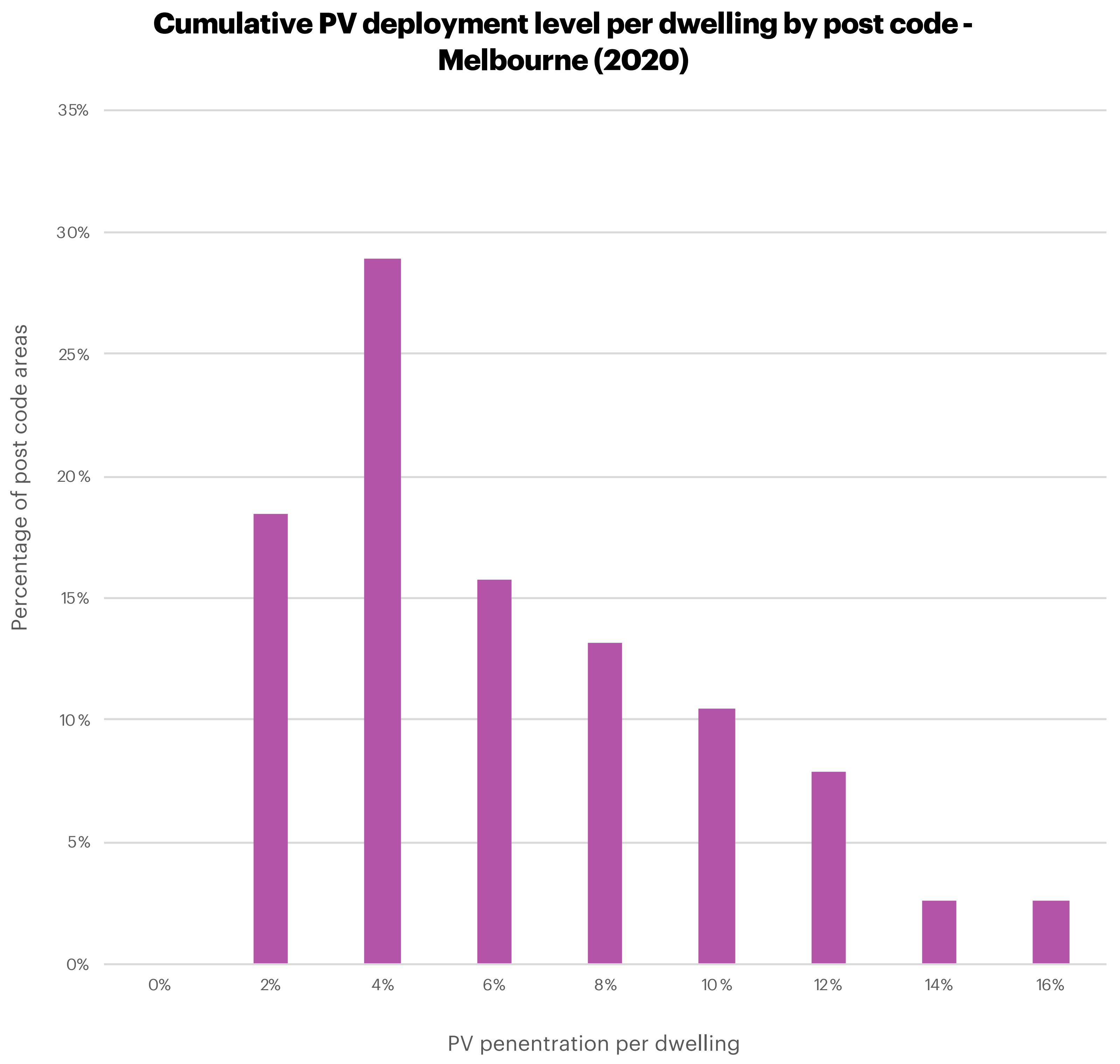
Uncertain and rapid changes in deployment rates

Distribution utilities need to strike a fine balance between under- and overinvestment in network reinforcement. Do too little and managing capacity constraints becomes difficult, stressing assets and impacting power quality and reliability. Do too much and risk creating stranded assets. If a hosting capacity for renewables is limited, it will leave little time to respond. A distribution operator that preempts large DG deployments and invests in significant network reinforcement runs the risk driving up distribution tariffs for little to no benefit to the consumer.

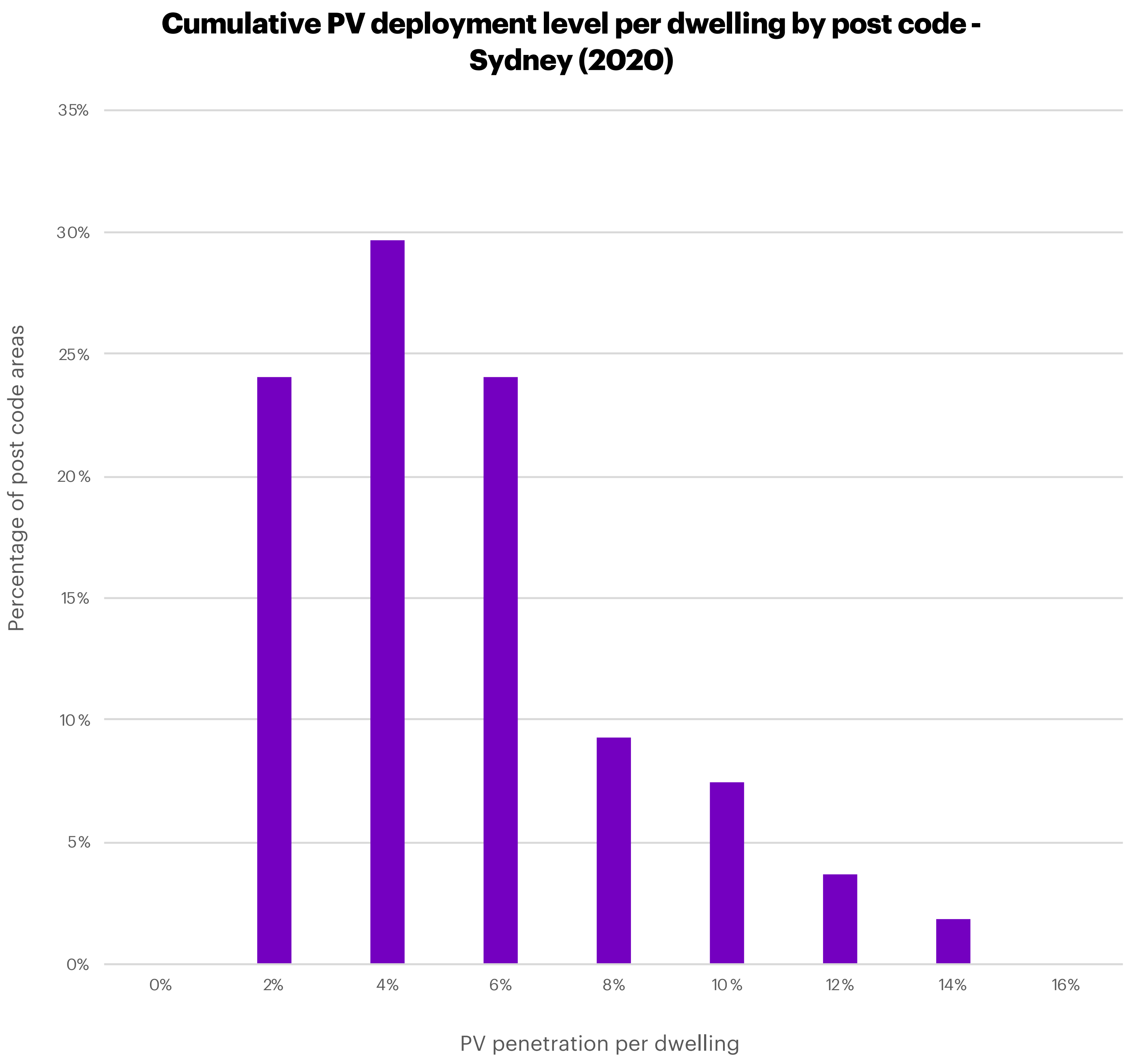
The majority (83%) of survey respondents believe that the long-term energy transition will be driven primarily by superior economics, not subsidies or incentives, rising to 89% in Asia-Pacific. Where DER deployment is no longer dependent on subsidies, a major mechanism to manage rollout speeds is lost, leaving businesses to face the risk of large-scale deployments over short time periods.

Sidebar: **Clustering of prosumer PV adoption in Australia[6]**

Accenture analyzed the post code-level deployment of prosumer PV in Australian cities. The analysis yields important insights into the spatial and temporal dynamics of prosumer deployment. It also provides insight on how to respond to customer DER deployments (PV, EV, storage, electrification) in distribution forecasting.



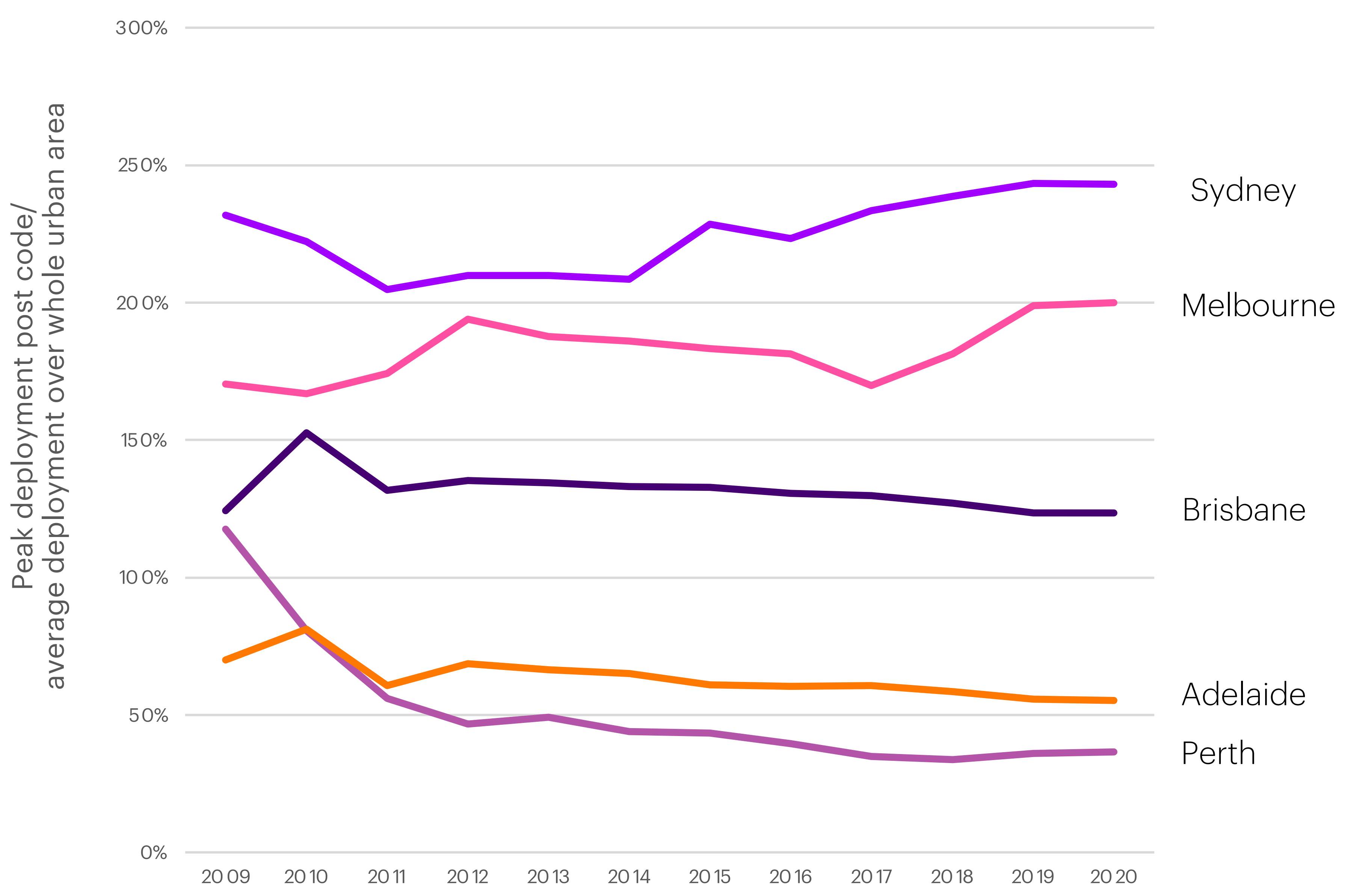
1. There is significant clustering of PV deployments. These clusters are caused by dwelling type, orientation, ownership, demographics and incentives, which are characteristic of a particular post code. This uneven deployment can make local grid assets highly stressed, even when neighboring areas don't experience issues.



Sidebar: **Clustering of prosumer PV adoption in Australia**

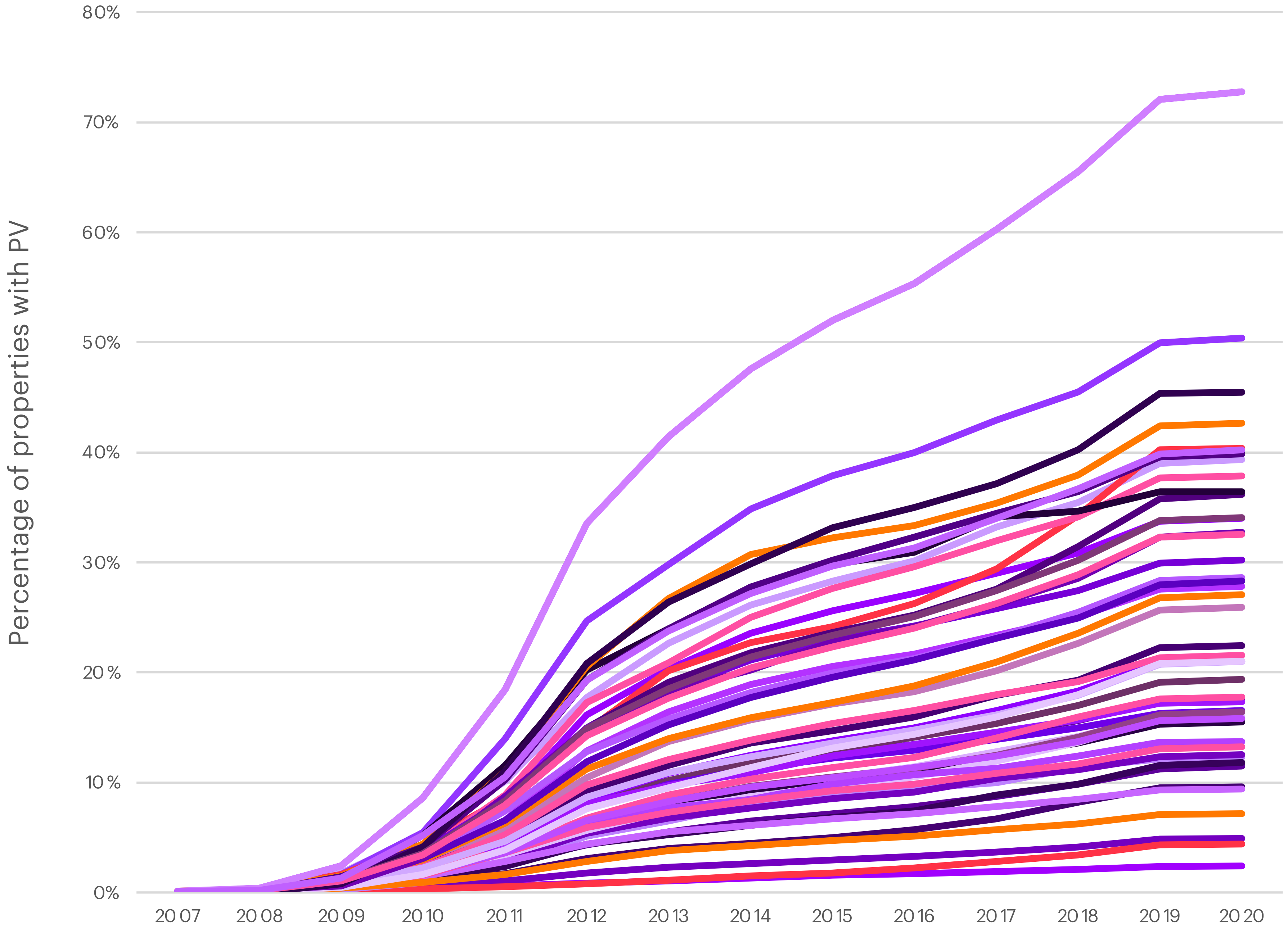
2. However, there are deployment characteristics that make distribution forecasting easier. Relative deployment across post-code areas do not significantly vary year to year. The deployment lines rarely cross in the graph below. As a result, distribution operators should be able to identify at-risk areas early in the PV adoption cycle.

Relationship between PV deployment in peak locations compared to the mean deployment - Australian cities



3. The relationship between average PV deployment across a city and peak PV deployment by post code remains stable as deployment increases. This factor varies between urban areas, but once ascertained for a particular city it can be used to inform DER deployment scenarios, allowing the timing of tipping points to be forecasted for different areas of the network.

Deployment of prosumer PV by post code – 55 post codes within 10 km of central Brisbane



Risks of unpreparedness

What happens if a tipping point is triggered and a business finds itself unprepared? While all distribution operators will respond to the energy transition in some way, the speed, breadth and depth will vary. The response will be the barometer of future success. The risks of inaction are substantial and will be felt across the value chain (see Figure 10).

Operational risk

There are several operational areas where deployment of low-carbon technologies, if not managed closely, could cause significant challenges. These can damage assets, reduce system reliability, impact power quality, threaten safety and drive up costs.

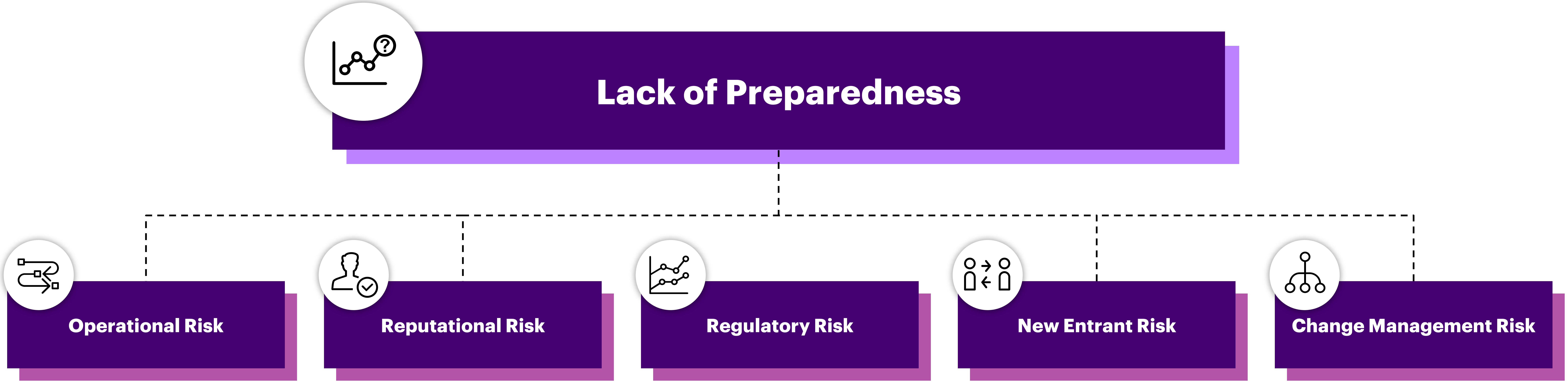
Reputational risk

Any attempt to curtail or delay DER deployment could cause serious reputational damage. The energy transition fundamentally underpins action to mitigate climate change, boost future economic growth and bring significant societal value. Failure to deliver could imperil distribution businesses from multiple directions: harsher government policies, more stringent regulation, harm customer opinion, and impact shareholder and bondholder attitudes.

There are many risks. For example, 72% of survey respondents believe that EV growth will be more rapid than the necessary grid capacity can be built to accommodate them. This figure rises to 85% in Europe, reflecting the greater deployment to date in many European countries and the particular challenges of densely packed cities with dominantly underground cables. Distribution businesses will need to find smart approaches in concert with energy retailers to manage EV loads to avoid potential public relations disasters. Constraints on charging behavior and pricing incentives are likely, but if these tools are overused and customers severely inconvenienced, the backlash could be harsh.

Long term, grids will require significant reinforcement to adapt to the changing demands. Of course, someone must pay for these investments and many costs are usually socialized across all users. The

Figure 10. Unpreparedness exposes distribution businesses to multiple risks.



costs of reinforcing and managing the distribution network through the energy transition will be considerable, though at this stage many utilities will not have a clear view of how much. Eurelectric recently reported that without additional investments of €375 billion to €425 billion by 2030,[7] Europe's distribution grids risk becoming a bottleneck for the wider electrification of Europe's economy. Similarly, research completed for the U.K. government estimated that an additional £40 billion in distribution reinforcement would be required by 2035 to meet the energy transition.[8] In the United States, the Biden administration's America's Jobs Plan includes investment to modernize the electric grid.[9] The gap between projected trends of investments in the U.S. distribution infrastructure with what will be needed by 2039 is estimated to be nearly $100 billion.[10]

However, reputational damage could occur if all customers are asked to pay for network upgrades that serve predominately the more prosperous segments of society. Currently, more prosperous parts of society are more likely to buy a new EV, or to live in owner-occupied houses where prosumer PV is an option. It is likely that many regulators and utilities will need to revisit the charging mechanism for distribution services as part of the energy transition.

New entrant risks

Core distribution network operations will continue to provide largely stable, secure revenues for most operators, but revenue growth will increasingly be tied to opportunities from transition-related new assets and services. Our survey illustrated the breadth of distribution utilities' ambition to extend into new products and services within the energy transition (see Figure 11). As part of the push to develop flexibility capabilities, 88% of respondents are looking to extend assets or services, at least moderately, to support a more flexible system over the next five years. Half are planning to significantly extend energy transition-related assets or services within that time frame. There are some significant variations across geographies, with 62% of North American respondents looking to extend assets or services significantly in at least one area, compared with 47% in Asia-Pacific and only 40% in Europe. This potentially reflects the more constrained set of growth options for many of the unbundled European distribution utilities.

All of these potential services—particularly microgrids, platform provision, peer-to-peer transaction services, DG and storage—are open to competition. Three-quarters (76%) of respondents believe new entrants—such as high tech, startups, automotive and others—have the potential to significantly disrupt the industry with new solutions. It will be critical to deliver choice at speed. Customers will not wait for distribution utilities to act. Indeed, 61% of respondents believe customers will bypass distribution businesses for other product and service providers if their energy transition needs are not met, with North American (66%) and Asia-Pacific (66%) utilities being more concerned than those from Europe (50%) and Latin America (58%).

Change management risks

These risks are all heightened by some utilities' limited capacity for change. The risk-averse nature of electricity networks and historically stable technology and regulatory landscape mean change management could be a major challenge. How can a distribution business successfully transform if they are dealing with an aging workforce, potentially restricted access to vital skills such as enhanced data analytics, communications systems and the Internet of Things (IoT)?

Regulatory risks

Regulators will demand both an effective and economic response from utilities to support the energy transition. In many cases they will increasingly favor innovative, digital, lowest-cost approaches before signing off on large-scale reinforcement projects. However, only 13% of respondents say they are currently incentivized to respond to the energy transition using non-traditional, flexibility solutions—or non-wire alternatives—to a "significant degree." And 78% agree that regulatory models are unfit for purpose to deliver the energy transition.

The regulatory response to the energy transition has often been slow. However, most respondents believe that regulators are waiting for distribution businesses to propose innovative models that incentivize flexibility (80%). The challenge for the utilities is to develop proposals to increase the use of flexibility solutions, detailing how they would encourage the participation of potential providers and incorporate flexibility use into everyday operations (see sidebar on page 25).

While this is a difficult challenge, it could also be a significant opportunity to self-define the way networks will be operated for the next century. However, many utilities are not yet ready to take on this leadership role in crafting the future regulatory model.

Example: **ENEL looks to expand power distribution business into United States[11]**

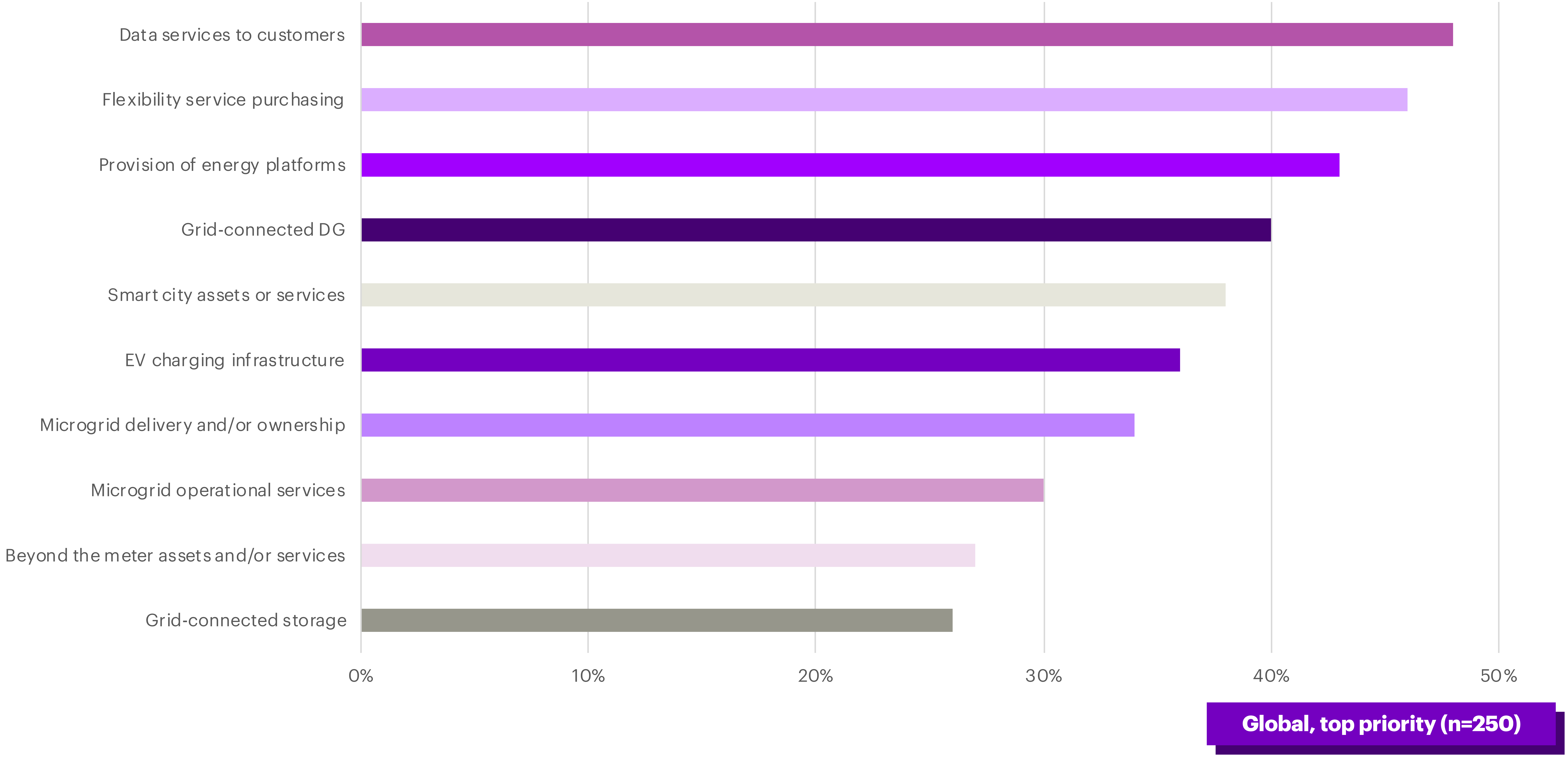
Enel, one of the world's largest integrated utilities, manages distribution grids in eight countries in with more than 74 million clients. The company is looking to expand its distribution business beyond Europe and Latin America and into the U.S. market, where it is currently focused on generation.

The company plans to spend €16.2 billion ($19.52 billion) on distribution networks in the next two years and €60 billion by 2030. Around 65% of that investment will focus on grid reinforcement and enhanced digital resilience to address the challenges of rapidly growing renewable energy sources.

Enel has also set up a company that would offer digital and infrastructure devices and services to other companies for managing grids, which will be operational by the end of 2021.

Figure 11. Executives are looking to extend assets or services, at least moderately, to support a more flexible system.

To what extent do you expect to extend your scope of assets and services in the following areas over the next five years?



Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

Sidebar: **Regulatory models that encourage innovation**

Regulatory models will need to evolve to respond to changing policy objectives, industry structure and customer requirements.

The challenge for regulators: How to effectively incentivize distribution businesses to deliver necessary changes, while still providing value-for-money for customers. Regulators will need to address how to:

- Integrate large volumes of distributed, low-carbon generation in the distribution grid.
- Deliver sufficient capacity to support growing demand from electrification of transport and heating.
- Support a wider role for distribution in the energy landscape.
- Ensure utilities deploy innovative approaches to reduce costs, deliver at speed and support new customer services.

Example: RIIO, UK electricity networks - An energy transition-focused regulatory approach[12]

The Revenue = Incentives + Innovation + Outputs (RIIO) model was developed by the U.K.'s Office of Gas and Electricity Markets (Ofgem) in 2010 to replace the RPI-X approach that had been used for 20 years. The aim was to better reflect the challenges facing modern distribution networks. Certain aspects of the previous regime—those that delivered strong cost efficiency and reliability improvements—were retained.

Key elements of RIIO include a longer regulatory period of eight years to provide better incentives for cost efficiencies. Capital and operating costs were combined in a single regulated approach—TOTEX. This supports a balanced business case approach and reduces the incentive to turn to capital-based solutions. Many responses to the energy transition increase operating costs, such as increased active grid operation and provision of platforms. Capital-friendly regulatory models are deterrents to investing in such new capabilities. Supporting RIIO were several incentives that drive improvements in connections, customer service, reliability, safety and the environment.

Example: Policy support for prosumers in the European Union[13]

The EU commission's Clean Energy Package has specified legislation that member states must adopt regarding the support for renewable energy communities (RECs) and citizen energy communities (CECs), both aimed at increasing the number of prosumers. RECs bring together a group of stakeholders that invest, produce and sell renewables, while CECs are not necessarily focused only on renewables. This policy support will be rolled out by individual member states through their own regulatory models.

Example: New York Reforming the Energy (REV) – strategy to build a clean, resilient, and affordable energy system[14]

In New York, the "Reforming the Energy Vision" (REV) strategy is actively spurring clean energy innovation, bringing new investments and improving consumer choice and affordability. Regulatory changes under the REV initiative are promoting more efficient use of energy, deeper penetration of renewable energy resources, and wider deployment of DERs and storage. It is also promoting markets to achieve greater use of advanced energy management products to enhance demand elasticity and efficiencies. These changes will empower customers by allowing them more choice in how they manage and consume electric energy.

Distribution operations are already upending

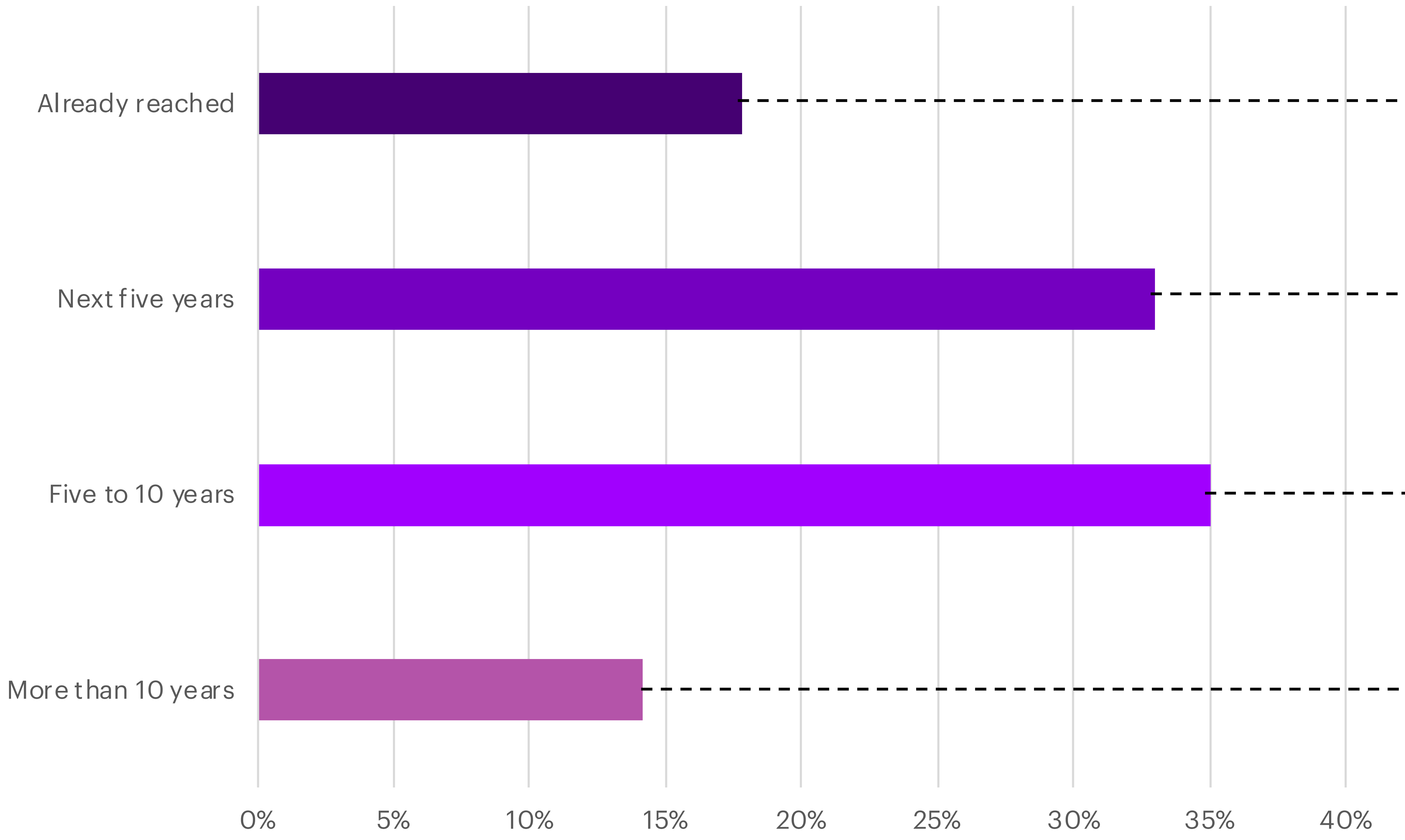
There is no hiding from the disruption and the results of our survey speak volumes. All our respondents report some form of energy transition-related disruption in their operations. Three-quarters say this disruption has already been significant.

PV prosumers are the largest cause of significant disruption worldwide, but all aspects of the energy transition are disrupting operations. Interestingly, the most disruptive forces differ in each region. In Europe, the largest disruptive force is demand growth from the electrification of space and water heating. In Asia-Pacific, it is demand growth from transportation electrification. In Latin America, it is prosumer PV, while in the United States it is the integration of grid-connected DG.

Non-traditional competition is already active in the market. New customer-facing technologies have the potential to alter demand and shift customer relationship dynamics. For example, sonnen's virtual power plant (VPP) in northeast Germany, aggregates wind power that might otherwise be constrained off the network. It also manages a 3,000-home VPP project in California, in collaboration with Wasatch Energy Group.[15] It is vital that distribution businesses position themselves now to take advantage of these future opportunities.

Figure 12. Most executives expecting a tipping point believe it will occur within 10 years.

When do you think your distribution business will reach the energy transition tipping point?



Regional Breakdown

	North America	Europe	Asia-Pacific	Latin America
Already reached	17%	21%	16%	13%
Next five years	41%	30%	25%	25%
Five to 10 years	32%	32%	39%	50%
More than 10 years	9%	16%	20%	13%

Global, n=191

Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

Tipping points to trigger within 10 years

When the tipping points will be triggered and how prepared utilities are when this happens will define success or failure.

Most of the executives who expect a tipping point to occur believe it will be triggered within the next 10 years (86%). In terms of utility planning, this is no time at all—large-scale tipping points can be triggered in the nest asset planning cycle. Again, there are some regional variations, with the United States as the earliest, followed by Europe (Figure 12). Worldwide, more than half of respondents believe it will occur within five years. And, importantly, few believe it will occur more than 10 years out. A decade is a short period of time in the world of distribution utility planning. Five years is almost the blink of an eye in terms of deploying new grid assets. As we have seen, regulatory changes and cost reductions could further accelerate the movement.

86% of utility executives we surveyed who expect a tipping point to occur believe it will be triggered within the next 10 years.

Responsive readiness: Confidence or chaos?

We are only in the early stages of the energy transition. Most utility executives (84%) believe uncertainty will grow over the next five years, even higher (96%) among Latin American respondents. However, fewer than half say they have better than "moderate confidence" in their ability to predict and respond to the most pressing issues of the energy transition—DG deployment, EV deployment, customer demand or regulatory changes.

These results are telling. They speak of an industry undergoing increasing disruption but finding itself ill-equipped to respond. This level of uncertainty would be alleviated by the evolution of regulatory frameworks to support network resilience to the energy transition and other risks such as cybersecurity and extreme weather. However, only 17% of our respondents have greater than moderate confidence in the stability and visibility of regulatory models.

The pace of energy transition is largely out of a utility's control. However, there is much that can be done now to invest in future success.

84% of utility executives we surveyed believe electricity distribution businesses will have to manage growing business uncertainty over the next five years.

03

Framing a data-driven, intelligent energy system

Data is the foundation for the future energy system. Distribution utilities will inevitably deploy more data-intensive business processes supporting a broad range of new capabilities (see Figure 13). Our survey respondents' priority areas to deliver flexibility are all focused on improving visibility as a key to delivering flexibility into distribution system operations—the grid's power status, consumer demand and prosumer exports, and into grid-connected assets. The other priority is enabling the sourcing of flexibility from grid-connected assets.

But this digital transformation will be progressive and may look more like evolution than revolution. In the earlier stages, distribution operators will focus on their most pressing needs. And digital strategies will be dictated by these requirements, which will vary depending on the level of DER deployment, the hosting capacity of the grid, industry structure and regulatory models.

Figure 13. Fundamental capabilities across the distribution business could be transformed by increased visibility.

Planning and asset management

- Detailed forecasting of demand, DG output, demand-side response (DSR), prosumer DG, EV and space heating deployment
- Capacity and ancillary service delivery plan—flexibility vs. grid reinforcement needs definition and business cases; this will need to be provided to third-party providers of flexibility services to enable them to plan their own asset development and service offering strategy
- An integrated view of asset, DG and EV to enable asset health evaluation and maintenance needs (physical, locational and operational history)

Flexibility and DSR service development

- Flexibility product development
- Flexibility and DSR response market development including platform development
- Determine flexibility service requirements over multiple time scales (years to minutes)
- Provide system data to third parties (TSOs, flexibility providers, aggregators, etc.) to enable market and system operations

System operations

- Accurately measure network physical parameters in real time to support grid analytics (power flow, state estimation, contingency, etc.)
- Short-term demand and DG output forecasting
- Enhanced grid automation and controls, self-healing and autonomous operations
- Monitoring, control and dispatch of DG in real time

Customer management

- Support the development of a wider range of connect contracts for DG and EV charging stations based on analysis of grid capacity and demand profiles
- Profiling of customers to support demand, demand-side response and deployment forecasts
- Power quality monitoring
- Outage identification and notification

Example: **EDP powering a new asset management paradigm with analytics**[16]

For Energias de Portugal (EDP), safely and efficiently delivering electricity to millions of customers was both a challenge and a priority. With an extensive portfolio of distribution assets and a far-flung network, EDP believed a data-driven approach to managing and monitoring assets would help it make smarter, faster and more cost-effective decisions.

EDP developed analytical models to predict asset health and failure probability for three asset classes—high-voltage overhead lines, transformers and circuit breakers—determine risk levels and optimize investment and maintenance planning. This effort involved extracting, verifying, consolidating, cleaning, and evaluating data from multiple data sources. The endeavor covered multiple forms of data, including asset context data, historical technical analyses, historical failure notices, inspection and test results, and even meteorological data.

The company successfully launched a new asset management capability that uses data and analytical models to drive improved investment decisions and more efficient and effective asset management strategies. The new modeling capability could provide CapEx and OpEx optimization of approximately 10% and 15%, respectively.

Analytical models and visualization dashboards support asset and maintenance managers in their decision making. Maintenance teams can now more accurately prioritize interventions and better anticipate failure and damage to network elements. And millions of customers are receiving more reliable energy, delivered safely, sustainably and efficiently through EDP's embrace of data analytics.

Example: **SCE is Reimagining the Grid for the future**[17]

Southern California Edison (SCE), a subsidiary of Edison International, is one of the largest electric utilities in the United States, serving approximately 15 million people in central, coastal and Southern California.

In 2019, the company created a roadmap, Pathway 2045, laying out its commitment to reach 100% carbon neutrality in California by 2045. Part of achieving this goal is creating an electric grid that can efficiently and effectively integrate carbon-free resources while ensuring climate adaptation and broader resilience. Reimagining the Grid is SCE's vision of the future grid.

SCE recognizes that developing critical grid capabilities must begin now so that they are ready when needed. Success requires a collaborative, industry-wide approach—bringing together policymakers, regulators, innovators, customers and utilities to help shape the policy and technology landscape and transform how to plan, design, build and operate the future grid. And as the grid modernizes and changes, safety remains critical.

While SCE continues working toward further defining the capabilities and design architectures of the reimagined grid, they are also taking actions now to begin realizing this vision:

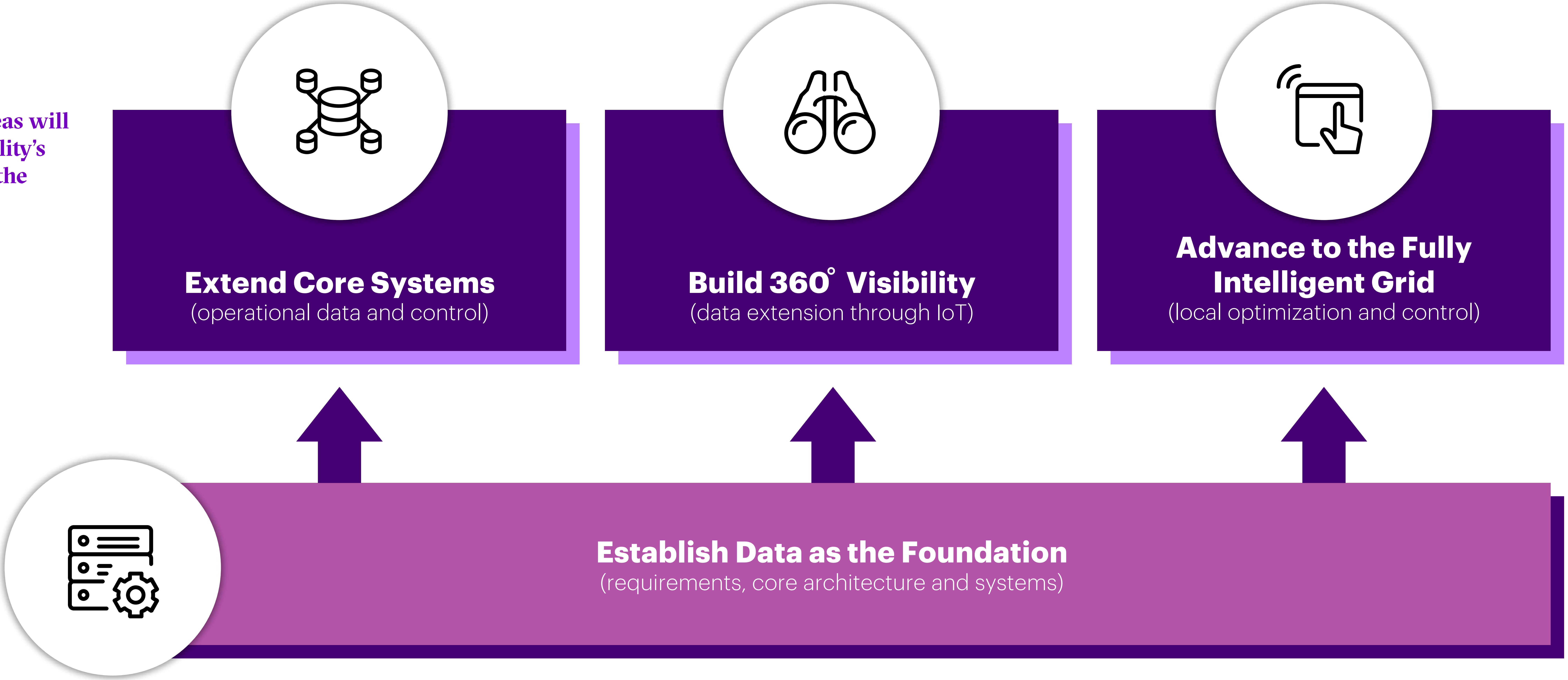
- Improving their "forward radar" to anticipate changes, particularly regarding the timing, nature and magnitude of customer technology adoption and grid impacts
- Engaging with key stakeholders—including regulators, federal agencies, industry and customers—to build a shared perspective on the grid challenges ahead and to work together on starting to shape future standards
- Integrating new tools and grid planning processes to lower deployment time, complement current grid efforts with future needs and make more adaptive decisions
- Accelerating development, testing, piloting and deployment of critical grid technologies

Four areas of approach to digitally transform distribution

We see four distinct areas underpinning a distribution's utility's digital transformation (see Figure 14). The first sets the foundation, making the best use of existing data and creating a data architecture that supports the evolving needs of the energy transition. The second extends core operational visibility and control, particularly targeting grid-connected DG and the solutions required to effectively integrate it. The third greatly expands the scope of data through the deployment of IoT devices. The fourth improves distributed intelligence and control, enabled by cloud, edge computing, 5G, digital twins and platforms.

These areas are neither exclusive nor linear, but depend on many factors including location, regulatory model and industry structure. Different utilities will begin at different stages within these areas and use different elements of each as they evolve. Some will choose to advance more rapidly in select areas, such as through partnerships with technology solution providers, to address specific challenges.

Figure 14. Four distinct areas will underpin a distribution utility's digital transformation for the energy transition.



Establish data as the foundation

A successful transition to active management of distribution network requires an evolved technology strategy. This will require a design to deliver enhanced data exchange across the distribution business, but also across the wider utilities industry ecosystem within which distribution plays a central role. The transformed architectures will need to feature:

- Integration of multiple data types including circuit and topology, asset performance data, operational history, geographic location, and customers.
- Scalability to incorporate exponential growth of IoT data.
- Flexibility to rapidly modify data capture and analytics in response to changing requirements.
- A combined operational and service focus that embraces the requirements of core operations and the coordination of many third-party services.
- A communications strategy that meets security, reliability, bandwidth, latency and cost requirements.

Extend core systems

Passive grid management requires limited visibility and control. Distribution utilities have focused their efforts on the high voltages, such as grid substations using SCADA and advanced distribution management systems (ADMS). In contrast, the energy transition necessitates much closer management of lower voltages.

Extending core ADMS systems toward their low-voltage networks will be necessary to actively manage the growth of DG. As we have seen, advanced flexibility services require real-time visibility and a robust distributed energy resource management system (DERMS), which must integrate with existing network management solutions. This should extend data exchange across the business and to third parties such as TSOs, EV charging companies, aggregators and generators. Key benefit areas include:

- Enhanced grid and DG power flow visibility.
- Improved DG integration with DERMS and flexibility contracts.
- Enabling the development of more sophisticated connection contracts.

Build 360° visibility

While utilities will extend core control systems to low voltages, they will also improve visibility of the broader system, into low-voltage networks and non-network assets. Enabled by IoT devices and gateways linking directly to the cloud, utilities will collect primary asset operating data, monitor asset condition and performance, environmental and site data. Greater visibility improves grid optimization, particularly through flexibility services, although most of the low-voltage grid may remain unmanaged in real time. Key benefit areas include:

- Sophisticated short-term DG output forecasts.
- Site and asset visibility.
- Primary system data from the low voltage grid.
- Improved demand and PV export forecasting.
- Complex flexibility service options, including reactive power and greater levels of circuit-specificity.

Advance to the fully intelligent grid

Edge computing and new communications support near-real-time optimization of local assets, orchestrating the grid, DG and demand response on the load side. These capabilities will likely be deployed as needed, rather than pervasively across the grid. Key benefit areas include:

- Virtual power plants (VPP).
- Microgrids.
- Protection coordination and outage location discovery.
- System analytics (power flow, state estimation, etc.).
- Digital twins.

04

Delivering the distribution system of the future

Establish data as the foundation

Legacy systems were not designed to cope with the exponential growth of data sources, and new operational requirements and services. The digital transformation of distribution forces the redefinition of data, architecture and system strategies to deliver enhanced data exchange across and beyond the distribution business. Putting data as the foundation prepares a distribution business for its new role delivering the energy transition.

Inevitably, each utility has a different starting point. Some have already made significant steps, creating unified versions of their data models or updating to ADMS. However, all utilities will have gaps in their data strategies, which should be regularly reviewed to reflect evolving business requirements.

Data architecture

It is vital to develop a conceptual, logical data architecture that supports evolving business capabilities through the energy transition. The architecture needs to be underpinned by a data model—such as the International Electrotechnical Commission (IEC) CIM—to enable effective data integration. Distribution utilities already have significant volumes of data, but this is often held across many systems and will not effectively support a more active grid.

For example, a utility holds static asset data in the enterprise asset management (EAM) system, real-time operational data in a SCADA historian, locational data in GIS, demand data in advanced metering infrastructure (AMI). Currently, this data often only serves the teams that own it. Combined, these sources can create data-rich, real-time insights into network dynamics.

Service architecture

Historically, distribution businesses ran separate architecture for operational and IT systems for sensible cybersecurity reasons. For example, SCADA systems run on physically separate architecture to billing. However, the energy transition requires a more integrated approach. DER management and contractual flexibility services straddle both IT and OT. They are operational control systems that also manage customer transactions.

This presents a major challenge to enterprise architects: How to maintain the integrity and security of the core ADMS while simultaneously integrating ADMS data with DER and other customer-owned IoT devices. In addition, data must be analyzed for forecasting, flexibility service and support all the customer transaction data. Finally, the system must be sufficiently flexible to support the agile development of new services.

There are several options available to combine the strengths of the monolithic core OT systems and agile, cloud-based services within an enterprise data platform (see Figure 15). For example, enterprise system buses can integrate core systems with field devices, using service-oriented architecture (SOA) gateways. This approach also supports the use of microservices to accelerate new service development.

Communications strategy

Communication technologies are critical for active grid management. Distribution utilities are experienced users of comms solutions that support data acquisition and control. However, in most distribution companies, existing comms technology is ill-suited for the requirements of the intelligent grid. Current comms technology lacks the bandwidth to support the rapid growth in sensors and actuators and often does not support heterogenous sensor types, especially consumer-owned IoT devices. Existing utility comms networks are commonly fragmented, with limited opportunity to integrate data, and using different approaches to cybersecurity.

Most utilities recognize the importance of a robust comms infrastructure that is sufficiently flexible to meet long-term needs. Executive survey responses indicated that communications reliability, bandwidth and latency is the biggest challenge when optimizing IoT devices; cybersecurity is the second biggest. Indeed, some utilities are seizing the opportunity to renew existing comms infrastructure now, to enable the intelligent grid of the future (see sidebar on U.S. trends on page 38).

There are many comms technologies available: fixed and mobile, licensed proprietary and public unlicensed. Specific requirements will drive individual choices, but no single technology can cost-effectively meet all needs. Most utilities will adopt a hybrid solution, combining the flexibility and deployment speed of mobile networks and the security of wired solutions.

The low latency and high bandwidth of 5G communications extends the potential of mobile broadband and brings a range of capabilities that support IoT and edge computing solutions. Network slicing is a key feature of 5G, where the functionality of specific service requirements is packaged into customized slices. For example, an ultra-reliable low-latency comms slice can be used for mobile-based drone and work safety use cases. Similarly, massive machine-type communications are necessary where there is a very high density of sensors and actuators, such as in a substation.

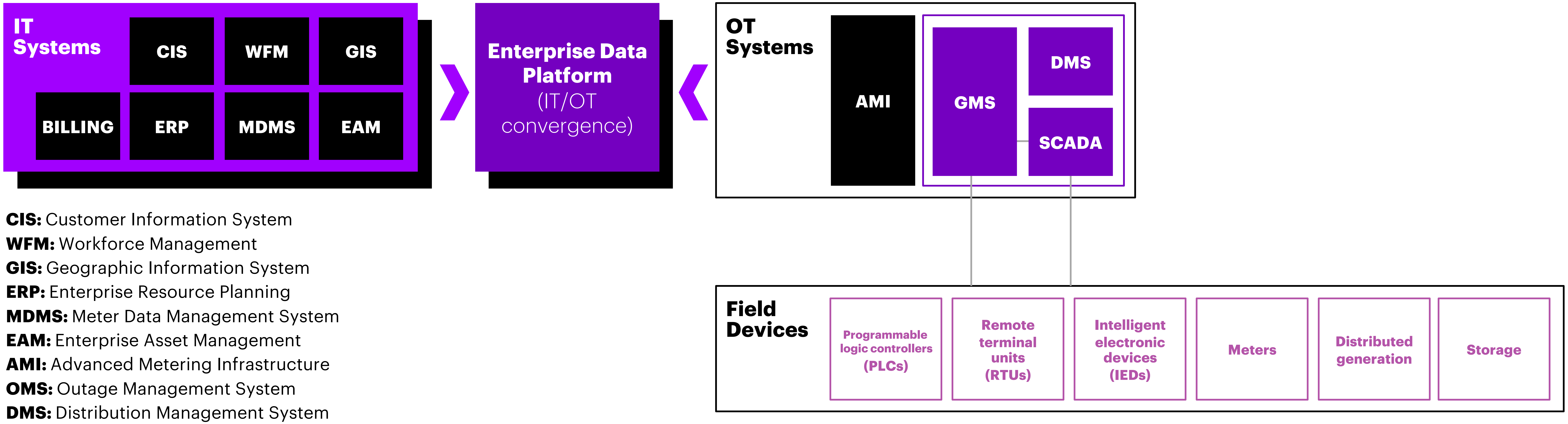
Utilities' existing comms infrastructure is built on multiple, proprietary and often arcane standards. Maintaining these systems is increasingly difficult and costly. In comparison, LTE is a global standard. Many comms vendors and service provision companies use LTE and have built a significant skills base. So, it is unsurprising that the utilities industry is increasingly adopting LTE.

Many intelligent grid sensors—such as smart meters—have low capacity requirements. For these, low-power wide-area (LPWAN) technologies, including unlicensed comms technologies such as LoraWAN and SIGFOX or licensed solutions such as LTE-M and nb-IoT, may be preferred.

The low-power functionality extends battery lives to between 5 and 10 years, which reduces cost and expands the number of IoT-based use cases a distribution utility can consider. LPWAN works with LTE technology—which is forwards-compatible with 5G—so could be a cost-effective complementary technology to 4G or 5G and therefore with low risk of obsolescence.

Figure 15. Many distribution businesses currently have separate, monolithic IT and OT systems.

Simplified core application map for many distribution businesses



CIS: Customer Information System
WFM: Workforce Management
GIS: Geographic Information System
ERP: Enterprise Resource Planning
MDMS: Meter Data Management System
EAM: Enterprise Asset Management
AMI: Advanced Metering Infrastructure
OMS: Outage Management System
DMS: Distribution Management System
SCADA: Supervisory Control and Data Acquisition
DERMS: Distributed Energy Management System

Sidebar: **Communications renewal trends in the United States**

Rationalization of multiple communications systems

Most distribution utilities' comms technologies have been deployed progressively to meet a particular application's needs, such as SCADA, AMI or workforce communications. The result is a siloed, fragmented landscape that is difficult and costly to maintain. These systems often lack the cyber resilience, bandwidth and latency required to meet future needs. The rationalization of utility comms systems has become a strategic imperative for many U.S. distribution utilities.

Private wireless broadband networking

There is increasing use of mobile technology, often complemented by fiber network backbone solutions. The approach overcomes the slow data rates of powerline solutions and their unavailability during power outages. U.S. utilities are increasingly acquiring broadband spectrum to build proprietary networks, which resolves some of the key problems with unlicensed solutions, such as interference, bandwidth constraints, and reliance on third parties to maintain and repair the network.

Example: US utilities placing their bets

Over the past few years, Ameren has been testing mobile broadband solutions for SCADA, remote engineering access, Wi-Fi, telephony, push-to-talk, and general workforce mobility applications. It is all based on LTE, complementing a well-developed fiber optic backbone. In a trial, Ameren replaced 20 separate networks with a single solution.[18]

Other utilities, such as Southern California Edison, San Diego Gas & Electric and Alabama Power have recently purchased spectrum. This is not a cheap exercise: in 2020, Southern California Edison is believed to have spent nearly $120 million on spectrum. It brings into focus how much utilities value effective comms, and its importance delivering future distribution business models.[19]

Extend core systems

Distribution businesses have deep experience monitoring and controlling high voltage assets, using SCADA and the wider ADMS. Over the years, SCADA/DMS solutions have been upgraded with new capabilities—such as smart substations—and have extended visibility and control to lower voltages and with other industry partners. Smart meters provide additional visibility at the grid edge. However, responding effectively to the energy transition requires an extension of these core utility systems, further improving visibility and enabling new levels of control.

New use cases driving new data requirements

Increasing DG deployments necessitate new grid management capabilities to control increasingly volatile power flow and incorporate new customer requirements. Distribution businesses will progressively adopt some of the capabilities traditionally associated with a TSO. State estimation, power flow and contingency analysis have not historically been needed in distribution, and they often lack sufficient data to perform such analysis accurately. However, these capabilities will become more common given the increased awareness needed to support system operation, request flexibility services and communicate with the transmission operator.

Some assets may already be monitored, but it is likely that new data must be captured. Large-scale DG deployment can cause reverse flow in a substation. If not recognized, reverse flow can have serious implications for protection systems, voltage regulation, asset loading, asset damage (including consumers in the same circuit), system-switching strategies, and longer-term system planning. But some existing monitoring systems cannot detect reverse flow as they were designed to monitor apparent power flow. Reverse flow cannot be determined solely from existing apparent power measurements. It also requires four quadrant power measurements.

Smart meter data capture has been designed around billing requirements. Existing AMI data is often used in distribution for capital and operational planning, but new challenges require access to more granular data. For example, the presence of unknown EVs can impair a distribution utility's understanding of the loading of low-voltage circuits, its load forecasting and operations. More granular consumption data yields insights into locational and charging characteristics of EVs, and the import-export behavior of prosumers. These insights can then be incorporated into forecasting models.

72% of utility executives we surveyed believe EV deployment will increase more rapidly than necessary new grid capacity in high-demand areas can be built.

Overcoming operator overload

Extensive growth of grid sensors and actuators massively increases visibility but risks complete operator overload. The operational complexity of a highly distributed grid threatens to overwhelm operators with thousands of alarms, and dozens of pages of SCADA data tables, particularly on critical days.

To effectively deliver active grid management, system operators will increasingly rely on advanced solutions to support their decision making. This requires improving situational awareness and providing insights, not just data. For example, system operators will need to know the cause of an alarm, rather than just know an alarm was triggered.

An ADMS is an important step toward augmented situational awareness. It brings analytical tools to automate operations and support decision making, and an integrated operation environment to simplify daily activities. However, much more is needed. Machine learning technologies could be used to process massive amount of data and forecast demand and generation capacity based on weather and situational awareness. Visualization should provide the system operator with insights that support their decision making. Therefore, incorporating advanced analytics into the system design can help identify the cause of a fault, risk types and the resulting security enhancements required. For example, adding analytics at a substation can interpret alarm data to identify the critical cause, such as which of a number of bays faulted first.

Enabling DG integration – DERMS and flexibility

The growth of DER will progressively strain existing operational systems. The strain will be compounded by new information flows required to support DER portfolio management, output forecasting, connection contract terms and operating conditions. These DER management requirements extend beyond traditional OT into IT, for instance into transaction management for flexibility services. Distribution businesses will need to make critical decisions concerning where DERMS should exist, either wholly within core OT as an extension of the DMS/ADMS, or as a standalone system that integrates with OT systems (see Figure 16).

Sidebar: **The state estimation use case**

State estimation and power flow

State estimation calculates the best estimate of the system's overall operating state. It is a fundamental component of transmission system operations but will need to be extended to the much larger, increasingly complex and often unbalanced distribution grids.

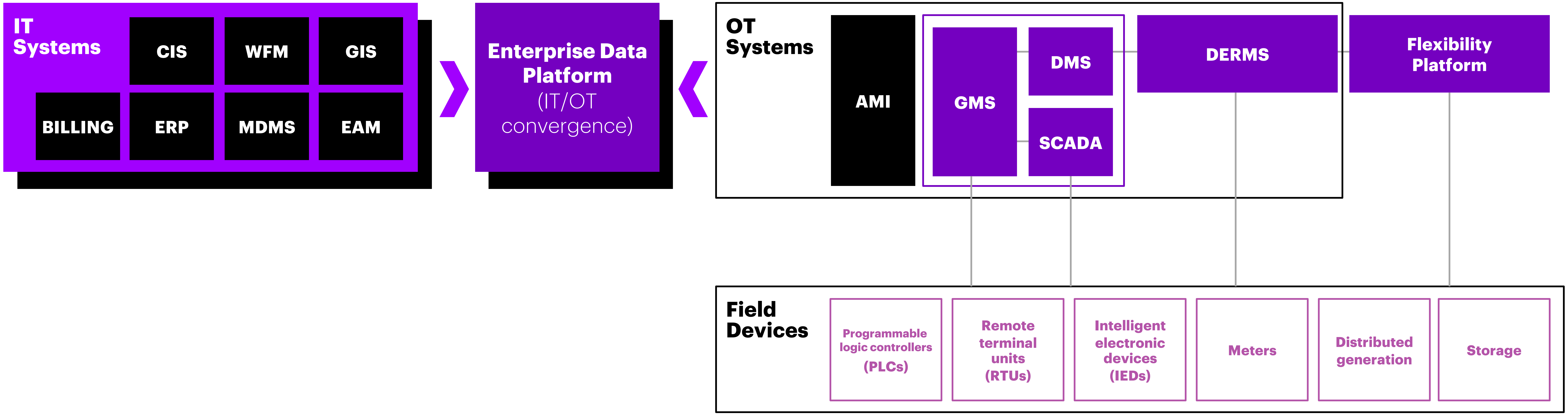
As the operational complexity of distribution grows, so does the importance of accurate distribution power models. State estimation is central to capabilities such as contingency analysis, flexibility service requirements identification, the digital twin, and operator training. For example, connection contracts for new grid-connected DG are becoming more complex. New flexible contract terms rely on detailed power flow intelligence to operate effectively. New contracts could place fixed or variable output constraints, forced curtailment or they could surrender output control to the distribution operator in return for faster connection or lower reinforcement costs.

In addition to DERMS, a flexibility platform will likely be deployed to support new flexibility markets. Flexibility platforms lie outside core OT systems. Operators will use DERMS to calculate their flexibility requirements but make requests in the externally-facing flexibility platform.

Local situations will drive this choice. Any decision will be part of an overall architecture plan, which must also decide how to:

- Maintain the security of the core ADMS.
- Manage the scale of DER devices being monitored and managed.
- Enable agile service development.
- Incorporate market and transactional processes.

Figure 16. Incorporating DER visibility and control enables greater system optimization.



Sidebar: **DERMS – enabling DG visibility and control**

In some geographies, such as Australia, PV is already deployed in more than 20% of dwellings. The next waves of EV and storage deployment could result in millions of DERs per distribution grid. The massive growth in DER, along with the significant potential from demand response, means distribution utilities must develop new management capabilities to maintain system stability and cost effectiveness over the next 10 years.

As previously noted, passive DER management will eventually be hit by cost increases and reliability and quality degradation. New capabilities are needed manage these risks, including:

- Maintaining operational capacity, protection settings and status data on DG, etc.
- Accurate forecasting, operational planning, flexibility demand and curtailment requirements.
- Dispatching flexibility demands and curtailment.
- Delivering effective restoration of DG after outages.
- Supporting operational data flow with utility systems.
- Supporting transactional processes with flexibility customers.

- These capabilities are increasingly being supported by DERMS solutions, which provide a range of management tools to optimize grid control.

Example: Multi-DER strategy at Arizona Public Service (APS)[20]

APS has deployed EnergyHub's Mercury DERMS platform to proactively leverage DERs to counterbalance grid conditions in an integrated way. EnergyHub enables APS to harness DER flexibility for system-wide and local load management, to soak up excess renewable generation while minimizing system peaks, and to provide visibility into behind-the-meter DERs across their service territory.

Example: Coordinating DERs for grid services at PG&E[21]

The PG&E DERMS technology demonstration implemented a DERMS developed by GE Grid Solutions for managing 124 kilowatts (kW) of residential PV coupled with 66 kW (264 kilowatt-hours [kWh]) of residential storage at 27 homes, 360 kW (720 kWh) of commercial storage at three commercial locations, and a 4-MW (28-megawatt-hour [MWh]) PG&E-owned utility-scale battery (Figure ES-1). PG&E partnered with Tesla to coordinate the residential DERs and ENGIE Storage to coordinate the commercial DERs.

Sidebar: **Enabling new flexibility markets through platforms**

Flexibility platforms have a degree of functional overlap with DERMS. But these platforms only provide coordination, trading, dispatch and settlement of services within a flexibility market. They do not provide the technical and engineering support that drives the planning and calling of flexibility services from third parties. Instead, these capabilities are undertaken by a system such as DERMS.

Flexibility services providers are either larger sites or aggregated smaller sites. They offer demand reduction or increase, capacity, voltage management, or potentially even frequency services. Geographic location is a key factor, allowing distribution businesses to better manage localized issues such as grid congestion. However, the same platform can also facilitate the purchase of services by the TSO to manage transmission stability. In practice, the number and types of platform will vary widely, potentially with competing markets in the same region. Alternatively, a coordinated approach may lead to one platform covering one or multiple distribution regions and different market products.

Example: Market design and platform for local flexibility market: Enera[22]

Rising renewables in Germany has been causing greater grid congestions at all voltage levels. To find ways of increasing availability of grid flexibility to address this issue, enera, a project with a consortium of 32 partners including TSO, DSOs and industry, was formed, supported by the Federal Ministry for Economic Affairs and Energy.

A central element of the project is the development of a flexibility platform on which select system operators enter into flexibility contracts with aggregators. The approach was to allocate and use decentralized flexibility through known market processes. A new verification platform confirms the delivery of flexibility and collects data to detect any unwanted market behavior. In addition, role models and processes were created for all relevant players and market communication based on already existing wholesale processes.

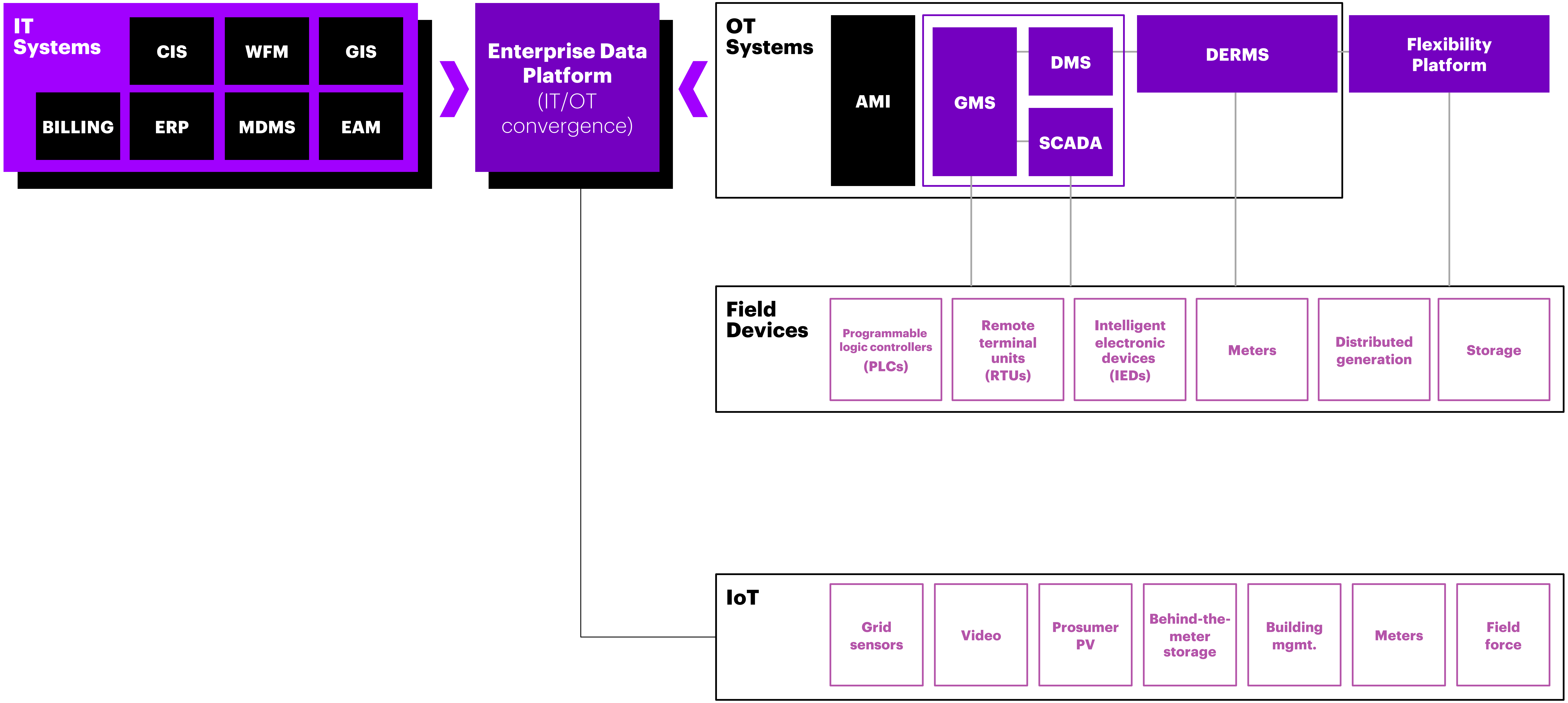
February 2019 marked the first successful completion of a trade of local flexibility via a power exchange platform, to avoid a congestion in the electricity grid. More recently, enera's developments and experience could give access to a broader pool of flexibility to system operators, allowing efficient alleviation of local grid congestions.

Build 360º visibility

There is much more to explore beyond the coverage and capabilities of core SCADA and ADMS systems. This is particularly relevant when data is primarily collected for analysis and not for real-time operations. Sources include environmental data, video sensors, connected worker sensors.

While they may not have to be collected in real time, they will be shared with the enterprise data platform, the flexibility platform and potentially with core operational systems (see Figure 17). These data are increasingly available via low-cost IoT devices proliferating in the energy sector.

Figure 17. Integrating IoT opens the potential for exponential increases in visibility and control.



Sidebar: **Use case - DG output forecasting**

Environmental data is the area of IoT-derived data expected to have the greatest impact on the business over the next five years by survey respondents. Wind speed, insolation, dew point and cloud cover are key inputs into effective forecasting of renewable generation output. Balancing supply and demand, managing asset loading, forecasting power flow and scheduling planned outages are all predicated on improved renewables forecasting.

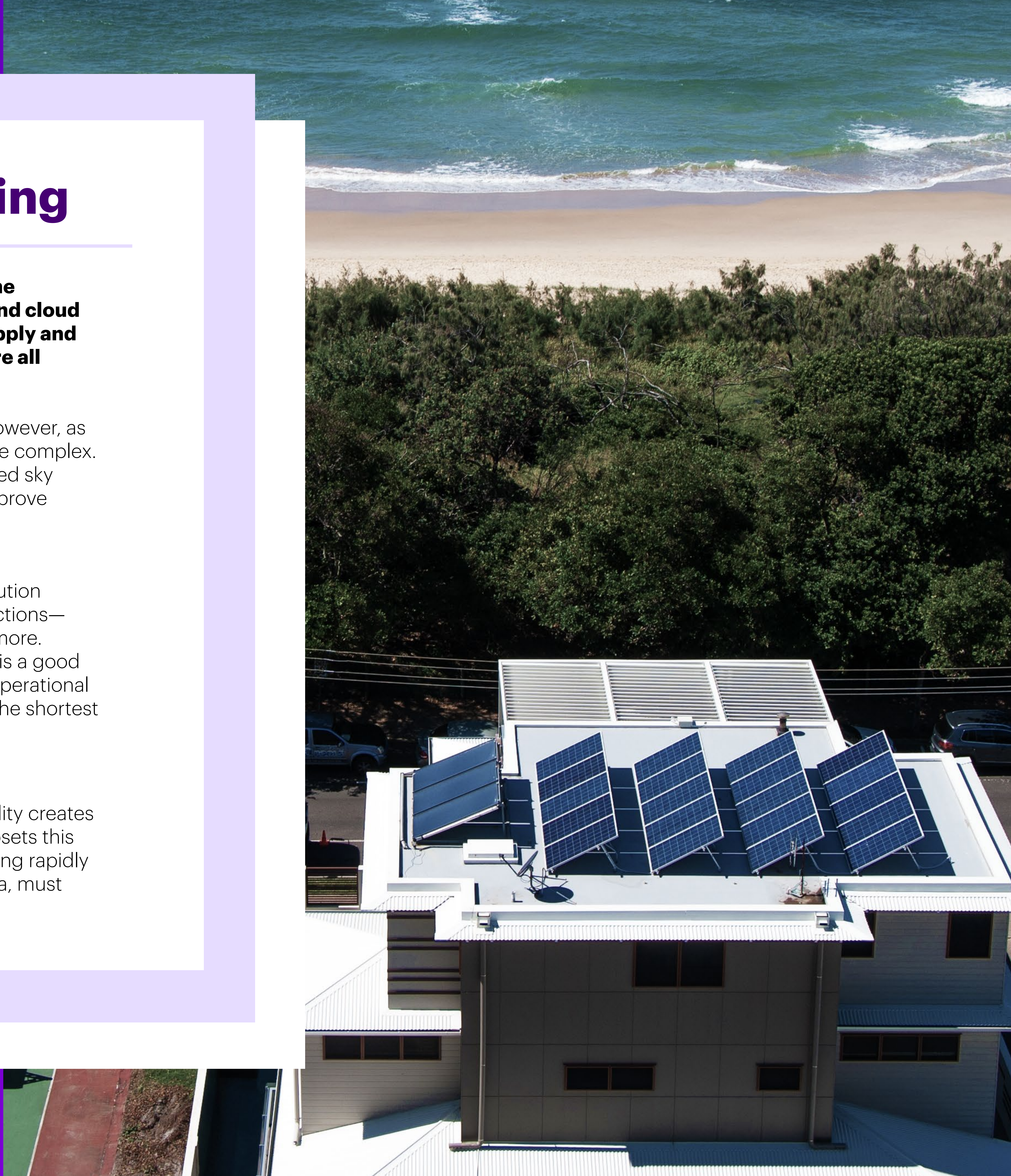
A generalized forecast for PV generation is relatively simple to develop, particularly in arid regions. However, as soon as clouds and local site characteristics are incorporated, the forecasting process becomes more complex. Clouds can cause major impacts on the grid, causing significant ramping of power output. IoT-enabled sky cameras, combined with wind speed measurement for wind turbines, can provide key inputs that improve short-term forecasting.

Spatial and temporal resolution

There are many methods to forecast renewable output, depending on the spatial and temporal resolution required. Bottom-up physical calculations—based on plant physical data and numeric weather predictions—can support longer-term planning down to a few hours, and with spatial resolution of a kilometer or more. Greater resolution can be achieved by incorporating real-time satellite imagery. Alternatively, if there is a good historical dataset for the PV plant, it is possible to develop probabilistic output models that support operational forecasting resolution of a few minutes and less than a kilometer. However, to accurately predict on the shortest timescales, real-time sky images are needed to determine the clearness index of the sky.

Prosumer net demand

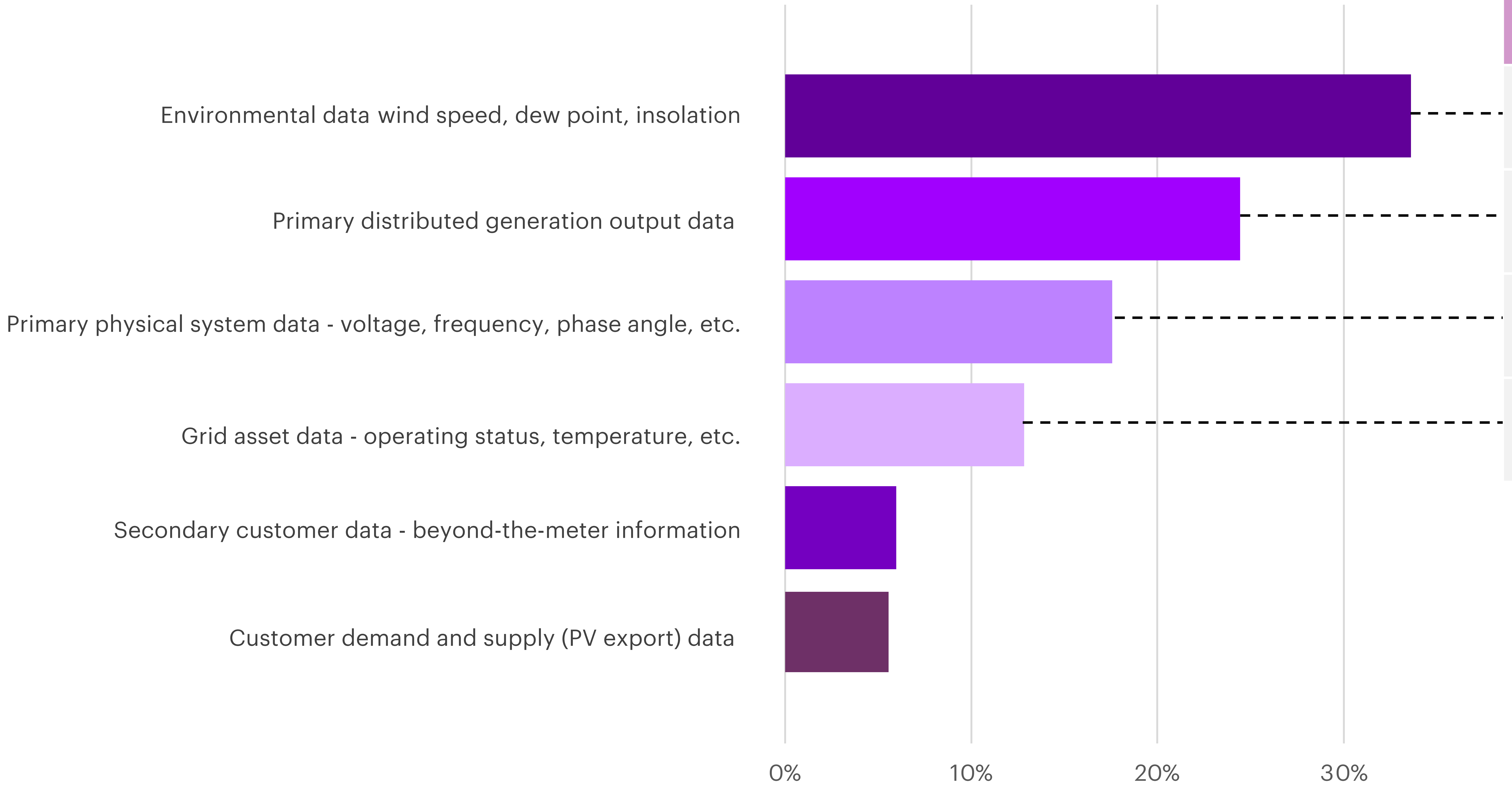
The growth of prosumer generation adds significant uncertainty into demand models. Typically, a utility creates a simplified demand forecast by averaging demand across a number of households. Prosumer PV upsets this method such that on a partially cloudy summer day, the net demand for a low-voltage circuit can swing rapidly from net export to peak demand in minutes. New demand models, supported by high-resolution data, must take account of PV deployment levels and weather patterns.



Distribution utilities are already collecting data from IoT devices. But the opportunity is largely untapped: 84% of respondents believe that IoT is fundamental to flexibility solution deployment. In our survey, executives expect to see the biggest impact from IoT in the areas of DG-related environmental data, DG operational data and primary grid data (see Figure 18).

Figure 18. The top two IoT priorities are related to distributed generation forecasting and control.

Which aspects of IoT-derived data do you expect to make the greatest impact to your business over the next five years?



Regional Breakdown

North America	Europe	Asia-Pacific	Latin America
34%	31%	36%	33%
20%	26%	29%	29%
18%	25%		
		13%	17%

Global, top priority (n=250)

Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

IoT challenges

While many distribution utilities have deployed IoT-based solutions at scale, significant challenges to get full value from deployments remain. The greatest challenges are communications (reliability, bandwidth and latency) and cybersecurity (see Figure 19). These challenges must be addressed from the beginning, as part of the system design process. As previously discussed, many utilities are deploying mobile broadband solutions that are well-suited to the management of massive IoT.

Cloud: The great enabler

Effective IoT management is intrinsically linked to cloud computing. Cloud will be a core component of most intelligent grids, and 73% of respondents have already deployed some amount of cloud and IoT. Cloud is tailormade to manage the vast growth in IoT data and deploy big data analytics (see sidebar on page 50).

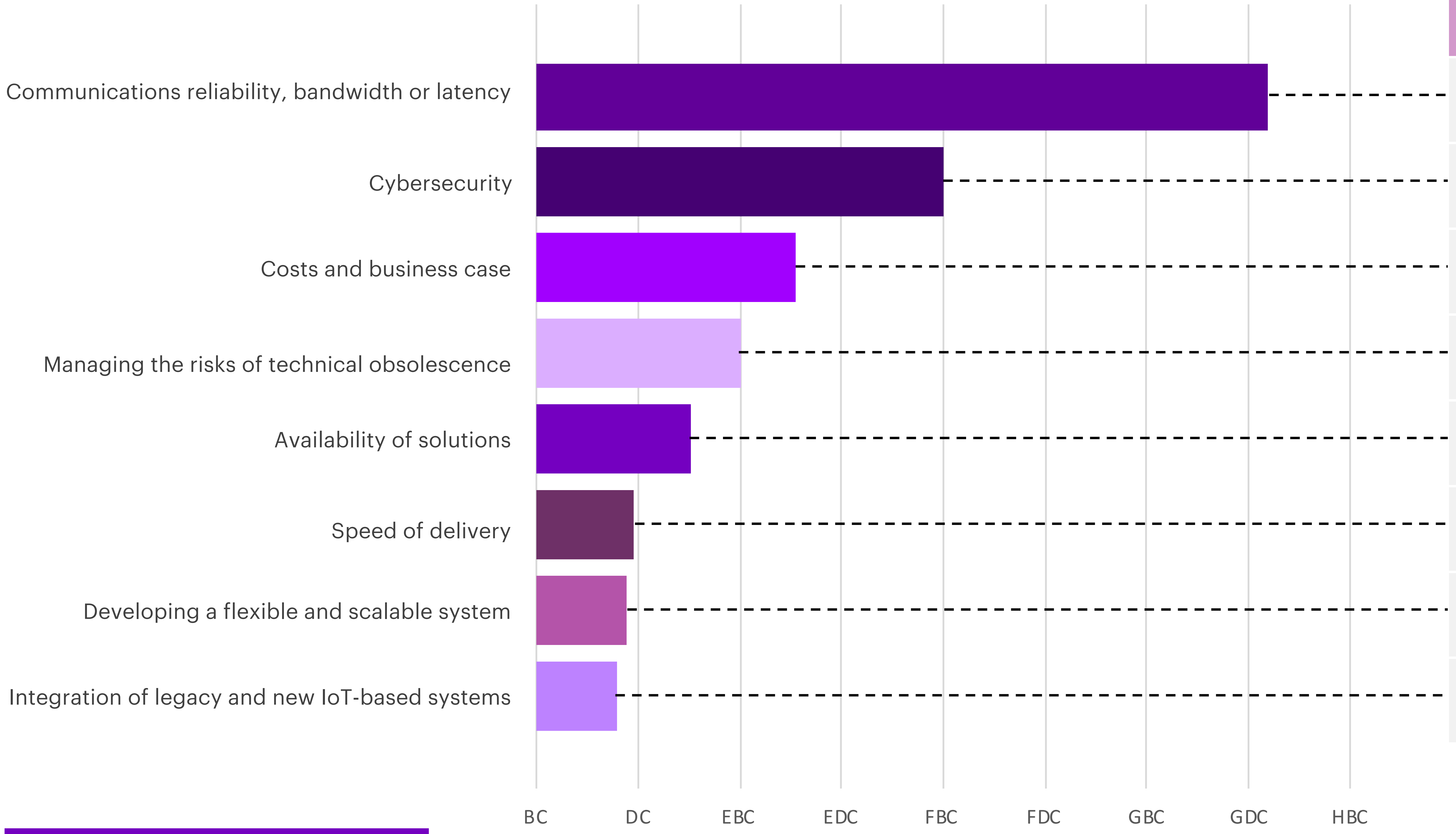
While many grid companies are beginning to leverage cloud in some areas, challenges to capitalize cloud-related costs and concerns regarding security persist. However, the potential for cloud and the capabilities it can unlock are too big to ignore, and both distribution utilities and regulators are laying the foundations to accelerate the move to cloud.

Regulators, cloud vendors and utilities are working together to address historical roadblocks related to account treatments and make it easier to make cloud a capital expenditure leveling the financial playing field with on-premise options. At the same time, cloud vendors are investing in security improvements and creating innovative architectural approaches to address concerns of risk-averse utilities—and some regulators—worries about moving highly sensitive operational or customer data to a public cloud. Hybrid or private cloud solutions will likely continue to be used for sensitive areas, however there are also opportunities for increasing security through an edge- or fog-computing layer choke point (see Figure 20).

While the journey to cloud requires careful staging and consideration, the clear benefits, combined with growing real-world experience from larger utilities such as Enel, will drive accelerating deployment, with security supported via various approaches. Indeed, as accounting approaches level the financial playing field for cloud, the huge investments in cloud security to date mean that for smaller distribution utilities, the move to the cloud may already improve their security levels for non-SCADA data.

Figure 19. What are the biggest challenges to effective optimization of IoT devices? Global dataset, top ranked response.

What are the biggest challenges to effective optimization of IoT devices?



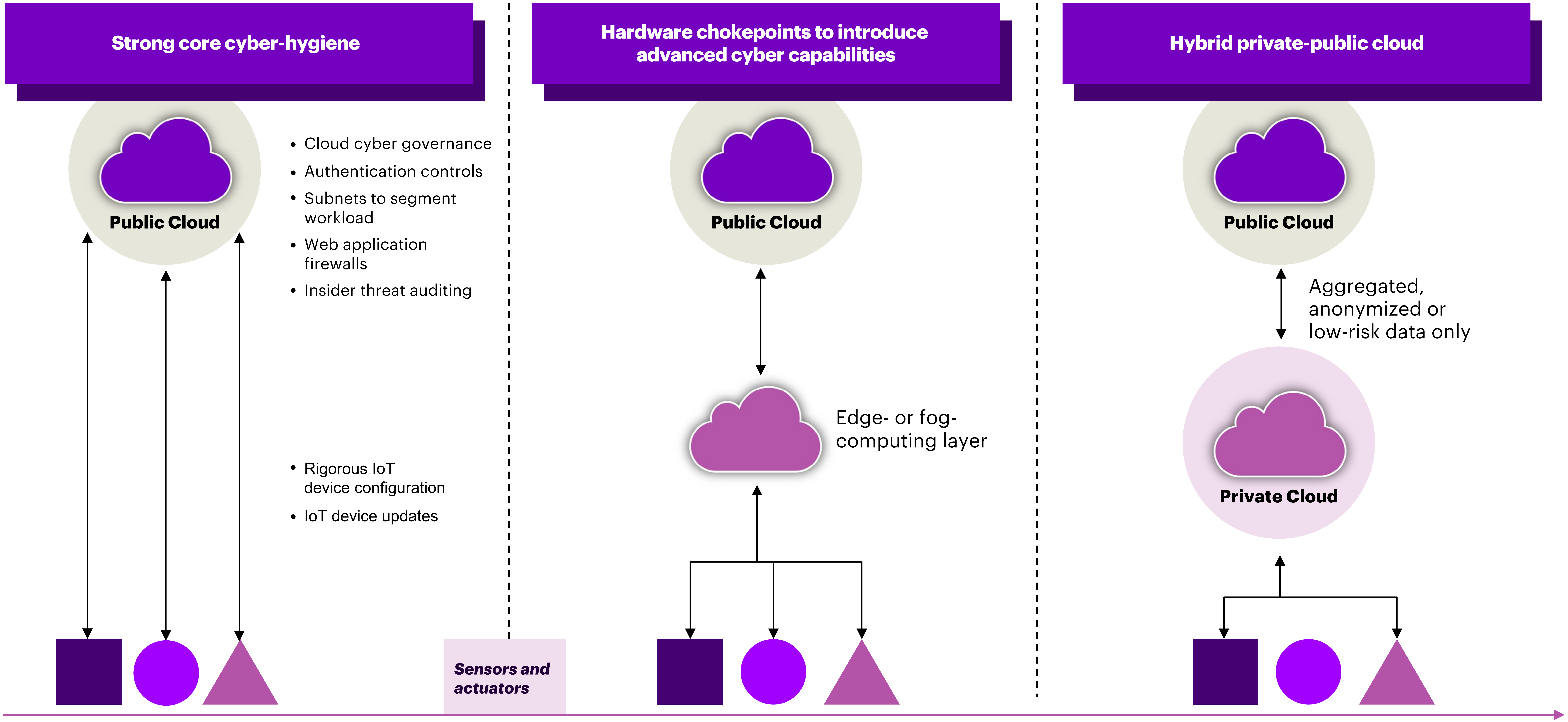
Global, biggest challenge (n=250)

Regional Breakdown

North America	Europe	Asia-Pacific	Latin America
36%	40%	35%	33%
25%	19%	11%	21%
	18%	16%	
15%			17%
		11%	

Source: Accenture's Digitally Enabled Grid research program, 2021 executive survey.

Figure 20. Effective IoT management is intrinsically linked to cloud computing, which also provides added security benefits.



Sidebar: **The cloud imperative**

Cloud technologies are foundational to facilitating a more complex energy system that requires orchestrating DERs, balancing renewables and offering deeper insight and control over energy usage. Beyond improving the current energy system, the cloud also has the potential to create platform energy economies and open innovation, bringing together data and services from multiple providers.

Many utilities have already embarked on their journey to cloud with incremental adoption of infrastructure and software solutions but tackling an enterprise strategy for cloud has been a challenge. For example, in our survey, while 73% of respondents indicated that they have already deployed cloud-based solutions in some form, but many of these are in specific areas of the business or for point applications rather than large-scale cloud transformations.

Utilities' slow move to cloud is for good reason. Historically, accounting treatments for cloud shifted much of the cost to operational expenditures rather than capital. For many distribution utilities, the cost, accounting and regulatory approach to cloud made the business case difficult to justify—but the landscape is shifting rapidly. Regulators recognize the value of cloud and are following broader shifts in accounting principles to relax how utilities can recognize and gain recovery for cloud-related costs. Meanwhile, cloud vendors are also working with utilities to create innovative approaches such as long-term licensing that recognize the unique financial considerations many utilities in regulated environments have.

A more holistic business case for cloud is also taking shape. Cloud can enhance business agility and resilience, optimize IT spending, accelerate innovation, enable new business capabilities and revenue streams—all while reducing technology related carbon emissions. For example, AWS users typically use 84% less power and, due of Amazon's renewable energy commitments, they also reduce carbon emissions by 88% compared to typical on-premise solutions.[23] There is no question there are significant benefits to large-scale cloud adoption and as historical roadblocks are removed, the question for utilities is how, now when to accelerate the move to cloud.

Example: Enel – Beyond Cloud Computing[24]

In 2020, Enel Group developed one of the largest corporate telecom network virtualization projects in the world, connecting more than 1,000 sites on three continents and in over 10 countries.

The initiative is part of Enel's broader strategic Beyond Cloud Computing program, in which the software-defined wide area network, technology that optimizes access to cloud applications and use of connectivity, and edge computing solutions merge to create a telecom architecture that helps achieve operational excellence through the comprehensive digitization of processes.

Beyond Cloud Computing project is part of a digital transformation program launched in 2015 with a migration to the cloud. The project is based on a lean virtual infrastructure that, in addition to private networks, also uses public networks. This public connectivity was made possible through adoption of a secure dedicated virtual network, offering high quality service and reduced costs, precisely because it was built by integrating public and private infrastructure.

The program has enabled the introduction of architectures and technologies aimed at accelerating digitization through a public cloud. It showcases the group's first step toward edge computing, which will reduce data processing latency, thus boosting the processing capacity distributed around the country.

Evolve to the fully intelligent grid

Central control limitations of the future grid

At a granular level, supply and demand are on a one-way path to becoming increasingly random, creating a stochastic grid. The combination of centralized generation and relatively stable average customer demand patterns meant that overprovision of capacity and passive grid management were a secure, low-cost strategy. In the near future, significant supply and demand swings—caused by variable output from grid and prosumer DG, embedded storage, EV charging and other customer behaviors such as peer-to-peer transactions—will lead to localized problems. Grid management processes must change to address such localized issues.

Distribution systems' centralized architecture places practical limits on the timescales and resolution of grid analytics. There is only so much data that can be collected and analyzed before computation and communication limits are encountered. Even the deployment of new fast solutions such as 5G cannot solve many practical issues:

- Managing a complex, highly diverse set of sensor and control devices.
- The efficient transfer of large volumes of data from IoT devices can be reliant on very high bandwidth comms and, therefore, large cloud service requirements.
- The time scales for centralized control of remote devices are typically in the order of one to two seconds, reducing the potential for real time optimization of a localized sets of devices.

Distributed intelligence for the distribution grid

In the highly dynamic grid of the future, a distributed intelligence approach to data flow and control is needed to ensure delivery of secure, scalable, economic and self-healing grids. In practice, distributed intelligence has three key components:

- Central control informed by probabilistic models and enhanced situational awareness.
- Intelligent data flow with local data management.
- Local optimization—autonomous operations—within prescribed limits.

Distributed intelligence relies on edge-computing solutions to manage data flow and local coordination of IoT (see Figure 21).

The value of local data management

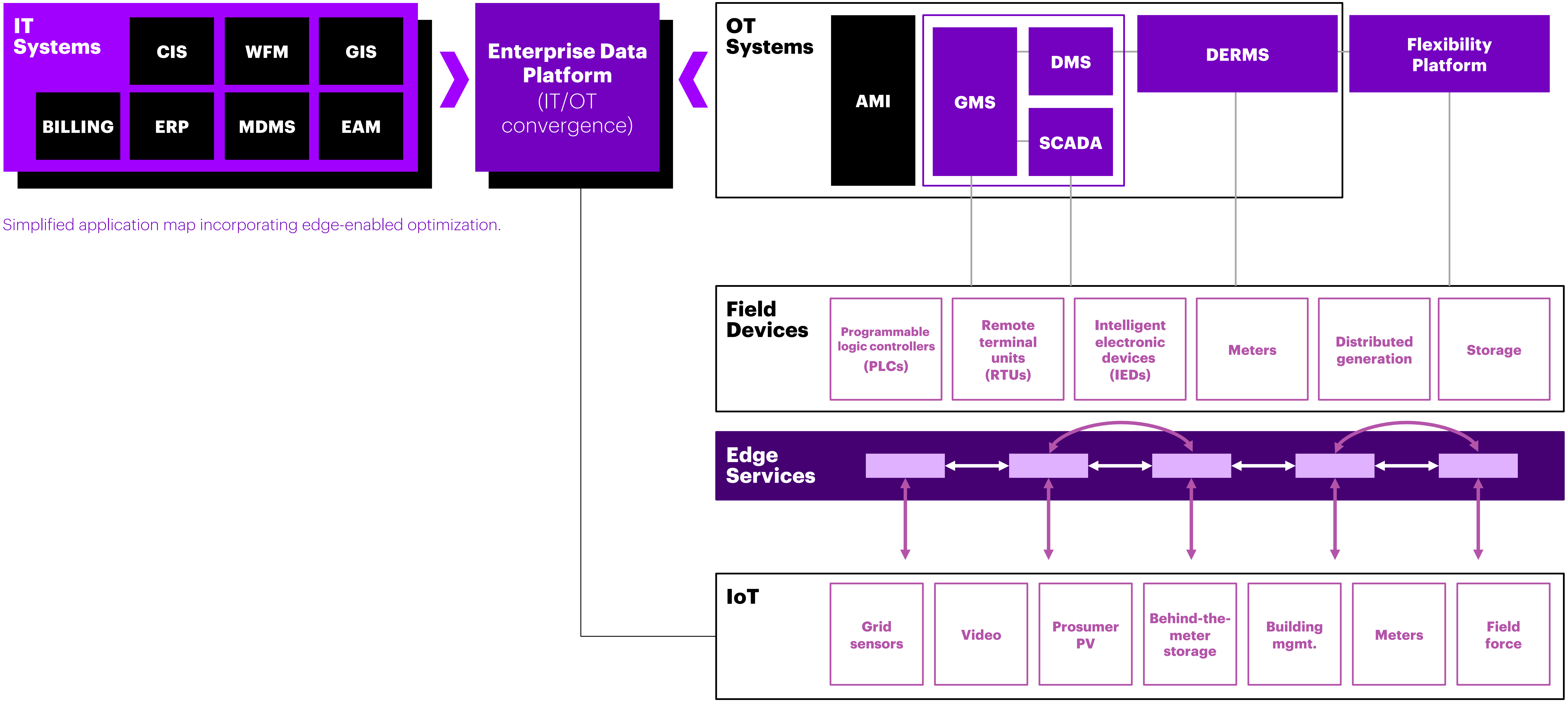
Enhanced communications should not be viewed simply as a "larger pipe" that brings enormous quantities of data to centralized systems. It is inefficient in terms of communications costs, cloud service costs and analyst time. Rather, 5G should be seen as a tool that, along with edge computing, facilitates modern virtualization approaches to manage data locally, reducing the need to transport sensitive information and optimizing communications (see Figure 22).

Enhanced use cases with edge computing

Edge computing distributes computation and data management across the grid, particularly on the periphery, where visibility and control has been lacking (see sidebar on page 57). The additional real-time control and security at the periphery could enable many use cases previously considered uneconomic (see Figure 23). Distribution utilities can focus their edge investments just on the parts of the network with significant operational issues or potential value.

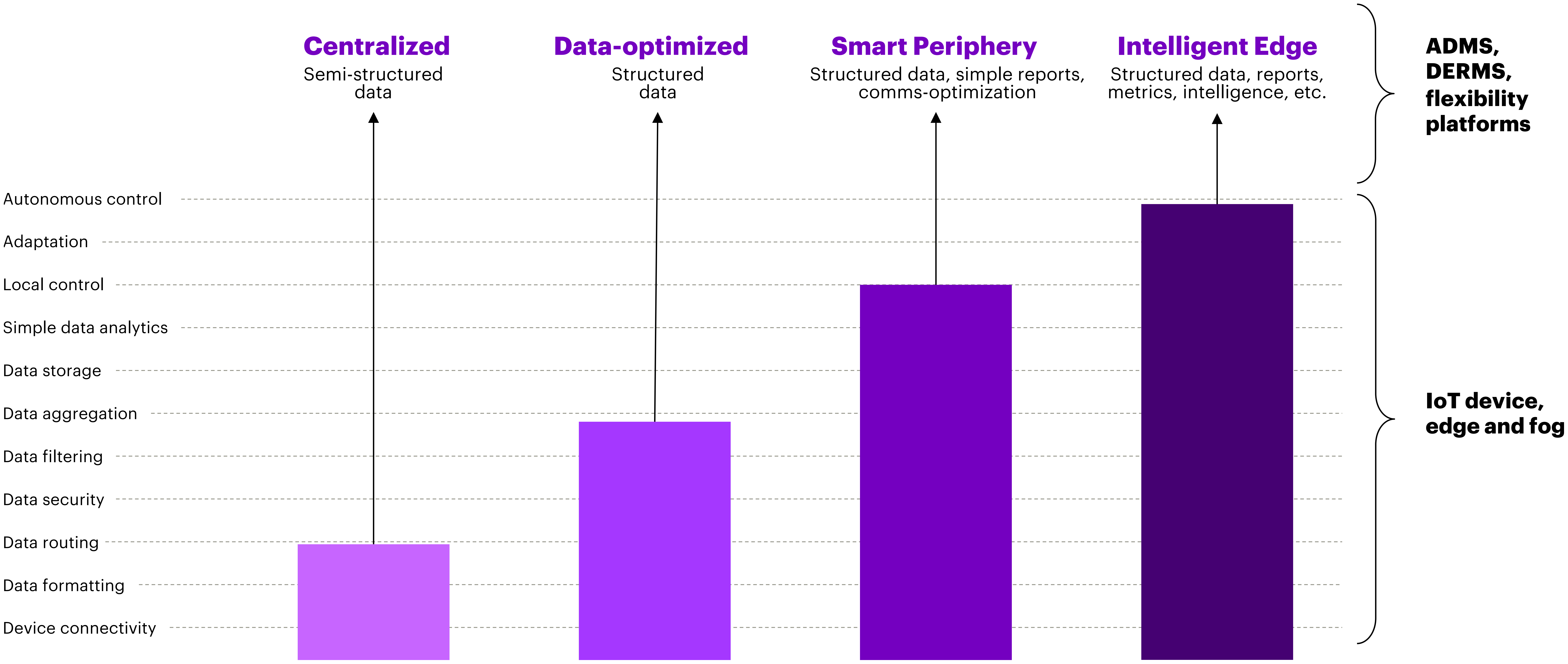
Grid-edge solutions are already being trialed. In the United Kingdom, Tesla—in partnership with Octopus Energy—launched the Tesla Energy Plan. It offers a flexible energy tariff to customers with solar and energy storage. These households can also plug into Tesla's UK Virtual Power Plant, a network of homes that generate, store, and dispatch electricity to the grid at peak times.[25]

Figure 21. Distributed intelligence relies on edge-computing solutions to manage data flow and local coordination of IoT.



Simplified application map incorporating edge-enabled optimization.

Figure 22. Applying edge- or fog-computing solutions can facilitate distributed data management.



Source: Accenture Analysis

Figure 23. Edge computing could introduce many use cases previously considered uneconomic.

Real-time monitoring

Alarm system improvement, due to electrical measurements analysis directly on edge

Predictive maintenance

"Near-real-time" analysis of electrical system dynamics to prevent faults

Smart fault selection

Fault processing algorithm, shifted to the edge to reduce protection intervention time

Enhanced distribution control

Increased system control autonomy of stations and substations to efficiently recalibrate the network in case of fault

Wire and cable monitoring

Wire and cable sensor data ingestion and sending to TSO/DSO data lake

Dynamic line rating

Real-time analytics to manage the variation of line's thermal capacity, to minimize grid congestion

IoT

Sensor data ingestion and elaboration, near the source of information, to enrich collected data

Infrastructure stability monitoring

Sensors collect and send data about infrastructure stability of trellis, to edge nodes spread across the grid

Metering

Processing data within the edge to enhance polling frequency and data analysis providing to users more detailed reports

AR maintenance

Computational layer in the stations and trellis to enable AR maintenance of electrical systems

Digital twin

Distributed elaboration layer that enables interaction with virtual grid and asset representation

Video monitoring

Processing video data within edge nodes installed near cameras for operational and security alarms trigger

Health and safety

Real-time reporting of a safety problem and, therefore, reduction of intervention time

Ice layers prevention

Edge nodes gather and elaborate, proactively, data from sensors related to ice formation on wires and cables

Demand response

Intelligent edge spread in medium-voltage/low-voltage grid to simplify demand response

Salt deposits prevention

A distributed computational layer can collect a huge amount of air salinity data, in order to trigger in time maintenance process

The concept of the digital twin, highlighted in Accenture's Technology Vision 2021 "Mirrored World" trend,[26] can power new possibilities through a digital-physical world. When built on comprehensive, compatible and trusted data, digital twins and mirrored environments can help utilities optimize operations, detect and predict anomalies, pivot to prevent unplanned downtime, enable greater autonomy, and dynamically adjust their designs and strategies with every new piece of data they collect or new test they run. This can help network operators and planners to make value-driven decisions across a range of operations, all the way from the boardroom to system operations.

For example, virtual "what-if" scenario planning makes it possible to test the implications of changes such as DG deployment or EV-driven demand growth, and to better determine appropriate levels of spend on new network capital and operational projects. In addition, virtual and augmented reality environments can mimic network locations, giving employees immersive learning and development experiences. Finally, simulations enable deeper insights into network assets, making it possible to predict and prevent failures to achieve greater performance as well as supporting the troubleshooting of real-time system outages.

Currently, none of our 250 respondents reported using digital twins, however, this is not surprising given the current level of system visibility for the large majority of distribution companies. As visibility is extended and enhanced analytics tools, such as state estimation, become more common, we would expect to see increasing uptake of the digital twin approach.

Sidebar: **The rise of edge computing**

There are many ways to deploy an IoT solution, depending on the functionality required. In cloud-enabled IoT, devices connect directly to the cloud via a gateway, and all calculations take place in the cloud. Fog-enabled IoT devices connect to local servers, which can then connect to the cloud. In edge-enabled IoT, an IoT gateway runs more advanced data management, analytics, local control and communication.

The more sophisticated the deployment, the more advantageous edge computing becomes. Edge devices have more advanced data handling capabilities (data filtering, compression, storage and aggregation), which optimize the volume of data transmitted by a comms network. For example, only data required for analysis needs to be transmitted to the cloud. This approach reduces lessens the latency and bandwidth strain on comms networks and cloud capacity required, which can reduce costs.

Second, edge computing enables localized, near-real-time system management of edge devices. A centralized control system has a 1 to 2 second response time; local, autonomous control can respond within milliseconds. Potential new capabilities enabled by edge computing include VPP, local protection coordination, small-scale DER optimization and building management systems.

Because much of the data is not transmitted, it is more secure by design. Also, edge devices have sufficient computing power and memory to install sophisticated security software.

Example: Iberdrola's collaboration for a digital platform, based on edge[27]

Iberdrola, in collaboration with a group of industry partners and technological companies, is driving the development of a new digital platform (SSP) for secondary substations. Based on edge computing, it will allow the company to continue leading the digital transformation of its network business. This technology facilitates the distribution of advanced computing capabilities onto different nodes of the grid (in this case, secondary substations) representing a significant step in the digitalization of the distribution grid and the ability to meet customers' new requirements, integrate new distributed resources, and support the increasing electrification of the economy, thereby promoting the energy transition.

05

Conclusion and strategic priorities

Conclusion

We've seen that the energy transition creates as many opportunities as it does threats. For distribution businesses to prosper, they must move on transformation now, adopting new digital capabilities and technologies, founded on radically improved visibility and control of the grid, DER and consumers.

We expect to see very different approaches around the world, based on business priorities and points in the journey. However, at whatever stage a distribution business takes on this transformation, a strong data foundation is paramount. An innovative mindset and agility to execute must be baked into every action made toward meeting the challenges of the energy transition.

Actions for distribution businesses

We have identified several select actions for utilities—those that can be taken today and some longer term—covering the next 10 years. And to a distribution business, a decade is practically right around the corner. However, just as businesses will begin at different stages of adoption, the rates of adoption will also vary, with various actions taken at different times.

Review current energy transition strategy
To start, determine that robust scenarios and forecasts are being used to inform DER deployment strategies. This could include a clearer understanding of customer expectations and their trigger points for investing in low-carbon technologies such as in EVs or DG. In tandem, it's important to have a thorough command of the regulatory and governmental policies for those technologies. External perspectives should also be included, such as technology cost forecasts, third-party forecasts, and the deployments experiences of other distribution businesses around the world.

Assess deployment scenarios against grid system models
Evaluate DER deployment scenarios against existing grid system models to identify areas of the network with the highest system risk This can be achieved by identifying potential DER deployment tipping points. From here, network planners can identify high-level solutions for each scenario, covering traditional reinforcement, operations changes and non-wire solutions.

Build use cases, functional specifications and associated business cases
Develop detailed use cases and the functional specifications for their delivery. These should include a high-level review of implementation implications, so that a cost-benefit analysis of solutions can be created. Following a complete review, businesses can begin to test and pilot prioritized use cases.

Refine the digital strategy
Incorporate any new requirements for the energy transition into the business's digital strategy. A key element of the delivery approach could be to form strategic partnerships with external providers to gain speed and skills. Nearly three-quarters of our respondents believe that scaling and deploying solutions is a significant or moderate challenge across the innovation lifecycle. But this could be eased through strategic partnering, helping distribution businesses deliver more effectively and increase benefit realization. Such partnership could increase access to core skills, accelerate deployments utilizing ready-made solutions, improve cost efficiency, and manage technology obsolescence risks.

Collaborate with regulators to evolve the regulatory model
Create a closer collaborative environment with regulators that can accelerate changes needed to meet the requirements of the energy transition. Part of this relationship would incorporate a clearly articulated leading role for distribution. The regulatory model should also articulate new revenue and incentive models, plus agreement on the potential scope of new service and asset provisions where applicable.

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