



# Smart Energy Consumption and the Smart Grid

## Executive Summary

The nation's outdated electrical infrastructure is being transformed. Fundamental changes that add intelligence, integrated communications and full transparency to the grid are underway. The resulting "Smart Grid" will be more efficient, more reliable, more secure and more environmentally sustainable.

Until now our electrical grid has been defined by three components: generation, transmission and distribution. The Smart Grid adds Smart Consumption, a fourth component that includes a building's energy usage and its associated technology, to provide a more complete picture of the power grid of the future.

Buildings account for approximately 40 percent of the world's energy consumption and 20 percent of total CO<sub>2</sub> emissions. So, in order for the Smart Grid to deliver on its promised benefit, buildings must change the way they use electricity through Smart Consumption. Dynamically managing energy usage, leveraging onsite generation and storage capacity, and integrating data analytics into building operations are hallmarks of Smart Consumption and enable buildings to optimize their energy performance.

This white paper will discuss the Smart Grid, Smart Consumption, and their impact on building operations. It also explains how the two-way communications of a new, improved grid, along with intelligent buildings, will enable participation in demand response programs.

## The Power of Smart Grid and Smart Consumption

During Scientific Engineering's 100th anniversary party, the company's offices reached maximum capacity. Temperature and CO<sub>2</sub> levels began rising. Sensors in the ceiling activated the ventilation system, which began bringing in fresh outdoor air. Chillers were turned on to assist with cooling. Sensors in the switchgear at the utility's nearest substation recorded the increased demand at Scientific Engineering's offices and routed power to the facility to address the load.

Magnificent Manufacturing makes brake parts for most major automotive companies in North America. Because the company has the ability to change production schedules with only one day notice, Magnificent signed up for a demand response program, committing to curtail two megawatts during an event. When events occurred during summer heat waves, Magnificent started the second shift later in the evening in order to meet their demand response reduction commitment. The payout for program participation was substantial.

Four of Gateway Light and Power's generators were accidentally shut down in a period of 30 minutes because of a software malfunction taking 19 megawatts of production capacity off the grid. Upon sensing the disturbance on the power line, Smart Grid technology began redirecting power from within its management area and began to draw power from neighboring control areas. Within seconds, power flows were redirected. Gateway Light and Power customers' electricity service was not impacted.

## The Smart Grid

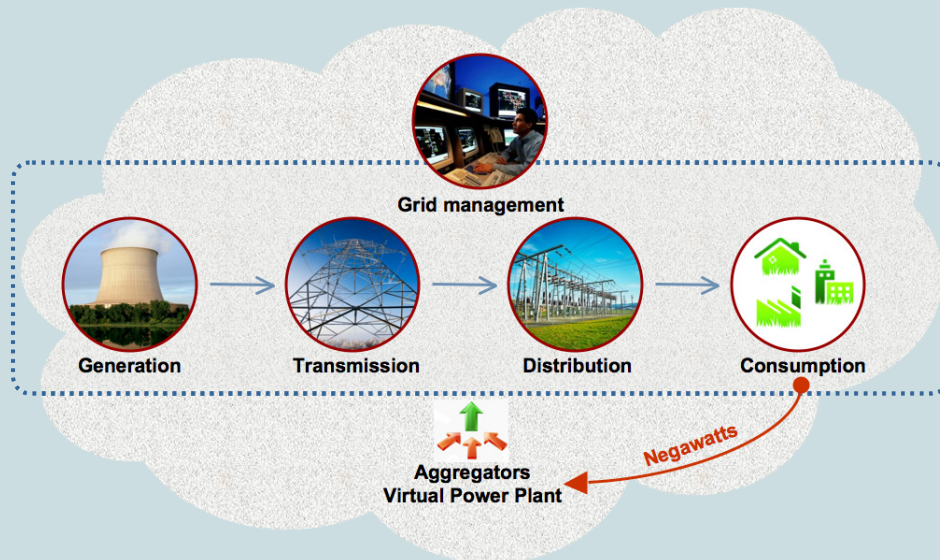
The U.S. Energy Information Administration (EIA) is expecting total demand for electricity in the commercial sector to grow 42 percent by 2035. Based on technology that was invented more than a century ago, the grid is straining to address the increasing demand for power and customers' desire for more information. In its current state, the grid cannot be depended on to adequately support robust economic growth in the future.

As the global population grows so does the demand for natural resources, which causes prices to increase. The potential solutions are to add supply, reduce demand or implement a combination of both. Adding supply is costly and time consuming. It becomes far more advantageous to decrease demand, particularly during peak times. This is where the Smart Grid will help.

### What is Smart Grid?

According to the U.S. Department of Energy's Electricity Advisory Committee, "A Smart Grid brings the power of networked, interactive technologies into an electricity system, giving utilities and consumers unprecedented control over energy use, improving power grid operations and ultimately reducing costs to consumers."

The Smart Grid initiative seeks to modernize and optimize the power grid so that it is more efficient, secure and environmentally sustainable. It will connect the entire supply chain of electric markets from generation to transmission to distribution to consumption. Once connected, the electric markets can become efficient, where all pertinent information is available to all participants at the same time and prices respond immediately to the current market.



The Smart Grid adds intelligent, integrated communication and full transparency to the grid. The resulting Smart Grid will be more efficient, more reliable, more secure and more environmentally sustainable.

The Smart Grid will reduce the occurrence and frequency of costly and debilitating outages by controlling the flow of energy better. This electrical power generation and distribution system will be self-healing; it will continuously examine and address problems, restoring the grid's performance efficiently. It will also anticipate disruptions and resume service quickly during an outage.

In addition to reducing power consumption during peak hours and facilitating the efficient use of electricity, the Smart Grid will:

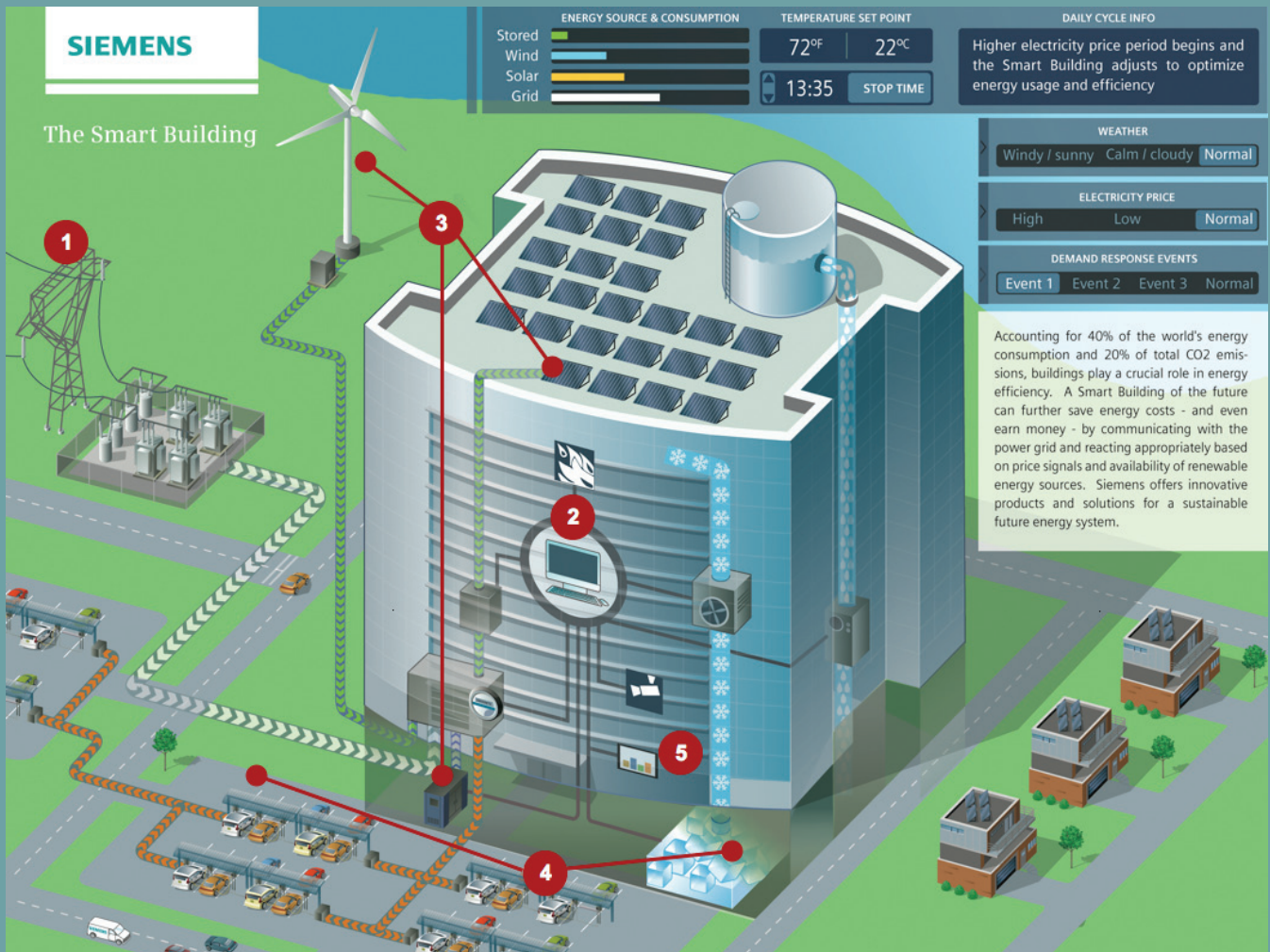
- Incorporate energy storage for distributed generation load balancing.
- Eliminate or contain failures, such as the widespread power outage that caused blackouts over much of eastern North America in 2003.
- Seamlessly interconnect with renewable energy sources, microturbines and other distributed generation and storage technologies at local and regional levels.

## Smart Grids Need Smart Consumption

The Smart Grid provides a great opportunity for building owners, formerly insulated from energy prices, to manage their buildings and operations based on the actual costs of producing and delivering electricity. To capitalize on this, building owners must upgrade their buildings for Smart Consumption. With advanced technology and integrated building systems, a building can dynamically manage its own energy demand and generation.

Reducing peak demand and overall consumption are two of the most significant benefits of Smart Consumption. In addition, owners can support their green/sustainability goals and potentially generate revenue. And because buildings with Smart Consumption capabilities know how to most efficiently use electricity and when to deploy onsite generation energy sources, and can store energy for use when it's needed most, these facilities are no longer passive consumers of electricity; they are active participants in the electricity supply chain. Because of their ability to proactively manage energy consumption, they support grid stability and reduce the need for utilities to build more power plants.

# Buildings with Smart Consumption technologies are equipped to optimize energy flow.



## Applications

- 1 Two-way communications with utilities
- 2 Proactive energy usage management
- 3 Onsite energy generation
- 4 Storage capacity
- 5 Active information management

The components of a building with Smart Consumption capabilities are illustrated on the left.

### **1. Two-way Communications with Utilities**

Commercial buildings have the option of using their building automation systems for automated communications to and from utilities. For instance, utilities can send information about prices and demand response capacity events. The building automation system could optionally send information to the utility about its predicted demand for the next 24 hours or the amount of onsite generated electricity it can sell back to the grid.

Commercial and industrial buildings typically have smart meters which track energy consumption and report on it at frequent intervals, such as every 15 minutes.

### **2. Proactive Energy Usage Management**

A building with Smart Consumption capabilities not only receives information about utility prices and weather forecasts, but predicts its demand and implements energy management strategies to meet the needs of its occupants and operations, while maximizing efficiencies and minimizing costs.

Installing the most efficient equipment and systems is a critical component of an overall energy management plan. This may include upgrades or replacements of mechanical systems, lighting systems and the building envelope (e.g. windows, insulation). It may also include implementation of energy management control strategies such as time-of-day scheduling, night set-back and chiller plant optimization.

Another key component of proactive energy usage management is integrating building sub-systems into the building automation/energy management system to provide holistic energy management and enable control of all energy-consuming equipment. Sub-system efficiencies and controllability contribute to “permanent” reductions in overall demand and consumption. Of course, reductions are only maintained with continued focus and ongoing service strategies.

With efficiencies and controllability in place, dynamic strategies can be implemented to flatten peak demand when needed. For instance, to avoid paying “ratcheting” demand charges on utility bills or to participate in demand response events discussed on the following pages.

### **3. Onsite Energy Generation**

Building owners and managers can add more control and flexibility to their energy management strategies by installing onsite generation assets such as generators, microturbines, and in the future, fuel cells. These assets can also include locally installed renewables such as solar and wind. Renewables are not controllable, but management and oversight is needed and incorporated into the overall energy management strategy. It is expected that the use of onsite generation will increase in the future to reduce a building or campus’ dependency on the grid, to enable participation in net metering programs where electricity is sold back to the grid, and to achieve its carbon reduction goals.

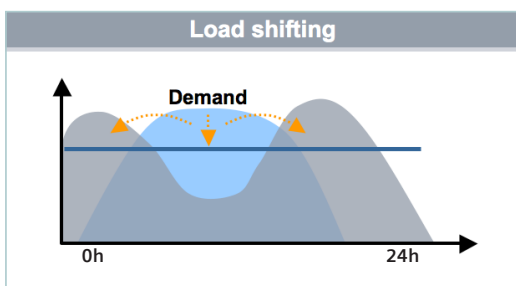
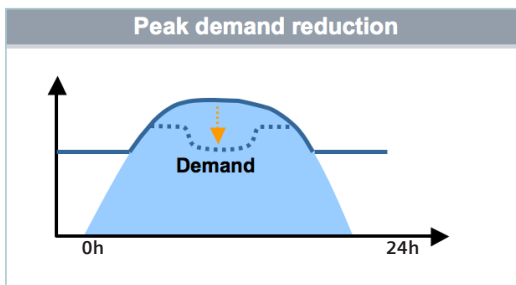
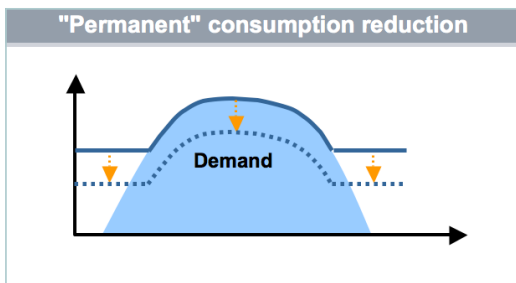
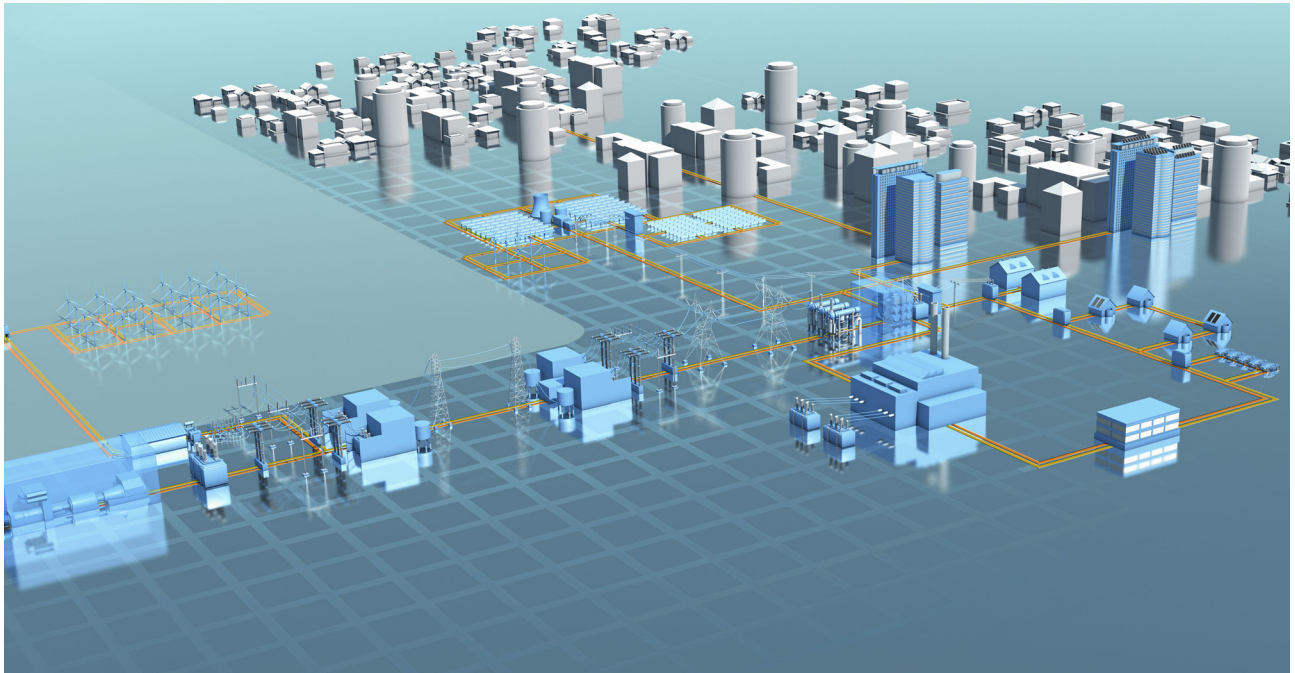
### **4. Storage Capacity**

With research and development occurring in the area of electric energy storage, future energy management strategies are likely to rely on storage capacity even more. With storage assets, what may be a consumer of energy in the morning may become a producer of energy to the grid in the afternoon only to return to a consumer again in the evening. For instance, today many buildings integrate thermal storage systems into their energy management strategies. Ice is made during the night for tomorrow’s use during the day when electricity prices are at their highest levels.

### **5. Active Information Management**

Data analytics is a key component of successful energy management:

- Building operators monitor building performance in real-time through dashboards and smart phone apps, for instance.
- Data visualization can be used to engage occupants in energy reduction initiatives. Occupants can see the impact they can have on reducing the building’s carbon footprint by turning lights off or raising the cooling temperature set point by a few degrees.
- Dynamic optimization strategies are recommended based on current and predicted operational and market conditions.
- Future energy management strategies will incorporate active carbon management as a component of building control.



## Demand Response

Demand response is a method of exercising greater control over an entire electrical grid system by using individual facilities' ability to reduce usage when the grid is overly stressed.

With two-way communications and the ability to manage energy usage, plus onsite generation and storage capacity, buildings are well prepared to take advantage of Smart Grid and demand response programs.

### Demand Response Players

Demand response programs are offered by:

- Utility companies
- Independent System Operators (ISOs) that operate a regional transmission grid or power pool over one or more states. Their customers participate in demand response programs through members called aggregators or curtailment service providers (CSPs), who act as agents for the customers.
- Third-party aggregators or CSPs that contract with utilities or ISOs. The world's largest providers of commercial, institutional and industrial demand response are third-party aggregators. They work with many utility companies or ISOs, helping customers design demand response and energy efficiency programs.

## Demand Response Incentives

Demand response is similar to an airline paying passengers to get off an overbooked flight; participants are paid to get off an overbooked grid. Building owners who participate in demand response programs may see reduced utility bills or receive other incentives from program administrators.

Depending on the contract, building owners might get a credit on their bill, be issued a check following an event or receive reduced kilowatt-hour rates for overall power. Demand response events are generally triggered by peak capacity (i.e. concerns about reliability) or high prices at the wholesale level.

Demand response programs are generally classified as either incentive-based or time-based.

**Incentive-based demand response** is a formal program (i.e. a customer signs a contract to participate) based on communication from a control center to the customer to signal each distinctive event. It includes reliability- or capacity-based programs, demand bidding and buy-back types of voluntary economic programs to supplement generation. Capacity-based programs are the most dominant demand response programs today. Building owners are typically offered a fixed monthly fee by the program administrator in exchange for the agreement to curtail demand by a certain amount during each demand response event, plus a smaller credit per event based on the actual load reduction delivered.

**Time-based demand response** programs involve customers making voluntary reductions based on price structures (i.e. critical peak pricing, real-time pricing or dynamic pricing) at each given point in time. A call for reduction is not initiated by a control center sending out a communication to customers; it is more of a market-driven program, letting the principles of supply and demand and corresponding prices naturally adjust the demand for electricity. These programs motivate rate payers to curtail load by passing along wholesale energy prices on an ongoing basis. Because there is no pre-arranged commitment to participate, decisions about how much load to shed are made on a daily basis and building owners are not directly penalized for inaction (although buying electricity at peak price could be considered a penalty). Energy spend is reduced by cutting consumption when prices are highest, incentivizing building owners; however, time-based demand response requires the automated control strategy to function effectively for building owners.

## Demand Response Strategies

Regardless of the program, participants must analyze where, when and how their facilities use energy and determine their load curtailment capability. The goal is to reduce demand in the least intrusive way while providing the best return. Load curtailment strategies may include:

1. Shedding – temporarily limiting or restricting load.
2. Shifting – moving demand from peak periods to low-tariff times.
3. Storage – a bank of batteries or a thermal storage device that collects energy during off-hours for consumption during peak pricing or demand.
4. Onsite generation – using renewable energy and back-up generators instead of electricity from the grid during peak demand or prices.

## Receiving Demand Response Signals

Once load curtailment capabilities have been assessed, strategies developed and a plan for implementation in place, building owners and managers must determine how they will receive and execute demand response signals.

1. Manual demand response involves personnel walking through a facility to turn off unnecessary lights or manually changing set points on equipment. Because this is the most labor-intensive approach, it can limit the load shed during an event.
2. Semi-automated demand response, by comparison, is when a building operator initiates a pre-programmed load shedding strategy in a centralized control system.
3. Fully automated demand response does not require human intervention. The control system automatically executes pre-established control strategies based on the receipt of an external communications signal, unless the building operator decides to override it.

The Smart Grid is emerging, and buildings of the future will need Smart Consumption technologies to fully realize its benefits. As Smart Grid technologies and demand response programs are developed and deployed, they will need buildings to dynamically manage energy demand and generation. Smart Consumption enables greater control over where a building's energy comes from, how and when it is being used and at what cost.

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