STEFFES CORPORATION
"Commitment to Innovation"

3050 Highway 22 North
Dickinson, ND USA 58601
Phone: 701-483-5400
Fax: 701-456-7497
E-Mail: offpeak@steffes.com

October 31, 2010

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

Reference: **"Smart Grid RFI: Addressing Policy and Logistical Challenges"**

Thank you for the opportunity to submit information to help with Smart Grid implementation in the United States. We strongly support the DOE effort to encourage the development of an interoperable Smart Grid. We see significant benefits for consumers, 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". In the paragraphs and pages that follow, we will provide information related to this request. Additional supporting documentation is also provided and will be referenced in this document. In the response we are providing, we directly refer to several paragraphs of Title XIII, section 1301 of the Energy Independence and Security Act of 2007 (EISA) with our responses. The information we provide and the recommendations we make can play a key role for advancing implementation and operation of the Smart Grid.

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

Most renewable energy resources have a variable generation pattern. In order to integrate renewable resources, additional "fast up and down" regulation is needed. The smart grid is a means to aggregate distributed electric storage assets to provide this low carbon regulation service. Furthermore, low-cost smart electric storage space and water heating is a cost effective way to integrate large amounts of renewable energy. Electric Thermal Storage (ETS) is a low-cost, proven distributed energy storage resource that has been used by consumers for over 30 years. ETS systems store electricity as heat during times when renewable or off-peak low cost/low value power is available and use this stored energy as needed to satisfy consumer comfort requirements on demand. 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 change, and greater at ramp rates than is achievable from many traditional generation technologies. Smart grid in the home brings the possibility of low-cost terawatt hours of electric energy storage to the system. This allows for higher percentages of renewable energy on the grid at lower cost. **Refer to attachment #1, 2 & 3 (pages 1-8) for more information on ETS products.**

Federal recognition for distributed storage, such as ETS, will advance implementation and usage of these devices. Energy storage at the point of use provides great benefit for the consumer, utility and the Smart Grid.

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

Demand response and demand side management programs have been used by utilities for many years to manage generation, transmission and distribution of power. Many utilities have been able to defer or eliminate the need for construction of new generation and other infrastructure because of the successful demand response programs they have.

Electric Thermal Storage (ETS) systems are tools utilities have used in their DSM programs for over 30 years. During off-peak hours, ETS heaters store low-cost electricity as heat and use this energy for heating homes 24-hours a day. During peaking hours, the heaters rely entirely on energy which was stored during off-peak hours. Utilities use direct load control equipment or the electric meter to signal equipment such as ETS. Power companies that include ETS systems in their DSM programs are successful in improving their load factors 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. Doing regulation with electric storage resources can reduce the carbon emission by 70% over doing regulation with fuel consuming resources. This brings a new dimension of conservation and efficiency to the grid.

Federal recognition and incentives that encourage utilities to implement Demand Response and DSM programs would be very beneficial to the smart grid. In addition, tax incentives would make it more affordable for consumers to invest in ETS technologies for their homes and business'.

(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 utilizes this stored energy during peak hours or hours of limited renewable energy availability. These smart appliances provide automatic control for the storage and discharge of energy, in addition to responding to identified needs of the grid. Time of Use or other preferential electricity rates make it beneficial for consumers to use this technology in their homes or business'.

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. While ETS equipment does provide a return on investment for consumers, tax incentives would make them more affordable and would accelerate deployment.

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

Approximately 50% of homes in the U.S. have electric water heaters today which are energy storage devices that can play a very key role in the implementation and utilization of the Smart Grid. While much has been written about the potential for using electric vehicle battery charging for energy storage, it is not well known that a domestic electric water heater has approximately the same storage capability as an electric vehicle battery, and there are literally tens of millions of them already in service. 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. With rapidly increasing amounts of renewable energy being added to our country's power generation mix, the need for energy storage is becoming more essential. Smart Grid controls were recently developed and provide utilities the ability to use electric water heaters as distributive storage devices. These controls provide the ability to do fast UP or DOWN power regulation in response to needs of the power grid, like ISO AGC signal for ancillary value as well as significant environmental value. 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" (attachment #4; pages 9-21) 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 and tax incentives for consumers will help advance introduction of these innovative storage and peak shaving technologies. These are cost effective solutions that are sustainable for the future.

(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. 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. While most homes today have domestic water heaters that have 55-gallon capacity or less, larger sizes provide greater energy storage capacity.

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. In terms of storage, a 100 gallon water heater can store a nominal 26kWh of storage, or approximately a two day supply of hot water for an average family and the full equivalent of typical electric vehicle battery storage capability.

Logistical Challenges

Affordable Energy Storage is needed for Grid Stability and Reliability

It is becoming very obvious that energy storage is needed in order to manage power generation and demand. Today, most of this storage capability is in the form of natural gas fields, coal piles, and hydro reservoirs. Especially with the growing amount of renewable generation, it is becoming difficult to integrate this resource with base load power generation. Couple this variable generation with the variability of energy usage by consumers, it is very challenging to manage power supply while maintaining grid stability and reliability. While most people believe energy storage is a key component for full implementation of the Smart Grid, conventional energy storage options available today are very costly and not economical. Examples of these storage options are CAES, Flow Cells, NaS Batteries and Flywheels. These have a cost range of $200 - $1,500 per kWh of storage capacity.

Electric Thermal Storage (ETS) is an energy storage technology that has been used in U.S. for the past 40-years. It is a distributive energy storage technology that stores electricity as heat during preferential times of the day or night. This energy is used for heating homes and commercial & industrial applications. ETS systems are proven, long life, low-cost energy storage devices **(Refer to attachment #5; pages 22-23 - labeled "Low-Cost Electric Storage")**. The installed cost of ETS systems ranges from $40 to $70 per kWh of storage capacity. Historically, utilities have used ETS products for demand response and load management purposes. Today and for the future, these fast response storage systems can provide additional value such as Grid Optimization, Renewable Integration and Frequency Control. Consumers benefit from lower heating bills (and electric rates) and our country benefits from a reduction of imported oil. Product literature for ETS systems is also attached (attachment # 1, 2 & 3; pages 1-8).

Federal recognition and encouragement for the use of ETS systems as viable energy storage devices will help advance implementation of the smart grid. Incentives for consumers or utilities to use this technology would help accelerate implementation.

Closing comments
In the past, power generation has followed load, which varies with the instantaneous needs of consumers. As our country's dependency on variable renewable wind and solar generation increases, there will be a greater need to have the load follow instantaneous generation. Renewable and Nuclear energy are "must take" resources. If we are going to have a high percentage of these variable and "must take" resources run our nation and the economy, smart energy storage is needed. To better use existing utility infrastructure and improve reliability and bring a new dimension of conservation and efficiency to the system, smart energy storage is needed.

The smart-grid is an enabling key, benefiting consumers, the economy and the environment. A cost effective way to bring load and generation into balance is to use the Smart-Grid to communicate with low-cost distributive energy storage in real-time. This allows extra generation to be stored when necessary and allows consumers to consume energy as needed. Federal policies that recognize the multiple economic and environmental benefits of low-cost "smart" electric energy storage and encourage their use will benefit consumers, the smart grid, the economy and the environment.

Thanks again for the opportunity to respond to this RFI. We welcome you to contact us to visit more. You can reach us at 701-483-5400 or psteffes@steffes.com. You may also view more information on this technology at www.steffes.com/off-peak-heating/smart-grid.html or www.steffes.com/offpeak.

Best regards,

Paul Steffes

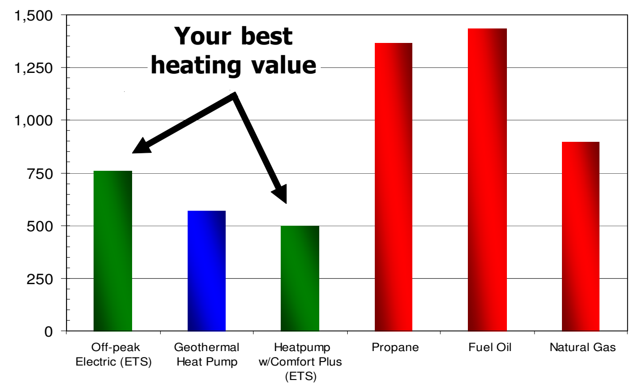
Paul Steffes, P.E.

Enclosures

Economics

Typical Annual Space Heating Comparisons*

(Based on a 45,000 BTU heat loss home)



** Annual costs in your area will vary depending on climate, electric rates, heating fuel cost, etc. A personalized heating comparison is available.*

Advantages of Off-Peak Heating

- A low cost heating option
- Electric is the safest form of heating
- Electric rates are stable and predictable
- No need to worry about filling a tank
- No need to worry about carbon monoxide
- Requires no routine maintenance
- Electric heating systems are very reliable
- Electric heat is very clean
- No hassles or messes
- No smoke...no chimney

Common Installations

- Residential
- Weekend Homes or Cabins
- Apartments or Condominiums
- Hotels/Motels
- Schools
- Courthouses
- Offices
- Warehouses
- Churches

Ask us about the right system for your application.

Off-Peak Heating...

The Smart Heating Solution

STEFFES CORPORATION

Manufactured in North America

Steffes Corporation • 1-888-783-3337 • www.steffes.com

Off-Peak Heating

Ask us how Electric Thermal Storage (ETS) technology can provide you low cost heating and unsurpassed comfort.

The Smart Heating Solution

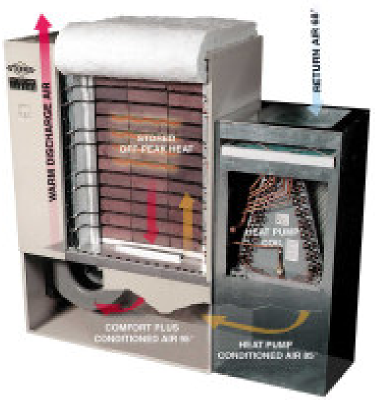
OFF-PEAK HEATING SOLUTIONS…
Low Cost, Comfortable, Safe & Reliable

Off-peak heating systems utilize Electric Thermal Storage (ETS) technology along with your Power Company's off-peak electric rate to provide very affordable and comfortable heating. During off-peak hours when electric costs are low, ETS heating systems store electricity as heat for use in satisfying comfort requirements 24 hours per day. In most situations, **off-peak heating provides the lowest cost of operation** when compared to alternative options. In addition, **owners are enjoying the comfort and convenience** these heating systems offer. There are whole house and room unit off-peak heating systems available to meet the needs of your home or business.

- ⇨ **No Smoke**
- ⇨ **No Fumes**
- ⇨ **No Mess**

Comfort Plus Forced Air System

The Comfort Plus forced air system is a centrally ducted product that provides a whole house heating solution. This system can be used as a stand-alone furnace or can be interfaced with a conventional air conditioner unit for cooling. Combine the Comfort Plus unit with a heat pump for even better efficiency, lower operating costs and greater comfort for heating and cooling.



Room Heating Units

Room Heating Units are designed to deliver low-cost off-peak heat to a specific area or room. Many times, these systems are used in conjunction with or replacement of electric baseboard systems or wood burners. You will enjoy the quiet operation of the room heating unit in addition to exceptional comfort, convenience and low operating cost.

- **Clean**
- **Easy to Operate**
- **Safe & Comfortable**
- **No Tank or Chimney needed**
- **Low Maintenance**
- **100% (or greater) efficiency**

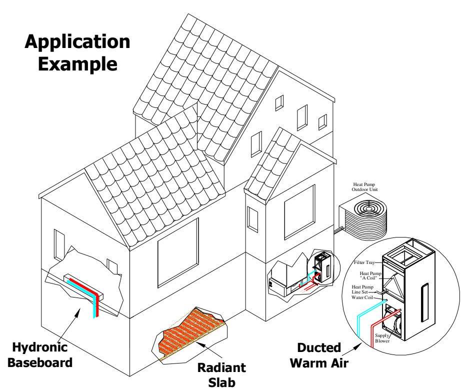
RELAX…It's All Electric

Please ask us for more information on any of these products and off-peak load controls. Large residential and commercial size systems are also available. We'd be happy to visit with you about the right system for your application.

Steffes heating equipment is backed by a 5-year limited manufacturer's warranty.

Comfort Plus Hydronic System

The Comfort Plus Hydronic system adds a new dimension to heating by blending hydronic heating with Electric Thermal Storage (ETS) technology. You can now enjoy the benefits of radiant heating along with the low cost of operation off-peak heating systems provide.



Common applications of this system include in-floor heating, under floor heating and hydronic baseboards.

Add the optional Steffes Air Handler and you will have the ability to receive the combination of forced air heating/cooling along with off-peak radiant hydronic heating.

STEFFES CORPORATION

Manufactured in North America

Great savings and comfort on your home heating with a Steffes Room Heater

Many people are taking advantage of low cost electricity rates from their local power company known as off-peak rates and saving hundreds, even thousands of dollars on their home heating bills. If you are looking for great comfort and relief from high propane, fuel oil or natural gas costs, now's the time for a Steffes Room Heater.

STEFFES Heating Systems

Get the "Off-Peak Advantage!"

Electricity is more expensive during the day – when we use a lot of it. Dishwashers, washers and dryers, water heaters, computers… it's a long list. Power companies charge lower rates at times when less electricity is used. These lower rates are called "off-peak rates."

how it Works

The Steffes Room Heater stores low cost, off-peak electricity as heat in its specially designed ceramic bricks. The amount of heat stored is regulated automatically based on the heating needs of your home and outdoor temperatures.

The heater's built-in room thermostat and fan deliver the stored heat into your home when needed to provide comfortable, even temperatures throughout the house. It's quiet, easy to use, and can satisfy your desired comfort 24 hours a day.

save money!

With a Steffes Room Heater, many homeowners are cutting their annual heating bills by up to 70%, saving hundreds and even thousands of dollars.

Steffes Room Heater

- Safe, Clean, Comfortable Heat
- No Smoke, No Fumes, No Mess
- Easy To Operate
- No Routine Maintenance
- 100% Efficient
- Manufactured In North America
- 5-Year Limited Manufacturer's Warranty

Unique Features

- Microprocessor Technology
- Low Cost Automatic Charge Control
- Heater Operation Display Lights
- Built-in Digital Room Temperature Thermostat
- Brick Core and Air Discharge Temperature Safety Controls
- Variable Speed Blower
- Built-in Controls to Reduce Installation Time & Costs
- Microprocessor Based Time Clock Module (Optional)

Any Application

- Electrically Heated Homes
- Fossil Fuel System Replacement
- Wood Stove Replacement
- Boiler Replacement
- Supplement to any Existing Heat Source

Perfect For

- Primary Residence
- Weekend Home or Cabin
- Manufactured Home
- Apartments or Condominiums
- Churches
- Hotels/Motels
- Schools/Offices
- Warehouses

Specifications

Standard voltage on all systems is 240VAC. Charging input voltages of 208 and 277 are also available.

MODEL	Charging Inputs (kW) Available (See Note 1)	Approximate Installed Weight (lbs)	Dimensions (Inches)		
			Length	Height	Depth
2102 (See Note 2)	2.4, 3.0, 3.6	267	30	24.5	10.5
2103	3.6, 4.5, 5.4	376	37	24.5	10.5
2104	4.8, 6.0, 7.2	478	44	24.5	10.5
2105	6.0, 7.5, 9.0	585	51	24.5	10.5
2106	7.2, 9.0, 10.8	692	58	24.5	10.5

NOTE 1: kW input must be specified at time of order. The appropriate model and kW input for your application will depend on heat loss of the area intended to be heated and the number of power company off-peak hours available. Contact your local power company, a contractor or Steffes Corporation for assistance in selecting an appropriately sized system.

NOTE 2: Model 2102 also available in a 1.32kW input with a 120V plug-in cord.

NOTE 3: A clearance of 12" is recommended on the right side of heater to ensure accurate room temperature sensing and for servicing purposes. If less than 12" is available, an optional remote room temperature sensor is available.

MINIMUM CLEARANCE REQUIREMENTS	
Top	4"
Front	15"
Sides (See Note 3)	2"
Back	1.5"

STEFFES
Heating Systems

701-483-5400
E-Mail: offpeak@steffes.com
Web: www.steffes.com

For More Information Contact:

STEFFES
Heating Systems

COMFORT PLUS

CENTRALLY DUCTED OFF-PEAK HEATING

MANUFACTURED IN NORTH AMERICA

Attachment 3

COMFORT PLUS

The World's Most Advanced Furnace and Air Handling System

Off-Peak Heating

The Steffes Comfort Plus Series heating systems are a type of Electric Thermal Storage (ETS) equipment which utilize low cost, off-peak electricity to provide economical and comfortable heating. ETS systems convert electricity to heat during off-peak hours and store that heat in specially designed ceramic bricks. Off-peak hours are those times during the day or night when electricity is plentiful and the electric power company can supply it at a lower cost. Power companies generally offer substantial discounts in rates (up to 40% or greater), for electricity used during off-peak hours. With this rate discount, consumers can realize significant savings in their energy bills when compared to alternative heating options.

Applications

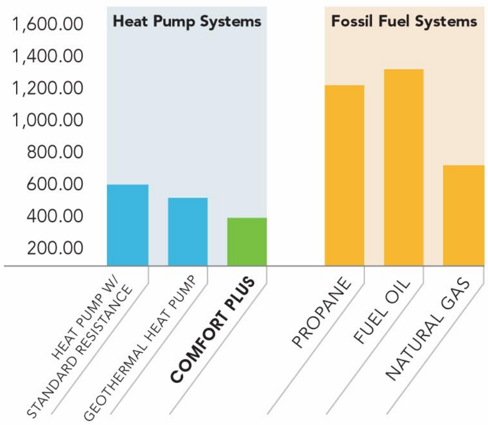
- Newly constructed homes or replacement of existing furnaces.
- Use as a stand-alone furnace or as a supplement to other heating systems, such as heat pumps.
- Can accommodate most auxiliary devices such as an air conditioner, central humidifier, electronic air filter, heat pump, etc.

Heat Pump Booster

Heat pumps are known for providing very efficient, low cost heating and cooling. However, during colder outdoor temperatures, traditional heat pumps often times do not deliver acceptable comfort. With the Steffes Comfort Plus unit, you can be assured good comfort while optimizing the heat pump's efficiency. As replacement to the electric resistance strip heat, which is typically used to supplement or back-up heat pump systems, the Comfort Plus unit adds the precise amount of off-peak, stored heat needed to ensure constant, even and comfortable air is being delivered 24 hours a day. During on-peak hours or when the demand for heat is at the point where the heat pump's capacity alone cannot satisfy the heating requirements, the Comfort Plus unit uses its stored, off-peak heat to supplement the heat pump output.

Typical Annual Heating Costs Example
(based on a 45,000 BTU/hr heat loss home)

Annual costs in your area will vary depending on climate, electric rates, heating fuel costs, etc.



The Comfort Plus/Heat Pump system offers many significant benefits:

- Provides for a high efficiency, low cost heating and cooling system all in one.
- Optimizes system performance by allowing the heat pump's efficiency to be fully utilized.
- Eliminates cool and uncomfortable discharge air temperatures associated with heat pump systems during cool outdoor temperatures.

Utilizing a Comfort Plus unit with a heat pump, in conjunction with an off-peak electric rate, has proven to be one of the most economical heating and cooling systems available.

Operation

Operation of the Comfort Plus is completely automatic. A sensor monitors outdoor temperature to regulate the amount of heat the system stores in its brick core. The room thermostat, along with the duct sensor in the Comfort Plus, controls heat delivery to ensure a warm and comfortable room temperature 24 hours a day.

Variable Speed Blower

The variable speed ECM blower system provides exceptional benefits:

- Substantially lower energy consumption and operating costs as compared to standard blowers
- Quiet operation with automatic ramp up and down speed control
- Interfaces with multi-speed air conditioners and heat pumps
- In "Fan Only" mode, blower operates in low speed providing uniform air circulation and constant air filtration.
- Improved humidity control
- Money-saving energy efficiency all year long.

Green Power and Smart Grid Ready

Comfort Plus systems are environmentally friendly solutions for today and tomorrow. They have the ability to respond to real-time-pricing, load and demand management, alternative energy, frequency control and other signals available from power companies. The energy storage ability of Steffes ETS heaters allows them to serve as a "Thermal Battery" to harness power from various renewable generation sources such as wind and solar.

COMPONENTS OF A COMFORT PLUS

1 Return Air Plenum
3100: provided with unit
(right side mounting only)
4100: separately ordered or installer supplied
(right or left side mounting)

2 Return Air Inlet

3 Air Conditioner or Heat Pump Indoor Coil
(installer supplied)

4 Air Filter
(Provided with return air plenum.)

5 Supply Air Outlet
(4100: bottom right or left side)

6 Insulation
Super-insulated to ensure low surface temperatures along with a doublewall cabinet design to minimize static heating.

7 Circuit Breakers
Element and controls circuit breakers are built in to every system to eliminate the need for a separate service disconnect.

8 Microprocessor Control Panel and Operating Display
This state-of-the-art, intelligent control system provides complete programmability of the system to allow for customization to user and power company immediate and future needs, as well as diagnostic testing through the operating display panel.

9 Heating Elements
Incoloy sheathed, low-watt density for long life.

10 Heat Storage Bricks
Specially designed to store vast amounts of heat for use 24 hours a day.

11 Electrical Compartment

12 Supply Air Blower
High efficiency ECM variable speed provides great comfort and cost savings.

3100
SERIES

OTHER FEATURES

- Built-in powerline carrier communication system.
- Selectable freeze protection.
- Built-in auxiliary load control ability for regulation of other electric loads such as a water heater.
- Time clock module for peak control signaling purposes *(optional)*.
- Completely automatic, making it extremely easy to operate.
- No routine maintenance necessary.

WARRANTY

Steffes Corporation proudly offers product warranties. The heating system is covered by a five-year limited parts warranty

SPECIFICATIONS *for standard 240V units*

208V, 277V, and 347V configurations also available. Contact factory for technical specifications.

1kW = 3412 BTU/hr 1kWh = 3412 BTU **US Pat #5086493 • Canada Pat #2059158**

MODEL	3120			4120			4130		4140	
Charging Input	14.0 kW	17.5 kW	21.6 kW	14.0 kW	19.2 kW	24.8 kW	28.8 kW	37.2 kW	38.4 kW	45.6 kW
Element Current Draw	59 amps	73 amps	90 amps	59 amps	80 amps	104 amps	120 amps	155 amps	160 amps	190 amps
Circuits Required										
Elements	2-40 amps	2-50 amps	2-60 amps	3-30 amps	3-40 amps	3-50 amps	4-40 amps	4-50 amps	4-50 amps	4-60 amps
Blowers/Control	1-15 amp *(6 amps maximum load)*			1-15 amp *(7 amps maximum load)*						
	Unit is factory-configured with multiple-line voltage, single-phase circuit connections. If single feed to the element and blowers/controls circuits is desired, an optional single-feed kit is available. Phase-balancing is recommended when making connections in 3-phase applications.									
Storage Capacity	86 kWh (293,432 BTU)			120 kWh (409,440 BTU)			180 kWh (614,160 BTU)		240 kWh (818,880 BTU)	
	The size and heating ability of the system required for an application is dependent on the heat loss of the area and the power company's off-peak hours. Refer to the Maximum Maintainable Heat Loss for heating abilities in specific charge strategies.									
Approximate Installed Weight	1,562 lbs			2,183 lbs			3,031 lbs		3,859 lbs	
	Contact a building contractor or architect if you have structural weight concerns of the installation surface selected. Adhere to all national and local electrical and building code placement requirements for electric heating appliances.									
Unit Dimensions - W x D x H										
w/o Ducting	41.6" x 27" x 60"			29.2" x 44.7" x 46.6"			29.2" x 44.7" x 57.6"		29.2" x 44.7" x 68.6"	
w/ Factory-Built Ducting (1/2 HP)	63" x 27" x 60"			77.7" x 44.7" x 46.6"			77.7" x 44.7" x 57.6"		72.8" x 44.7" x 68.6"	
w/ Factory-Built Ducting (1 HP)	N/A			82.2" x 44.7" x 46.6"			82.2" x 44.7" x 57.6"		77.3" x 44.7" x 68.6"	
	There are required installation clearances to account for. Contact the factory for this information.									
Duct Openings										
Supply Air Outlet (1/2 HP)	10.1" x 16"			18" x 22.6" (in factory-built plenum)						
Supply Air Outlet (1 HP)	N/A			22.5" x 22.6" (in factory-built plenum)						
Return Air Inlet	21.4" x 21.4" (in factory-built plenum)			10.5" x 22.3" (in unit) or 26 1/16" x 22 3/16" (if using a factory-built plenum)						
Maximum Coil Dimensions (W x D x H)	26" x 22 1/16" x 30 15/16"									
	The factory-built return air plenum is configured for housing an indoor coil. Dimensions listed are that of the inner coil area in this plenum. For larger coils, field provisions to the plenum are necessary or it will need to be supplied by the installer.									
Supply Air Delivery (Field Selectable)										
1/2 HP Variable Speed CFM ratings	1000, 1200, 1400, 1600			1000, 1200, 1400, 1600						
1 HP Variable Speed CFM ratings	N/A			1200, 1400, 1600, 2000						
Heating Ability Based on Charge Time (BTU/hr)										
8 Consecutive Charge Hours	20,414	23,512	23,512	20,414	27,996	32,808	41,994	49,212	55,992	65,615
12 Consecutive Charge Hours	30,621	31,350	31,350	30,621	41,994	43,774	62,991	65,615	83,988	87,487
6/4/6/8 Charge Strategy	30,621	38,276	47,097	30,621	41,994	54,242	62,991	81,363	83,988	99,735
	The size and heating ability of the system required for an application is dependent on the heat loss of the area and the power company's off-peak hours. If the unit is not installed within the heated area, heat lost statically must be taken into account. Contact your local power company, a contractor, or Steffes Corporation for assistance in selecting an appropriately sized system for your specific charge strategy. The 6/4/6/8 strategy listed is 8 hours off-peak at night plus 4 hours off-peak mid-day. (The Heating Ability figures listed have a heat use allowance factored in for sizing purposes. Average BTU delivery rate is the listed value multiplied by .78 heat use factor.)									

STEFFES Heating Systems
"Commitment to Innovation"
ISO 9001 COMPLIANT

3050 Highway 22 N • Dickinson, ND 58601-9413
phone: 701-483-5400 • **fax:** 701-456-7497
e-mail: offpeak@steffes.com
websites: www.steffes.com • www.HeatForLessNow.com

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.

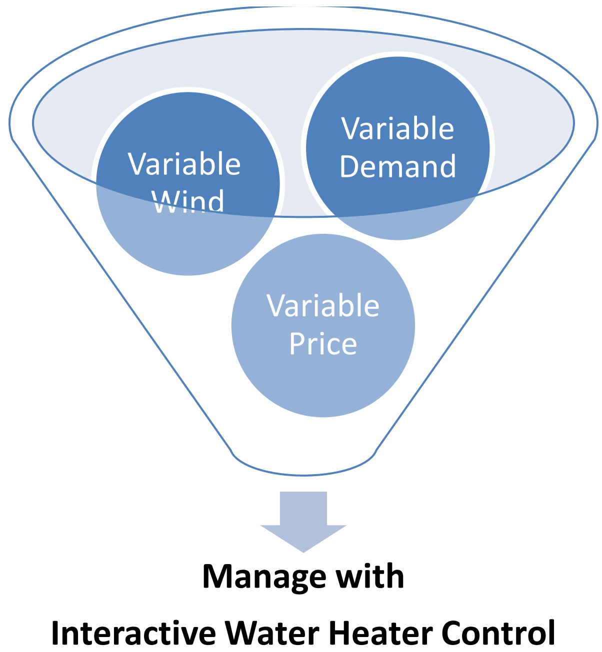
Because most renewable energy resources are variable, there is great benefit to the utility and society if an electric water heater can take on additional charge or “store” more energy when renewable or off-peak low-cost electricity is available. There is also benefit, when the demand for electricity 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



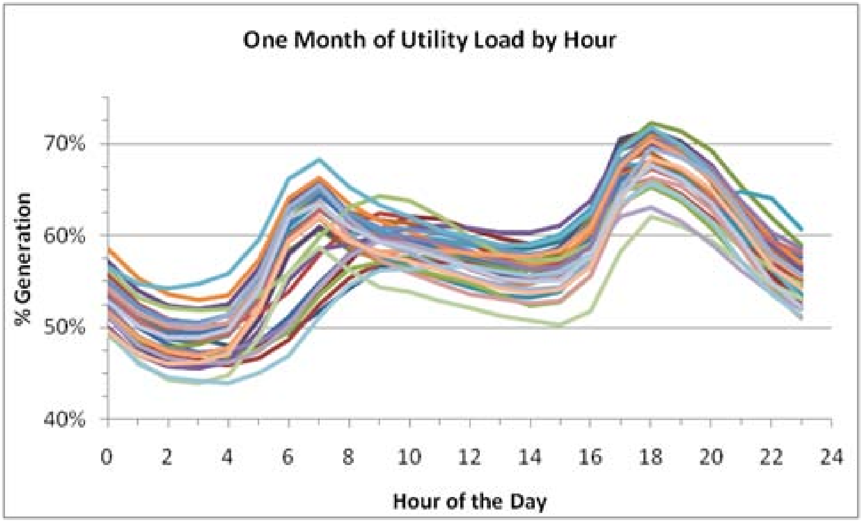
Grid-interactive renewable water heaters have smart controls that quickly change their charge rate and charge level, factoring in real-time renewable generation and other critical needs of the grid. This significantly reduces carbon and brings a new dimension of conservation and efficiency to the electric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

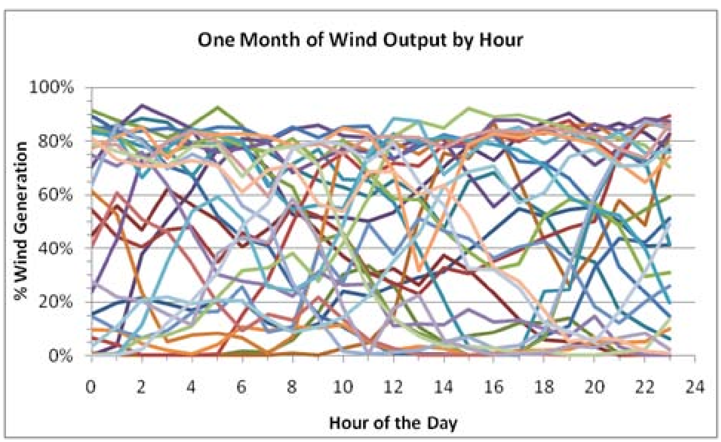
- Three years of hourly wind generation percentages for a Midwest utility
- Three years of actual hourly wind farm generation
- Three years of corresponding hourly wholesale cost of energy (LMP prices)
- Hourly average water heater load data from EPRI

The Variable Consumer Demand:

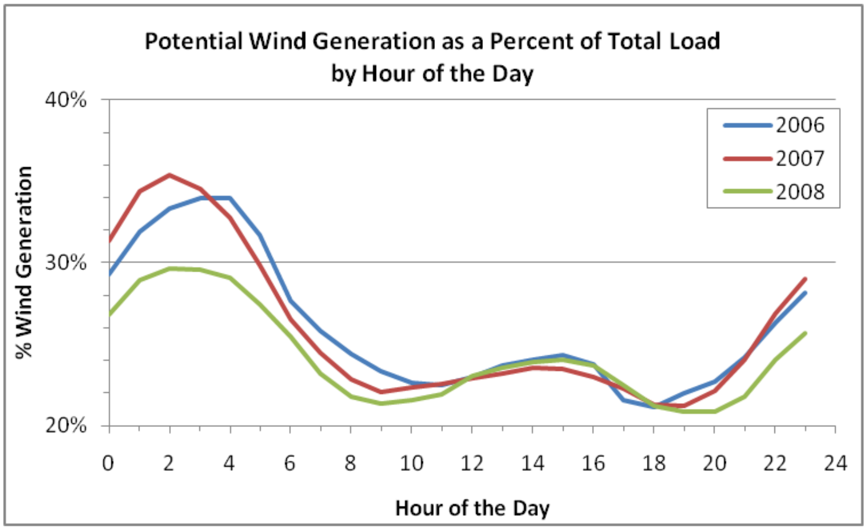


This graph represents one month of a utility's daily load curve. You will notice a definite pattern from day to day. The need to balance generation exactly with this variable load is something grid operators have done for years. When variable renewable generation is added to the variable load pattern,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

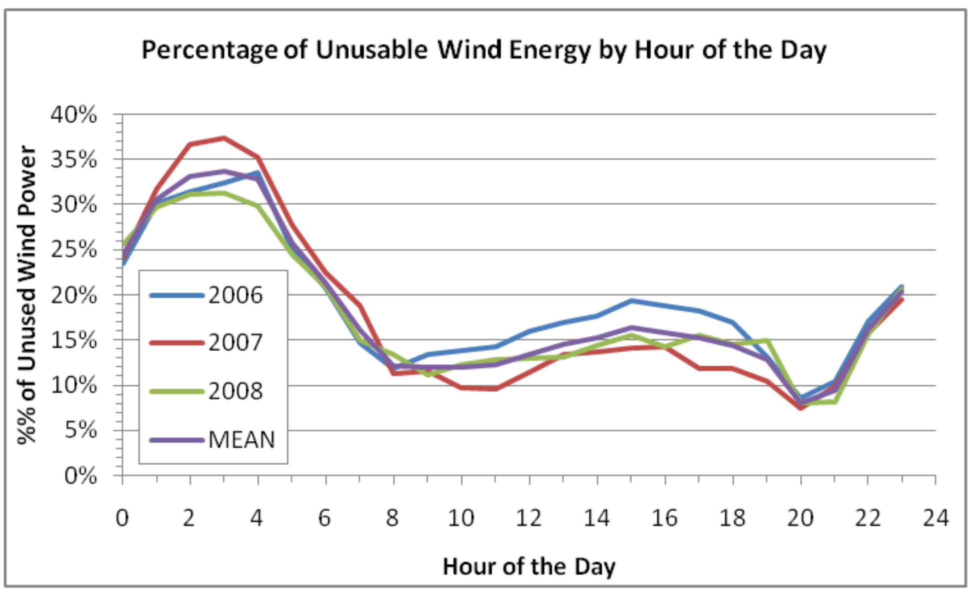
The Variable Wind:



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.

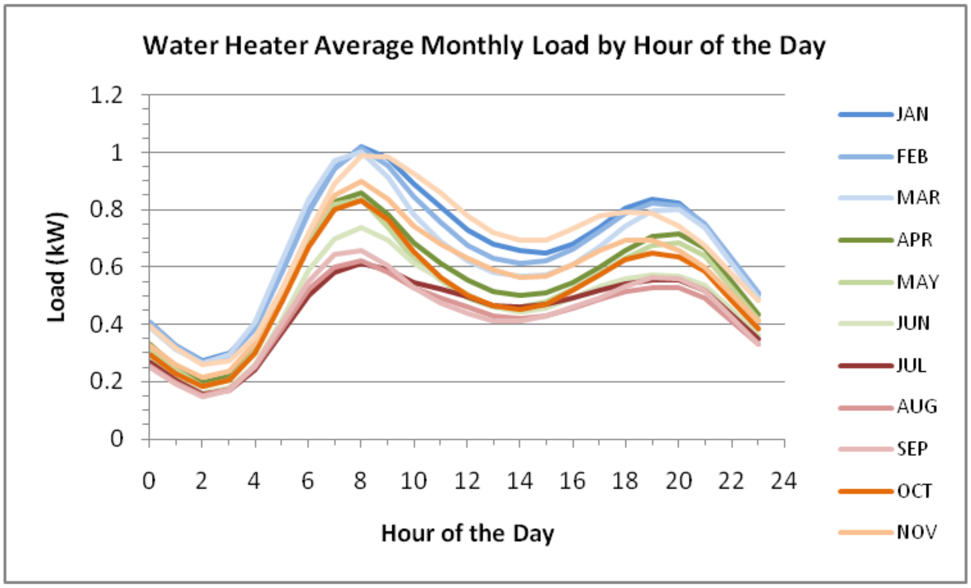


When reviewing average daily wind data over a three-year period, there is a similar pattern from year to year. On average, there is a higher percentage of renewable generation during the early and late hours of the day and a lower percentage during the hours from 8am – 6pm. It is clear that significantly 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.



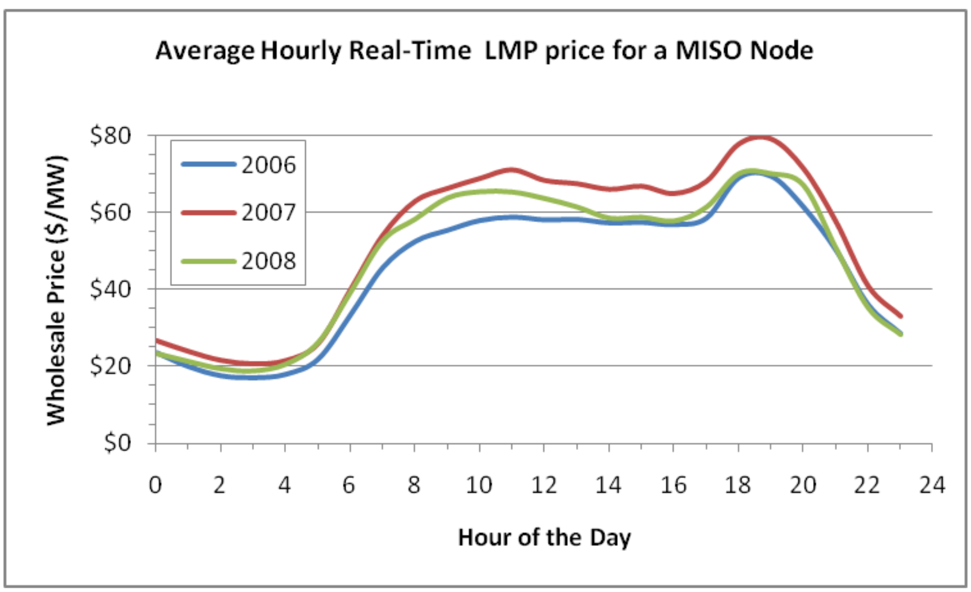
The preceding graph shows the average percentage of unusable wind generation by hour of the day. When wind energy and minimum generation levels exceed consumer demand, energy storage is needed to utilize this carbon-free resource. If this energy cannot be stored, it must be curtailed (turned off or wasted). 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 <u>all</u> hours of the day, making real-time communication essential to integrate renewables whenever they are available.

The Variable Water Heater Load:

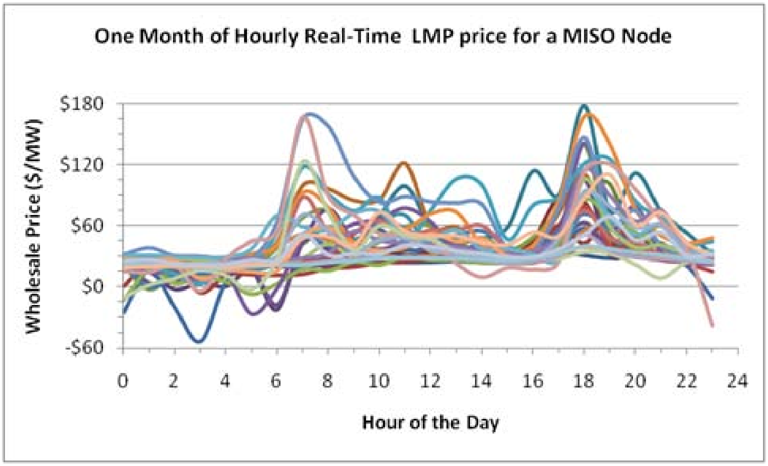


This graph represents the average hourly electric water heater load by month (based on EPRI load data from the Midwest). “Uncontrolled” electric water heaters draw little power in the middle of the night and consume the most energy when loads are typically peaking. Uncontrolled electric water heaters 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:

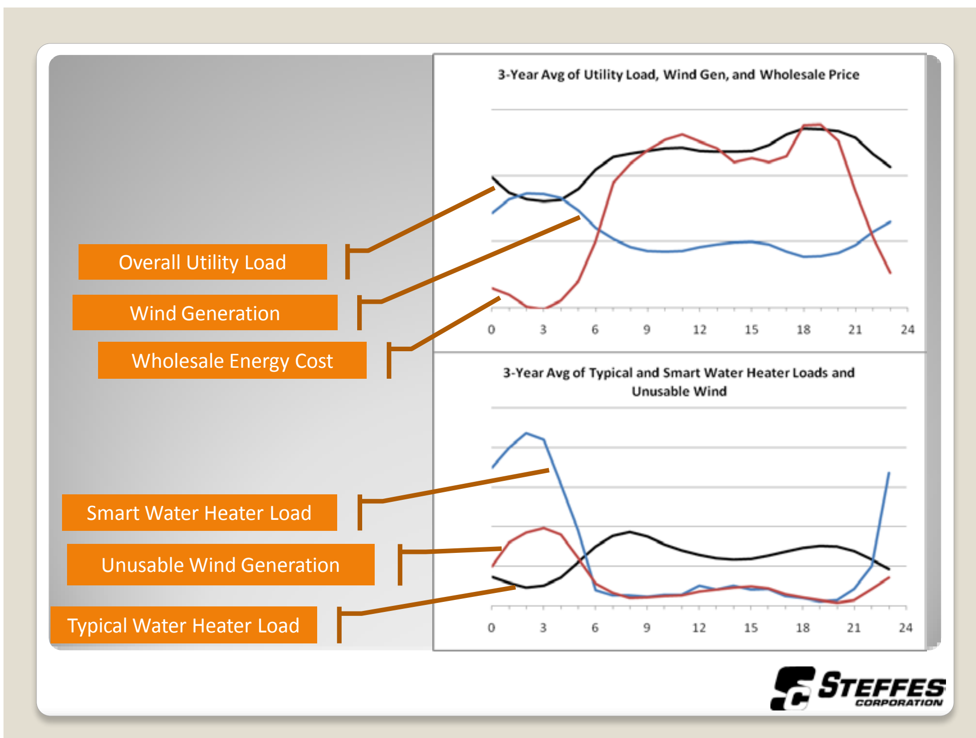


This graph compares three years of average daily energy wholesale costs, commonly referred to as the Locational Marginal Price (LMP). As you can see, the average price by hour is relatively stable year to year.



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 24%	3649 76%	Baseline
85-gal Grid-Interactive Storage Water Heater with Smart Signal	$133	4940	2726 55%	2214 45%	1436
105-gal Grid-Interactive Storage Water Heater with Smart Signal	$126	4974	2840 57%	2134 43%	1515
150-gal Grid-Interactive Storage Water Heater with Smart Signal	$127	5082	3053 60%	2029 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 24%	1828 76%	1821
55-gal Heat Pump Water Heater (Zone 2)	$140	2662	649 24%	2014 76%	1636
55-gal Heat Pump Water Heater (Zone 3)	$153	2934	717 24%	2218 76%	1432
55-gal Heat Pump Water Heater (Zone 4)	$176	3335	820 25%	2515 75%	1134
55-gal Heat Pump Water Heater (Zone 5)	$187	3566	880 25%	2686 75%	964
55-gal Heat Pump Water Heater (Zone 6)	$193	3669	911 25%	2757 75%	892
55-gal Heat Pump Water Heater (Zone 7)	$205	3899	972 25%	2928 75%	721
55-gal Heat Pump Water Heater (Zone 8)	$212	4074	1020 25%	3054 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.

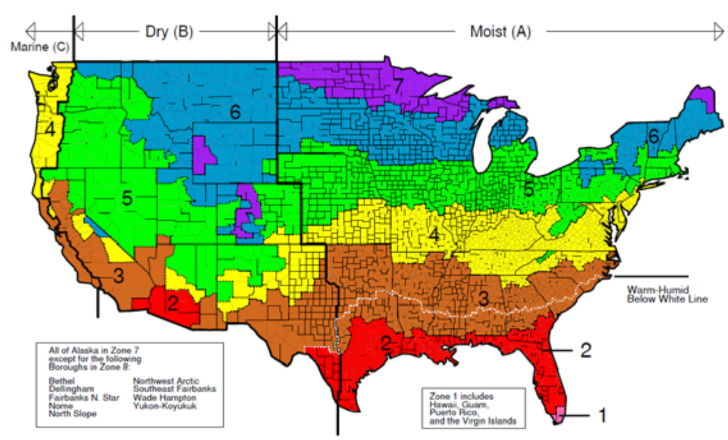
California ISO feels it will need 4,000 MW of resources like electric storage to balance the planned renewable generation.

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).

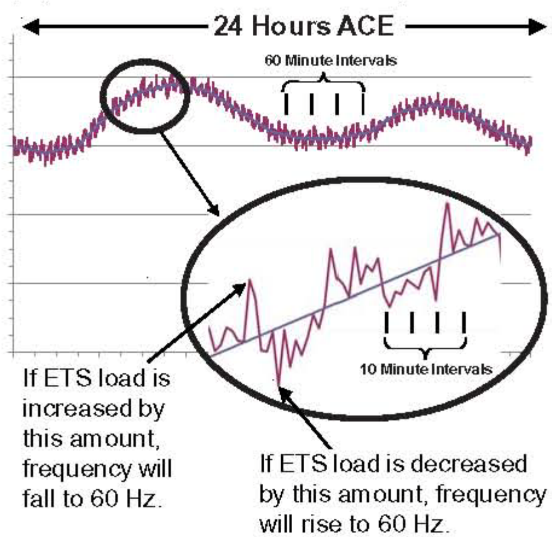
Bonus Ancillary Economic and Environmental Value

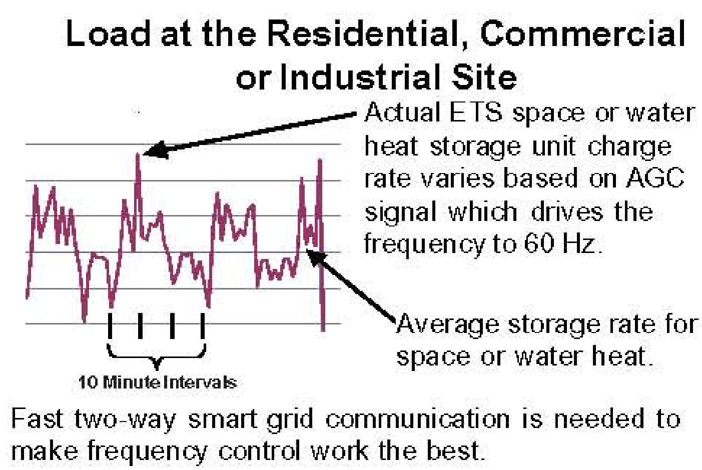
Frequency Control:

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.

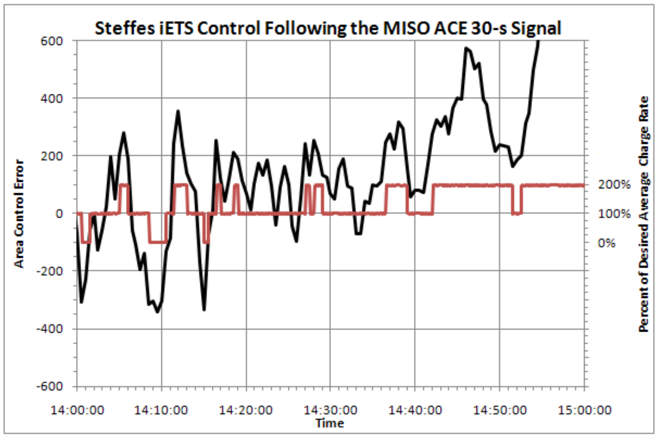


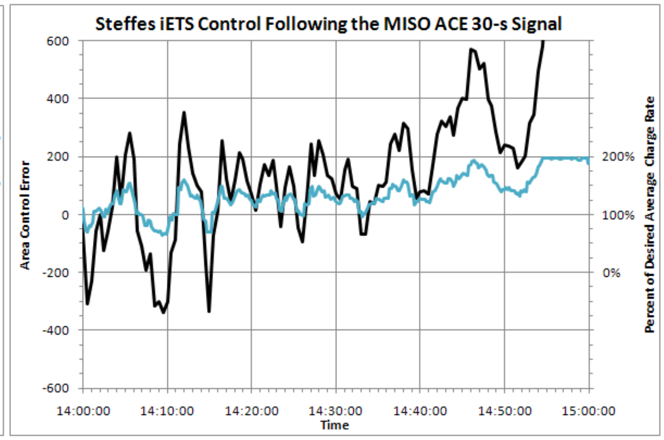


Smart Signal Following

MISO 30-s ACE or 4-s AGC Signal

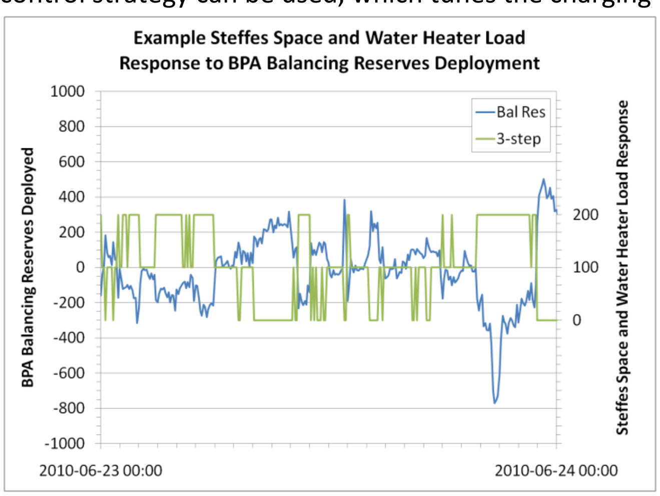
The Midwest ISO (MISO) has an Area Control Error (ACE) signal that indicates the instantaneous difference between net actual and scheduled interchange. When the ACE signal is positive, it indicates that generation exceeds demand and when the ACE signal is negative, it indicates that demand exceeds generation. 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.

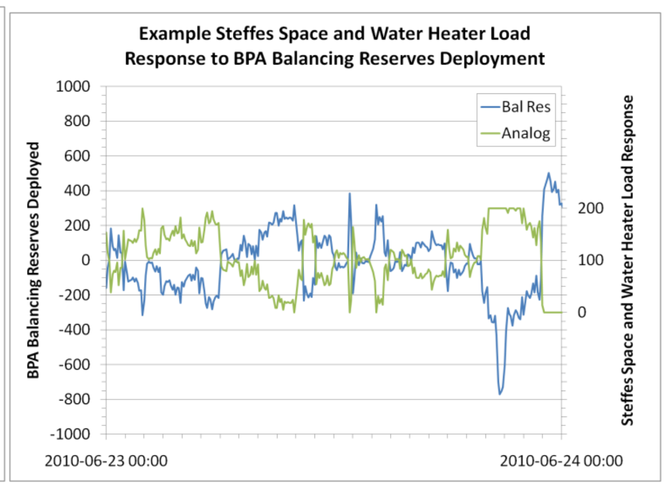




BPA Balancing Reserves Deployment Signal

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

<table>
<tr><th>Benefit</th><th>Mechanism</th></tr>
<tr><td>Enhance Power Quality</td><td rowspan="7">Quickly vary load</td></tr>
<tr><td>Regulate Grid Frequency</td></tr>
<tr><td>Support Renewable Integration and Enhance Renewables Value</td></tr>
<tr><td>Minimize Environmental Impacts and Qualify for Environmental Credits</td></tr>
<tr><td>Provide Arbitrage Value</td></tr>
<tr><td>Provide Spinning Reserve</td></tr>
<tr><td>Improve On-Site Power Quality and Mitigate Resultant Financial Losses</td></tr>
<tr><td>Defer Transmission, Distribution, and Substation Upgrades</td><td rowspan="7">Time-shift load</td></tr>
<tr><td>Defer New Generation Capacity Investments</td></tr>
<tr><td>Extend Transmission and Distribution Asset Life</td></tr>
<tr><td>Increase Transmission and Distribution Asset Utilization</td></tr>
<tr><td>Reduce Transmission and Distribution Loss Costs</td></tr>
<tr><td>Reduce Retail Demand Charges</td></tr>
<tr><td>Reduce Retail Energy Costs</td></tr>
</table>

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.

Economic Benefit

- Lower power production costs
- Utilize low or negative cost wind energy during off-peak wind periods
- Reduced cost of energy purchases
- Decreased frequency control costs or receive ancillary payment
- Lower electric rates for consumers
- Improved heat pump efficiency and lower operating costs

Energy Independence

Renewable energy and off-peak power are domestically produced electric resouces which are abundantly available during many hours of the day. Electric Thermal Storage (ETS) systems provide the ability to fully utilize these beneficial energy resources for space and water heating purposes. Doing so reduces our dependence on imported oil for these purposes. In addition, our environment benefits from the lower emmissions associated with these power generation sources.

ETS Benefits:

- The Power Company
- Consumers
- Our Environment
- Our Nation

ETS systems are perfect for consumers who have availability to the following off-peak electric rates:

- Time of Use
- Smart Meter
- Real-Time Pricing
- Any Other Preferential Electric Rates

Common Installations

- Residential
- Apartments/Condos
- Hotels/Motels
- Schools
- Courthouses
- Offices
- Warehouses
- Churches

Contact Steffes Corporation to learn more.

The Smart Heating and Power Management Solution

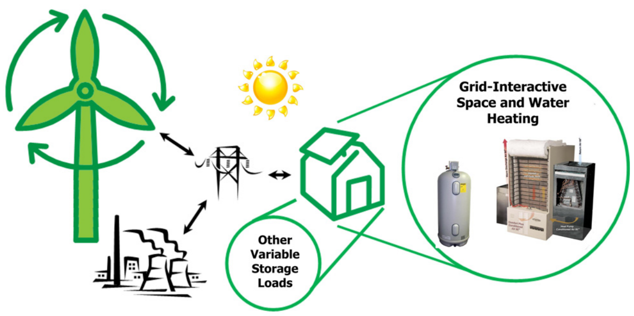
STEFFES CORPORATION

Manufactured in North America

Steffes Corporation • 1-888-783-3337 • www.steffes.com

Low-Cost Electric Storage

for Grid Optimization, Renewable Integration, Frequency Control and Lower Electric Rates



Electric Thermal Storage

Electric Thermal Storage (ETS) is a technology whereby electricity is converted to heat and then used for heating homes or businesses. ETS heaters store heat in dense ceramic bricks in the heater core. Electric storage can occur during off-peak hours, during times when renewable energy is available, or during other times deemed necessary to meet the needs of the power company or grid. Heat is extracted from the brick core as needed to satisfy the comfort requirements of the consumer.

ETS ~ Low-Cost, Long-Life "Thermal Battery"

- 13.5kWh - 480kWh storage capacity models available
- ETS is a small fraction of the cost of other electric storage options

Interactive Water Heater Control

Transform a conventional electric water heater into an enhanced energy storage and power management device.

- Varies the target water temperature and input power
- Provides consumer comfort assurance by first charging the water heaters that need energy the most
- An 80 gallon water heater effectively becomes a 21kWh battery

NEW

Grid Optimization

- Better utilizes off-peak and renewable resources
- Defers substation upgrades
- Reduces transmission congestion and losses
- Improves generator efficiency
- Precision load shaping to meet system, economic, and environmental goals
- Reduces peaks and better utilizes existing generation and transmission resources
- Improves grid reliability

Renewable Integration

Studies have clearly documented the variability of wind generation. The wind blows more during winter than summer and as much at night as during the day. As our country's percentage of wind generation increases, the ability to store energy, especially during low demand off-peak winter hours, becomes extremely important.

Wind and solar resources ramp up and down very quickly as weather changes. ETS systems can respond just as fast to store the renewable energy. This allows a higher percentage of renewables to be utilized.

Store renewable energy when it's available and use it productively as needed.

NOTE: *Wind Assisted Heating white paper is available upon request detailing extensive study on renewables.*

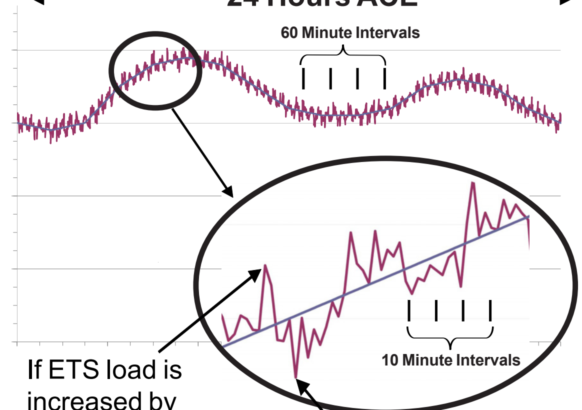
Frequency Control

As more variable renewable energy is added, 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, associate emissions, improving grid reliability, yielding monetary ancillary payments or reduced cost of regulation.

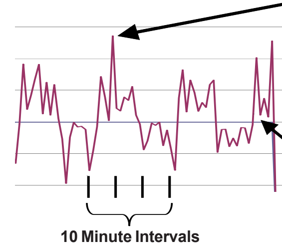
24 Hours ACE



If ETS load is increased by this amount, frequency will fall to 60 Hz.

If ETS load is decreased by this amount, frequency will rise to 60 Hz.

Load at the Residential, Commercial or Industrial Site



Actual ETS space or water heat storage unit charge rate varies based on AGC signal which drives the frequency to 60 Hz.

Average storage rate for space or water heat.

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

Renewable Integration with Distributed Storage

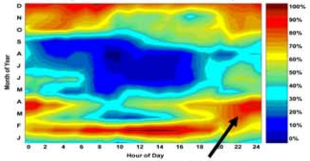
Attachment 6

Renewable energy and a smarter grid are keys to managing our nation's energy resources and keeping electric rates low

Renewable Energy

Renewables have a variable generation pattern that can ramp up or down quickly. Low-cost electric storage allows this resource to be fully used.

Regional Wind Generation Output



More wind generation during heating months and off-peak times

The challenge of effectively utilizing large amounts of renewables and maintaining reliable electric supply is relieved with electric storage.

% of Unusable Wind Energy (Oct-May)

For days with Unused Wind Energy

Assumptions: 25% of total generation is wind and baseload generation is turned down to 25% of capacity.

As renewable generation grows, so does the need for affordable energy storage in order to fully utilize and manage this power supply.

Without storage there will be significant unusable renewable energy.

Grid-Interactive "Thermal Battery"

Low-Cost Distributive Energy Storage for

- Renewable Integration
- Frequency Control
- Grid Optimization
- Lower Electric Rates

Hot Water Storage

A 100 gallon water heater stores the equivalent of 26 kWh's to provide year-round energy storage.

Energy is stored in high density ceramic bricks or in domestic water heater.

A distributed array of interactive storage space and water heaters can absorb Gigawatts of power and store many GWH's of energy.

Input and charge levels vary to integrate renewables and for grid optimization while delivering constant comfort.

Space Heat Storage

An ETS furnace can store up to 480 kWh of energy and provide continuous comfort for consumers.

Energy Storage Cost Comparison

Technology	Cost (/kW·h)	Cost (/kW)
Electric Thermal Storage[†]	\$30 - \$60	\$100 - \$200
CAES (above-ground)	\$200 - \$250	\$700 - \$800
ZnBr Flow Cell	\$280 - \$450	\$425 - \$1300
Pb-Acid Battery	\$330 - \$480	\$420 - \$660
NaS Battery	\$350 - \$400	\$450 - \$550
Flywheel	\$1340 - \$1570	\$3360 - \$3920

Source: EPRI 2009 energy storage technology cost estimates

[†]Source: Steffes Corp.

ETS is a proven, low-cost energy storage solution

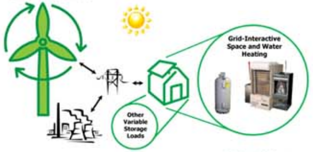
ETS allows renewable energy to be used as a dispatchable load

Smart Control

If electric loads can quickly be varied to match current generation mix without inconvenience to the consumer, variable renewable resources can be fully integrated into the grid. A smart control signal can direct low-cost electric storage to productively utilize extra renewable energy when available and supply hot water and space heat energy when renewable energy is not available.

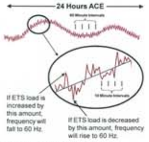
Smart Communication

The communication needed to vary loads for precision load shaping and renewable integration can also be used to optimize existing generation, transmission and distribution assets. In addition, this communication can bring significant monetary and environmental benefit by doing Frequency Control or Regulation without consuming fuel. This provides lower electric costs to the power company and consumer.



Ancillary Value

Fast, smart control signals can quickly ramp space and water heater loads up and down as needed in response to increased or decreased frequency.



This reduces generator fuel consumption and associated emissions, improves grid reliability, and yields significant monetary ancillary payments or reduced cost of regulation.

STEFFES CORPORATION — Learn More at www.steffes.com • 888-783-3337

Customer-owned electric thermal storage (ETS) space and water heaters along with smart control can integrate renewables at a very affordable cost