

Grid-Connected Energy Storage

5A. *Controls, Monitoring and Retrofits*



Paul Steffes March 22, 2018

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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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**Not only Grid-Connected
This is Grid-Interactive
OR
Grid-interactive Electric Thermal Storage (GETS)**



***Cost-Effective
Grid Scale
Energy Storage***



Set Precise Charge Rate (0-100% wattage)



Set the Target Charge Level (temperature)



Report Individual Unit Current State of Charge



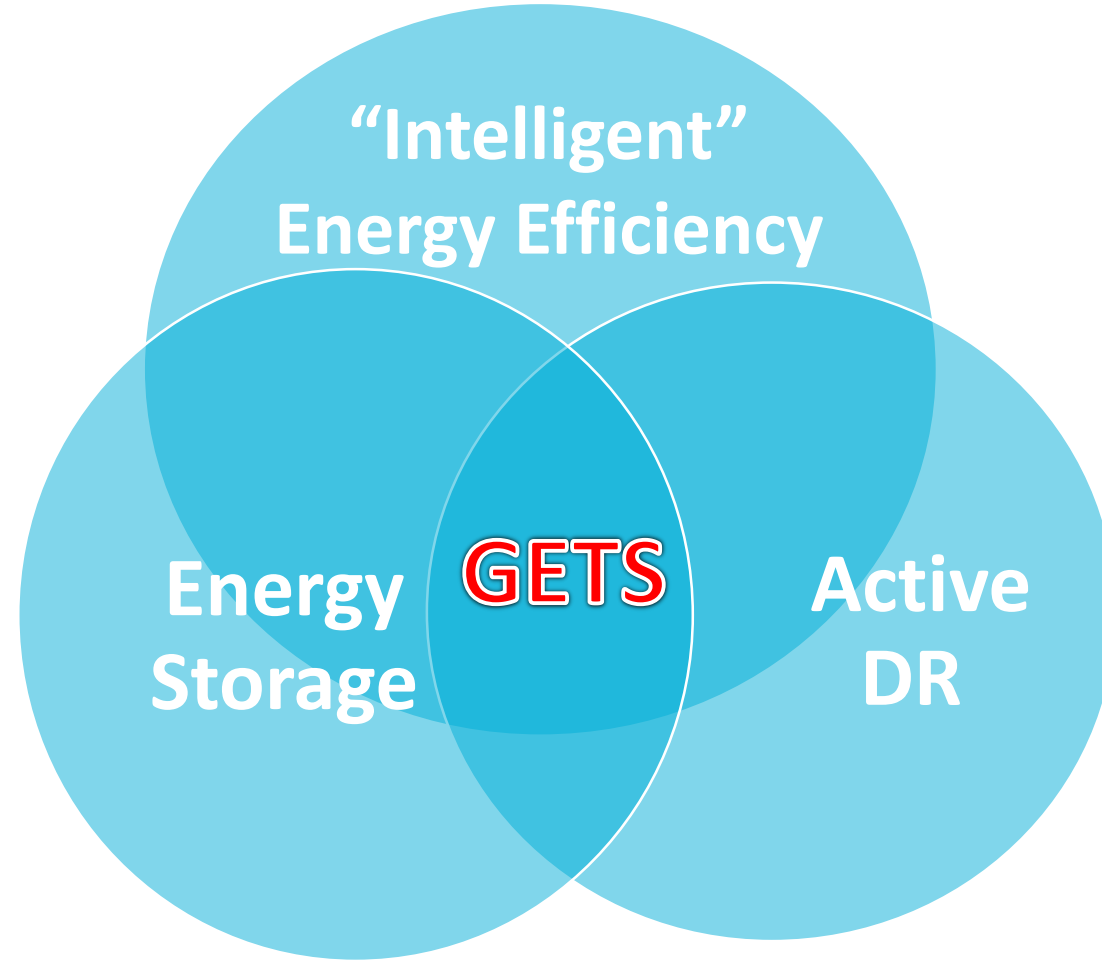
Report Power and Energy Metering for Verification



Selectively Charge the colder Water heaters faster

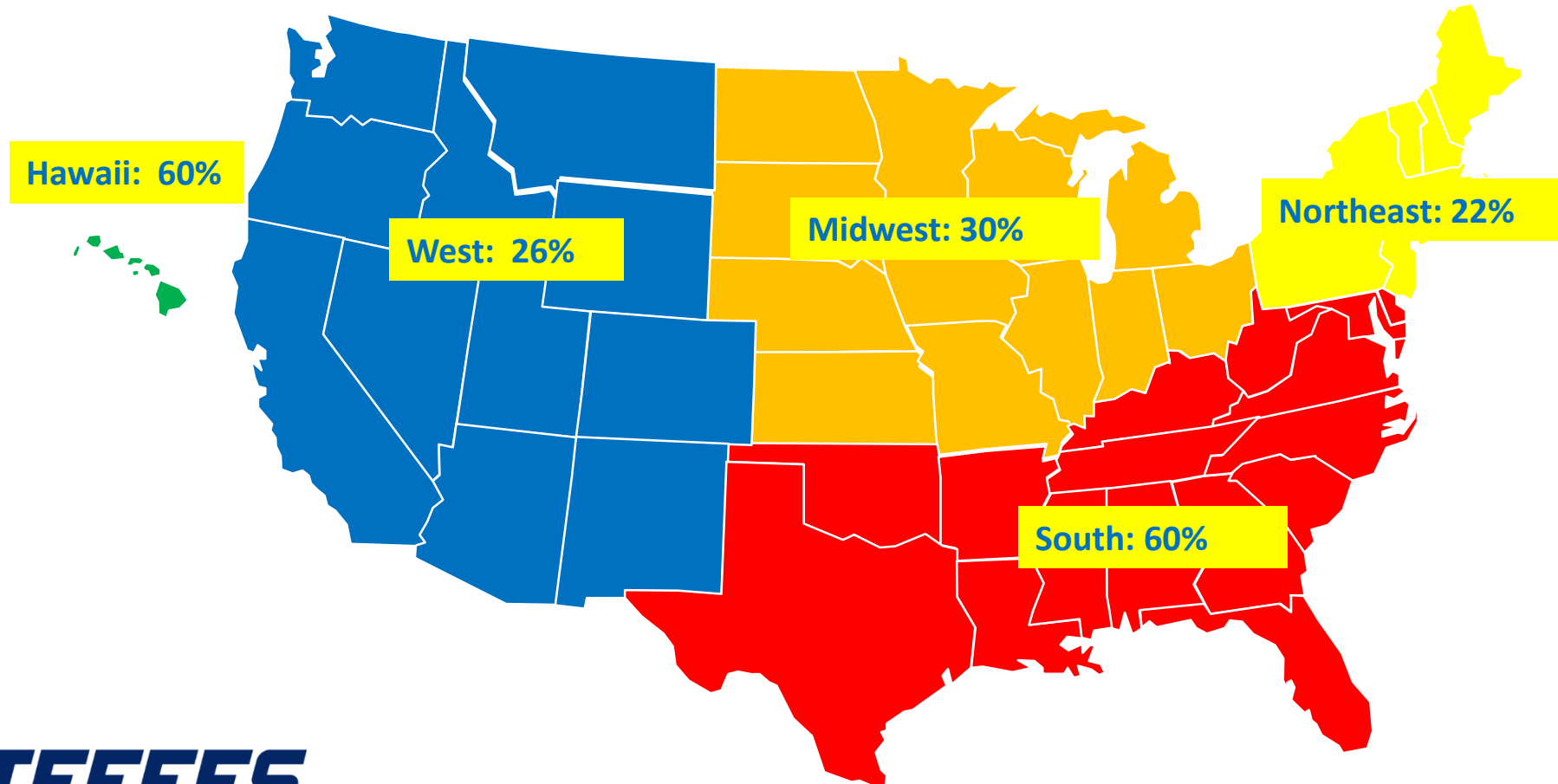
**With Precise
Visibility-Controllability- Verification
these
Distributed Energy Storage Devices
become an essential
Grid Scale Flexible Resource**

GETS – Flexibility



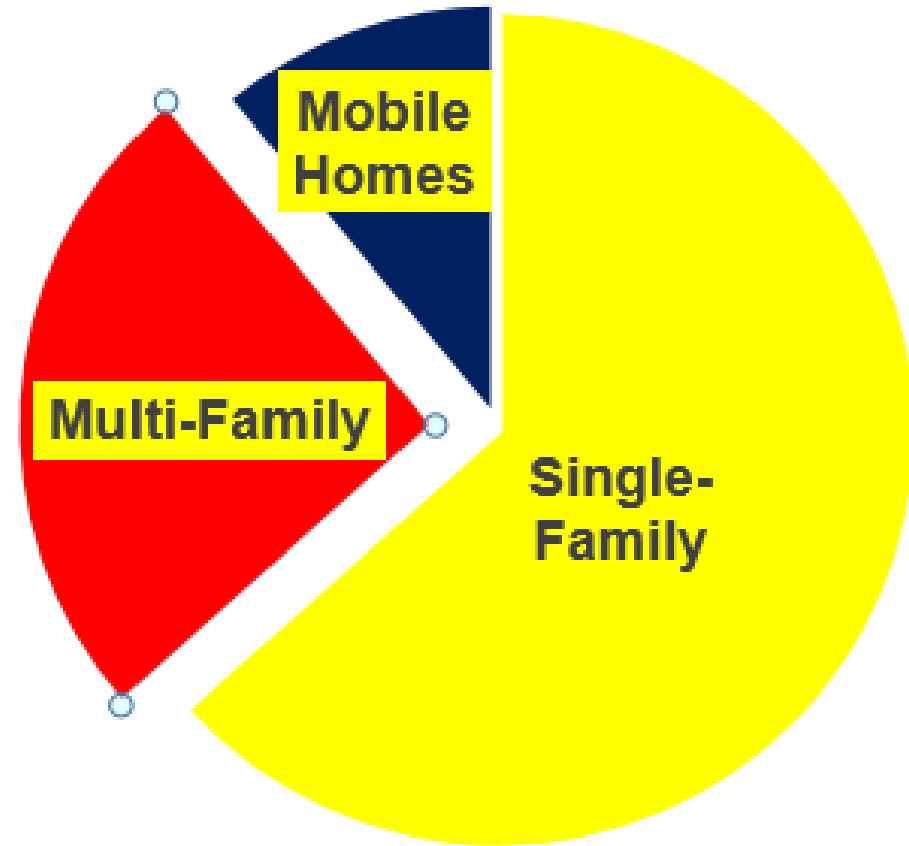
Win – Win - Win

41% Electric Water Heat Saturation



Magnitude of Potential

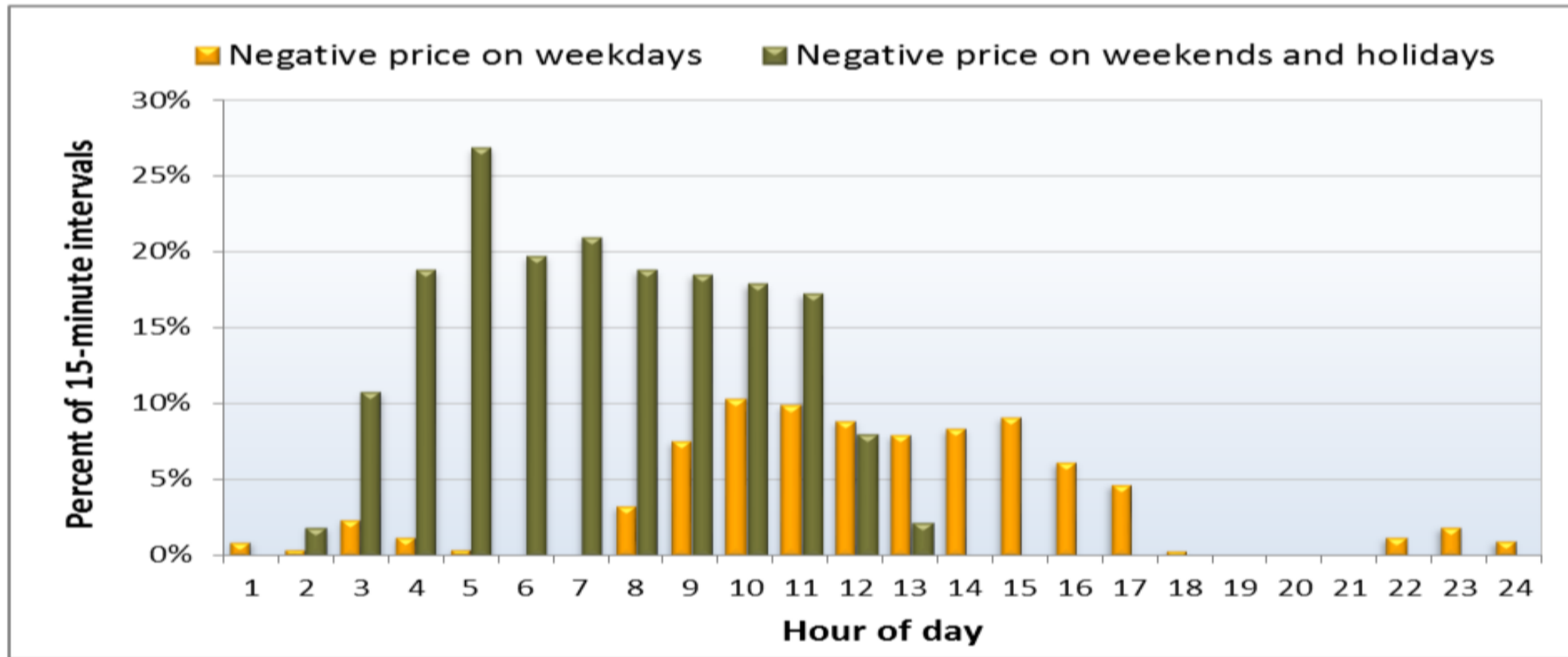
45 Million Water Heaters		Total
Capacity	4.5kW/ea.	202.5 gW
Energy Storage Capacity	12kWh	540 gWh
Annual Energy	3800kWh/ea.	171 tWh



Current Grid Challenges

CAISO - Impact of PV & Wind to Net Load

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



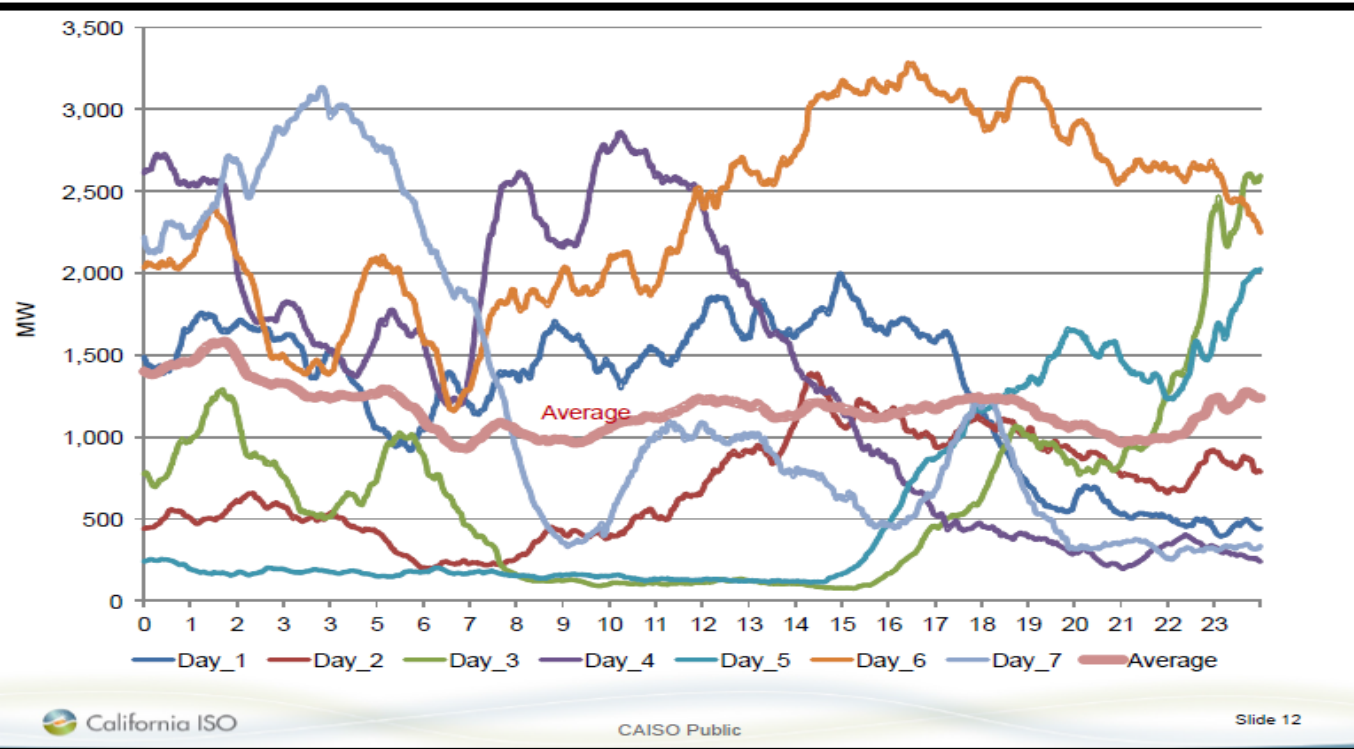
Percent of Negatively Priced Hours

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

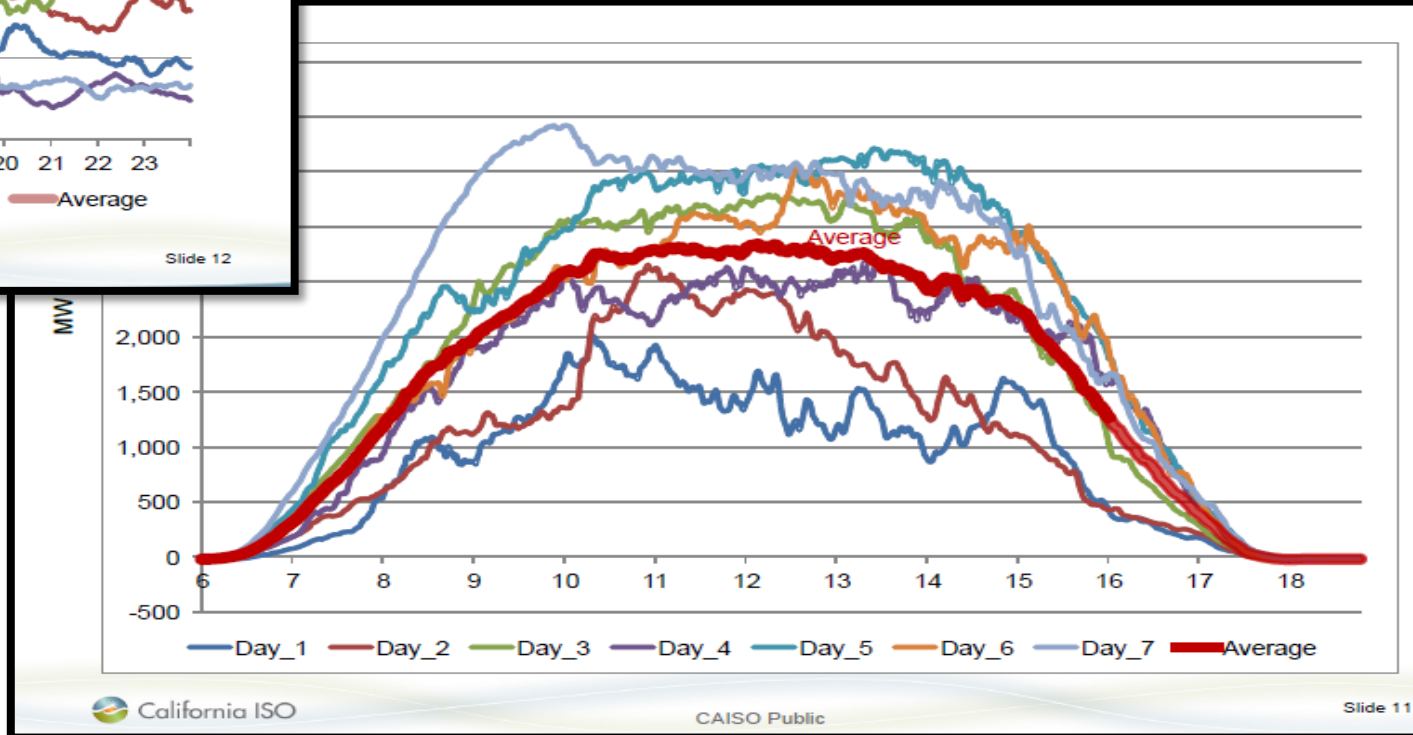
Year	Month	Hour																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
2016	10				3%	3%				3%	13%	16%	19%	13%	10%	10%	6%									
	11			3%			3%	3%	7%	13%	20%	20%	20%	33%	20%	10%	3%								3%	
	12					6%	6%				3%	10%	29%	26%	26%	10%	3%									
2017	1	3%	6%	6%	10%	10%	10%			6%	19%	13%	16%	26%	23%	13%	13%	6%								
	2		7%	7%	18%	25%	11%	4%		18%	39%	36%	43%	29%	29%	29%	29%	25%							4%	
	3		3%	6%	13%	39%	13%	3%	10%	23%	45%	52%	55%	52%	65%	42%	48%	32%	10%				3%		6%	
	4	7%		10%	10%	17%	13%	7%	13%	30%	23%	30%	50%	37%	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 Electricity

Generation Variability



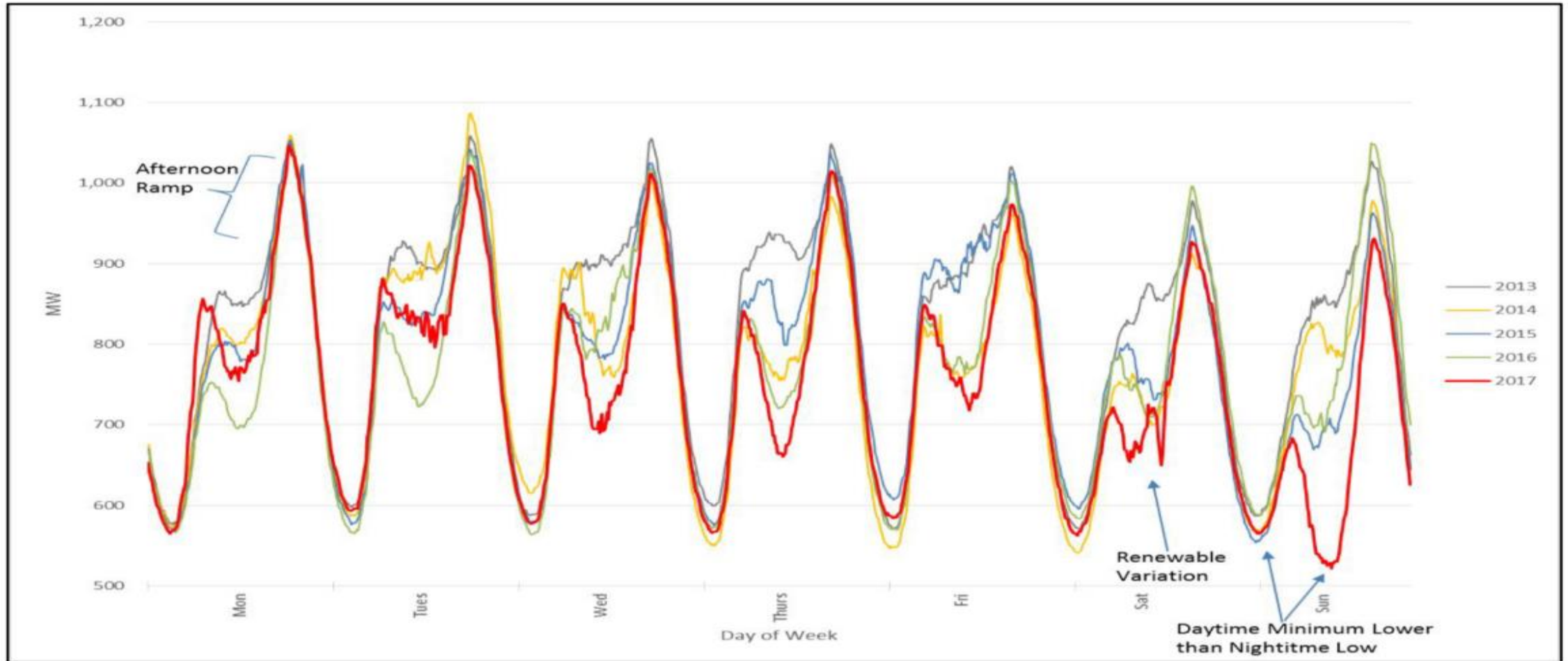
Solar Variability



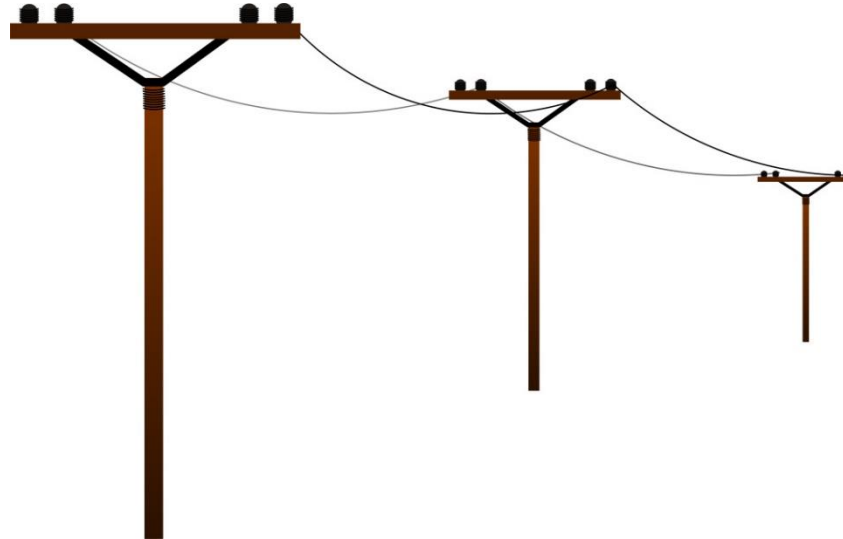
Wind Variability



A Dramatic Evolution: O'ahu's Load Curve



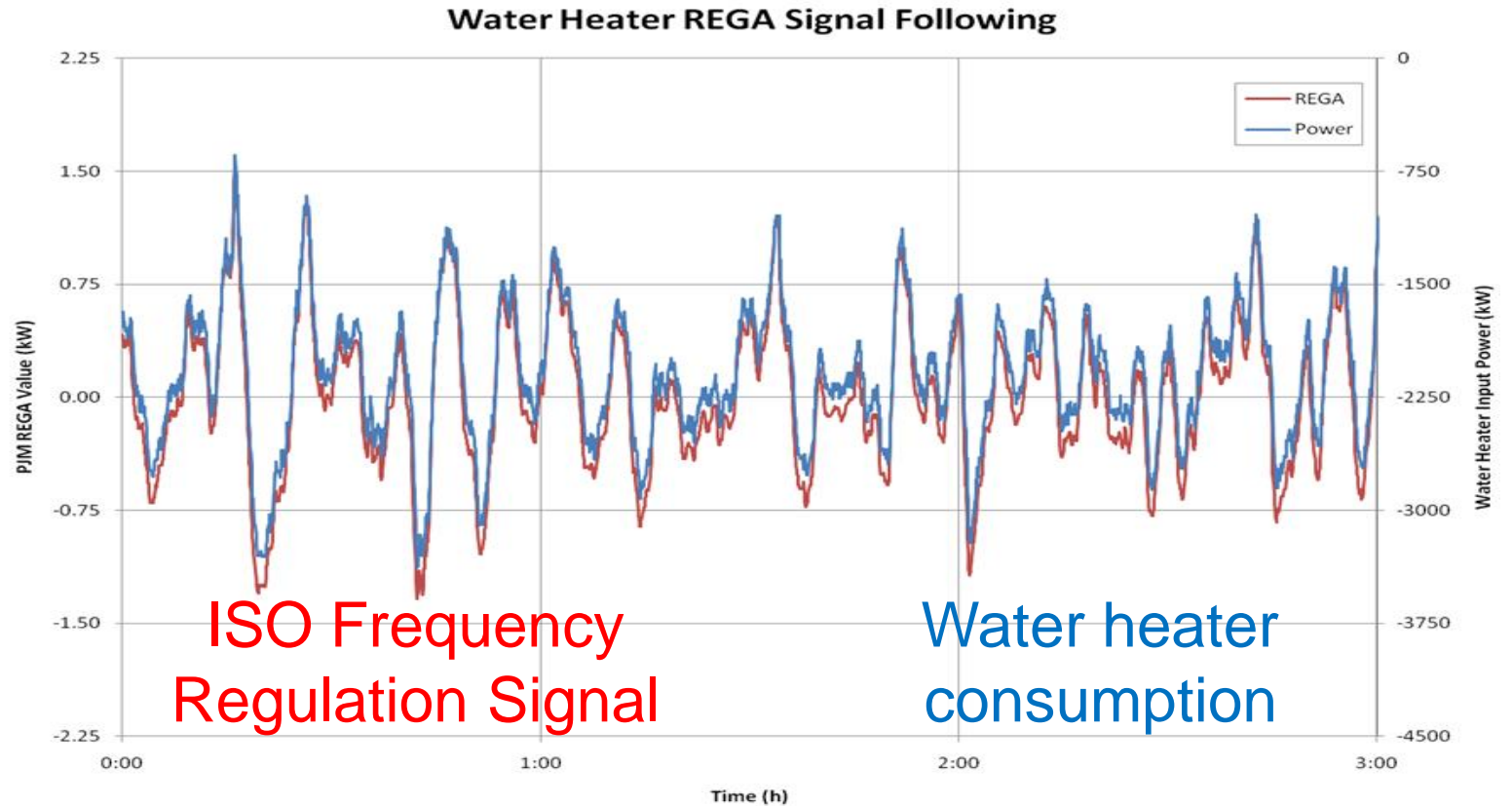
Bi-directional Power Flow Feeder Constraints



**Net Metering is not sustainable, Self
Consumption**

Fast Regulation to balance the Grid

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



How can Smart Water Heaters Help?

Glimpse of the Retrofit Process



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



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



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

Individual GETS Water Heater

End Point Details

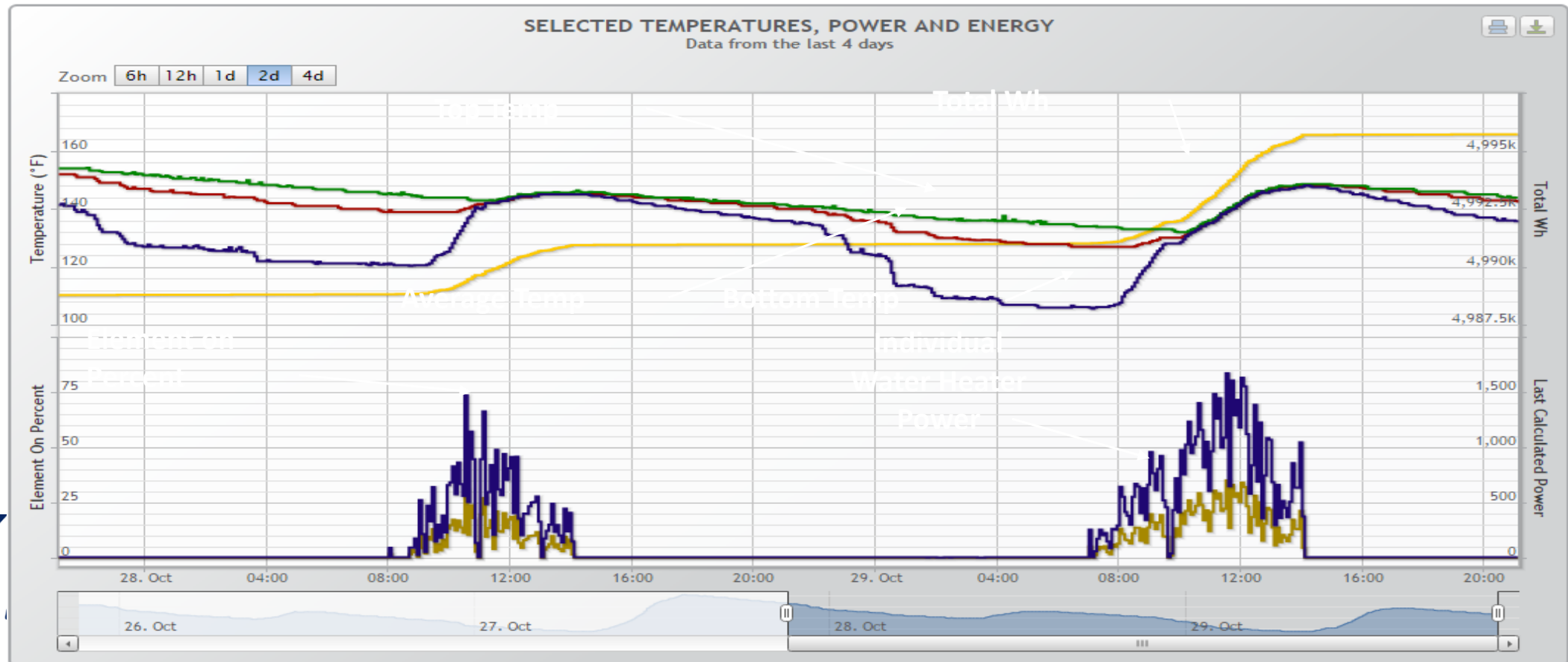
Water Heater: SITE05 - Water Heater

CONTROL STRATEGY
AGGREGATE BALANCING CONTROL
OVERRIDE CONDITIONS
NO OVERRIDES
ERROR STATUS
NO ERRORS
DEVICE STATUS
ACTIVE

CONTROL SIGNAL	0
LOCKED CHARGE LEVEL	124
CHARGE LEVEL INDEX	66

ACTUAL POWER	4 Watts
AVAIL POWER	4,888 Watts
MAX POWER	4,892 Watts

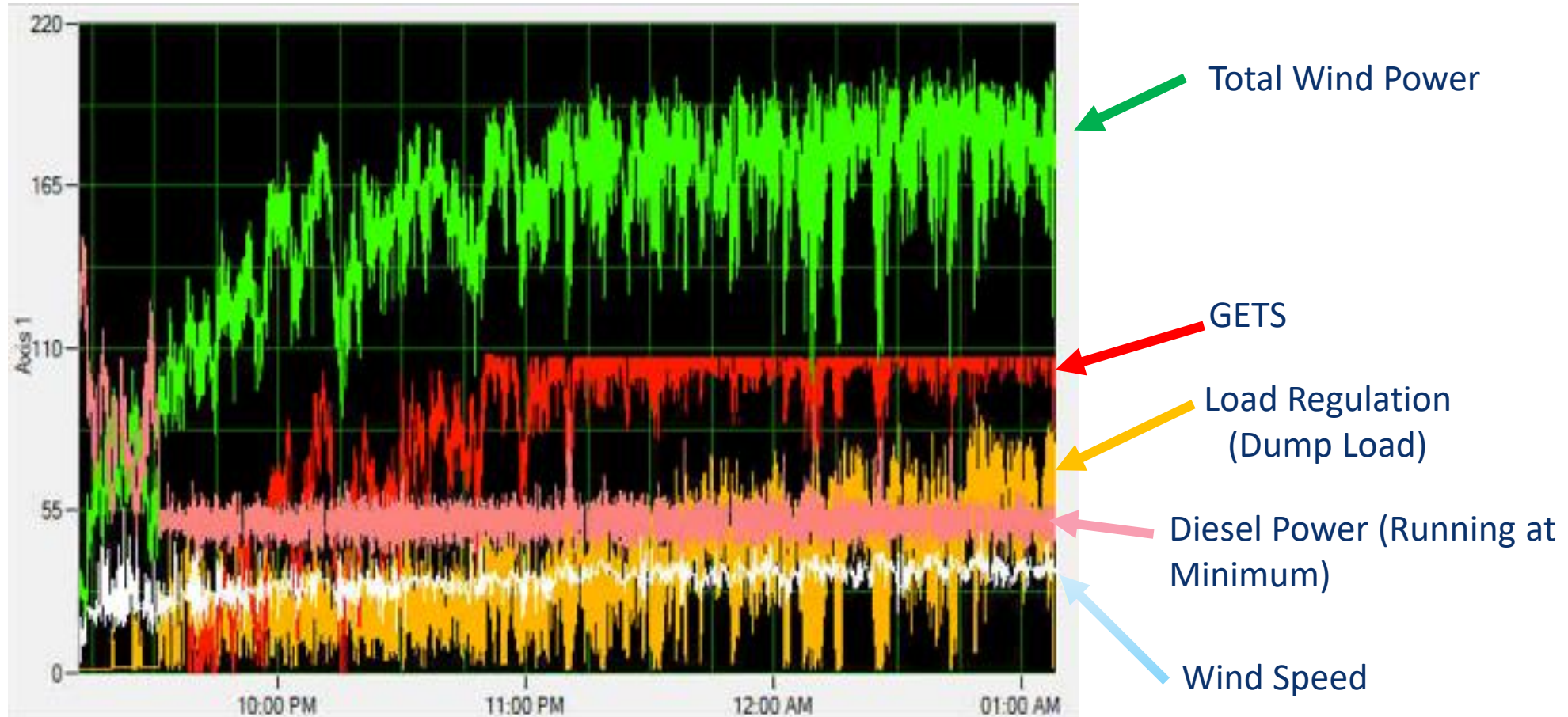
STORED ENERGY	10,088 Wh
AVAIL ENERGY STORAGE	4,462 Wh
MAX ENERGY STORAGE	14,550 Wh



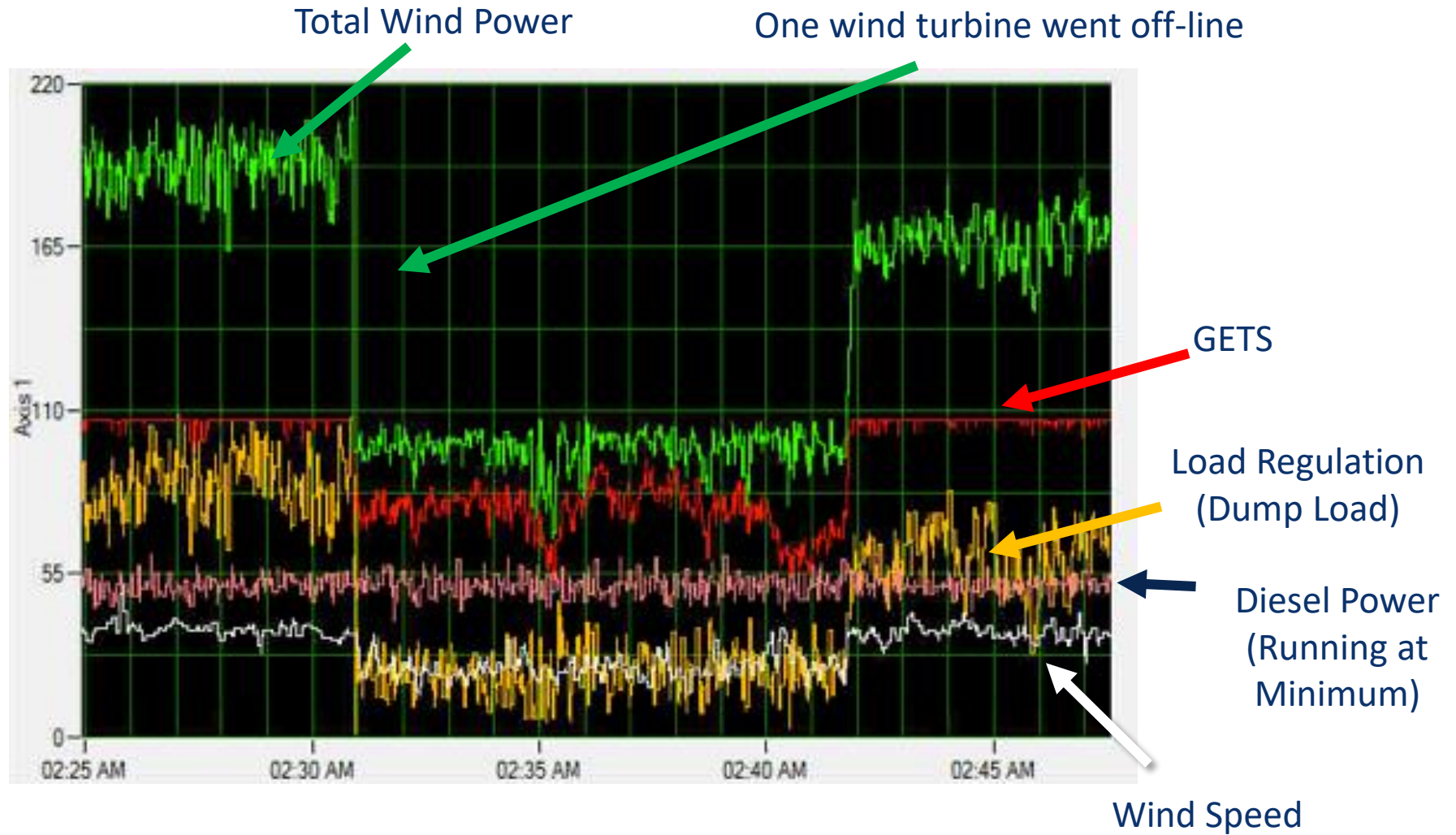
Microgrid: Wind integration demonstration



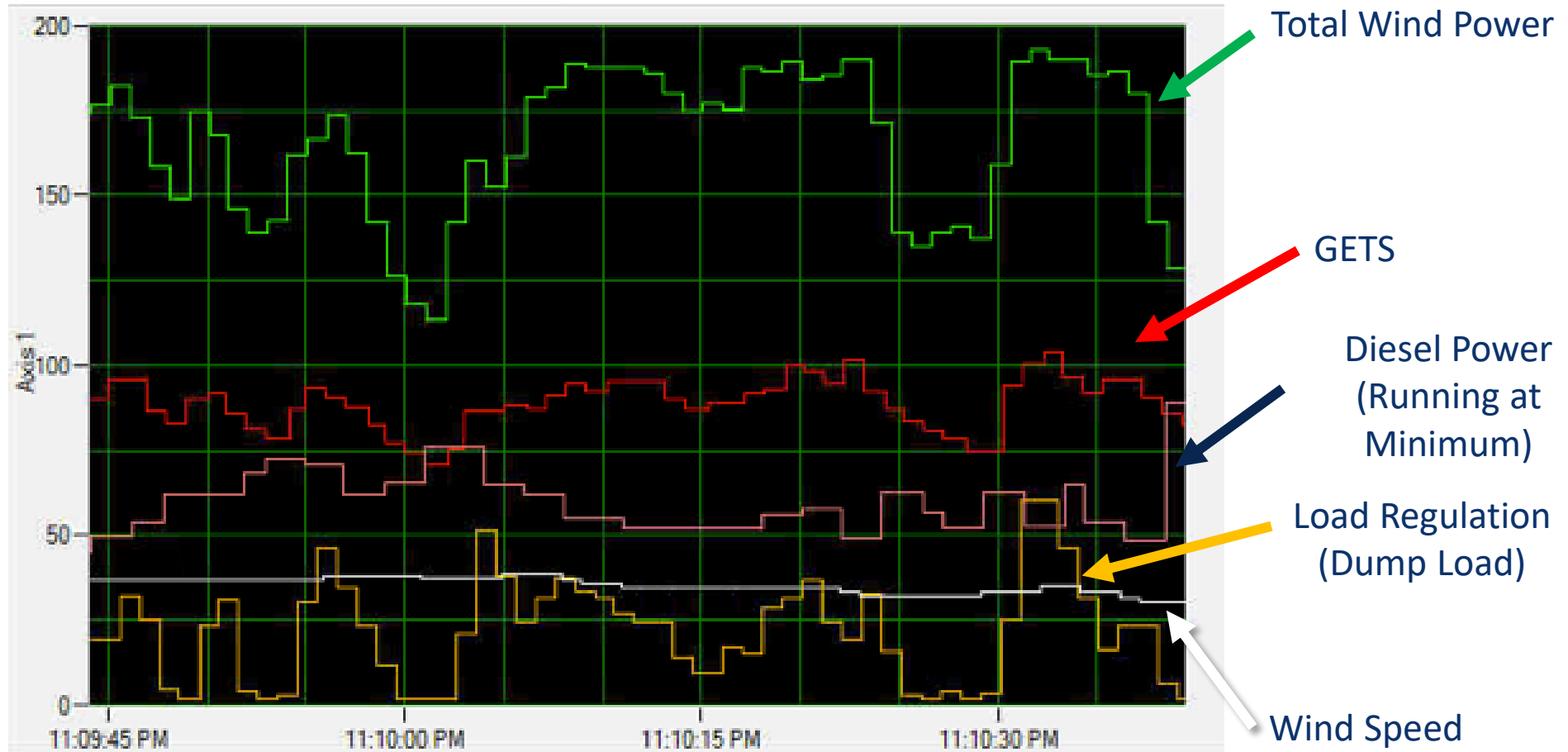
Microgrid: Wind Ramping



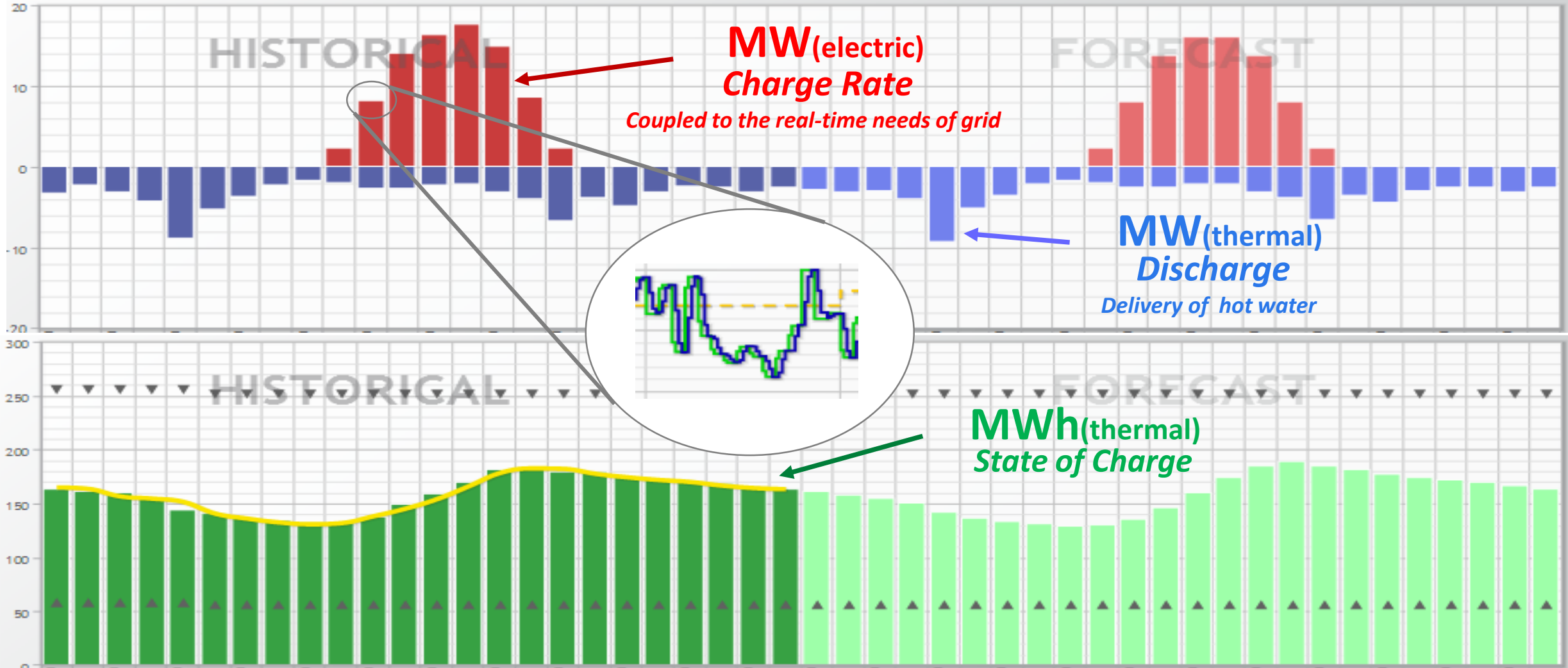
Microgrid: Dynamic Balancing



Microgrid: Balancing Second by Second



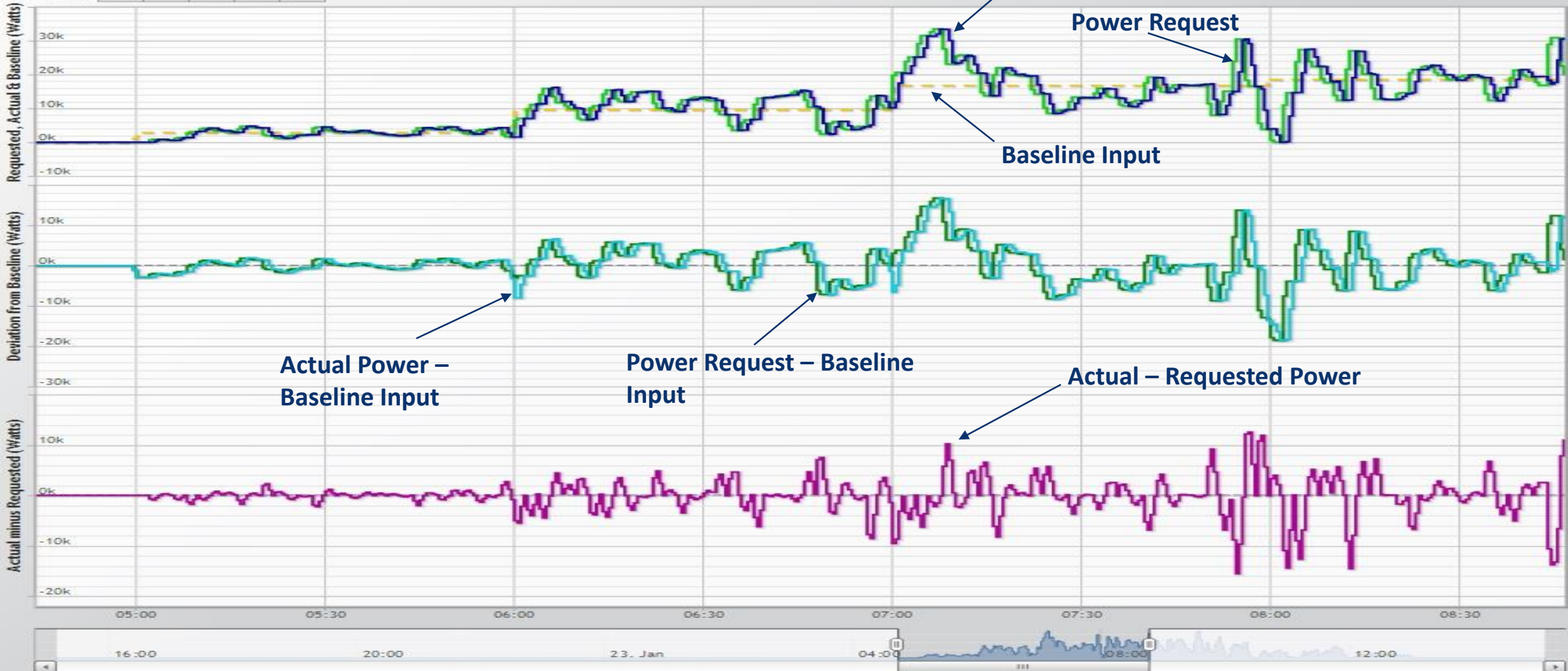
Dispatchable Aggregated Resources



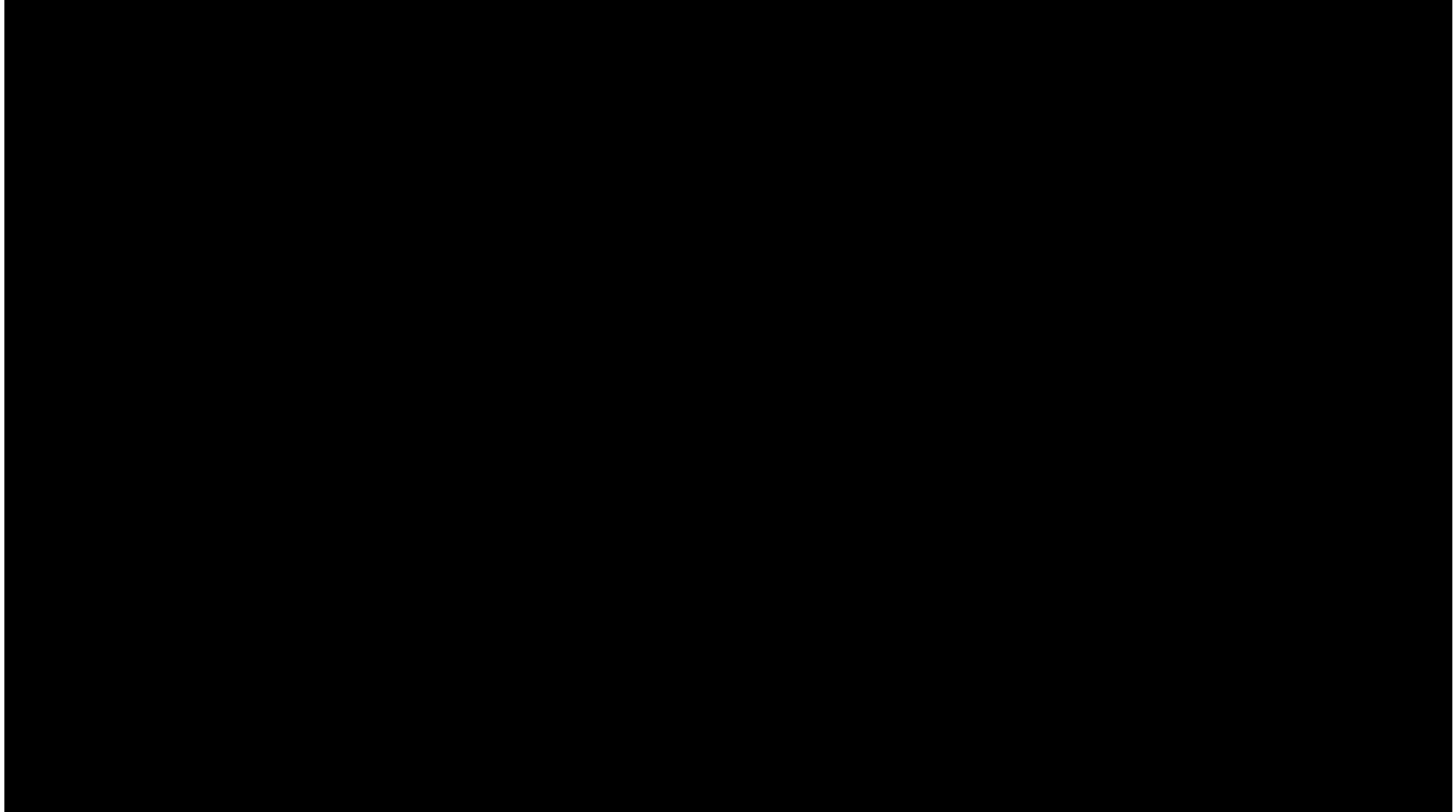
Real-Time Community Storage Aggregate Control 5.4MW–42MW-h

REAL-TIME LOAD History
Last 24 hours

Zoom 1h 4h 8h 12h 24h



Steffes Microsoft Video



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



Later this afternoon I will present on:

1)Integrated Hydro Plus WH

**2)Grouping Grid Connected energy storage units for
economic and environmental gain**

3)Various communication methods

Steffes

“Commitment to Innovation”



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