NAVIGANT RESEARCH

**WHITE PAPER**

# Liberating Microgrids (and All DER)

## Aligning Customer Needs with Solutions Provider Offerings


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# Section 1
# WHY MICROGRIDS ARE SO MISUNDERSTOOD

## 1.1 The Tyranny of Definitions

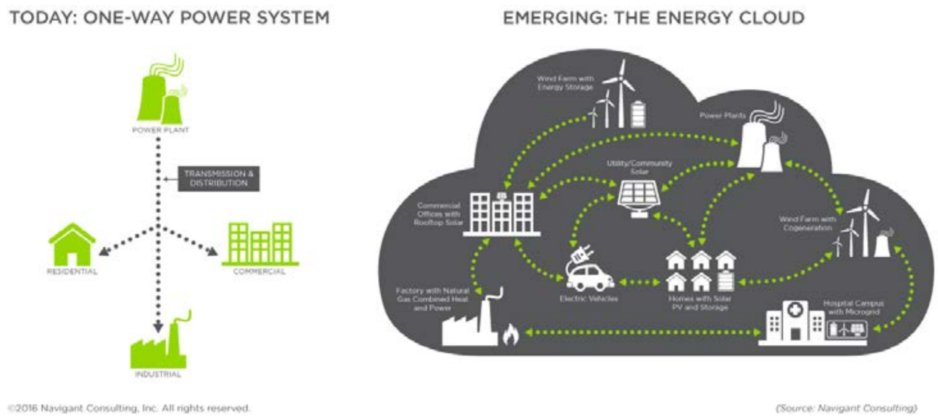
Since 2009, Navigant Research has spent a great deal of effort trying to define and segment various distributed energy resources (DER) solutions. Yet, no matter how one labels a project, there is always someone who will disagree. Some vendors—for example, large established market players—may want to define solutions narrowly, especially if they have to report on the progress they have made (or may not have made) in a specific market to company higher-ups. Others, most notably smaller vendors seeking publicity, often want to define DER solution aggregations broadly. They want to take advantage of market hype and search engine optimizations and be identified with trendy monikers.

Navigant Research has tried to draw lines between microgrids and other DER solutions. However, bridging technologies such as energy storage (ES) and the increasing sophistication of software are making clear distinctions more difficult. Definitions may be important to researchers trying to put diverse DER projects into specific categories when delivering forward-looking market forecasts. But to the customer or solutions provider, labeling a solution is, in many ways, irrelevant. As long as the DER project serves the needs of the client, what label one attaches to the solution is no longer important.

## 1.2 It's a Microgrid. It's a VPP. No, It's IoT!

The Energy Cloud concept illustrated in Figure 1.1 rests on the foundation of a digitally-enabled intelligent grid architecture. The vast majority of contemporary microgrids exhibit the hallmarks of the emerging Energy Cloud. This concept is characterized by a shift from a one-way power flow model focused on centralized generation to a two-way relationship with formerly passive consumers based on the aggregation, integration, and optimization of DER via microgrids and virtual power plants (VPPs).

***Figure 1.1 The Emerging Energy Cloud: Moving from One-Way to Two-Way Power Flows***




- Large, centrally located generation facilities
- Designed for one-way energy flow
- Utility controlled
- Technologically inflexible
- Simple market structures and transactions
- Highly regulated (rate base) and pass through

- Distributed energy resources
- Multiple inputs and users, supporting two-way energy flows
- Digitalization of the electric-mechanical infrastructure: smart grid and behind the meter energy management systems
- Flexible, dynamic, and resilient
- Complex market structures and transactions
- Regulation changing rapidly around renewables, distributed generation (solar, microgrid, storage), net metering etc.

*(Source: Navigant Consulting, Inc.)*

The defining feature of a microgrid, per the US Department of Energy definition, is the ability to island, or to disconnect from the larger utility grid. This is often cited as a defining feature of a microgrid, even if this islanding function may only be exercised in times of a power outage. These grid-tied microgrids will operate in grid-connected mode 99%+ of the time. This latter fact is why some use the term microgrid more loosely.

Spirae takes a slightly different view. A microgrid is simply a collection of DER that, when managed as a single system with appropriate control software, turns that collection into a virtual system with well-defined properties and capabilities. The key requirement for a microgrid is that it be able to actively manage power and energy flow within some defined ranges. This allows for microgrids to be grid-tied, grid-independent, or capable of both, depending on the capabilities of available equipment. Islanding from the grid is an optional capability that the owner of the microgrid may or may not choose to include—no different from whether you choose leather seats when you buy a new car. And just as leather seats don't define whether a car is a car, a single capability such as islanding does not define a microgrid. However, this is not a universal view.

According to Navigant Research, the key defining feature of a VPP is that energy, capacity, and ancillary services provided by retail DER assets such as solar PV coupled with batteries in a home migrate upstream to a utility or a transmission grid operator when they are needed at the precise times they are needed. (Spirae does not offer up its own VPP definition.) Demand response (DR) is the most mature segment of the VPP model, though growth in ES is beginning to alter assumptions about VPPs. For instance, VPPs are often composed of systems that Navigant Research has dubbed “nanogrids.” But they are also enabled by the Internet of Things (IoT), especially if VPPs reach out to the residential customers. IoT is the connectivity that enables diverse appliances and other electric loads to be transformed into nodes available for VPPs (or microgrids and nanogrids.)

Confused? You are not alone. There are also terms such as “digital power plant,” “software-defined power plant,” and “transactive energy.” The bottom line is that all of these terms overlap with each other. The lines between these definitions are not getting sharper, but rather, fuzzier and fuzzier with time. Again, these labels are attempting to segment an emerging ecosystem of solutions, all of which require some form of software and controls to transform disaggregated DER into customer-facing solutions that provide two-way power flows and bidirectional value propositions.

## 1.3 Why So Many Microgrid Projects Fail

Nevertheless, it is not the fault of definitions that leads to a high mortality rate among projects billed as “microgrids.” Instead, the high failure rate is often due to their framing as infrastructure projects, requiring sophisticated and expensive upfront analysis followed by complex design-build phases. The high costs incurred before a shovel is even put in the ground are thwarting the creation of a truly sustainable microgrid (and DER) market. Too many feasibility studies are confusing potential investors, developers, utilities, and consumers with technical analyses that entirely miss the point and conclude that microgrids are too expensive for the value they deliver.

This white paper aims to move beyond this custom-engineering paradigm and articulate what a microgrid market should look like, if managed intelligently, taking advantage of new planning and design tools that leverage new technologies to provide deeper value to the customer. Solutions providers will benefit from this streamlined approach, delivering projects on time, on budget, and in a way that can transform and make the Energy Cloud a reality sooner rather than later. The end goal is to provide a blueprint for how to meet the needs and wants of both customer and solutions provider while arresting the current high mortality rate of projects that seek to harness the power of DER to fulfill the vision of what Navigant Consulting, Inc. (Navigant) has deemed the Energy Cloud.

Singularity Institute’s CEO, Rob Nail, talks about the “scream of humanity” when confronted with nonlinear change—the extreme resistance to ideas and technologies that force people to change in some fundamental manner. The electricity system that has served us well for 100 years is facing a fundamental threat to its existence—the possibility of an energy future that is fossil-free and does not require an extensive network of long distance wires to serve the energy needs of consumers. The scream is visceral, and it is bound to get louder before the inevitable energy transition is complete.

The catalyst to powering this transition is the ability to scale. One-off energy projects won’t do the trick. In order to achieve their true potential, DER and microgrid adoption has to convert from deployments of tens to hundreds, to hundreds of thousands, to millions. That future is here with the convergence of smart DER technologies and intelligent energy management software.

# Section 2
# EMPOWERING CUSTOMERS

## 2.1 What Does the Customer Really Want?

More often than not, the customer may think he or she is in need of a microgrid, but the reality may be something different. Customers may even say they want a microgrid because it's becoming a familiar and ubiquitous term, but what they are really looking for might be something simpler. For example, they may be looking to maximize their renewables contribution, leverage local energy storage (ES), enable backup power during grid outages, or tie together diverse distributed energy resources (DER) for energy cost minimization—none of which requires seamless islanding capabilities. In order to better understand customers, perhaps it is best to describe the discrete services that one can receive from the smart customization of DER. Once this list of energy, capacity, and grid services is better understood, one can appreciate how a microgrid solution is capable of delivering what the customer needs.

### 2.1.1 Energy Cost Reduction

All customers want lower energy costs. But what is the best way to achieve that goal? In some cases, a microgrid may cost more than other solutions that involve DER, especially if seamless islanding is part of the equation. The most common way to reduce energy costs via DER aggregation and optimization strategies is to attack the demand charge component of the customer's monthly bill. One does not necessarily need a microgrid to accomplish this goal, though a microgrid can help mitigate demand charges in much the same way as demand response (DR) or an ES or solar PV system.

### 2.1.2 Renewables Integration

One of the most compelling value propositions tied to microgrids is the ability to integrate variable renewables into a larger system with baseload fossil generation and/or load management systems that can fill in gaps when the sun is not shining or the wind is not blowing. This goal can be accomplished through a variety of networking functions, one of which is a microgrid.

### 2.1.3 ES Optimization

ES devices are capable of a wide range of energy, power, and ancillary grid services. Yet, they offer their greatest value when well integrated with other DER, whether that is in the form of dispatchable DR or as a bridging resource for variable renewables within a microgrid. In any case, tapping the full potential of ES systems is emerging as a fundamental driver behind microgrids, virtual power plants (VPPs), and related DER aggregations. The key to realizing this more complex optimization is to reach beyond the ES system itself with a sophisticated controls platform.

### 2.1.4 Demand Flexibility

Demand is load and load is a resource that can be tapped to provide value to both the grid and customer. Microgrids can leverage demand flexibility as a resource to optimize their internal operations. Customers become interested in demand flexibility solutions when they realize that their loads are not just cost centers, but also a valuable resource that can be utilized to control costs. But one does not need a microgrid in order to offer up demand flexibility to a market to capture new revenue streams in the form of DR. In fact, one could argue demand flexibility is really more a function akin to load aggregations leaning toward a VPP concept. That said, microgrids may act as a network that can be treated as a DR resource—if there is a utility program or organized market for such services at the wholesale market level of operations.

### 2.1.5 Resilience

Resilience is often proposed as the core of the microgrid value proposition. The ability to island when the larger power grid goes down due to extreme weather, a terrorist physical or cyber attack, or any other threat is what has motivated the US Department of Defense (DOD) and a growing list of US states to create programs supporting the deployment of microgrids. These microgrids typically focus on providing continuous power to critical facilities. While this is a valid value proposition, it is one that often lacks a clear mechanism to price the resilience attribute. A lot of discussions regarding resilience seem to be driven by the desire to build an economic microgrid while getting the resilience attribute as a side effect at no extra cost. Ideally, the value that customers place on resilience should be established independent of the value placed on energy.

### 2.1.6 EV Charging

Plug-in EV (PEV) batteries typically remain unused for large portions of the day. Early research into vehicle-to-grid (V2G) technology marked an attempt to unlock this potential for the benefit of utilities, campus owners, and even individual households. With V2G equipment delivering power to and from the grid, vehicles become the equivalent of mobile ES devices. A primary application is for V2G vehicles to take power off the grid at times of the day when it is inexpensive or in abundance (i.e., during off-peak hours), store it in batteries, and supply it to the grid during times of peak demand or when there is a capacity bottleneck on transmission lines.

### 2.1.7 Optionality, Choice, and Energy Personalization

Customers want choice. If the telecommunications industry is used as an example, the rapid proliferation of cell phone and related technologies underscores this fundamental point. Likewise, the popularity of smart thermostats such as those offered by Nest, Ecobee, Honeywell, and others that enable consumers to control comfort and corresponding energy usage in their homes illustrates how the personalization of energy management is following in the footsteps of the telecommunications industry. Choice comes in many forms. One can opt into a green power program where an aggregator or a utility may charge a premium for green power; yet, recent trends point to onsite solar PV and batteries as the preferred path. Microgrids offer the ability for a business, a community, or a cluster of homes or businesses to pool their personal power assets into a customized network. Some customers may choose to not do anything different at all. Enabling customer choice will be the hallmark of large-scale microgrid deployments.

### 2.1.8 Ease of Use and Maintenance of Onsite DER

A small subset of customers will want to have a hands-on experience with energy management. However, the vast majority of consumers will not want to be directly involved with the daily (or even hourly) mechanics of optimizing DER—even if such optimization carries direct financial benefits. Most consumers will delegate the details of their onsite DER to others, whether that be the local utility, a DR/DER aggregator, or the owner or operator of a microgrid. A microgrid is only one path to reach this often shared and common goal.

## 2.2 Bottom Line for Customers

For customers, whether the solution they need is a microgrid or something else is a key question. In order to best answer that question, they need to think through what they really need, what they may want, and how much and in what way they want to pay for it. The rise in DER offers customers the opportunity to incorporate any or all of the above referenced services and attributes into a personalized energy system tailored to their unique circumstances. But as you will soon learn, that doesn't necessarily mean you need a microgrid or a complex and expensive custom-engineered solution.

# Section 3

# LIBERATING MICROGRIDS (AND ALL DER)

## 3.1 Microgrid Analysis Paralysis

Over the past few years, tools for microgrid design have been proliferating. The options are numerous:

- Tools supported by private companies such as Homer (originally from the National Renewable Energy Laboratory).
- Tools developed by national labs such as the Distributed Energy Resources–Customer Adoption Model (DER-CAM) from Lawrence Berkeley National Laboratory and the Microgrid Design Toolkit (MDT) from Sandia.
- Proprietary microgrid design methodologies from engineering consulting companies, engineering, procurement, and construction companies, and project developers.

All of these tools share a common feature: the assumption that microgrids are complex energy systems that require customized high-end design expertise and even higher levels of project management and finance experience to implement. This general assumption has been compounded by large engineering companies with assertions such as the one from Siemens: “A microgrid is a scaled down version of the centralized power system that generates, distributes, and regulates the flow of electricity.”[1] The implication is that a microgrid is best left to the grown-ups in the industry.

Energy regulators have contributed to this misrepresentation by adding obtuse requirements to highly publicized microgrid initiatives such as NY Prize. The NY Prize initiative defines microgrids as “local energy networks that are able to separate from the larger electrical grid during extreme weather events or emergencies, providing power to individual customers and crucial public services such as hospitals, first responders, and water treatment facilities.” Then it lays out a multiyear analysis competition to design microgrids that require interoperability between multiple stakeholders to keep the lights on in the event of grid failures. However, single facility and campus microgrids are excluded from participating in this competition. While ambitious in its system resilience objectives, the program fails to address basic limitations such as the lack of supporting regulatory frameworks for potential participants to commercially build and operate such systems without violating existing utility monopoly rules.

[1] Siemens website: https://goo.gl/bjzPOY.

Another widely recognized microgrid initiative is the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program, intended to assist the US DOD in securing critical facilities using microgrids. While perhaps appropriate for federally funded projects without the usual commercial economic feasibility constraints, the industry seems to believe that these complex projects are the norm when it comes to microgrids.

The list of pilot projects, feasibility studies, and complex tool development goes on and on. This list is aided and abetted by consultants and researchers that are in the business of showcasing how complex problems and solutions are—reinforcing the perception that microgrids are niche solutions not meant for mass adoption. The net result? Analysis paralysis—solving problems for a very narrow 0.01% of the market, leaving the remaining 99.99% of industry stakeholders high and dry and wondering what the hullabaloo is all about.

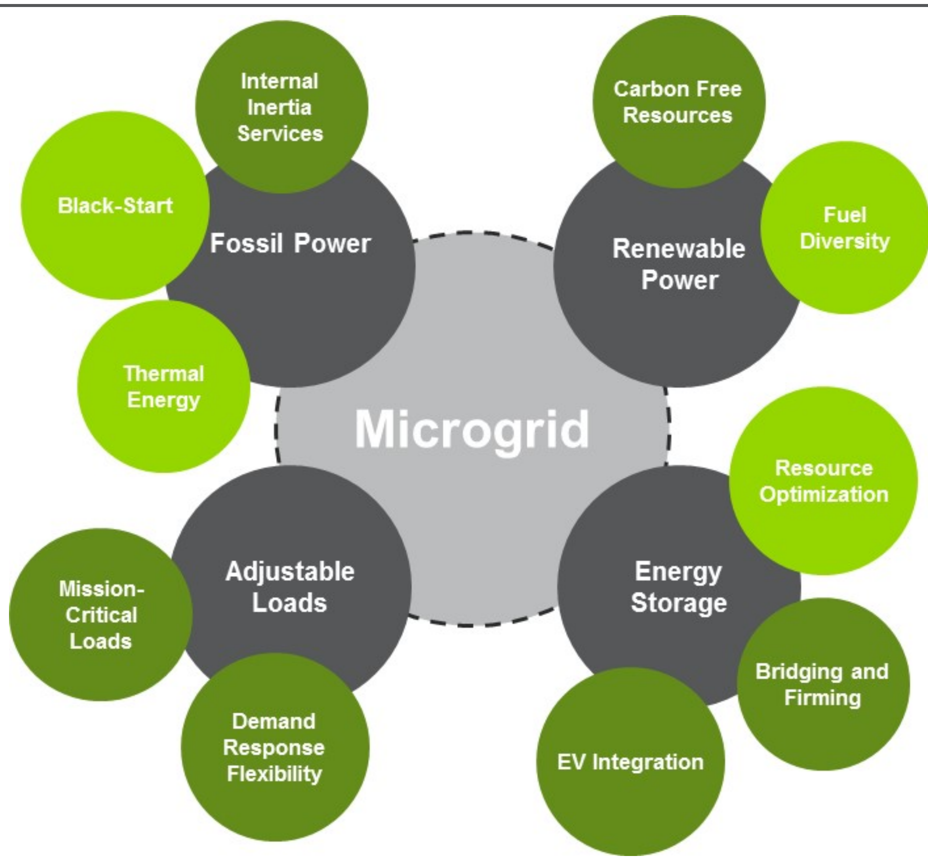
## 3.2 Jailbreaking

**DER** and smart **microgrids** represent the **jailbreak** for energy consumers

Most people have heard the term "jailbreaking" as applied to smartphones. A smartphone is typically locked to limit it to a single telecom carrier. It prevents key files and system configurations from being updated or reconfigured except by the carrier. Jailbreaking is the term used to describe the art of breaking out of this carrier-imposed restriction and taking control of a phone's destiny yourself as the owner of that device. When it comes to energy systems, customers have seldom had any ability to control their own energy destiny. They have no choice but to take the kilowatt-hours delivered to their doorsteps.

Microgrids empower energy consumers to take active control of their energy systems and operate their interconnection with the grid as a managed resource. They also empower innovative energy services companies to offer energy solutions to consumers in ways not possible before. And they empower communities and corporations to set goals and implement solutions that transcend the narrow limitations of a kilowatt-hour mindset while simultaneously meeting consumer objectives and larger social imperatives such as greenhouse gas reduction and energy security. Figure 3.1 shows the range of benefits that DER brings to consumers, with a microgrid being the organizing force that delivers specific results at specific times to specific parties—all under the control of the facility owner and operator.

***Figure 3.1 Microgrid: Enabling Multiple Streams of DER Benefits***




*(Source: Navigant Research)*

The convergence of DER technologies has been accelerating over the past few years, and we are now fast approaching a tipping point. Edge of grid technologies, such as generation, storage, and active demand management (including flexible EV charging), have matured and their price points are rapidly dropping, driven by more competition and greater customer demand. However, market adoption to date has been mostly driven by narrowly defined incentives around DR programs, PV net metering, storage projects, and the like. This narrow approach to siloed incentives has resulted in DER fragmentation.

Increasing levels of device smartness, pervasive communications, and maturing interoperability standards are driving convergence toward integrated operations. Solutions that fell into the slow-paced realm of custom integration can finally be delivered rapidly with plug-and-play compatibility. Integrated energy solutions that take advantage of demand flexibility at a facility or home can be mixed and matched with off-the-shelf ES solutions and solar PV production technologies (ranging from building integrated and rooftop solar to solar canopies and community solar) to deliver a range of energy services. These solutions can be offered to residential or commercial customers in a manner akin to ordering cable service at a particular location. Plug-and-play equipment can be mixed and matched in many combinations to meet a wide array of customer objectives—with no custom engineering.

The closest analogue to a smart system composed of DER is a virtual battery. It can absorb or produce active or reactive power within certain defined performance limits. The ability to turn any node in the electric power system into a virtual battery is the recipe for the coming energy jailbreak. That's the true power of microgrids.

Properly configured microgrids are exemplary stewards of DER on behalf of their owners. The various capabilities of individual equipment can be assembled in multiple configurations to deliver value to different parties at different times at different locations. The ability to virtualize large portfolios of DER and reliably deliver multiple value streams is what makes microgrids completely different from all the backup generators, combined heat and power (CHP) plants, PV systems, and battery installations that came before it. This capability gives microgrids center stage in the electric power system transformation battle currently underway.

### 3.3 Fork in the Road: Customize or Standardize?

Central power plants are expensive and time consuming to build, dominated by turnkey engineering design and construction companies with specialized systems engineering, project management, and financial skills. Designing, constructing, delivering, and often operating large infrastructure projects are their core competency. Many of the subsystems for such projects are even designed to order. Control software and user interfaces for such systems are designed and implemented using mature process and plant control systems by highly skilled engineers. These highly customized systems are commissioned, tested, and handed over to trained plant operators.

Distributed energy systems, on the other hand, are made up of many nodes that are part of a larger system. They tend to be hybrid systems made up of flexible loads, electrical, thermal, and mechanical storage systems, and local conventional or renewable production systems. The smarts for linking various components together to meet specific operational objectives are supplied by specialized software. This approach can establish the basis for standardized solutions.

Ideally, installing and commissioning such systems should be no different from how cable companies turn on Internet, telephone, TV, and home security services in a home within a few hours. However, that is not the case in the distributed energy industry today. The industry is hamstrung by mindsets and business models borrowed from infrastructure project development companies.

### 3.3.1 The Traditional Project Development Path: Customization and Expert Engineering

Many major DER and microgrid project development companies assume that the best way to build microgrids is to follow a scaled-down version of building conventional power plants. A typical project development cycle involves the following major steps:[2]

- Technical, economic, and regulatory feasibility studies
- Conceptual engineering
- Financial modeling and analysis
- Budget preparation
- Third-party capital identification
- Power purchase agreement and construction contracting
- Engineering, procurement, and construction
- Start-up and commissioning
- Project management

This process can literally take more than 1 year of time and burn away thousands if not millions of dollars before a single shovel is put into the ground. When uncertainty levels are high, these types of analysis and design-heavy approaches are essential for project success. However, such projects limit microgrids to a small subset of possible applications—typically subsidized through federal or state government initiatives in low volumes. A better way is needed to push the Energy Cloud vision into a mainstream reality.

[2] For a more detailed overview, see: https://goo.gl/S3AH7o.

### 3.3.2 The Path to Scale: Standardize, Then Let Software Do Its Magic

Bringing economically feasible solutions to the vast majority of energy consumers requires a complete rethinking of what microgrids are, a standardized approach to deploying them with smart DER, and the ability to utilize locally available, licensed electrician-level skills. This is an area where we can learn a lot from cable companies.

Innovation in every industry goes through several well-documented phases: an initial leap of faith by inventors and innovators that leads to prototypes and demonstration systems; lack of interest or outright dismissal from industry incumbents; early adoption by visionary and technically capable customers; and technology and process maturation leading to mass adoption. In the field of distributed energy, we are just beginning the transition from early adoption to mass adoption.

Early adoption depends on research, analysis, pilot projects, subsidies, and lot of patient pioneers. Projects are valued for adopting innovative technologies and serving as demonstration platforms for educating industry stakeholders. Tools and expertise are borrowed from other fields to execute the projects, often resulting in brute force solutions, high costs, and low returns.

The transition to mass adoption requires standardization, simplification, and personalization. These requirements include the flexibility to match the acceptable and appropriate level of risk, as well as the preferred business model of the customer. Consumers (be they residential or commercial) have to be able to quickly identify with solutions, become excited about what it means in their own personal or professional lives, and procure solutions with limited risk. This transition also requires new tools and processes to train and activate a large workforce already skilled in large-scale deployments in adjacent industries. DER software is making this a reality with plug-and-play device interoperability, data-driven system configuration, and equipment installation and commissioning that are within the capabilities of most licensed electricians.

Certain engineering problems are inherently complex. Building autonomous drones for the military is inherently more complex than building consumer-grade drones. Approaches to designing and building them and expectations about how they perform are also vastly different. Technology allows us to take complex engineered solutions and turn them into everyday products accessible to just about everyone. Similarly, DER and microgrid solutions can be specialized for unique applications when needed, but also standardized for mass adoption.

This does not mean that consumer-grade solutions are any less reliable or of poorer quality than custom-engineered solutions. On the contrary, consumer-grade solutions have to be very well engineered, have very high reliability, and be extremely easy to use. In other words, they are replicable and scalable. They will not be able to solve every problem or be applicable in every circumstance, but they will meet the majority of energy consumer needs at a fraction of the cost of custom-engineered solutions.

### 3.4 From Equipment-Defined to Software-Defined, Configurable Solutions Sets

Today, the range of intelligent DER available on the market is greater than it has ever been. DER are becoming more capable and efficient, smarter, more interconnected, remotely operable, and cheaper by the day. This trend is expected to continue—and potentially accelerate—over the next few years.

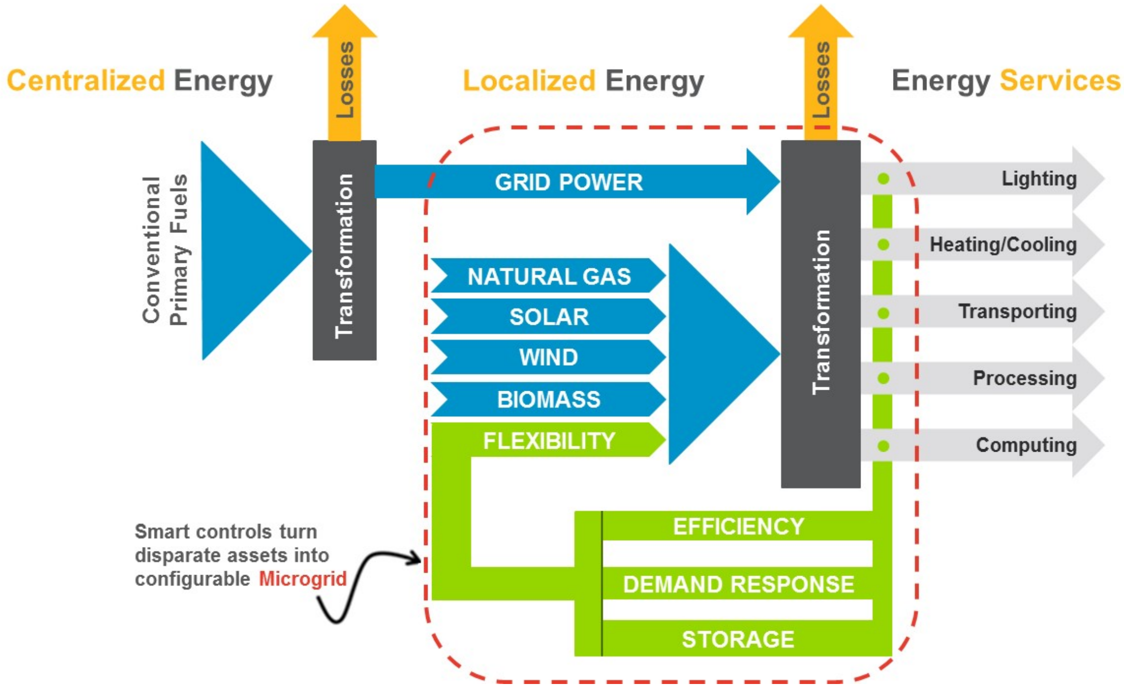
Designing and building an energy system simply comes down to figuring out how to identify, size, finance, procure, install, configure, and commission various DER (which include meters and power flow equipment such as breakers, transformers, protective relays, etc.) to meet system objectives within budgetary constraints. The billion-dollar question is how to go about it at scale.

> The answer lies in leveraging the **abstraction** and **virtualization** capabilities that software offers

Ultimately, plug-and-play hardware disappears behind software systems that characterize the form and function of the equipment and makes it available to other applications. Higher-level applications within a single system or third-party software can schedule and dispatch individual pieces of equipment or call on composite microgrid capabilities to meet various goals.

This level of local intelligence makes it easy for service providers to provision specific services at customer locations. Lowering energy costs, maximizing renewables, and enhancing resilience are some examples of energy services that service providers can offer their customers. These services take advantage of the capabilities of new DER as well as existing assets to meet service provider objectives. The utility grid is also treated as a resource available to the site controller with specific properties, constraints, and operating costs. Built-in optimization algorithms utilize this portfolio of DER (including the grid) to meet operating objectives without violating technical and contractual constraints.

***Figure 3.2 Smart Software Controls Turn Disparate Assets into Configurable Microgrid***

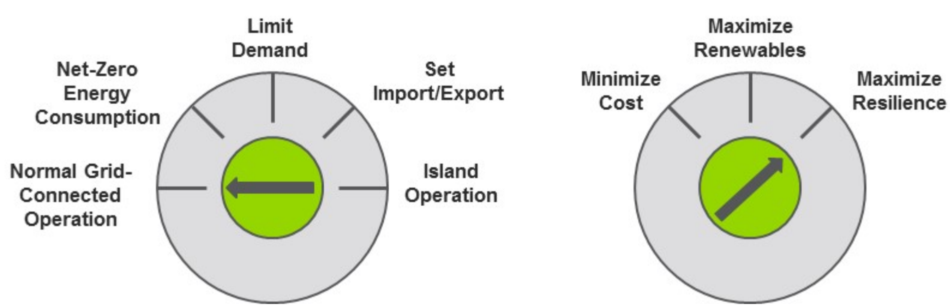



*(Source: Spirae; Navigant Research)*

Intelligent software will provision system capabilities without regard to the underlying hardware. Service providers are now able to configure services at customer sites by treating each site as a virtual battery. Not only can service providers configure customer-facing services using this approach, they can also aggregate resources such as ES systems and DR assets for market participation and to share benefits with customers.

Figure 3.3 illustrates how microgrid software abstracts the underlying hardware and presents a simple choice for customers. Customers can set the desired operating mode (or operating objectives) and set the priority for meeting those objectives. The service provider configures which choices are visible to customers depending on the level of service chosen.

***Figure 3.3 Microgrid Operating Mode and Priority Settings***




*(Source: Spirae; Navigant Research)*

# Section 4
# A NEW ROLE FOR ENERGY SOLUTIONS PROVIDERS

## 4.1 How to Deliver Energy Solutions at Scale

The opportunities and risks facing electric utilities, energy services companies, and various DER aggregators and service providers come down to two primary questions:

- How will DER-based energy solutions be delivered to customers at scale
- Who will cost-effectively deliver them?

Section 3 deals with standardizing and configuring distributed energy solutions using DER. This section describes how the right software systems enable service delivery platforms to deliver DER-based energy services to customers anywhere. The challenge of taking solutions to customers at scale has transitioned from individual device capabilities and price points to service delivery platforms, plug-and-play device integration, and innovative business models responsive to customer needs.

The major question that most stakeholders in the industry are struggling with revolve around who will deliver these services to customers. While electric utilities are best-positioned to serve as channels to customers and as the service provisioning entity, it is not clear whether they will have the regulatory certainty or the wherewithal to take advantage of this opportunity. Likewise, while there are many large energy services companies and technology companies in the services business, they too are limited by existing business models that rely on low-tech boots-on-the-ground strategies as the means to scale.

The energy industry still hasn’t figured out how to scale energy businesses (other than by aggregating megawatts), which most other technology businesses have mastered. From Airbnb and Uber to GoPro, there are endless examples of companies beating the odds to achieve scale and transform whole industries. However, the good news is that societal demands for sustainable development and cleaner power and new market entrants from adjacent markets are challenging the status quo and accelerating the transformation of the electric power industry. Regardless of who ultimately wins the race to the top in the distributed energy marketplace, the path to that market dominance will most likely include mastering DER-based solution development and their delivery using software platforms.

### 4.1.1 Microgrid-Based Energy Services

Energy service providers and project developers are increasingly leveraging DER to bring new solutions to customers. Microgrids offer these service providers the ability to use a single platform to deliver a range of energy products. They offer not only a powerful abstraction for virtualizing resources, but also the functional capabilities to implement them. Energy service providers can now sign up customers for value-added services such as energy cost reductions, renewable energy delivery, carbon footprint reduction, ancillary markets participation, resilience services, etc.; drop in an energy services gateway (akin to a cable box); and activate services for a monthly fee. These services may be offered at one location or across a corporate customer's global footprint. Energy service providers manage the service delivery platform, monitor service nodes, ensure quality of service, and generate additional value through aggregation and market participation (distribution or transmission).

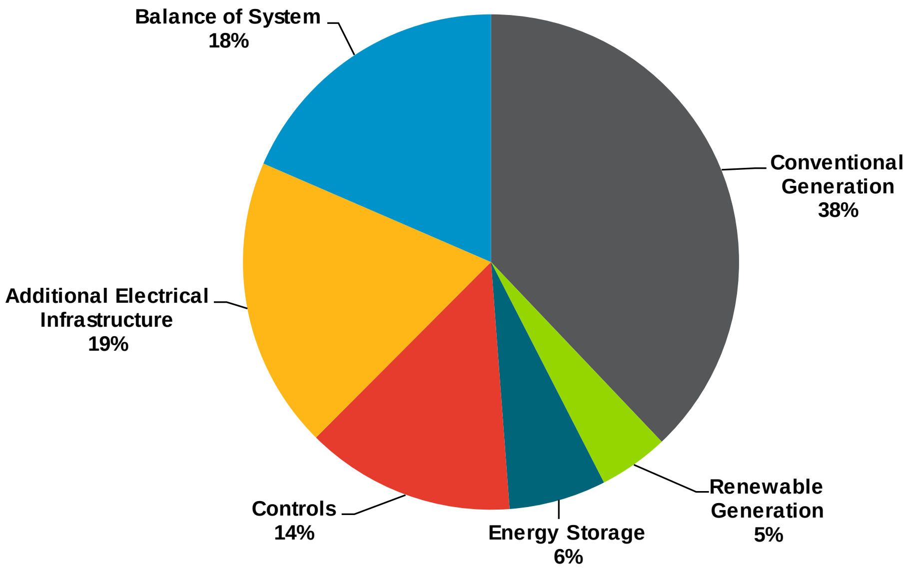
Just as consumers may purchase a wireless router from a consumer electronics store and set it up themselves or receive it as part of an Internet service provider's offering, energy consumers have the freedom to install an energy services gateway (a.k.a. microgrid controller) themselves or have it provisioned as part of a managed service offering. The plug-and-play capabilities of the gateway and compatible DER give customers this option, and the jailbreak described in Section 3.2 begins to unfold. Empowered customers now have to be courted with meaningful solutions and services—a new opportunity or a threat to existing business practices—depending on one's point of view.

### 4.1.2 Taming (and Trimming) Soft Costs

Soft costs have been the bane of the renewable energy industry for years. The hardware costs attached to solar PV panels, racking systems, EV charging stations, electric batteries, meters, industrial controllers, and networking components have been radically declining. However, the soft costs associated with regulatory, environmental, and interconnection compliance, as well as marketing, customer acquisition, and preliminary engineering studies, have continued to climb as a percentage of system costs.

While the cost of equipment gets driven down through competition and policy-driven incentives, soft costs are primarily driven through non-competitive regulatory friction. Service providers are tackling this problem through standardization of services, DER, and operating practices. Standardizing services with prequalified service gateways, compatible DER, building code-driven installation, and data-driven commissioning is made possible with intelligent energy services gateways (with embedded microgrid controls) and service delivery platforms. This is possible because all the variances that occur due to custom engineering (triggering soft costs) are eliminated in this service delivery model. Drag-and-drop system design, data-driven system configuration, and plug-and-play DER commissioning features similarly reduce engineering costs by an order of magnitude or more compared to engineered systems. Additionally, DER installation can now be carried out by locally available, licensed electrical contractors without the need for extensive retraining or high-end engineering support, further reducing costs. Chart 4.1 highlights some data from utility distribution microgrids in North America. Note that balance of system, additional electrical infrastructure, and controls costs sum up to 51% of total microgrid costs. These are the soft costs that could be greatly reduced by a shift to configurable microgrids.

***Chart 4.1 Breakdown of Costs for Utility Distribution Microgrids in North America***




*(Sources: Navigant Research, National Renewable Energy Laboratory)*

These cost reductions ensure that DER-based solutions can now be delivered to customer locations at price points that are only tens of percent above DER costs—as opposed to the current situation, where soft costs are often several times the cost of base equipment (e.g., where solar PV system costs used to be). This is especially true for small and medium-sized systems and the primary reason why the minimum viable threshold for most microgrid project developers has been multi-megawatt systems and up.

Intelligent microgrid software and service delivery platforms are **changing** the landscape, **democratizing** microgrids and DER, and **bringing** them within the grasp of most energy consumers

### 4.1.3 Standardized Service Offerings, Customized Operating Objectives

One of the self-fulfilling statements we often hear in the industry is: "If you have seen one microgrid, you've seen one microgrid!" This is self-fulfilling in the sense that if the majority of analysts and practitioners believe this to be true, every project will go through a design-build cycle that continues to make it true. However, there is no inherent reason for this situation to continue to be true. In fact, many DER vendors, software companies, and energy services companies are standardizing products, software capabilities, and services to achieve scale. These initiatives will make custom-designed microgrids look quaint in the near future. Relabeling any old CHP plant and calling it a microgrid is only useful for maintaining the status quo—and that is changing fast.

The meaningful challenge that service providers face is to be able to configure energy services to meet quantifiable customer needs. Some customers are motivated to reduce energy costs, others may want to reduce their carbon footprint, and yet others may want a more resilient energy infrastructure that can ride through grid outages. Energy service providers have the opportunity to provision energy services targeting these types of specific customer needs and wants. They now have the ability to do this with a range of DER. By standardizing on a set of DER with known performance characteristics and functional capabilities, service providers can auto-configure solutions for customers. Software systems are now capable of repeatedly and reliably configuring systems for meeting specific operating objectives using a library of compatible DER.

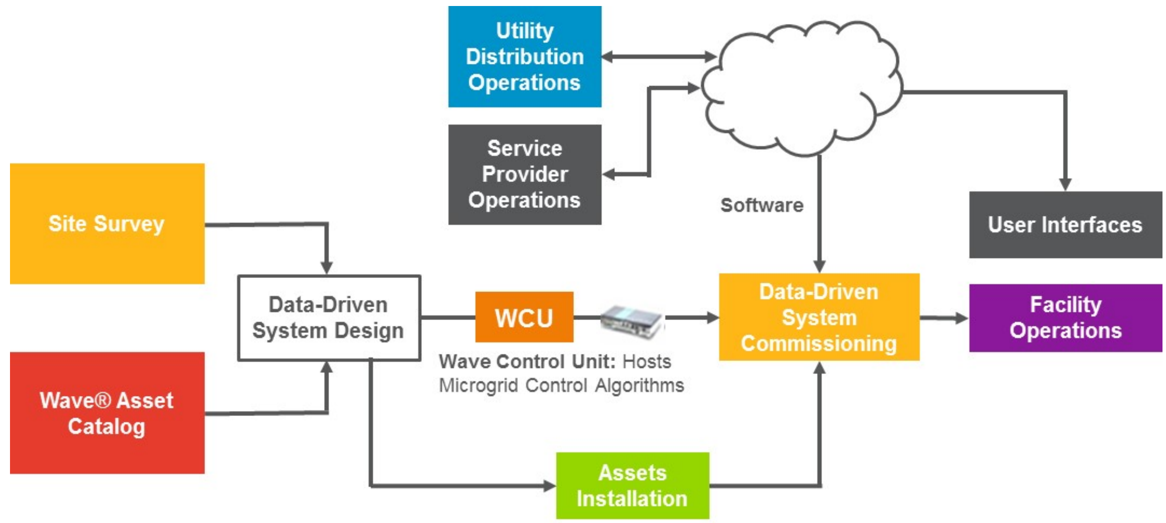
This approach satisfies the Pareto principle: it captures 80% of benefits with 20% (or less) of effort, significantly improving the odds for distributed energy businesses. The days of calling in expert consultants for design-build charrettes, preliminary and detailed designs, and value engineering and bankable designs are giving way to standardized and modular designs. While complex, custom-engineered projects are great for consultants and large infrastructure companies, end customers, energy services companies, and most project developers need data-driven configurable designs with the built-in smarts for achieving various operating objectives without having to write new software each time. Service providers that standardize their offerings, DER portfolios, and operating objectives and that use software to do the heavy lifting are poised to transform the industry.

#### 4.1.4 A New Service Delivery Platform: Configurable Network Nodes

Software as a service (SaaS) has matured in most industries and is making significant headway in the electric power industry as well. While terms like microgrid as a service have been making the rounds for some time, there is no general consensus on how such a system will actually be delivered. However, there are four general requirements for such systems: intelligent gateways that host local applications; a backend that hosts system applications; service provider network operations; and customer portals.

Figure 4.1 shows a schematic representation of how site requirements, asset libraries, software, and data-driven system commissioning come into play to form a complete service delivery infrastructure. Such an infrastructure uses microgrid capabilities for delivering a configurable range of services to any customer site.

***Figure 4.1 Spirae's Service Delivery Streamlines Deployment Process***




*(Source: Spirae; Navigant Research)*

## 4.1.5 Energy Market Participation via Aggregation

The final piece of the economic puzzle for service providers entering the distributed energy marketplace is DER aggregation and ancillary market participation. The past several years of ancillary market experimentation have all but proven that sustainable DER businesses cannot be built on the economics of market participation alone. Whether you call them VPPs, DR capacity, or ES procurement targets, the stark reality is that the economics of single-purpose DER aggregation do not work.

The good news is that the convergence of DER technologies, intelligent gateways, and distributed software is making it unnecessary to reinvent DER management infrastructures in isolated silos such as customer-facing energy management systems, DR applications, renewable energy systems, VPPs, microgrids, and the like. Service providers that implement an infrastructure such as the one described in Figure 4.1 gain the ability to mix and match resources in their portfolio; aggregate them to meet specific market requirements; and schedule, dispatch, and settle transactions as an almost-free side effect of implementing a customer-facing service delivery platform.

# Section 5

# 10 KEY CONSIDERATIONS FOR SUCCESSFUL DER PROJECTS

## 5.1 For Customers

DER aggregations—such as a microgrid—represent the personalization of an energy system tailored to the specific priorities of a single customer or a cluster of customers served by a distribution network where each customers' energy system may be treated as a controllable node. What such a network can do for a customer is configurable by solutions providers. A successful DER project requires the customer(s) to clearly articulate what kinds of services they want; how they want to finance this infrastructure upgrade; and what role—if any—they want to play in the ongoing operations and maintenance. The following five points sum up the responsibility of a customer in order to create a successful DER project.

### 5.1.1 Decide If Grid-Independent Resilience Is What You Really Want

Do you really need a microgrid that can operate independent of the grid to accomplish your goals, or will something different be a better fit? The key determining factor is whether the cost of islanding can be justified by the additional expense of incorporating this feature into the DER project. If the answer is "yes," then the question becomes: How long do you want the system to island? Cost considerations will likely be different for the capability of islanding for 2 hours versus for 2 weeks.

### 5.1.2 Ignore Buzzwords and Hype—Instead, Quantify Preferred Outcomes

Microgrid, nanogrid, VPP, or IoT? Don't get caught up in trendy buzzwords and the latest industry hype. Instead, clearly define what you are looking for and try to quantify the outcomes you would like to achieve, either by what you are willing to pay or by how you would measure success. The best way to get what you want from a DER project is being as specific as you can get in defining your problem by quantifying and prioritizing desired outcomes. Rather than think in terms of microgrids or ES requirements, think in terms of cost or carbon reduction, power quality or resilience enhancement, or future energy cost exposure or service-level guarantees using grid power as the baseline for comparison.

### 5.1.3 Determine the Acceptable Level of Risk

The electricity business is risk averse; if a DER project is mishandled, the risks are high in terms of public safety as well as private and public costs. Similar to your investment portfolio, do you want to bet on the upside (future sales of ancillary services) or would you rather play it safe and be less ambitious in your project design? Is it better to own the system so you receive the full benefits of new investment? Or would you prefer to allow outside parties to carry the risks, and in exchange, settle for better service or more stable energy costs. When evaluating a DER project, be clear about the acceptable level of risk.

### 5.1.4 Innovate In-House or Sign Up for a Managed Service?

Energy consumers must decide if they value in-house energy innovation or if they prefer the comfort of proven solutions and performance guarantees offered by specialized service providers. How important are your values to your business, institution, community, or utility? If privately financed, what are the expectations of your investors? Managed services offer customers the opportunity to take advantage of DER-based solutions that do not require internal expertise. Service providers invest in developing, hardening, scaling, and supporting solutions. They bring standardized offerings to market that benefit from economies of scale, unlike custom-built solutions that are more expensive to build and harder to maintain.

### 5.1.5 Choose the Right Business Model

When selecting your solutions provider, the ultimate decision will likely hinge on the business model that best aligns with your answers to the previous points. Financial considerations embedded in a business model always take top billing. Doing homework on solutions provider performance, scale of previous projects, and track record are all important considerations contributing to your final decision. The business model may be just as important as the technology and service offerings.

## 5.2 For Solutions Providers

The customer is always right, or so goes the saying. When it comes to DER projects, this long held axiom may not be true yet. They may want a microgrid for riding through grid outages or a net-zero energy campus for sustainability, and they may be enamored with the latest product innovations. However, the uncertainties associated with building one-off projects makes them financially infeasible, often frustrating all parties involved. Solutions providers have an incredible opportunity to lead the way by developing a standardized portfolio of energy services that deliver simple and quantifiable value propositions for customers. An energy cost reduction of 10% over a 5-year period, 50% carbon reduction relative to the previous 12 months, and annual power outages of less than 10 minutes are examples of quantitative outcomes that customers can easily identify with. The following five points will help you understand where you can best add value.

### 5.2.1 Leverage Your Strengths (and Don't Reinvent the Wheel)

Service providers leverage different strengths to successfully compete in the marketplace. They may already have proprietary analytics for customer acquisition and efficient methods for energy audits, greater access to capital markets for project financing and equipment leasing, or local service technicians coupled with central network operations centers. These strengths provide the foundation for DER-based energy services. Service providers can quickly build energy services products for the customers they know best by adding the right DER management software to a standard portfolio of DER. By remaining equipment agnostic, leveraging relationships with customers, and focusing on efficient delivery of standardized solutions, service providers have the potential to meet pent-up demand by leveraging what they are already good at to bring solutions to the market.

### 5.2.2 Engineering Services or Service Delivery?

Many vendors are happy to focus on high margin upfront engineering service contracts. Yet, this approach leads to market stagnation, as too many microgrid projects fail to ever make it across the finish line. In many cases, they don't even make it past the feasibility study phase. Custom design approaches limit viable solutions to a small subset of customer cases. A better way to build a sustainable long-term market is to place greater emphasis on providing standardized product offerings to specific customer segments at scale. In other words, create offerings that can be dropped in and configured for customers if a few threshold criteria are met. Shifting from design-build project development to the delivery of standardized solutions tailored for specific customer classes will yield economies of scale and new market opportunities for service providers.

### 5.2.3 Microgrids as a Means to Meeting Multiple Customer Needs

The best way to design and deliver a microgrid is to create multiple value streams from the same DER. This is the key to making the economics of both ES and microgrids work. Ideally, each microgrid would deliver at least three essential services to customers; the three most common would be economics, renewables integration, and resilience. A microgrid delivered as a node on a managed network gives service providers the flexibility to augment its capabilities over time and incrementally capture new value streams. It offers customers the option to start with basic services and upgrade to higher levels of service as their confidence in the technologies and service provider increases. A microgrid is therefore best viewed as a means to deliver modular, configurable, and scalable energy services to a range of customers.

### 5.2.4 Move from Custom Designs to Configurable Standardization

No two microgrids will be exactly alike, because most DER projects either incorporate legacy assets or are tailored to the precise needs of a specific customer. However, rather than accepting the premise that custom engineering is the pathway for vendor success, the end goal should be configurable standardization—stripping out costs linked to inefficiency while delivering greater customer value through creative plug-and-play platforms. Though few microgrids are identical, the industry can build upon the tremendous technological progress with devices such as smart inverters, ES, and software that has occurred over the past 5 years.

#### 5.2.5 Solution Platforms that Transform Grid Nodes into Configurable Microgrids

Each node on the power grid is a resource that, with the right hardware and software, can be transformed into a solution for customer (or set of customers) needs. Controls platforms that can grab any type of device and quickly configure it into a resource that can provide bidirectional value represent a transformative approach to building a market for DER. The ability to quickly and cost-effectively tap grid nodes and transform them into configurable microgrids is vital for customers and service providers alike. This capability will also go a long way toward unlocking the vision of activating DER for customer benefits, grid operations, transactive energy systems, and societal goals of sustainable growth and decarbonization. Over the long term, such configurable microgrids will revolutionize today's power industry.

### 5.3 Conclusion: Think Like Uber, Deliver Like Comcast

Stripped to its core, a microgrid is a means for harnessing the optionality contained within energy systems. Like most energy systems, a microgrid is in charge of assets that sit idle most of the time. Even when in use, microgrids usually have excess capacity that can be further utilized. Many customer loads are discretionary and some can be time-shifted without adversely affecting comfort or convenience. However, some loads must be served at all times, such as elevators, servers, and the espresso maker. Smart solar PV inverters, ES systems, EV chargers, HVAC systems, commercial motor controls, and many industrial processes have a lot of capabilities built into them that are underutilized. Just like Uber has built a huge business by leveraging the underutilized capacity in personal automobiles, microgrids that are based on the Energy Cloud concept unleash the full potential of DER. And just as intelligent software is required to capture the fragmented and unused capacity of cars and individual drivers into a seamless experience for passengers, intelligent microgrid software is required to harness the full potential of DER by optimally utilizing them to realize maximum value.

In order to scale DER-based energy services, service providers are turning to plug-and-play-type microgrids as strategic service delivery assets. It is all about standardization, simplification, and personalization. An intelligent site gateway connected to a service provider's headend system enables the provisioning of many energy services to those sites. Sophisticated microgrid software, deployed to site gateways, auto-discovers compatible DER and configures them for integrated operations. Simple user interfaces give individual site owners full access to their systems while simultaneously allowing remote DER network operators to manage the system as a whole. When service providers and customers work together to leverage DER to meet clearly defined objectives, DER projects are fast and easy to deploy. Activating energy services at new locations will look much more like Comcast turning on TV and Internet services at a new location than like building a new power plant.

***Figure 6.1 Formula for the Enabling Mass Adoption of Microgrids***


*(Source: Navigant Research, Spirae)*

# Section 6
# APPENDIX: SPIRAE PROFILE

## 6.1 Spirae

Spirae, LLC provides comprehensive distributed energy resource management systems (DERMS) and real-time microgrid control systems for electric utilities and energy service providers. Based in Fort Collins, Colorado, Spirae has developed, refined and validated its control platform and its menu of market-driven applications through numerous full scale and pilot projects in North America and Europe since 2002. Spirae's Wave® control platform is a control system with a flexible and scalable architecture for integrating and managing high levels of renewables and DER. The Wave platform and the suite of Wave Apps can be configured for a specific DER portfolio and system topology, tested in simulation, and field deployed without writing any new code.

Wave Microgrid comes with standard capabilities such as Asset Monitoring and Control, Scheduling and Dispatch, Active and Reactive Power Import and Export Control, Islanding and Resynchronization, Frequency Control, Voltage Control, and Spinning Reserves Management. For DERMS applications, Wave includes additional capabilities such as Network Awareness, Constraint Management, Forecasting, Resource Valuation, and Optimal Demand Response. With its standard Application Programming Interface (API), Wave can be quickly extended to implement custom economic and optimization logic to meet different customer and market requirements.

Wave provides project developers, aggregators, IPPs, and utilities the ability to reliably operate microgrids with portfolios of renewable and DER. These microgrids enable business models based on energy arbitrage, fuel offset, VPP operations, market participation, energy independence, and system resilience. Wave also enables new business models based on DER-based energy services, grid operations optimization, peak load management, grid de-carbonization, and microgrid integration within distribution grids.

# Section 7

## ACRONYM AND ABBREVIATION LIST

API.......Application Programming Interface

CEO....... Chief Executive Officer

CHP.......Combined Heat and Power

DER....... Distributed Energy Resources

DER-CAM.......Distributed Energy Resources–Customer Adoption Model (Lawrence Berkeley National Laboratory)

DERMS .......Distributed Energy Resources Management System

DOD .......Department of Defense (United States)

DR ....... Demand Response

ES.......Energy Storage

EV....... Electric Vehicle

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

IoT .......Internet of Things

IPP....... Independent Power Producer

MDT.......Microgrid Design Toolkit (Sandia)

PEV .......Plug-In Electric Vehicle

PV.......Photovoltaics

SaaS.......Software as a Service

SPIDERS.......Smart Power Infrastructure Demonstration for Energy Reliability and Security

TV.......Television

US ....... United States

V2G .......Vehicle-to-Grid

VPP ....... Virtual Power Plant

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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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