NAVIGANT
RESEARCH

WHITE PAPER

Defining the Digital Future of Utilities

Grid Intelligence for the Energy Cloud in 2030

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Section 1
EXECUTIVE SUMMARY

1.1 Future Utility Value Chain of 2030

This white paper complements Navigant Research's existing research into the development of the Energy Cloud. It builds on discussion in Navigant Research's *Navigating the Energy Transformation*[1] white paper on an aggressive Energy Cloud scenario, where the grid is two-way, networked, distributed, clean, and intelligent. In this scenario, distributed energy resources (DER), which include solar PV, energy storage, and EVs, are near ubiquitous. The same is true of transactive energy (TE), whereby DER owners can trade their self-generated power. In addition, utilities rely heavily on machine learning and analytics-driven automation to manage the grid.

By 2030, the future utility value chain will have transformed significantly. Navigant Research argues that current distribution network operators will have transformed into distribution service orchestrators; they will be responsible for far more than just network operations. Likewise, the current energy supply business—already transitioning to a service-based model—will be fully transformed into an energy service provider (ESP) model. Companies will offer end-to-end energy services that have little in common with today's volume-based approach to revenue generation.

The resulting new business models will require new IT infrastructure that relies heavily on the analysis of huge volumes of data. Distribution orchestration platforms will rely on the integration of existing advanced distribution management systems (ADMSs) and DER management software, as well as the incorporation of a market pricing mechanism to reflect the changing value of millions of connected endpoints throughout the day. ESPs will rely on TE platforms that enable prosumers to sell their power into the market, incorporate customer portals to provide in-depth account details, and provide billing and settlement functionality.

1.2 Intelligent and Distributed Future

This Navigant Research white paper provides an overview of the opportunities and challenges that the industry will face during the transition to an intelligent and distributed future. Note that it purposefully ignores any barriers to the development of the Energy Cloud. Its purpose is to bring color to a scenario that would cause significant disruption to existing utility business models.

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[1] Navigant Research, *Navigating the Energy Transformation,* 2016.

Further, the discussions in the following sections focus specifically on residential customers. While commercial and industrial (C&I) customers will be important stakeholders in the future, the C&I segment is further along the road to a sophisticated, transactive future. Many C&I customers are already interval-metered multiple times each day (or hour) and are charged tariffs pegged to the cost of generation. They actively participate in demand response (DR) programs and some will also have embedded generation that is aggregated and bid into the wholesale market. The aggressive Energy Cloud scenario sees many residential customer relationships become as sophisticated by 2030.

This is not intended to be purely an academic, hypothetical exercise; there are many practical considerations that are relevant to utilities in 2017. The industry is shifting inexorably toward a more dynamic and volatile distribution network, where self-consumption and micro-trading will be the norm. The disruption created by this scenario will be deep and pervade the entire energy value chain. Utilities cannot ignore the threats and opportunities that lie within the Energy Cloud and must plan now for every possible eventuality.

It must be emphasized that an aggressive scenario is used in this report. While some elements of this scenario will materialize over the next 10-15 years, a world of ubiquitous DER and TE may be beyond the thinking of some utilities. However, this white paper should still be highly relevant. It makes practical recommendations for even the most conservative of utilities because these utilities must still plan for every eventuality. These recommendations both build on and complement Navigant Research's *Navigating the Energy Transformation* white paper and the "Energy Cloud Playbook."[2]

[2] Mackinnon Lawrence and Jan Vrins, "Energy Cloud Playbook," *Public Utilities Fortnightly*, July 2016.

Section 2
THE 2030 UTILITY VALUE CHAIN

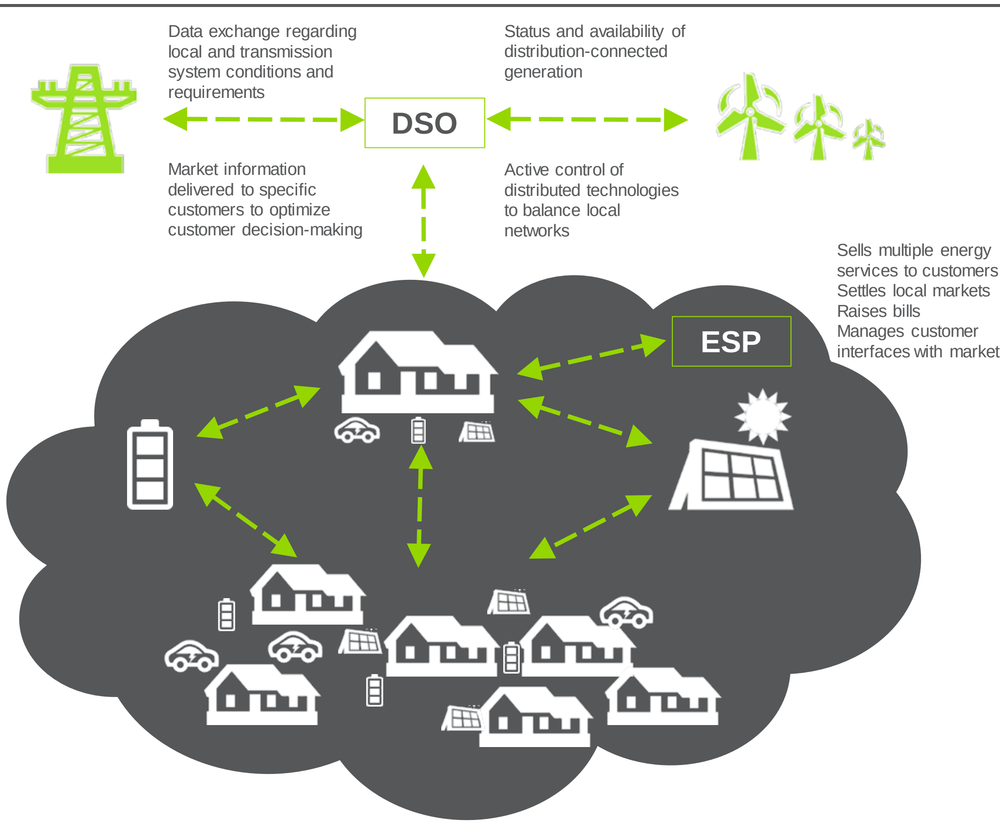
2.1 Fast Forward to 2030

In the first decade of the 21st century, customers had little choice regarding electricity consumption; it was simply a question of paying a standard rate for each kilowatt-hour consumed. In Navigant Research's view of the 2030 energy landscape, the world is very different, with the customer sitting at the heart of the Energy Cloud:

- **The Energy Cloud is a mature set of technologies.** Ubiquitous solar PV and storage create a customer-centric energy value chain where customers' consumption is largely met by self-generated electricity.
  - Utility-scale and distributed renewables account for 50%-100% of generation; distributed energy resources (DER) uptake is widespread, accounting for the majority of new build capacity.
  - High penetration rates of EVs put a strain on network capacity, which is managed using pricing signals and automatic demand response (DR).
- **Data is as valuable a commodity as electrons.** While in 2017 the industry struggled to maximize the value of enterprise data, in 2030 the energy supply chain is fully digitized and its efficient operation is heavily based on analytics-based automation. This automation relies on the huge volumes of data created by technologies within the Energy Cloud.
- **The industry has undergone significant digital transformation.** Data and artificial intelligence (AI)-based algorithms become important competitive differentiators. Data offers visibility into each prosumer's electricity exports and imports, providing the fundamental basis of the transactive energy (TE) market. This data also allows the newly formed distribution service orchestrators to actively manage the dynamic and volatile distribution networks, either through pricing signals or by actively interrupting the power supply.
- **Utility business models have transformed from supply- to service-based.** Rather than focus purely on the delivery of grid-sourced power, energy service providers (ESPs) offer individualized products and services to suit their customers' specific needs. These services will include DER sales, maintenance, and aggregation; DR; energy efficiency initiatives; flexible, time-of-use charging; and TE platforms.
- **Markets are far more competitive in 2030 compared to 2017.** The convergence of the old regulated supply business model and deregulated service-based model creates opportunities for new entrants. Many new service providers have entered the market, exploiting the new value streams from decentralized electricity.

- **The smart grid of 2017 has transitioned to a neural grid.** The new grid is nearly autonomous and self-healing, leveraging innovations in AI and cyber-physical systems (e.g., Internet of Things [IoT], self-driving EVs, and the smart grid).
- **Distribution operators have evolved into distribution service orchestrators to manage this neural grid.** Advanced platforms incorporate advanced distribution management systems (ADMSs), DER management systems (DERMSs), and pricing signals to manage the more volatile and dynamic grids.
- **Two separate, yet complementary technology platforms underpin the market.** TE and distribution orchestration platforms enable prosumers to sell self-generated power on open markets and manage the highly volatile and dynamic distribution networks.
- **In 2030, prosumers trade their self-generated power on the open market.** This is a dramatic change from relying on the subsidies or net metering that supported residential solar PV in 2017. Electricity is bought and sold at market rates and revenue from a TE platform alone totals $6 billion per year. To bring this into the perspective of other disruptive innovators, TE revenue in 2030 is 4 times the size of Uber's 2015 revenue.

Figure 2.1 Customers Sit at the Heart of the Energy Cloud in 2030

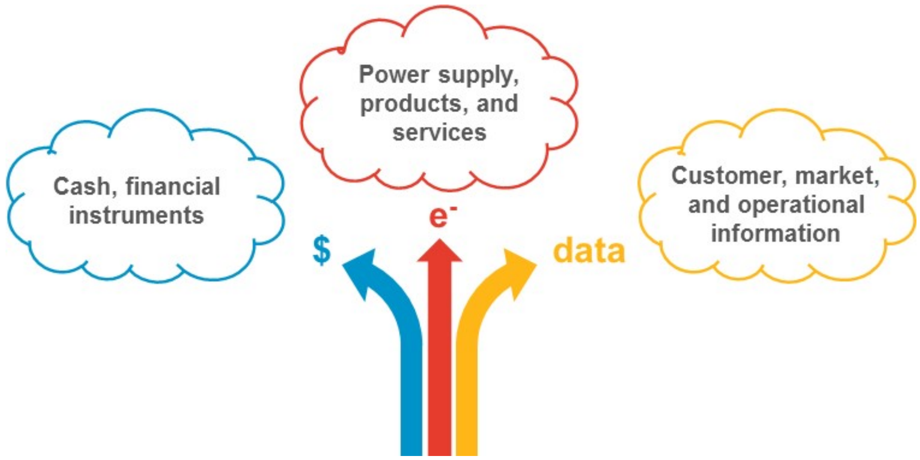


(Source: Navigant Research)

2.2 Cash, Electron, and Data Flows within the Energy Cloud

The electricity industry relies on the flow of three things in 2030: cash, electrons, and data.

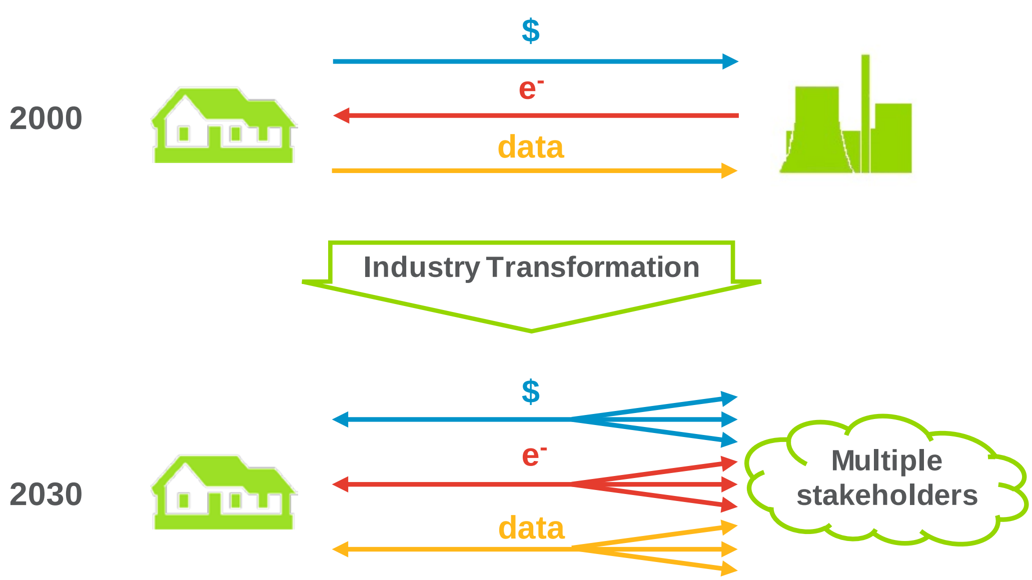
Figure 2.2 The Industry Relies on the Flow of Cash, Electrons, and Data



(Source: Navigant Research)

Energy markets can be accurately described based solely on how these flow and who controls the flow. The differences between the energy market in 2000—which predates smart metering, competition, and DER—and 2030 can also be described by illustrating these flows.

Figure 2.3 Flows of Cash, Electrons, and Data Are Bidirectional between Multiple Stakeholders



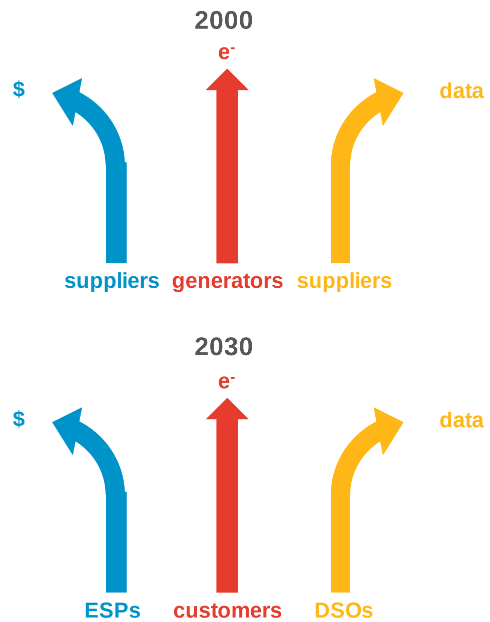
(Source: Navigant Research)

At the turn of the century, everything flowed in one direction. Electrons flowed from centralized generation across the networks to the consumer; cash and (very limited) data flowed from the consumer to the utility.

By 2030, however, all flows are bidirectional. Electrons flow both into and from a prosumer's residence; customers pay for electricity they draw from the grid but are also paid for electricity they export. Data flows both to and from a customer, informing AI algorithms within smart contracts of the optimum time to store excess generation, sell it to the grid, participate in DR programs, etc. Data from a customer's premise feeds DER management platforms, informs market operators of consumption and production, and alerts potential customers of when and how much power the prosumer can export.

In essence, control of the flows of electrons, money, and data has shifted away from suppliers and generators into the hands of ESPs, customers, and distribution service orchestrators.

Figure 2.4 Control of Flows Shifts from Suppliers and Generators to ESPs, Customers, and Distribution Service Orchestrators



(Source: Navigant Research)

The Energy Cloud value chain of 2030 is dominated by three sets of stakeholders, all focused on the lower voltage networks:

- The **ESP** role manages the flow of money and financial instruments across the value chain; ESPs are the primary managers of customer relationships.
- **Customers** have transformed into prosumers. Rather than just consuming energy, they produce it as well, and their DER investments have a measurable value in the market.
- **Distribution service orchestrators** are responsible for the flow of electrons and manage the networks.

In unbundled markets, the same organization cannot perform both ESP and system orchestrator roles; there are inherent conflicts of interest between a network orchestration business, which also manages generation assets that dispatch onto its network, and the provision of competitive energy services. A distribution service orchestrator could prioritize access for clients of its ESP business over other stakeholders. As a result, organizations wishing to perform both roles have to separate these businesses, which must operate on an arm's length basis.

Figure 2.5 Key Stakeholders in the 2030 Energy Cloud Value Chain

ENERGY SERVICE PROVIDERS

- **TE platform provider:** Owns and operates the transactive energy platform, which acts as the access point to the electricity market for most customers. Manage peer-to-peer trading, DR events. And integrates with DER management platforms
- **Solar/storage vendors:** Sell DER hardware to customers
- **VPP service operators:** Customers with distributed generation, storage and the ability to participate in DR programs will make an attractive prospect to VPP vendors

CUSTOMERS

- **Prosumers:** Own solar and storage. Profits maximized by using electricity when it's cheap; sell excess generation or stored electricity when spot prices are high
- **Consumers:** Customers without solar or storage can participate in a TE program, by opting to buy power from a prosumer rather than their existing supplier. Can also participate in DR events

DISTRIBUTION SYSTEM ORCHESTRATORS

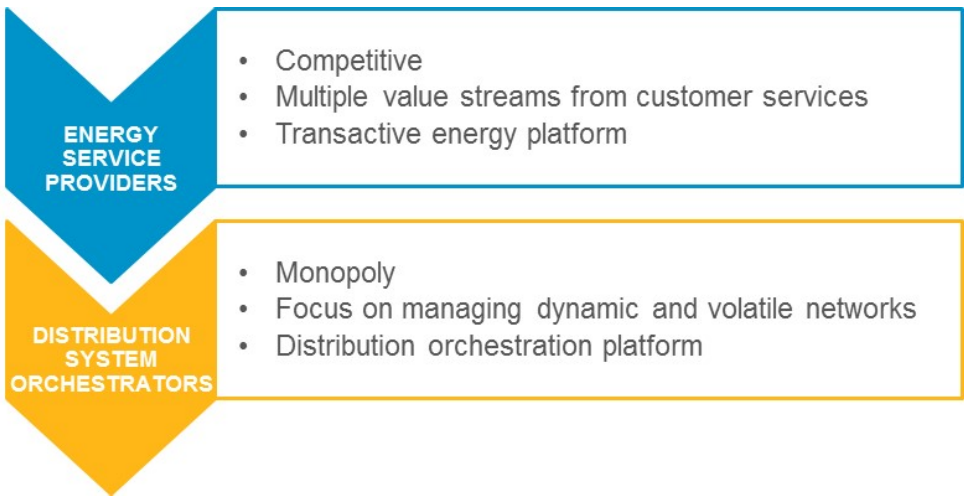
- **Distribution system orchestrator:** Uses advanced DER management tools to balance a far more dynamic and volatile distribution network

(Source: Navigant Research)

The ESP is able to generate multiple value streams from different services, while the distribution service orchestrator is restricted to managing the dynamism and volatility of the network. These two business models are underpinned by separate platforms, but the platforms rely on an overlapping dataset and must work together to optimize the TE marketplace.

On one side is the TE platform, which is the market entry point for customers. On the other is a distribution orchestration platform, which monitors and controls supply and demand connected directly to the distribution network and calculates dynamic pricing based on local network conditions.

Figure 2.6 ESPs' and Distribution Service Orchestrators' Business Models and Technology Platforms

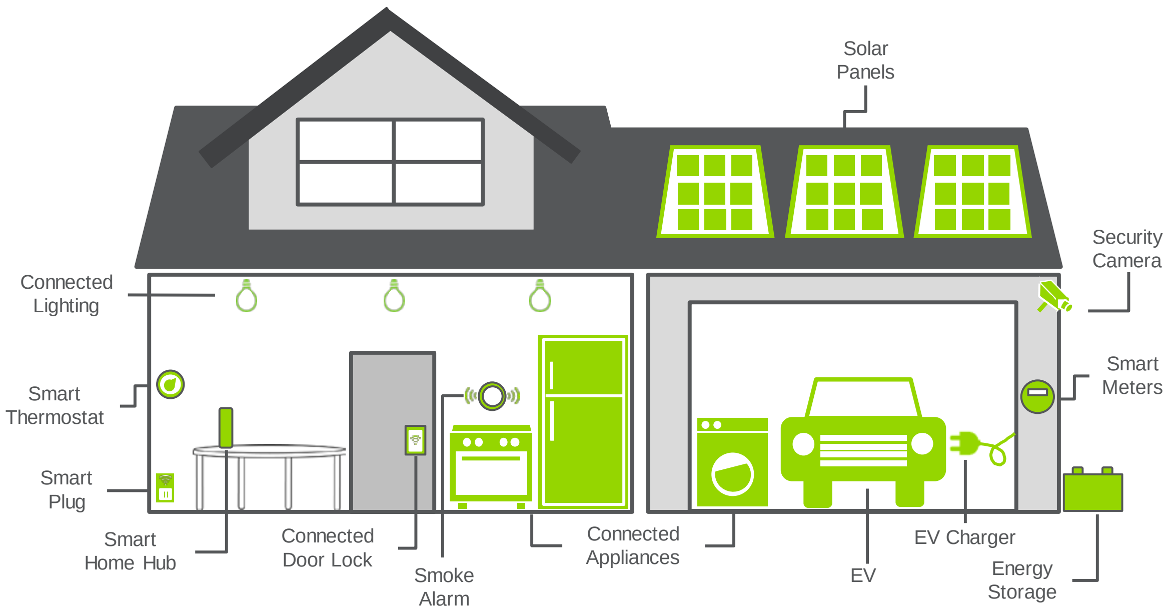


(Source: Navigant Research)

2.3 Customer Centricity, Customer Choice, and the Shift to Energy Services

Customer centricity is no longer a marketing buzzword; in 2030, it accurately describes the entire utility value chain. Customers are no longer the endpoints of a linear value chain from generation through transport to consumption. After a decade-long transformation, the Energy Cloud is a mature ecosystem of technologies, previously disparate services have converged onto a single platform, and the majority of customers are now prosumers and sell excess generation at market prices. Prosumers sit at the heart of a value chain that encourages self-consumption and the use of locally generated electricity.

Figure 2.7 Residential Premises Are Highly Connected in 2030



(Source: Navigant Research)

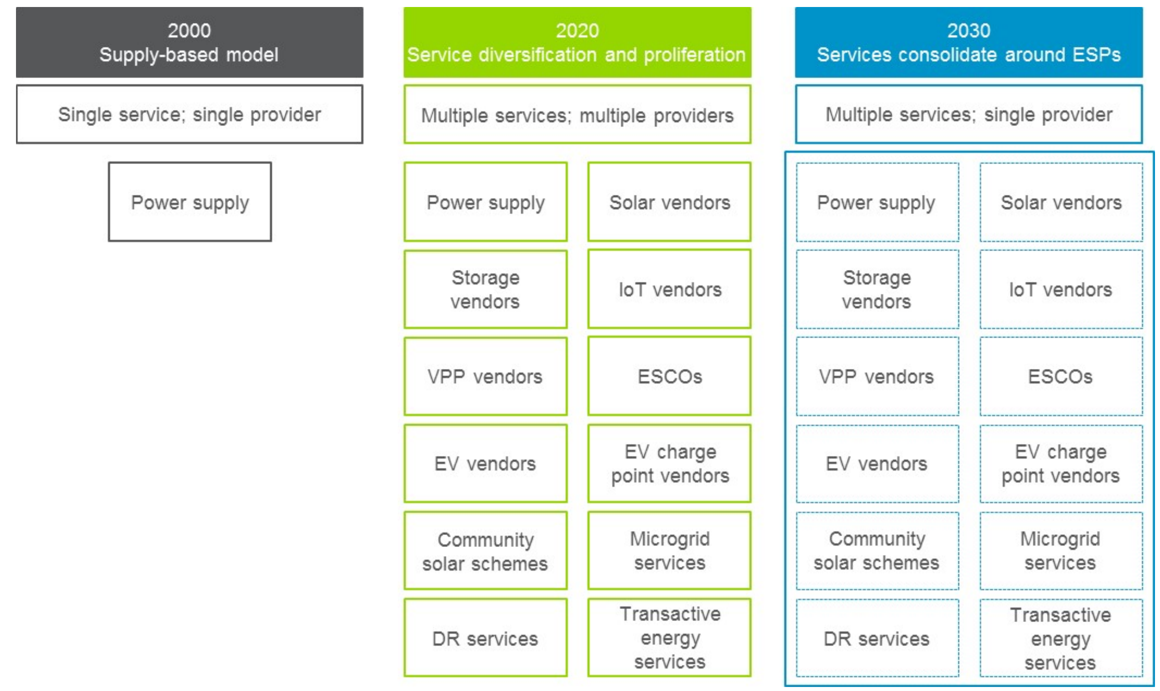
It is important to remember that in 2030, not all customers have invested in any or all of these technologies; however, most connect to the energy market through platforms that were not even thought of at the turn of the century. Each customer is able to choose whether to be active or passive market participants. They can also choose from a range of different ESPs to connect them to the energy market. Not every customer wants to, or can, own DER. Yet, every customer can access the TE platform to source power from numerous suppliers to suit their specific needs.

Customers' EVs can act as prosumers, too; their owners will again strike a balance between costs and convenience by recharging at the cheapest rate during the day while ensuring the car is available when next needed. EVs can also be used as secondary storage devices, feeding power into the grid or home.

2.4 ESPs Were Created after a Sustained Period of Disruption

The market in 2030 was created after a period of significant change. Rather than utility suppliers making a gentle and measured transition into ESPs, the transition was marked by huge disruption caused by significant numbers of new entrants to the market. These new entrants—both startups and established businesses—challenged the old utility business model by bringing a diverse set of products and services to market. Over a decade-long period, these companies helped define and create the electricity market of 2030. This prolonged period of disruption was followed by industry consolidation into ESPs, which were formed around the companies with the most successful business models.

Figure 2.8 ESPs Evolved through the Consolidation of Multiple Services



(Source: Navigant Research)

2.5 ESPs Own the Customer Relationship

In the aggressive Energy Cloud scenario, customers have lots of choices about their power consumption, but do not want complexity. The majority are happy to automate their interactions with the electricity market. And these interactions occur on the same TE platform, which is described in more detail in Section 3. It follows that who owns the platform owns the customer relationship.

The industry of 2030 has shifted from supply-based to service-based business models. Reliability and efficiency are still fundamental imperatives for the power industry, but a service-based approach has created much more complex and personalized customer relationships. Customers have far more choice about how they consume power.

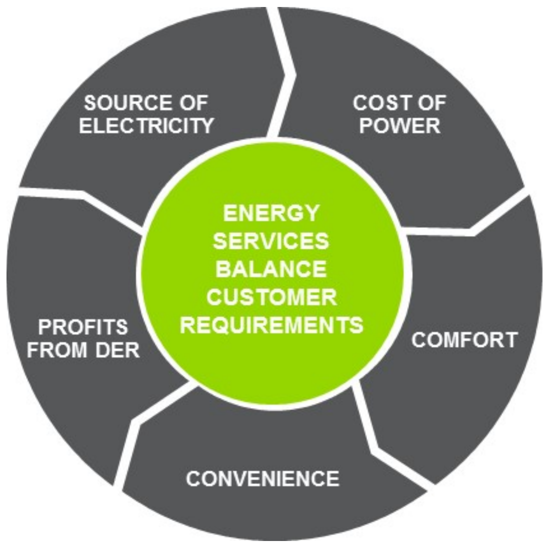
ESPs have replaced the old utility supply businesses. While some old utilities made the successful transition to ESPs, others did not. Those that clung to the old model of centralized generation and grid-sourced power supply saw their generation assets unwanted for the majority of the day and demand for grid-sourced power fall precipitously. A refusal to react to the requirements of the 21st century energy industry saw these monolithic dinosaurs vacillate their way into extinction.

New entrants—technology vendors, telcos, media companies, retailers, oil & gas companies, and specialist startups—entered the market in 2020s without any legacy generation assets or supply businesses. They were quicker to recognize where the value lay in the Energy Cloud and brought a fresh approach to customer service. The fundamental change is that ESPs focus on customers before assets.

2.6 ESPs Provide Customer Choice through Multiple Services

The ESP's business model is to deliver customers choice, simplicity, and reduced costs. ESPs help customers to balance comfort and convenience against expenditure. Customers can choose from whom they buy their electricity—either locally generated or grid-sourced electricity. They can change from whom they buy power, at any point in the day, choosing the cheapest or cleanest source of electricity at any point in time. They can choose to only buy electricity from renewable sources. They can choose to consume power whenever they want to maximize comfort or engage in DR programs that reduce their overall electricity bills.

Figure 2.9 Balancing Comfort, Cost, Profits, and the Environment in 2030



(Source: Navigant Research)

The old supply business model of the early 2000s offered customers no choice. The model was built around the supply of grid-sourced electricity, measuring consumption and billing. In the service-based business model of the 2030s, grid-sourced electricity supply is only one of many different value streams available to ESPs, which can profit from helping their customers consume less. The different value streams include solar PV sales and TE market settlement, among others:

- Solar PV and storage sales, where ESPs sell customers solar PV and storage hardware, and additional services such as arranging finance and repair and maintenance contracts
- Smart EV recharging station sales
- Home energy management equipment—smart thermostats, smart appliances, sensors, other devices, and HVAC—sales and related services

- Access to a TE platform:
  - Prosumers actively sell power into local markets
  - All customers can participate in DR programs
  - Participation in community solar, virtual power plants (VPPs), microgrids, or other aggregation programs
  - Purchase of power from locally sourced generation
  - Purchase of grid-sourced electricity
- Cash collection, TE market settlement, and additional services

Service providers earn revenue from the volume of power traded through a subscription and/or charge per kilowatt-hour of energy bought on the TE platform. Navigant Research believes that ESPs will earn at least $6 billion in revenue just from customer participation in TE platforms in 2030. There are several different business models for TE. For instance, ESPs can charge a small margin on each transaction or a flat annual access charge based on sharing cost savings with customers. Depending on how customers participate, the trading element of the TE platform will deliver between $30 and $120 of revenue per customer per year.

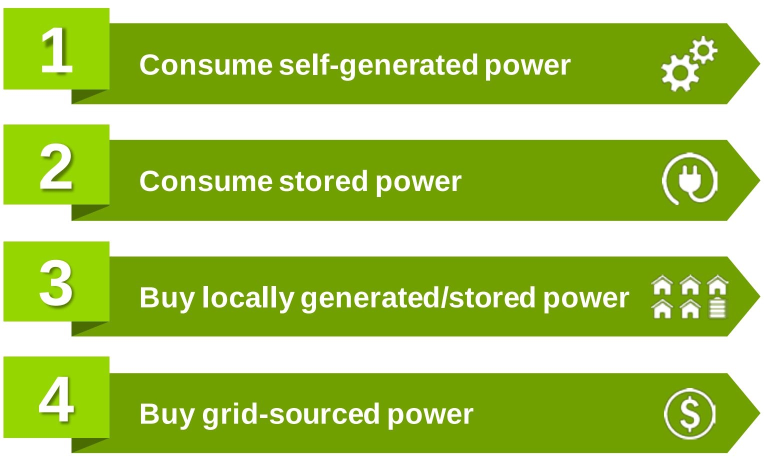
But TE is not the only revenue stream available to ESPs. They can also profit by aggregating DER to bid into wholesale markets or to trade power individually in local markets. And they can profit from the provision of grid-sourced power in the same way that suppliers in 2017 did.

When DR is part of an overall package, ESPs act as a sales channel for smart home/ appliance manufacturers and ensure that the in-home technology interoperates with DR control software. The service provider may also provide further consumer services, such as broadband, mobile telecommunications, fixed line communications, pay TV services, home security, water service, and gas supply.

With all these potential revenue streams, it matters less in terms of profits how much grid-sourced power a customer uses. Given that on sunny days, prosumers with energy storage meet most, if not all, of their own energy requirements, the grid-sourced electricity value stream has diminished significantly.

In 2030, due to widespread distributed generation at the point of consumption and aggregated generation and storage in localized or community-based schemes, the need for long-distance electricity transportation is dramatically reduced. Grid-sourced power contributes a low level of baseload and feeds evening peaks. For prosumers, who are incentivized to take power from the cheapest provider, the old utility often comes last in their preferred list of suppliers, as centralized electricity bears the highest transportation cost.

Figure 2.10 Customers' Order of Preference for Buying the Cheapest Electricity in 2030



(Source: Navigant Research)

By 2030, the once dominant supply of centralized generation—while still an essential part of the network—has been sidelined. Suppliers that ignored the potential impact of the energy transformation and clung to their old business models have seen their revenue shrink year-over-year. The more successful recognized the need to adapt and created new value propositions around energy services that could compete with more agile new entrants.

2.7 Distribution Service Orchestrators Manage the Electricity Infrastructure

None of this new energy market would be possible without a revolution in the networks business. The shift from a supply- to service-based market has transformed the customer relationship, but networks have also made a 180° shift.

In the old supply-based model, networks businesses were concerned with the safe and reliable delivery of power from generators to the customer premise. As a result, their primary focus was to work with generators and major energy users to ensure reliable supply and avoid bottlenecks. These distribution operators rarely had anything to do with end customers, particularly small businesses and residential, except to provide new connections or outage restoration.

Assets were the beating heart of a distribution network operator's business. The majority of assets were not connected; there was little economic sense to install monitoring and control equipment in low voltage networks because residential electricity demand was predictable and fairly stable.

The service-based model of the 2030s means network operators' primary focus is now on end customers and networks are far more dynamic, volatile, and unpredictable:

- The rise of the prosumer means that power flows have become two-way.
- Self-consumption by PV and electricity storage owners significantly changes load curves to evening peaks when solar PV is no longer generating power.
- New, power-hungry appliances such as EVs and heat pumps place significant new demands on network capacity.
- The aggregation of DER into VPPs creates dispatchable power connected directly to low voltage networks.
- TE systems encourage rapid switching between the export and import of power from many premises throughout the day.

DER aggregation and management become a critical component of a distribution service orchestrator's role. Network volatility and dynamism require more active management of low voltage networks, particularly managing the peak consumption periods when customers shift from self-generated consumption to grid-sourced electricity.

Distribution service orchestrators also work closely with customers and transmission system operators to balance network volatility—historically the preserve of transmission operators on high voltage lines. Distribution service orchestrators balance their networks using a number of tactics: interrupting the electricity supply to EV recharging stations, sourcing power from embedded combined heat and power generation, tapping into grid-scale storage, sending real-time pricing signals to consumers, volt/volt-ampere reactive (Volt/VAR) control, conservation voltage reduction, and so on.

Section 3
PLATFORMS CREATE ACCESS TO THE MARKET IN 2030

3.1 Technology Infrastructure

The complexity of customer choice and the large number of prosumers connected to the network require close monitoring and control by equally complex platforms. In 2030, technology infrastructure is as critical to efficient market operation as the poles and wires that form the physical infrastructure.

There are two separate, but interacting platforms that underpin the electricity market. First, a TE platform—owned by the ESP—provides customers with access to the electricity market. Second, the distribution service orchestrator's distribution orchestration platform monitors the state of the distribution network and uses several tools to manage the peaks and troughs of demand.

3.2 TE Platform

As discussed previously, the function of the TE platform in 2030 is to connect customers to the network and with other stakeholders, and it is the primary gateway for a customer to access the energy market. As a consequence, TE platform providers—the ESPs—effectively own the customer relationship.

Given that most customers want simplicity, the TE platform has evolved from a standalone trading platform into a full service suite of customer-facing applications. There are three pillars to the TE platform:

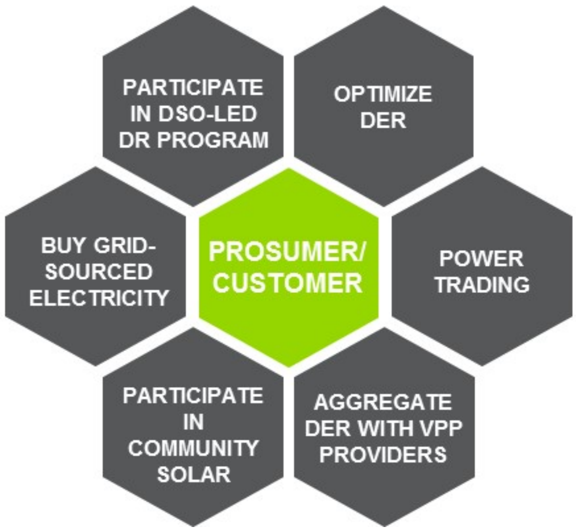
- An energy trading platform
- A customer portal
- Billing and settlement

3.2.1 TE Platforms Provide an Automated Trading Platform for Customers in 2030

While customers are able to shop around for any service and are not forced onto a single platform, a single provider is the simplest way to access the market. The TE platform is designed to optimize a customer's DER investments and source power from the cheapest or cleanest possible source.

AI and blockchain are combined to underpin the trading element of the TE platform. AI algorithms are used to optimize customers' DER investments by deciding on the most profitable or cost-effective course of action at any point in the day. The AI is embedded in smart contracts, which self-initiate and self-validate trades on a blockchain-based trading platform. Blockchain removes the need for a central market authority to approve trades, while its distributed ledger ensures trust among market participants and reduces the scope for fraud.

Figure 3.1 A TE Platform Connects Prosumers and Customers with Other Stakeholders



(Source: Navigant Research)

Figure 3.1 shows how a TE platform connects customers with other stakeholders. In more detail, the TE platform provides the following:

- **DER optimization:** Built-in analytics help prosumers optimize their DER investments. Algorithms decide the right time for a customer's system to use, export, or store self-generated electricity, depending on current and projected future spot prices. For example, when to store electricity in a stationary unit, when to recharge an EV battery, when to export directly to the grid, when to buy grid-sourced power, when to use stored electricity, or when to sell self-generated or stored power into the market.
- **Manage DR events:** The platform can also be used by distribution service orchestrators to operate DR platforms. The distribution service orchestrator can send pricing signals to customers via the TE platform, which automatically trigger a switch to stored or self-consumed power, or shut down appliances. The TE platform records these events and the customer is rewarded through a variety of methods: lower rates, power tokens, reward programs, and so on.

- **Power trading:** While many customers will want to automate the export of self-generated power into the market, some will want to actively sell their excess generation. The TE platform provides these customers with a market access platform where they can instantly trade power with other market participants.
- **DER aggregation:** The customers' DER can be aggregated to create a VPP, which then bids generation and interruptible supply into the wholesale market.
- **Community solar:** Some customers will be part of a community solar program, which creates localized islands and microgrids. The TE platform can be used as the technology infrastructure of these microgrids. While a VPP seeks to maximize profits, the community solar program seeks to maximize the benefits for the local community by reducing costs and maximizing renewable energy.

3.2.2 TE Platforms Support Advanced Customer Portals

While TE platforms have to provide the infrastructure to support this market access, customer portals are another important element. The TE platform is a relatively complex system, and most customers must rely on trust that their ESP always deliver the best deal. This trust is the weakest point of the ESP/customer relationship, and it is something ESPs have to work hard to build up and then maintain. To earn this trust, ESPs provide their customers with information about their performance, recommendations on system improvements, and other energy-saving tips. This information includes:

- Overall energy consumption
- The efficiency of PV and storage
- Where a customer's power is sourced: self-generated, own storage, or sourced from the grid
- How green a customer's electricity consumption is (i.e., how much was sourced from renewable generation)
- How profitable solar is
- How to save money or increase profits by changing consumption patterns
- The price paid for power from different sources
- The customer's performance benchmarked against similar customers

The basis of this information is to provide customers with sufficient visibility into the service that they are confident of getting the best deal on the market; other ESPs will exist and price competition will be fierce. However, the ESP can use this information to up- and cross-sell different services to customers.

For example, they could demonstrate how participation in DR programs could save customers money, then profit from the sale of connected appliances, smart thermostats, etc. Alternatively, solar efficiency data could be used to show a customer when to replace their old panels with new panels or sign up to DER maintenance programs.

3.2.3 TE Platforms Must Also Support Billing and Settlement

The third pillar of the TE platform replaces the old utility billing system. All TE trades have to be settled, with cash collected and disbursed to all market participants. There is no separate billing system for grid-sourced electricity and other services. Instead, cash settlement and service subscriptions and other payments are carried out in the same place, and respective market participants are presented with a single bill. This bill will reflect all electricity consumed or generated and any subscription or service payments due.

Because AI-based smart contracts react to real-time pricing signals, a customer's premise can alter its power source multiple times each day. As a result, each customer has a complex tally of debits and credits for every day within a billing period, which are recorded on a distributed ledger. The ESP's role must work out who owes how much and to whom and settle the market. At the highest level, this involves billing and cash collection from residential customers. as well as paying for grid-sourced power.

But not all customers will buy locally generated power all the time. Customers will still have to be billed for the grid-sourced power they consume. Grid-sourced power can be purchased directly from a third party (including incumbent utilities) or from the ESP (particularly if the ESP is the incumbent). If the ESP is a new entrant, it can purchase bulk electricity on the forward or spot markets.

3.3 Distribution Service Orchestrators Require Distribution Orchestration Platforms

By 2030, the aggressive Energy Cloud scenario introduces significant volatility and dynamism to the distribution networks. To manage this change, distribution service orchestrators have created new orchestration platforms by converging existing technologies and developing automated pricing mechanisms to balance networks. An orchestration platform merges functionality previously found in ADMSs with DERMSs. The distribution service orchestrator also uses automated market pricing to help balance electricity networks. There is good reason for this. The volume of DER connected to the grid has increased dramatically. In addition, the DER interact with the grid in a more dynamic fashion, turning on and off in response to real-time pricing signals on the network. This dynamism is unrecognizable to distribution operators of 20 years ago.

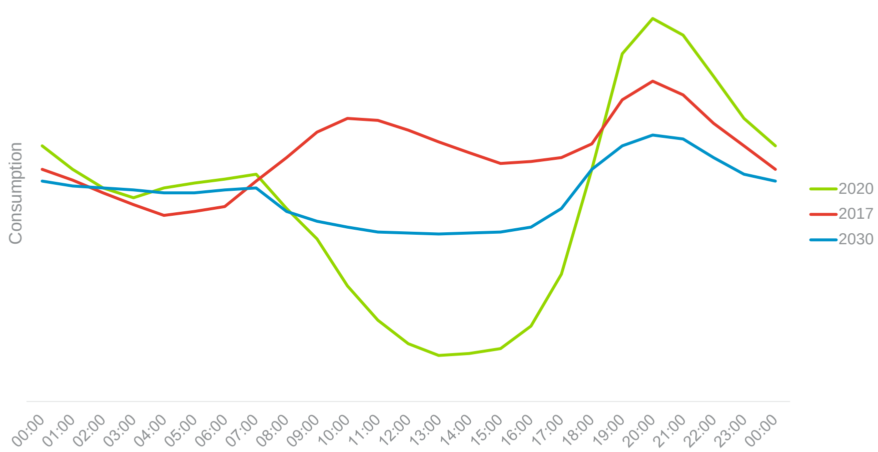
3.3.1 ADMS, Market Pricing, and DERMS Technologies Converge

The distribution orchestration platform is built around previously distinct applications: ADMSs, DERMSs, and new functionality that automates market pricing. The ADMS monitors the health of the network and automatically controls distribution service orchestrator-owned assets to ensure grid reliability. The DERMS gives the distribution service orchestrator an element of control over third party-owned DER. Market pricing systems automatically send out pricing signals across the network in response to capacity or power quality issues.

In the early days of DER, DERMSs were not needed because the low penetration of DER had little effect on the network. When penetration increased to the point where it became an issue for grid operators, DERMSs were developed to more actively manage DER to help balance networks. However, DERMSs were designed to control power flows and lacked the functionality to set financial incentives that encouraged different consumption and generation behaviors. Therefore, market pricing systems were developed to fill this gap and more accurately reward customers for helping balance networks.

For example, high penetration rates of solar lead to the duck curve consumption pattern, where system demand hits a low level during the period of peak solar production. However, this low is then followed by a sharp spike in demand as solar production comes to an end and residential peak consumption begins.

Figure 3.2 Storage and TE Flatten Duck Curve Peaks (Indicative)



(Source: Navigant Research)

As a result, system orchestrators set a low export price during high solar activity to encourage either self-consumption or storage during the day. They then set high prices in peak periods to encourage the use of stored electricity or to defer consumption to different times of the day.

A distribution service orchestrator can use pricing signals to manage demand for EV charging. A customer's EV will charge itself based on market signals, selecting the cheapest time to recharge while ensuring batteries have sufficient charge for the owner's requirements. High concentrations of EVs below individual feeders can have significant, but highly localized effects. Therefore, pricing must reflect local conditions as set prices below each feeder.

While pricing is a softer option than interrupting power supply, there will be times when pricing alone cannot manage all the system's capacity requirements. In these periods, the distribution service orchestrator initiates automated DR events by shutting down (when demand is too high) or turning up (when more load is needed to cope with oversupply) the appliances—such as air conditioning units or EV recharging units—of participating homeowners.

To actively manage dynamic distribution networks with high volumes of DER, distribution service orchestrators must make full use of market pricing and DR tools to ensure network stability. However, the two must work seamlessly within a wider ADMS.

Section 4
DATA IS THE KEY MARKET DIFFERENTIATOR

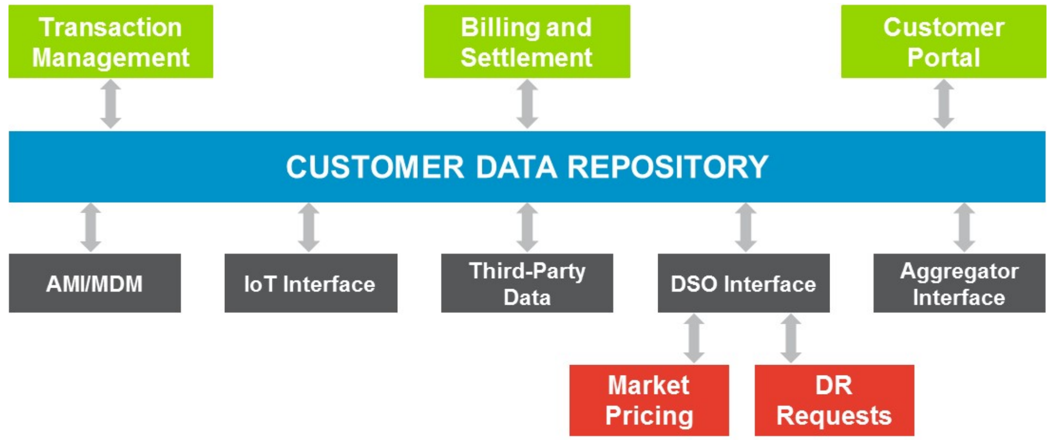
4.1 Data Flows Are as Important as Power Flows in 2030

In 2030, TE platforms manage the flow of cash and distribution orchestration platforms manage the flow of electrons. However, data flows are just as important. Data is an irreplaceable commodity: it is the operational currency of the 2030 energy market. And crucially, for the TE market to function, data must be made available to all market participants without prejudice. The importance of data has not gone unnoticed by the market. All the leading players in the utility market in 2030 have undergone a significant digital transformation so that their technology platforms meet the market's demanding data requirements.

4.2 TE Platforms Have Significant Data Requirements

TE platforms are hungry for data. Data is created across the value chain from multiple sources. This data then feeds the many different requirements of associated applications. For example, to ensure they make the right decisions, the AI and smart contracts that underpin the TE system rely on accurate and timely data, analytics, and insights from numerous sources. Figure 4.1 describes one potential technology stack with a central customer data repository. In practice, this repository becomes an aggregation platform that links data persisted in multiple locations: on-premise data centers, an ESP's cloud, an IoT vendor's cloud, stored on a customer's own devices, and so on.

Figure 4.1 The Transactive Energy Platform Technology Stack



(Source: Navigant Research)

Table 4.1 details several different data types created across different parts of the value chain and what applications rely on this data. One of the biggest challenges to the development of a TE market was the sharing of data across and between multiple organizations. As with strong algorithms, data management also became a critical market differentiator for competing ESPs by 2030.

Table 4.1 Different Applications Rely on Data from Multiple Sources

Source	Data Type	Customer Portal	Billing	Settlement	Transaction Management	Distribution Orchestration	Load Forecasting	Wholesale Market
AMI*	Smart Meter Consumption Data	x	x				x	
IoT	EV Battery Status and Requirements	x	x	x	x	x	x	
IoT	PV Output and Performance	x	x	x	x	x	x	x
IoT	Storage Output and Performance	x	x	x	x	x	x	x
IoT	Smart Thermostat	x			x	x		
Third Party	Weather Data	x			x	x	x	x
DSO	Pricing Signals	x	x		x	x	x	x
DSO	DR Requests	x	x		x	x	x	x
Market	Current Spot Price	x			x	x	x	x

AMI: Advanced metering infrastructure.

(Source: Navigant Research)

While some data is made available to all market participants, ESPs differentiate their offerings with innovative data and analytics that maximize returns for customers. It is not sufficient to offer a platform through which customers gain access to the TE market; ESPs show their true value in data services.

4.3 AI Algorithms Choose the Most Favored Path for Customers

Even at a basic level, the buying and selling of power by residential customers on a TE platform will rely on diverse datasets and analytics. For example, to optimize the financial return of solar PV and storage, the customer's smart contracts have to know when to get the best price for electricity. AI is used to decide the most profitable action during the course of a day while still making power available to the customer when they need it. Several options exist:

- Use electricity as it is generated
- Sell excess electricity to the grid as it is generated
- Store electricity for personal use later in the day
- Sell stored electricity to the grid to exploit peak prices
- Switch from self-generated electricity to storage or to grid-sourced power

To decide on the best course of action, AI algorithms need visibility into the forward market, if only for a few hours or at most 2-3 days. If conditions indicate that there will be large spikes in evening peak pricing, there are several actions that can be taken to ensure customers maximize their opportunity to exploit future high prices.

Typically, an AI algorithm would direct as follows. Storage is filled to capacity when a customer is self-generating or when grid-sourced power is cheap, so that the customer can export electricity to the grid when peak prices are reached. In addition, power use during the peak period is minimized. A customer can prepare for the peak event by fitting their consumption around the event (e.g., by cooling or heating the property to a desired level before peak pricing occurs or by deferring use until prices become cheaper).

4.4 Aggressive Energy Cloud Scenario Requires Powerful Analytics

While ESPs work with large volumes of data and run their own analytics for their customers' benefit, the volumes of data distribution service orchestrators have to work with are several times greater. Most customers will not notice a delayed response to a pricing signal; they will certainly notice an outage caused by a delayed response to an overloaded transformer.

Distribution service orchestrators have invested heavily in their technology infrastructure, which extends across the networks and into customers' premises. Managing dynamic and volatile networks needs close monitoring, so distribution service orchestrators have installed monitoring equipment across the majority of their distribution assets. They also monitor the production and consumption of individual households through smart meter and smart PV inverters.

TE would not function without numerous stakeholders accessing accurate and real-time data. Therefore, distribution service orchestrators and ESPs have invested significantly in data management infrastructure. While no company has exactly the same infrastructure, each must balance the need for flexibility, speed to decision, and cost management.

As a result, there is no single blueprint for data management. Rather, each organization will approach data management to best suit its own business processes, its customers' requirements, and the needs of other stakeholders.

In effect, grid processes in 2030 are far more granular than previously experienced. There are many more generators that are highly distributed—all operating at much smaller scale, but with relatively complex behaviors. Because processes are more granular, visibility and monitoring have to be granular and so does the related analytics and data management.

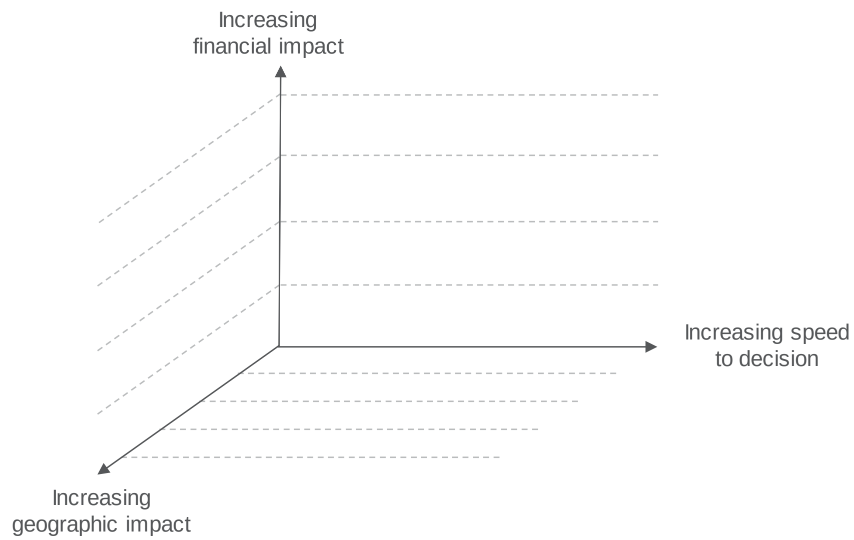
Distribution service orchestrators use analytics to predict peaks and troughs in demand and can react to potential capacity constraints using pricing signals and DR programs. However, it is neither practicable nor necessary to collect and store all this data centrally while making real-time decisions based on this data; distributed energy requires distributed intelligence. The vast majority of distribution control is now automated. Decision-making has been pushed into the network so that localized pricing signals are transmitted at the transformer level. For example, if too many EVs are charging below a single transformer and causing capacity issues, DR signals—either through pricing or direct supply interruption—are sent direct from the transformer.

4.5 Distribution Service Orchestrators' Data Management in 2030

Optimizing data management requires an assessment of each data type in terms of the importance of the business processes it supports. This importance is measured in terms of financial impact (i.e., the financial impact that data can have), the required speed to decision (e.g., does this data need to analyzed in real-time or in a batch process?), and geographic impact (does the data have a local or systemwide impact?). These metrics have been plotted in Figure 4.2.

Financial impact is often closely related to geographic impact. A blown fuse on a local transformer serving only a handful of residential properties has a much lower financial impact on both the distribution service orchestrator and its entire customer base than a failure at a medium voltage substation serving thousands. However, there is not always a direct correlation. For example, if a heat wave is predicted to lead to demand exceeding capacity, a distribution service orchestrator can use DR to limit the impact of high temperatures. In this case, geographic impact may be high, but overall financial impact is relatively low.

Figure 4.2 The Value of Data Relates to the Value of Underlying Business Processes



(Source: Navigant Research)

Given that much processing is done at the edge of the grid in 2030, distribution service orchestrators have adopted a distributed approach to data management. Instead of pulling in all data from the network into a centralized database, much of the data created at the edge will be persisted there or not stored at all. Distribution service orchestrators will only pull in data when an event occurs outside business-as-usual parameters.

Cloud computing is used to persist and analyze data types with medium to low financial impact; mission-critical control room data is still collected centrally. While historically, distribution service orchestrator data was virtually all highly structured and stored in relational or columnar databases, unstructured data—ranging from written maintenance reports to social media data—provides distribution service orchestrators with a rich vein of previously untapped data. To manage this data, the open-source software Hadoop is used for distributed storage and processing of lower value structured and unstructured data. However, it has not replaced more traditional databases. For example, a Hadoop-based data lake has to work alongside a SCADA historian to create insights into current network health and asset planning.

Table 4.2 summarizes the concept of different data strategies for different data types and their related business processes. The table is not meant to be exhaustive; instead, it demonstrates that there is no one-size-fits-all approach to data management.

Table 4.2 Different Data Types Require Different Data Strategies

Measurement	Financial Impact	Geographic Impact	Speed to Decision	Data Strategy
Voltage magnitude in medium voltage substation	High	High	High	SCADA Analyze in distribution orchestration platform Store in historian
Weather forecast predicts impending peak event	Low	High	Medium	Analysis provided by third party Distribution orchestration platform transmits DR messages to ESPs or direct customers Store in data lake
Long-term asset planning	High	High	Low	Extract and analyze data from data warehouse
Overloading on low voltage transformer	Low	Low	High	Process locally Self-healing decisions made locally Event data persisted in cloud for future analysis

(Source: Navigant Research)

4.6 Data Collaboration, Security, and Privacy in 2030

It is imperative that all stakeholders share data between themselves. Financial transactions cannot take place without data sharing; neither can the flow of electrons. As a result, distribution service orchestrators and ESPs work closely together to ensure the smooth operation of the TE market. Distribution service orchestrators also work closely with their transmission system operator counterparts to ensure the stability of the entire electricity system in 2030.

A fine balance has to be struck between managing data requirements and managing customer privacy. ESPs have access to an unprecedented volume of customer data. Residential customers have many connected sensors and devices in the home, including smart meters, smart inverters, EVs, stationary storage, smart thermostats, smart lighting, smart appliances, and security devices. The data from all these devices gives detailed insights into a customer's consumption habits, which ESPs are keen to mine to up- and cross-sell. However, trust, while intangible, is a prerequisite for any TE market to function. As a result, ESPs use a number of incentives—reduced rates, reduced costs for devices, power tokens, etc.—for customers to share their data. Care must also be taken to manage risks of any stakeholders accessing privileged information that could give them an unfair advantage in the market.

The distribution service orchestrator, because it was historically regulated, adopted the role as market data aggregator and shares data with respective stakeholders. It has insights into the current and historic state of the network, its own forecast capacity requirements, and projections of when peak pricing and DR events will take place. In 2030, the distribution service orchestrator knows where, when, and how much electricity is being used. It uses this data, alongside its ESP partners, to target customers within particular geographies for specific services that alleviate pressure on the network.

Section 5

BACK TO THE PRESENT: RECOMMENDATIONS FOR UTILITIES IN 2017

5.1 TE Could Be the Catalyst for Rapid PV Growth

Every utility must recognize the risks of ignoring the TE business model and understand the consequences of inaction. 2030 is a long way into the future, and there are many potential barriers that could hinder the development of a fully mature Energy Cloud with ubiquitous DER. Many markets could take even longer to reach this point; some may never get there. However, that is not an open invitation for utilities to do nothing. The revenue a prosumer gains from TE can replace existing feed-in tariff programs, creating an environment that supports subsidy-free solar. The industry could see rapid adoption of solar in a world where customers do not just break even, but also make money from their PV investments.

In early 2017, TE is embryonic; however, it could grow rapidly. And there will be significant downside risks for those that do nothing. This report has discussed at length how the ESPs, as owners of the TE platform, will own the customer relationship. If incumbents do not plan for TE in 2017, and the aggressive Energy Cloud scenario evolves around them, they will lose the majority of their current market share.

The biggest risk to incumbent suppliers is their current business model, where profits are derived from their centralized generation assets and supply of grid-sourced power. A transactive future will see millions of customers rely less and less on centralized generation, except as backup. As a result, large-scale generation assets will generate fewer profits, as they will sit idle for long periods in the day. The more storage is adopted, the longer these idle periods will become. And suppliers—whose business model relies on volumes of power traded—will see their profits shrink as customers consume less grid-sourced electricity.

It is reasonable to expect at least some generators and suppliers to resist rather than embrace change. Often, those that stand to lose the most are those that stand still the most.

5.2 Customers Sit at the Heart of the Future Energy System

The term “customer centricity” is often used as a platitude in public relations announcements. However, any organization that thinks it can develop an ESP without placing customer needs at the center of their strategy will rapidly fail. Ubiquitous DER will drastically alter the electricity market and customers will become the central focus.

Value for ESPs will be created at the point of consumption, rather than at large-scale, centralized generation sites, as is the case in 2017. Aspiring ESPs must recognize that this value will be created at or behind the meter and must build business plans around these value areas. While there will be an element of grid-sourced power supply, this will diminish with every PV system installation. The majority of value will come from the services that help customers reduce their overall consumption and maximize the return on their DER investments. Business models that fail to recognize new value streams will fail to compete with those that do.

5.3 Long-Term Strategy Must Be Sufficiently Flexible to Accommodate Change

No one knows exactly what the energy market will look like in 2030. The purpose of this report is to explore the aggressive Energy Cloud scenario and analyze what this means for the market. Perhaps this scenario will never come to pass; it is quite reasonable to argue a fully transactive market will never get off the ground. It is also only one of numerous competing scenarios. However, there are compelling reasons for it to exist, and as such, the industry has to plan for its potential emergence. The industry will not wait for the last company to move. Many utilities are already investigating how TE can transform the customer experience, how new products and services can drive future growth, and how distribution networks businesses must transform to support the Energy Cloud's requirements.

Every incumbent utility, whether in generation, transmission and distribution, or supply, has to have a plan that enables the company to transform into an entity that can compete in a transactive world. The industry must shake off its sclerotic past; the most successful businesses will embrace change by being flexible, adaptable, and agile. Navigant Consulting, Inc.'s (Navigant's) Energy Cloud Playbook details some of the actions that will support the successful transformation to the new energy economy.

Figure 5.1 The Energy Cloud Playbook

STAGE	ACTION
1	Sponsor a cross-functional team that will spearhead a strategy with a view toward a robust, integrated Energy Cloud plan.
2	Assess how the Energy Cloud is evolving across markets in which the utility operates or has targeted for expansion.
3	Identify inefficiencies in the organization's current value chain and business models.
4	Develop more efficient and cost-effective solutions.
5	Innovate relentlessly across the organization.

(Source: Navigant Consulting, Inc.)

5.4 Digital Transformation Is Central to a Flexible IT Roadmap

A business cannot be flexible, adaptable, and agile with outdated IT infrastructure. The next decade will be incredibly disruptive, and change will be the only constant. The importance of technology will grow, and the industry must invest in state-of-the-art IT that can support this disruption.

It is virtually impossible to overstate the importance of technology platforms as a future differentiator. It is similarly impossible to state in 2017 the exact requirements of a platform in 2030. Yet, it is not just feasible, but also imperative, to design an IT roadmap that allows a business to plan and develop an IT infrastructure that meets a company's current and future needs. IT teams need to be sufficiently flexible and agile to adapt to the industry's changing requirements. Likewise, IT teams should also participate in any planning processes across the organization. In effect, IT must have a long-term roadmap that plans for every eventuality.

5.5 Treat Data as the Most Valuable Asset

If the TE and distribution orchestration platforms are the vital organs of the future energy system, cash, electrons, and data are its blood cells. A transactive and customer-centric market cannot function without all three. While utilities in 2017 are adept at managing cash and electron flows, the industry is less skilled at managing data. Without the flow of timely and accurate data, the TE market will be anemic.

Any aspiring ESP or distribution service orchestrator—whether an incumbent or a new entrant—will be a data company. Getting the right information to the right people at the right time will define an ESP's success, as it will determine the efficiency, accuracy, and profitability of the system. As a result, a rigorous and extensive data management roadmap must sit alongside the long-term strategy to develop an ESP business.

Data and analytics will deliver considerable differentiation in the future. For every potential market scenario, a good data manager will ask what data is required, by whom, and how that data will be accessed. They will ask what analytics are required to provide the most valuable insights to key stakeholders. Finally, they will plan the most efficient and cost-effective infrastructure to deliver this data and insights.

None of this will be possible without a strong, collaborative organization with a solid focus on governance. If that does not describe an existing organization, significant changes must be made.

5.6 Upskill to Meet Future Challenges

No incumbent organization has all the skills to meet future requirements. Once a roadmap has been developed, the next step is to assess an organization's ability to develop that roadmap. This analysis will uncover the extent and location of weaknesses and identify the areas that need the most attention.

Organizations will then be faced with a difficult decision on how to address these capability deficiencies: Should they be developed in-house? Is it preferable to partner with third parties to fill in these gaps? Or will it be more effective to acquire these businesses? There is no standard answer to these questions—no two companies will have the same requirements—but it is imperative to ask them.

Section 6
ACRONYM AND ABBREVIATION LIST

ADMS .... Advanced Distribution Management System

AI .... Artificial Intelligence

AMI .... Advanced Metering Infrastructure

C&I .... Commercial and Industrial

DER .... Distributed Energy Resources

DERMS .... DER Management System

DR .... Demand Response

DSO .... Distribution Service Orchestrator

ESCO .... Energy Service Company

ESP .... Energy Service Provider

EV .... Electric Vehicle

HVAC .... Heating, Ventilation, and Air Conditioning

IoT .... Internet of Things

IT .... Information Technology

PV .... Photovoltaics

SCADA .... Supervisory Control and Data Acquisition

TE .... Transactive Energy

TV .... Television

VAR .... Volt-Ampere Reactive

VPP .... Virtual Power Plant

Section 7

TABLE OF CONTENTS

Section 8

TABLE OF CHARTS AND FIGURES

Section 9

SCOPE OF STUDY

Navigant Research has prepared this white paper as part of its Energy Cloud thought leadership series (For further reading, see *The Energy Cloud*, *Navigating the Energy Transformation,* and "Energy Cloud Playbook."[3]) The focus of this paper is to provide current and interested stakeholders at all levels of the electricity value chain—including utilities, regulators, technology suppliers, service providers, investors, and policymakers—with an overview of the opportunities and challenges that the industry will face during the transition to an intelligent and distributed future. Note that the report does not aim to offer detailed assessments of industry transformation. Such analyses are discussed in more detail in Navigant Research's in-depth market and technology reports.

SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Navigant Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Navigant Research is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Navigant Research is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

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[3] Navigant Consulting, Inc., *The Energy Cloud*, 2016.
Navigant Research, *Navigating the Energy Transformation,* 2016.
Mackinnon Lawrence and Jan Vrins, "Energy Cloud Playbook," *Public Utilities Fortnightly*, July 2016.

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