BPA Grid Operations, Bi-Lateral Markets, and Transactive Energy (A Summary)

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About BPA

- Not-for-profit federal electric utility
- Owns and operates high-voltage transmission grid of more than 15,000 miles of lines in Washington, Oregon, Idaho and Montana
- Markets more than a third of the electricity consumed in the Pacific Northwest – customers are utilities, not end-users.
- BPA helps fund and manage the largest fish and wildlife program in the world
- Since 1980, BPA's conservation efforts have saved more than 1,000 average megawatts for the region. That's enough electricity to serve a city about the size of Seattle

B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Federal Columbia River Power System

and

BPA Service Area

About BPA

Service area (sq. miles) Primarily Washington, Oregon, Idaho, Western Montana)	300,000
Transmission circuit miles	15,215
BPA substations	263

Grand Coulee Dam

2010 Balancing Authority (BA) Statistics	**FCRPS/CGS**	**BA Total**
Nameplate Rating (MW)	21,600	
Peak Generation (MW)	16,300	18,400
Average Generation (aMW)	6,900	8,000
Peak Load (MW)		9,800
Average Load (aMW)		5,900

Today's Electric Grid is Changing.

- Relation between generation and the loads connected to the bulk electric grid the power system is increasingly different.
  - Historically: provided electricity when and where people needed to use it,
  - Now (with renewables): increasingly called upon to find loads for wind or solar when they are available.

- Increasing need to manage transmission congestion.
  - Focus on increasing capacity of existing system,
  - Operating the optimal generation sources could cause some transmission lines to be overloaded if certain single contingencies occurred,
  - Increasing interest in modifying transmission and distribution loading to delay capital investment.

Some Questions

- What alternatives do we have to the expense of keeping generation reserves on standby to provide reliability and flexibility?
  - For controlling grid congestion?
  - For deferring major capital investmen without compromising reliability?

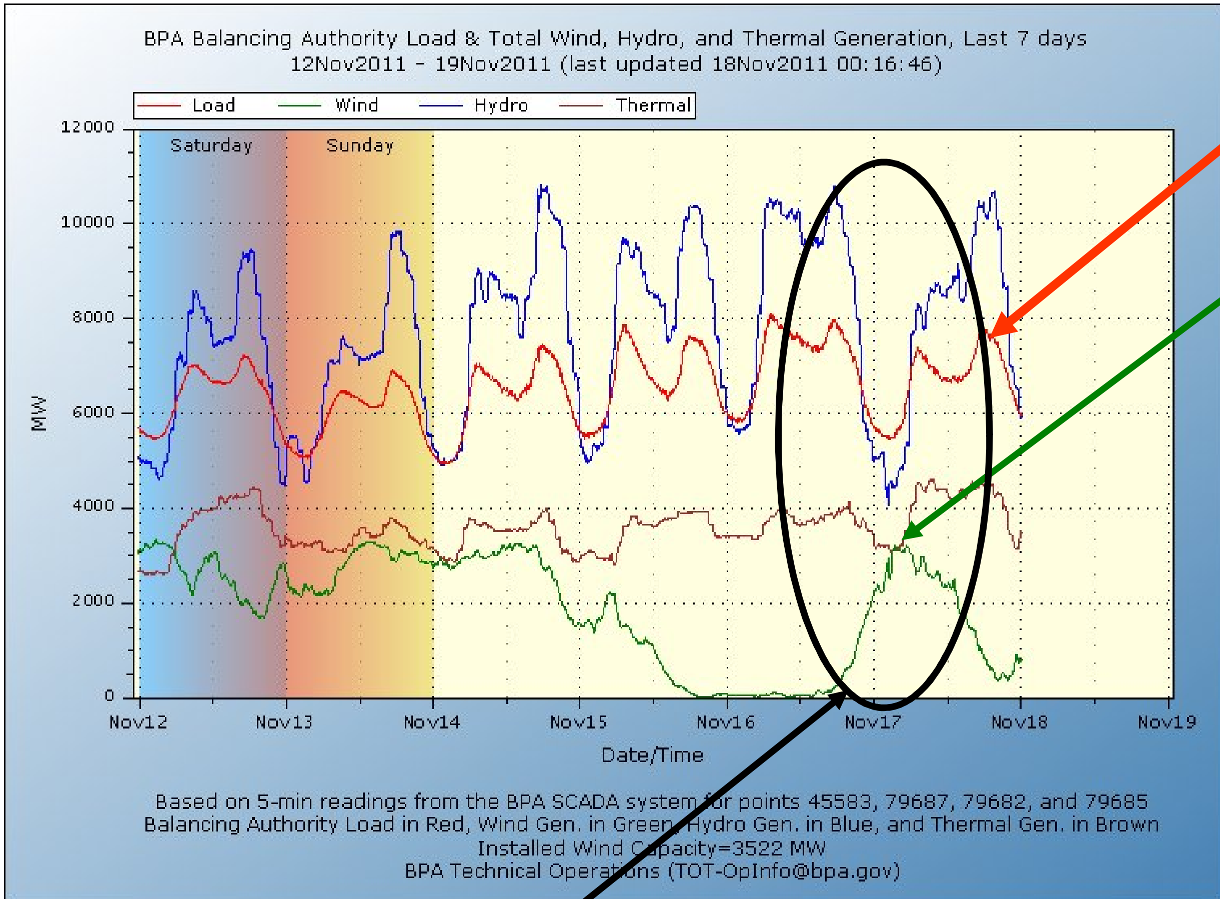
- Can demand response ***reliably*** shut off (or turn on) consumer load to balance for short periods until other sources can be put in service?
  - If so, how are such resources coordinated, considering that different entities own the assets and have control?

Some Questions (cont.)

- How can we assure that critical requirements are met and the true highest priorities served?
- What mechanisms can be used to negotiate this in real time with many levels of interactions taking place?

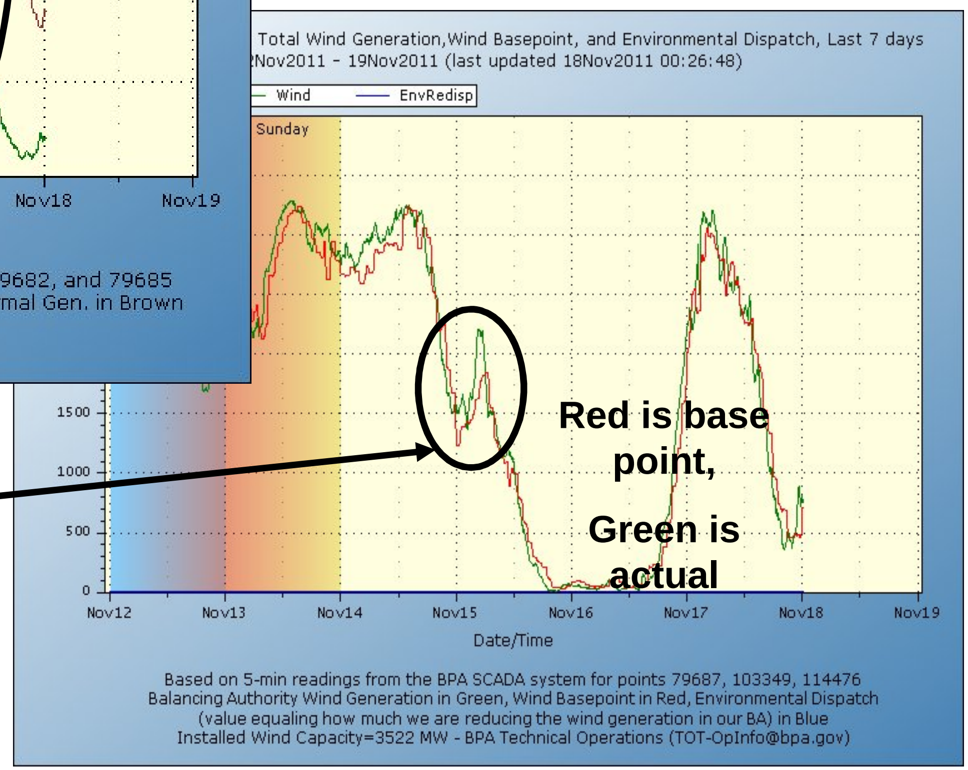
Do transactive controls offer a potential solution, establishing a methodology and means for addressing many of these issues?

Among BPA's Challenges: … Generation / Load Balancing



BPA's Load

Total Wind

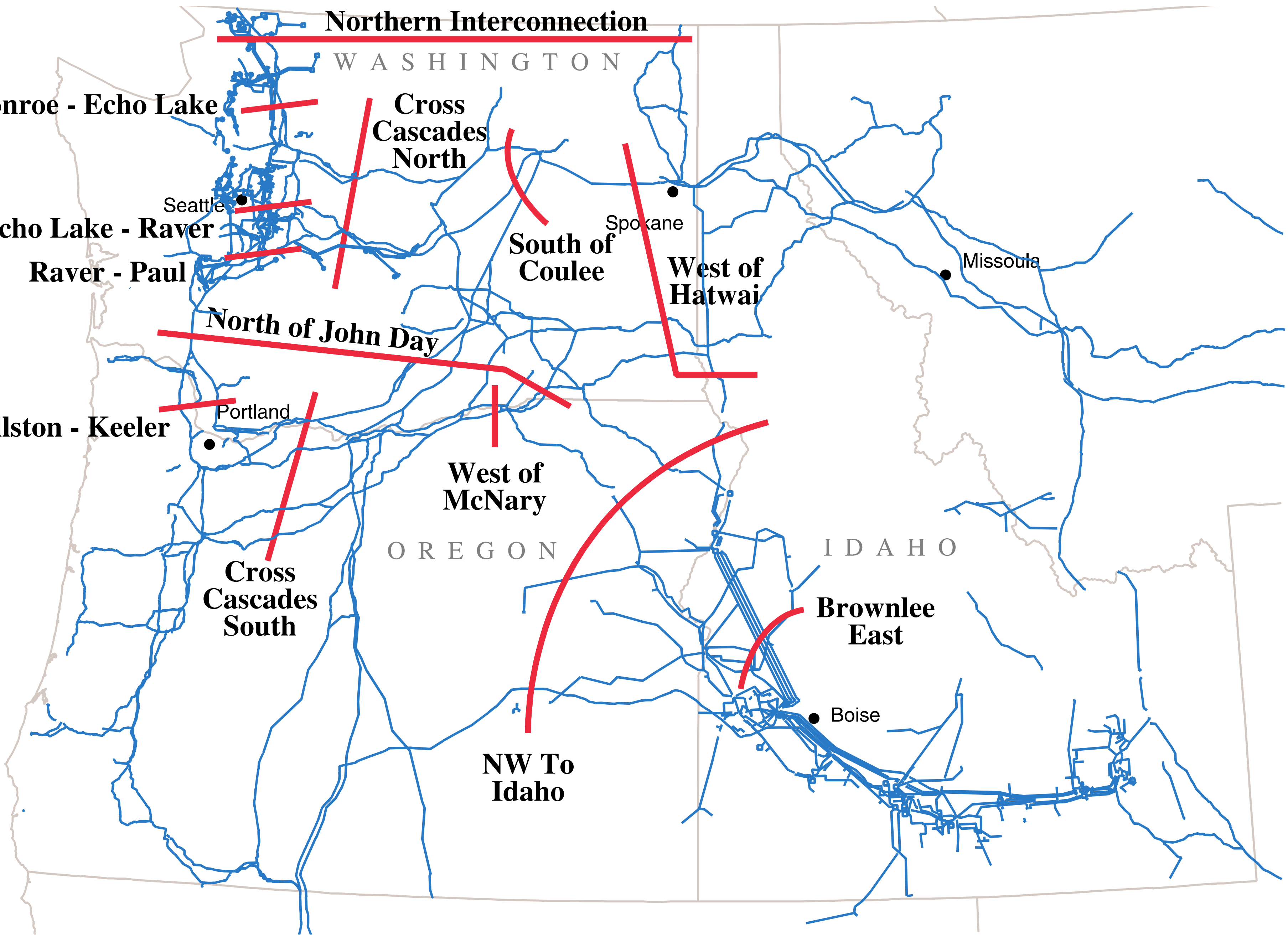


Red is base point,

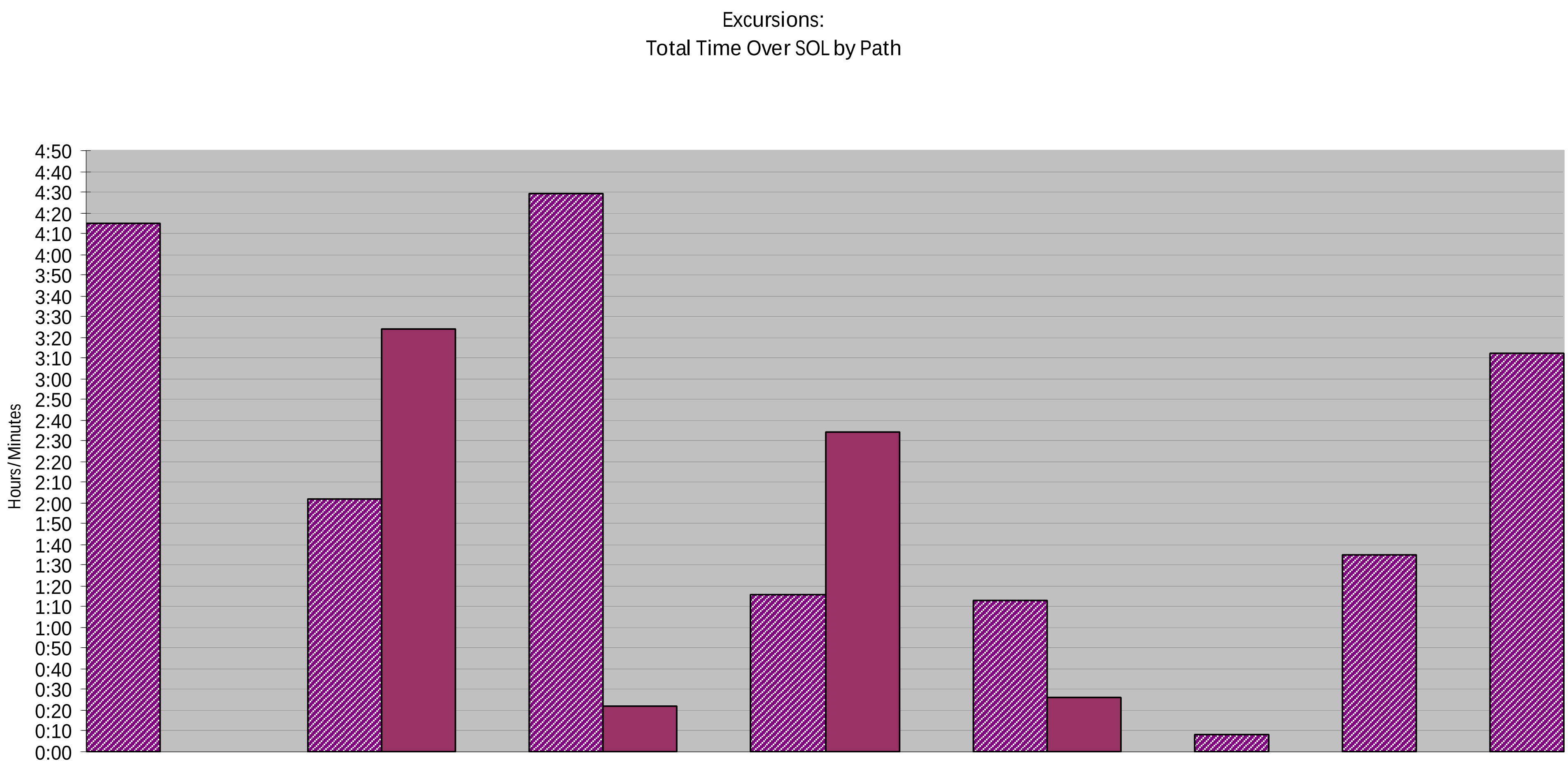
Green is actual

What's wrong with this picture?

Constrained Paths



More Challenges....
Managing Constrained Capacity of the System

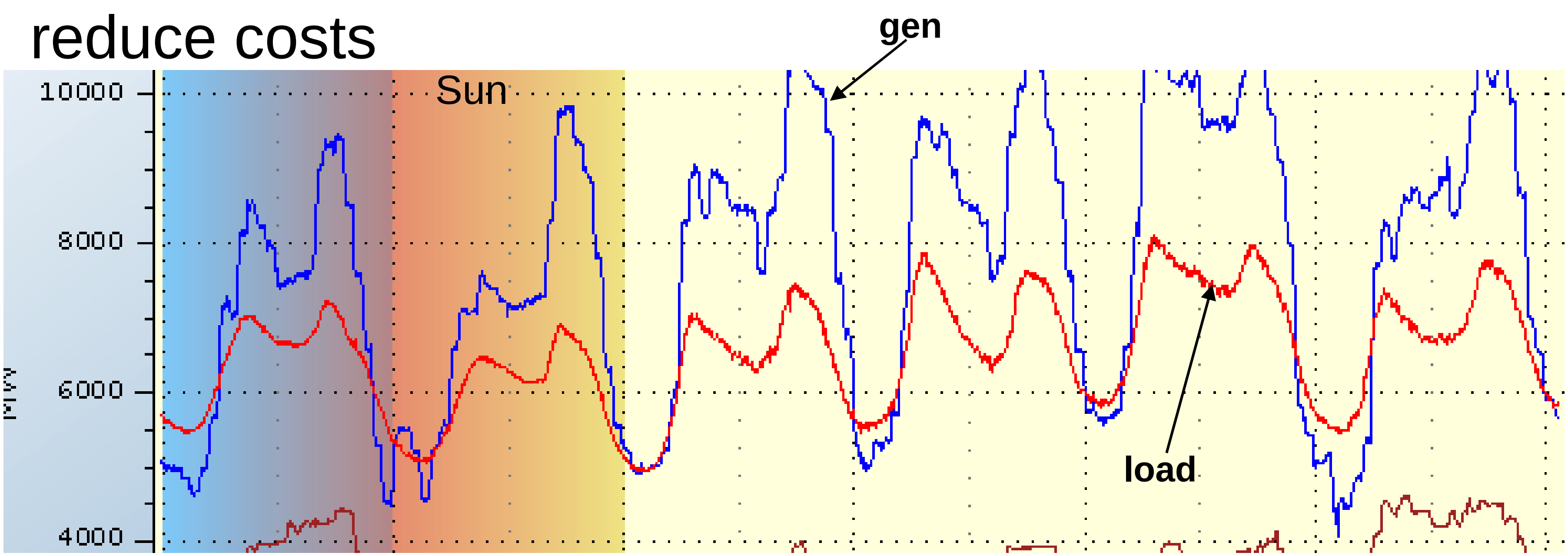


Hours over the System Operating Limit (SOL) for various constrained paths (none violating reliability Requirements)

Based on 1-minute data via SCADA/PI

More Challenges, Peak Shaving

- Red is the BA Load, a morning and evening peak, approximately
- Transmission lines are usually at their highest loadings and generation costs the highest during these peak.
- If you can shift these you can defer investments and reduce costs

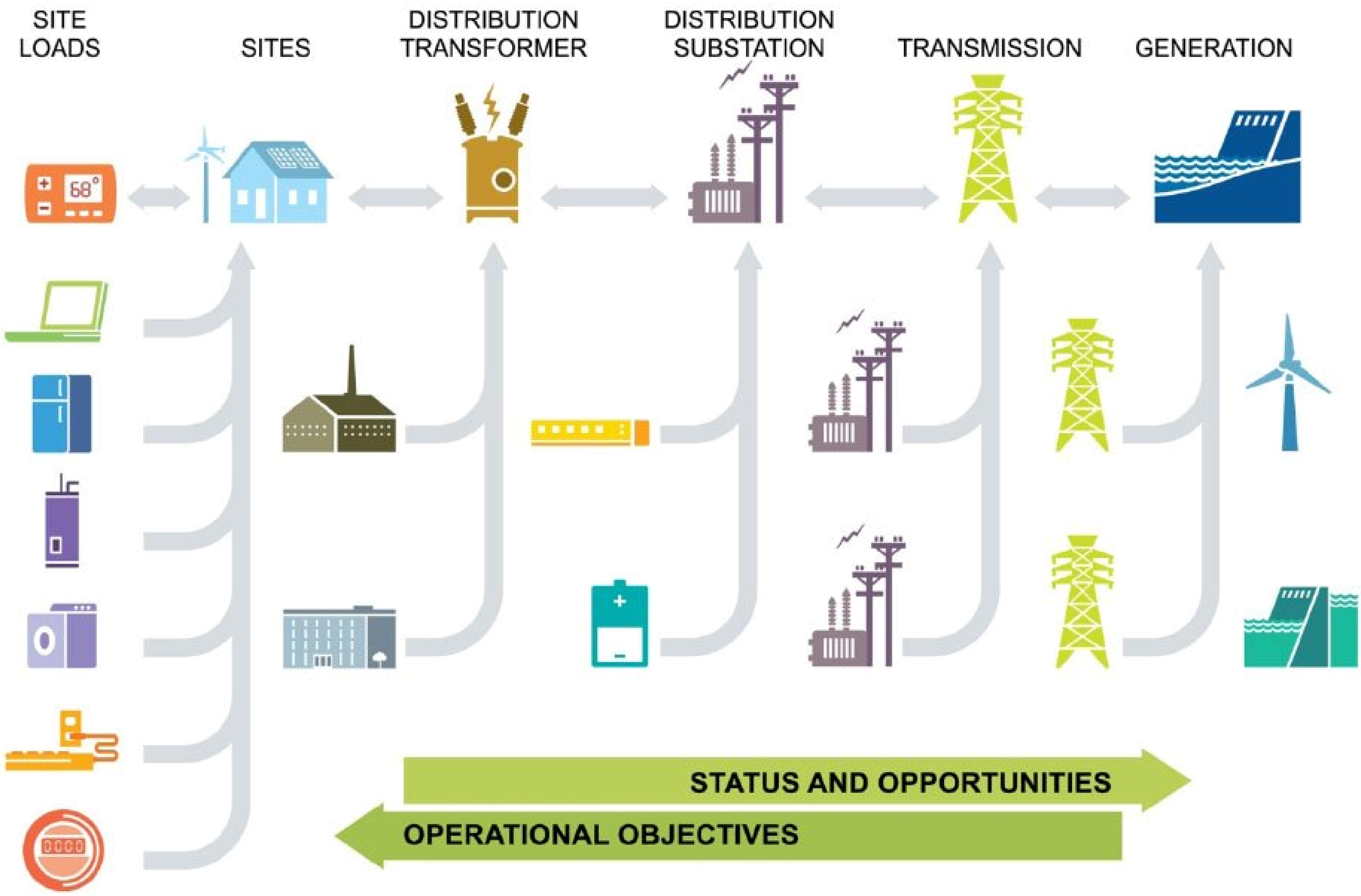


Unconventional Requirements

- **Providing for absorbing energy when you can't otherwise reduce generation**

  Can we expand Demand Response to not just reduce loads but also to increase or dispatch loads in periods of excess renewable generation availability, to "pre-deliver power" to end-users in anticipation of impending system peaks or severe transmission congestion?

- **This means that DR is no longer 'essentially the same' as altering generator output.**
  - It instead provides for either reducing or increasing a load to manage demand.
  - Possible where there are thermal equivalent energy storage such as water heaters that are capable of increasing or decreasing energy use across a broader comfort period due to enhanced thermal lag.

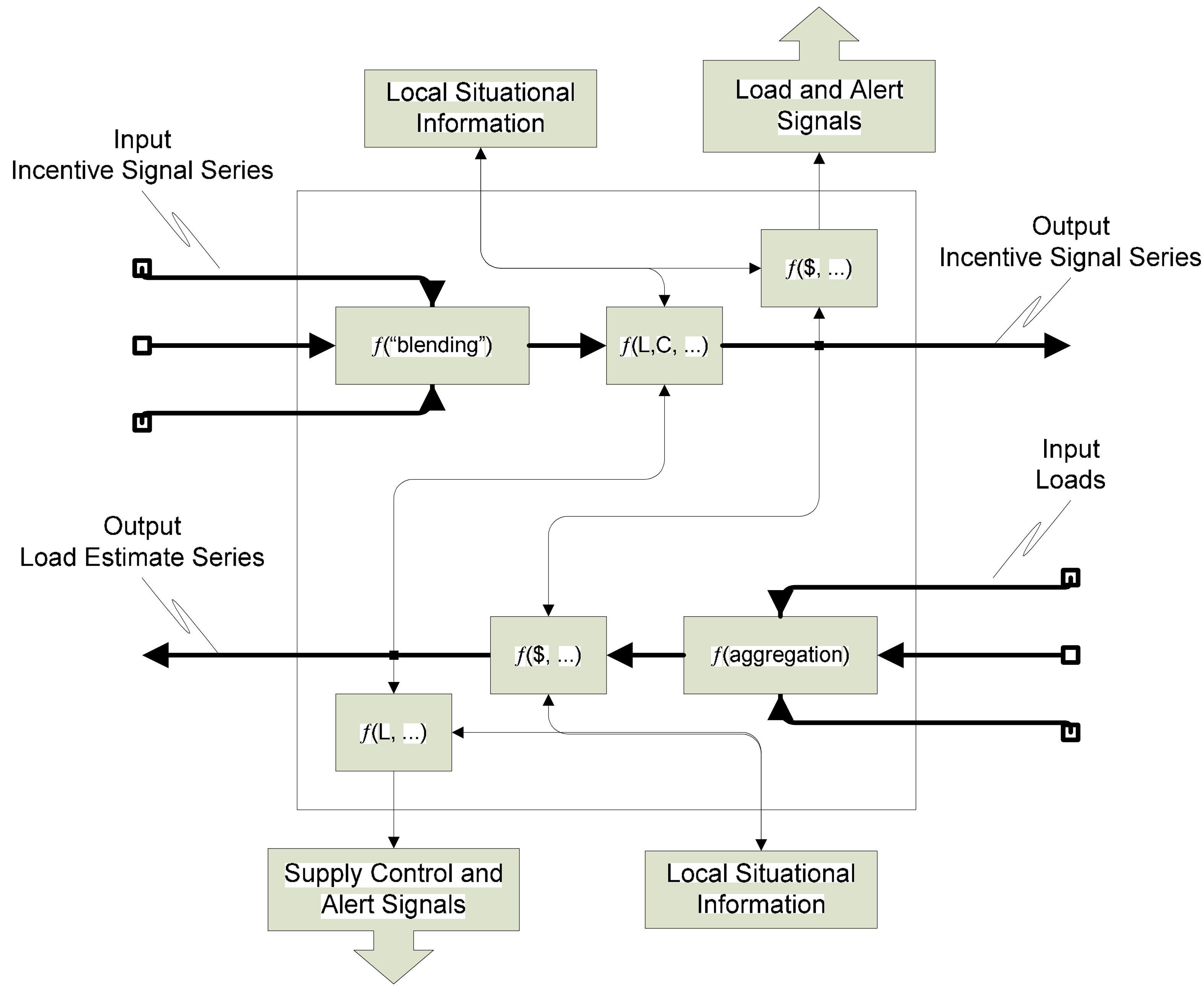


Aggregation of Power and Signals Occurs Through a Hierarchy of Interfaces

Transactive control

- Transactive control is a negotiated system of nodes based on market-like interactions.
- Changes in the transaction of energy is initiated based on some form of dynamic bid or feedback that is received from responsive electrical loads and generators.
- Most basic element is the individual nodes and their characteristics.
  - All nodes will negotiate optimal states in view of what they "learn" from their interactions with the other nodes.
- While transactive control makes conceptual sense, it is through the smart grid (SG) that the tools become available to translate the theoretical into reality.

Transactive Energy



Transactive Traits

"…Convert normally idle distributed generation into actively participating resources that were ***optimally coordinated in near real-time*** to reduce stress on the local distribution system. "

"The Smart Grid and Key Research Technical Challenges, M.G. Rosenfield, IBM T.J. Watson Research Center, Yorktown Heights, NY

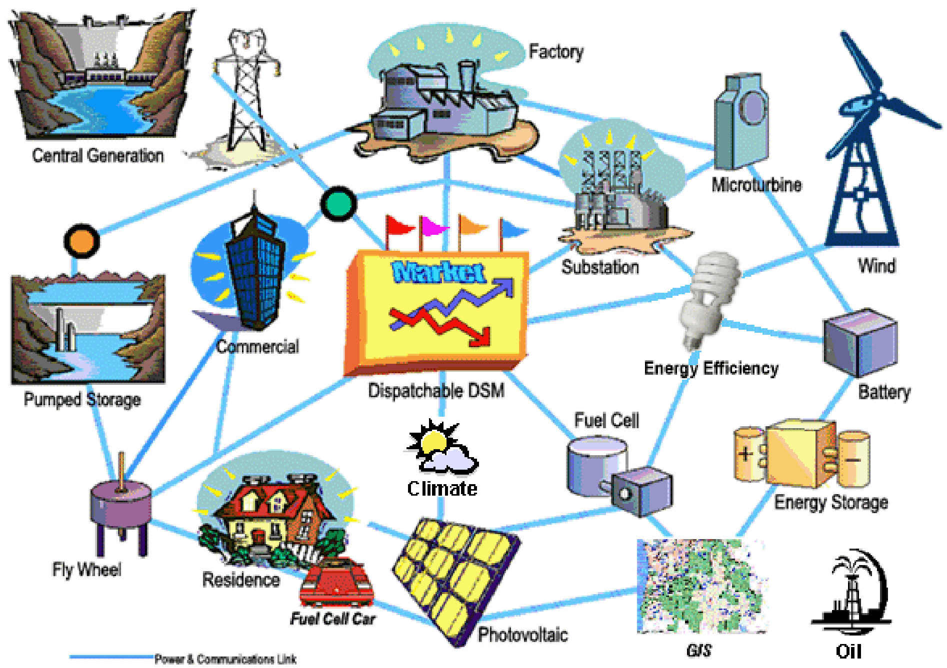
"...employ(ing) a combination of ***smart technology*** and ***dynamic pricing*** to enable consumer-centric, decentralized coordination that achieved enhanced reliability increased capacity utilization, and higher customer satisfaction".

"Decentralized Coordination through Digital Technology, Dynamic Pricing and Customer-Driven Control: the GridWise Test bed Demonstration project, Chassin and Kiesling

Who is at the Node Controls?

The importance of [the Olympic Peninsula] experiment is that for all pricing structures, it was the technology and not the end-user that was engaged around the clock in managing energy usage, informed by the rule set established by the customer.

The infrastructure required by the utility was to enable the transmission of the pricing information rather than to directly control in-premises devices.



An example of adjusting room temperature

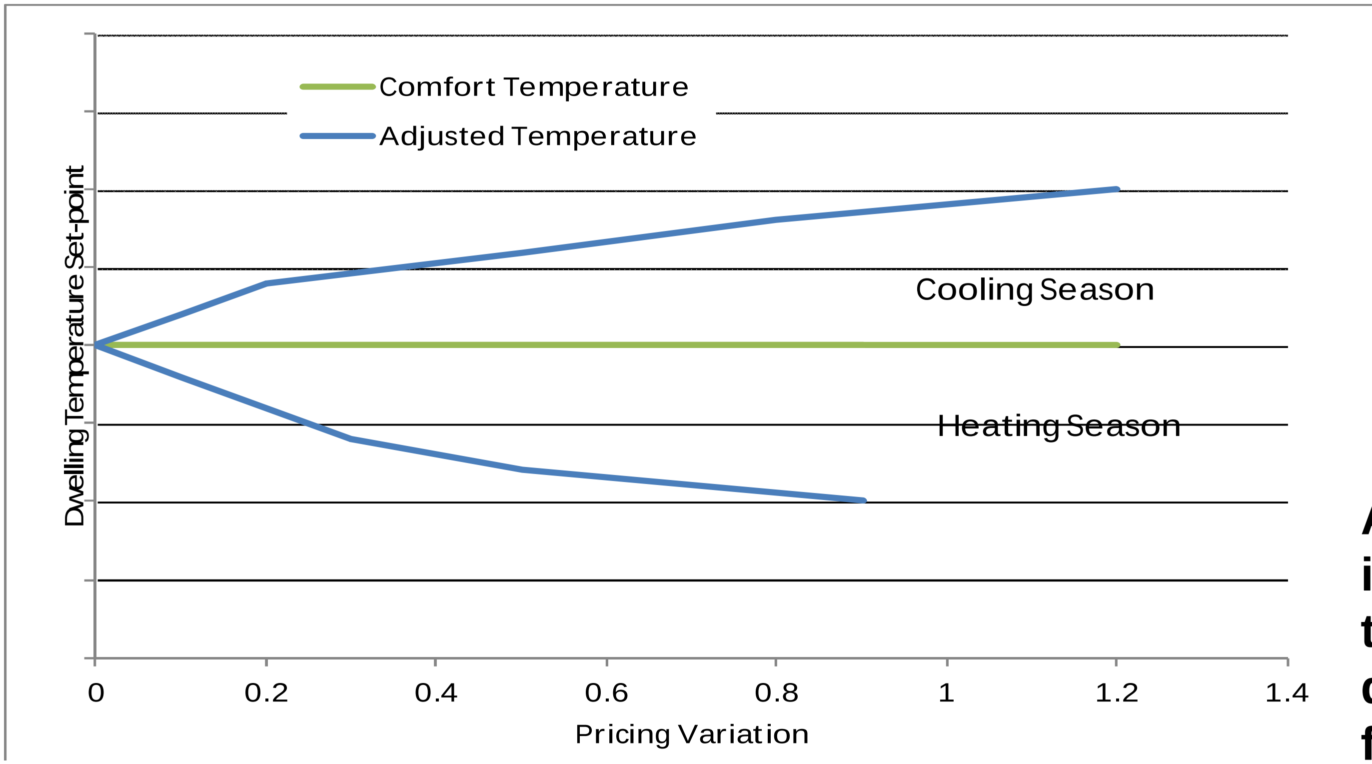
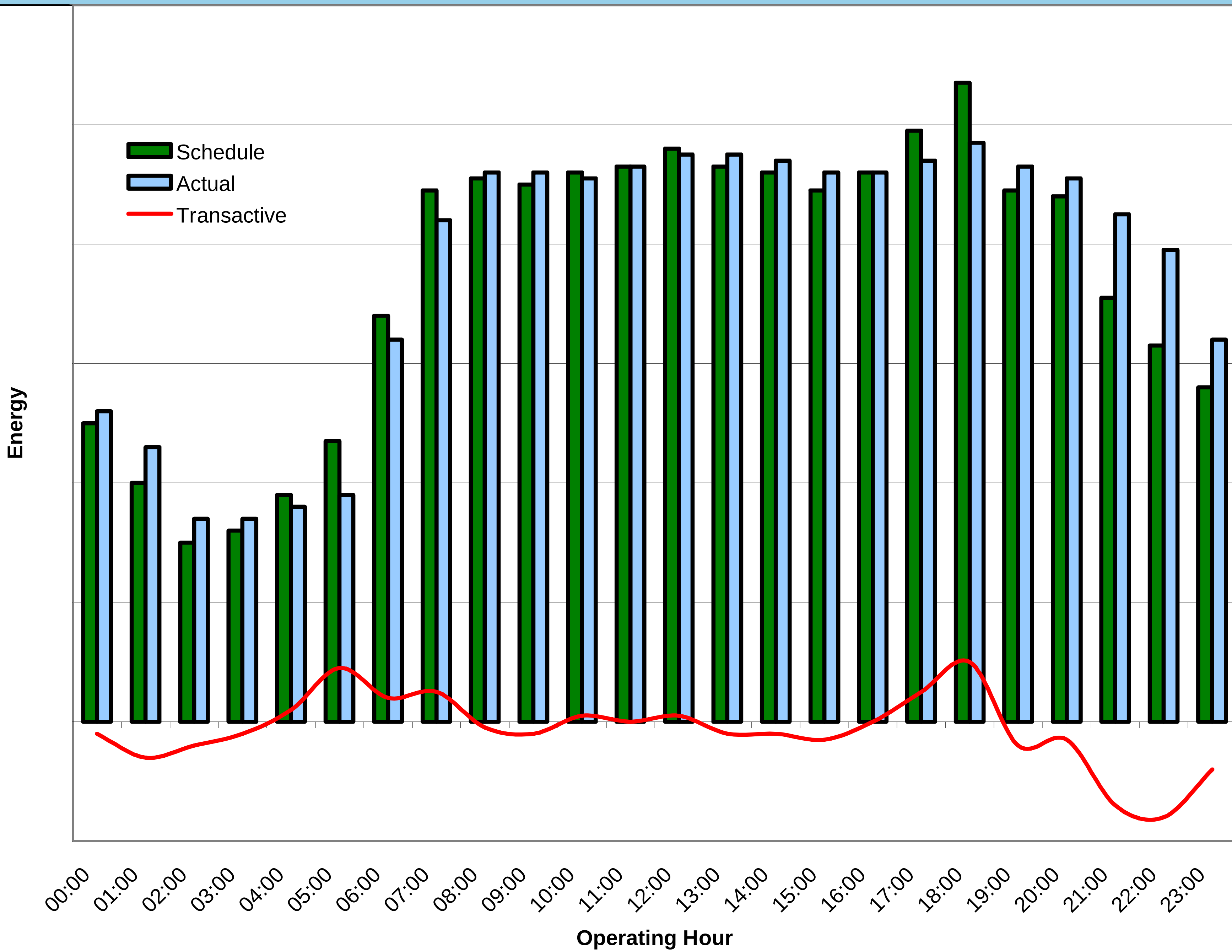


Figure . Example of the Transactive Signal at Work.

As the incentive increases, the temperature deviates further from the "Comfort Temperature".

What Does This Look Like?



The Possibilities

- The value of the transactive signal could conceivably increase as dependency on the electric utility grid grows to meet new demands such as wide use of electric vehicles and needs to meet these as economically as possible.

- It establishes a platform that can more easily integrate and optimize energy use for highly distributed local generation, sophisticated local distribution and transmission management networks, and reconfigure equipment for micro-grids, intentional islanding, and manage for promotion of ‘net-zero’ buildings.

The Possibilities

- Enabling the integration of intermittent renewables
- Opportunity for end-users to save on power costs.
- Provide end-user choices to manage their electricity costs/Impact.
  - Option to make change or modify their degree of commitment.

Once the extended and enlarged projects validate the results of this early pilot program, incentivizing manufacturers to incorporate the communications and control devices with the next generation of energy smart appliances will insure a growing pool of customers enabled to participate as the programs develop and mature.

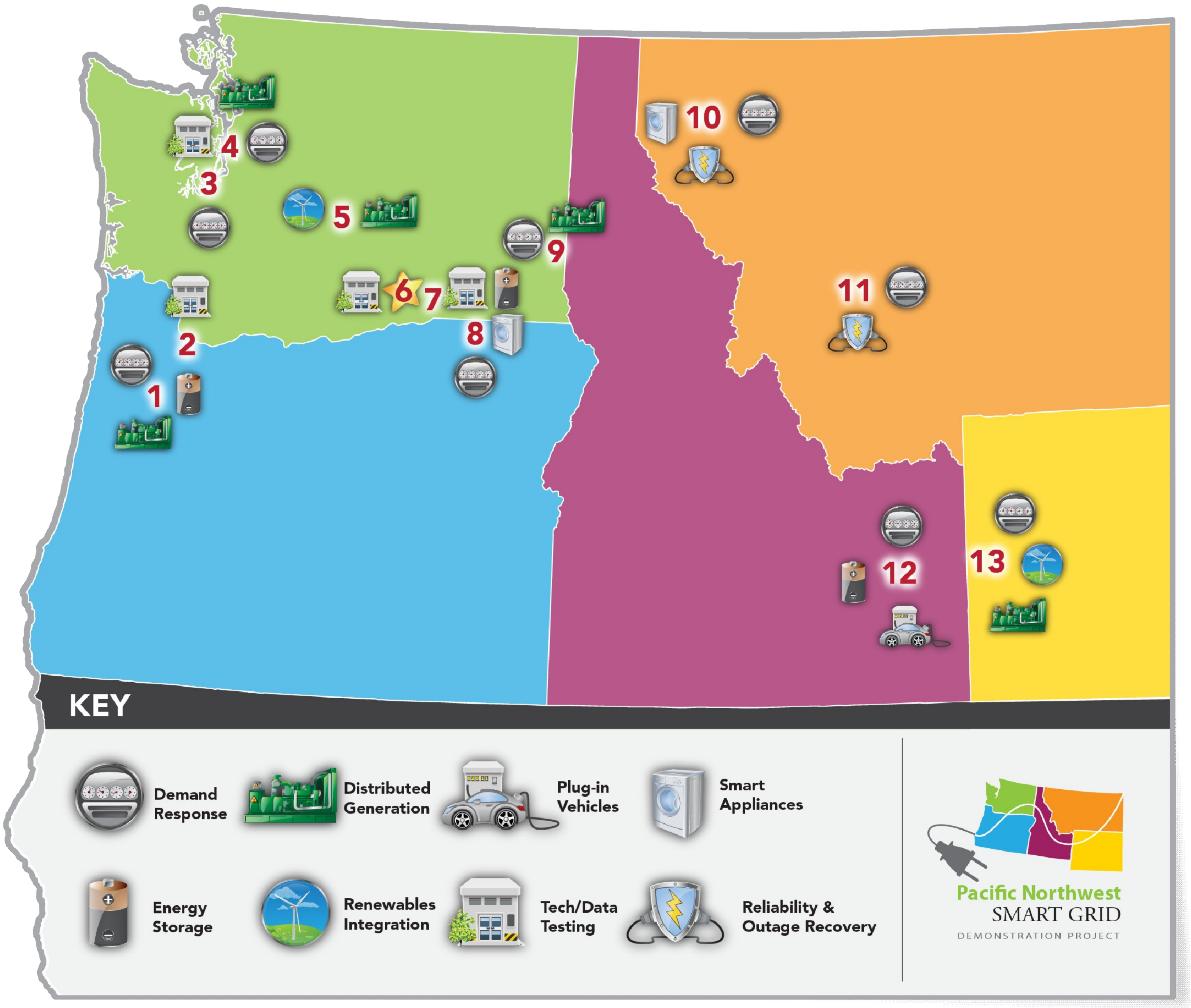
Pacific Northwest Smart Grid Demonstration

- As a follow up to the Olympic Peninsula Demonstration Project, the Pacific Northwest Smart Grid Demonstration is under way
  - Comprised of five project-level infrastructure providers, 11 subproject utilities and the University of Washington, and the Bonneville Power Administration (BPA).
  - Led by Battelle Memorial Institute, Pacific Northwest Division, the demonstration will last five years, from 2010 into 2015.
- Designed as “a truly regional demonstration of smart grid functions.
- Featured innovation: demonstration of scalable, hierarchical transactive control

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

- …"Transactive control is the approach being used by the demonstration to couple the … operational objectives to the dynamic behaviors of a set of representative responsive assets in the demonstration region.
  - Most generally, transactive control is a bidirectional negotiated system behavior.
- Market-like principles facilitate the negotiation; however, the signals need not be used to account for any monetary or revenue exchanges.
  - In theory, the "winning" behaviors are optimal in some sense, having competed successfully in a "market" against alternative actions that could have been taken."

Pacific Northwest Smart Grid Demonstration



The "Promise" of Transactive "Control"

- Gaining the potential flexibility and resilience such that a smart, distributed-control electrical grid will provide the ability needed to effectively adjust the operation of the entire system to
  - Minimize congestion,
  - Aid in balancing load and generation, and
  - Shift peak electricity use.
- Platform for taking full advantage of new thinking, operating theory, and technology integration on the electric grid.

Challenges

- **Incentives:** To make transactive control systems viable on a large scale with full participation of regional generation and transmission, a means of a financial value has to be developed as the basis for transactive activity
- **Regulation:** The role of regulatory institutions is significant. Institutionalizing even the ‘simple’ transference of funds as practiced during the Olympic Peninsula Demonstration Project may require regulatory changes or reform.
- **Activating a transactive signal:** A fundamental economic consideration is establishing the actual clearing prices that will be applied to activate the transactive signal

Challenges (Cont.)

- **Generation Reserves for Generator/Load Balance:** BPA operates under North American Electric Reliability Corporation (NERC) and Federal Energy Regulatory Commission (FERC) mandatory reliability standards
- **Critical infrastructure:** There are stringent mandatory standards for cyber security under NERC's Critical Infrastructure Protection plan
- **Back office systems:** Significant complexity exists in the back office systems of utilities and wholesale power marketers. (Scheduling, Metering, Billing, and Settlement systems)

Why do we care?

- Early results of applying the transactive signals to affect electricity use demonstrated the potential for impressive gains.

- Transactive controls can aid in
  - integrating large amounts of variable renewable energy and
  - increasing transmission capacities,
  - thus deferring large capitol investments.

It also provides a potential schema for a whole new way of building, managing and optimizing every element of the electric infrastructure.

Looking Forward

- Costs and the benefits will need to be carefully identified, understood, and addressed.

- The experiments and analysis of the Pacific Northwest Demonstration Project will yield valuable instruction on what we can expect from such controls and how to make them effective on an ever larger Scale

More research into potential impacts on transmission system Reliability – both positive and negative – is required to inform the Region on the best implementation strategy – and the rate of adoption.

The transactive signal is an enabling technology that can make the transition to new energy systems attainable and may help us avoid significant negative impacts and disruptions.

Questions or advice?