

Grid-Interactive Energy Storage: *Specific Applications*

How to Communicate with and get Economic and Environmental Value



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BENEFICIAL ELECTRIFICATION
Off-Peak Space & Water Heating

GRID-SCALE ENERGY STORAGE
Lower Green House Gases


CONTINUOUS DEMAND RESPONSE
Renewable Integration

WIN-WIN-WIN
Consumer-Utility-Environment


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Electric Thermal Storage (ETS)




15 to 500 kWh
Energy Storage



10 to 25 kWh
Energy Storage

- Largest users of energy in the home 60+%
- Have storage capability



Applications



- Residential
- Commercial
- Industrial

100,000 installations in North America
A distributed 8 GWh "Thermal Battery"



Industrielle Alliance - Montréal, QC
800 kW controllable load
5 mWh storage



1st Lutheran Church - Bottineau, ND
480 kW controllable load
2,640 kWh storage



Campbell School – Campbell, MN
1,120 kW controllable load
6,160 kWh storage



Chugwater School – Chugwater, WY
400 kW controllable load
2,200 kWh storage



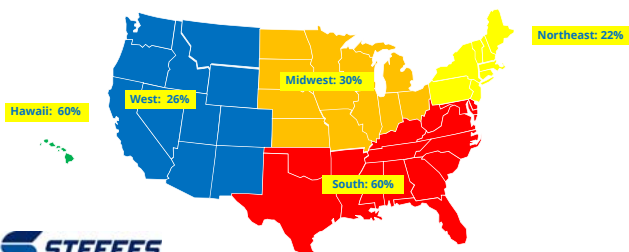
Richland County Courthouse & Law Enforcement Center - Wahpeton, ND
200 kW controllable load 1,100 kWh storage



Armory - Bottineau, ND
280 kW controllable load
1,500 kWh storage



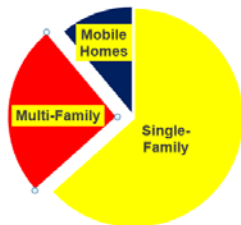
41% Electric Water Heat Saturation



Census Housing Survey Table 2.5 (2010)

Magnitude of Potential

45 Million Water Heaters		Total
Capacity	4.5kW/ea.	202.5 gW
Energy Storage Capacity	12kWh	540 gWh
Annual Energy	3800kWh/ea.	171 tWh



Grid-interactive Electric Thermal Storage (GETS)

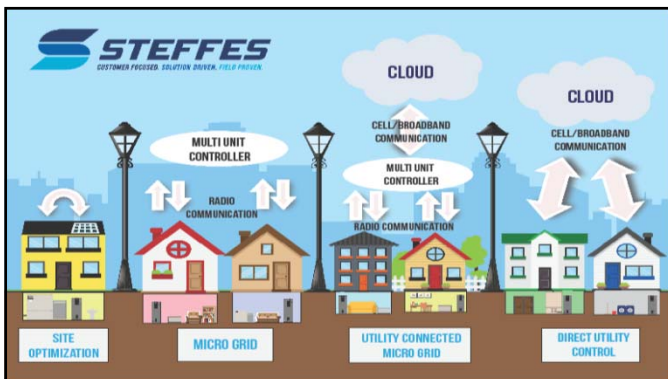
Dynamically couples consumer usage to real-time grid needs



Grid-interactive ETS (GETS)

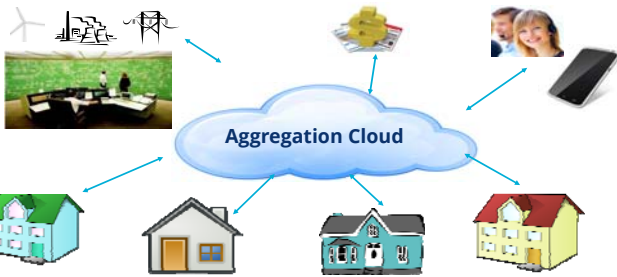
- Provides Grid Reliability, Stabilization, and Optimization
- Improves System Efficiency
- Helps Integrate Large Quantities of Renewables
- Provides Economic Value:
 - Market Price
 - Regulation Services
 - Less renewable curtailment
 - Stops paying to sell renewable energy
 - Helps manage 'bi-directional' feeder constraints





Hydro Plus Solar Water Heater





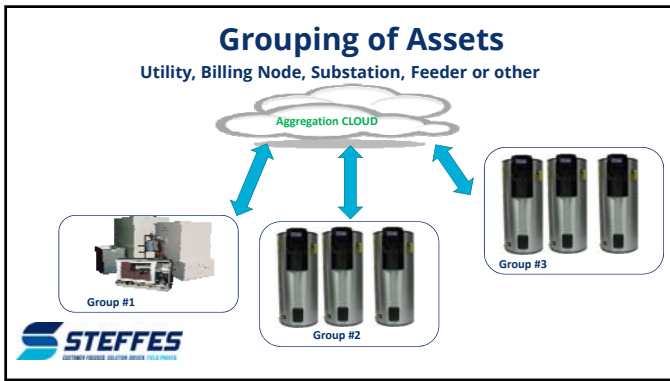
Wide Area and Home Area Communication Options

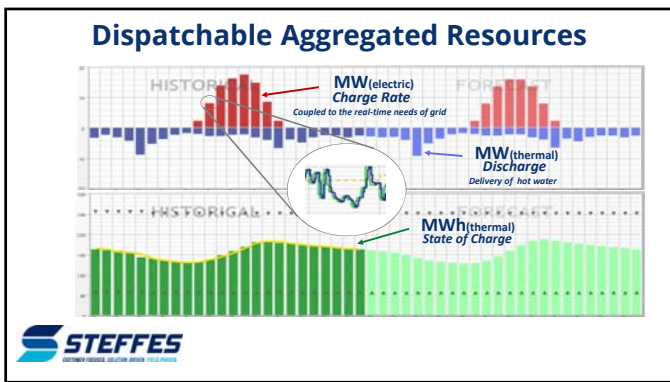


- Utility Owned Broadband
- (WAN) Utility Grid-Interactive Signal to Home**
- Homeowner Broadband
 - Utility Owned Broadband
 - 3G or 4G Cellular
 - Cellular: Cat. M1
 - NB-IoT
 - LoRa
 - Other Wide Area Two-Way Communication

- (HAN) In-Home Communication Network**
- Ethernet Cable
 - Home Plug Ethernet over Powerline
 - Zigbee
 - Bluetooth
 - Wifi
 - Other In-Home Two-Way Communication

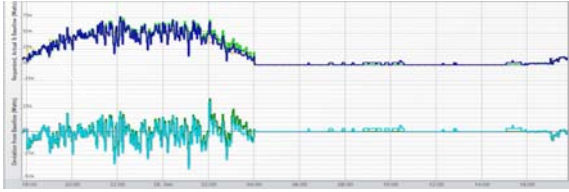






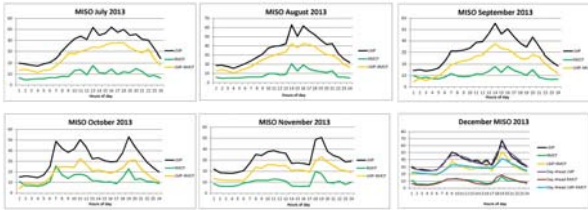


Real-Time Community Storage Aggregate Control 2.2 MW—5MW-h



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

MISO 2013 Data



Microgrid: Wind integration demonstration



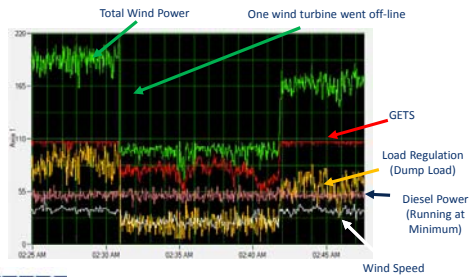
Why is GETS technology important?

WIN-WIN-WIN
Consumer, Utility, Environment

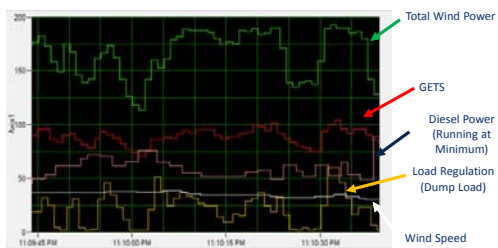
- **Saves consumers money**
- **Lower Utility demand charges**
- Provides fast regulation
- Better uses existing utility infrastructure
- Integrates large quantities of renewable
- Reduces GHG's
- **Cost-effective** Energy Storage



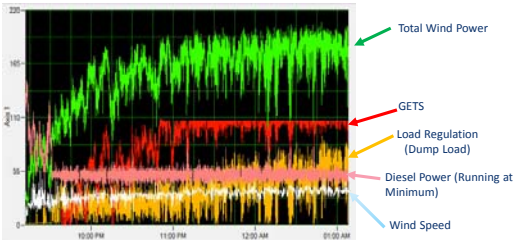
Microgrid: Dynamic Balancing



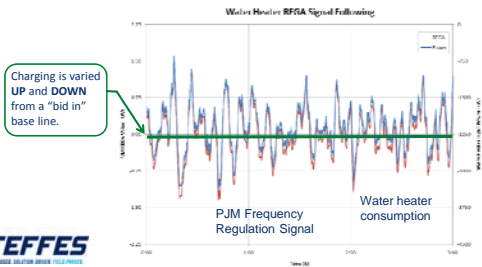
Microgrid: Balancing Second by Second



Microgrid: Wind Ramping

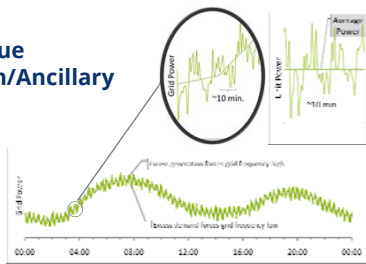


GETS Provides High Speed, Up and Down, Regulation



Maintaining 60Hz on the Grid

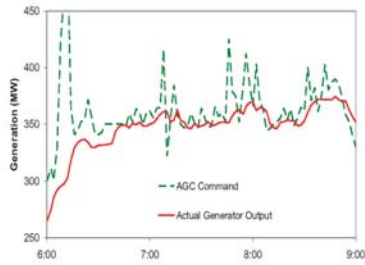
Bonus Value Regulation/Ancillary



Fast Regulation – Speed Matters...

A fossil power plant following a fast regulation command signal --

It cannot keep up!!



Manage Bi-directional Feeder Constraints



Steffes

"Commitment to Innovation"



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