Grid-Interactive Energy Storage
Space and Water Heating

Paul Steffes February 15-16, 2018
psteffes@steffes.com www.steffes.com

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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
Paul Steffes | Steffes LLC | psteffes@steffes.com

Current Grid Challenges

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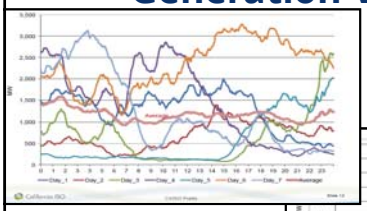
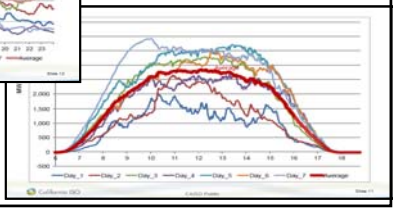
Generation Variability

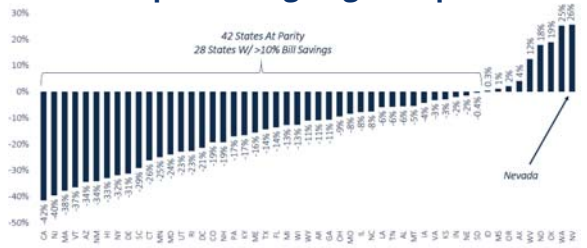


Wind Variability

Solar Variability

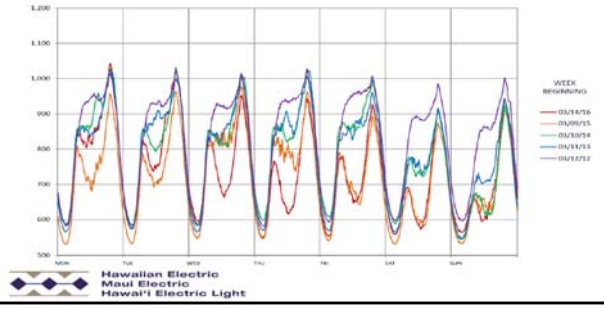


Roof top solar is going to explode! 2020



Bi-directional Power Flow Feeder Constraints

A Dramatic Evolution: O'ahu's Load Curve



Hawaiian Electric
Maui Electric
Hawai'i Electric Light

CAISO - Impact of PV & Wind to Net Load

Figure 4. Frequency of negative LAP prices in 15-minute market (April – June 2015)

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Percent of Negatively Priced Hours

Percent of Negatively Priced Hours for ELAP_AZPS
Source: California ISO load settlement reports

Year	Month	Hour 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2016	10				3%	3%					3%	13%	16%	19%	13%	10%	10%	6%							
	11			3%			3%	3%	7%	13%	20%	20%	20%	33%	20%	13%	3%								3%
	12					6%	6%				3%	10%	29%	26%	26%	16%	3%								
2017	1	3%	6%	6%	6%	10%	10%			6%	19%	13%	16%	26%	23%	13%	13%	6%							
	2		7%	7%	18%	25%	11%	4%			18%	39%	36%	43%	29%	29%	29%	25%							4%
	3		3%	6%	13%	39%	13%	3%	10%	23%	45%	52%	55%	52%	65%	42%	48%	32%	16%				3%		6%
	4	7%		10%	10%	17%	13%	7%	13%	20%	23%	20%	60%	67%	33%	37%	33%	27%	13%	3%		3%			3%
	5	3%	3%	3%	3%			6%	23%	26%	16%	19%	16%	19%	19%	19%	10%								
	6				7%			17%	23%	30%	27%	17%	13%	13%	10%	10%	7%								3%
	7	3%	3%	3%			3%	3%	3%	6%	3%														

Don't pay AZ to take your surplus Electricty

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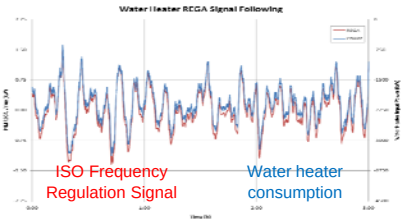
Fast Regulation to balance the Grid

Under FERC Order 755, fast acting regulation resources could be compensated at **much** higher rates than today.



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Great Variability of need for Hot Water

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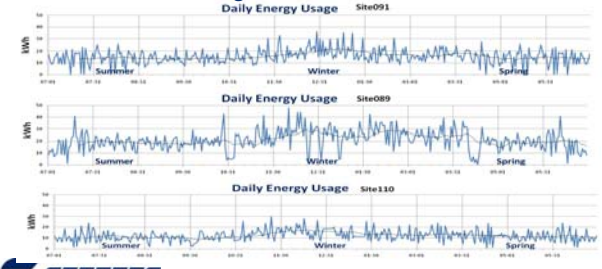
BPA – Actual kWh / day Single WH over 365



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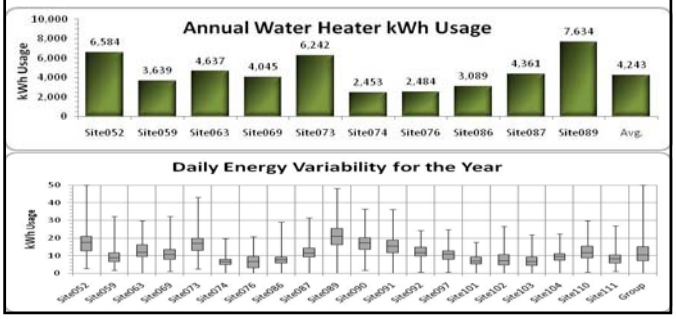
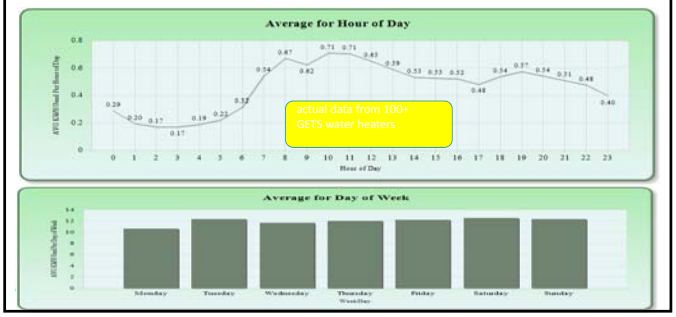
Note: There is greater average daily usage during winter months

Energy Analysis



Group of 150 Water Heaters



What is GETS?

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Electric Thermal Storage (ETS)

- Residential
- Commercial
- Industrial

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

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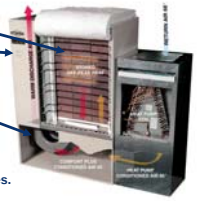
Electric Thermal Storage

- 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

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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***

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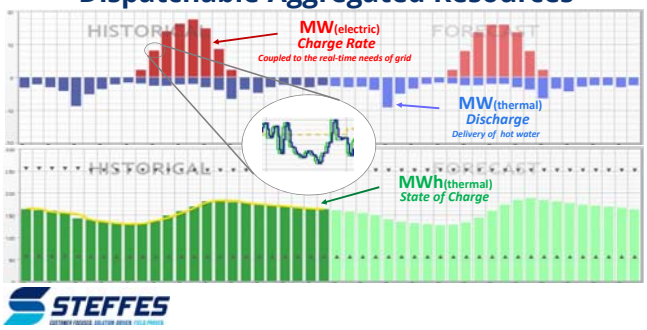
Dispatchable Aggregated Resources



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Grid-interactive Electric Thermal Storage (GETS)

Dynamically couples consumer usage to real-time grid needs

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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

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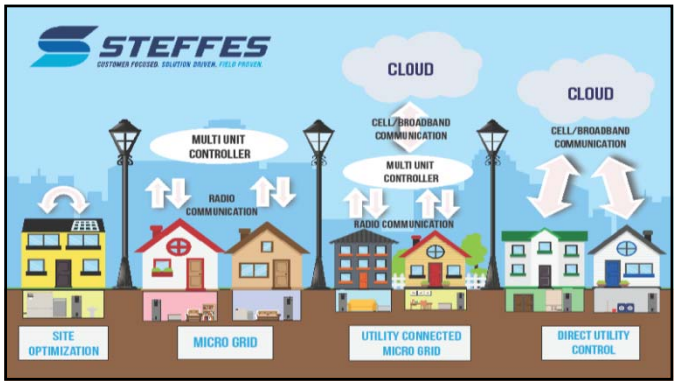
Integration of various groups?



Steffes Microsoft Video

https://youtu.be/v9_FaeOfaRA

Hydro Plus Solar Water Heater

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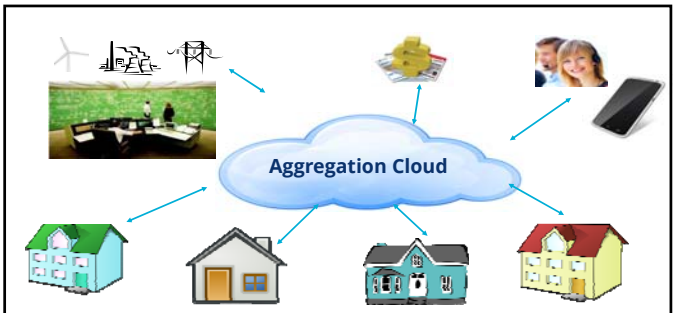

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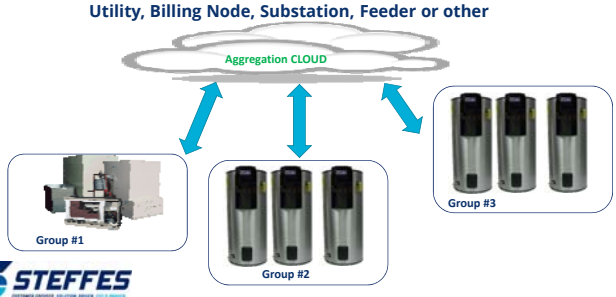
Grouping of Assets

Utility, Billing Node, Substation, Feeder or other



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

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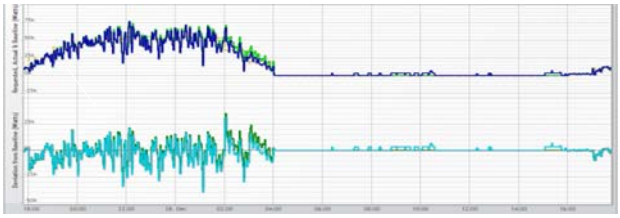
Real-Time Community Storage Aggregate Control 2.2 MW—5MW-h



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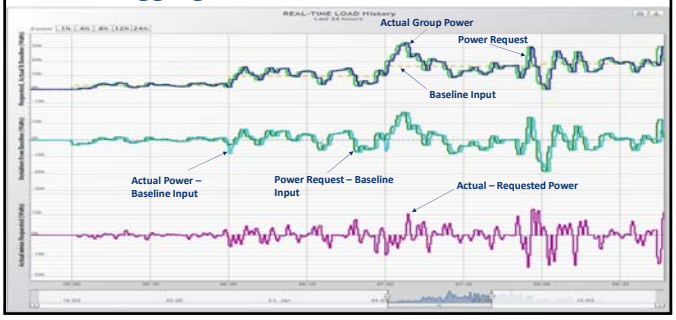
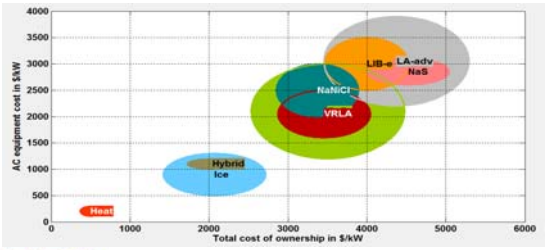
Over 100 water heaters acting in concert to provide predictable, precision control

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



Economic Value

Sandia – Energy Storage Costs



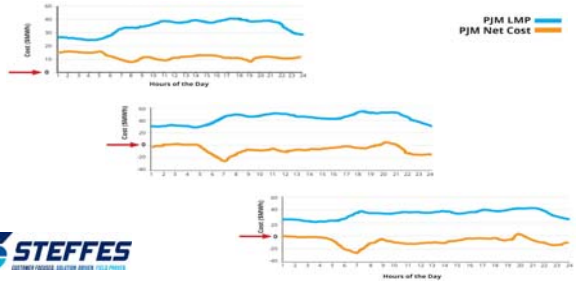
Car vs GETS vs Battery

Nissan Leaf
- 9.5 kWh / day
- ~$30,000

Steffes Hydro Plus
- 10 kWh / day
- ~$1,500

Tesla Battery
- 7 kWh
- ~$6,500

Value of LMP optimization and fast regulation



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

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"Commitment to Innovation"

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