# The Value of Direct Access to Connected Devices

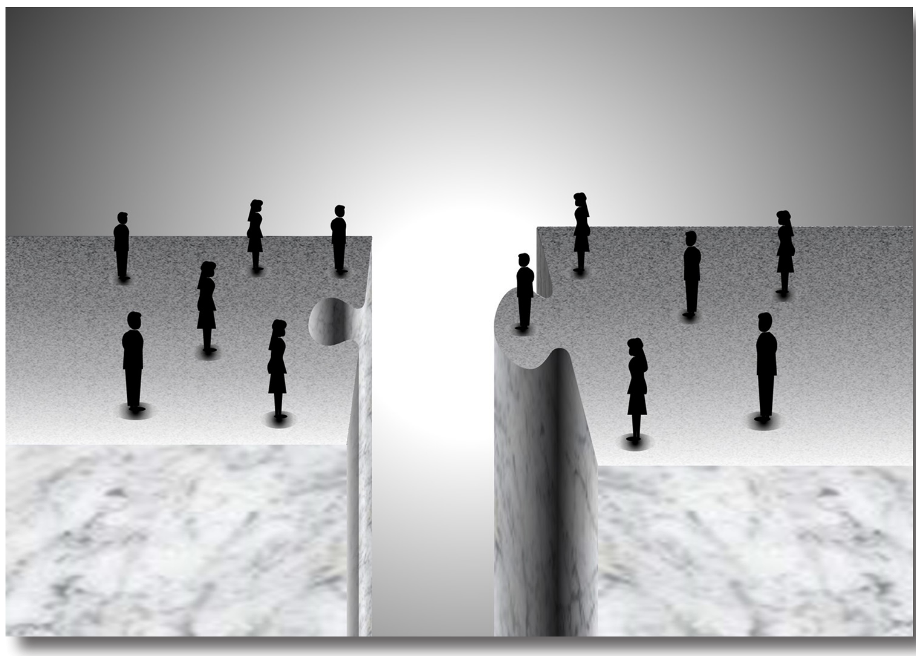
**Technical Brief — *Information, Communication, and Cyber Security. Power Delivery & Utilization. Distribution & Utilization.***

## Abstract

Communication technologies have advanced at a rapid pace, leading to abrupt and widespread incorporation of communication capability in consumer and commercial/industrial devices. Although this capability is most common in low-power electronics such as computers and televisions, communication features are now showing up in large-load devices that are of significant impact to the electric power grid. These devices are of interest to utilities because it will become increasingly necessary to monitor and manage them as variable generation such as solar photovoltaics becomes more common.

Depending on how communication capability is designed, future generations of products may be more or less accessible and compatible with home automation and grid-supportive systems. Although compatibility with energy programs may be among the reasons a manufacturer adds communication capability to their products, multi-brand interoperability and long-term sustainability of access is often not.

In this broad context, this whitepaper identifies the values of direct, standard, and open access to devices. These terms are defined and contrasted with alternatives. Some of these values relate to risk-mitigation, addressing risks that are unavoidably taken if such access does not exist. Through the design of utility programs and communication architectures, the electric power industry is creating a unique opportunity for connected large-load devices. With support from device manufacturers, this opportunity can allow consumers/owners of devices to participate in new and innovative ways to maximize the value received.



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## Situational Analysis

Communication technologies have progressed rapidly in recent years. The progress has been driven by consumer connectivity, voice and data services, and has been enabled by advancements in RF system-on-chip (SOC) devices that integrate transceiver and microprocessor elements. These components reduced the cost, size, and power consumption of two-way communication products. Just a few years ago, a two-way radio was composed of hundreds of discrete components and was difficult to manufacture. Today, similar performance is achieved with just a few components and is significantly smaller and less expensive. As a result, communication capability is appearing everywhere – not just in computers and cell phones, but in smaller, simpler things such as televisions, watches, and even tennis shoes.

Meanwhile, the nature of the electric grid is changing. The emergence of distributed energy resources (DER) such as solar photovoltaic (PV) systems and battery storage are shifting the target of system control and balance from central bulk generation to widely dispersed loads and distributed resources. Utilities are actively deploying information and communication systems that increase connectivity between field devices, substations, and operations. Sensors of many types make more sense, now that their data can be cost effectively transported, monitored, and used for analytics.

These trends in the communication and utility industries naturally converge in consumer products that are significant consumers of electric power, because of core changes in the way electricity is generated and delivered. As generation becomes more distributed and intermittent, as is the case with solar and wind energy, it is increasingly necessary that loads be informed and responsive to grid conditions. This is because the operation of the electric power grid is such that the total power produced must equal the total power consumed at all times. For products that operate in areas of highly variable renewable generation, knowing when and how to consume energy becomes as important as how much they consume. Energy consumption could even become transactive – with end devices and facilities negotiating with energy sources or markets prior to consumption. In any case, communication systems that connect these resources become mission-critical when the connected devices exist in quantities capable of disrupting the grid.

## Terminology Explained

Consumers that purchase connected devices may do so for a variety of reasons and may have wide-ranging ideas of how they will be used and the benefits that will be realized. Motives for connectivity will likely vary by product type, with some products serving remote automation purposes and others such as water heaters serving more functional, energy-related purposes.

Likewise, manufacturers who add communication capability to their products may do so for a variety of reasons and with a variety of business opportunities in mind. Manufacturers will make decisions regarding product design, customer relationships, data management, and future opportunities.

This paper addresses one particular aspect that will be a factor for both buyers and sellers: whether the local communication interface to the product is standard or proprietary. Before continuing, it is useful to define a few terms that relate to connectivity. These are sometimes used interchangeably but are in fact distinct and should be considered individually. In the context of this paper, the following definitions apply:

**Open:** When referring to communication interfaces, the term "open" identifies whether or not the technical description is available and freely usable by any interested party. For example, a communication protocol description that can be downloaded from a vendor's website and used by other companies without limitation or royalties would meet this definition of "open", whereas a protocol description that can only be obtained through special business partnership, under NDA, with royalties or other strings attached would not be considered "open".

It should also be noted that "open" does not mean "standard" (see definition below). Terms such as "open" are sometimes used loosely, and may be used in a way that does not fit this definition, therefore care must be taken in all circumstances to verify the situation. The opposite of "open" in this context could be referred-to as "closed" or "secret" in that the entity that created the protocol protects it and chooses to retain control over access by other entities.

**Standard:** What makes a communication specification a standard is being owned and managed by a legal standards development organization (SDO) such as those recognized by the International Standards Organization (ISO). Examples of SDOs include the American National Standards Institute (ANSI), International Electrotechnical Commission (IEC), and the Institute of Electrical and Electronics Engineers (IEEE). SDOs ensure proper governance, providing fair and open opportunity to all interested stakeholders to participate in the process of maintaining and evolving the specification going forward. Although sometimes criticized for being slow, SDO development processes are rigorous, transparent, and well planned. They help ensure a quality specification through broad participation, review, public comment, and resolution.

The opposite of "standard" is "proprietary" which indicates that a protocol is created-by and unique to the products manufactured by a particular company. Standards are inherently "open", whereas proprietary specifications may be either open or closed. Standards tend to endure and become most common over time.

The term "application programming interface" (API) refers broadly to any specification that explains how to access, or communicate with, a device or software product. In this sense, communication-related open standards are one kind of API. But in the common vernacular, "API" often refers to a proprietary specification rather than a standard.

**Direct Access:** "Direct Access" relates to where in the communication pathway an open, standard interface exists. All communication follows some path to reach an end device. These paths may flow through head-ends, cloud applications, servers, networks, gateways, and/or other physical products as illustrated in Figure 1 (see page 3).

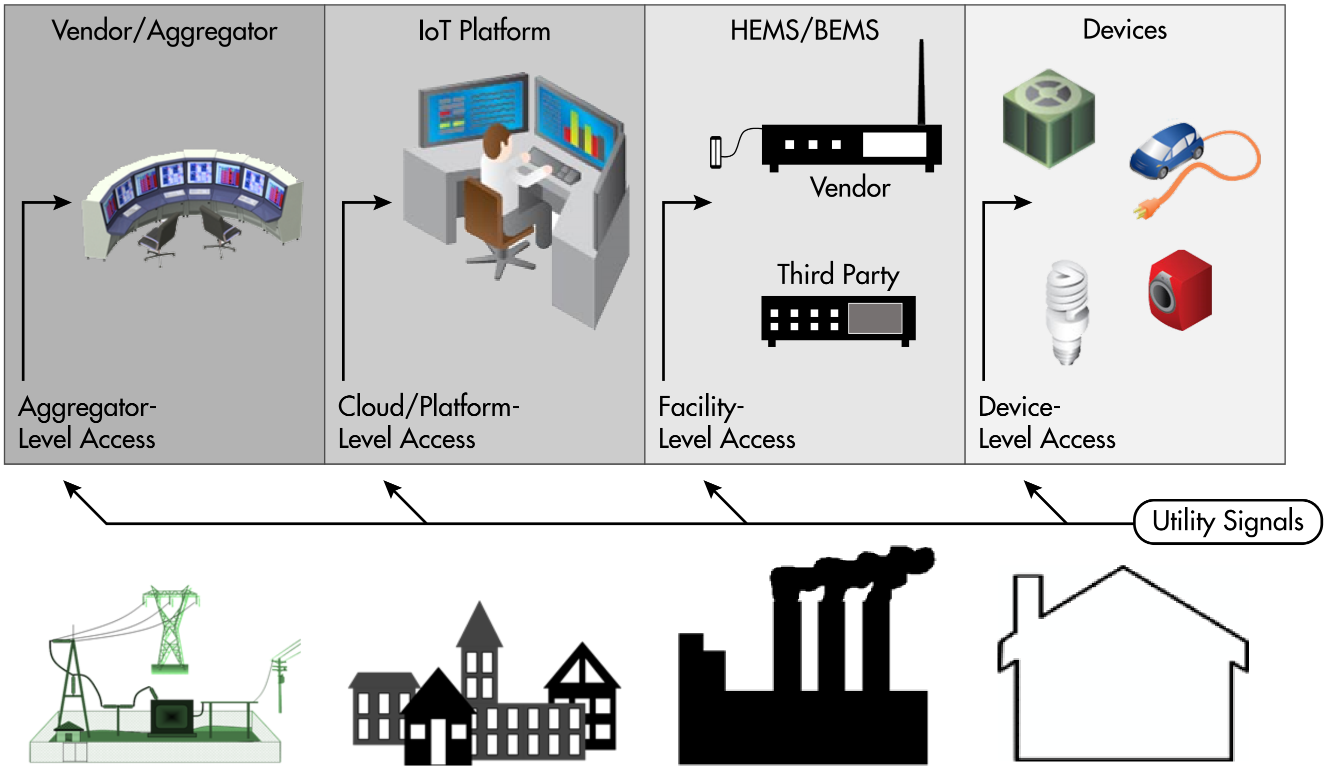


*Figure 1. Examples of Connected-Device Access at Various Levels*

Specifically, "Direct Access" in the context of this paper means that an open, standard interface exists at the device. Generally speaking, if open, standard interfaces are provided only at some other point, then access to the product is ultimately controlled in some fashion and access may be blocked or lost in the future as discussed in this paper. Direct access does not preclude the existence of other systems identified in Figure 1 such as the provisioning of gateways, networks, and cloud applications by device manufacturers and other parties. It simply provides that in addition to whatever other equipment and services are offered, the product is also directly accessible.

# Value of Open, Standard, Direct Access

This paper is focused on identifying the value of open, standard, direct access to devices and in noting the risks that are assumed if such access does not exist. Before diving into this material however, it is useful to acknowledge that there are certain reasons a consumer or manufacturer may be drawn to use a proprietary interface, at least initially. Locking-in the customer and avoiding competition may be a factor, but there are also possible technical motivations:

- Standards may not exist or may be lacking in scope, and the manufacturer has creative ideas that demand that non-standard information be exchanged
- Standards processes are slow, and the manufacturer can bring product to market in a more timely fashion
- Standards may lack clarity, and interoperability between the products of a small community of business partners may be simplified by closely managing the interfaces between multiple devices or software
- The manufacturer may have concerns about the security of open alternatives

It is the goal and responsibility of SDOs to address these concerns, maturing standards to a level that addresses the technical needs. If and when this is accomplished, a wide range of benefits to manufacturers, the electric power system, and the general public are achieved.

In new or immature markets, vendor innovations will often outpace the development of standards. The development of the Hypertext Markup Language (HTML) and the "browser wars[1]" provides a recent example. As initial versions of HTML were published, Netscape and Microsoft more or less supported the existing HTML standard, but also added innovations ahead of the standard. However, these innovations would eventually be published in new HTML versions. HTML rapidly evolved over a decade and stabilized on version 4.01, which created a foundation for innovation predicated on predictable behavior. A full fifteen years then elapsed before a new version was released, reflecting a technology and market that had matured.

Building on the definitions in the preceding section, this paper makes the case that communication interfaces for grid-supportive connected devices should be open, standards-based, and direct access. The combination of these elements provides a wide range of benefits and reduces or eliminates a number of significant risks as outlined in the following sections and

[1] Microsoft Explorer and Netscape Navigator were rapidly developing new features with their browsers in an attempt to capture the emerging market provided by the world wide web.

*Table 1. Summary Values of Open, Direct Access*

| Value of Open, Standard, Direct-Access | Risks Otherwise Assumed |
|---|---|
| Facilitates architectural flexibility, for example, coordination at local levels | Restricted architectural flexibility |
| Enhances network effectiveness, maintenance, and utilization | Higher cost of network maintenance and difficulty in network evolution |
| Facilitates cohesive integration of multiple device types | Inability to coordinate at the facility level, separate apps for each device type |
| Multiple brands of products can work together, consumers can choose the device brands they wish | Isolated and competing ecosystems, restricted to the vendor's product family or select partners |
| Continuity of access/availability, even in disaster situations | Device access contingent upon the availability of various remote networks and operations centers |
| Facilitates consumer choice of connectivity providers | Restricts consumer choice of connectivity providers |
| Innovation is encouraged and accelerated | Innovations are limited to those of one (or few) company(ies) |
| Open competition drives cost efficiency | Lock-in eliminates natural competition |
| Actions may be better aligned with grid state/ configuration | Device actions/services may be limited to those without awareness of grid state/configuration |
| Access over the life of the product | Access may be lost, for example if a manufacturer chooses to no longer offer a particular service |
| Demand responsive services can be mapped to specific accounts for incentives | It may be difficult to verify that a certain service was requested-from or rendered-by at a certain account |

summarized in Table 1. These benefits may be realized by the consumer, the integrator, and/or the utility in relation to achieving goals of safe, reliable, affordable and environmentally responsible electricity.

## Architectural Flexibility – Enabling Many Use Cases

There are many possible communication architectures and systems for end devices. Each architecture may be more or less effective for a given use case and a given functional goal. For example, latency requirements may force decision-making to be local. If control actions need to occur within a second or less, the latency connecting to or through vendor cloud or control systems may simply take too long to be effective. Some architectures may involve peer-to-peer interfaces in which devices communicate directly with one another to coordinate or perform a common task. Other architectures may involve centralized points of control that orchestrate the actions of multiple devices to achieve a desired aggregate effect. Such coordination may be desired at many levels, including:

- At the premises-level: a building or home energy management system might be desired for coordinating the devices within the premises and optimizing for bill savings at the premises level.
- At the distribution transformer level: a smart transformer or storage device at the distribution transformer level might coordinate the activity of equipment within a group of homes to improve power reliability and to better accommodate, for example, electric vehicles and rooftop solar.
- At the neighborhood or community level: Smart communities may have generation and storage facilities and community-level control systems that operate at the local level to provide energy savings to the community.
- At the microgrid level: With a goal of microgrids being that of autonomy and reliability, microgrid controllers may use local networks that have no outside dependencies to carry out their functions.
- At the feeder-level: advanced distribution management systems (ADMS) may have distributed processors and intelligence that includes load-management on a feeder-by-feeder basis. This level of control may become necessary as quantities of distributed renewable generation on the feeder increase.

In these and other scenarios, open, standard, direct access to devices is an enabler. It results in end devices that are flexible and can be dynamically grouped to support the needs of a feeder, a community, or a home. It enables devices to function equally well in any architecture, including those not yet conceived-of at the time the devices were manufactured.

Lacking architectural flexibility, the risk is assumed that end devices go unconnected or unenrolled due to not being compatible with the control system architectures preferred by the consumer or required by a given use case. For example, a device that can only be controlled from a vendor's cloud-based headend cannot be connected locally to a building energy management system nor serve as a part of a self-sufficient microgrid which by design requires local, internal communication pathways.

### Enabling Cohesive Integration of Diverse Equipment Types

Residential and commercial premises have a wide range of equipment types, and it is increasingly necessary that this diverse equipment work in concert to perform desired functions. Growth in distributed generation, such as solar photovoltaic systems, and technology advancements in battery energy storage have elevated the need for local communications and interactions between multiple equipment types.

An example that benefits from local integration of diverse equipment is that of customer demand management when enrolled in an energy+demand rate structure. In this scenario, customers gain significant savings by keeping their peak demand to the lowest possible level. These customers need devices that have visibility to one another, the ability to be collectively managed, with logic to sequence their activity to minimize total peak demand.

The risk that is assumed if diverse products cannot be cohesively integrated is that it may not be possible to support use cases that are concerned with local aggregate parameters. For example, management of individual devices at a given facility or home in a way that is unaware of the status of other devices may be useful for reducing system-wide demand, but does not meet the needs of individual consumers in terms of managing their whole facility or home optimally.

### Enabling Cohesive Integration of Diverse Equipment Brands

Consumers enjoy the freedom to select and use a variety of appliance brands in their homes. Traditionally, this has been possible without limitation as the only requirement was that all their appliances use the same electrical voltage and frequency. Going forward, it is likely that consumers will desire the same freedom with connected appliances.

Consider the example of a person who is selecting a new connected HVAC system with one goal being that it will work in concert with a water heater that was purchased previously. If both have open standard communication interfaces, then it is likely that they can function together effectively. In this case, the range of brand choices for the new purchase is not limited by the previous purchase choice. The consumer can have cohesive, integrated systems, smart phone apps, and interfaces through which they can manage a mix of product brands.

Relative to other consumer electronics, large-power consuming devices generally have long service lives. Over such spans, homes may change hands or the attractiveness of a given brand may change in the eye of the purchaser. In this way, a whole-home of devices is accumulated over time, not acquired as a set. Coordinating with home builders to outfit new construction with smart devices has initial value, but the connectivity is not sustainable unless the devices are also able to work with other, future devices the owner may select.

The risk of deploying single-brand or limited-brand scenarios is that the number of eligible locations is limited to those at which a single brand exists. As noted, such scenarios are naturally difficult to sustain over time due to differences in the life expectancies of products.

### Supporting Local Accessibility During and Following Disasters

Advancements in solar and storage technologies are making it increasingly likely that customers, facilities, and communities have the basic ingredients for energy independence and backup power when the grid is down. This opportunity has been highlighted following recent weather-related disasters[2] such as super-storm Sandy, and will become increasingly common as penetration levels of these technologies rise.

As noted in the previous section, this scenario requires diverse types of equipment to work together, including local generation, storage (possibly in the form of an electric vehicle) and smart loads. Area communication systems, including the Internet, may not be available during such events. Therefore it is beneficial to have the option of direct access to devices so that local communications can continue without interruption and consumers can maximize their comfort and safety following natural disasters and other events that impact the grid. If the local interfaces of end-devices are proprietary, the assumed risk is that these devices are not available to provide support during emergencies or outages.

### Providing Consumers with Choice Regarding Connectivity Providers

Providing consumers with choice regarding network types and providers increases the likelihood of participation in energy management programs, increasing overall consumer and grid benefit. Systems may vary widely in cost, complexity, performance, and reliability. Where one consumer may be attracted to a particular high-tech system, another may find the same system too complicated to commission and maintain. Likewise, one consumer may be satisfied with a simple communication system that requires no setup, but another may find it to be lacking desired features or cyber security.

Network flexibility also enables privacy in that there are options in which signals remain within the premises (e.g., scheduled time-of-use management) and others that involve only one-way communication into the home (e.g., broadcast of real-time-price or events) without a return signal. While connected devices are likely able to support two-way communication for demand-response applications, some customers may prefer the personal privacy of systems and providers that do not read information from their home.

As noted previously, homes may be bought and sold several times over the life of a given load device and each new owner may have network-provider preferences that differ from the previous tenant. For example, one occupant may be willing to have a two-way system and to pay a monthly fee for access to an energy-management service. The next occupant may only be open to a one-way system and may prefer to sign-up for a program that carries no fee. For some device types, such as clothes washers, dryers, and electric vehicle chargers, consumers may take them along when they move. In this case, the systems and networks into which they

[2] Solar Companies Seek Ways to Build an Oasis of Electricity, The New York Times, Diane Cardwell, November 19, 2012.

wish to connect may be different in the new location.

Direct local access to devices expands the range of possible ways and systems that may be used. It provides consumers with more choice and more flexibility and allows them to change or upgrade the systems they are using over time. If consumers do not have choice regarding connectivity providers, there is risk that devices go unconnected, or unenrolled in energy programs because:

- The provider restricts or limits functionality in an undesirable way, for example not allowing the consumer access to a given energy program
- The owner drops out because a new device is not able to participate in a program with the other devices
- The provider's system lacks key features the device owner desires, such as smart phone remote access
- The provider's system performance level becomes unacceptable, for example, not staying online continuously, or having latency in response that makes the consumer dissatisfied

## Network Effectiveness and Metcalf's Law

The value of a network increases as the number of devices connected to it increases. Metcalf's Law[3] suggests that the value of a network is proportional to the square of the number of connected devices. This could be amended to say that while the value increase may be as suggested by Metcalf, it is reduced by the differing number of interfaces required to support the connectivity. Differing interfaces represent a drag on the network value for any integrator or system operator. The greater the number of disparate interfaces, the greater the maintenance. This is because each interface that differs from a standard assumes some amount of architectural debt and some form of "care and feeding" to maintain the interface.

$$value = \frac{devices^2}{interfaces}$$

Moving forward, when considering the number and types of devices that a utility or other device integrator is going to support, it is important to keep in mind this extension to Metcalf's Law. Adding to the complexity of the technology is not "free", but rather comes with an on-going support and maintenance cost.

## Encouraging Innovation

Providing open, standard, direct access to devices encourages innovation, creates new business opportunities, and enables competition. With connected load devices just emerging, there is a great opportunity and expectation of innovation in the area of energy monitoring and management systems. A broad range of companies could participate in advancing the state of the industry, but may only be able to do so if there is interoperability. Specifically:

- Makers of new, innovative end-use products may need to be able to connect and participate in existing control and automation systems
- Makers of new, innovative communication and control networks may need to be able to integrate with the array of consumer device types and brands that have accumulated in homes over many years

The more accessible the market, the higher quality the outcome in terms of functionality, performance, and customer participation. Direct local access to devices allows utilities, aggregators, and consumers to change or upgrade the systems they are using over time without necessarily upgrading the devices involved. In an open eco-system, utilities and other stakeholders can develop energy applications that were not needed or not even thought-of at the time the end-use devices were created. Similarly, new and/or future innovations can enable customer value and economic advantages yet to be defined by the utility industry and the customer's personal energy environment.

## Ensuring Affordable Access

Per the definition of "open" identified previously, access is inherently free. This is the case for common load management standards such as OpenADR and IEEE 2030.5 as well as local interfaces such as CTA-2045, Ethernet and USB, the use of which doesn't involve royalties. This doesn't mean that various automation and networking services offered by device manufacturers or other integrators won't involve costs, but it does mean that access to end devices is unencumbered and doesn't add unnecessarily to the cost of participation. This is beneficial, both to the consumer and to the electric power system of the future, in that it increases opportunities for participation.

Without open, standard, direct access, the consumer is locked-in and so there is risk that a manufacturer could impose fees for access that the consumer is not able or willing to bear or that are not competitive relative to similar or other alternatives.

## Coordination with Dynamic Power System Configurations

Distribution systems are becoming increasingly dynamic in their configuration. As illustrated in Figure 2 (see page 7), improvements in efficiency and reliability are being achieved through ties to multiple substations and the regular use of sectionalizing switches to optimize feeder configurations. Microgrids are becoming more practical and are anticipated to further the dynamic nature of local circuits.

With these changes, it is increasingly necessary that connected devices be managed in coordination with the circuit configuration. For example, a load that is near the head of a feeder one moment may be at the tail of another feeder a moment later. A load that is connected to the utility grid at one moment and in no need of curtailment may suddenly be part of an island and need to reduce consumption.

This creates challenges for communication and control systems that will likely require hybrid and/or hierarchical communication architectures. As the complexity of the power system rises, communication system architectures will need to be tied-in and situationally-aware. For example, a given load may need to be connected in such a way that it can receive signals from a building or home energy management system, a microgrid controller, a distribution management system (DMS), and/or a grid-operator's wide-area energy management system. Direct access to device provides architectural flexibility that can help address the challenges of the next

[3] Carl Shapiro and Hal R. Varian (1999). *Information Rules*. Harvard Business Press. ISBN 0-87584-863-X.

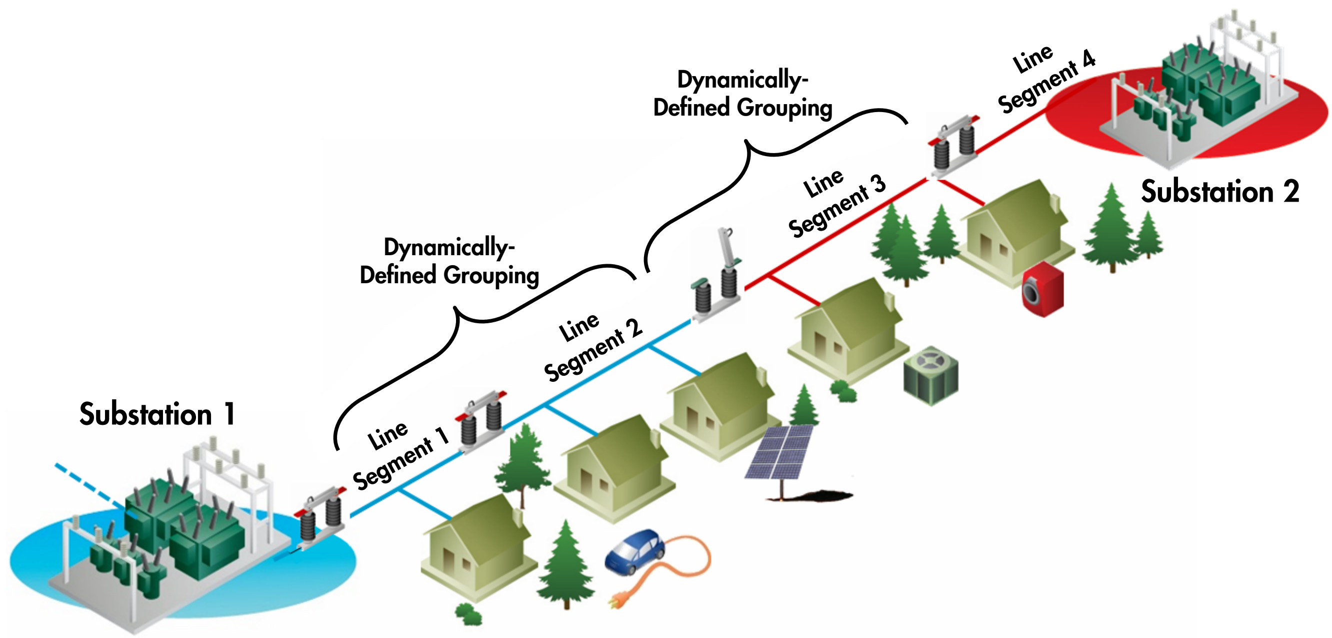


*Figure 2. Dynamic Power System Configuration*

20 years, enabling multiple levels of control to maximize value and reliability.

### Continuity of Access over the Life of the End Device

Companies regularly reevaluate the nature and types of businesses in which they are engaged and make strategic decisions regarding their future direction. As such, they may decide to add new products or services or to drop existing ones. Under competitive pressure, companies are sometimes acquired by competitors or go out of business entirely. The business of connected-devices and residential demand response is not immune to these forces and may be highly dynamic as technologies and products evolve.

Direct access, as opposed to remote cloud-only access, is important in such an environment because physical devices are the enduring components that consume and/or generate electricity and affect the power grid for the lifetime of their existence. Interfaces at remote head-ends and cloud aggregation systems, even if open and standard, can come and go and do not ensure future accessibility of devices. If the local interface is proprietary, the consumer loses the ability to connect their device if the remote system becomes unavailable or unaffordable.

Over time, a continued evolution of businesses and business interests would necessarily result in mass quantities of devices that cannot be reached, at least not economically. Such an outcome cannot be accommodated as the operation of the grid continues to shift to more distributed forms of generation and load-side resources.

### Expanding Measurement and Verification Options

Some demand response programs provide fixed incentives to consumers through payments or credits for program participation. As devices become more intelligent, there is opportunity to provide consumers with more choice and flexibility regarding how extensively their devices respond. This has sometimes been described as a slide-setting that ranges from "comfort" to "savings" with financial incentives that correspond. This kind of flexibility is desirable in order to improve participation in energy programs by allowing consumers to find the balance that best suits their interests.

Variable consumer responses do, however, create technical challenges in terms of compensation of the consumer. Rather than a fixed payment, it may be necessary to compute variable credits, using meter and other data to discern the degree of participation in events. This kind of computation requires tight association and coordination between the communication systems connecting to devices and those that meter the home. Direct access makes a range of architectures possible that may aid in correlating control signals with response levels.

## Moving Forward

There is a nascent opportunity to shape the future of connected devices – particularly those device types for which the primary motive for connectedness is energy management and savings. For products like HVAC systems, water heaters and pool pumps, the ability to participate in energy programs may be one of the top reasons that consumers want them to be connected. On the other hand, for smart phones, tablets, and home automation devices (such as door locks, garage doors, or safety lighting), compatibility with energy programs may play little or no role at all. It is important for stakeholders to recognize the difference, and where appropriate to engage in development activities to accumulate over time the greatest possible quantity of demand responsive load.

Mathematically speaking, maximizing connected load should be viewed as an integration function with the goal to maximize the area under the curve of "connectable" vs. time. In other words, it is less about what is on store shelves at a single point in time and more about the practicality of managing the collective set of devices that have come off those shelves over a 20 year span of time. Developments that lack open, standard, direct access risk the accumulation of "architectural debt" – a term referring to future costs and business impacts that may result from present integration decisions.

In the past, loads were managed primarily by control switches and the criteria for program eligibility were simple: the right device type and size (wattage). With the transition to connected devices, the criteria for program eligibility will necessarily be broader, including device response characteristics, configurability, certifications, and communication interfaces. Signals that relate to energy programs naturally originate at the utility, including energy market prices, locational marginal price, curtailment events and advanced notifications. Likewise, the utility is the destination for status signals that reflect availability, participation and the level of response provided to support measurement and verification (M&V). A responsibility lies with utilities to be clear regarding the communication protocols, interfaces, and architectures that lead to sustainable and scalable energy-interoperability of consumer devices. Device manufactures, likewise, have a responsibility to ensure their products support a responsive, flexible and future-proof architecture. These devices must continue to provide added value opportunities for their customers as systems and programs evolve to support energy systems of the future.

Overall architectures for device integration involve many actors and are inherently complex and evolving. It is a large-scale system-of-systems and a case in which identification of key interfaces is necessary to make the problem manageable. This paper has identified one such key interface – at the device. This interface ranks high in terms of architectural significance because it is here that:

- Ownership changes hands – that which belongs to the consumers meets that which belongs to an integrator, aggregator, or network provider
- Life expectancy differs – long life products connect to shorter-lived communication networks
- The quantity of unique pairings (networks x devices) is extraordinarily high

Providing standard access at the device level does not imply that the consumer, vendor or utility must utilize this open interface immediately. Devices may initially be connected in other ways, or using other protocols, to manufacturer-specific equipment or systems that satisfy the consumer's immediate interests. However, it is still prudent, and in the interest of society, to ensure that devices are built with the option of direct access through open standards, so that such devices might remain active elements and usable to the consumer over their service life.

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