Grid-Connected Energy Storage

7A) *Grid-Connected Electric Resistance Water Heaters*

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Paul Steffes March 22, 2018

psteffes@steffes.com www.steffes.com

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

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

Paul Steffes | Steffes LLC | psteffes@steffes.com

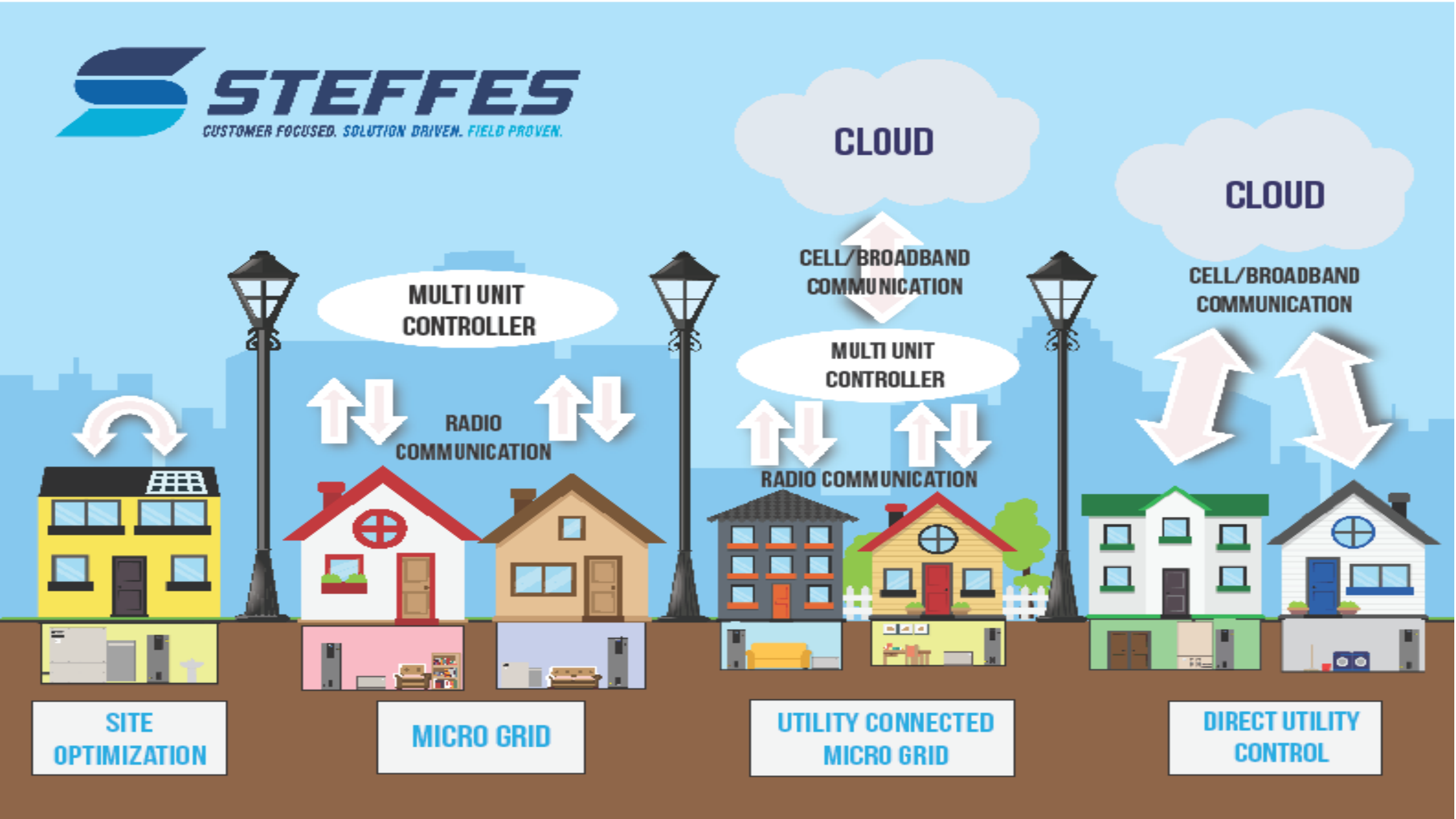
Integration of various groups?

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.



Site Optimization (one home)

STEFFES

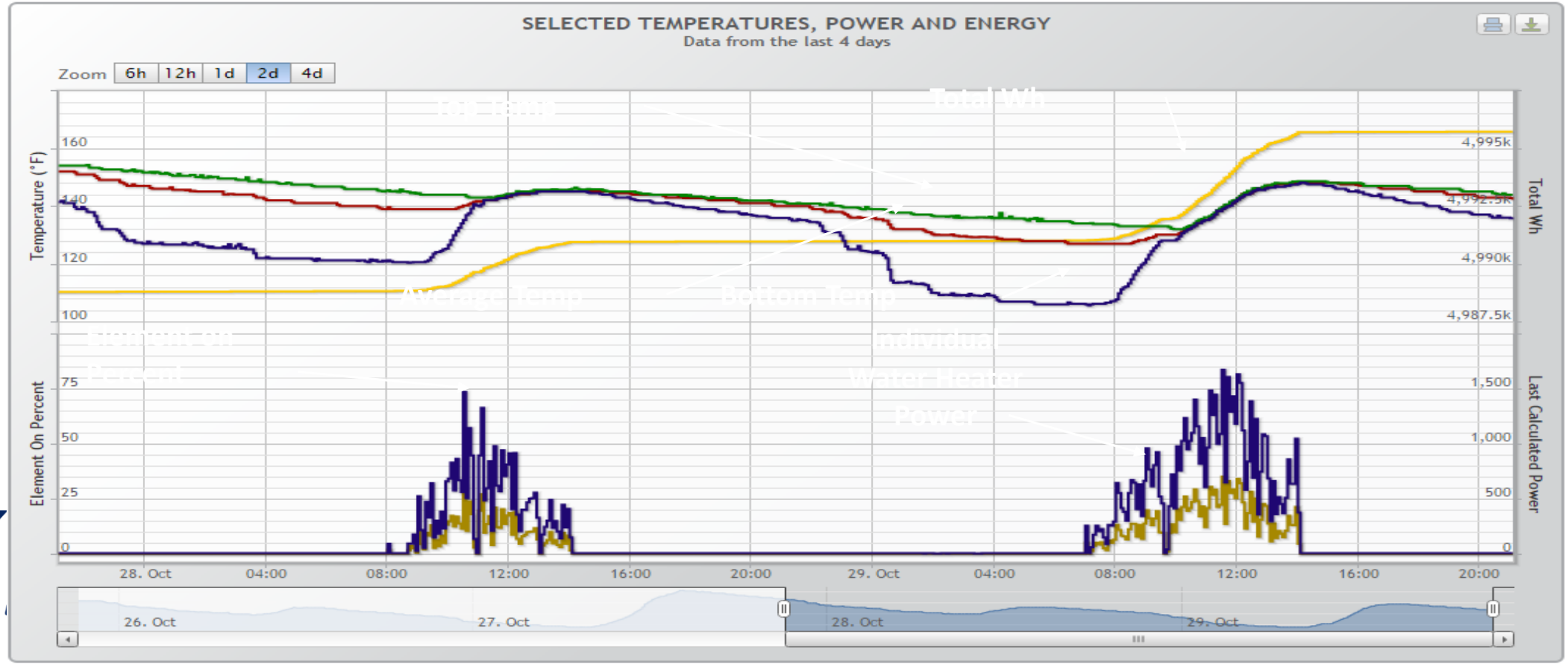
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Individual GETS Water Heater

End Point Details

Water Heater: SITE05 - Water Heater

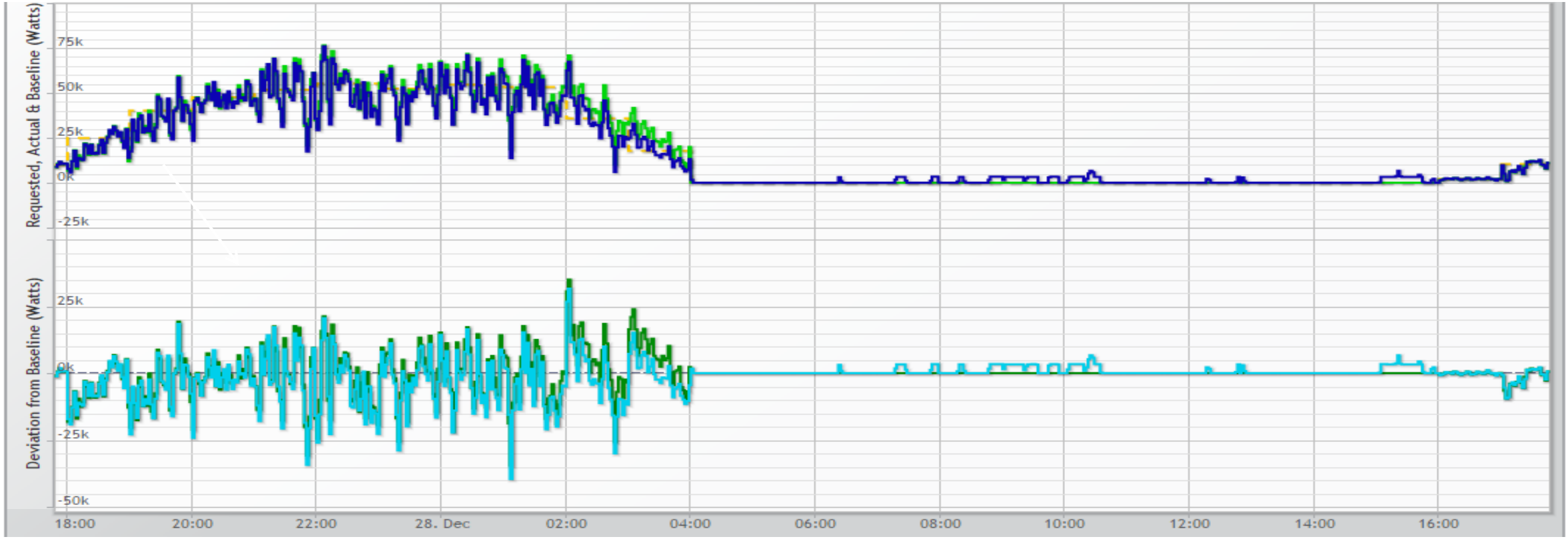
CONTROL STRATEGY AGGREGATE BALANCING CONTROL	CONTROL SIGNAL 0	ACTUAL POWER 4 Watts	STORED ENERGY 10,088 Wh
OVERRIDE CONDITIONS NO OVERRIDES	LOCKED CHARGE LEVEL 124	AVAIL POWER 4,888 Watts	AVAIL ENERGY STORAGE 4,462 Wh
ERROR STATUS NO ERRORS	CHARGE LEVEL INDEX 66	MAX POWER 4,892 Watts	MAX ENERGY STORAGE 14,550 Wh
DEVICE STATUS ACTIVE			



Hawaiian Electric's 1st BTM Residential Energy Storage 2.2 MW—5MW-h "Micro-grid"

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

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



STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

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

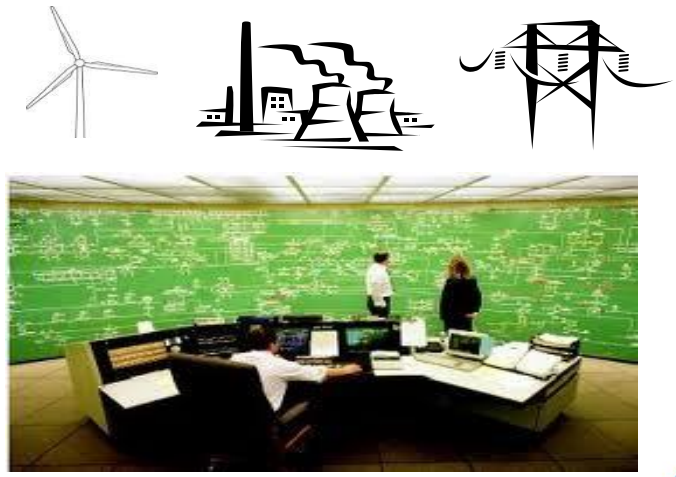
Utility Connected Micro-Grid

Allows for Micro-grid optimization and for larger grid need optimization as well

Direct Utility Control

Allows for individual water heaters and other grid edge storage assets to be aggregated for larger grid optimization.

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

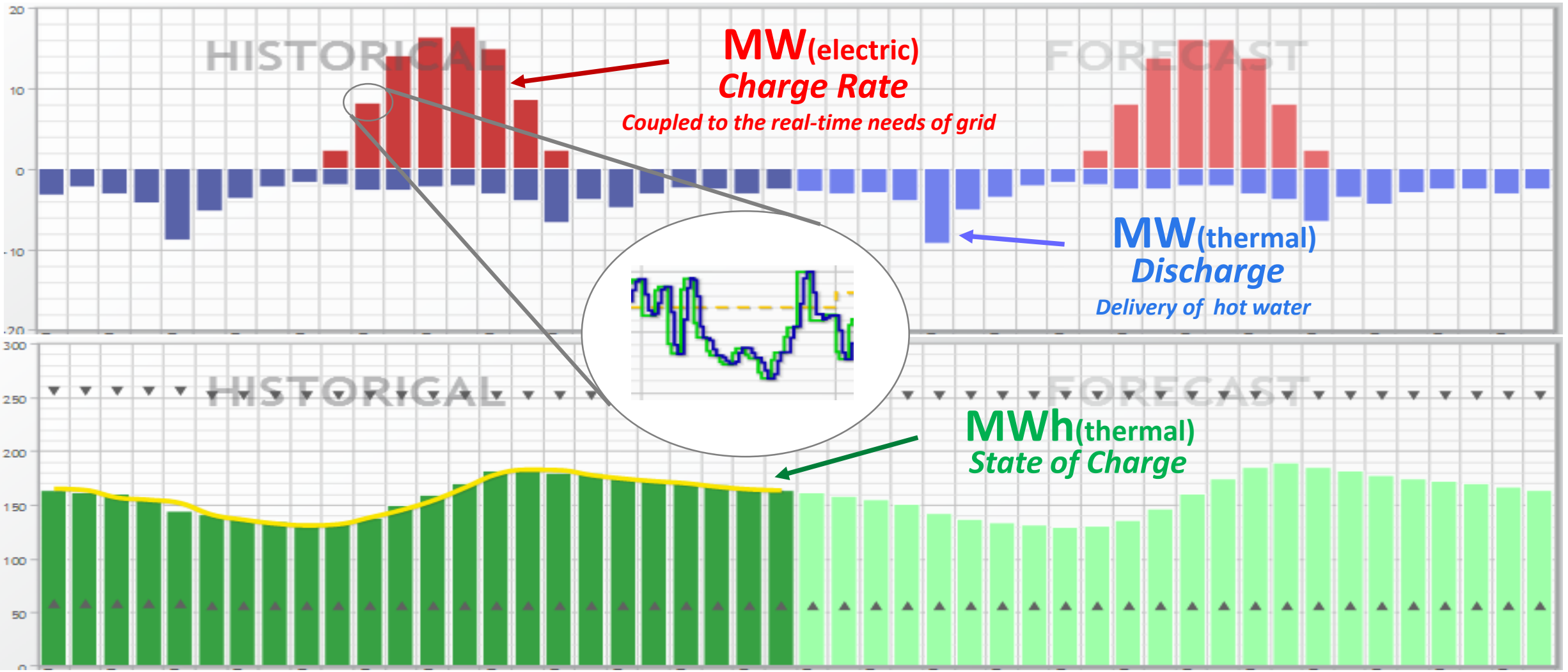


Aggregation Cloud

STEFFES

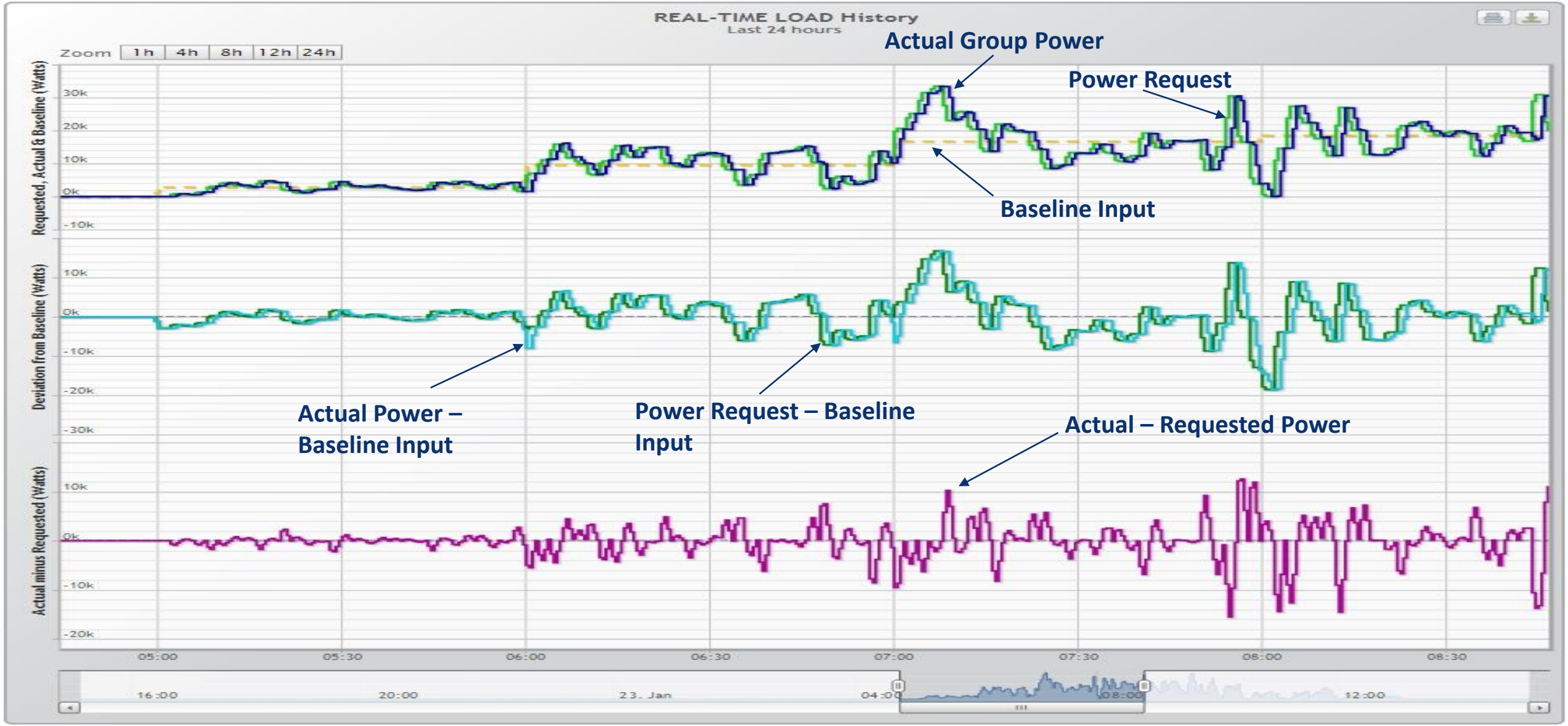
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Dispatchable Aggregated Resources



STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Real-Time Community Storage Aggregate Control 5.4MW—42MW-h



Grouping of Assets

Utility, Billing Node, Substation, Feeder or other

Aggregation CLOUD

Group #1

Group #2

Group #3

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Grid-interactive Electric Thermal Storage (GETS)

Dynamically couples consumer usage to real-time grid needs

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Why is GETS technology important?

WIN-WIN-WIN

Consumer, Utility, Environment

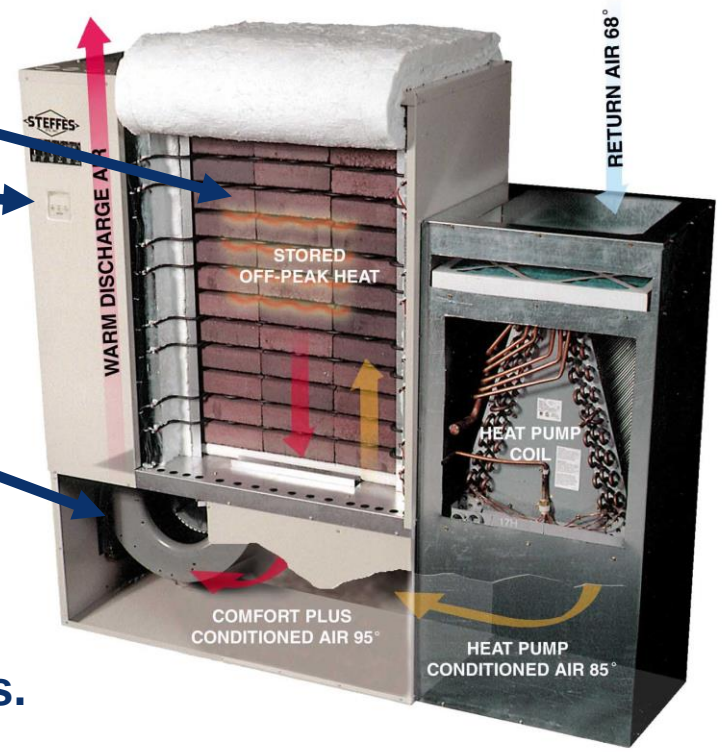
- **Saves consumers money**
- Provides fast regulation
- Better uses existing utility infrastructure
- Integrates large quantities of renewable
- Reduces GHG's
- ***Cost-effective*** Energy Storage

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Electric Thermal Storage

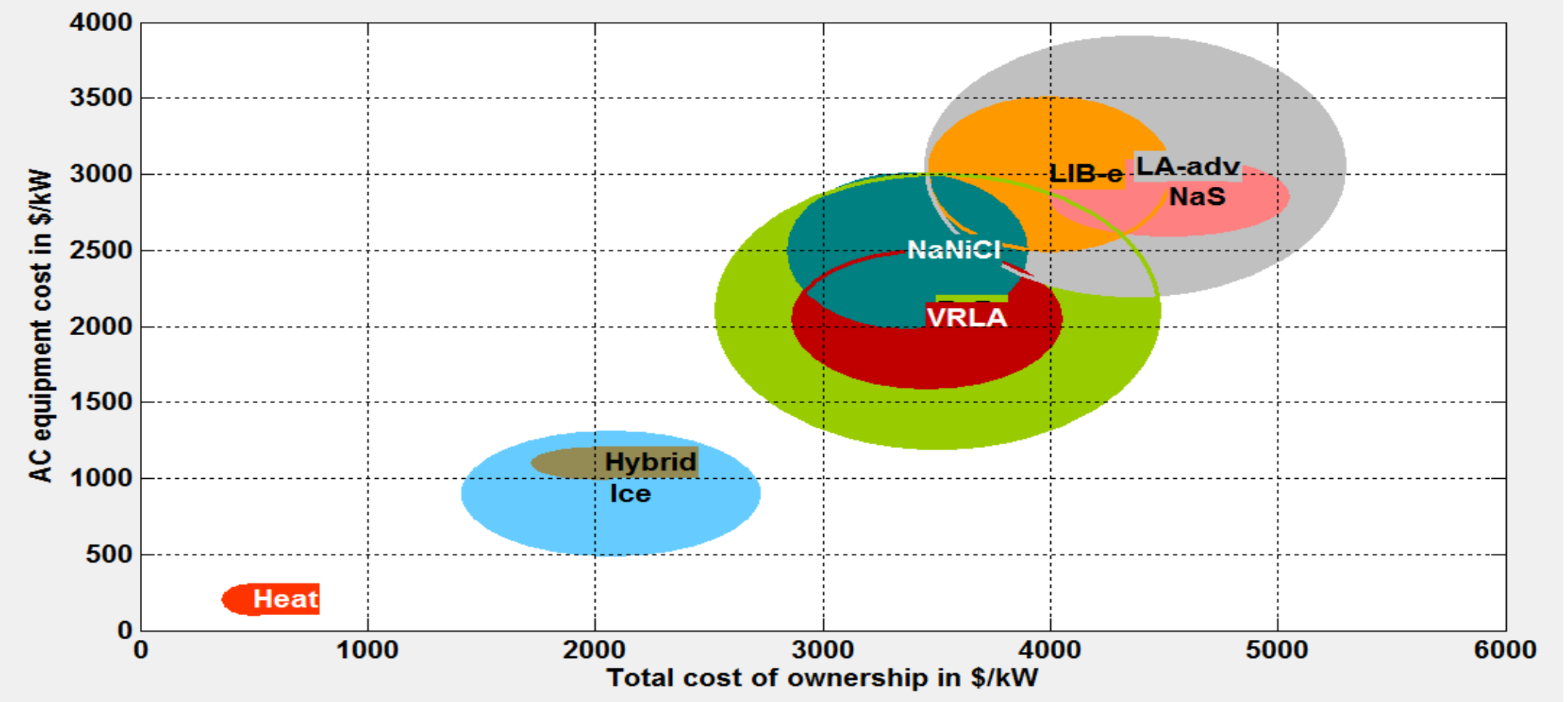
- Electricity is stored as heat in a well insulated brick core.
- On-board Microprocessor based control system regulates charging and discharging.
- Internal blower system delivers the heat to the conditioned space as needed to maintain comfort 24/7.
- **It's FULLY AUTOMATIC**
  - **Storage occurs based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



All heating is accomplished by using off-peak or renewable energy

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Sandia – Energy Storage Costs



STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Electric Thermal Storage (ETS)

15 to 500 kWh
Energy Storage

10 to 25 kWh
Energy Storage

- *Largest users of energy in the home*
- *Have storage capability*

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Car vs GETS vs Battery

Nissan Leaf

- 9.5 kWh / day
- ~$30,000

Steffes Hydro Plus

- 10 kWh / day
- ~$1,500

Tesla Battery

- 7 kWh
- ~$6,500

STEFFES

CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

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 curtailment or paying to sell renewable energy
  - Reduces GHG
  - Provide regulation services

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.

Steffes

"Commitment to Innovation"

Paul Steffes, Founder
Steffes LLC
3050 North Highway 22
Dickinson, ND 58601
701 483 5400
psteffes@steffes.com

STEFFES
CUSTOMER FOCUSED. SOLUTION DRIVEN. FIELD PROVEN.