CAPACITY FOR CHANGE

Enabling the Edge of the Grid

ISGF – March 2015

HEADQUARTERS
2900 N. Quinlan Park Rd
Suite B240, #215
Austin, TX 78732
512 318 2154

www.innovari.com

NOC & TECHNOLOGY CENTER
19720 NW Tanasbourne
Drive
Suite 320
Hillsboro, OR 97124

BACKUP DATA CENTER
Santa Clara, CA

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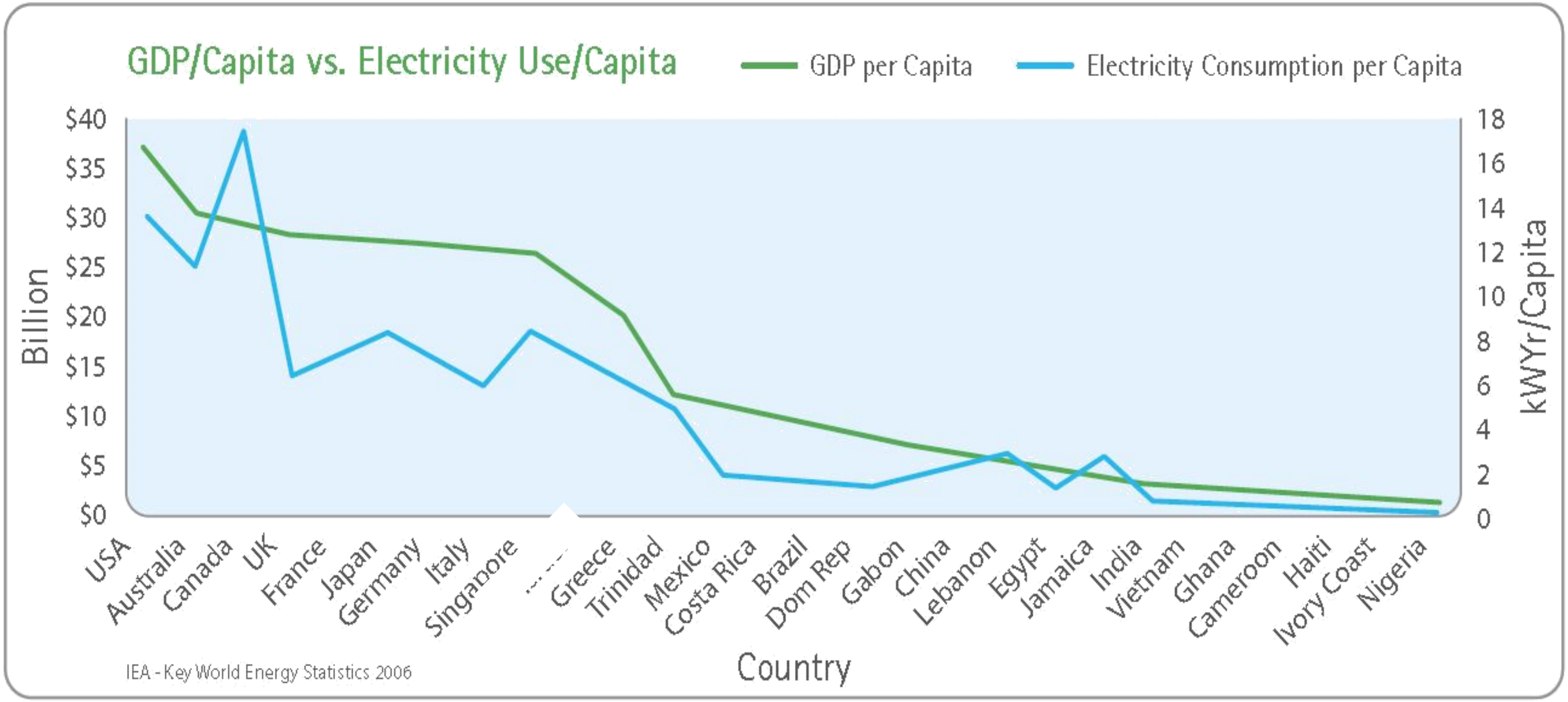
Innovari Activity around the world

Electricity is the ONE thing that drives a country's GDP

- Access to reliable, secure and affordable electricity defines a nations health, welfare, quality of life and overall success!



Demand Side
What's all the fuss about?

- Why care about the demand side?
  - What benefits should we expect?
  - How should we measure and/or track?
  - What have others done?
  - Program Activity versus Metric Driven Success on the Demand Side
- Real Example of System Optimization through ADSM
- Economics of System Optimization through ADSM
- How does ADSM really work?

The Load Duration Curve Reveals our Industry Problem

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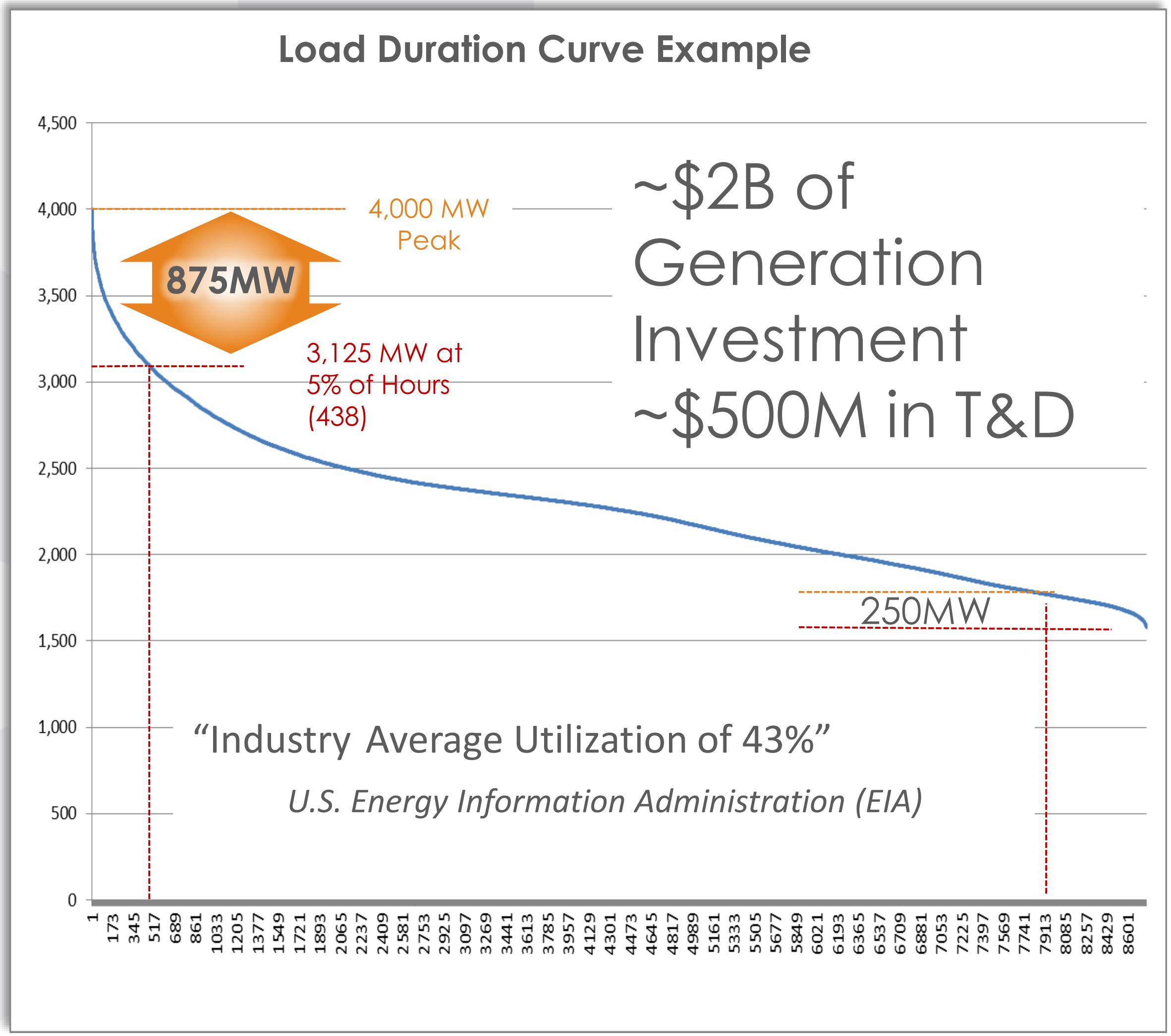
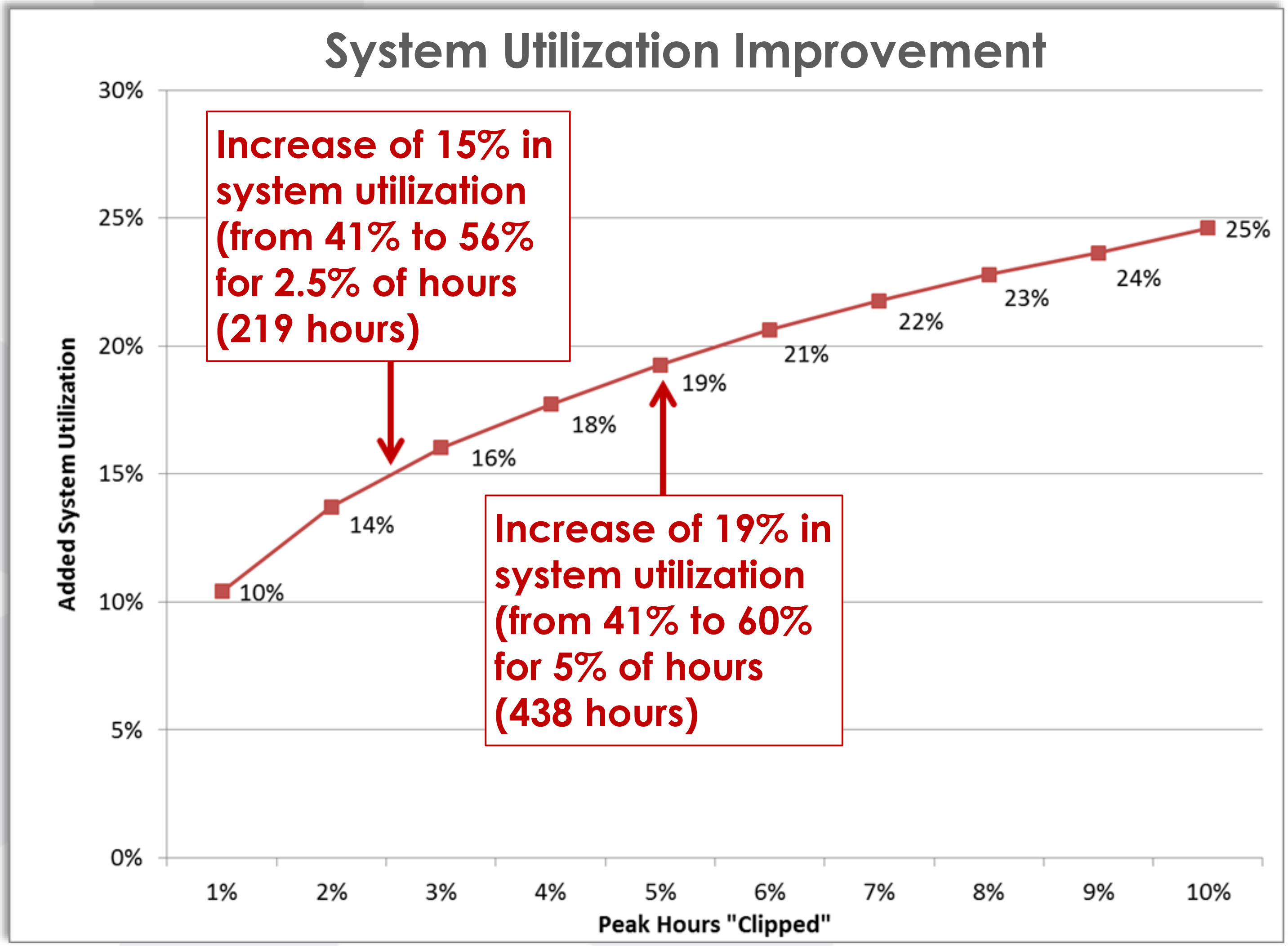


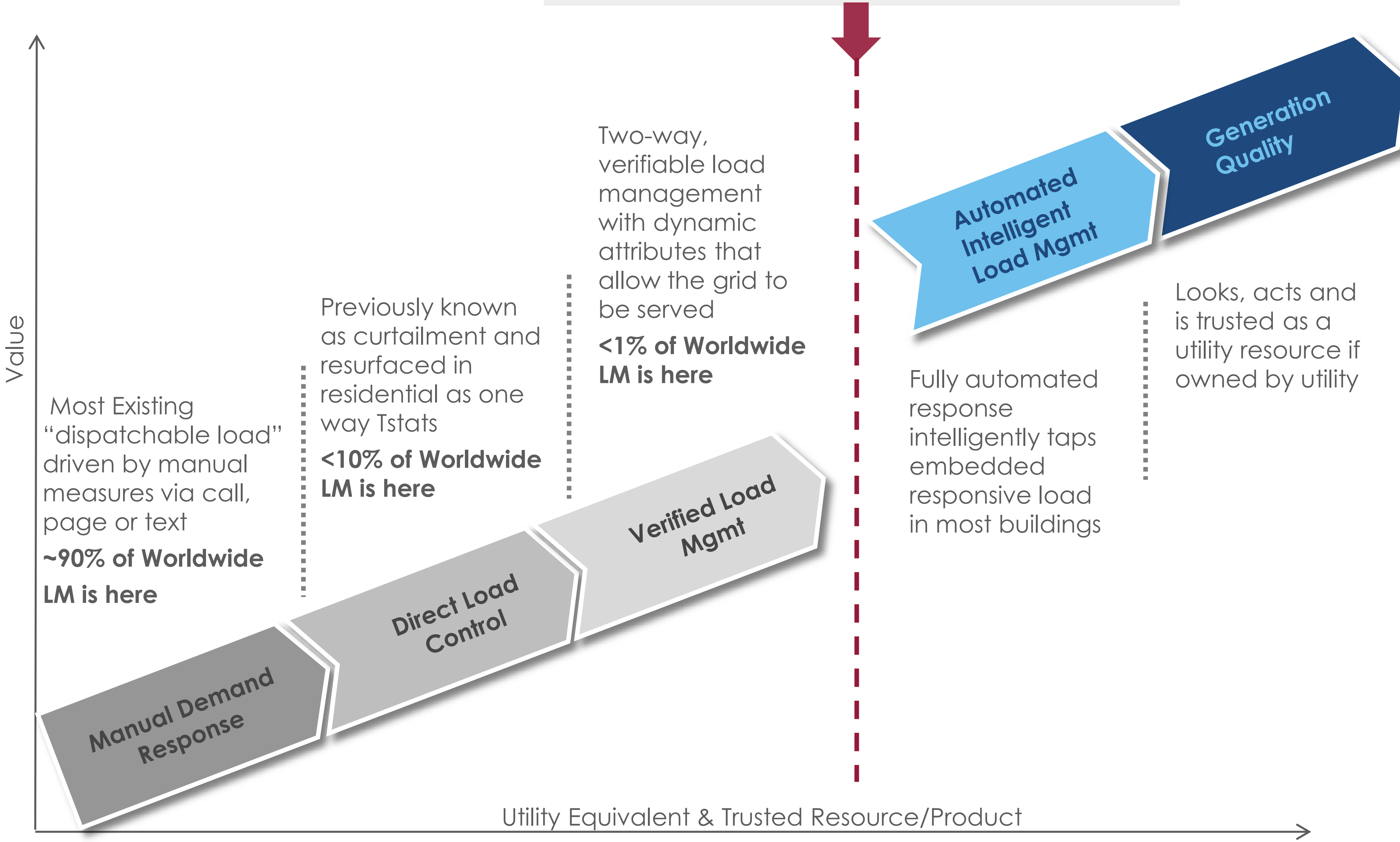
- Modest improvements in load management results in large improvements in the system utilization of all existing assets (generation, transmission, and distribution)
- Defers or eliminates costly T&D upgrades (feeder reconductors, substation retrofits, etc.)
- Helps improve total system utilization and reliability
- It's not just load reductions, it also load 'bury' - A dynamic resource is required

Improving Overall System Utilization

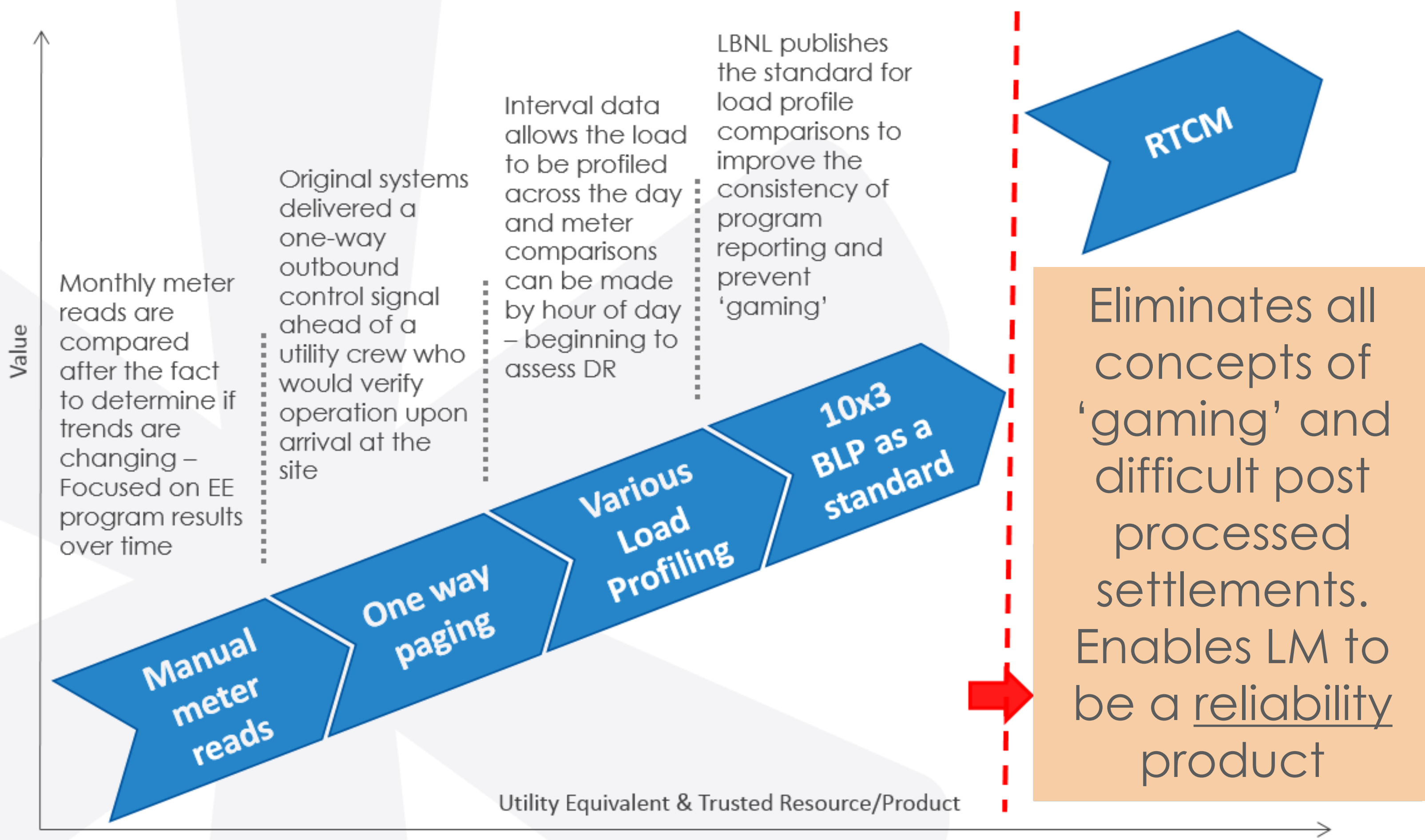


Evolution of Load Management

Any initiative that creates dynamic communication and control across this boundary must be secured at the highest level to protect the power grid and the control room that is responsible to maintain the reliability of the power grid.

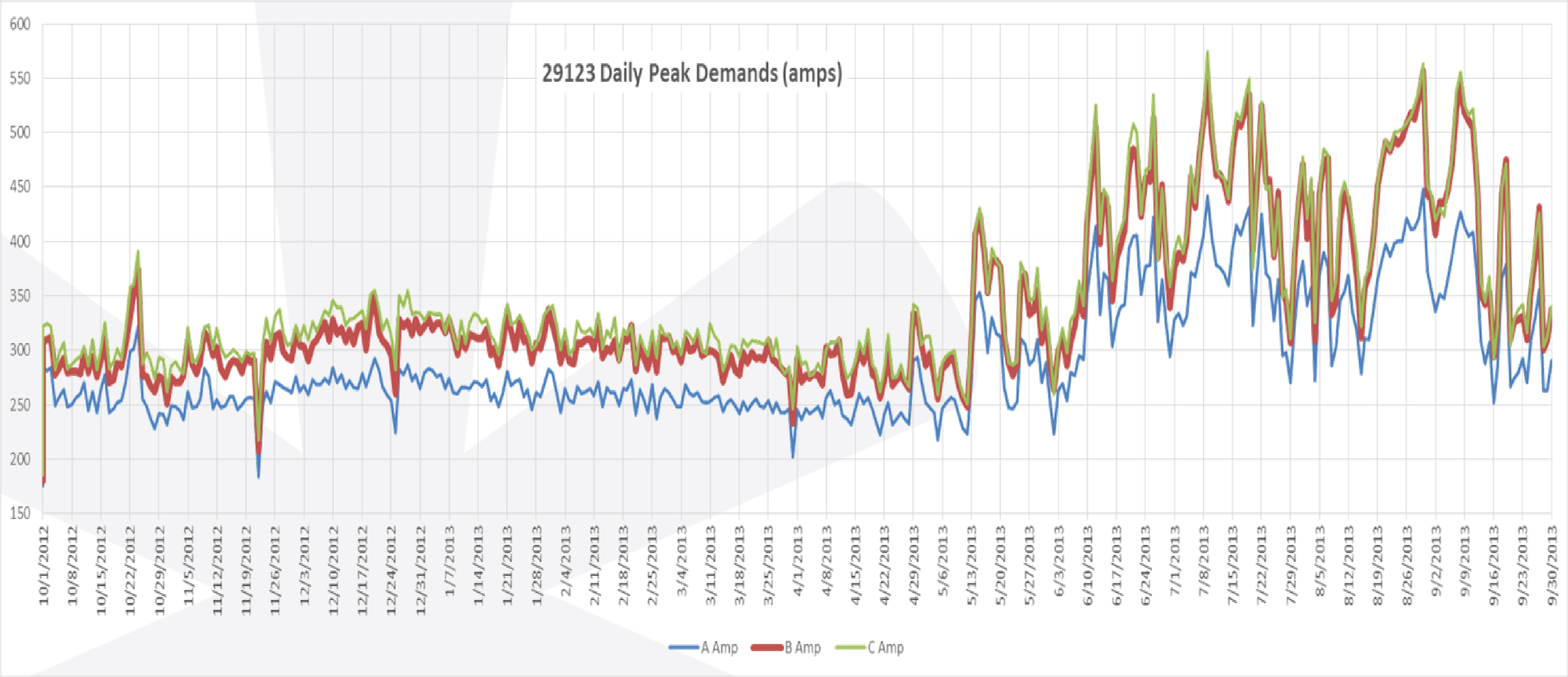


Evolution of Measurement & Verification



REAL EXAMPLE OF SYSTEM OPTIMIZATION THROUGH ADSM

Start at the lowest system level – A single feeder



- SCADA shows ~70 hours over 500 Amps. Maximum peak ~574 Amps
- To manage 50 to 75 Amps on this feeder, 620 to 930kW of load management would be required to keep the feeder at or below 500 Amps

Optimize Operational Goals

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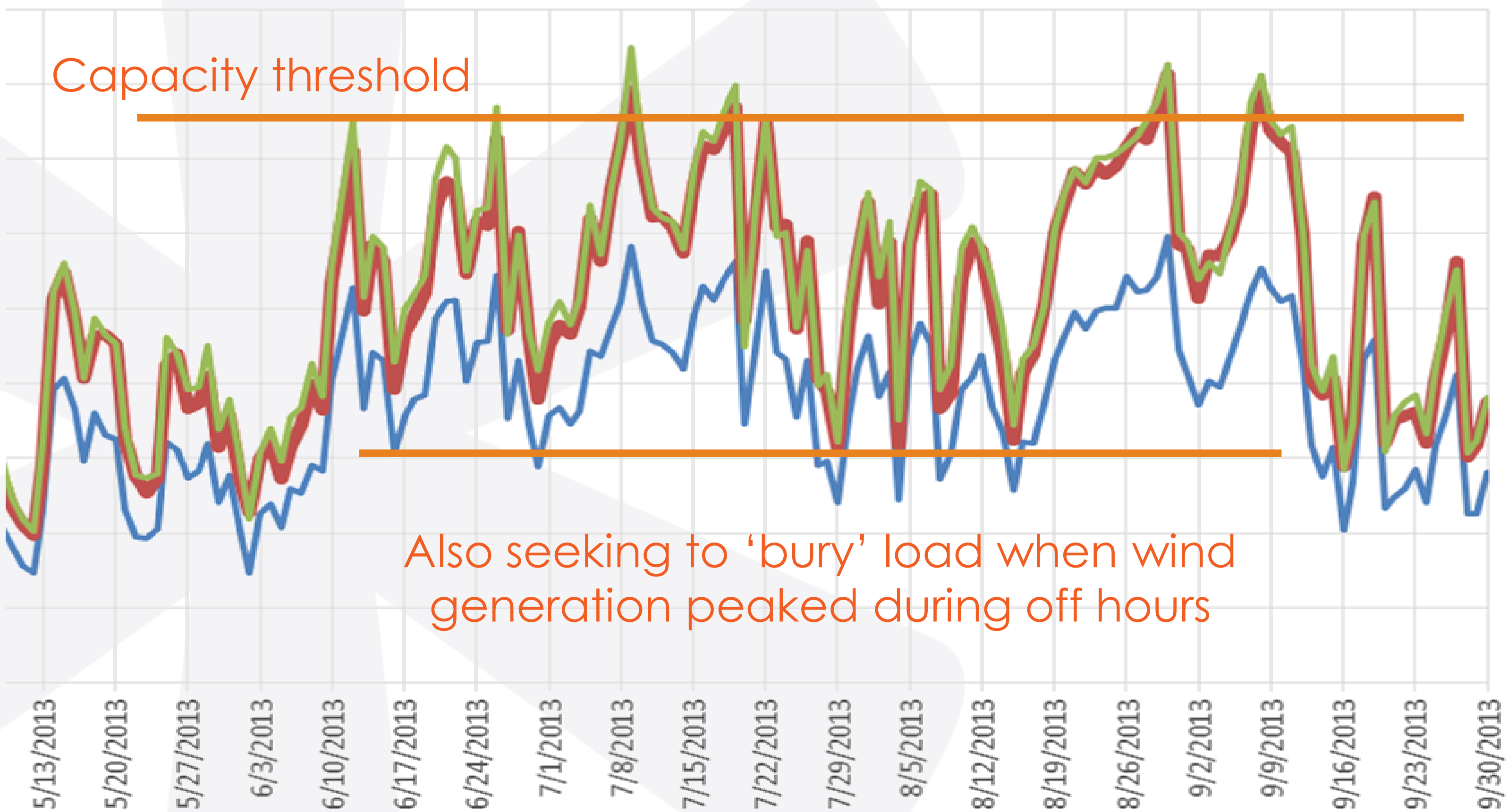
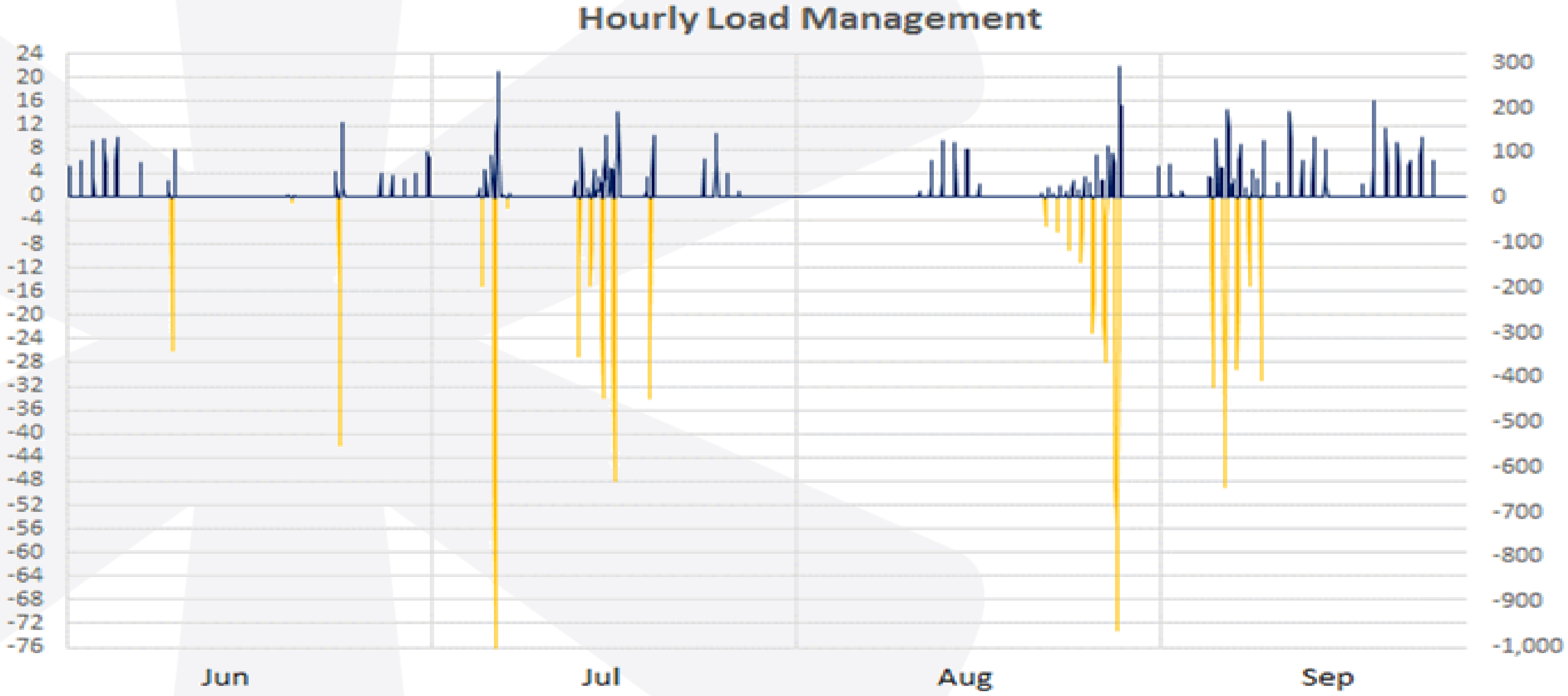
This utility was seeking to optimize feeder usage to meet equipment operating limits and defer or eliminate the need for feeder and substation upgrades as previously planned



Real Time Monitoring and Two-way Closed Loop Control

A combination of operating objectives can be achieved including peak load management to mitigate system constraints, load bury to optimize renewable energy resource production (in this example wind at night), and individual building management such as pre-cooling to shift load profiles, even a few hours a day. (EX: to balance the post solar peak)



* Example illustrates 362 hours of dispatch on one feeder from a peak load reduction of 1MW to a peak load bury of 275kW

Move to Substation Level

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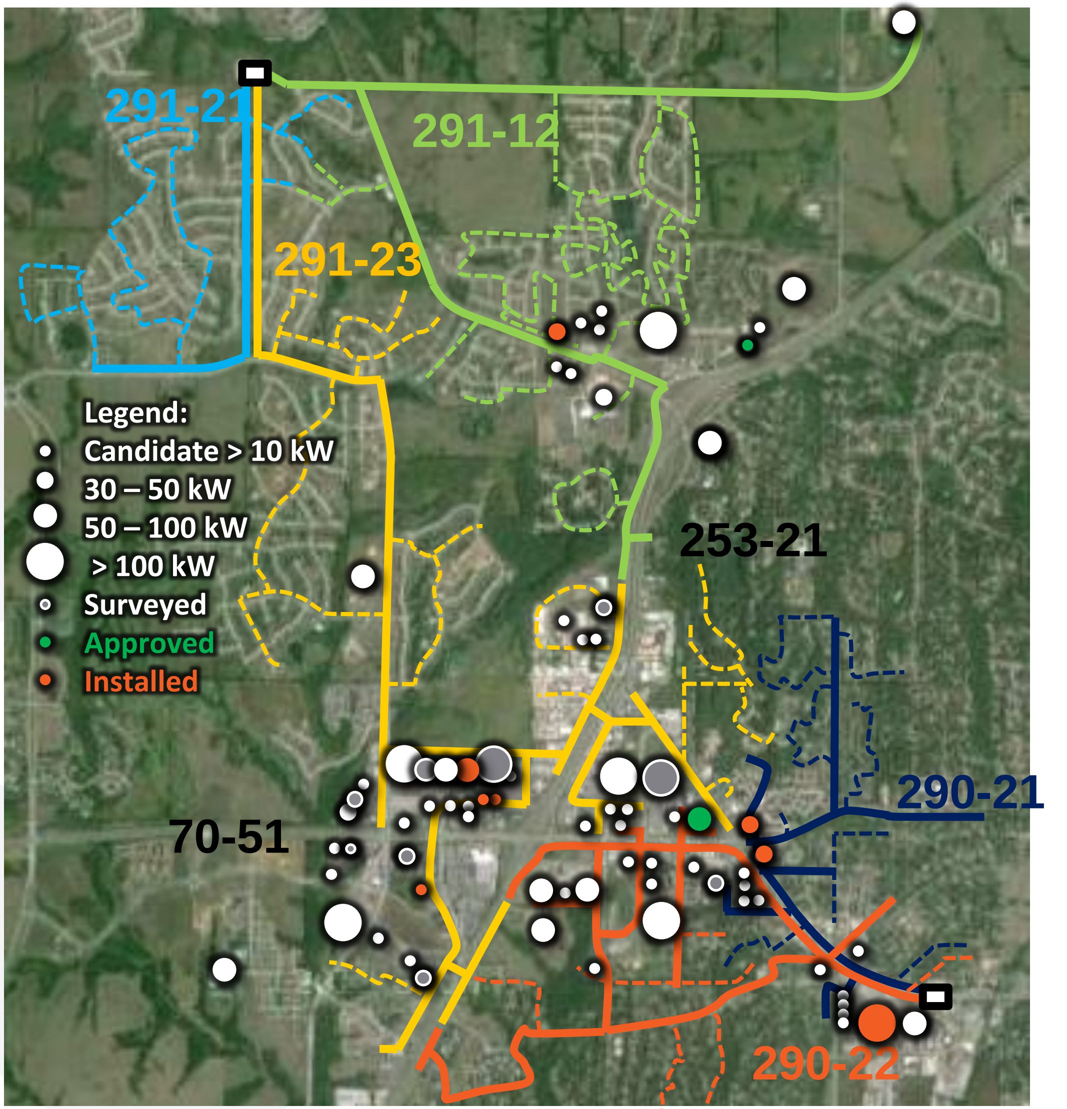
Pursue the entire area with emphasis on feeder 291-23

	Delivered Site kW				
Feeder	10-30	30-50	50-100	100+	Total kW
290-21	2	1	0	0	100
290-22	2	3	3	1	700
291-12	2	2	0	1	300
291-23	**4**	**3**	**6**	**2**	**900**
Total (all Feeders)					~2.0MW

- $4.8 million feeder reconductor deferral on feeder 291-23
- $8.7 million substation upgrade deferral on substation 291
- $1.4 million dollar ADSM project



Targeted Expansion

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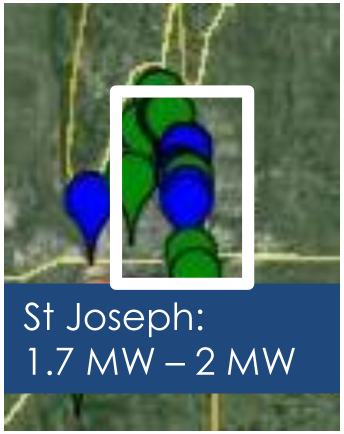

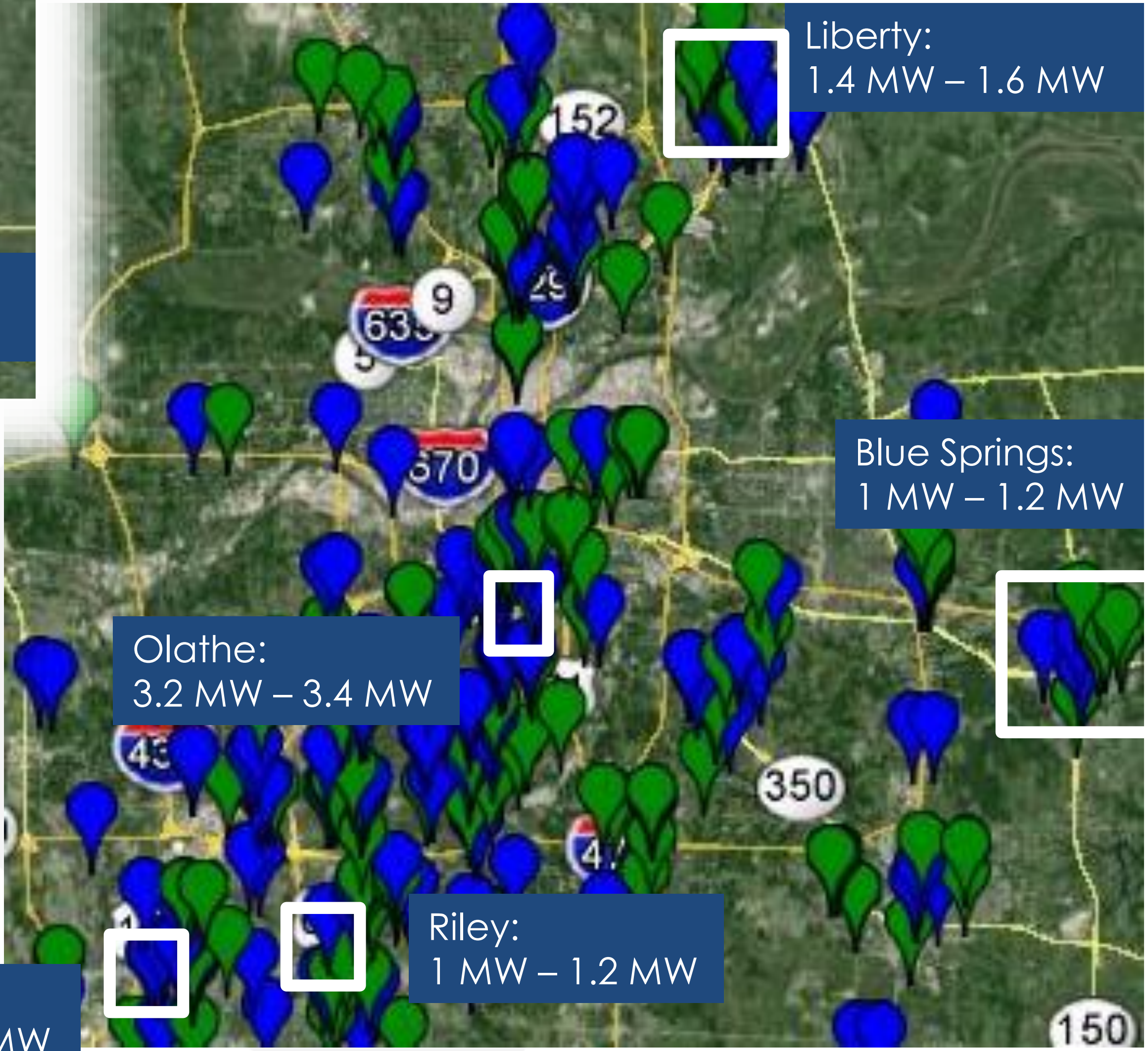

- Substations – 6
- Feeders – 34

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Move to a System Level View

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50 MW Project Benefits:

- 6 deferred substation upgrades $43M
- 14 deferred feeder upgrades $35M
- 50 MW peaker eliminated $92M
- Significant Loss improvement, reduced emissions, improved customer satisfaction and regulatory relationship

Benefits > **$ 170 M**

- Project cost: $35M

Choosing a Sustainable, Lower Cost Asset to Optimize Your Grid

Increases Customer Relationship and Loyalty

Asset: Central Station Generator

- Single, rate based Asset
- Ongoing O&M costs
- Fuel = Fossil fuels
  - Ongoing, highly variable
  - Increases grid losses
  - Negative environmental effects
  - No End-Use Customer interaction

Asset: Virtual Power Plant
(Approx 50% less cost)

- Many distributed sites as one rate based Asset
- Ongoing O&M costs
- “Fuel” = Site Incentives
  - No fossil fuel or variable cost
  - Reduces grid losses
  - Positive environmental effects
- End-Use Customer incentives increase customer loyalty

ADSM is a game changer

- Dramatically Improve System Utilization – as much as 20%
- Defer or eliminate "Inefficient Regulatory Assets" (Feeder reconductor, substation upgrade, etc)
- Defer or eliminate a portion of the required peaking power plants
- Eliminate the need to burn fossil fuels for Ancillary services such as spinning reserves
- Real time phase balancing
- Real time aggregation of DER (Solar, Battery, Generation, etc.)
- Real time balancing of intermittent central station & distributed resources
- Put the control in the hands of the utility/grid operator and improve both the regulatory and consumer relationship
- Dramatically improve Grid Situational Awareness to the lowest level of the network – to the "edge of grid"

Benefits all Utility groups

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○ Lower benefit ● Higher benefit

#		Benefit	Generation	Transmission	Distribution
1		Generator Deferral	●	◑	◔
2		Energy Sales	●	◔	◔
3	**	Return on Assets	●	●	●
4		Feeder Deferral	○	◔	●
5		Ancillary Services	●	◔	◔
6	**	Lost Revenue Recovery	●	●	●
7		Environmental CO2e Reduction	●	◔	◔
8	**	BMS Energy Efficiency Savings	●	●	●
9		System Loss Savings	◔	◑	●
10		Substation Deferral	○	◑	◑
11		Outage and Restoration	◔	◑	●

* Assumes vertically integrated utility
** Corporate benefit

ECONOMICS OF SYSTEM OPTIMIZATION THROUGH ADSM

Is it used and useful and economically superior than next best option.

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Typically a two step process

1. Direct comparison and/or IRP
   - Examine a direct comparative of next best option with direct cost comparisons for instant overnight costs and recurring costs
   - Input 8760 profile into IRP tool with cost parameters to compare against other options
2. Explore the Total Value of the Solution
   - Determine appropriate value categories
   - Input relevant cost data
   - Examine costs versus benefits

The Choice for a Utility 50MW of What?

Peaking Power Plant Comparison

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Traditional Peaker (2-6 or ??? Years)	Innovari IES (6-24 months)
Purchase Land	No Land
Siting Process	No Siting Process
EA/EIS - Environmental Permits	No EA/EIS or Permits (RECs!!!)
Interconnection Study	No Interconnection Study
Gas Line Extension	No Gas Line Extension (No fuel cost)
Construction Costs/Delays	No Construction Costs/Delays
Interconnection Facility	No Interconnection Facilities
Total delivered at end of project	Delivered as acquired – even day one!
Losses on Grid (10% = Lose 5 MW!!)	REDUCES losses (Gain 5 MW)
Increases Spinning Reserve Requirement (12% = Build another 6 MW!!!)	REDUCES Spinning Reserve Requirement (Gain 6 MW)
50MW – 5MW – 6MW = **39MW IRP EFFECT**	50MW + 5MW + 6MW = **61MW IRP EFFECT**
Delivered for $1,500 to $2,500 per kW	Delivered for $695 per kW*
O&M and Fuel Variable each year	Annual Programmatic fixed $43 per kW-yr*
New Emissions and increased fuel requirement	Reduce current and future emissions and fuel use
$75-$125M capex variable	$34.75M capex fixed
$4-$8M opex variable	$2.15M opex fixed

*plus applicable shipping/customs/tax/customer incentive/etc

The Choice for a Utility 50MW of What?
California Capacity Bidding Program

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Traditional Utility DR Program (CA CBP)	Utility-Owned ADSM (IEP Program)
Outsource C&I relationships to third party	No third party disintermediation with utility C&I customers
Marketing, customer acquisition by third party	Marketing by third designed to enhance utility relationship with their customer
Payment of Technology Audit (TA) and Technology Incentives (TI) for 3 yr commitment	No TA or TI incentive payments
Event dispatch to customers from third party	Utility contolled dispatch of any event
Confirmation of performance 30-60 days post event	Performance verified in real time with RTCM™
Post event M&V to validate participation / payments	No post event M&V required
Legal costs for any settlement disputes	No settlement disputes – all incentives fixed, no variable
Customer retention for program rests with third party	Customer retention included on behalf of utility
Program expenses recovered as pass through-no earning	Asset purchase allows utility rate of return (20 yr asset)
Program participation rates vary by vendor	Contracted capacity guaranteed
Program for May to Oct, between 12p-8p; not more than 24 hours per month; Annual usage is <80 hours per year	Resource available for dispatch 24x7x365
Delivered for $150 per kW to $350 per kW in TA/TI for 3yr; kW must be re-signed or replaced each 3 yr term	Designed for annual usage of 487 hours per year
Annual Programmatic incentive of $71 per kW-yr*	Delivered and installed for $695 per kW*
Annual Costs for energy for any event called	Annual Operational Cost fixed $43 per kW-yr*
$20M-$36.5M TI each program term + $3.5M/yr opex + Energy Payments for events called	No energy settlement and No energy costs
20 year NPV for CBP = $160.3M	**$34.75M capex (one time) + $2.15M/yr opex fixed**
	20 year NPV for ADSM = $67.5M
*does not include utility internal costs of program management, adminstration and settlment	*plus applicable shipping/tax/incentive/etc

The Choice for a Utility 50MW of What?
California Capacity Bidding Program

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- Delivered for $150 per kW to $350 per kW in TA/TI for 3yr; kW must be re-signed or replaced each 3 yr term
- Annual Programmatic incentive of $71 per kW-yr*
- Annual Costs for energy for any event called
- **$20M-$36.5M TI each program term + $3.5M/yr opex + Energy Payments for events called**
- **20 year NPV for CBP = $160.3M**

*does not include utility internal costs of program management, adminstration and settlment

Utility-Owned ADSM (IEP Program)

- No third party disintermediation with utility C&I customers
- Marketing by third designed to enhance utility relationship with their customer
- No TA or TI incentive payments
- Utility contolled dispatch of any event
- Performance verified in real time with RTCM™
- No post event M&V required
- No settlement disputes – all incentives fixed, no variable
- Customer retention included on behalf of utility
- Asset purchase allows utility rate of return (20 yr asset)
- Contracted capacity guaranteed
- Resource available for dispatch 24x7x365
- Designed for annual usage of 487 hours per year
- Delivered and installed for $695 per kW*
- Annual Operational Cost fixed $43 per kW-yr*
- Annual Customer incentive $30/kW-yr
- No energy settlement and No energy costs
- **$34.75M capex (one time) + $2.15M/yr opex fixed**
- **20 year NPV for ADSM = $90.4M**

*plus applicable shipping/tax/etc

The Choice for a Utility 50MW of What?

PJM Forward Capacity Market Program

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Traditional ISO DR Program (PJM FCM)

- Outsource C&I relationships to third party
- Marketing, customer acquisition by third party
- Event dispatch to customers from third party
- Confirmation of performance 1-45 days post event, (utility meter v customer owned meter)
- Post event M&V to validate participation / payments
- Legal costs for any settlement disputes
- Customer retention for program rests with third party
- Program expenses recovered as pass through-no earning
- Program participation rates vary by vendor
- Program June 1 – September 31, between 12p-8p; not more than 10 events/yr lasting up to 6 hrs in duration
- PJM conducts up to 4 capacity auctions for each delivery year leading to variable incentives
- $44-$52/kW-year capacity* + $1/kWh energy payment
- **$2.6M capex/yr + $0.68M/yr energy payments for 13.5hrs** *(avg. number of hrs called 2010-2013)*
- **20 year NPV = $53.2M**
- **$2.6M capex/yr + $24.4M/yr energy payments for 487hrs**
- **20 year NPV = $438.1M**

* **Average range for Delivery Year (DY) 2015-16.** Does not include utility internal costs of program management, adminstration and settlement

Utility-Owned ADSM (IEP Program)

- No third party disintermediation with utility C&I customers
- Marketing by third designed to enhance utility relationship with their customer
- No TA or TI incentive payments
- Utility contolled dispatch of any event
- Performance verified in real time with RTCM™
- No post event M&V required
- No settlement disputes – all incentives fixed, no variable
- Customer retention included on behalf of utility
- Asset purchase allows utility rate of return (20 yr asset)
- Contracted capacity guaranteed
- Resource available for dispatch 24x7x365
- Designed for annual usage of 487 hours per year
- Delivered and installed for $695 per kW*
- Annual Operational Cost fixed $43 per kW-yr*
- <u>No</u> energy settlement and <u>No</u> energy costs
- **$34.75M capex (one time) + $2.15M/yr opex fixed**
- **20 year NPV for ADSM = $67.5M**

*plus applicable shipping/tax/incentive/etc

Total Value Model

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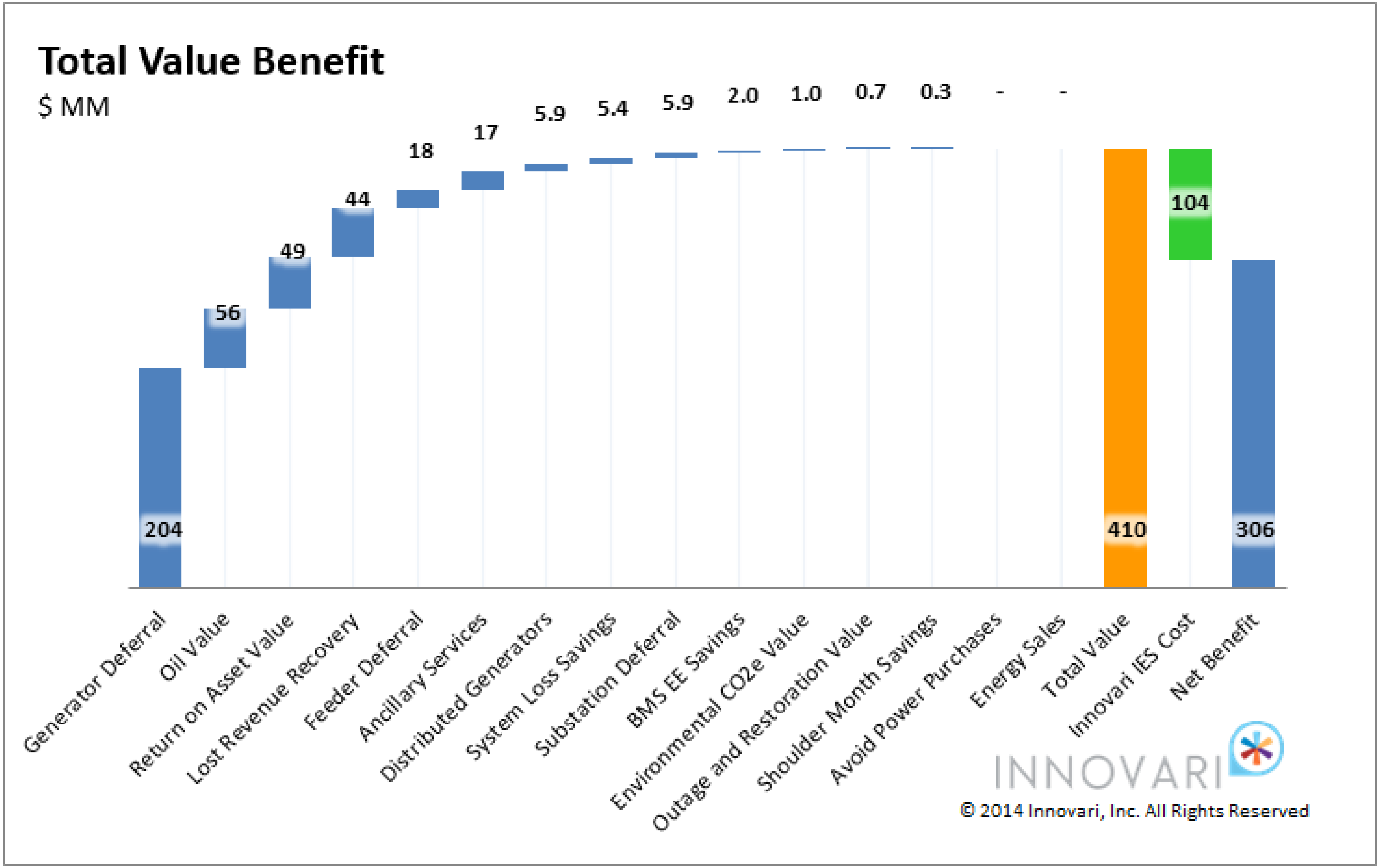

Any effort undertaken should strive to connect utilities, their customers, and their communities to improve how the world uses energy.

HOW DOES THE INTERACTIVE ENERGY PLATFORM REALLY WORK? HOW DOES IT ENABLE THE EDGE OF THE GRID?

A Platform that delivers now and enables the future

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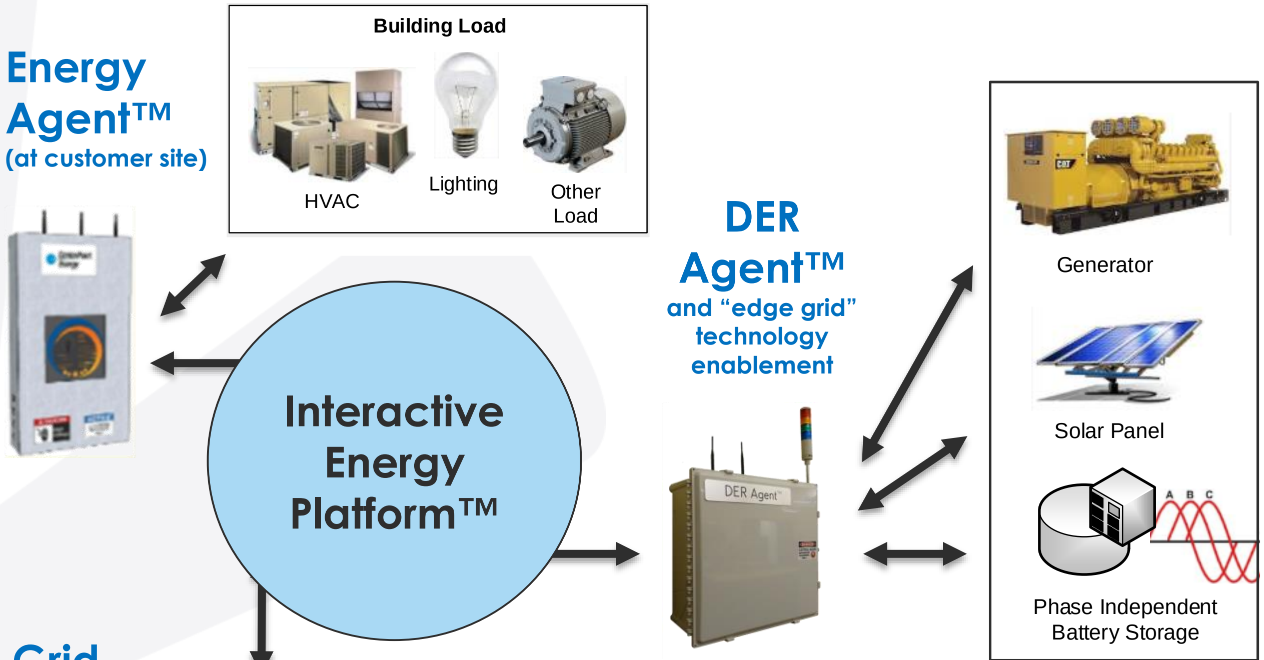
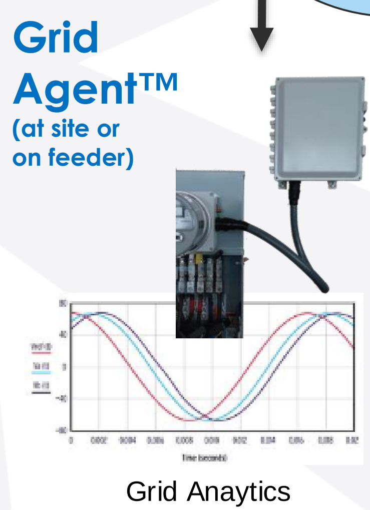
<u>Now</u>: Two-way, verifiable, closed loop control. ADSM dispatched by the utility. The possibilities go far beyond load management. Ancillary services (Spin and Non-Spin reserves), feeder management, substation management, congestion management, peaking generator deferral or elimination, positive environmental benefits, etc.



<u>Now and in the future</u>: Utility has greater visibility deep into the grid, with advanced monitoring and analytics:

- Volt / VAR,
- Power Quality,
- DG & PV integration/monitoring
- Harmonics
- Digital Fault Recording
- Distribution level PMU



Grid Anaytics

<u>Now and in the future</u>: Utility enables edge-grid technology and DER, even microgrids. Incorporate customer-owned, or in the future, utility-owned distributed generation. Manage distributed solar with building loads where it is deployed or with additional load on the feeder so the whole system is not affected by this resource. Balance central station intermittent renewables. Incorporate distributed storage and use it to optimize phase balance and feeder efficiency as well as protect customers from outages.

Pharmacy Facility Overview

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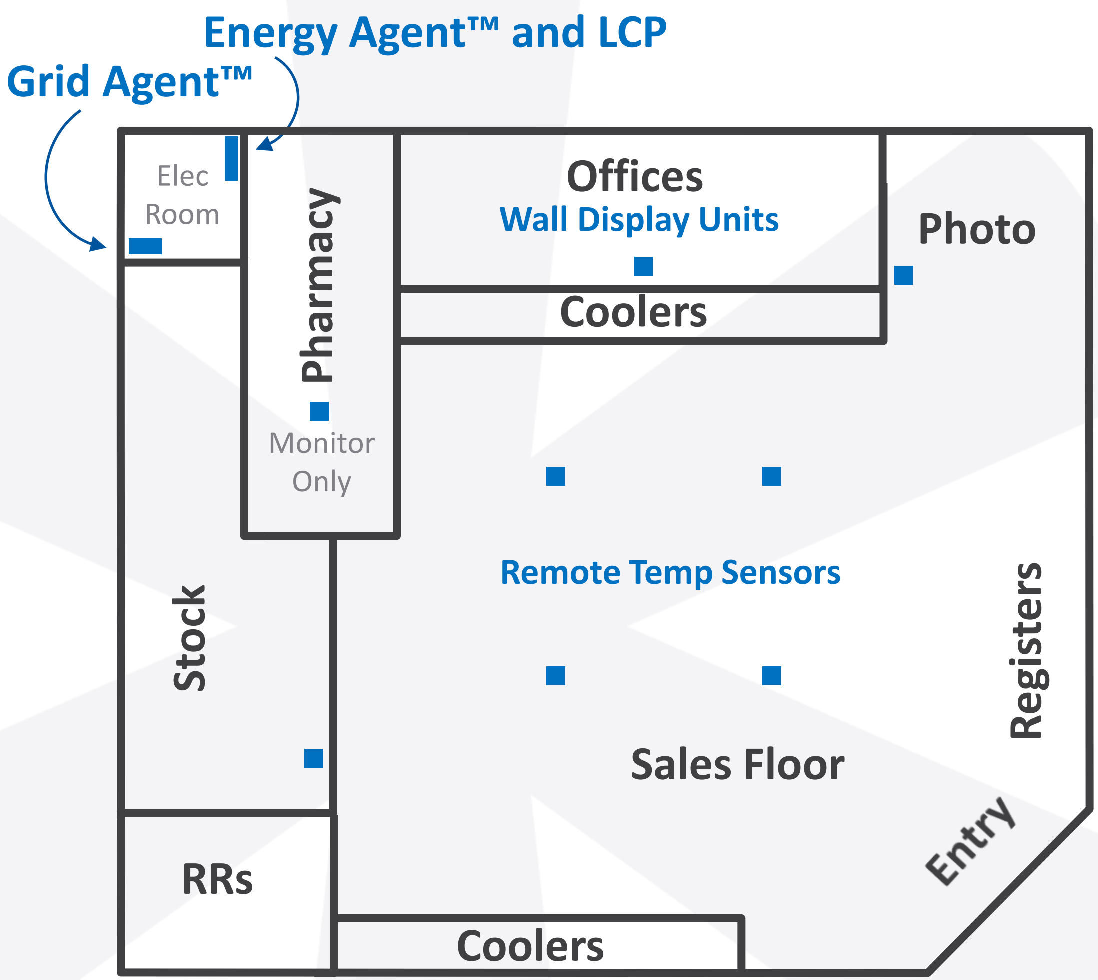


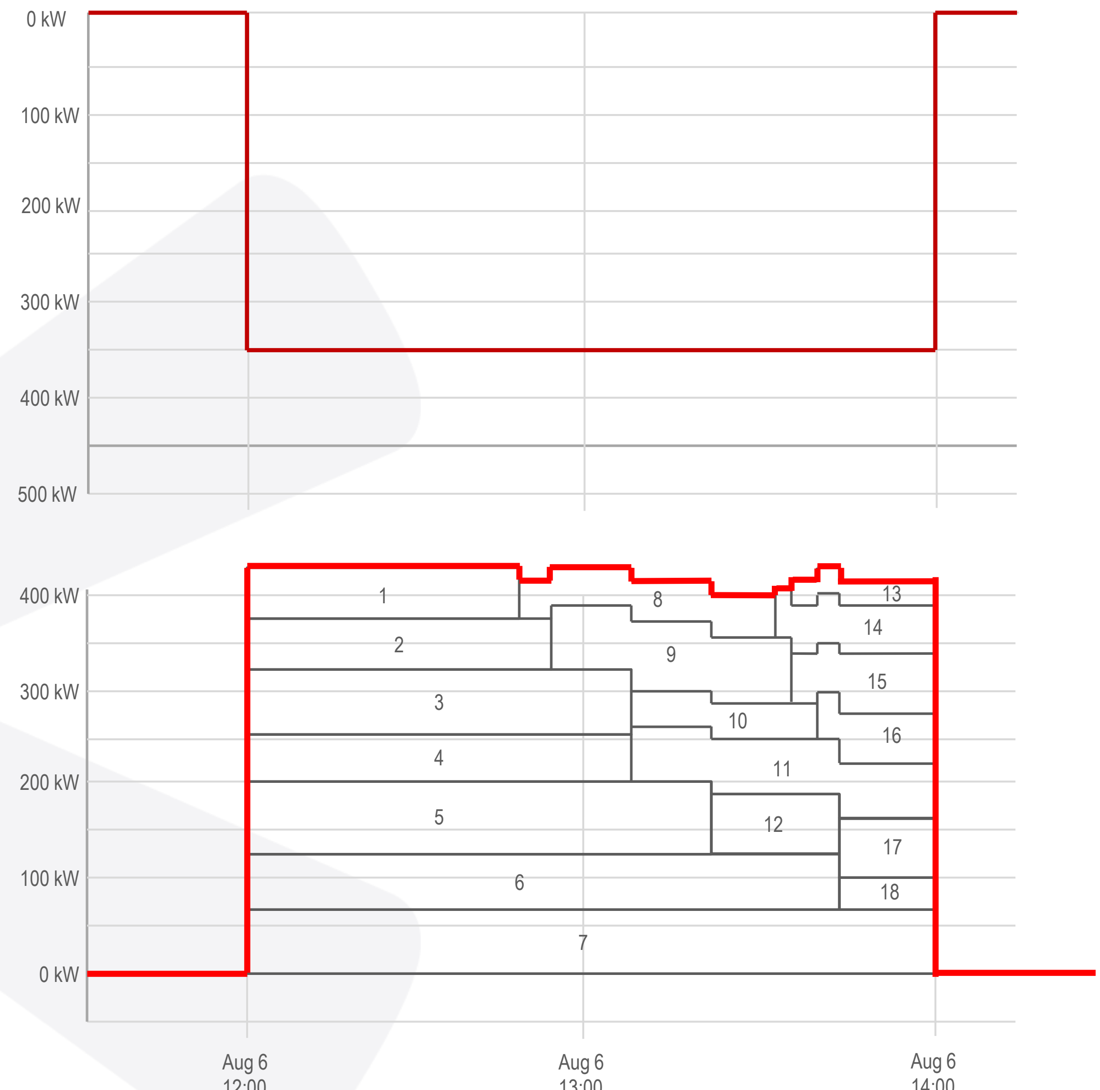
AREA	Temp ↑	Temp ↓
Sales Floor	2	3
Offices	0	2
Stock	6	10
Drink Cooler	4	6
Food Cooler	2	4
Freezer	6	8
Pharmacy	0	0

Lighting

- Changes for each level of Consequence
  - Contract Capacity
    - Near windows, soffit, coolers, 4 rows of sales floor
  - Medium Consequence 3 kW
    - 25% of floor lights
    - 25% of stock room lights
  - High Consequence
    - 50% of floor lights
    - 50% of stock room lights
  - Grid Emergency
    - 90% of floor lights
    - Photocopy

Visualizing an Event

- The upper graph represents a dispatch Event where 350kW is requested for a period of two hours
- This request may be targeted at a specific Feeder or an aggregate need across any portion of the Utility Grid
- The lower graph shows how the IEP then selects a combination of devices, each represented by a “brick” (capacity and duration), which are stacked and sequenced to meet the dispatch request



Calculating Performance

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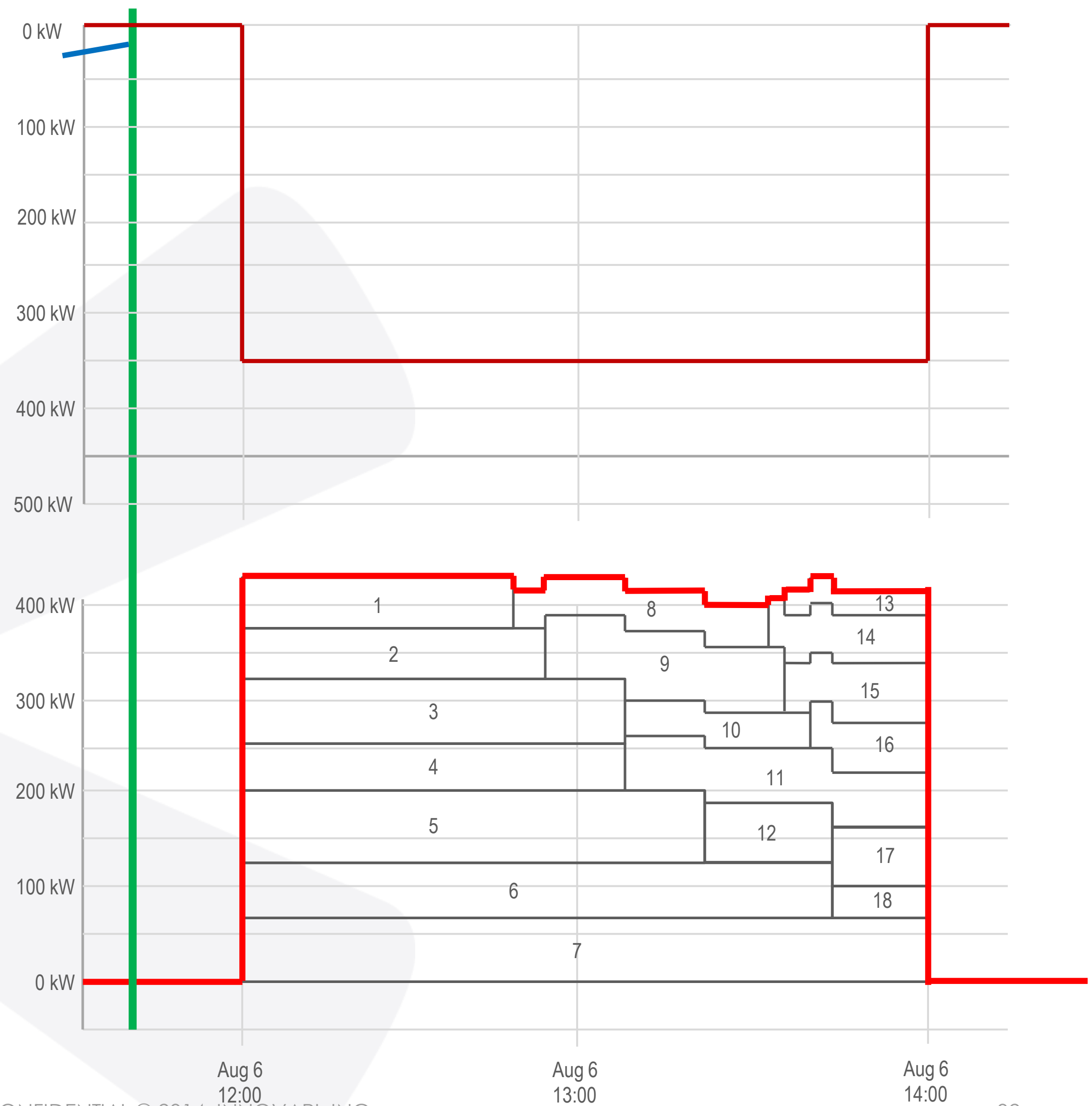
At any point in time, the IES determines and reports the state of each device under three cases:

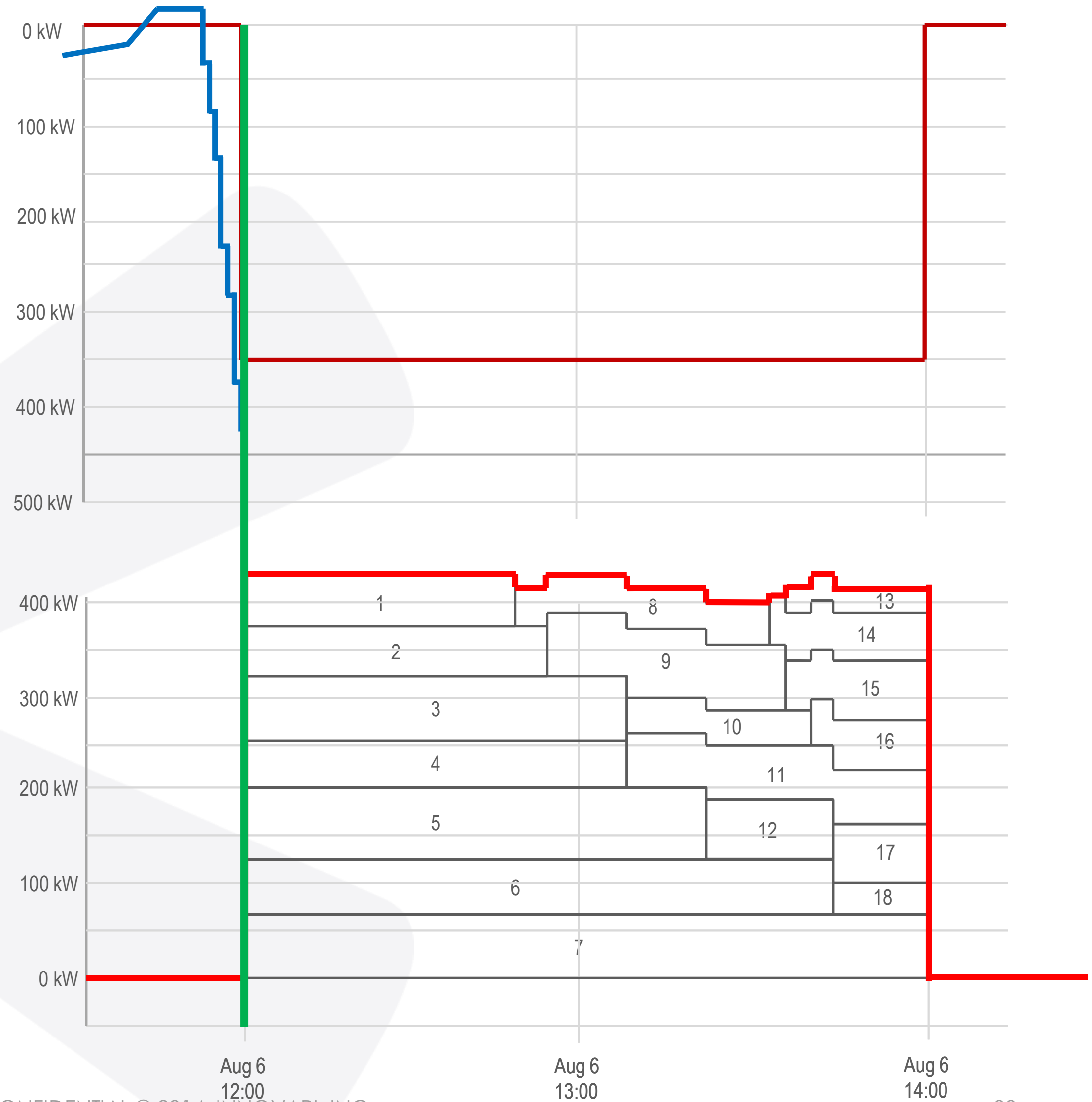
- Before t = Tstart
- During the Event
- After t = Tend



Note: In this example the IES will initiate control requests to 18 different devices "bricks" at different times during the Event to maintain the dispatch request. There are other factors not illustrated here which include ramping, temperature dependence, forecasted operating schedules and other considerations

Performance at Event start

- The solid blue line represents the status and capacity of each device
- Pre-Cooling and Ramp up of devices before Event
- In this example, bricks 1-7 are the only devices called to operate at the beginning of the Event as they fulfill the capacity of the dispatch request plus an operating margin
- Verification at the time of Event includes the observation of a state change (ON to OFF) for each device



Performance during Event

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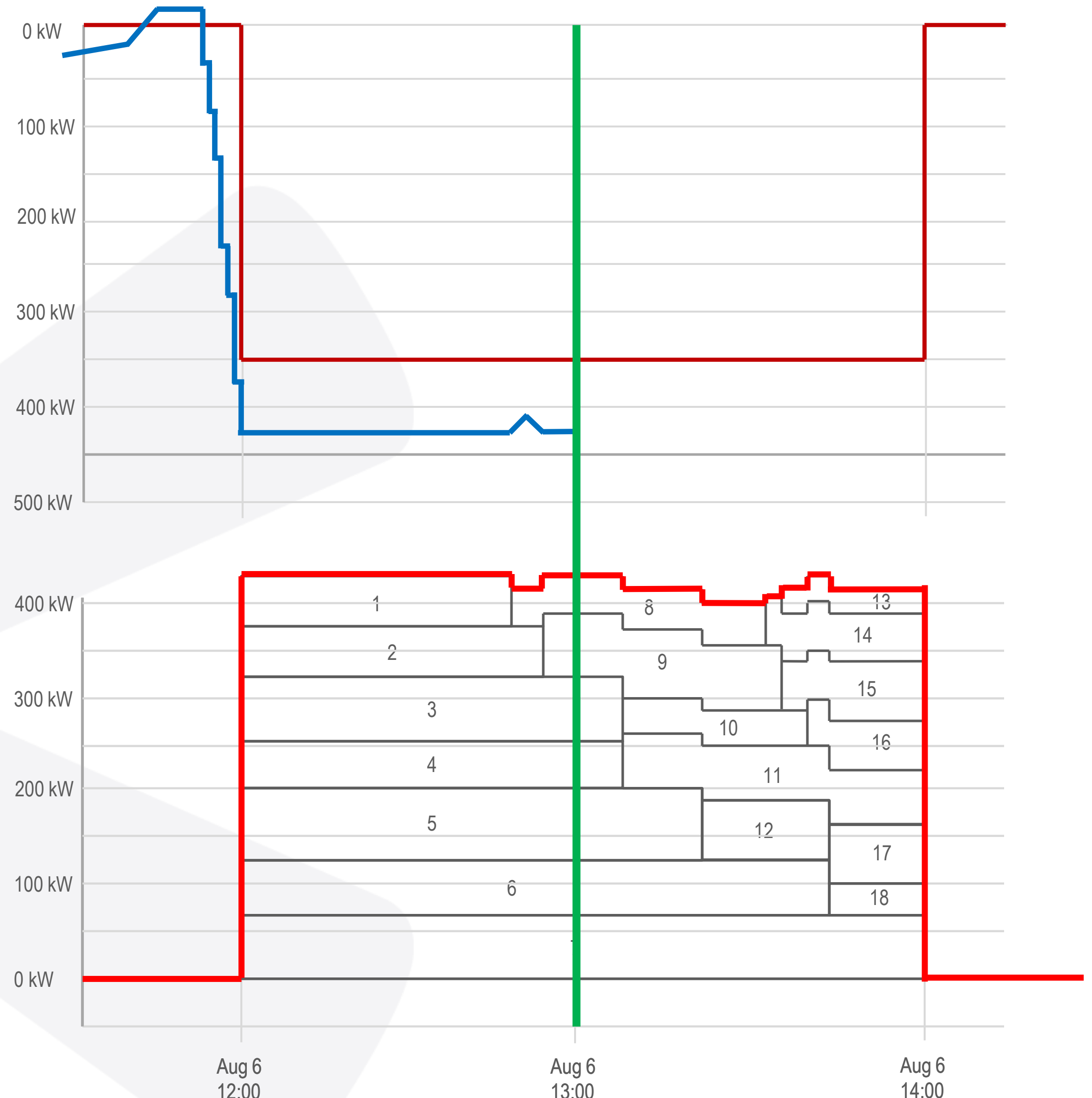
- In this example, bricks 1 and 2 had known dispatch durations of 40 and 50 minutes, less than the desired dispatch request of two hours
- Two additional bricks, 8 and 9 have been added to the portfolio to maintain the dispatch request

Note: In this example the IES will initiate control requests to allow for overlapping start and stop of bricks and other factors not illustrated here which include time to full state change and other considerations



Performance during Change

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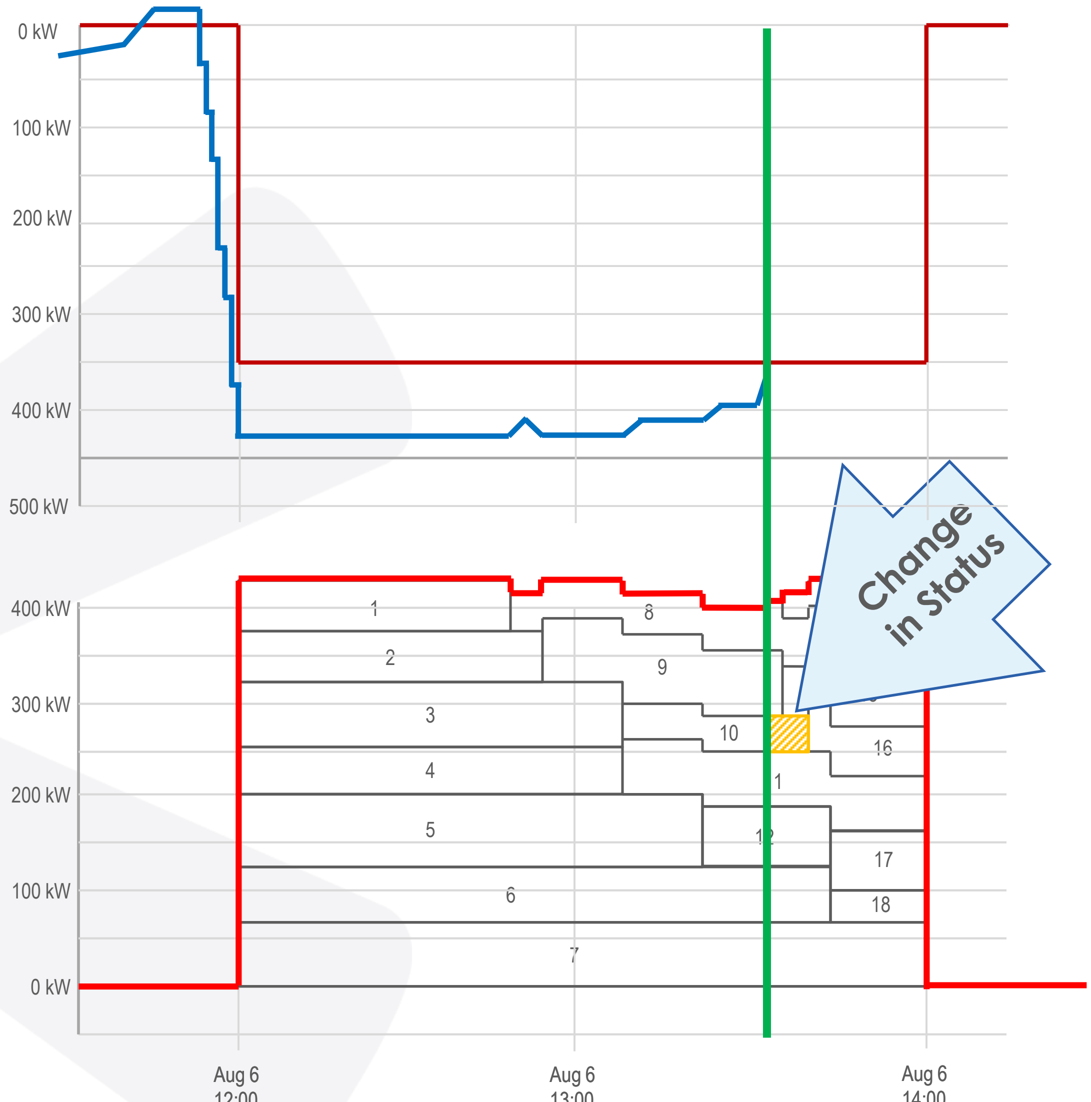
- In this example, brick 10 has been observed to change state prior to the intended duration by any of several factors:
  - Manual override of the Event by the customer
  - Automatic recovery due to building operating temperature exceeding limits
- The operating margin allows for these variances of each individual device performance and additional bricks are called in real-time when needed



Performance Monitoring

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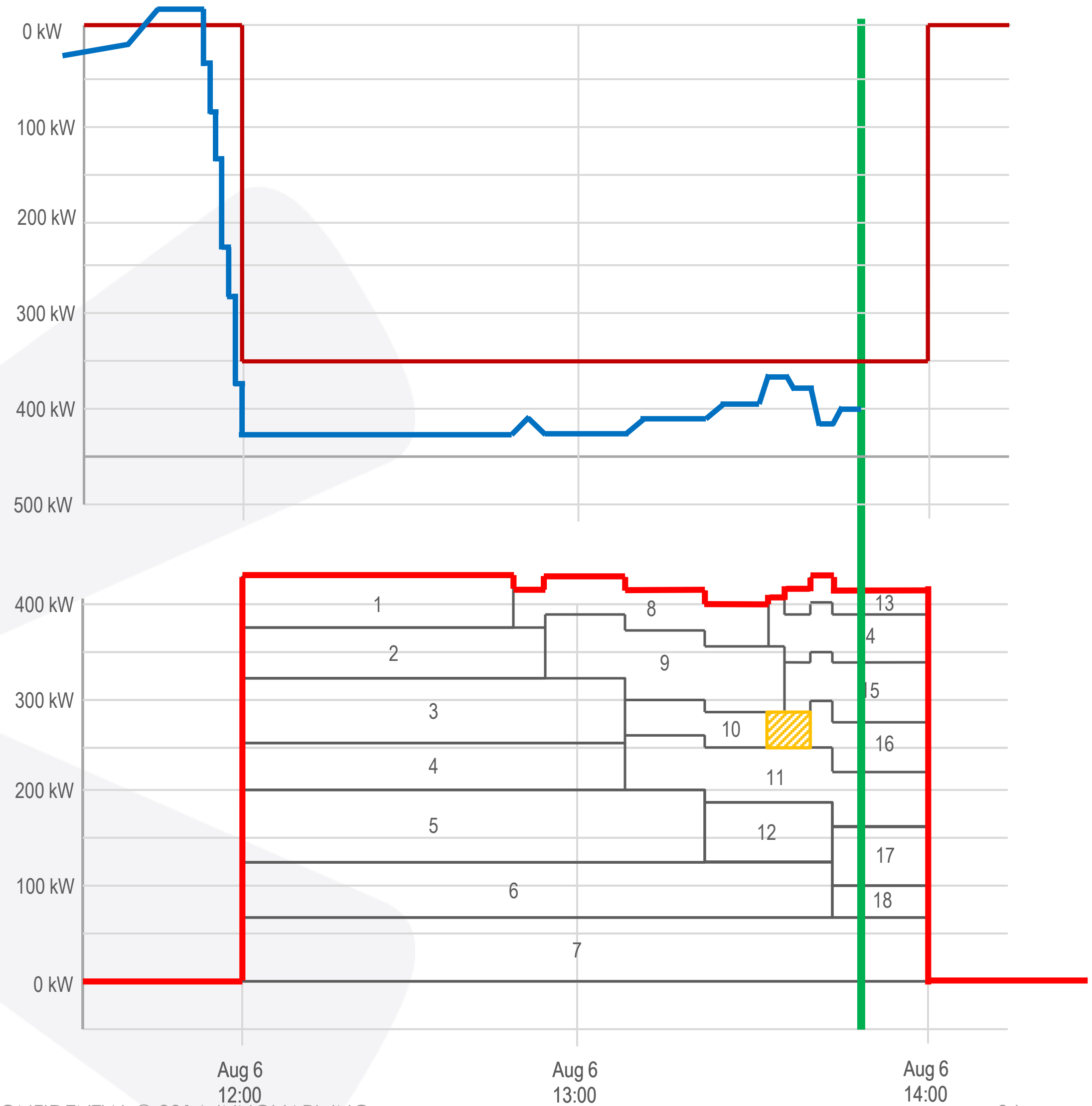
- The real-time monitoring of each individual device is presented as aggregated capacity (solid blue line) continuously over the period of the Event regardless of the number or sequence of participating "bricks"
- Operating margin is determined and maintained by the IES dependent on the characteristics of each participating "brick"



Performance at end of Event

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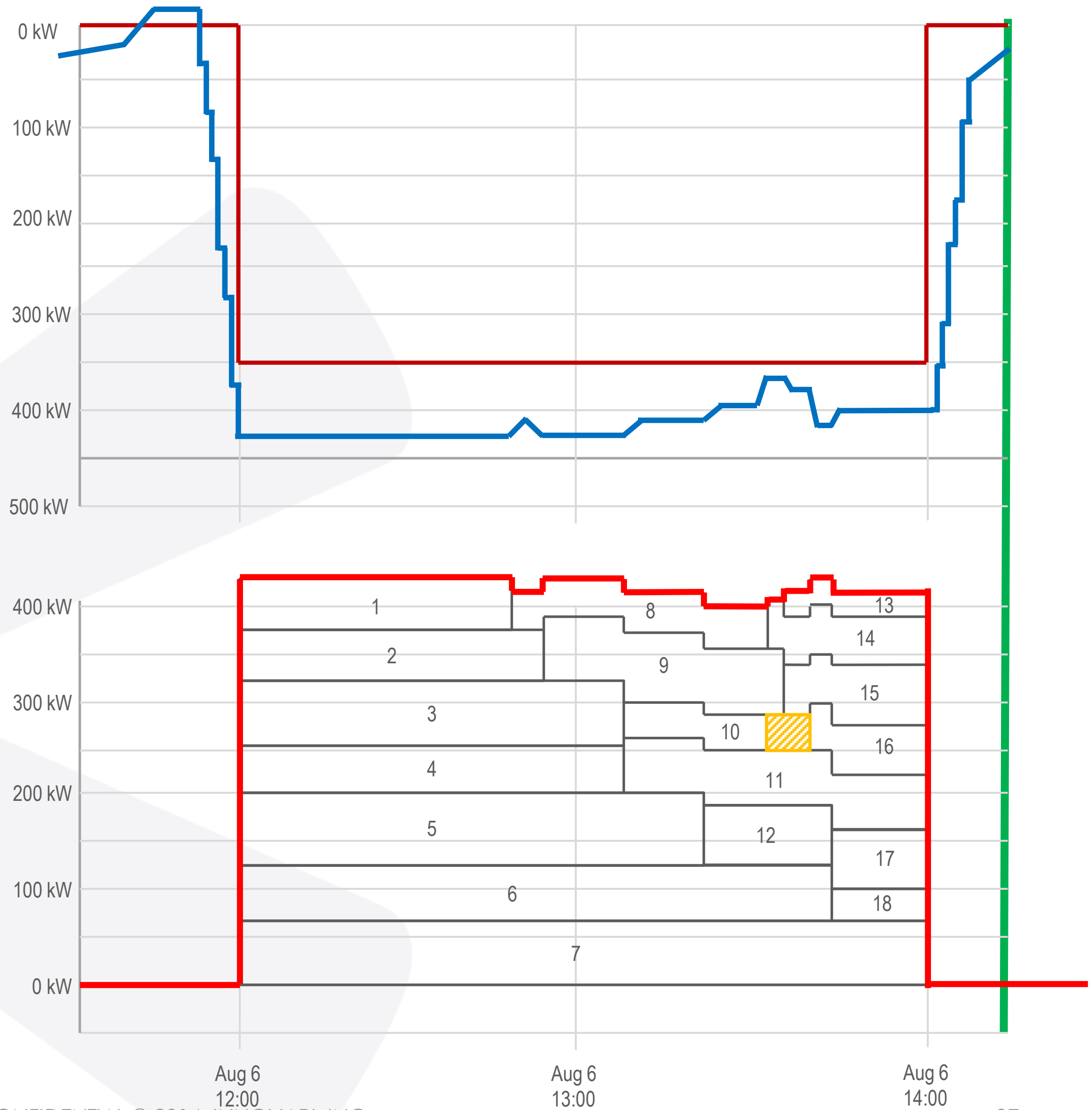
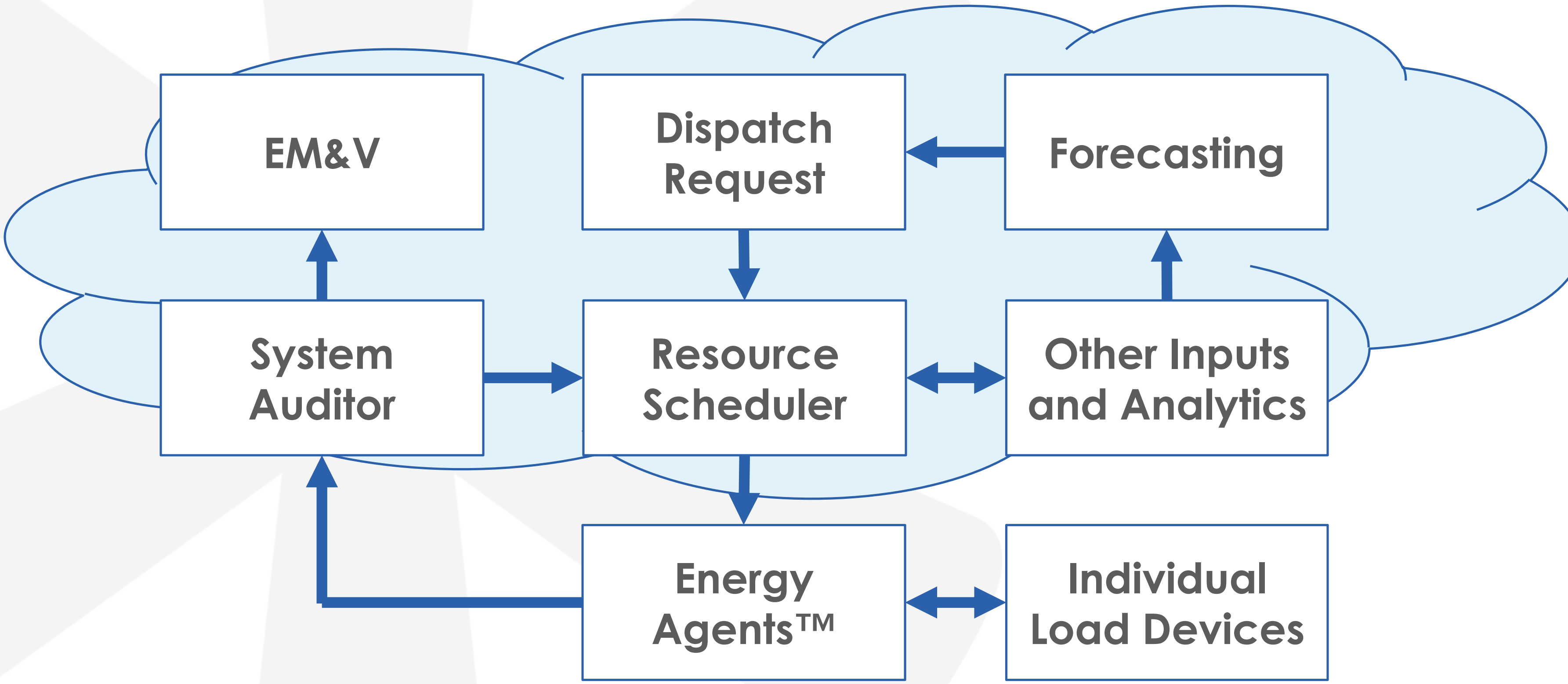
- Ramp up of devices to following end of Event
- Verification at the end of an Event may include the observation of a state change (OFF to ON) for each device
- Ensure no "snap back"

Note: There are other factors not illustrated here which affect when switched loads may return to an operating state include ramping, temperature dependence, forecasted operating schedules and other considerations



RTCM Event Management

The IEP includes a two-way communication system with real-time sensing and control equipment – internal auditor functions assure a dispatch request is aggregated, delivered and maintained for the duration of the event



Utility Portal

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Available Capacity by Duration

Historical and 24 hour forecast

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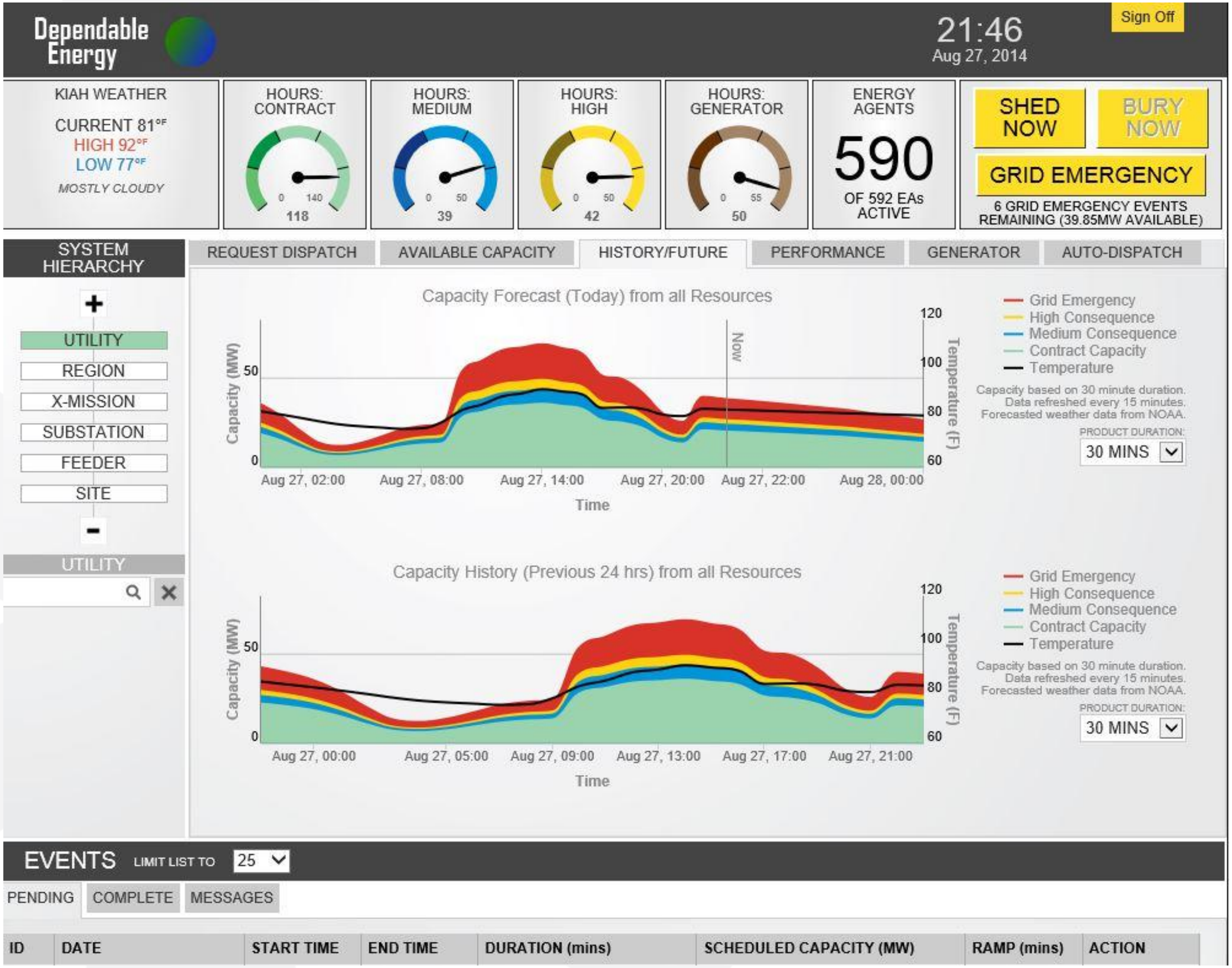
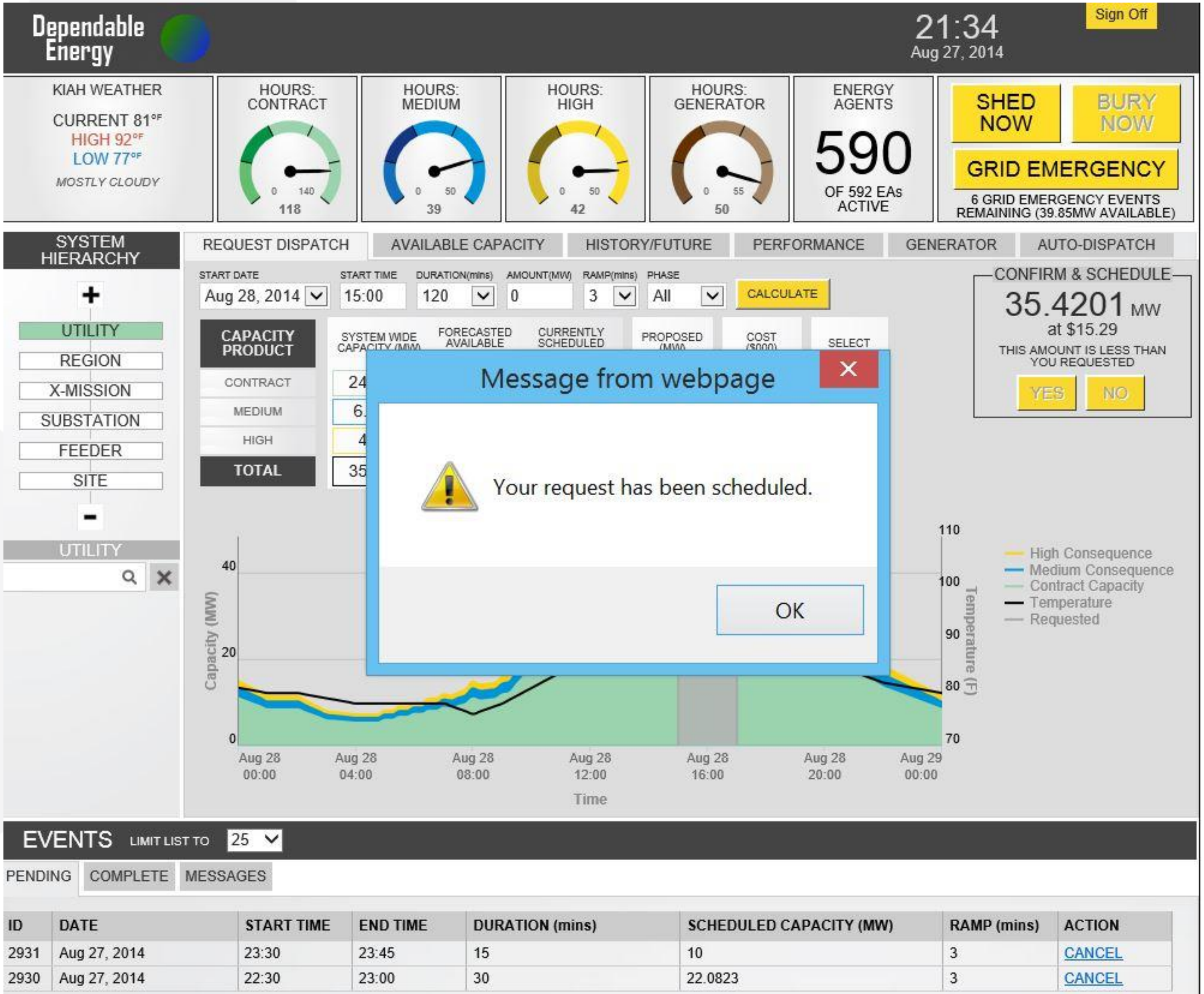


Request 2 hour dispatch - System

Request Confirmation



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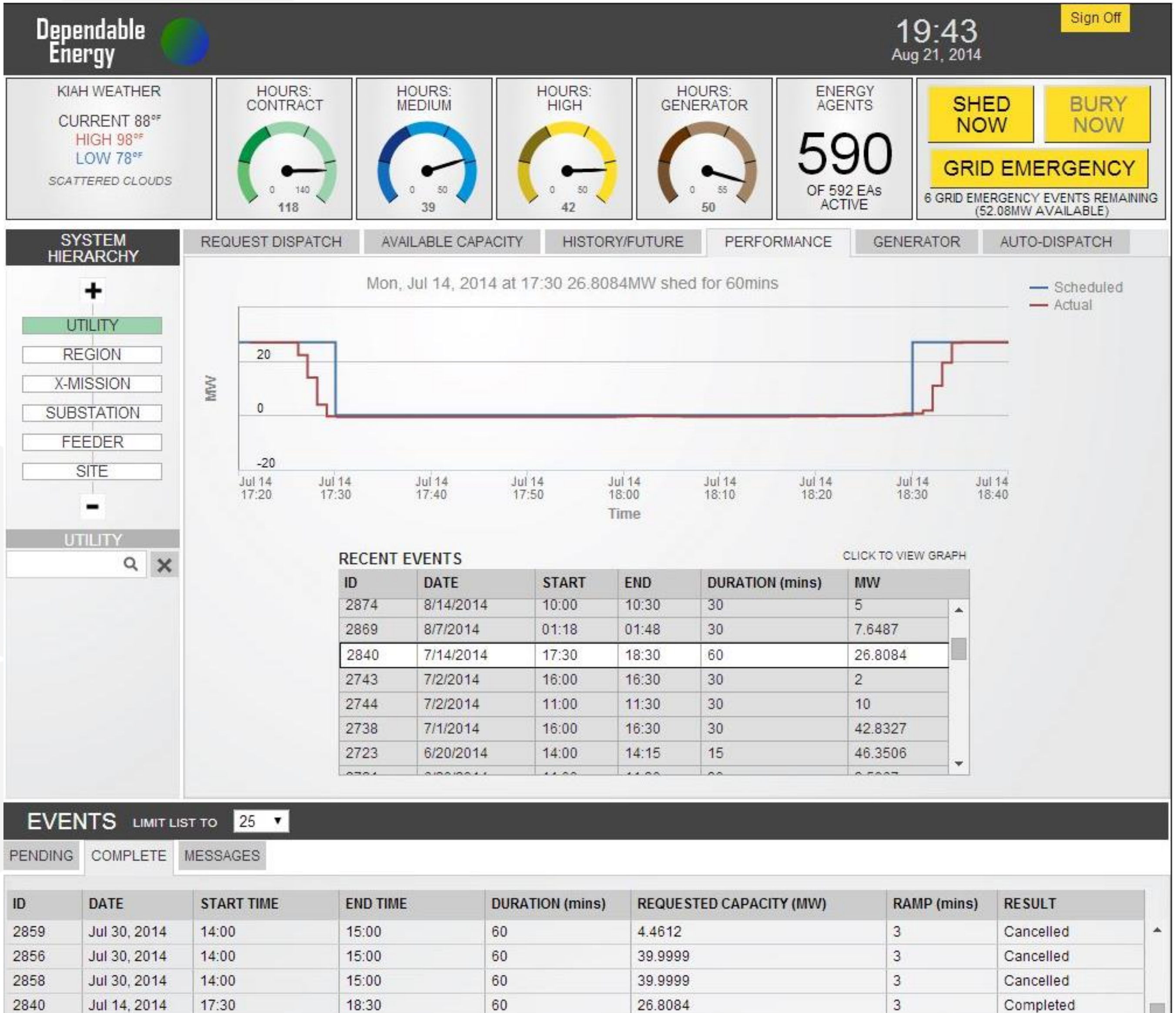
Event Performance



Continue on this path?

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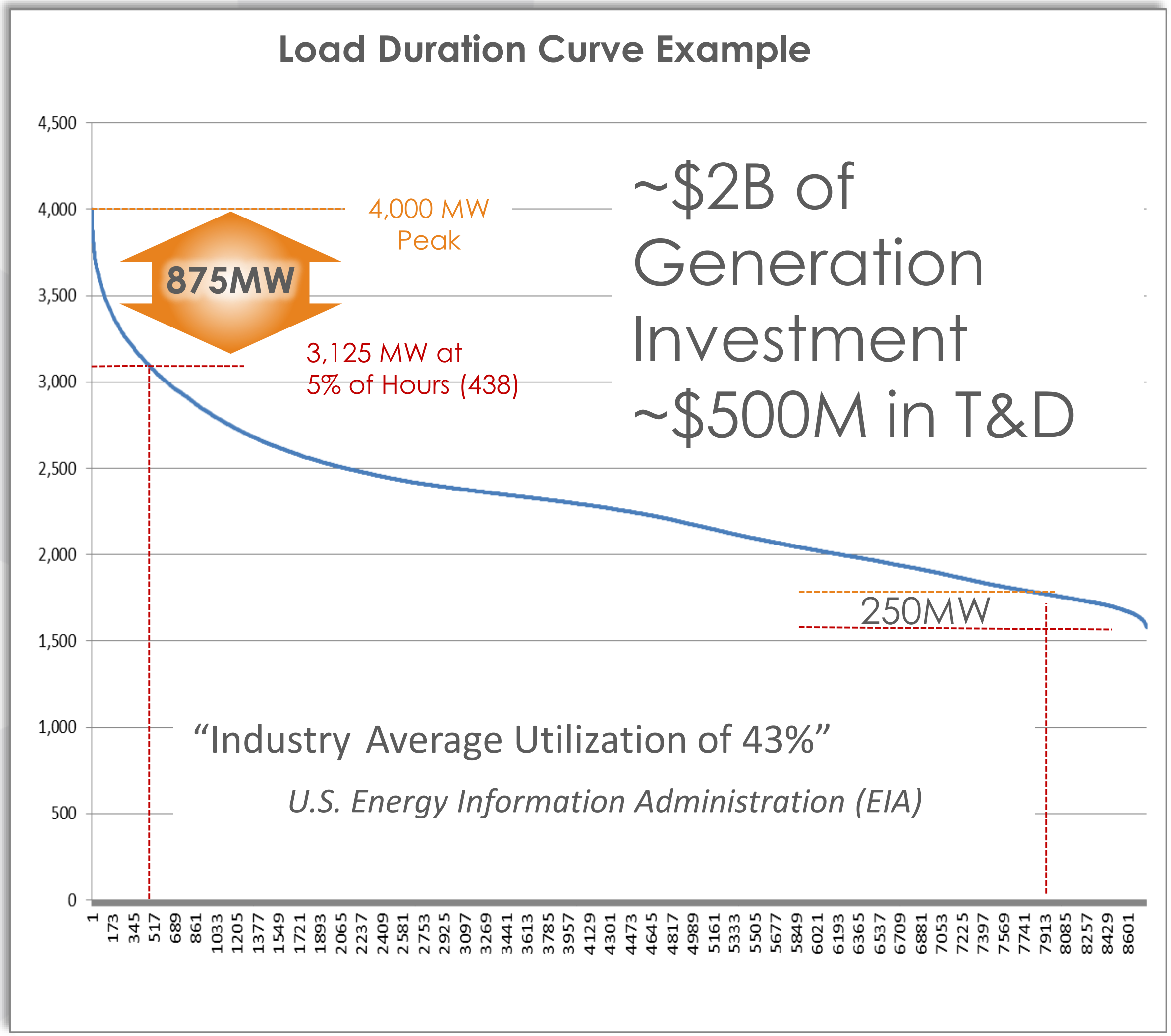

- Billions spent on underutilized infrastructure
- Fuel costs and emissions increased through use of inefficient peaking power or hot stand-by
- Peaking units use increased and life decreased to attempt to balance renewables on the grid
- Customers resources stranded and not dramatically under utilized
- System technical losses and imbalance increasing over time

India is a Leapfrog Nation

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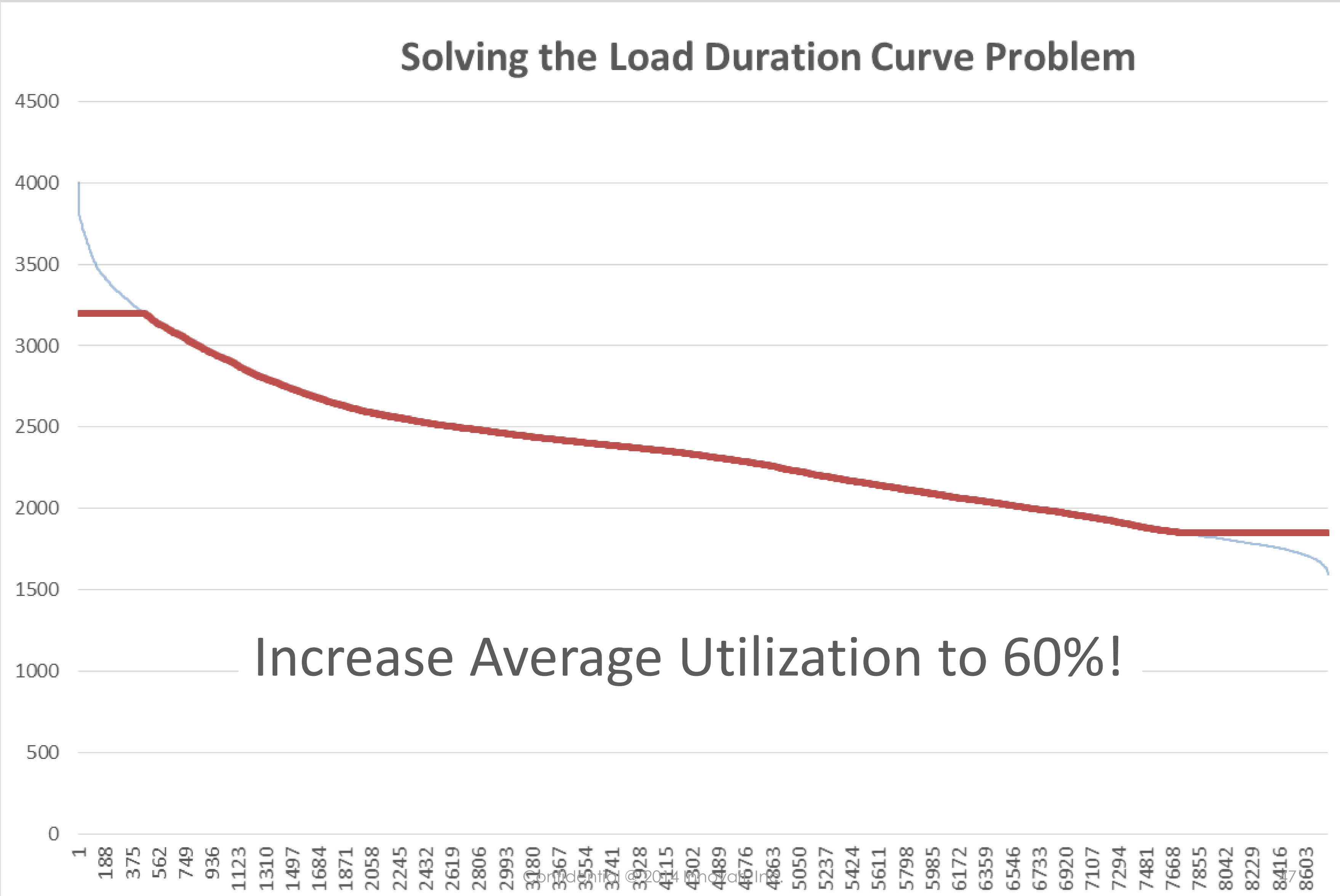
- India has rapid and sustained growth
- India will move from a 200GW peak to 600-700GW peak
- India has demonstrated the willingness to abandon old paradigms and leapfrog to a new reality based on solid science
- India is the only nation that we can see that has the real opportunity to leap frog traditional electri grid paradigms

India will show the world



THANK YOU!

Questions?

HEADQUARTERS
2900 N. Quinlan Park Rd
Suite B240, #215
Austin, TX 78732
512 318 2154

www.innovari.com

NOC & TECHNOLOGY CENTER
19720 NW Tanasbourne Drive
Suite 320
Hillsboro, OR 97124

BACKUP DATA CENTER
Santa Clara, CA

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Buenos Aires, Argentina
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Mumbai
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Bangalore