Evolution of the Grid Edge:
Pathways to Transformation

A GTM Research Whitepaper

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At its core, the concept of the "grid edge" is about the most significant transformation that the electricity sector has witnessed in a century. GTM Research launched the grid edge concept in October 2013 with a white paper, and it has grown into the core way Greentech Media views the market, approaches research and fosters a network of industry leaders impacting this new ecosystem. As with any transformation, this change will not be linear and systematic. As the grid-edge ecosystem and market develops, utilities will follow different paths of adoption based on the needs and issues specific to the territories they serve. Customer needs in California differ from those in North Carolina, and the stresses on reliability and resiliency will inevitably be different in New York versus Florida. As such, it is important to understand the various ways this market will evolve, as this will have inherent implications in terms of how and when hardware and software providers should bring solutions to potential utility customers.

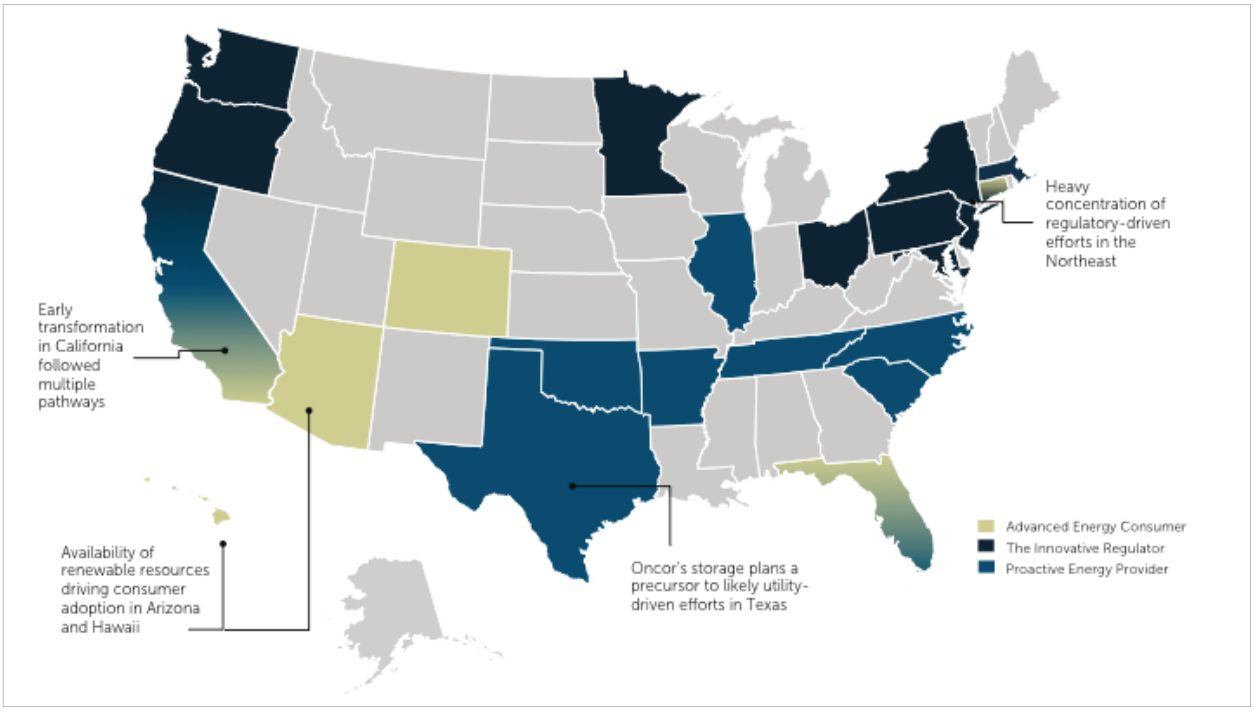
'The grid edge comprises the technologies, solutions and business models advancing the transition toward a decentralized, distributed and transactive electric grid.'

While every market will experience this transformation through a unique process, we categorize these pathways in three distinct groups. Though some of these will share overlapping trends and may appear on the surface to have similar tendencies, they provide some individual milestones as to when various grid-edge technology decisions will be made. Additionally, these pathways provide a framework for solution providers to plan when their offerings could offer the most value to utilities and energy providers undergoing this transformation. The following summarizes the characteristics of each pathway:

- **The Advanced Energy Consumer:** Customer-driven pathway led by early adopters, as seen in Hawaii and Arizona
- **The Innovative Regulator:** Regulatory-driven pathway, with the most notable current example being New York
- **The Proactive Energy Provider:** Utility-led transformation, which can be applied to upgrades underway at Duke and Southern California Edison

The following map shows GTM Research's predictions of which states are likely to follow certain pathways. In some cases, grid-edge technology adoption is already well underway, while other states are just beginning their journey. As more states begin to review their grid modernization plans, this map may change or evolve over time.

Figure 1: Predictions of Grid Edge Technology Adoption Pathways



Source: GTM Research

It is important to note that as this market matures, some regions may glean lessons from other states or regions and adapt their own approaches accordingly. Still, it is helpful to consider some of the common paths toward maturation, which demonstrate that this market is becoming the kind of cohesive, interdependent ecosystem required to support the electric system of the future.

Figure 2: Comparison Chart: Adoption Pathway Characteristics

PATHWAY	TYPICAL CHARACTERISTICS	RELATIVE SPEED OF ADOPTION	PREDICTED STATES
Advanced Energy Consumer	• Rate structures resulting in comparably high bills • Tiered rates • Peak-time charges • High C&I demand charges • Abundance of renewable resources • Tech-savvy customer base	Fastest; customer demand drives action	• Hawaii • Arizona • Colorado • California* • Florida*
The Innovative Regulator	• Aging infrastructure • High cost of service • Regulator interest in deferring capital expenditures • Active ratepayer advocacy groups • Local economic considerations • Specific resiliency or reliability needs	Slower; driven by pilot projects	• New York • Massachusetts • Minnesota • New Jersey • Pennsylvania • Maryland • Ohio • Washington • Oregon • California*
Proactive Energy Provider	• Capacity constrained (at distribution/circuit level) • Strong focus on operational efficiency • Current or expected population growth	Slower; driven by regulatory approval process	• Illinois • Texas • Oklahoma • North Carolina • South Carolina • Tennessee • California* • Florida*

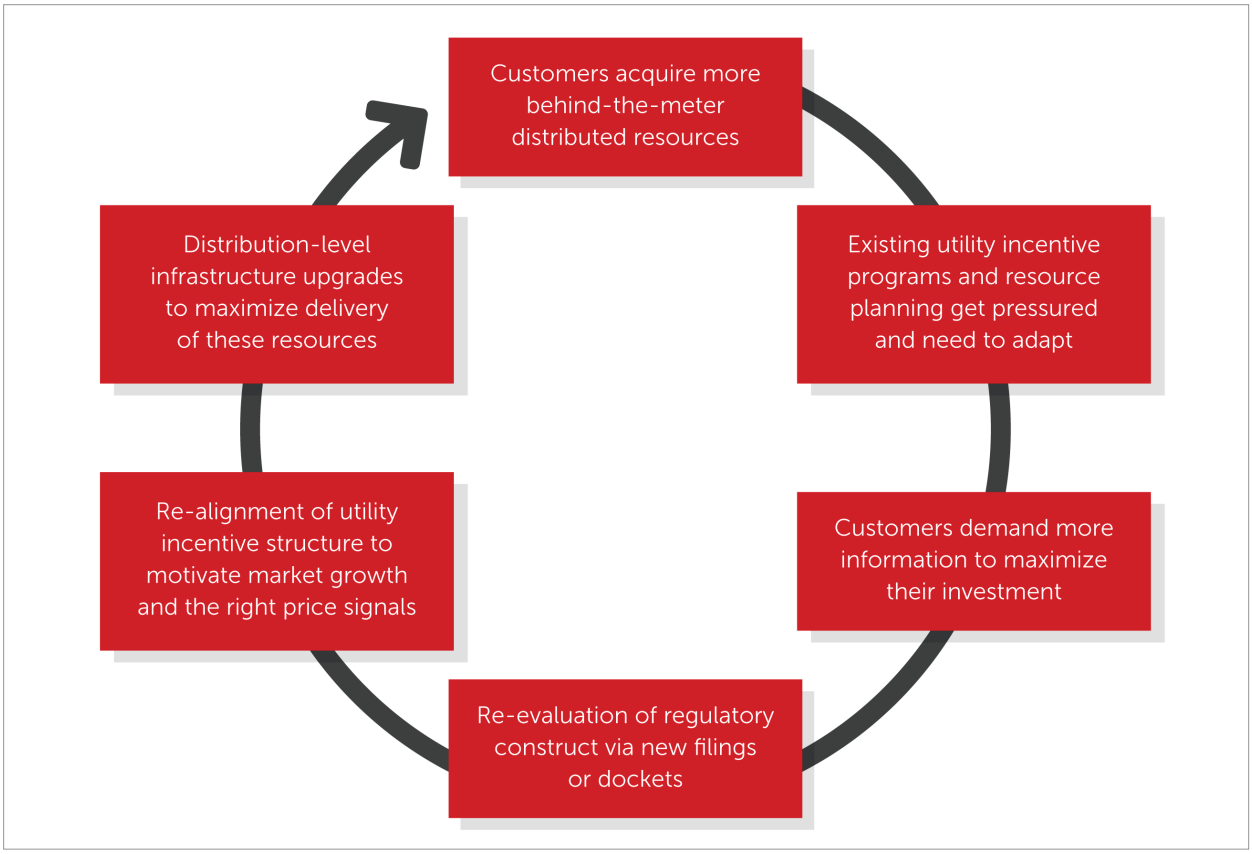
Note: *Denotes state that is predicted to go through multiple pathways of grid-edge transformation

Source: GTM Research

I The Advanced Energy Consumer

We expect to see this adoption cycle take places in states like Hawaii, Arizona and Colorado. Relatable elements are present in California with the anticipated rise of behind-the-meter storage and increased EV penetration, as well as Florida which is expected to see solar growth over the coming years.

Figure 3: Advanced Energy Consumer Adoption Pathway



Source: GTM Research

1. **Customers acquire more behind-the-meter distributed resources.** Growing customer interest in owning the assets needed to generate electricity has fostered the evolution of the grid-edge ecosystem in a number of markets. These markets typically have characteristics including high residential electricity rates, substantial demand charges for commercial and industrial customers, an abundance of renewable resources, and a more progressive, tech-savvy customer base.

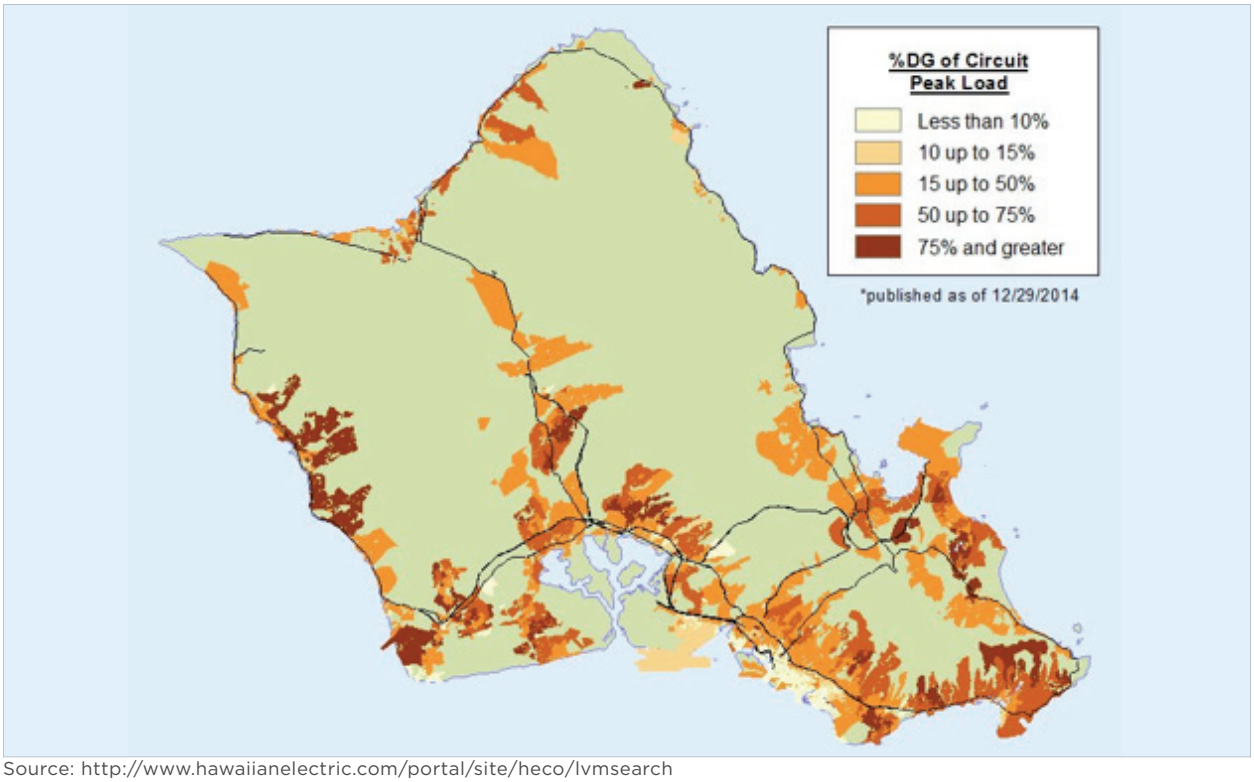
   Hawaii and Arizona are prime examples of this pattern of grid-edge deployment, as they both have an abundance of renewable resources and are early leaders in the deployment of distributed solar. Additionally, Hawaii is a primary testing ground for behind-the-meter energy storage. It could also be argued that early solar adopters in California followed a similar path and motivated the creation of net metering tariffs, the California Solar Initiative, Power Purchase Agreements (PPAs), etc. With

the anticipated rise of the energy storage market in other states, expect this adoption cycle to play out elsewhere and even potentially repeat itself in a second-generation grid edge maturity process within renewable-saturated markets.

2. **Existing utility incentive programs and resource planning get pressured and need to adapt.** As distributed energy resources proliferate and require interconnection with the grid, utility load curves shift. This fundamentally changes the nature of utilities' integrated resource planning and procurement of energy, and also impacts how utilities compensate customers for their generation.

   Recent reviews of net metering tariffs and PPAs are clear examples of this, but perhaps the larger challenge facing this part of the customer-led grid-edge deployment process is how best to redesign utility management of the grid to maximize the use of these customer assets. In Hawaii, this is manifesting in the need for a more locally focused integrated resource plan (e.g., on a circuit-by-circuit basis), addition of new distributed energy goals and, improved processes for customer interconnection.

Figure 4: Hawaii Electric Distributed Generation Penetration by Circuit



Source: http://www.hawaiianelectric.com/portal/site/heco/lvmsearch

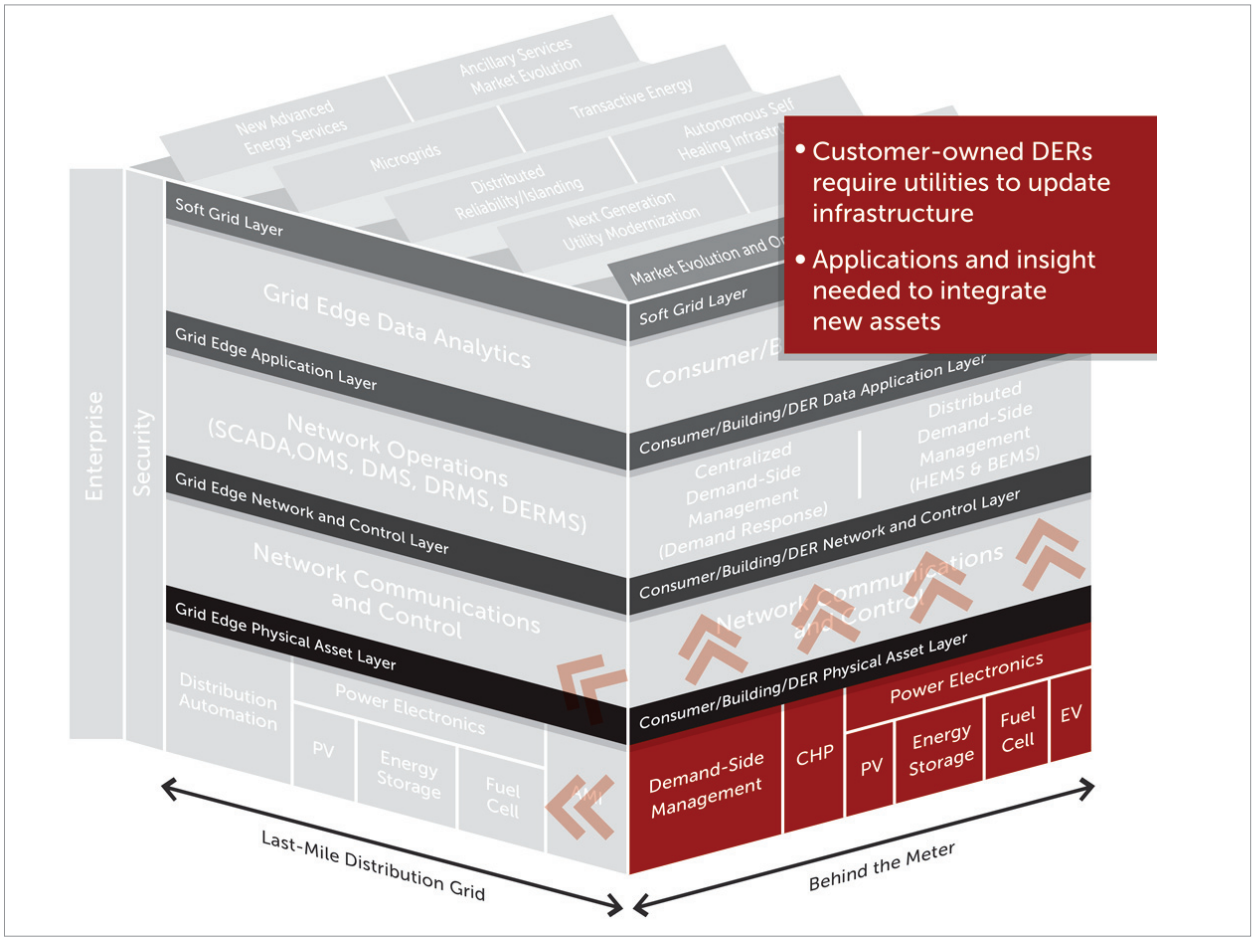
3. **Customers demand more information to maximize their investment.** Understanding the performance of behind-the-meter investments is key to customers recouping their costs and achieving their goals. Grid-edge software and analytics investments are required in order to be able to show customers these benefits, and they require interoperability with extant utility data systems. Utilities require more intelligent systems to enable them to offer more market-driven pricing signals. This in turn will allow utilities to make more efficient use of these assets and open up new opportunities for customer-facing value-add products and services.

4. **Re-evaluation of regulatory construct via new filings or dockets.** The pathway to transformation described in this discussion will inevitably lead to a need to re-examine and reform public utility regulations. In a customer-led process of grid-edge transformation, pressure begins with customers' perception that the current construct is limiting their ability to self-generate and participate/interconnect with the grid. This is the key part of the transitional process Hawaii is grappling with today, particularly in a proceeding that is looking at the current decoupled structure of HECO.

   (For a detailed look at the current regulatory landscape in Hawaii and four other key states, see GTM Research's recently published report Regulating the Utility of the Future: Implications for the Grid Edge.)

5. **Re-alignment of utility incentive structure to motivate market growth and the right price signals.** Another inevitability in this change process is a fundamental shift in how utilities operate in a world of widespread distributed generation. This can happen in a number of ways, whether it be adjustments in the utility compensation model, rewriting of decoupling or net metering rules, additions of new items such as fixed charges or real-time pricing, or re-evaluation and overhaul of rate structures, which GTM Research believes to be critical to utilities' long-term success. Returning to the Hawaii example, the outcome of the proceedings currently underway in that state could provide signals as to how this step in the process will play out in other markets.
6. **Distribution-level infrastructure upgrades to maximize delivery of these resources.** In an established market, regulatory guidance is provided, incentives for utilities to integrate DERs are balanced, and investment in a distribution infrastructure that can support a profitable grid-edge market becomes a necessity. This opens up opportunities beyond the immediate physical asset layer and includes a new grid-edge application layer that can provide utilities and grid operators with necessary intelligence across a more distributed infrastructure. Distributed automation and other related investments help utilities react to the inherent volatility these new assets introduce onto the grid and enable them to meet appropriate service levels.

Figure 5: The Advanced Energy Consumer Technology Adoption Pathway

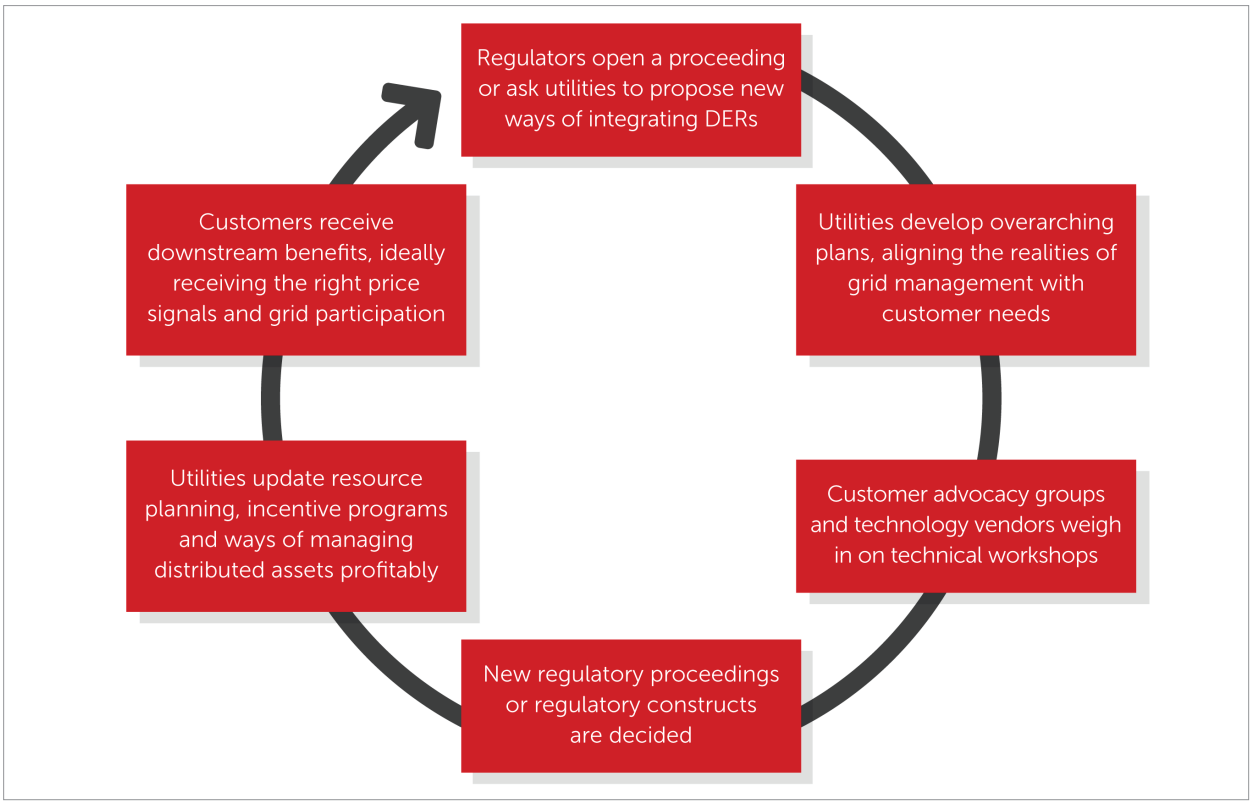


Source: GTM Research

II The Innovative Regulator

We expect to see this adoption cycle take place in states such as New York, Massachusetts, Minnesota, Washington, Oregon, New Jersey and Pennsylvania, among others.

Figure 6: The Innovative Regulator Adoption Pathway



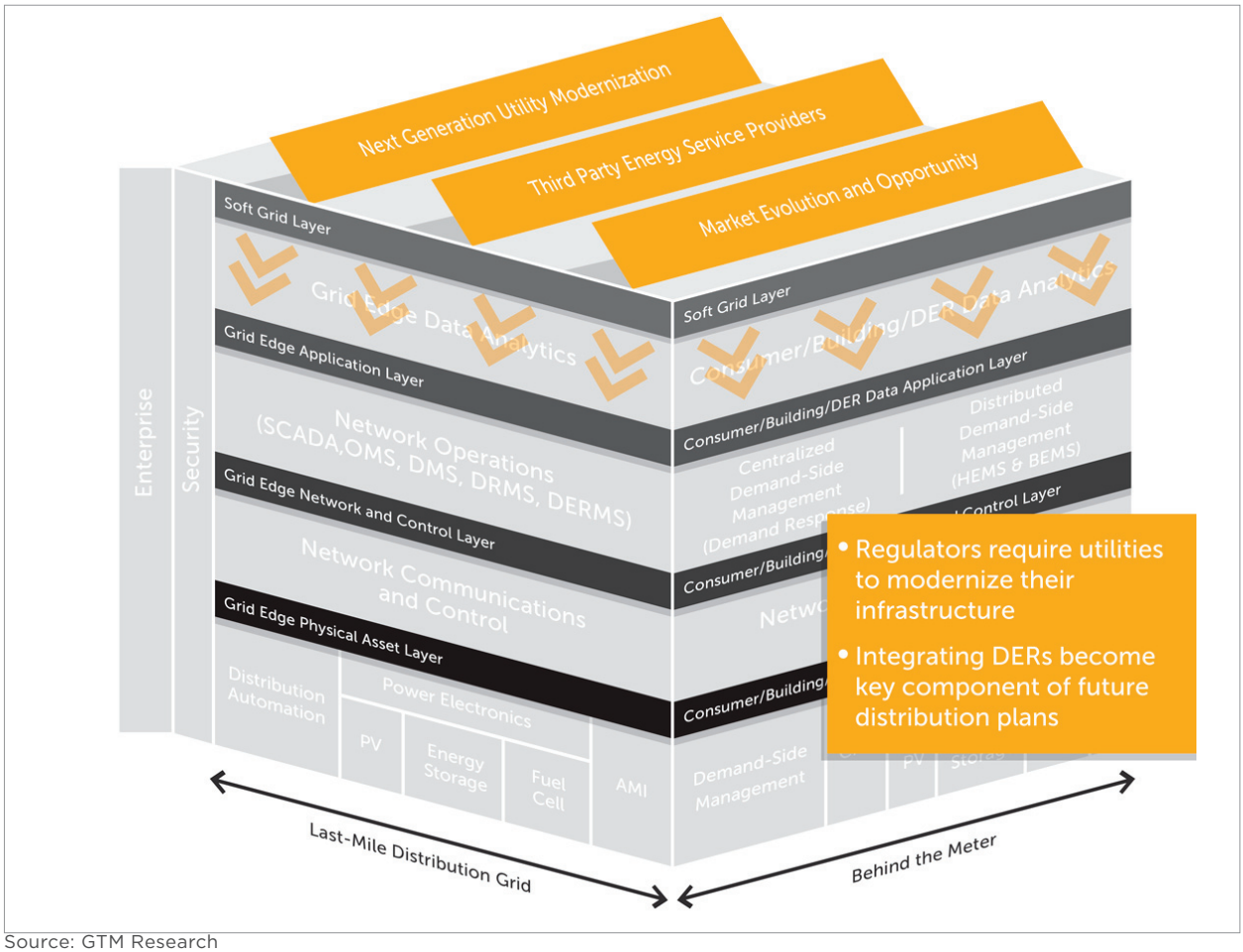
Source: GTM Research

1. **Regulators open a proceeding or ask utilities to propose new ways of integrating DERs.** This process of grid-edge adoption begins with an acknowledgment from regulators that the status quo is not sustainable. Customer demand has not yet reached a critical stage, but other factors such as an aging, strained infrastructure or heightened resiliency requirements are driving a regulatory-led reform agenda. The New York "Reforming the Energy Vision" (REV) proceeding is a prime example, but parallels to this process can also be seen in adjacent markets, such as New Jersey passing renewable portfolio standards for utilities, a move that facilitated the creation of the state's SREC market.
2. **Utilities develop overarching plans, aligning the realities of grid management with customer needs.** In response to requests from regulators, utilities develop plans to reach specific distributed energy goals. This often leads to some pilot projects that are either grid-focused (pertaining to the distribution network) or customer-focused (such as new incentives for distributed energy

generation or improved interconnection requirements). Con Ed's Brooklyn-Queens substation deferral project, although a $500M investment that exceeds the scope of most typical pilot projects, is an example of a utility focusing on demand-side management tactics to avoid investing in a new large-scale capital project.

3. **Customer advocacy groups and technology vendors weigh in on technical workshops.** As utilities review options and pilot various technology projects, the larger market ecosystem weighs in on the regulatory process to help shape how the future market will look. In the case of New York's REV initiative, a series of workshops have recently concluded in the first track of the proceeding, the findings of which will likely impact regulatory guidance and utility requirements. For technology vendors, this can often be a critical part of the transitional process, governing multi-million-dollar RFPs and the selection of solutions and providers.
4. **New regulatory proceedings or regulatory constructs are decided.** New incentives, mandates and goals are imposed on utilities. In the case of New York, the role of incumbent utilities will likely change to include different business goals and needs (e.g., the role of newly created distributed service platform providers). In California, the result of the three IOUs filing their new distribution plans in mid-2015 may have a similar transformative impact. Regardless of the specific nature of the change, it is this part of the regulator-driven transformation process that opens up the grid-edge market and begins to motivate rapid technology upgrades and stimulate customer adoption of DERs.
5. **Utilities update resource planning, incentive programs and ways of managing distributed assets profitably.** Utilities respond to calls for reform by creating new customer programs, expanding technology pilots, and updating their integrated resource plans. Customer education becomes a key component of utility activities. Grid-edge software and analytics also become key at this stage, allowing utilities and regulators to gain insight into upgraded networks and maximize their investments.
6. **Customers receive downstream benefits, ideally receiving the right price signals and access to full grid participation.** If incentive programs and utility rate structures are designed successfully, customer-owned DERs are integrated with the grid and compensated appropriately. Utilities avoid the need for large capital improvements to maintain grid stability and reliability. The market achieves transparency through integrated data flows between customer-sited generation, the distribution network, and the larger transmission and wholesale power markets. Continued innovation in areas such as maximizing assets, improving intelligence and expanding automation proliferate in this stage.

Figure 7: The Innovative Regulator Technology Adoption Pathway

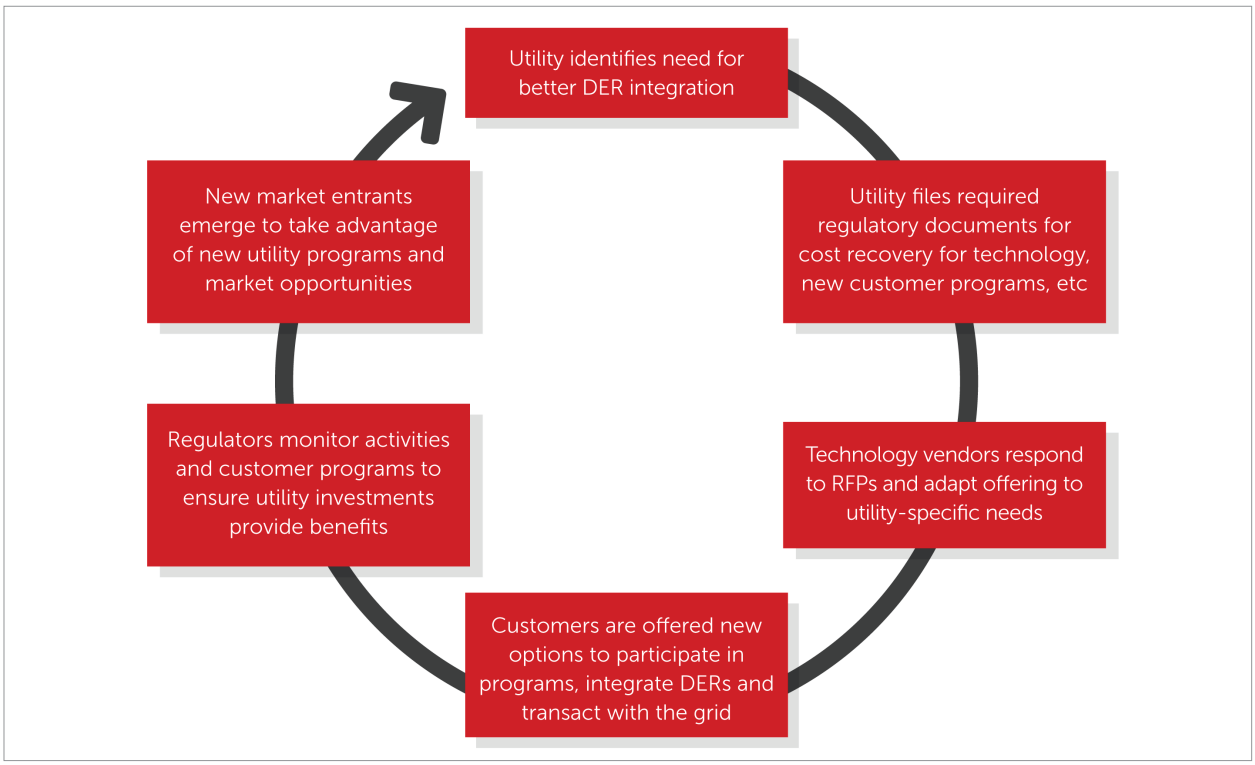


Source: GTM Research

III The Proactive Energy Provider

GTM Research expects to see this adoption cycle take place in states such as Texas, North Carolina, South Carolina and Illinois, among others. The upcoming filing of distribution plans by the three California investor-owned utilities could also spur this technology adoption cycle in that state.

Figure 8: The Proactive Energy Provider Adoption Pathway

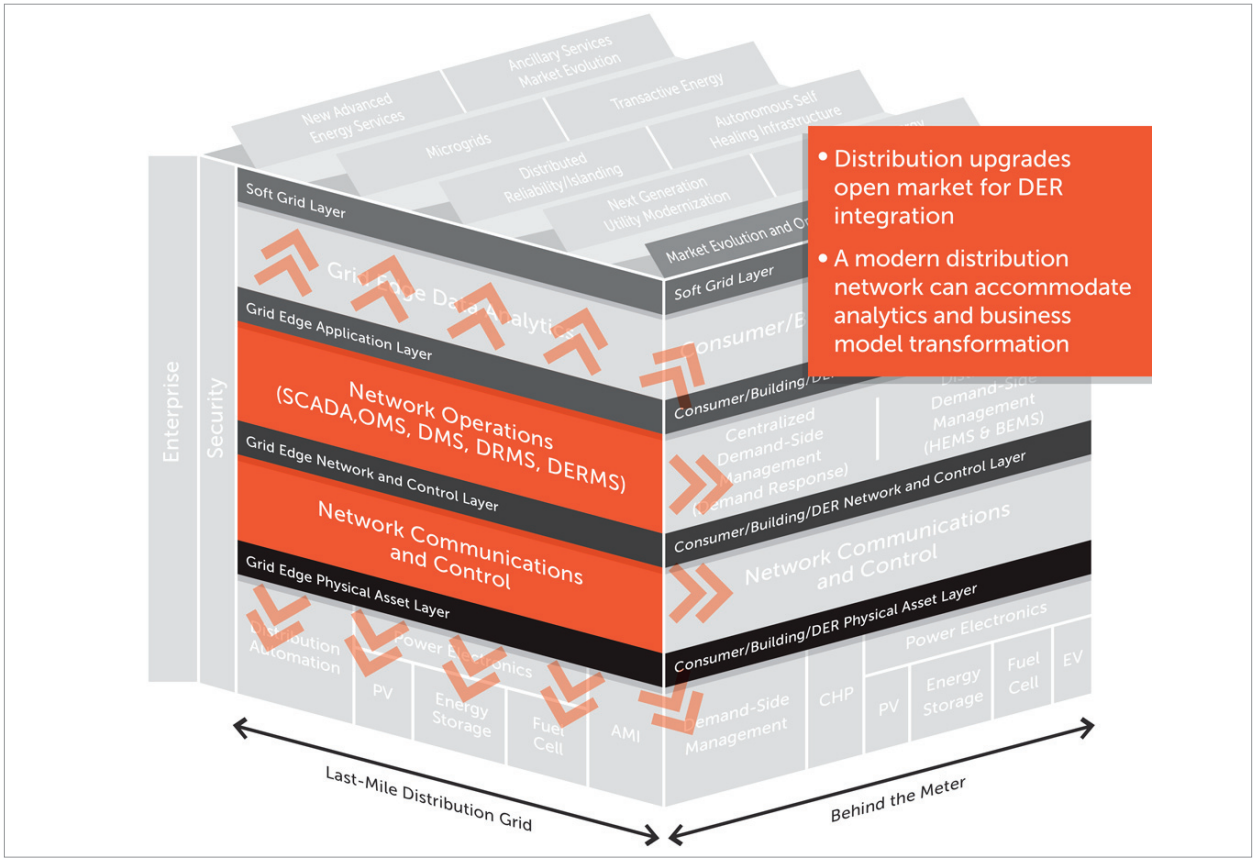


Source: GTM Research

1. **Utility identifies the need for better DER integration.** In this change process, the utility seeks to take the lead on defining the market for DERs within its service territory. The impetus could range from a specific infrastructure need (e.g., Southern California Edison's aggressive storage procurements following the closure of San Onofre Nuclear Generating Station) to a desire to drive the regulatory agenda rather than be driven by it. Duke's efforts in North Carolina, particularly the commitment of $500 million for solar power development, is a prime example of a utility-led grid-edge change process. Additionally, some utilities have more aging distribution infrastructure that requires attention, adding urgency to the transition.

2. **Utility files required regulatory documents for cost recovery for technology, new customer programs, and other elements.** If necessary, utilities file for cost recovery or to otherwise reallocate money within a general rate case or other proceeding to fund pilot projects or encourage local grid-edge investment. In some instances, utilities may see the financial benefit of jump-starting the grid-edge market without asking for immediate cost recovery in order to demonstrate a particular technology's effectiveness.
3. **Technology vendors respond to RFPs and adapt their offerings to utility-specific needs.** As utility budgets for grid-edge products and services are defined, program managers begin to evaluate specific technology needs and define requirements to address the growing amount of distributed resource assets. This can lead to long-term deployment contracts, but it can also take many years for utilities to evaluate and may require multiple project phases.
4. **Customers are offered new options to participate in programs, integrate DERs, and transact with the grid.** As utilities become comfortable with the operation of new technology, customer programs are offered to motivate adoption, increase satisfaction and maximize distributed resources as they come on-line. As the capabilities for grid-edge software and analytics mature, utilities can hone incentives and price signals by circuit and by neighborhood. As more data becomes available, the overall distribution network becomes more intelligent.
5. **Regulators monitor activities and customer programs to ensure that utility investments provide benefits.** Typically conducted in the review of cost recovery requests or within new rate case proceedings, regulators audit programs and technology investments to ensure certain goals and operational efficiency metrics are achieved. Additionally, successful deployments could lead to new renewable portfolio targets, net metering rules, and other changes that could impact the utility's business model.
6. **New market entrants emerge to take advantage of new utility programs and market opportunities.** As the market matures, new entrants may offer customers additional value-add products and services. In deregulated regions, retail energy providers seek to maximize profit-making opportunities and disaggregate customers from their incumbent utility with new product offerings. In regulated markets, a more open and transparent distribution energy market yields quicker technology innovation and data exchange with end-customers. In either case, incumbent utilities continue to re-evaluate their infrastructure and invest in grid-edge technology to reduce operating costs, improve intelligence, and seek new ways to maintain customer satisfaction.

Figure 9: The Proactive Energy Provider Technology Adoption Pathway



Source: GTM Research

Looking Forward

While the transformation at the grid edge will not be uniform in every market and within every utility service territory, the end result will likely look very similar throughout the U.S. This new ecosystem will leverage advanced infrastructure, new technology and a robust software and applications layer to facilitate a yet to be achieved level of integrated planning and intelligence.

Solution providers can target more precisely given the different dynamics within each state. For example, in Hawaii, a software and analytics provider should target the third stage in the "Advanced Energy Consumer" pathway to maximize the opportunity to provide intelligence and information to both customers and utilities as DERs begin to proliferate on the grid. In North Carolina or Texas, the second stage of the process becomes critical for network infrastructure providers as utilities scope their needs and look to the market for options to solve their specific distribution challenges. Finally, for utilities, understanding these different grid edge adoption pathways can help inform future resource planning and distribution investment strategies.

Customers are no longer regarded as ratepayers who are due "minimum service requirements" but rather as active participants and assets that contribute to the success of the entire ecosystem. Additionally, this market transformation is not a new phenomenon – it is prevalent in virtually any other customer-serving industry, from retail to banking to consumer electronics. However, understanding these different pathways of transformation can help solution providers better plan and target solutions to meet the various needs of their customers, at the ideal decision points in time, and help contribute to the speed of this necessary, and inevitable, evolution.

The Grid Edge Executive Council

Where GTM Research gathers industry leaders to discuss this transformation

The Grid Edge Executive Council represents an exclusive group of decision makers driving the future of the electric grid. Through the Council, members can access research on market trends, learn about technological developments, and engage with peers to tackle the electric grid's most pressing questions.

By fostering regular communication through one-on-one interaction, web-based conferencing, and in-person Council meetings, the Executive Council brings together key players in the Grid Edge market to push the industry forward. Facilitated by GTM Research analysts, these engagement opportunities allow members to think critically about new technologies, solutions, architectures, and business models alongside fellow experts in distributed energy resources and utility grid modernization.

COUNCIL ENGAGEMENT	MARKET ANALYSIS
In-Person Executive Council Meetings	In-Depth Market and Technology Reports
Regular Web-Based Council Meetings	Exclusive Report Briefings
Grid Edge Membership Directory	Grid Edge Data Services
Industry Conferences	GTM Research Analyst Access
GTM Council Engagement Manager	Quarterly Market Briefing

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GTM Research Grid Edge Reports

In-depth reports are released over a rolling twelve-month period (see report titles below). Market research reports are generally 30 to 100-plus pages in length, blending quantitative and qualitative analysis. Depending on the scope, the report may cover some or all of the following topics: utility deployment strategies and business models, industry technology choices/comparisons, market trends, vendor profiles, regulation and policy analysis, market forecasts, segmentations, and industry drivers and challenges.

PLANNED REPORTS
Volt/VAR Control Markets: Regulation, Adoption, and Forecasts (Jan 2015)
Storage Management Systems 2015 - 2020: Applications, Players, & Forecast (Jan 2015)
Regulating the Utility of the Future: Implications for the Grid Edge (Jan 2015)
Energy in the Connected Home: Landscape, Distribution Channels, and Markets (Q1 2015)
Ancillary Services at the Grid Edge: Opportunities, Risks and Competition among DERs (Q1 2015)
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