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Transactive Energy Markets and Grid Services: Field Demonstrations and the GridWise® Architecture Council's TE Roadmap

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Technical Meeting on the Reference Guide for a Transaction-Based Building Controls Framework

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Transactive Grid Control Overview

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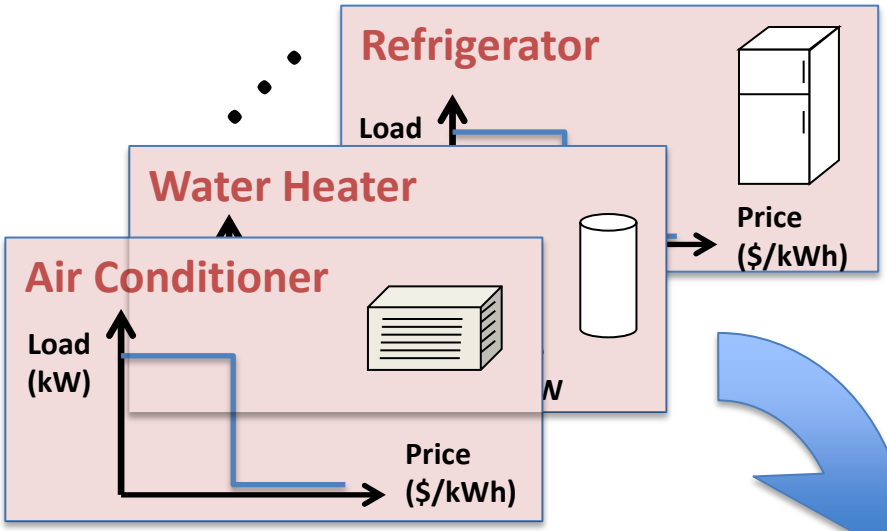
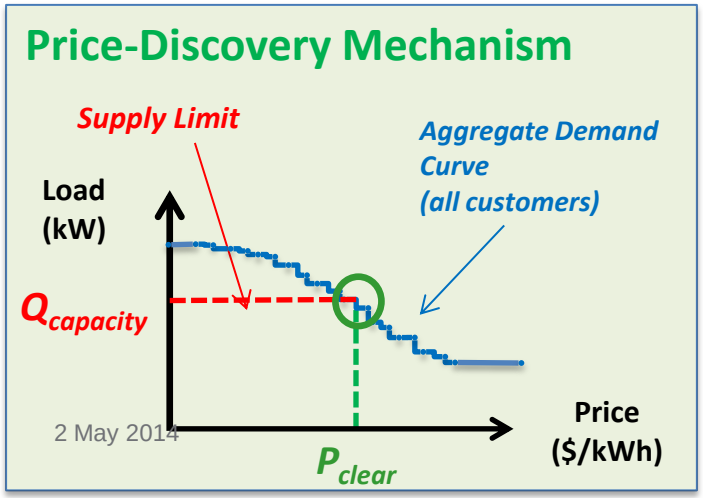
1. Automated, price-responsive device controls express customer's flexibility (based on current needs)

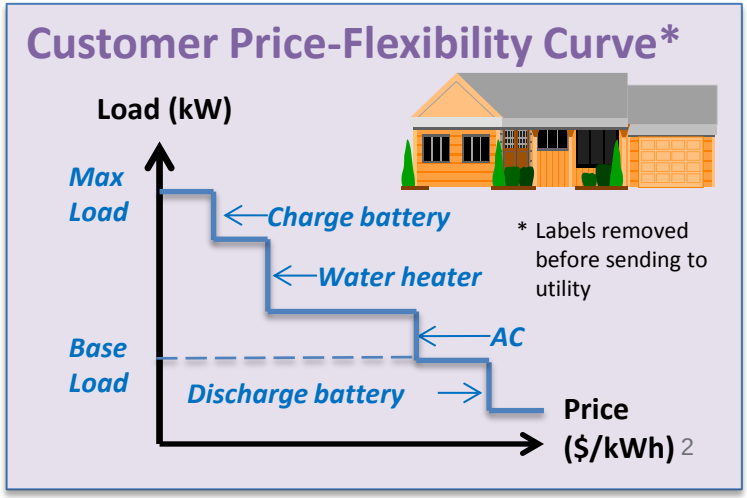


2. Customer system aggregates responses to form overall price flexibility curve

3. Utility aggregates curves from all customers

4. Aggregator determines price at which grid objective achieved, broadcasts to consumers





OlyPen Managing T&D Constraint with Prices

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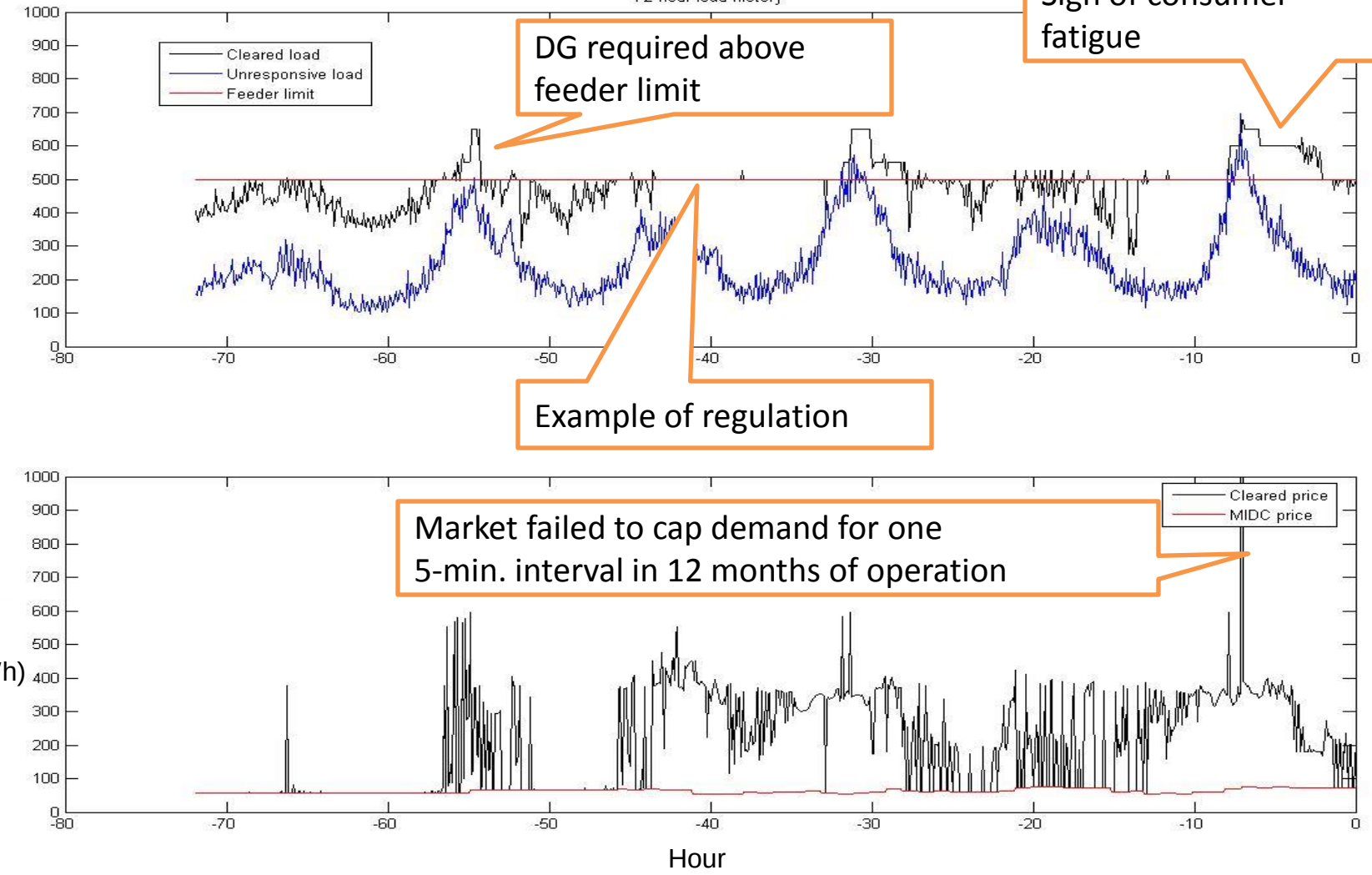

From Olympic Peninsula Demonstration

OlyPen Key Findings

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Significant demand response was obtained:

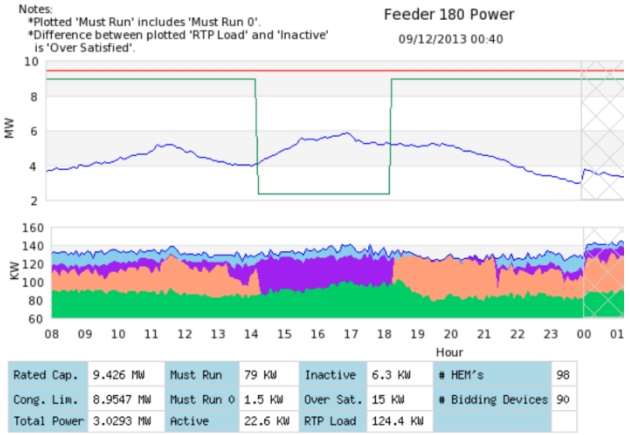
- 15% reduction of peak load
- Up to 50% reduction in total load during shoulder periods
- Manage local distribution constraint
- Potential to provide regulation, other ancillary services
- Same signals integrate distributed generation and storage

Customers will respond to *dynamic pricing* schemes **if they are offered**:

- Opportunity for significant savings (~10% was suggested)
- A “no-lose” proposition compared to a fixed rate
- Control over how much they choose to respond, with override
- Technology that automates their desired level of response
- A simple, intuitive interface to automate their response

gridSMART® RTPda Demo

- First real-time market at distribution feeder level with a tariff approved by the PUC of Ohio
- Value streams
  - Energy purchase benefit: function of PJM LMP
  - Capacity benefits: distribution feeder and system gen/trans limitations, e.g., peak shaving
  - Ancillary services benefits: characterized, but not part of the tariff
- Uses market bidding mechanism to perform distributed optimization – transactive energy
  - ~200 homes bidding on 4 feeders
  - Separate market run on each feeder
  - "Double auction" with 5 minute clearing
- HVAC automated bidding
  - Smart thermostat and home energy manager
  - Homeowner sets comfort/economy preference
  - Can view real-time and historical prices to make personal choices



gridSMART® RTP in Action

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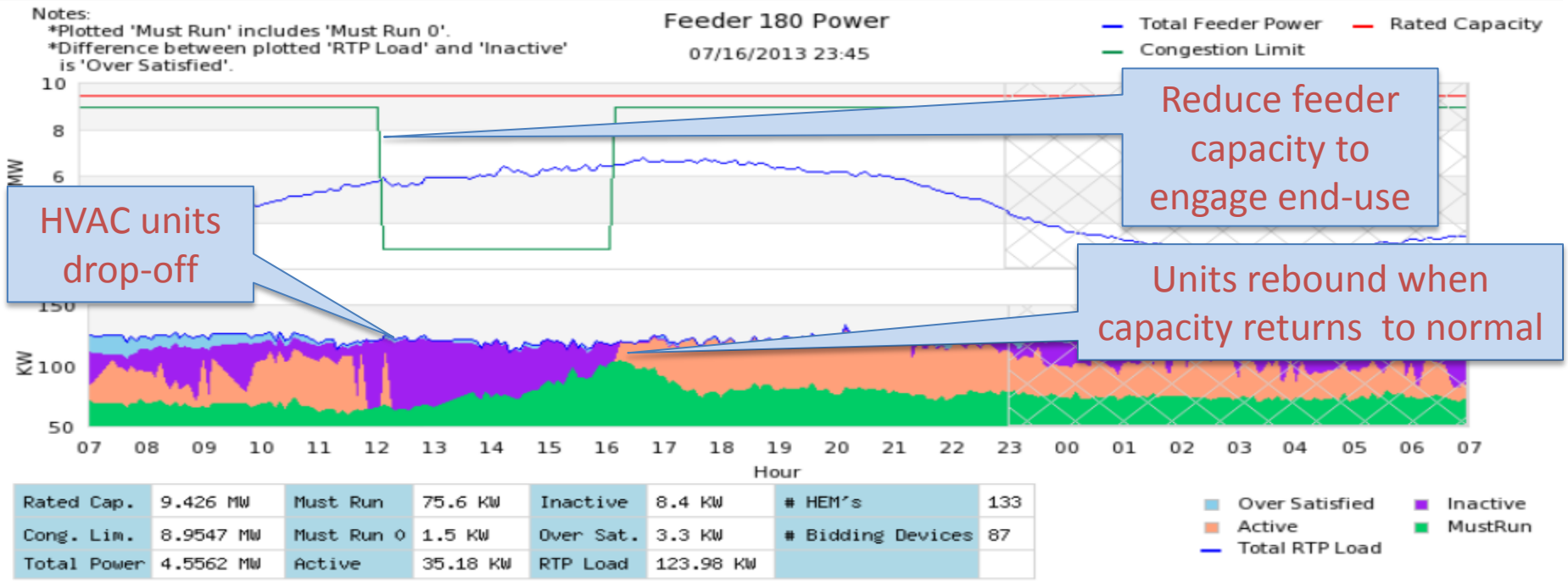
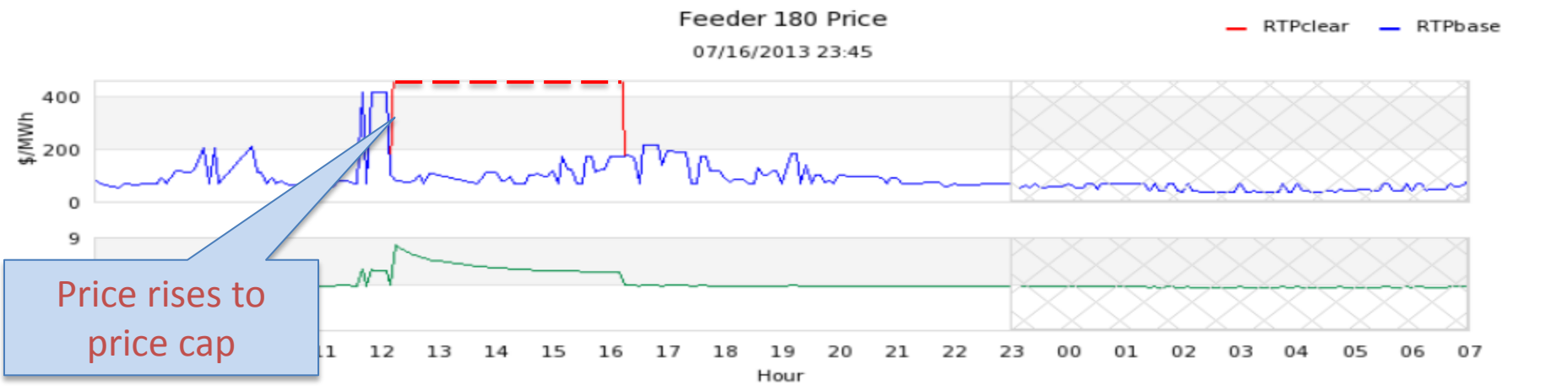


Rated Cap.	9.426 MW	Must Run	75.6 KW	Inactive	8.4 KW	# HEM's	133
Cong. Lim.	8.9547 MW	Must Run 0	1.5 KW	Over Sat.	3.3 KW	# Bidding Devices	87
Total Power	4.5562 MW	Active	35.18 KW	RTP Load	123.98 KW		



RTPclear	69.26 $/MWh	RTPbase	69.2631 $/Mwh	Sigma RTPclear	-0.4949

Summary of RTP Demo Analysis

- Experiments analyzed Jun – Sep 2013
- Electric system impacts
  - Wholesale purchases: energy use and cost reduced by ~5%
  - System peak shaving: ~6.5% peak load reduction at 50% simulated RTP household penetration
  - Feeder peak management: ~10% peak feeder load reduction at 50% simulated household penetration
- Household impacts
  - Bills: ~5% average reduction (includes peak management incentive)
  - Thermostat overrides over 4 month duration
    - 2 hr events < 10 overrides
    - 4 hr or greater events < 20 overrides
  - Customer satisfaction
    - Over 75% satisfied (40% very satisfied)
    - Perceived monthly bill impact: 51% savings, 39% same, 10% increase

Pacific Northwest Demonstration Project

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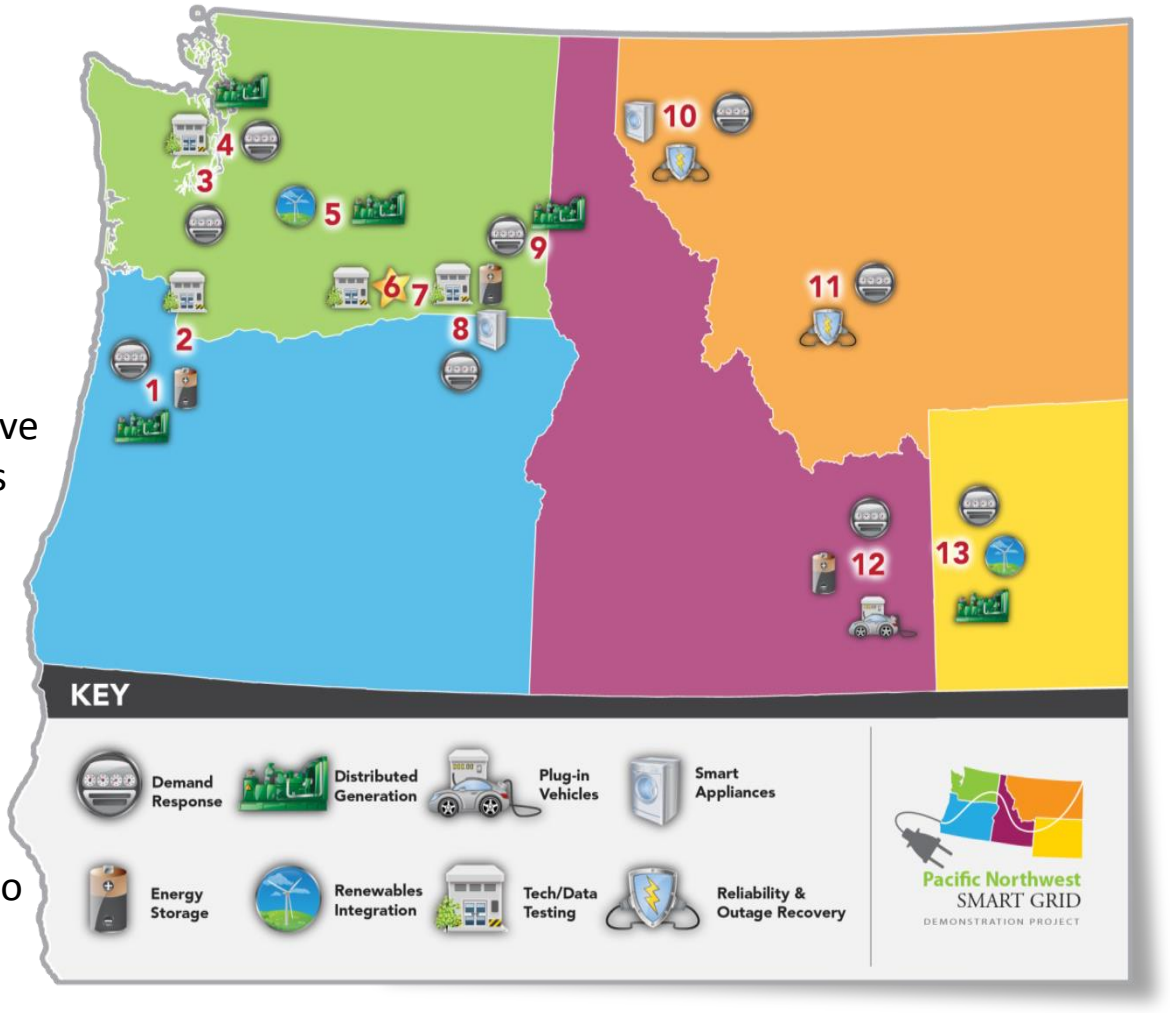
What:

- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

Why:

- Develop communications and control infrastructure using incentive signals to engage responsive assets
- Quantify costs and benefits
- Contribute to standards development
- Facilitate integration of wind and other renewables

Only project of its kind integrating resources across multiple utilities to achieve regional benefits.



Project Basics

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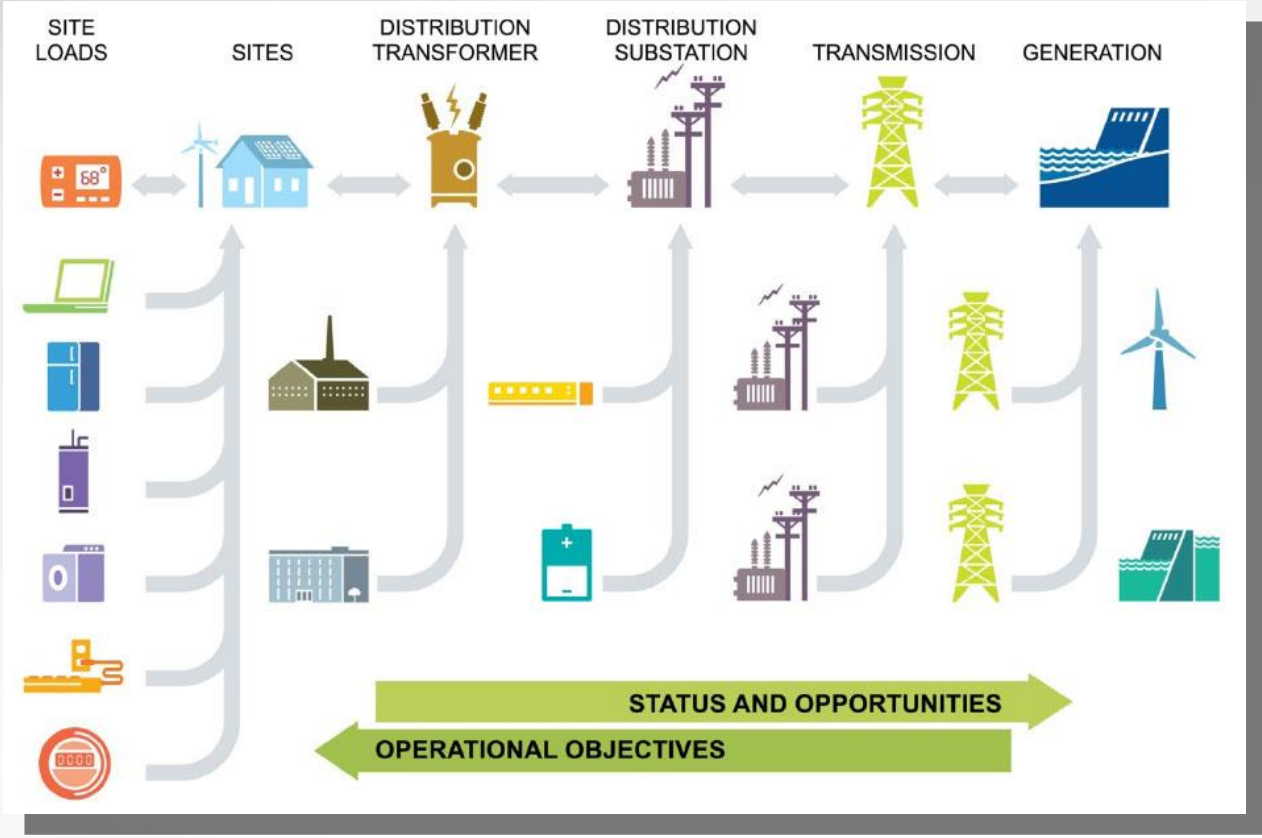
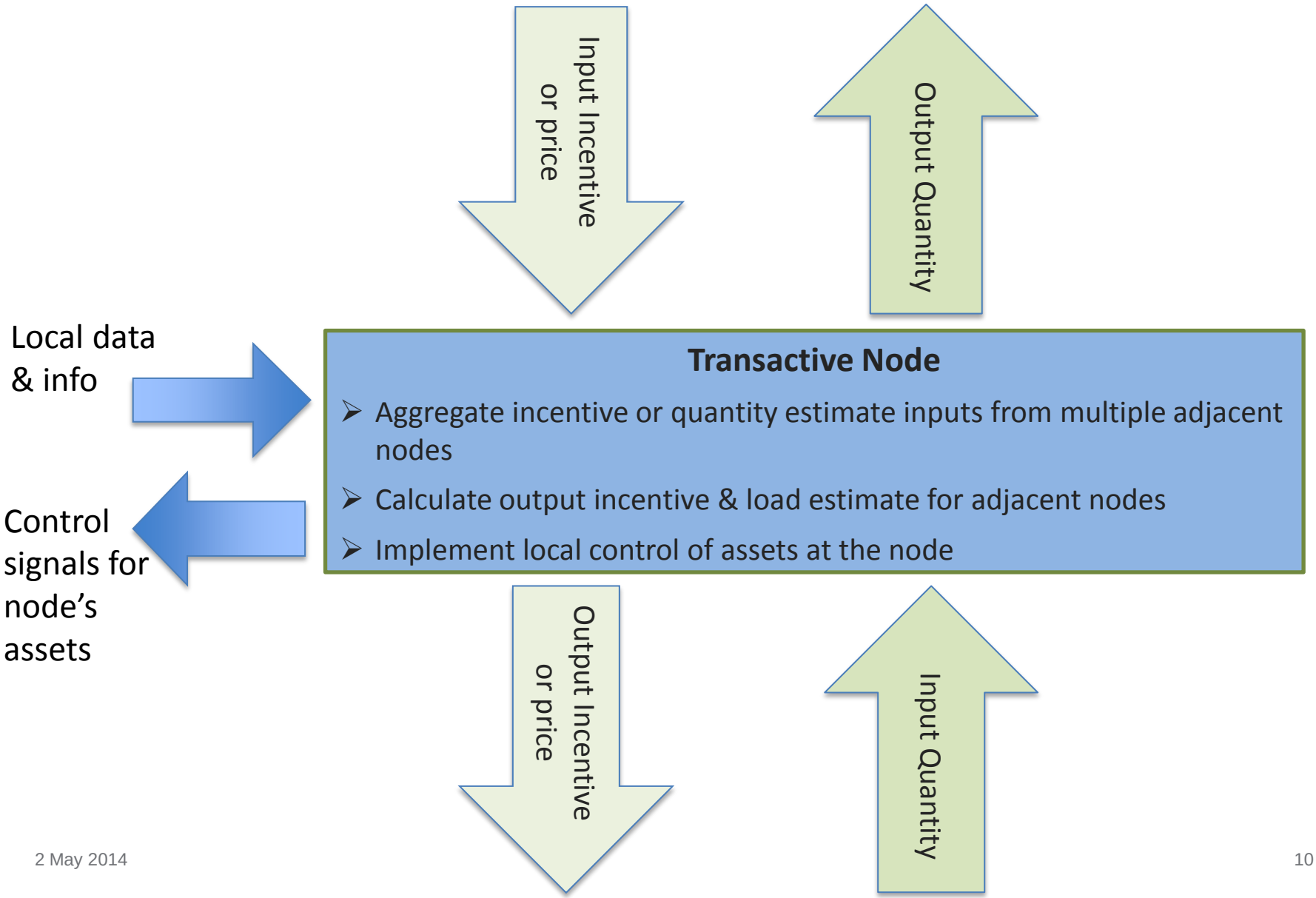
Operational objectives

- Manage peak demand
- Facilitate renewable resources
- Address constrained resources
- Improve system reliability and efficiency
- Select economical resources (optimize the system)



Aggregation of Power and Signals Occurs Through a Hierarchy of Interfaces

Generic Transactive Control Node Inputs & Outputs



Realizing Transactive Grid Control

Purpose

- Transactional frameworks are established to incentivize and coordinate the response of millions of smart energy assets

Characteristics of a Good Solution

- Privacy, free will, and cyber-security concerns are mitigated
- Simple cyber-interaction paradigm, applicable at all levels of the system and supported by standards
- Offers a viable transition path that co-exists with traditional approaches
- Smooth stable, predictable, and graceful failure

Outcomes

- Accepted by business and policy decision-makers as a valid, equitable, and advantageous revenue/investment recovery mechanism
- Vibrant vendor community supplies transactional products and services, e.g., operating systems and system- & device-level controls

GRIDWISE Architecture Council

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GridWise Architecture Council's Transactive Energy Activities

Transactive Energy Framework

Transactive Energy Initiative

- **GWAC's mission**: formed by the DOE to promote and enable interoperability among the many entities that interact with the nation's electric power system
- **Interoperability Context-Setting Framework**: provide context for identifying and debating interoperability issues to simplify the integration of devices and systems that support smart grid capabilities
- **Transactive Energy Framework**: provide context for identifying and debating transactive issues to simplify the integration and participation of distributed energy resources in the electric system (drafted)
- **Transactive Energy Roadmap**: provide broad direction to evolve the electric system toward a highly interactive, self-organizing, efficient, and reliable energy grid that enables and respects the participation of all stakeholders (in discussion)

TE Framework