DAIRYLAND POWER
COOPERATIVE

November 1, 2010

U.S. Department of Energy
Office of Electricity Delivery and Energy Reliability
1000 Independence Avenue, SW, Room 8H033
Washington, DC 20585

SUBJECT: "Smart Grid RFI: Addressing Policy and Logistical Challenges"

Thank you for the opportunity to submit information about the Smart Grid implementation at Dairyland Power Cooperative. Dairyland strongly supports the DOE's effort to encourage the development of an interoperable Smart Grid. We see significant benefits for our consumer members, the economy and the environment. The request for information indicates "The Department of Energy is seeking comments on policy and logistical challenges that confront smart grid implementation, as well as recommendations on how to best overcome those challenges." We trust that our response will assist the Department of Energy in this initiative. In this response, we will refer to several paragraphs of Title XIII, Section 1301 of the Energy Independence and Security Act of 2007 (EISA) and how a ruling by the DOE (10 CFR Part 430 DOE ruling) that will eliminate the production of large capacity electric water heaters (larger than 55 gallon) starting April 16, 2015, will have a significant impact on implementation of smart grid control in homes.

**Who We Are**

With headquarters in La Crosse, Wis., Dairyland Power Cooperative is a generation and transmission cooperative (G&T) that provides the wholesale electrical requirements and other services for 25 electric distribution cooperatives and 16 municipal utilities in the Upper Midwest. In turn, these cooperatives and municipals deliver the electricity to consumers--meeting the energy needs of more than half a million people.

Dairyland was formed in December 1941. Today, Dairyland's generating resources include coal, natural gas, hydro, wind, landfill gas, animal waste and solar. Dairyland delivers electricity via more than 3,100 miles of transmission lines and nearly 300 substations located throughout the system's 44,500 square mile service area.

Dairyland's service area encompasses 62 counties in four states (Wisconsin, Minnesota, Iowa and Illinois). Dairyland, a Touchstone Energy Cooperative, has provided low-cost, reliable electrical energy and related services for nearly 69 years.



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Please visit our Web site at www.dairynet.com for more information on Dairyland Power Cooperative. For a map of our service territory, see Attachment 1.

Dairyland Power has had a robust load management program for 30 years. This program has been used for the traditional seasonal peak shaving that most load management programs have been used for. However, Dairyland has also used load control of water heaters, heating systems and air conditioners for economic dispatch hundreds of times a year to avoid high cost purchases of energy or to avoid temporarily ramping up a fossil fueled power plant to cover a short spike in demand. For the last few years, Dairyland initiated overnight water heater control to build load in the middle of the night to avoid pushing energy into the market below our cost of generation.

**References to Title XIII, Section 1301 of the Energy Independence and Security Act of 2007 (EISA):**

**(3) Deployment and integration of distributed resources and generation, including renewable resources**

Dairyland's service territory includes areas of Minnesota and Iowa with significant wind resources that have a variable generation pattern. In order to integrate renewable resources, additional "fast up and down" regulation is needed. Currently, Dairyland provides regulation into the MISO market with fossil fueled power plants. Dairyland is currently the first utility in the country to pilot a system of distributed electric storage water heaters to provide this no carbon regulation service. Dairyland is hosting the pilot with equipment provided by Steffes Corporation and Cooper Power Systems. Low-cost, distributed, smart electric storage space and water heating is a cost effective way to integrate large amounts of renewable energy into the electric grid. Electric Thermal Storage (ETS) is a low-cost, proven distributed energy storage resource that has been used by Dairyland's consumer members for 30 years. ETS systems store electricity as heat during times when renewable or off-peak power is available and use this stored energy as needed to satisfy consumer comfort requirements. Smart signals ensure a continuous supply of hot water and space heat for the consumer and vary the charge rate and charge level of the ETS units up and down as fast as renewable generation changes. This allows for higher percentages of renewable energy on the grid. However, the current ruling by the DOE (10 CFR Part 430 DOE ruling) will eliminate the production of large capacity electric water heaters and thus Dairyland's ability to use this distributed resource for the benefit it can provide the consumer, utility and the Smart Grid.

**(4) Deployment and incorporation of demand response, demand-side resources, and energy-efficiency resources**

Dairyland Power has used demand response (load management) and demand side management programs for 30 years to manage generation, transmission and distribution of power. As a result, Dairyland has been able to defer the need for construction of new generation and other infrastructure because of the successful demand response programs it has implemented.

Electric Thermal Storage (ETS) systems and large storage water heaters (80 gallon and larger) are tools that Dairyland has used in our DSM program for 30 years. During off-peak hours, ETS heaters and large water heaters store low-cost electricity as heat and use this energy for heating homes and hot water 24-hours a day. During peaking hours, the heaters and water heaters rely entirely on energy which was stored during off-peak hours. Dairyland Power uses direct load control equipment to control equipment such as ETS and storage water heaters. As a result, Dairyland has been successful in improving load factor and system efficiency, in addition to deferring costly system upgrades. In the future, the smart grid will provide a real time link between the immediate need of the grid and each ETS system and large water heater, bringing a new dimension of conservation, efficiency and actual carbon reduction to the grid.

*Federal recognition that encourages utilities to implement Demand Response and DSM programs would be very beneficial to the smart grid.*

**(6) Integration of 'smart' appliances and consumer devices**

Space and water heating are the two largest energy loads in homes. Smart appliances, such as Interactive ETS Space and Water Heaters, provide significant value for the advancement and management of the Smart Grid. Operation of these systems can be regulated to meet the needs of the grid without requiring any lifestyle adjustments or sacrificing of comfort by consumers. These systems have the ability to store significant amounts of energy during hours when demand is low or extra renewable energy is available, and utilize this stored energy during peak hours or hours of limited renewable energy availability. These smart appliances allow automated control for the storage and discharge of energy, responding to the needs of the grid. Preferential electricity rates make it beneficial for consumers to use this technology in their homes or businesses.

*Recognition that ETS space and water heaters are smart appliances that can respond quickly to the needs of the smart grid would be extremely beneficial to widespread implementation of these technologies. Current and proposed DOE rules do not separate these smart appliances from standard equipment. If this situation does not change, the opportunity to advance relatively inexpensive storage into the grid will be lost.*

**(7) Deployment and integration of advanced electricity storage and peak-shaving technologies, …**

Over 60% of homes in the Dairyland Power system have electric water heaters today. These water heaters are energy storage devices that can play a very key role in the implementation and utilization of the Smart Grid. Energy Storage has been identified as a critical component for managing the nation's system of power generation, transmission and distribution while maintaining grid reliability and stability. With rapidly increasing amounts of renewable energy being added to our country's and Dairyland's power generation mix, the need for energy storage is becoming more essential. Steffes Corporation recently developed Smart Grid controls that provide Dairyland and other utilities the ability to use electric water heaters as distributed storage devices. These controls provide the ability to do fast UP or DOWN power regulation in response to needs of the power grid. Not only does this provide powerful and effective power management, it allows for full integration of variable renewable generation sources such as Wind and Solar. Refer to the attachment titled "Grid-Interactive Renewable Water Heating" for a detailed analysis and explanation of economic and environmental value for energy storage with domestic water heaters.

In addition to interactive water heaters, interactive Electric Thermal Storage space heating systems can be used to achieve additional benefits while serving the space heating needs of consumers. Each of these technologies has the ability to do traditional load management, such as peak shaving, while also providing the ability to do regulation and other power management services.

*Federal recognition of interactive space and water heaters will help advance implementation of these innovative storage and peak shaving technologies.*

**(10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.**

In early 2010, there was a ruling by the DOE (10 CFR Part 430 DOE ruling) that will eliminate the production of large capacity electric water heaters (larger than 55 gallon) starting April 16, 2015. This ruling will have a significant impact on implementation of smart grid control in homes. Approximately 50% of homes in the U.S. (over 60% in Dairyland) have electric water heaters today which are energy storage devices that can play a very key role in implementation of the Smart Grid. Energy Storage has been identified as a critical component for managing our system of power generation, transmission and distribution while maintaining grid reliability and stability.

*It is very important that the DOE add a new category or modify the above referenced ruling (10 CFR Part 430 DOE ruling). We suggest a modification that will allow large capacity water heaters (larger than 55 gallon) if they have "Smart Grid" controls that allow the water heater to be used for the integration and storage of renewable energy, management of power generation, and contribute to grid reliability and stability. A 100 gallon water heater can store approximately 26 kWh of energy, or approximately a two day supply of hot water for an average family. Smaller water heaters don't have the storage capacity to allow for smart charging when the grid requires it while still satisfying consumer comfort requirements.*

**Conclusion**

*It is obvious to Dairyland Power that energy storage is required to manage our demand for power and increase the ability for the grid to reliably absorb large amounts of renewable energy. With the new interactive control capability becoming available, large storage water heaters (greater than 55 gallon) and ETS heating systems are the most economical way to add energy storage to the grid. Dairyland Power is the first utility in the country to begin a pilot of* *these devices to determine how they will be utilized as well as the economic benefits for the consumer and utility. However, if current and proposed DOE rules do not separate these smart storage appliances from standard equipment, the opportunity to advance relatively inexpensive storage into the grid will be lost.*

Thank you for the opportunity to respond to this Request for Information. I encourage you to contact me for more information or to clarify my response.

Sincerely,

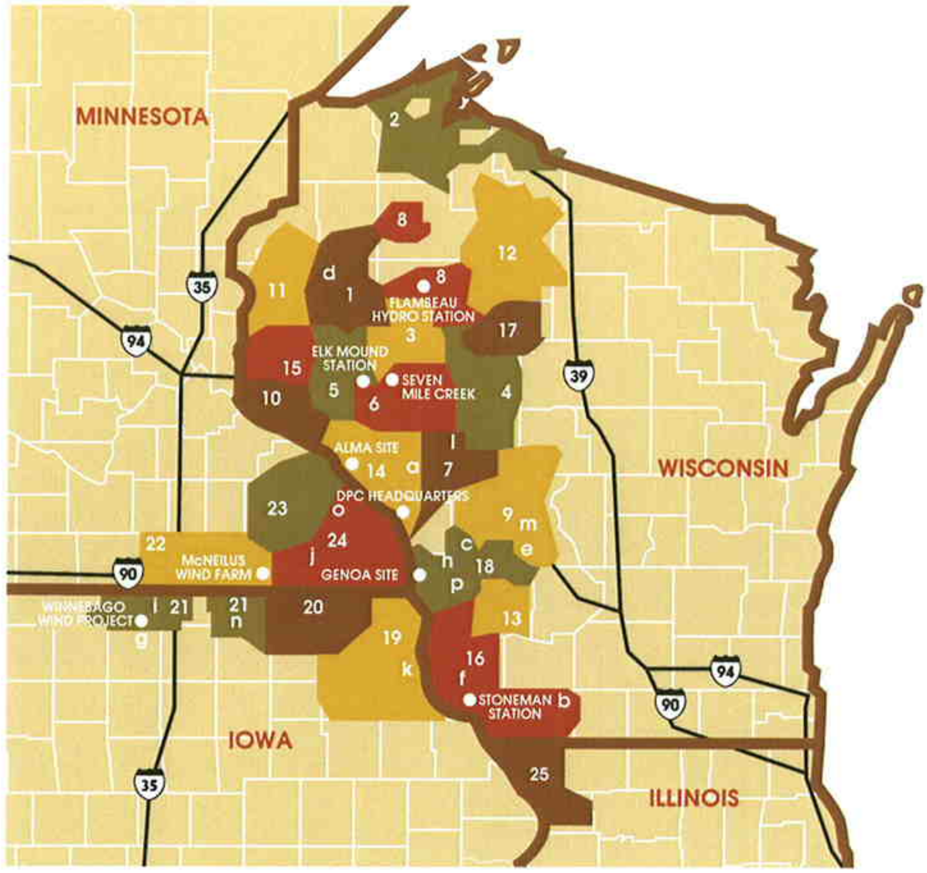
Ed West

Ed West, Director
Information Services

JEW:daj

Attachments

**Attachment 1**



# *Grid-Interactive Renewable Water Heating*
# Economic and Environmental Value

Grid-interactive renewable water heaters have smart controls that quickly change their charge rate and charge level, factoring in renewable generation and other critical needs of the grid; thereby significantly reducing carbon emissions and bringing a new dimension of conservation and efficiency to the electric grid. The Steffes grid-interactive renewable water heater controller provides utilities with an affordable and effective way to integrate renewable generation into the grid while providing uninterrupted hot water to the consumer.

In recent years, many states have set Renewable Portfolio Standards (RPS) to reduce the need for traditional fossil fuel-based power generation, thereby improving our environment and decreasing reliance on imported energy. Due to the variability of generation from renewable energy resources like wind and solar, it is very clear that affordable and effective electric energy storage is needed to balance – in real time – these variable power inputs and to maintain power grid stability. Domestic electric water heaters are energy storage devices that can provide significant distributed renewable integration and interactive Smart Grid power management solutions.

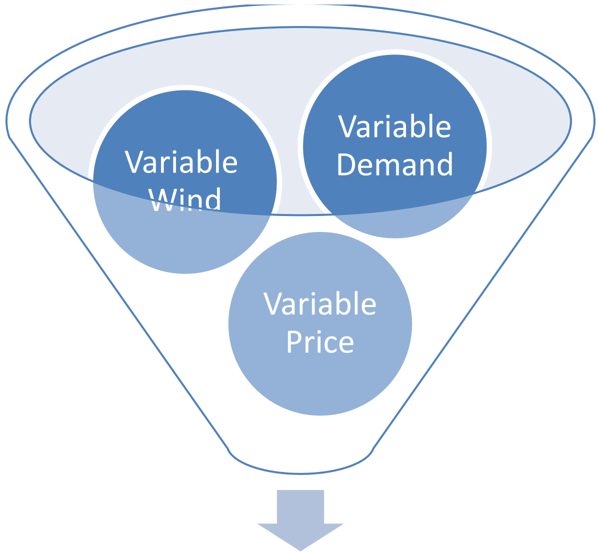
Because most renewable energy resources are variable, there is great benefit to the utility and society if an electric water heater can take on additional charge or “store” more energy when renewable or off-peak low-cost electricity is available. There is also benefit, when the demand for electricity is high or when no renewable power is available, for “controlled” minimal or no charging of the water heater. Utilities and consumers can minimize renewable energy curtailments, reduce carbon footprints, and lower the cost of operation by varying the amount and duration of electric water heater charging sequences. Additionally, larger water heaters can provide hot water to homes for longer periods of time without consuming power when renewable energy is not available. This provides a very powerful tool to help regulate and manage the electric grid and allows for full integration and utilization of renewable energy resources.

Grid-interactive renewable water heater controllers are designed with flexible communication options for existing and future Smart Grid technologies. They allow an electric water heater to provide dependable, dispatchable, and verifiable symmetrical or asymmetrical up and down regulation. They integrate large amounts of renewable energy, provide fast frequency control and regulation, selectively use low-cost wholesale or retail real-time prices, and provide numerous other generation, transmission, and distribution benefits. These benefits, like regulation for frequency control, bring extra economic benefit as well as significant additional carbon reduction.

This grid-interactive renewable water heater control technology can fill a significant portion of our nation’s electric energy storage needs today. It can also be a valuable carbon reduction component of the Smart Grid and other clean energy initiatives in the future. It is an effective tool for integration of renewable energy resources and fast regulation of the electric grid.

*Managing Renewables, Off-Peak Energy, and Consumer Demand*

## Balancing Variable Generation with Smart Variable Water Heaters




**Manage with**
**Interactive Water Heater Control**

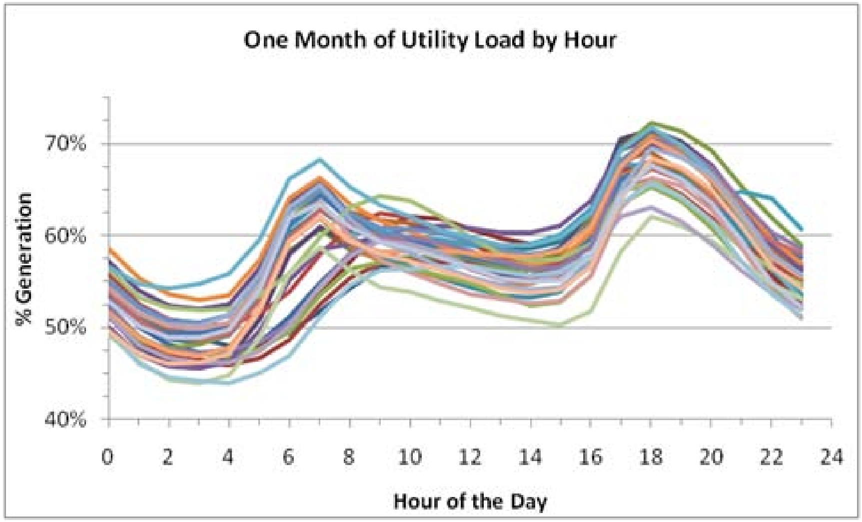
Grid-interactive renewable water heaters have smart controls that quickly change their charge rate and charge level, factoring in real-time renewable generation and other critical needs of the grid. This significantly reduces carbon and brings a new dimension of conservation and efficiency to the electric grid.

Renewable energy is recognized as the "green" or environmentally-friendly energy solution. Many States have adopted aggressive Renewable Portfolio Standards (RPS) in an attempt to shift power generation away from fossil fuel generation sources. Most of this new generation will come from wind farms. When load or other generation resources cannot change as fast as the wind, significant amounts of this carbon-free resource are wasted. This variability must also be carefully integrated with other generation sources to maintain grid stability. Grid-interactive renewable water heater loads can adjust and change as fast as wind and other renewable generation, allowing more renewable energy to be fully-integrated into the grid. This ability to track and use real-time renewable generation and other critical needs of the grid can significantly reduce the water heating carbon footprint **and** lower the cost of operation.

To help quantify the economic and environmental value of grid-interactive renewable water heating, the following information was used:

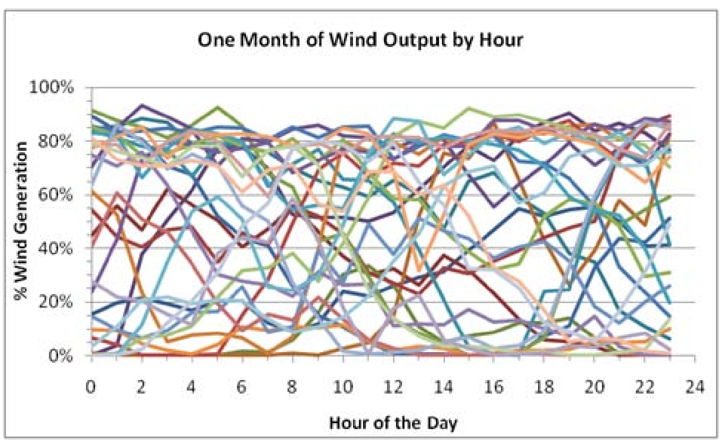
- Three years of hourly wind generation percentages for a Midwest utility
- Three years of actual hourly wind farm generation
- Three years of corresponding hourly wholesale cost of energy (LMP prices)
- Hourly average water heater load data from EPRI

**The Variable Consumer Demand:**

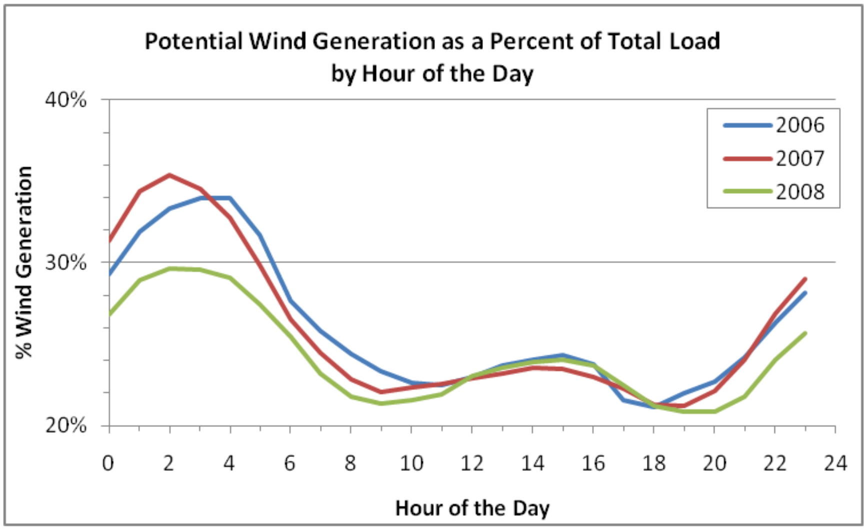



This graph represents one month of a utility's daily load curve. You will notice a definite pattern from day to day. The need to balance generation exactly with this variable load is something grid operators have done for years. When variable renewable generation is added to the variable load pattern, the need for regulation to balance the grid and maintain the 60-Hz frequency increases.

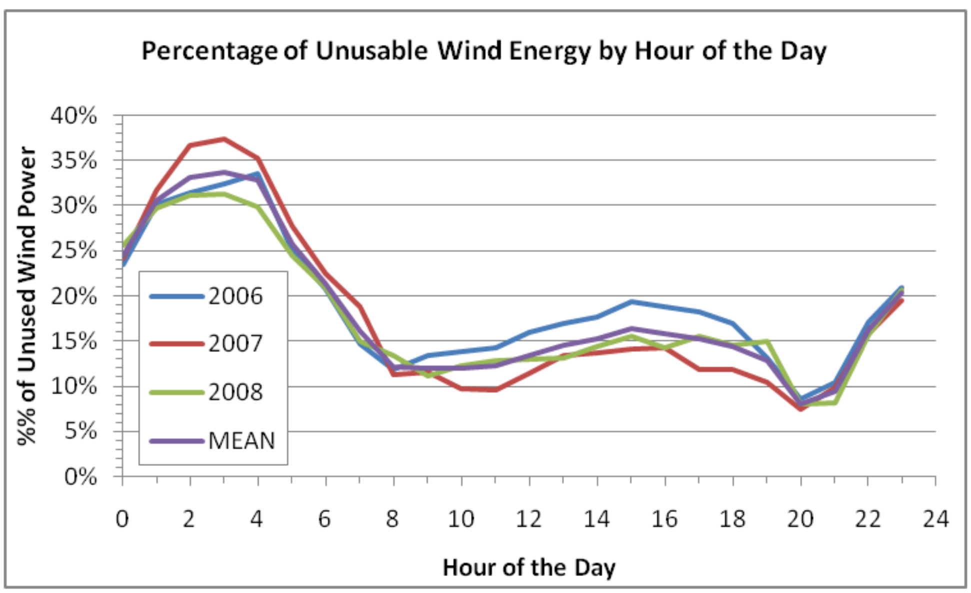
**The Variable Wind:**




This graph represents one month of daily wind generation output. As you will notice, there are drastic swings in output not only from hour to hour, but from day to day. There is similar variability with solar generation. The grid-interactive renewable water heater is able to change its charge rate as fast as renewable generation to store more renewable energy when it is available and stop charging when renewable energy is not available.

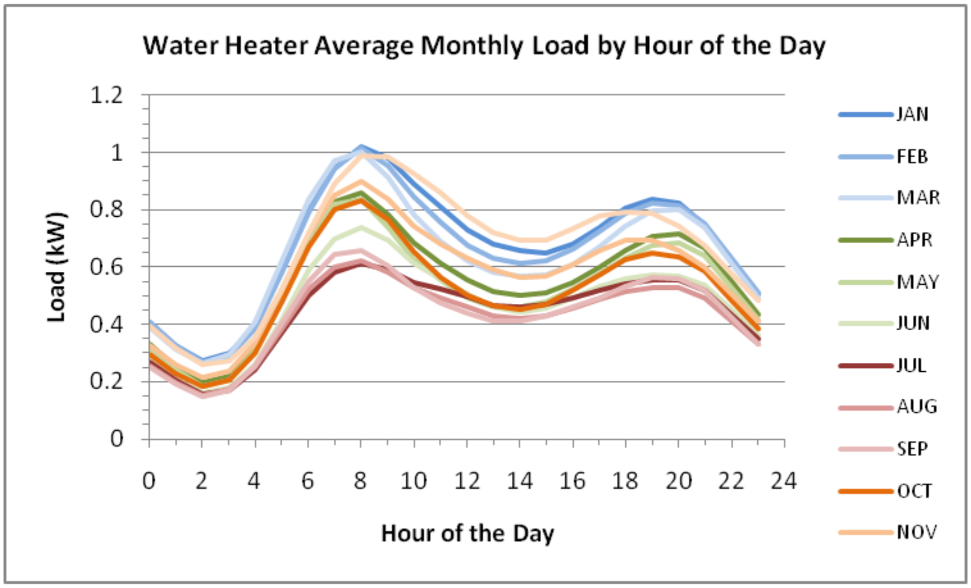



When reviewing average daily wind data over a three-year period, there is a similar pattern from year to year. On average, there is a higher percentage of renewable generation during the early and late hours of the day and a lower percentage during the hours from 8am – 6pm. It is clear that significantly more renewable energy is available, on average, during traditional off-peak hours when consumers are using less. This is also the time period when utilities may have excess wind generation, even after reducing their base load generation output to minimum levels.



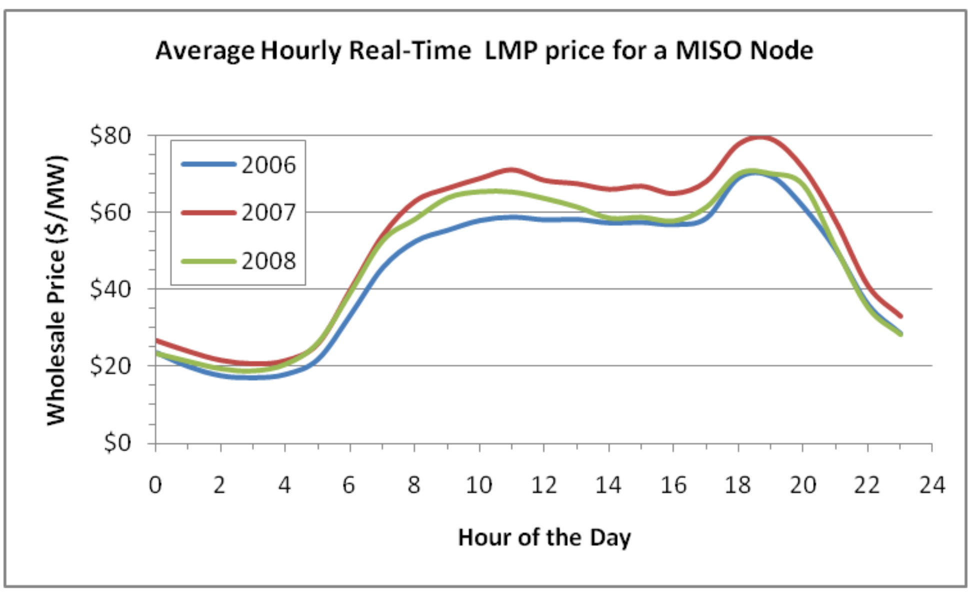

The preceding graph shows the average percentage of unusable wind generation by hour of the day. When wind energy and minimum generation levels exceed consumer demand, energy storage is needed to utilize this carbon-free resource. If this energy cannot be stored, it must be curtailed (turned off or wasted). Low-cost grid-interactive renewable water heaters can use this energy which otherwise would have been curtailed. Note that most of the unusable wind is in the middle of the night, but there is also unusable wind at all hours of the day, making real-time communication essential to integrate renewables whenever they are available.

**The Variable Water Heater Load:**

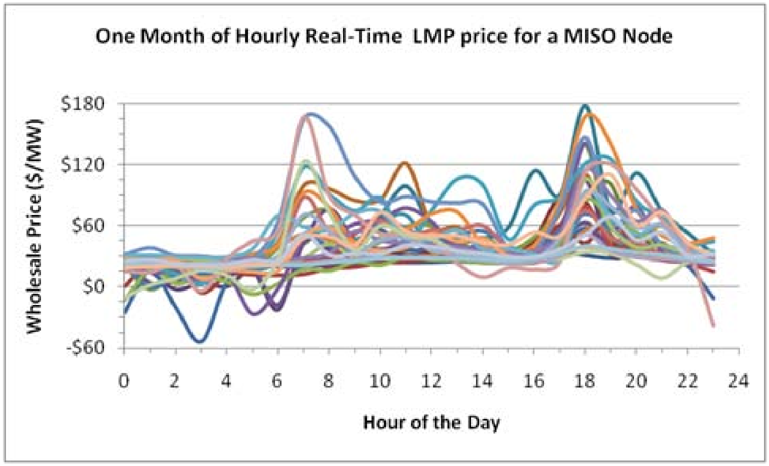



This graph represents the average hourly electric water heater load by month (based on EPRI load data from the Midwest). "Uncontrolled" electric water heaters draw little power in the middle of the night and consume the most energy when loads are typically peaking. Uncontrolled electric water heaters add to the utility's peak load. The water heater is one of many consumer loads currently contributing to load variability, but it is a load that can quickly be controlled to meet the real-time needs of the electric grid and more-efficiently utilize existing generation, transmission, and distribution infrastructure, providing significant economic and environmental value.

**The Variable Price for Energy:**

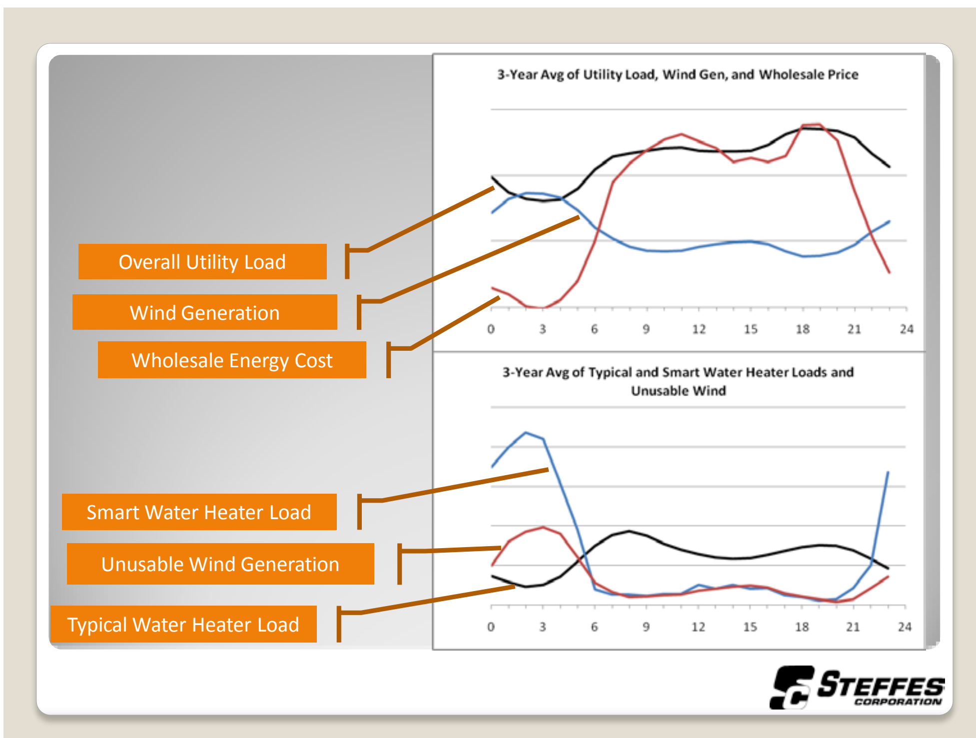



This graph compares three years of average daily energy wholesale costs, commonly referred to as the Locational Marginal Price (LMP). As you can see, the average price by hour is relatively stable year to year.




However, over a one-month period, the real-time LMP pricing varies very dramatically from $.18 per kW·h to a negative $.06 per kW·h. The LMP or wholesale energy price changes in most cases every 5 minutes. The LMP often goes negative when the wind blows during low-demand times.

**Putting it All Together:**




- The annual average overall utility load is low in the middle of the night.
- The average annual wind generation is almost the exact opposite of overall load, and the time with the highest percentage of wind is in the middle of the night.
- The wholesale energy price is lowest in the middle of the night.
- Most unusable wind is in the middle of the night.
- Unfortunately, the typical water heater load is also lowest in the middle of the night.

A grid-interactive renewable water heater can integrate renewable energy and at the same time be a low-cost option. This load can continually change in real-time, based on the current output of renewable energy source, LMP, and other needs of the grid.

## Balancing the load with Grid-Interactive Renewable Water Heating

The Grid-interactive renewable water heater is a precisely-controllable balancing load.

As quantities of renewable-generated electricity increase, a growing amount of this variable resource is curtailed or unusable because it cannot be consumed when it is generated. The inability to integrate renewable energy into the grid can happen at any hour of the day. The ability to quickly turn a water heater charge rate up or down can provide significant value to fully-utilize renewable energy. Grid-interactive renewable water heater control provides better integration of renewable energy into the grid, brings a new dimension of system conservation and efficiency, and keeps electric rates low.

This also allows water heaters to be fast, non-fuel-consuming regulators and frequency controllers. It provides increased grid reliability and reduces power plant cycling and fuel consumed for regulation and brings significant monetary and environmental value to electric grid operators and consumers.

Grid-interactive renewable water heater controls change the electric water heater into a "thermal battery" or grid end node that can affect the system like any other electric storage technology, but at a fraction of the cost. As we move toward a low-carbon future, electricity storage is critical, and renewable water heating is a low-cost option to help achieve that goal. The grid-interactive water heater control transforms a conventional electric water heater into an enhanced energy storage and power management device. When excess renewable energy is available at attractive pricing, the controller can “super charge” the water heater to a higher temperature. A tempering mixing valve is used in this system, to ensure safety. A 105-gallon water heater, used in this application, effectively becomes a 26-kW·h thermal battery, storing up to two days-worth of an average family’s energy needs. A distributed system of grid-interactive renewable water heater controls also varies the target water temperature and input power of individual water heaters to charge the water heaters that need energy the most first and at a higher rate.

### Comparative Data – Water Heaters, Energy, Renewable Integration & Carbon

Below, Table 1 provides a comparison between a conventional 55-gallon electric water heater (referred to as the baseline) and larger 85- and 105-gallon electric storage water heaters with grid-interactive renewable controllers. In addition, you will see comparative data for a heat pump water heater for the eight referenced climate zones in the U.S. For each water heater type, you will find information on the Wholesale Cost of Energy, Total Energy Used, Wind (renewable) Energy Used, Non-wind Energy Used and Carbon Reduction ($CO_2$). A short list of definitions follows:

Wholesale Cost: This is the cost of energy to the utility based on Locational Marginal Price (LMP) prices. Generally the utility’s costs are reflected in the electric rate consumers pay.

Total Energy Used: Energy used based on average home hot water consumption and the efficiency of the water heater.

Wind Energy Used: This is the amount of renewable energy used by the water heater.

Carbon Reduction: This is the amount of carbon reduction as compared to the baseline model (55-gallon conventional). The assumption used is 1 lb of $CO_2$ reduction for each non-renewable kW·h used.

Table 1: A comparison of water heater technologies

This analysis uses three (3) years of actual load, wind generation (scaled to 25% of load), LMP, and one (1) year of average water heater data.

| Energy Storage Method | Wholesale Cost ($/y) | Total Energy Used (kW·h/y) | Wind Energy Use (kW·h/y) | Non-wind Energy Use (kW·h/y) | $CO_2$ Reduction† (lb/y) |
|---|---|---|---|---|---|
| 55-gal Uncontrolled Storage Water Heater | $251 | 4805 | 1156<br>24% | 3649<br>76% | Baseline |
| 85-gal Grid-Interactive Storage Water Heater with Smart Signal | $133 | 4940 | 2726<br>55% | 2214<br>45% | 1436 |
| 105-gal Grid-Interactive Storage Water Heater with Smart Signal | $126 | 4974 | 2840<br>57% | 2134<br>43% | 1515 |
| 150-gal Grid-Interactive Storage Water Heater with Smart Signal | $127 | 5082 | 3053<br>60% | 2029<br>40% | 1620 |
| Assumes that COP = 2 above 55°F and COP = 1 at or below 55°F | | | | | |
| 55-gal Heat Pump Water Heater (Zone 1) | $126 | 2407 | 580<br>24% | 1828<br>76% | 1821 |
| 55-gal Heat Pump Water Heater (Zone 2) | $140 | 2662 | 649<br>24% | 2014<br>76% | 1636 |
| 55-gal Heat Pump Water Heater (Zone 3) | $153 | 2934 | 717<br>24% | 2218<br>76% | 1432 |
| 55-gal Heat Pump Water Heater (Zone 4) | $176 | 3335 | 820<br>25% | 2515<br>75% | 1134 |
| 55-gal Heat Pump Water Heater (Zone 5) | $187 | 3566 | 880<br>25% | 2686<br>75% | 964 |
| 55-gal Heat Pump Water Heater (Zone 6) | $193 | 3669 | 911<br>25% | 2757<br>75% | 892 |
| 55-gal Heat Pump Water Heater (Zone 7) | $205 | 3899 | 972<br>25% | 2928<br>75% | 721 |
| 55-gal Heat Pump Water Heater (Zone 8) | $212 | 4074 | 1020<br>25% | 3054<br>75% | 595 |

†Assumes 1 lb of $CO_2$ per kW·h of non-wind energy use.

Since the evaporator of the heat pump water heater is in the conditioned space, it was assumed that below an outdoor temperature of 55 degrees F, the cooling of indoor air is undesirable and therefore, we used a COP = 2 above 55°F and COP = 1 at or below 55°F.

**Additional notes and comments:**

- With larger water tanks, higher percentages of wind energy can be utilized.
- As costs of photovoltaic (PV) electric generation are reduced, more variable renewable PV will be installed. Grid-interactive renewable water heaters can help balance this resource as well.
- Renewable energy is a must-take resource. As we build more nuclear generation, which is a must-run resource, there will be additional need for balancing loads with electric storage systems.

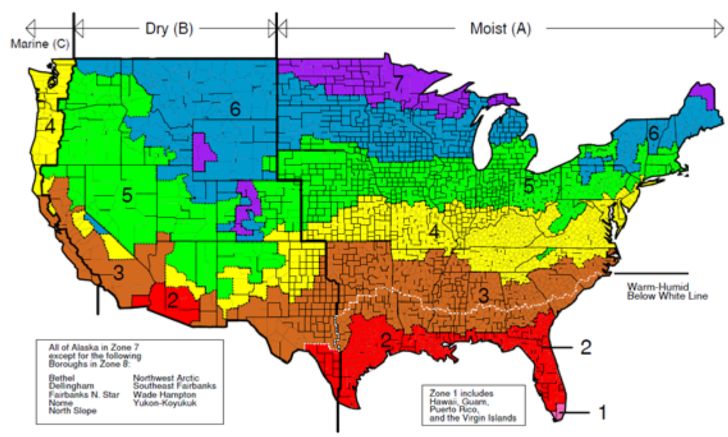
California ISO feels it will need 4,000 MW of resources like electric storage to balance the planned renewable generation.

**Findings:**

There is a significant difference in wholesale energy cost between the baseline 55-gallon water heater and the larger 85 & 105-gallon grid-interactive renewable water heater. The wholesale energy cost for the power is approximately 50% less with the grid-interactive renewable water heater, due to utilizing renewable and off-peak energy. The amount of energy consumed by the grid-interactive renewable water heater is slightly greater due to increased energy loss from the larger tanks. With the grid-interactive renewable water heater, 55% - 57% of the energy usage comes from a renewable generation source, which greatly reduces the amount of baseline generation power needed and the associated $CO_2$.

The performance data with the heat pump water heater varies depending on where the consumer is located. The heat pump water heater takes heat out of a home and transfers it to the water. In Southern climates, when daytime outdoor temperatures are high, this is very effective. The heat pump water heater provides cooling to the home at the same time it heats water. During these times, the heat pump water heater will have a coefficient of performance of approximately 2.0. At higher latitudes, when daytime outdoor temperatures are cool (55°F or cooler), we assumed the heat pump water heater has the same efficiency as a conventional water heater since there is not excess heat in the home to use for water heating. The table shows information for eight Department of Energy climate zones. In Zone 1, which encompasses the Southern tip of Florida and Hawaii, the wholesale cost of operation is better than the baseline 55-gallon model, as predicted, and the overall energy used is lower. The percentage of renewable energy used is the same. Since there is reduced overall energy consumption, as compared to the baseline, the amount of carbon reduction is also better.

Map of DOE's Proposed Climate Zones




The major finding in this table is between the grid-interactive renewable water heater and the heat pump water heater. With the exception of Zone 1, which represents a very small fraction of the geographical area of North America, the grid-interactive renewable water heater has better performance in all categories. It provides the lowest wholesale cost, utilizes the greatest percentage of renewable power and offers the greatest amount of carbon reduction as compared to the alternatives. In addition, the grid-interactive renewable water heater provides the ability to do electric grid power balancing (regulation and frequency control).

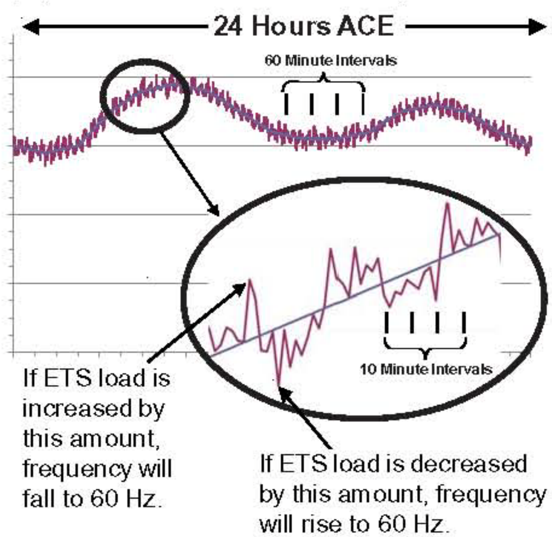
# Bonus Ancillary Economic and Environmental Value

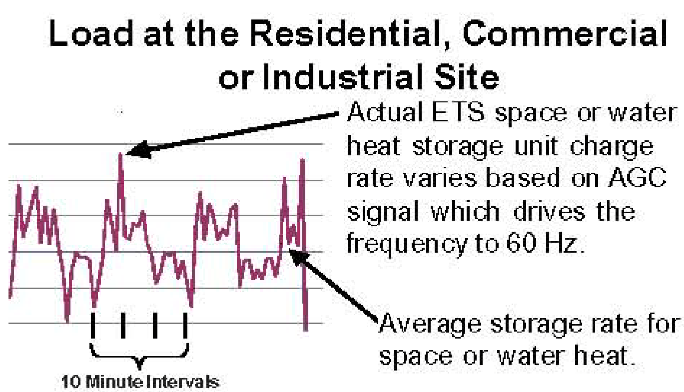
## Frequency Control:

As more variable renewable energy is added to the nation's electric grid, the need for power regulation increases.

Area Control Error (ACE) is the difference between supply and demand of electricity. This makes the frequency go high or low.

Electric Thermal Storage (ETS) space and water heaters can be used as a fast regulation tool to respond to an Automatic Generation Control (AGC) signal, thus reducing generator fuel consumption and associated emissions. In addition, grid reliability is improved. This yields monetary ancillary payments or reduced cost of regulation for utilities.



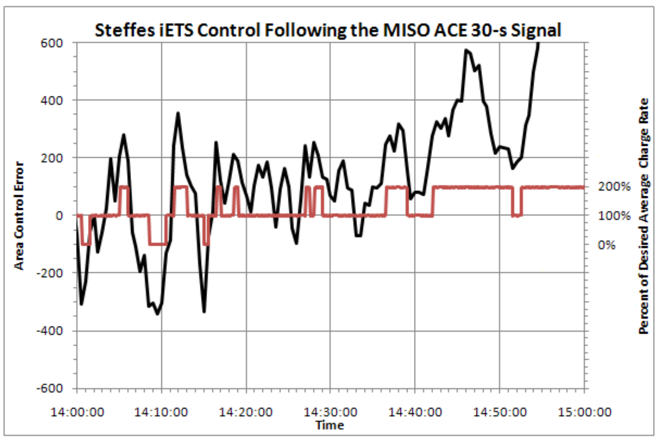



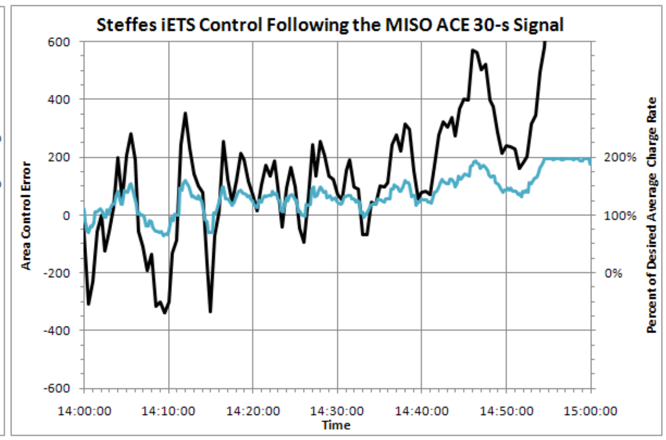

Fast two-way smart grid communication is needed to make frequency control work the best.

# Smart Signal Following

## MISO 30-s ACE or 4-s AGC Signal

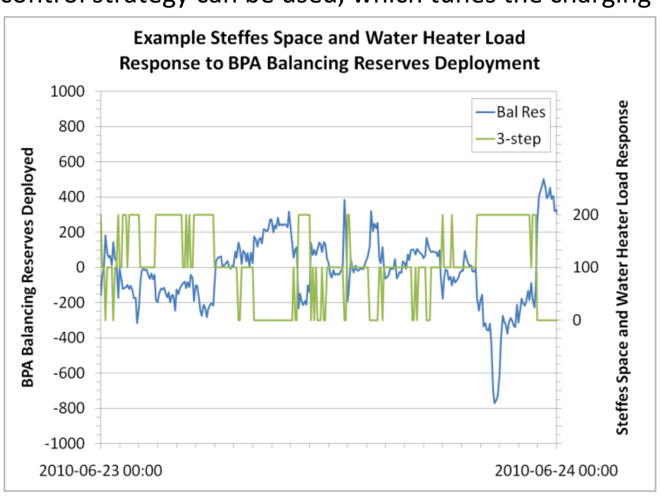
The Midwest ISO (MISO) has an Area Control Error (ACE) signal that indicates the instantaneous difference between net actual and scheduled interchange. When the ACE signal is positive, it indicates that generation exceeds demand and when the ACE signal is negative, it indicates that demand exceeds generation. Grid-interactive renewable water heater controls can use this signal to add load when the signal goes high and shed load when it goes low. If the controlled load is small compared to the needed regulation capability, a 3-step charging methodology can be used to maximize the impact. If the controlled load is a significant percentage of the needed regulation capability, a much finer control strategy can be used, which tunes the charging magnitude to grid needs. The grid-interactive renewable water heater control is able to follow the 4 second Automatic Generation Control (AGC) signal in the same way.

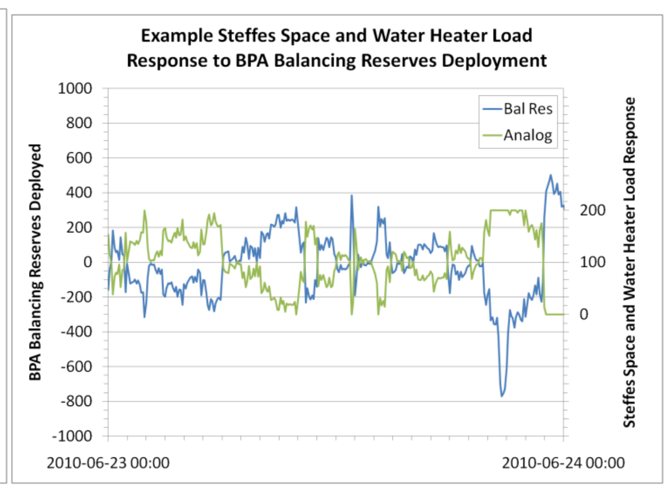



## BPA Balancing Reserves Deployment Signal

The Bonneville Power Authority (BPA) has a Balancing Reserves Deployment signal that is used to balance renewable energy resources and demand variations with generation resources. This is the difference between predicted wind and actual wind generation in the area. When the Balancing Reserves Deployment signal is positive, it indicates that generation was increased to balance the grid and when the signal is negative, it indicates that generation was decreased to balance the grid. Grid-interactive renewable water heater controls can use this signal to shed load when the signal goes high and add load when it goes low. If the controlled load is small compared to the needed regulation capability, a 3-step charging methodology can be used to maximize the impact. If the controlled load is a significant percentage of the needed regulation capability, a much finer control strategy can be used, which tunes the charging magnitude to grid needs.



# Other Benefits of Electric Storage

**(taken from the SGiP PAP07 Scoping Study Document)**

The grid-interactive renewable water heater provides additional benefits by helping to

- Enhance power quality and regulate grid frequency by quickly ramping demand up and down as needed
- Support renewable integration and enhance value, enabling greater penetration and utilization of these assets, reducing the cost of integration for wind developers, and increasing the price of wind energy which at this time is negative during windy low-demand periods.
- Mitigate environmental impacts and qualify for environmental credits by enabling greater penetration and utilization of renewable energy assets
- Provide arbitrage value by enabling energy market participants to buy and store low-cost energy and sell demand reduction when energy prices are high
- Provide spinning and supplemental reserve by reducing demand during times of insufficient supply
- Defer transmission, distribution, and substation upgrades and generation capacity investments by reducing peak demand
- Extend transmission and distribution asset life and increase utilization by reducing peak demand and time-shifting load profiles
- Reduce retail energy costs to consumers by leveraging time-of-use or other variable rate structures and reducing peak demand to avoid demand charges
- Improve on-site power quality and mitigate financial losses related to power quality fluctuations by quickly ramping demand up and down as needed to offset grid conditions
- Reduce transmission and distribution loss costs

| Benefit | Mechanism |
|---|---|
| Enhance Power Quality | Quickly vary load |
| Regulate Grid Frequency | |
| Support Renewable Integration and Enhance Renewables Value | |
| Minimize Environmental Impacts and Qualify for Environmental Credits | |
| Provide Arbitrage Value | |
| Provide Spinning Reserve | |
| Improve On-Site Power Quality and Mitigate Resultant Financial Losses | |
| Defer Transmission, Distribution, and Substation Upgrades | Time-shift load |
| Defer New Generation Capacity Investments | |
| Extend Transmission and Distribution Asset Life | |
| Increase Transmission and Distribution Asset Utilization | |
| Reduce Transmission and Distribution Loss Costs | |
| Reduce Retail Demand Charges | |
| Reduce Retail Energy Costs | |

# Conclusion:

In a perfect world, there would be no fluctuation of energy consumption, generation and prices. Everything would be well-defined and very predictable. In the real world, there is much variability and uncertainty. Maintaining grid stability with the variability of renewables consumer demand is challenging. It is clear that fast-acting electric energy storage is necessary in order to reap the full benefits of renewable energy. Grid-interactive renewable water heaters can fill a significant portion of our nation's electric energy storage needs at a fraction of the cost of other technologies. They can also be a valuable carbon reduction component of the Smart Grid and other clean energy initiatives in the future. A grid-interactive renewable water heater provides more carbon reduction than a heat pump water heater in most US climate zones and provides additional electric grid balancing services. In order to achieve a zero-carbon economy, we must encourage the use and development of innovative products and technologies that have the potential of getting us there. It is essential that grid-interactive renewable water heaters be used by utilities and consumers to manage our energy future.