REPORT

Demand Response in the Pacific Northwest

SMART BUILDINGS CENTER
A project of NEEC

THE CHALLENGE OF PEAK DEMAND

Buildings' demand for power varies with time of day, climate pattern, and seasonal dependencies. During hot summer days, demand for electricity peaks in the afternoon and early evening as a response to space cooling needs. In the winter, demand for natural gas peaks in the early morning as businesses start up and again in the evening when homes are reheated or cooled. As a power utility's customer base grows over time, its peak demand grows with it. Unless consumption patterns drastically change to drive peak demand down, the utility's typical response to meet peak energy needs is to expand large-scale infrastructure by adding new power plants. Without significant conservation measures or adequate infrastructure, the strain on the electrical grid caused by peak demand periods can result in "brownouts" (a drop in system voltage) or "blackouts" complete power outages.

Historically, the Pacific Northwest has relied on an abundant supply of hydroelectric power both as a base-load energy source and to meet peak demand (or load) by relying on those hydro projects that have storage to store energy in their reservoirs. Increasing in peak loads and small but steady decreases in regular snowpack, yield Pacific Northwest hydro power beyond capacity to effectively address peak loads. Other renewables like solar, wind, and geothermal make up an increasingly large part of the energy supply, but because solar and wind are far more variable, they are an unsatisfactory option for meeting peak demand. Additional reliability measures are required to reduce the risk of outages and prevent utilities from needing to expand the infrastructure for non-renewable energy sources.

Thus, utilities' interest in "demand response" is to satisfy peak demand. The Federal Energy Regulatory Commission defines demand response (DR) as "changes in electric usage by end-use customers from their normal consumption patterns in… times of high wholesale market prices or when system reliability is jeopardized." This is usually stimulated by electricity pricing structures[1] or incentives strategies and requires the appropriate enabling systems to be in place.

PRICING STRUCTURES AS A SOLUTION

One strategy is the introduction of pricing structures to reduce peak use (with regulatory approval). Utilities can implement time-of-use (TOU) pricing plans that charge customers more during high demand periods and less during low demand periods. Under the scheme, customers who shift the majority of their use to off-peak times directly benefit from lower electricity bills. If the customer base as a whole can reduce peak demand consistently enough to eliminate the need for infrastructure expansion, it is a win for both the utilities and the customers, since utilities often pass on any new infrastructure costs to their customers via increased rates.

Portland General Electric (PGE) is the one of a few utilities in the Pacific Northwest to offer TOU pricing plans (Figure 1) to all large industrial and commercial customers as well as a number of small commercial customers. PGE has also made TOU plans available to all residential customers and are primarily marketing to electric vehicle owners, as they typically have higher electricity use. PGE is able to offer TOU pricing because the utility has established an Advanced Metering Infrastructure (AMI), which installed smart meters for every customer in order to provide the utility with real-time consumption data about each customer (with regulatory approval).

An example of time-of-use price, the table below shows Portland General Electric's Commercial Time-of-Use Pricing, which is divided into three different pricing categories depending on day and time.

Period	Time	Description	Price per kWh
On-Peak	**Summer** M-F: 3-8pm **Winter** M-F: 6-10am, 5-8pm	Demand for electricity is highest and, therefore, one pays the highest price (higher than basic service) per kilowatt-hour.	10.890¢/kWh
Mid-Peak	**Summer** M-F: 6am-3pm, 8-10pm Sat: 6am-10pm **Winter** M-F: 10am-5pm, 8-10pm Sat: 6am-10pm	Demand for electricity is between on-peak and off-peak and so are the prices.	6.189¢/kWh
Off-Peak	**Summer & Winter** Everyday: 10pm-6am Sun/holiday: 6am-10pm	Demand for electricity is the lowest and, thus, one pays the lowest price (lower than basic service) per kilowatt-hour. Nights, Sundays and major holidays are considered off-peak.	3.632¢/kWh

Figure 1: Portland General Electric's Commercial Time-of-Use Pricing [2]

Aside from PGE, only a few Pacific Northwest utilities have rolled out TOU pricing or smart metering infrastructure, though several are planning to or exploring alternatives:

- Idaho Power Company and Pacific Power (PacifiCorp) offer TOU pricing with smart metering
- Puget Sound Energy (PSE) has historically offered TOU pricing during electrical shortages; PSE customers have automated meters (Automatic Meter Reading or AMR—only provides one-way communication, from customer to utility) that provide real-time consumption data
- Seattle City Light will install smart meters in 2016 and is anticipated to begin offering TOU programs following the roll-out
- Eugene Water & Electric Board has a residential TOU pilot program
- Clatskanie PUD, City of Forest Grove Light & Power, and Hermiston Energy Services are other utilities with plans to offer mostly commercial TOU pricing in the future

DEMAND RESPONSE AS A SOLUTION

A more direct approach to reduce the need for expanded infrastructure and the likelihood of power outages involves a collaborative effort between utilities and customers to implement demand response strategies. While TOU pricing is generally successful at reducing peak usage, DR can involve a more direct approach in which utilities make real-time requests of their customers to curtail usage when most needed.

PGE's Energy Partner Program[3] offers an example of how a DR program works. Businesses can opt in to the program and cooperate with PGE to develop demand response conservation strategies, which can be implemented when called upon. After PGE alerts customers, they have between 10 minutes and 4 hours to reduce usage depending on the urgency of the utility's need. The utility strives to give the most notice possible to the customer, but depending on the circumstances may give only 10 minutes. Customers are then paid for every kilowatt-hour they reduce. As the only Northwest utility with TOU pricing, PGE is also the only one to currently offer a real-time demand response program to customers.

During demand response periods, both customers and utilities can implement DR strategies:

Customer DR Strategies

- **Demand Shifting:** Performing energy intensive tasks during off-peak hours
- **Load Shedding:** Reducing usage during peak hours by dimming lights, implementing global temperature adjustments, or making other minor comfort or non-critical reductions that do not affect core operations

Utility DR Strategies

- **Grid-Scale Battery Storage:** Using large-scale batteries to store energy for peak demand periods
- **Utility-Controlled Load Shedding:** Pre-scheduling controlled outages across the customer base

CUSTOMER DEMAND SHIFTING

Lighting, heating, and cooling are the three major areas that commercial and industrial customers can use for demand shifting. Customers can achieve their lighting and heating, ventilation, and air conditioning (HVAC) needs during peak hours by pre-charging systems such as battery storage. This could include charging a large battery during off-peak hours and using it to power lighting systems during peak hours. Heating strategies could include pre-heating the building just prior to peak hours. Cooling strategies are those that store thermal energy, by freezing or super cooling a particular medium and then insulating it until the HVAC system needs to be powered down. At that time, the medium is exposed to the air and cools by absorbing heat energy from the surrounding environment.

Another demand shifting strategy is to perform energy-intensive work during non-peak times. For example, if a part of a manufacturing process is very energy-intensive, this could involve careful analysis of how it can be done during off-peak times without disrupting output. These changes can be made permanently, by shifting worker schedules, or on specific critical-peak days.

CUSTOMER LOAD SHEDDING

Commercial, industrial, and residential customers can minimize non-critical loads during peak hours to limit energy use. Load shedding DR strategies include temporarily reducing loads that are unlikely to severely affect productivity. A study[4] published by Lawrence Berkeley National Laboratory in coordination with the Demand Response Research Center and funded by the California Energy Commission found that the two most often applied tactics for load shedding are global temperature adjustment and dimming or turning off lights (Figure 2), with the former often having the most significant reduction (Figure 3). An example of an HVAC DR tactic is an office building increasing its thermostat set point "dead-band" (increasing the cooling set point and decreasing the heating set point) and an example of a lighting DR tactic is a department store reducing its spotlighting, both applied during peak afternoon times.

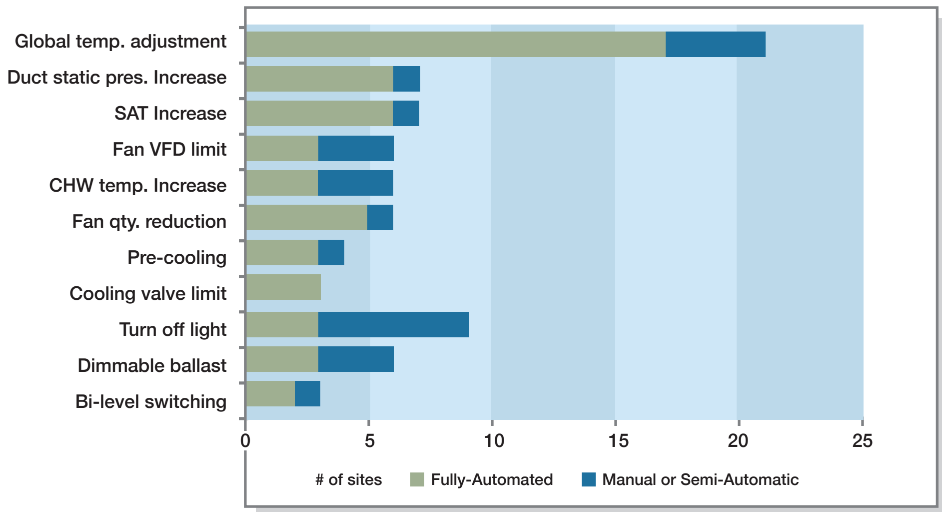

Figure 2: Frequency of Various DR Tactics Applied in California[5]

In addition to commercial reductions, installation of "smart appliances" is also an option. A smart appliance provides the owner with a means to remotely control the appliance's energy use and function; combined with a smart meter, the appliance may be controlled by the utility as well.[7] GE, Samsung, LG, and others are now manufacturing smart appliances that can interact with a smart grid and can be controlled from a remote location. Smart appliances can include air conditioners, heaters, hot water heaters, washing machines, and televisions. There have been efforts to incorporate smart appliance capability into Energy Star requirements, but none has been successful so far.[8] As the Pacific Northwest installs more AMI, it will be easier to encourage smart appliances that utilities can partially control during DR periods.

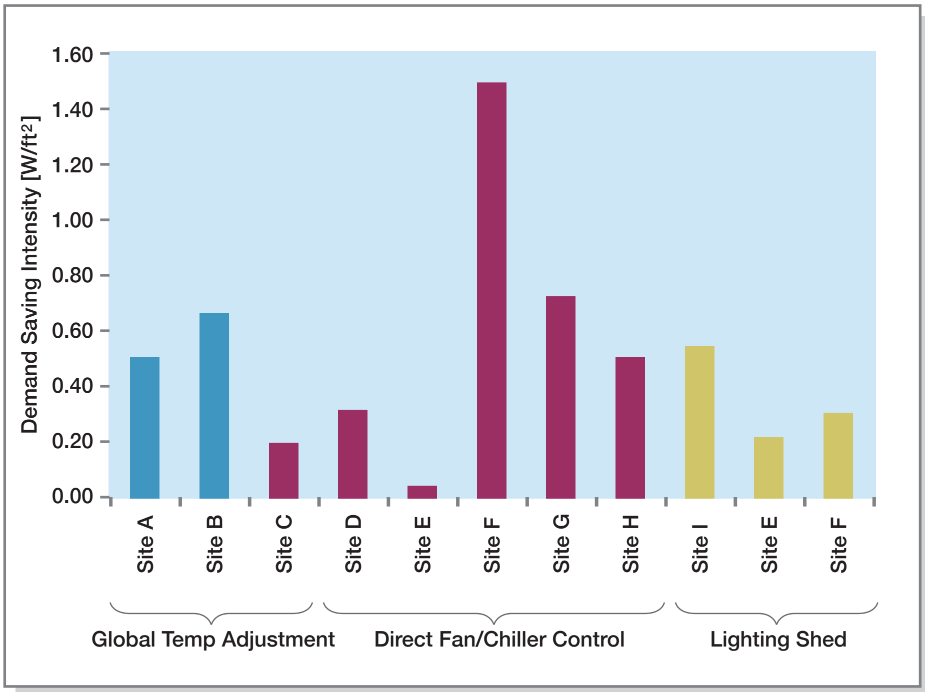

Figure 3: Demand Saving Intensity (W/ft2) by Shed Tactics Applied in California[6]

UTILITY GRID–STYLE BATTERY STORAGE

Grid-scale battery storage can be used as a demand response strategy by utilities. Companies like UniEnergy Technologies, Powin Energy and Tesla are producing large-scale battery solutions to store enough energy for use during peak demand periods. Multiple utilities, including Avista, Snohomish PUD, and PSE, are currently piloting projects to determine the efficacy of these solutions to address grid capacity constraints. This will allow the utilities to store energy during off-peak hours when energy prices are low and then deliver it to the grid when prices would have been high. These systems are especially valuable in capacity-constrained areas where utilities have difficulty meeting demand.

UTILITY–CONTROLLED LOAD SHEDDING

If the electrical grid becomes overwhelmed with high demand, the result can be equipment damage, brownouts, and/or widespread blackouts. To prevent this extreme situation, utilities can schedule controlled outages across their customer base (where enabled by regulation). Implementing relatively minor utility-controlled load shedding can be particularly effective in emergency situations to ensure that critical facilities like hospitals remain in operation. During the California electricity crisis, also known as the Western U.S. Energy Crisis of 2000 and 2001, utilities adopted rotating outage policies. A rotating outage, according to Southern California Edison, is "...a temporary and scheduled electric outage conducted under utility control that lasts approximately one hour, depending on circumstances."[10] These outages are implemented when California's Independent System Operator declares a Stage 3 Emergency, meaning electrical reserves are at less than 3 percent.

Figure 4: Powin Mobile Energy Solutions[9]

ADDITIONAL DR CONSIDERATIONS

Industry Incentives

The U.S. Green Building Council (USGBC) began to promote DR by offering one pilot point under the LEED v2009 (v3) rating system to buildings for participation in DR programs. The new LEED v4 rating system now offers two points in the Energy and Atmosphere category, achievable by participating in an existing utility program or by providing "infrastructure in the building to take advantage of future demand response programs or dynamic/real-time pricing programs."[11] Such infrastructure could include interval recording meters with communications automated as part of the Building Automation System, as well as planning measures such as comprehensive plan for load shedding, the inclusion of DR processes in the commissioning authority's scope of work, or contacting the local utility to discuss interest in future DR programs.

How Renewables May Change Peak Times

As solar and other renewables become a larger part of the energy supply, the energy industry predicts that the current definition of "peak" will shift towards the evening, when solar energy production is negligible. To address this, Tesla has developed the Powerwall residential battery solution, and is working on a battery bank for commercial applications as a tool for storing solar energy during the day and shifting its use to the evening. This may garner significant interest in areas with TOU pricing, especially for residences and commercial facilities that operate outside of standard 9-to-5 business hours.

CONCLUSION

Reduction of peak loads helps reduce the need for increased power infrastructure, the cost of which is paid by utility customers. As smart meter infrastructure in the Pacific Northwest becomes widespread, options for demand response expand for both the customer and the utility. This may include Time-of-use pricing plans, direct Demand Response programs, and customer and utility controlled smart appliances. Utilities can work with customers, especially energy-intensive commercial and industrial customers, to develop load shedding and demand shifting strategies. Utilities can also explore battery storage options to increase their own flexibility and the practicality of variable renewables like solar and wind.

1 Balijepalli, Murthy; Pradhan, Khaparde (2011). "Review of Demand Response under Smart Grid Paradigm". IEEE PES Innovative Smart Grid Technologies.

2 Portland General Electric. "Business: Pricing," https://www.portlandgeneral.com/business/small/your_account/billing_payment/time_of_use/pricing.aspx.

3 Portland General Electric. "Business: Energy PartnerSM," https://www.portlandgeneral.com/business/medium_large/products_services/demand_response/default.aspx.

4 Watson, David S.; Kiliccote, Sila; Motegi, Naoya; Piette, Mary Ann; Lawrence Berkeley National Laboratory (2006). "Strategies for Demand Response in Commercial Buildings," http://escholarship.org/uc/item/22t2d863#page-4.

5 Ibid.

6 Kiliccote, Sila; Piette, Mary Ann; Hansen, David (2006). "Advanced Controls and Communication Systems for Demand Response and Energy Efficiency in Commercial Buildings," https://www.ece.cmu.edu/~electricityconference/2006/kiliccote-piette-hansen%201-9%20v2.pdf.

7 Green Building Advisor, "Musings of an Energy Nerd," http://www.greenbuildingadvisor.com/blogs/dept/musings/get-ready-smart-appliances.

8 H.R. 2685 (113th Congress), "Smart Grid Advancement Act of 2013," https://www.govtrack.us/congress/bills/113/hr2685.

9 Powin Energy, http://www.powinenergy.com/solutions-3/.

10 Southern California Edison, Power Bulletin (2012). "Outages: Expect the Unexpected," https://www.sce.com/wps/wcm/connect/83344ac4-195c-4f98-86c7-f24bc9b83815/1206_PowerBulletin.pdf?MOD=AJPERES&CACHEID=83344ac4-195c-4f98-86c7-f24bc9b83815.

11 U.S. Green Building Council, "Demand Response," http://www.usgbc.org/credits/demandresponse.

About the Smart Buildings Center

The Smart Buildings Center (SBC) is a project of the Northwest Energy Efficiency Council (NEEC), which is a non-profit industry association of the energy efficiency industry. The SBC supports growth and innovation in the Pacific Northwest's energy efficiency industry, serving as a hub for industry activities and raising the visibility of energy efficiency companies and projects.

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