Grid-Interactive Loads: Pursuing Market Acceptance through Codes and Standards

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Leader In Cost Effective Electric Storage

- Load Management
- Fast Regulation
- LMP Optimization
- Renewable Integration

Work with over 200 Electric Utilities, many for over 20 years
Steffes Corporation

- Manufacturer of Innovative Products and Services for the Energy, Utility and Construction Industries
- Over 40 Years in Business
- 200,000 sq feet of Manufacturing Space
- 300+ Employees
- Sales Territory - North America

ASME

UL

ISO 9001 2008
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”
Grid-interactive Electric Thermal Storage (GETS)

Dynamically couples consumer usage to real-time grid needs

Space Heating

Water Heating
Hydro Plus Water Heater

with Dynamic Dispatch™

Cost-Effective
Distributed yet GRID SCALE
Energy Storage

Set Precise Charge Rate (0-100% wattage)

Set the Target Charge Level (temperature)

Report Individual Unit Current State of Charge

Report Power and Energy Metering for Verification
Why is GETS important?

• Saves consumers money
• Helps Integrate Large Quantities of Renewables
• Helps Utilities Manage Load Shape
• Reduces Emissions of Greenhouse Gases
• It’s low-cost Energy Storage “Thermal Battery”
• Aggregated Water Heaters are Distributed Energy Resources yet GRID SCALE flexible load
• Think of 50 Million Electric water heaters as a Terawatt-hour, 200 Gigawatt, “Battery”

WIN-WIN-WIN

Consumer, Utility, Environment
Demonstrations and Deployments

• Last 30 years: Deployed 100,000 passively controlled ETS units in all areas of USA and Canada

• Last 10 years: Demonstrated 1,000 actively controlled GETS units in over 25 projects in all regions

• Last 1 year: Deployed hundreds of actively controlled GETS units
Building Codes


• Worked to allow Grid-interactive water heaters in Building Codes Since 2007
• 2015 IGCC has recognize GETS as an approved option
• Three current submittals into IECC for the 2016 code cycle for flexible thermal energy storage devices
• Member of TC 6.9 (Energy Storage) for 25 years
• Chapter 51 rework in ASHRAE 2016 Handbook
• Recognition in 189.1, 90.1 and 90.2
• More ongoing code work in progress
How does GETS bring value?

• Provide fast regulation to stabilize the grid

• Integrate much higher percentages of renewable electricity
A fossil power plant following a fast regulation command signal --

It cannot keep up!!
A very fast grid-interactive water heater

Not only can the water heater keep up – it does so very accurately
Putting it all together in PJM…

Hourly Net Energy Cost

Cumulative Annual Energy Cost

- Uncontrolled Cost
- Controlled Cost

Cumulative Uncontrolled Costs
Cumulative Controlled Cost

$168

-$79
Solar Over Generation

Typical Spring Day

- Ramp need
  - ~13,000 MW in three hours

Over generation risk

Net Load 14,160 MW on April 5, 2015 at 15:46
Daily Energy Production from a 5-kW Photovoltaic (PV) Array - Honolulu, HI
Daily Energy Production from a 5-kW Photovoltaic (PV) Array - Los Angeles, CA

- MAX = 30.8 kW·h/d
- MIN = 3.72 kW·h/d

1. Energy Production vs. Day of Year
2. Energy Production vs. Sorted Day
Daily Energy Production from a 5-kW Photovoltaic (PV) Array - Minneapolis, MN

- **Energy Production (kW-h/d)**
  - Day of Year
  - MAX=33.82
  - MIN=3.03

- **Energy Production (kW-h/d)**
  - Sorted Day
  - MAX=33.82
  - MIN=3.03
Daily Energy Production from a 5-kW Photovoltaic (PV) Array – Portland, OR

- Maximum energy production: 31.91 kW-h/d
- Minimum energy production: 2.02 kW-h/d

The chart on the left shows daily energy production over the year, with energy production ranging from 0 to 40 kW-h/d. The chart on the right shows a box plot for sorted days, indicating the spread and central tendency of energy production data.
Individual Water Heaters Daily usage
Variability over the Year

Note: There is greater average daily usage during winter months
Dynamic Dispatch - Aggregate Group
System View (actual case study data and display)

MW\textsubscript{(electric)}

Charge Rate
Coupled to the real-time needs of grid

MW\textsubscript{(thermal)}

Discharge
Delivery of hot water

MWh\textsubscript{thermal}

State of Charge
Individual GETS Water Heater

End Point Details

<table>
<thead>
<tr>
<th>CONTROL STRATEGY</th>
<th>CONTROL SIGNAL</th>
<th>ACTUAL POWER</th>
<th>STORED ENERGY</th>
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<tr>
<td>ACTIVE</td>
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</table>

Selected Temperatures, Power and Energy

- Top Temp
- Average Temp
- Bottom Temp
- Individual Water Heater Power
- Element on Percent
- Total Wh
Community Storage 5.4MW—42MW-h

Actual Group Power

Power Request

Baseline Input

Actual Power – Baseline Input

Power Request – Baseline Input

Actual – Requested Power
Community Storage 2MW–4MW-h

Power Request (Green) – Ramps UP or DOWN based on need
Measured Power (Dark Blue) – Confirms high-accuracy following in real-time

Individual water heaters take on energy to satisfy customer and grid need

Over 100 water heaters acting in concert to provide predictable, precision control

Planned charging buffered by actual solar conditions and real-time grid needs
Focused on Standards and Interoperability since the founding meeting of the NIST Smart Grid Interoperability Panel (SGIP) in November of 2009

George Arnold spoke of the interesting chicken or egg comparison to new industries and standard

Must me room for new innovations
Current Communication Standards

- OpenADR
- TCP/IP Ethernet & WIFI
- DNP3
- BACnet
Future Communication Standards

- MultiSpeak
- IEC 1850
- ANSI C12
- SEP 1.x and 2.0
- OASIS EMIX
- CEA 2045
- Satellite or FM Radio
- Zigbee
- Z-wave
- 6LoWPAN
- LORA
- ????????
Provides “Double Green” benefits:

- Economic
- Environmental

And
Questions?

Steffes Corporation

“Commitment to Innovation”

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