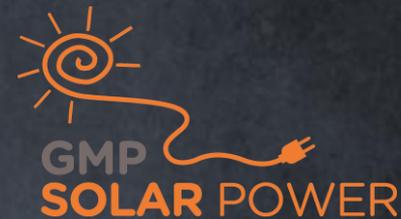




DOE Peer Review - 2016

# Stafford Hill Solar Storage Project

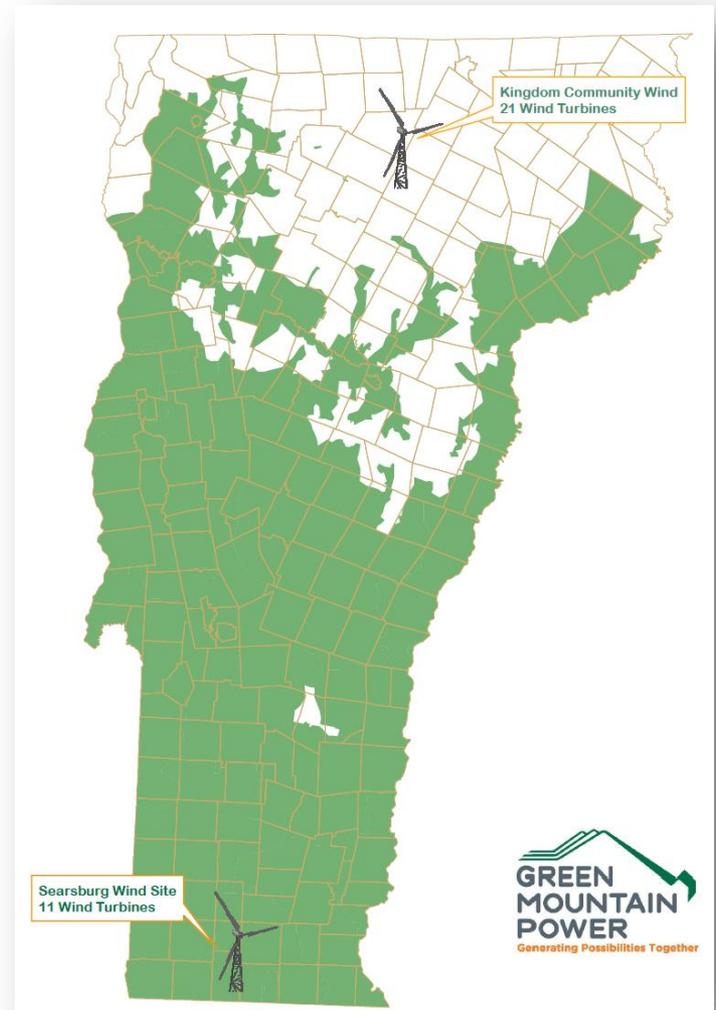


September 27, 2016

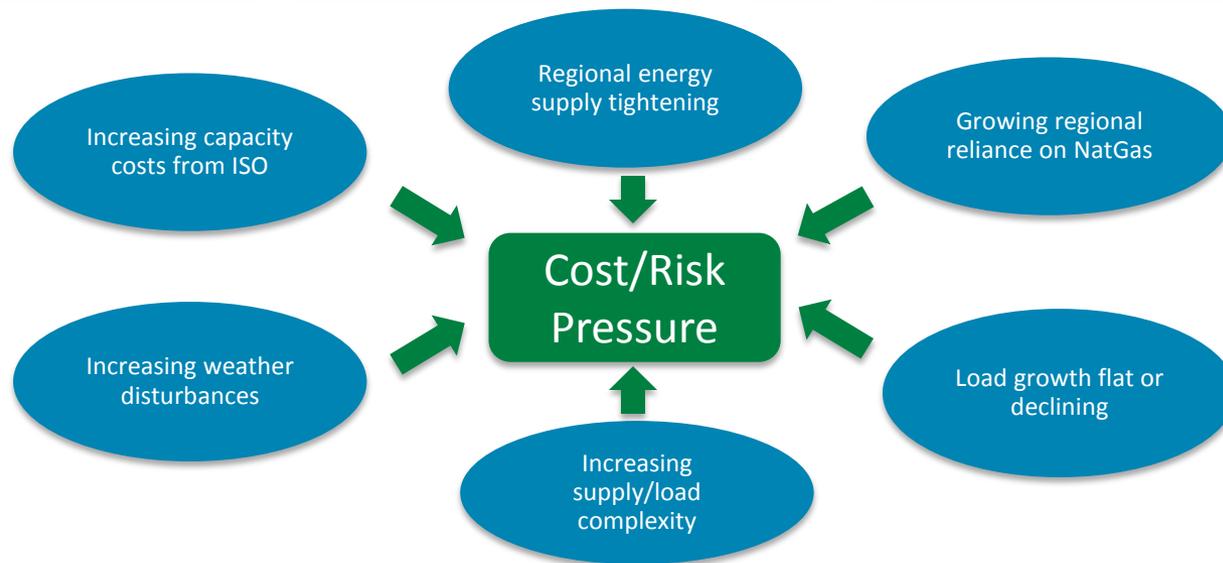


# Who We Are

- We serve 260,786 Customers in 202 towns in 7,500 square miles of service territory
- We operate
  - 32 Hydro Plants
  - 12 Solar Projects
  - 3 100KW Wind Turbines
  - 1 Joint-Owned Biomass Plant (McNeil)
  - 6 Peaking Plants
  - 2 Wind Farms
- We maintain
  - 976 miles of transmission lines
  - 11,273 miles of distribution lines
  - 185 substations



# Current Challenges/Opportunities



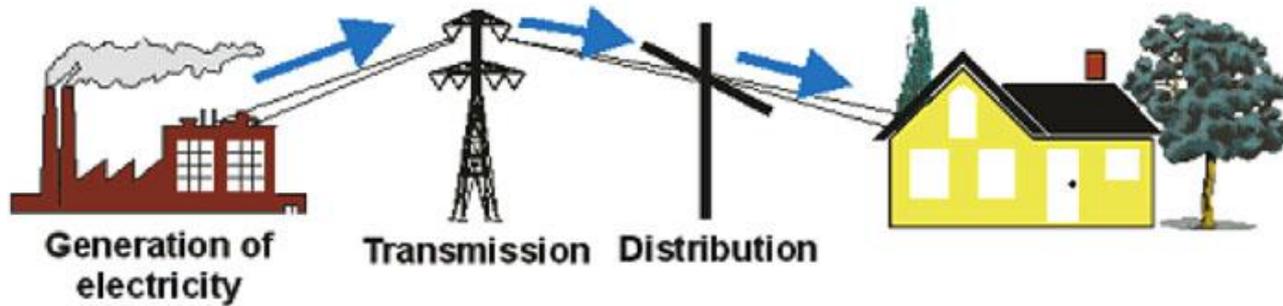
*Technology creates an opportunity for us to embrace progress and transition to another business model*

So what do we do?

Three Strategic Imperatives:

- 1) *Change the distribution grid model or grid transformation*
- 2) *Engage customer value*
- 3) *Increase reliance on local resources*

# Today



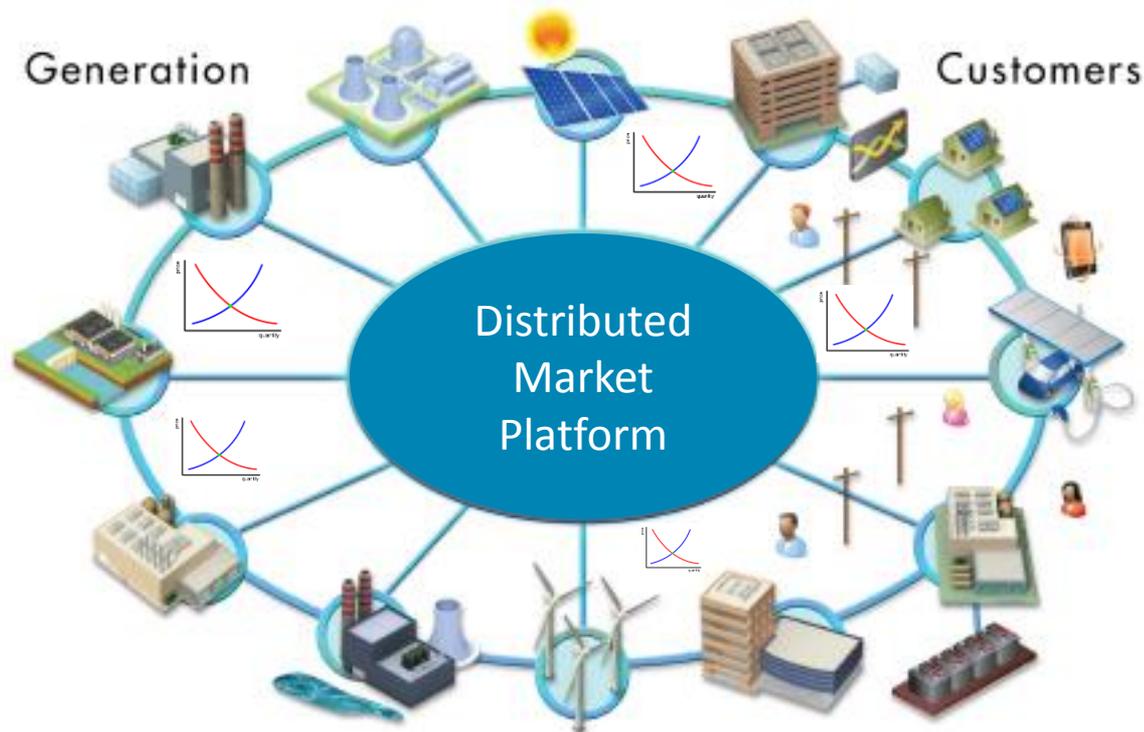
Today:

- Supply goes from one direction over long distances, leading to losses and immense infrastructure requirements
- Supply built to accommodate demand => Inefficient asset utilization

# Tomorrow

*Guiding Philosophy: Shift the locus of control from the bulk power grid to the near customer distribution grid and subject as much as possible to market forces.*

- Exploit and create value from energy supply and demand assets behind customer meter
- Leverage advanced software and controls to automate grid observation and response functions for greater resilience and efficiency
- Complete re-focus on grid investments to maximize local values and resiliency



# Grid Transformation

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- Adding Distributed Generation and Controllable energy resources
- Micro-Grid control systems
- Energy storage is critical as it enables:
  - Peak load management
  - System loss reductions
  - Power quality and reliability
  - Grid resiliency
  - Renewable integration
  - Ancillary grid services (i.e. frequency regulation)

# Stafford Today

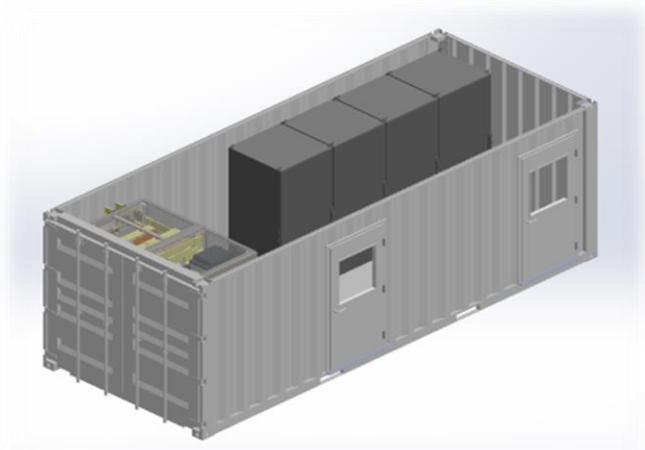


# Stafford Hill Solar Storage Farm

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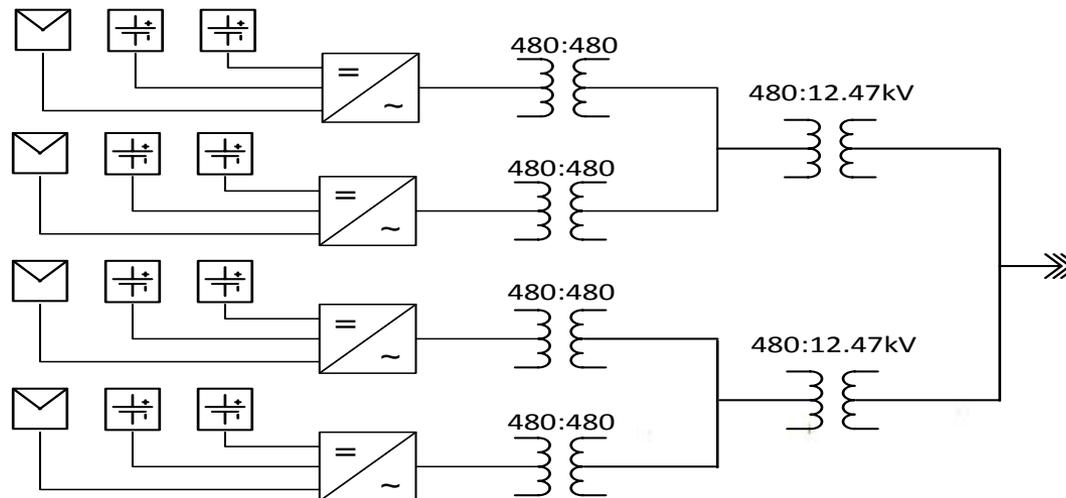
- Partnership with DOE, Clean Energy States Alliance and the State of Vermont to develop a unique solar & energy storage system
- Testing multiple battery technologies and a specialized inverter system
- Worked with Vermont regulators to permit the first system of it's kind in Vermont
- Will provide back up power to the Stafford Technical Center which also acts as an emergency shelter

# Stafford Design



## Stafford Hill Solar+Battery

- Topology – 4 identical system in parallel
- 2.5MW-DC Fixed Solar on Landfill Cap
  - About 7000 panels
- 2MW/1MWH Lithium Ion Batteries
- 2MW/2.4MWH Lead Acid Batteries
- 4 – 500KW Multiport Inverters





# Stafford Construction



- Concrete ballast mount to avoid penetrating landfill cap

- Trash beyond landfill perimeter caused the need for accelerated compaction before placing container foundations to assure long term stability
- 170,000 lbs Pb container X 2
- 32,000 lbs Lithium Ion container x 2



# Stafford Storage Operation

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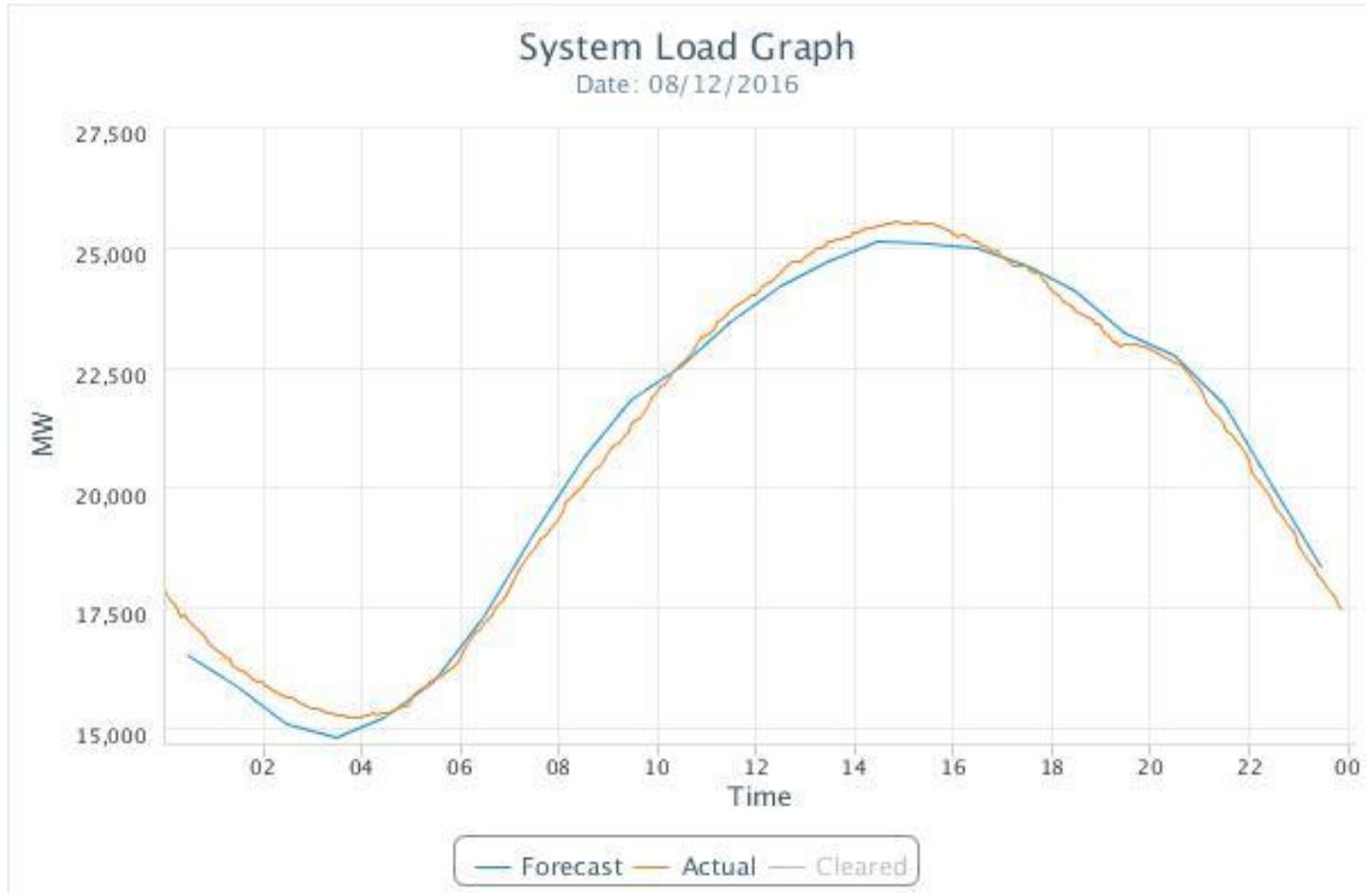
- Peak Shaving Management
- Solar Smoothing
- Frequency Regulation (operation under test)
- Islanding (2017)



**Energy Storage in Action!**

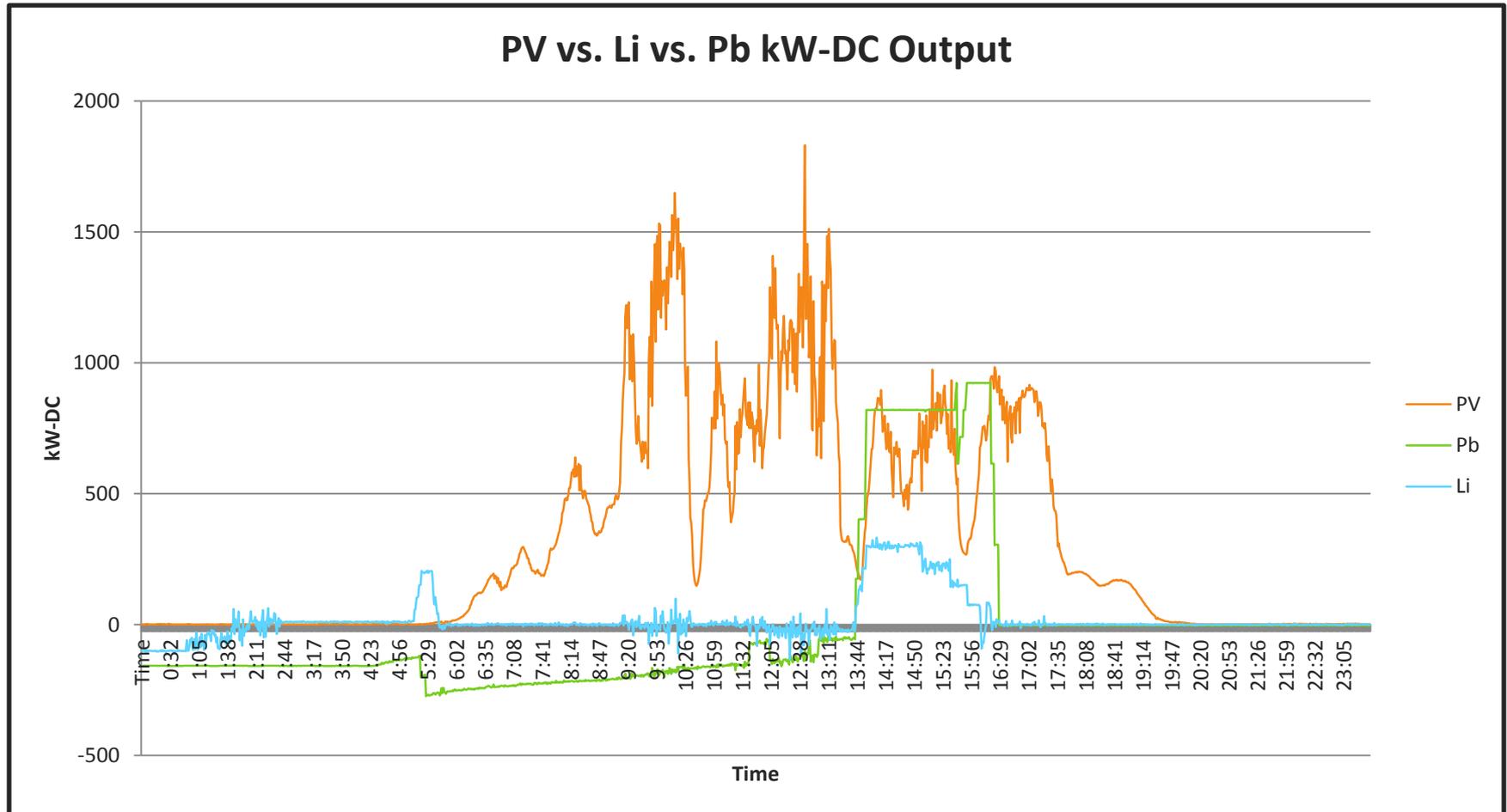
**Shooting for FCM Peak...**

# ISO-NE Forecast and Actual Data



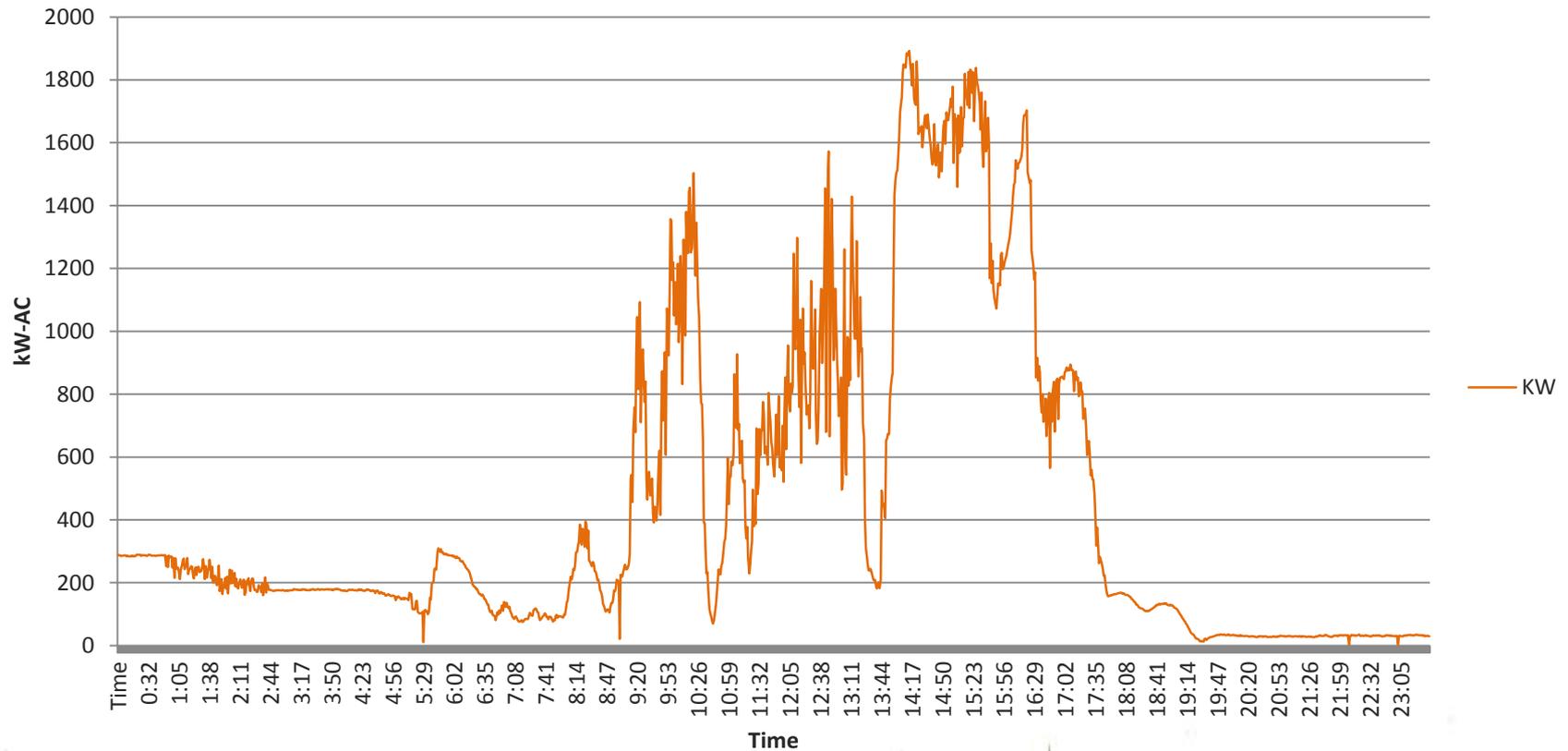
Preliminary Data Projected Peak = August 12<sup>th</sup> | hour 15:00 to 16:00

# Stafford PV and Battery Data

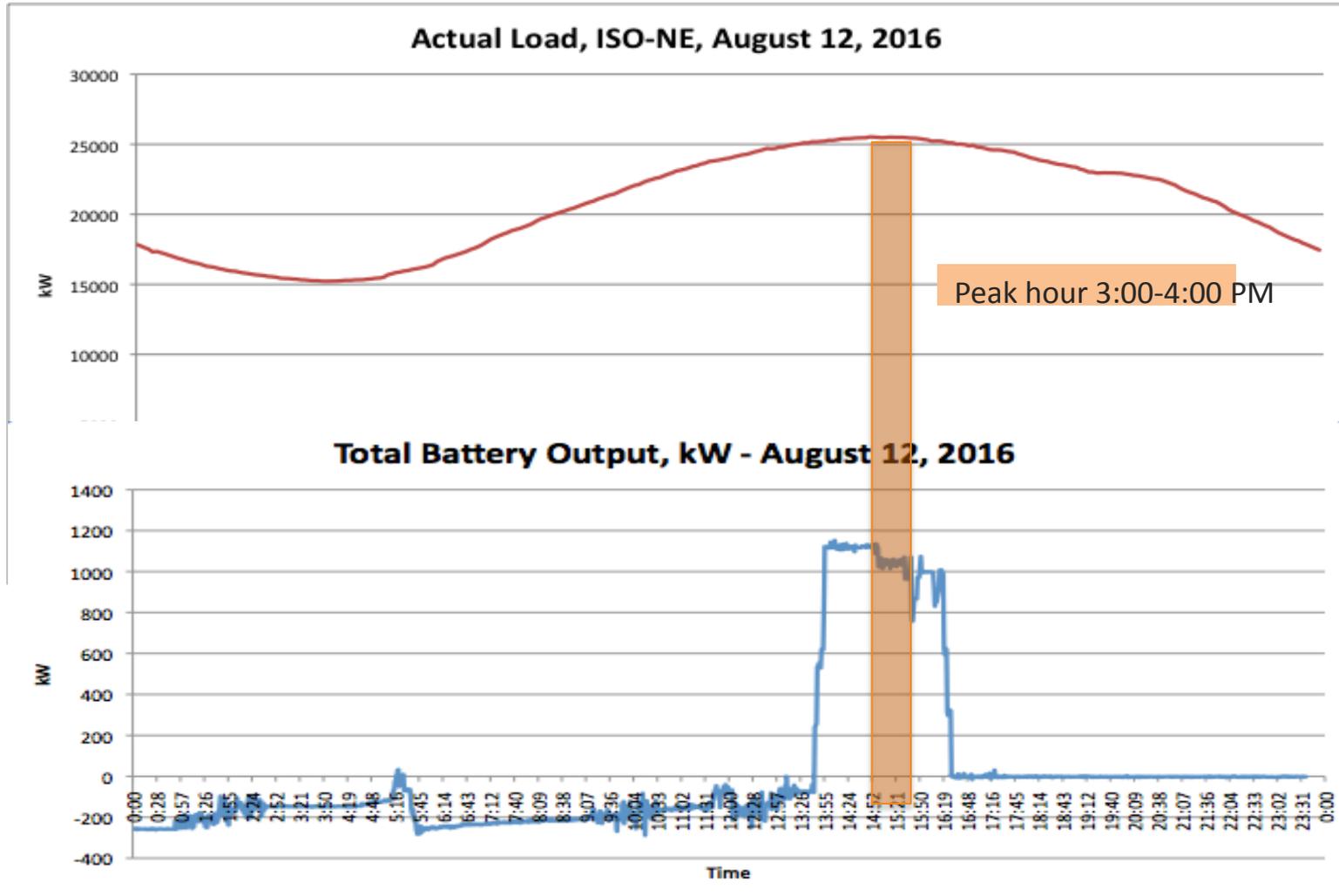


# Stafford Output

## Total Inverter Output (PV + Battery) - kW-AC



# Knocking Down the Peak!



# Calculating the Projected Savings

Assuming the ISO-NE peak on August 12<sup>th</sup> hour ending 16:00...

- The Stafford Storage avoided load-based charges by reducing GMP's load requirements in the ISO-NE market.
- During the projected peak hour, the average combined output of batteries is 1,000kW.
- Based on the applicable auction price in the year June 2017 through May 2018 (FCM#8, \$7.025/kW-month), assuming 20% reserve margin, the potential savings is about **\$101,160**.

Results of the Annual Forward Capacity Auctions

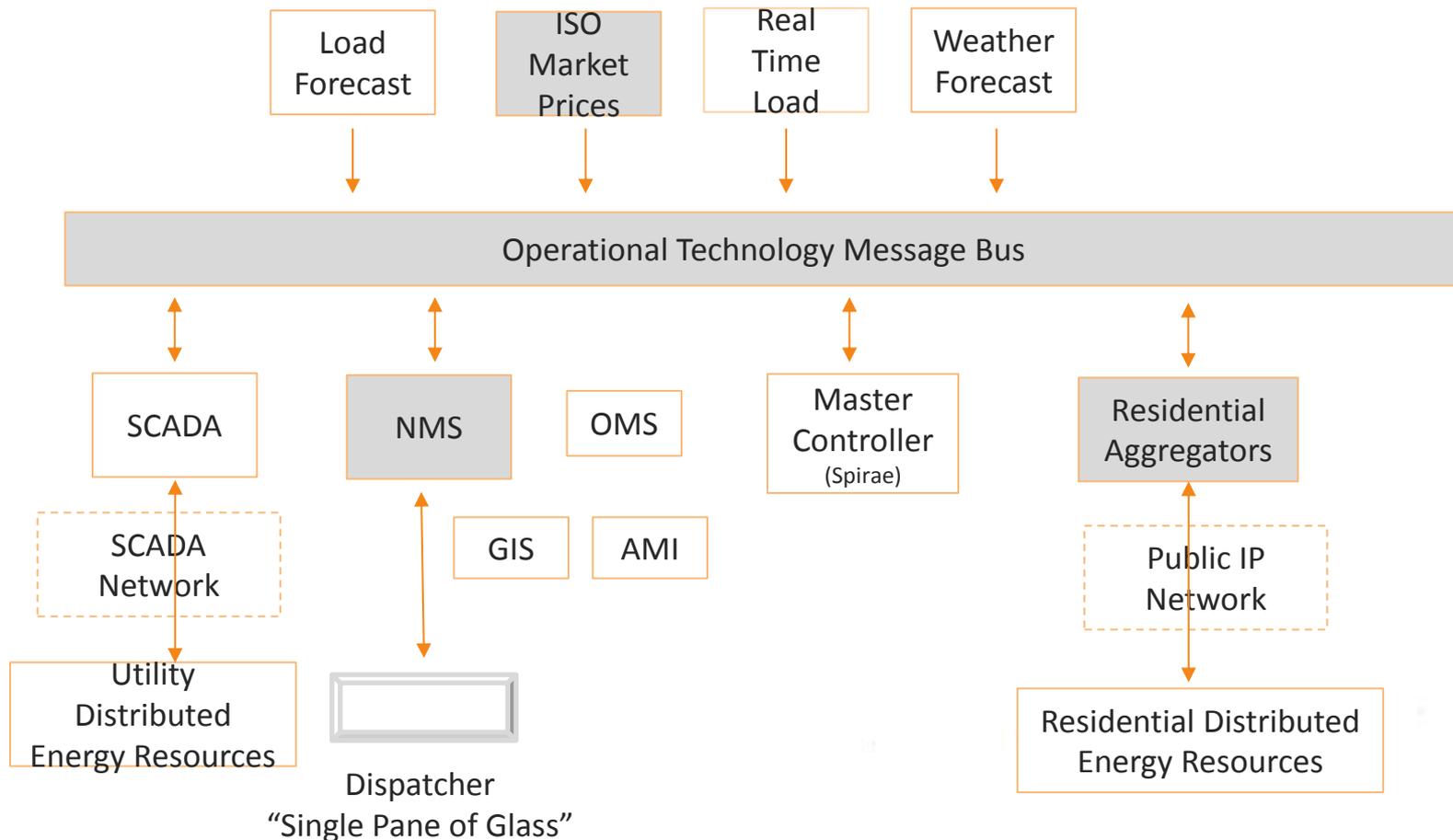
AUCTION COMMITMENT PERIOD	TOTAL CAPACITY ACQUIRED (MW)	NEW DEMAND RESOURCES (MW)	NEW GENERATION (MW)	CLEARING PRICE (\$/KW-MONTH)
FCA #1 2010/2011	34,077	1,188	626	\$4.50 (FLOOR PRICE)
FCA #2 2011/2012	37,283	448	1,157	\$3.60 (FLOOR PRICE)
FCA #3 2012/2013	36,996	309	1,670	\$2.95 (FLOOR PRICE)
FCA #4 2013/2014	37,501	515	144	\$2.95 (FLOOR PRICE)
FCA #5 2014/2015	36,918	263	42	\$3.21 (FLOOR PRICE)
FCA #6 2015/2016	36,309	313	79	\$3.43 (FLOOR PRICE)
FCA #7 2016/2017	36,220	245	800	\$3.15 (FLOOR PRICE) NEMA/Boston: \$1.99
FCA #8 2017/2018	33,712	394	30	\$15.00/new & \$7.025/existing System-wide: \$9.55
FCA #9 2018/2019	34,695	367	1,060	SEMA/RI: \$17.73/new & \$11.08/existing
FCA #10 2019/2020	35,567	371	1,459	\$7.03

# Grid of the Future System Architecture

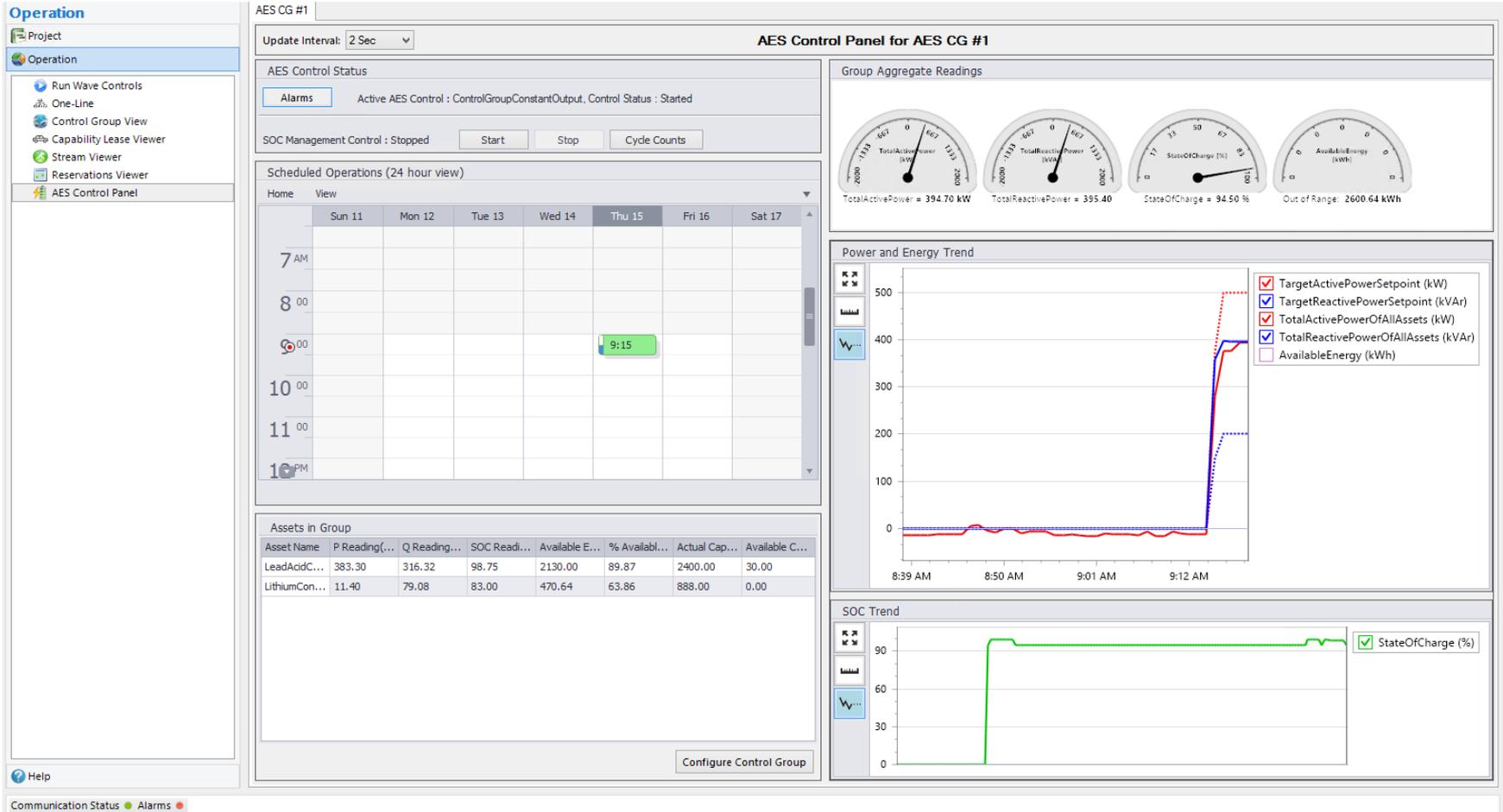
Key:

 On GMP Roadmap, not implemented yet

 Existing System or Data Stream



# “Single Pane of Glass” Dashboard



# Thank You

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