Off-Peak Water Heating

Teaching an Old Dog to Do New Tricks

presented by

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STEFFES
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GRID-INTERACTIVE ELECTRIC THERMAL STORAGE
Cost-Effective Scalable Energy Storage Delivering Space & Water Heat

ADVANCED DEMAND RESPONSE
Renewable Integration Fast Regulation
Smart Thermal Energy "Batteries"
Electrical Energy Demand

Figure 75. U.S. electricity demand growth, 1950-2040 (percent, 3-year moving average)
Off-peak Water Heating

Traditional Value

- Build kWh sales – offpeak
- Member benefit – Savings
- Load Management Resource
- Good Margin for Cooperative
- Optimize electric infrastructure – generation, transmission & distribution
- Provides ability to adapt to future needs of electric industry – Renewables, Regulation and other Ancillary Services
Grid-interactive Electric Thermal Storage (GETS)

Dynamically couples consumer usage to real-time grid needs, while ensuring the real-time consumers need for space and water heating continuously met.
Grid-Interactive Space & Water Heaters Are…

“THERMAL BATTERIES”

With smart control, you effect the grid exactly like other electric storage technologies.
Grid Challenges

The needs of the Smart Grid today include the balancing of...

- Variable Generation
- Variable Demand
- Variable Price

ETS Space and water heaters are grid interactive solutions
Balancing Supply & Demand

**Imbalance Conditions**

**Over-generation**
- Total Generation > Total Demand
- Frequency > 60 Hertz
- Generators momentarily speed up

**Under-generation**
- Total Generation < Total Demand
- Frequency < 60 Hertz
- Generators momentarily slow down
Grid-interactive ETS (GETS)

Ancillary Services - Regulation

A fossil power plant following a fast regulation command signal —

It cannot keep up!!

GETS Provides High Speed, Up and Down, Regulation

Charging is varied UP and DOWN from a “bid in” base line.

PJM Frequency Regulation Signal  Water heater consumption
Win with Low-Cost GETS

Lose – Lose

- Increasing amounts of curtailed renewable energy
- Low or Negative electric energy sales growth

Win – Win – Win

- Grid Balance by consumers using electricity to meet the real-time needs of the Grid
- Utilities make money by delivering fast regulation services and previously curtailed renewable energy
- Participating consumers share in utility profit directly and all consumers gain from overall lower electric rates
Provides “Double Green” benefits:

- Economic
- And
- Environmental
GETS is Very Low-Cost

ES-Select™ created by KEMA for Sandia National Lab 5-2012
GETS Demonstrations

Water Heater

PJM Demonstration

- 105 Gallon Water Heater
- Control Inputs
  - Energy Price
  - Frequency Regulation Signal
Water Heater – Optimization of LMP and Frequency Regulation

Charging during low LMP periods

And

Following frequency regulation signal

Pilot water heater in use by PJM Technology Center
Putting it all together…

Hourly Net Energy Cost

Cumulative Annual Energy Cost

$168

-$79
### Wholesale Annual Operating Cost

**for Electric Water Heater**

<table>
<thead>
<tr>
<th>Type/Method</th>
<th>Energy Cost</th>
<th>Demand/Trans. Other Costs</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled</td>
<td>$256</td>
<td>$50 - $200</td>
<td>$306 - $456</td>
</tr>
<tr>
<td>Grid-Interactive LMP Optimized</td>
<td>$108</td>
<td>0</td>
<td>$108</td>
</tr>
<tr>
<td>Grid-Interactive with Regulation</td>
<td>-$80</td>
<td>0</td>
<td>-$80</td>
</tr>
</tbody>
</table>

- **Uncontrolled Water Heater**: No controls installed on water heater
- **Grid-Interactive Water Heater**: Consumes energy when LMP is low, but not doing regulation
- **Grid-Interactive with Regulation**: Consumes energy when LMP is low and provides regulation (Under FERC Order 755, possibly -$230?)
Electric Thermal Storage

Storage of Renewable or Off-Peak Electricity in the form of Heat

- Electricity is stored as heat in a well insulated brick core.
- On-board Microprocessor based control system regulates charging and discharging.
- Internal blower system delivers the heat to the conditioned space as needed to maintain comfort 24/7.
- Storage occurs based on availability of renewable or off-peak energy or as signaled by the utility for ancillary services.

It’s FULLY AUTOMATIC

All heating is accomplished by using off-peak or renewable energy
Dynamically Couples Consumer Electric Usage to the Real-time Needs of the Grid
+Actively ensuring Consumers always have heat

Two-way, Real-time, Steffes Smart Controller

• Set Precise Charge Rate (0-100% wattage)
• Set the Target Charge Level (temperature)
• Report Individual Unit Current SOC (State of Charge)
• Report Metering and Verification
Note: There is greater average daily usage during winter months
January 2012 WH Data

Average for Hour of Day

Average for Day of Week

actual data from 100+ GETS water heaters
Steffes Dynamic Dispatch

Control Signal
- LMP
- AGC
- BRD
- Congestion
- Weather

Market Aggregator
Utility or Virtual Power Plant

Interoperable Communication

Steffes “GETS” Cloud

Endpoint Aggregator

Optional Home Owner Web Portal

Steffes GETS
Space and Water Heaters

eDirector
Grouping
Feeder, substation, billing node or other

STEFFES GETS CLOUD

GETS Group #1
GETS Group #2
GETS Group #3
Dynamic Dispatch

Unit Energy Proportioning (selective charging)

High Usage VS Low Usage

Seamlessly assign preferential load levels to end points with lower reserve capacities
• Power Measurement
• Revenue Grade Accuracy
• Real-time performance feedback
• Performance archiving and retrieval

STEFFES GETS CLOUD

GETS Group #1

GETS Group #2

GETS Group #3
Aggregated Group of Water Heaters

- Actual Group Power
- Power Request
- Baseline Input
- Actual Power – Baseline Input
- Power Request – Baseline Input
- Actual – Requested Power
Wide Area and Home Area Communication Options

(WAN) Utility Grid-Interactive Signal to Home
- Homeowner Broadband
- Utility Owned Broadband
- 3G or 4G Cellular
- Other Wide Area Two-Way Communication

(HAN) In-Home Communication Network
- Ethernet Cable
- Home Plug Ethernet over Powerline
- Other In-Home Two-Way Communication
Questions?

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Steffes Corporation
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