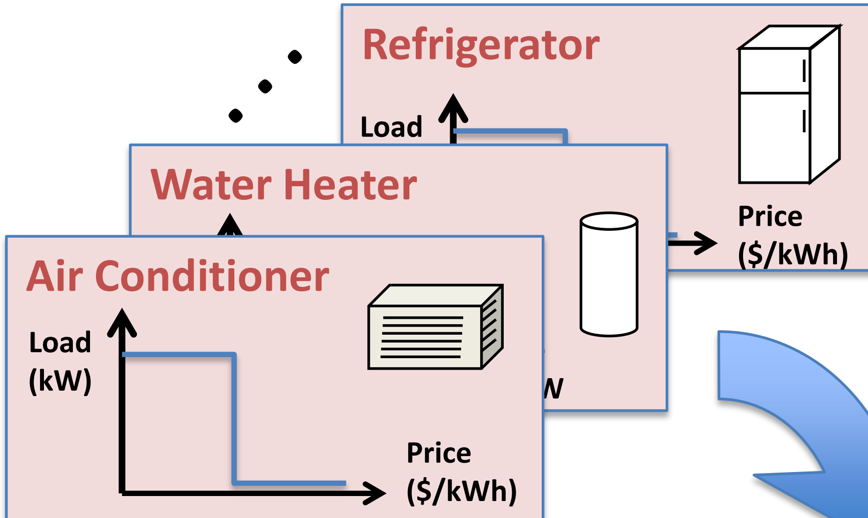
Residential Real-time Pricing Experience

Steve Widergren
Pacific Northwest National Laboratory

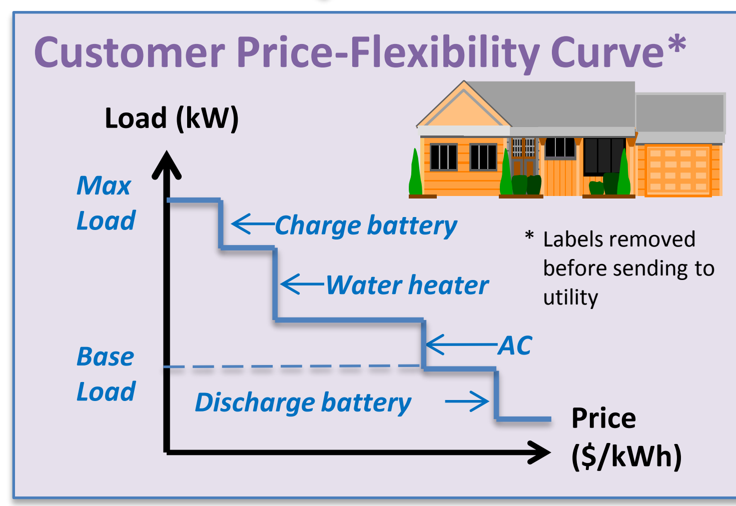
Workshop on DSM Potentials, Implementations and Experiences
Graz, Austria
20 May 2014

Transactive Grid Control Overview

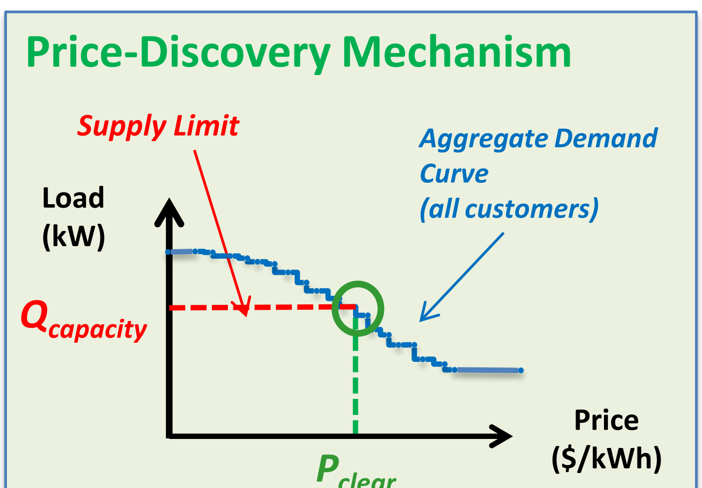
1. Automated, price-responsive device controls express customer's flexibility (based on current needs)



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



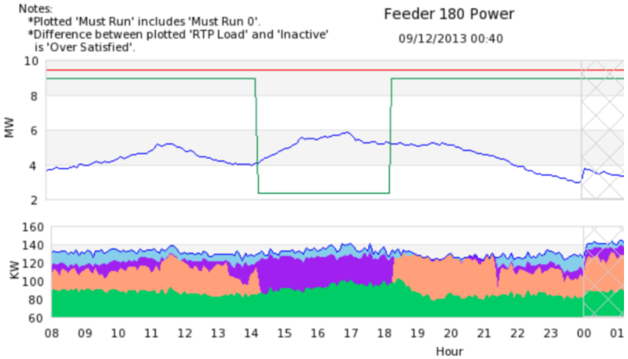
3. Utility aggregates curves from all customers



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

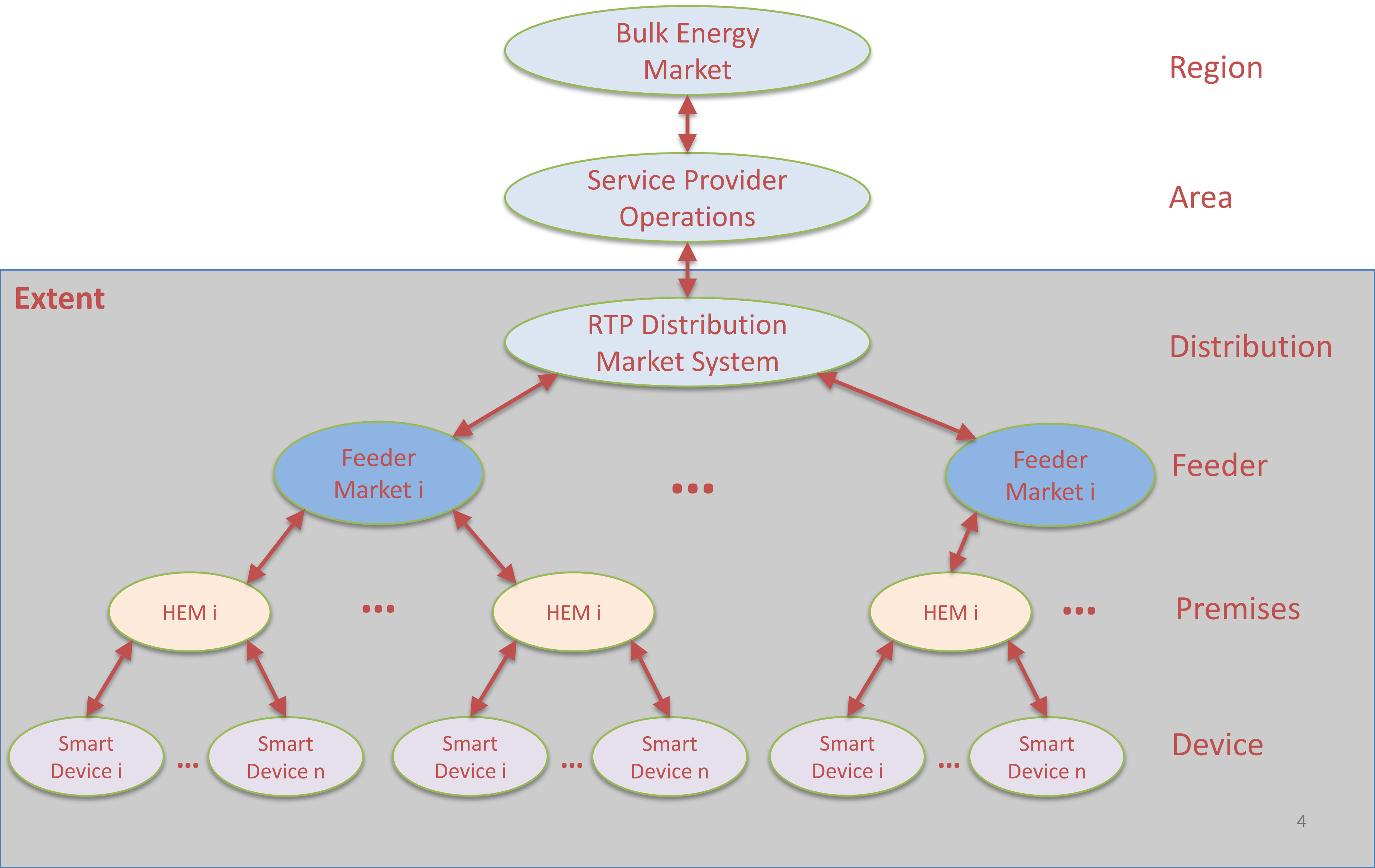
gridSMART® RTPda Demo

- 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 market 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

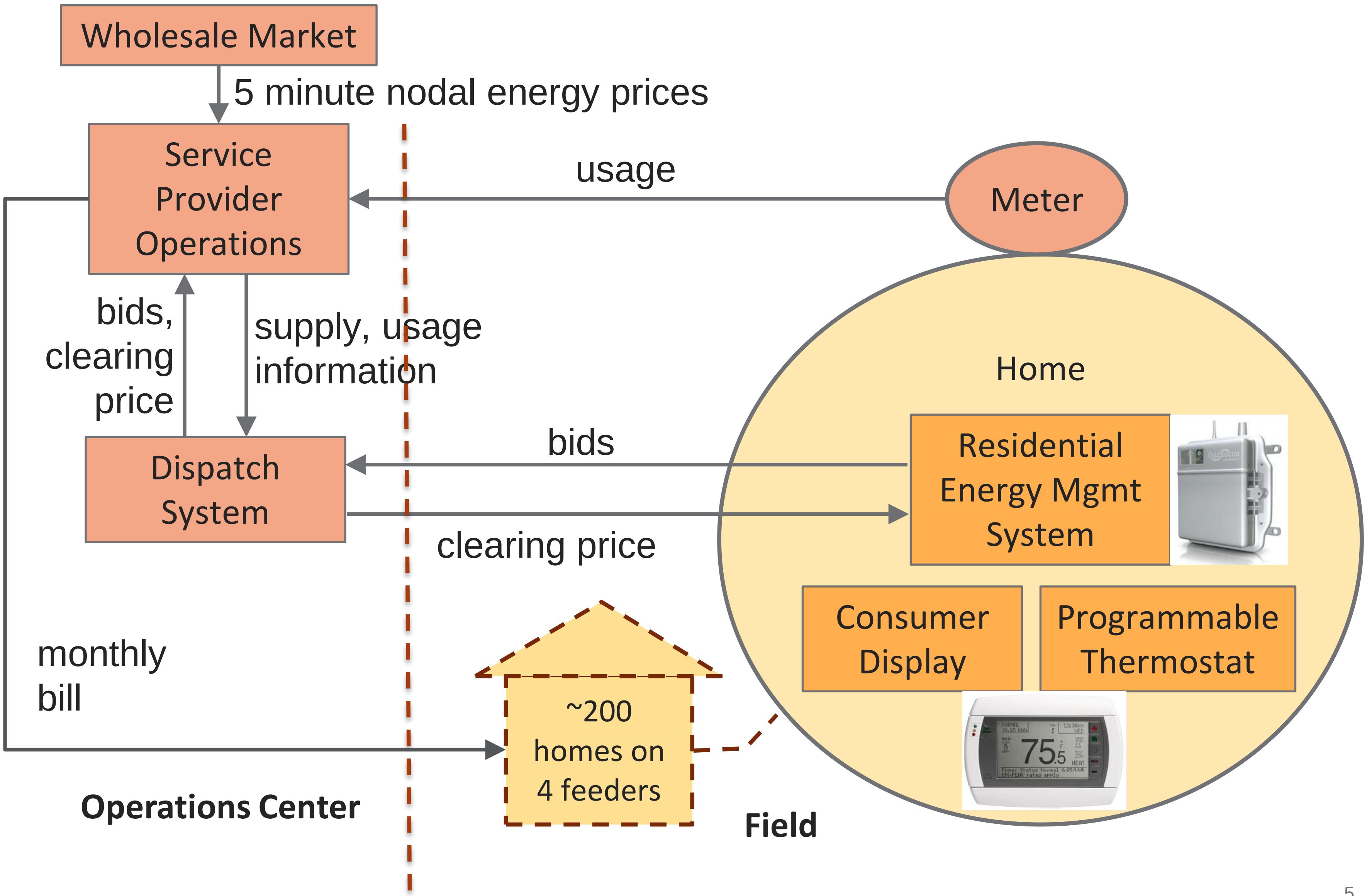


Rated Cap.	9.426 MW	Must Run	79 KW	Inactive	6.3 KW	# HEM’s	98
Cong. Lim.	8.9547 MW	Must Run 0	1.5 KW	Over Sat.	15 KW	# Bidding Devices	90
Total Power	3.0293 MW	Active	22.6 KW	RTP Load	124.4 KW		

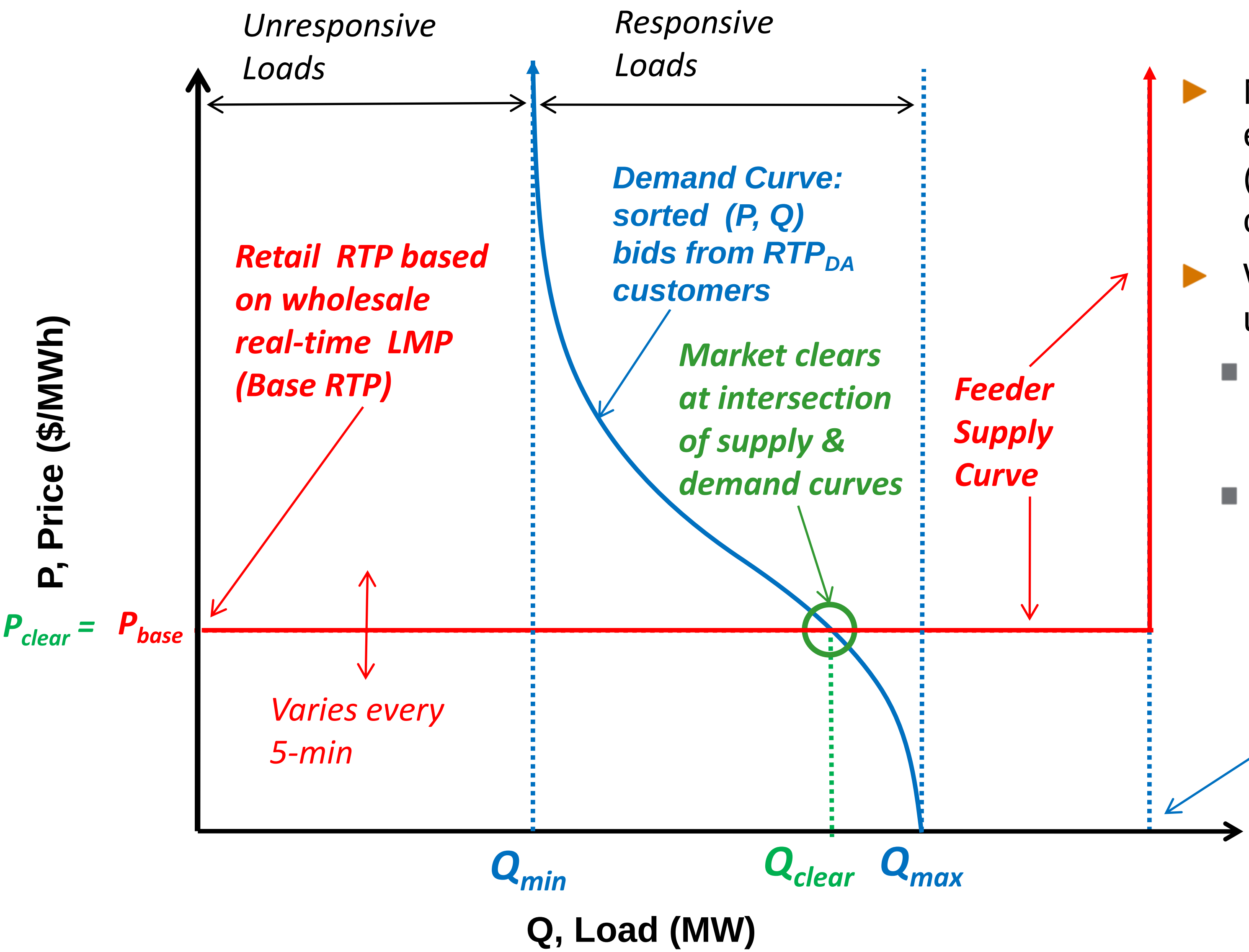
Architecture



RTP System

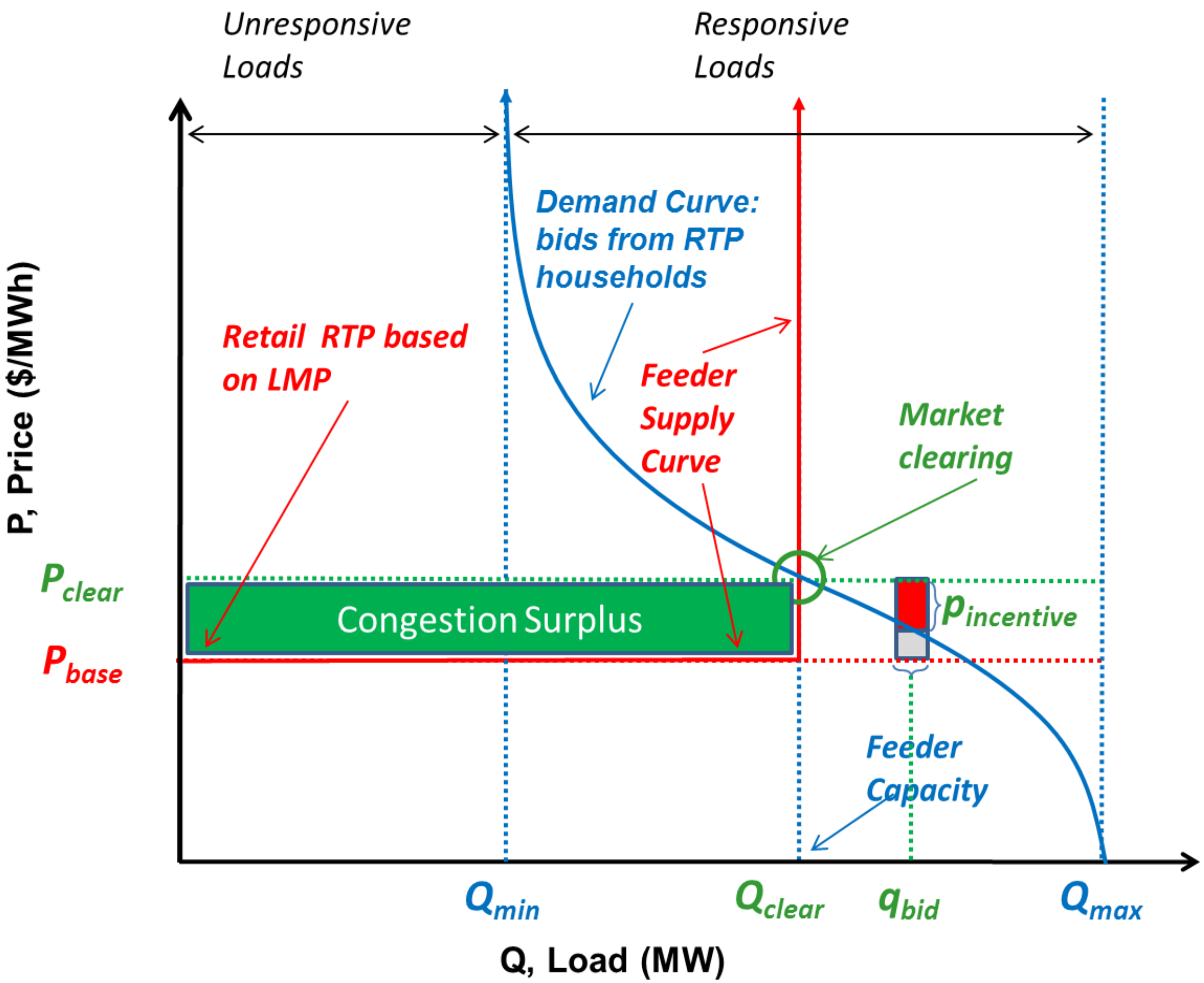

Wholesale Market
5 minute nodal energy prices
Service Provider Operations
usage
Meter
bids, clearing price
supply, usage information
Home
Dispatch System
bids
Residential Energy Mgmt System
clearing price
Consumer Display
Programmable Thermostat
monthly bill
~200 homes on 4 feeders
Operations Center
Field

RTP Market Uncongested Conditions



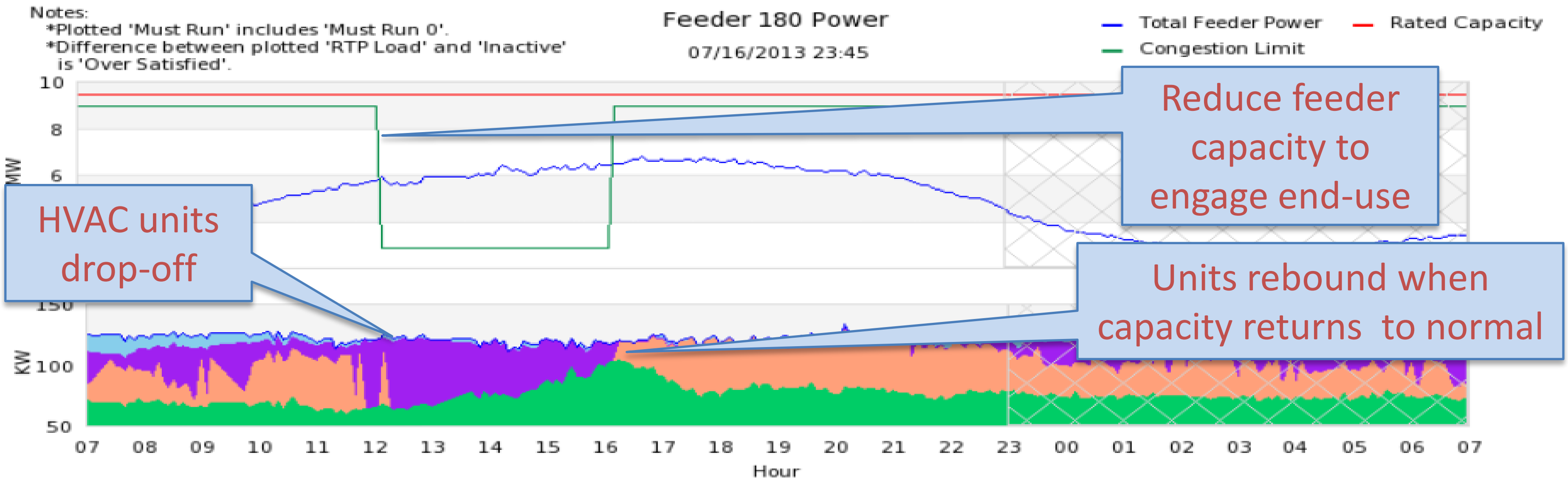
- Market clears every 5-min (~match AC load cycle)
- When uncongested:
  - Quantity (Q_{clear}) varies with demand curve
  - Price (P_{clear}) is constant, equal to *Base RTP*

RTP Market Congestion Conditions



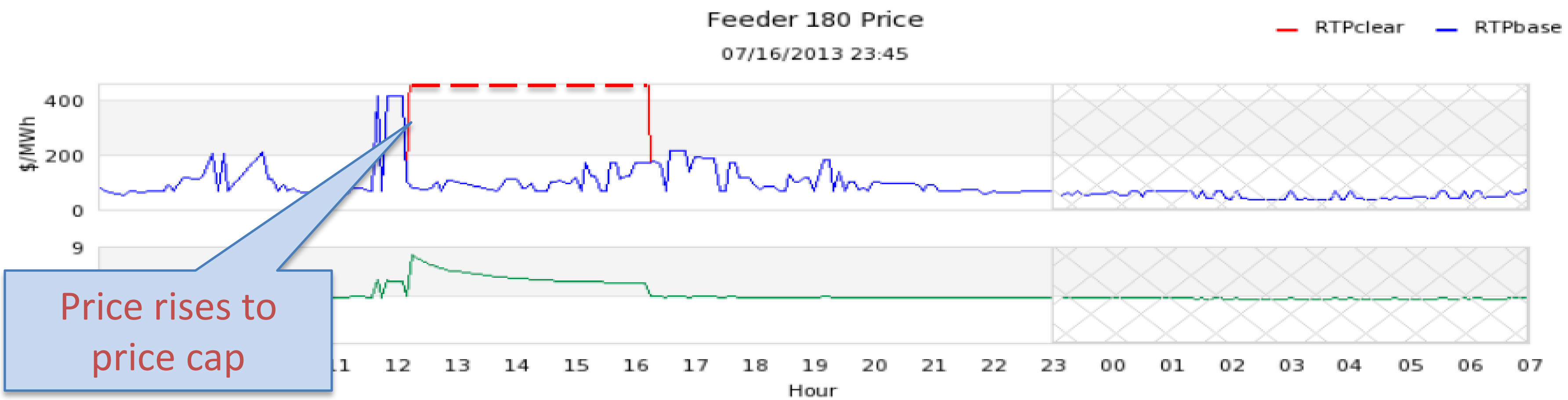
gridSMART® RTP in Action

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



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		

Over Satisfied
Inactive
Active
MustRun
Total RTP Load



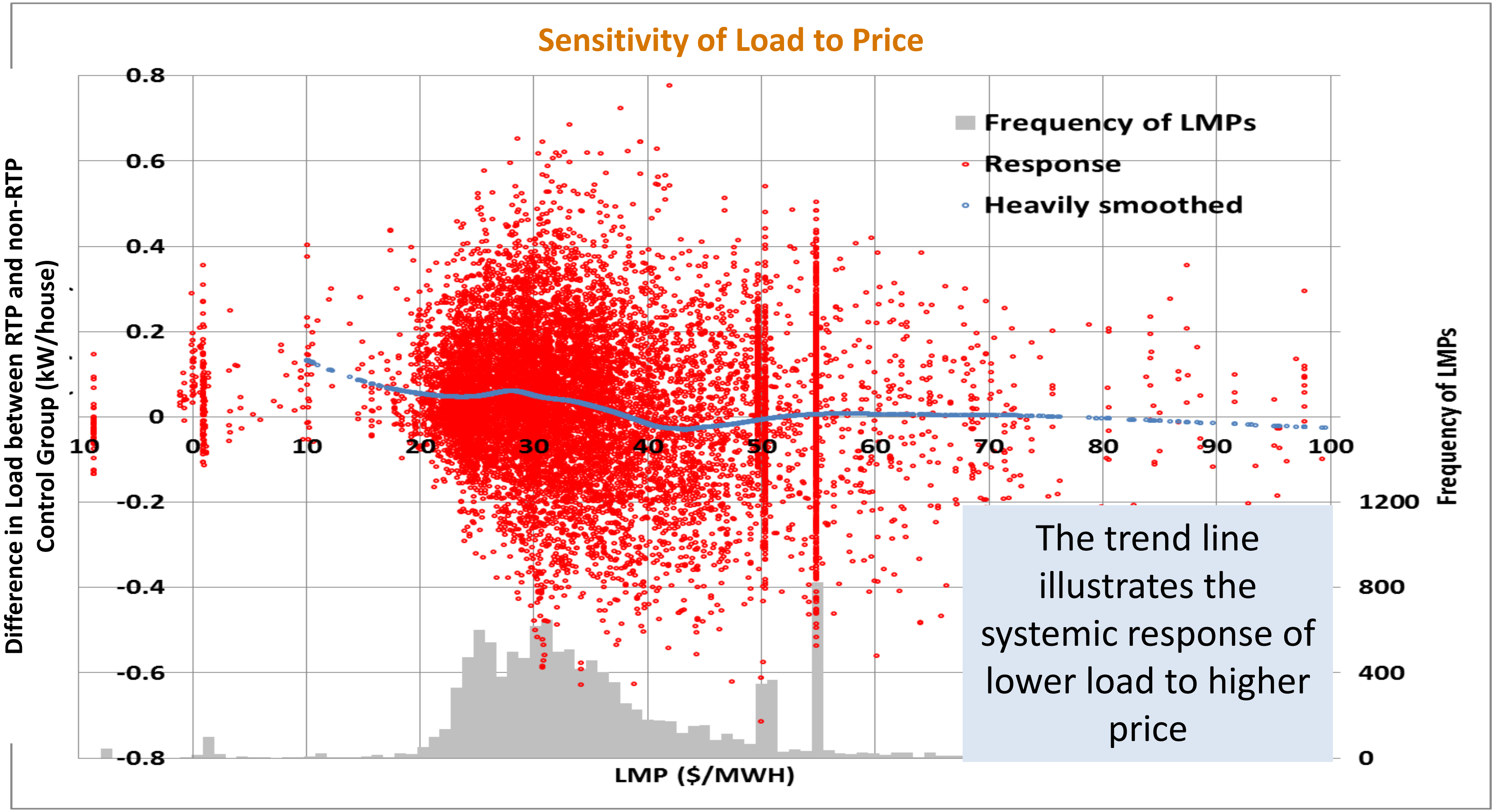
RTPclear	69.26 $/MWh	RTPbase	69.2631 $/Mwh	Sigma RTPclear	-0.4949

σ RTPclear

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

Swarm of Responses to Price



Actual load response versus LMP for about 12,000 5-min data points covering the period June–September 2013
Bottom shows histogram of the frequency of LMPs up to $100/MWh

Pacific Northwest Demonstration Project

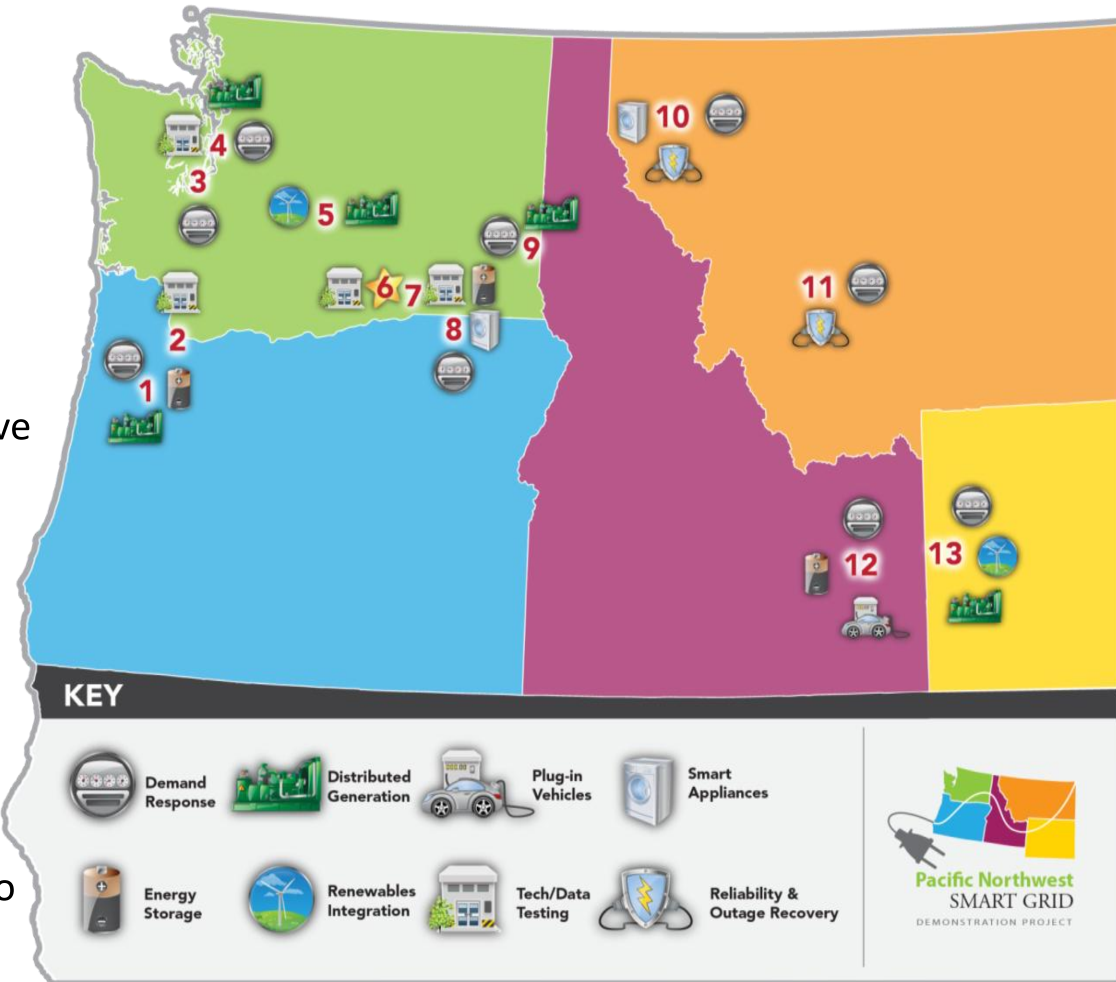
What:

- $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.

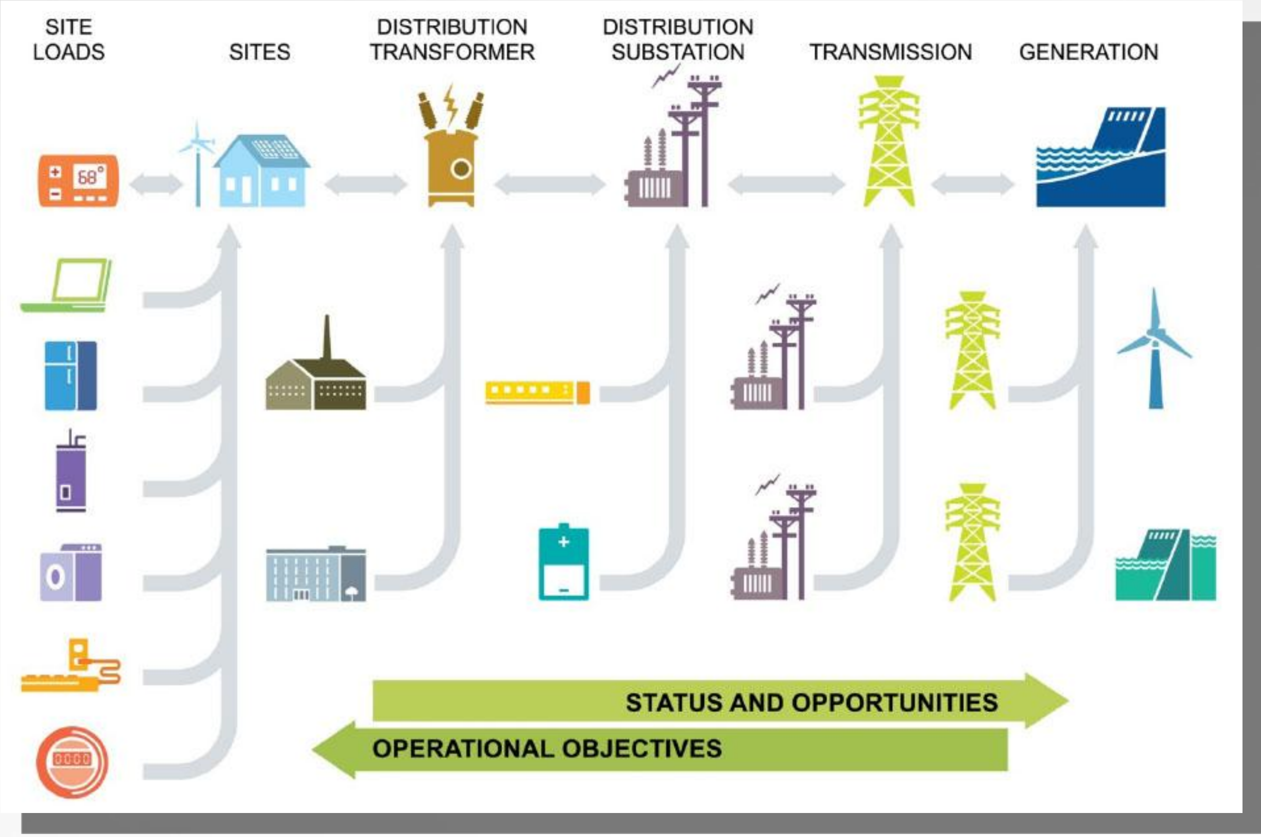


Project Basics

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

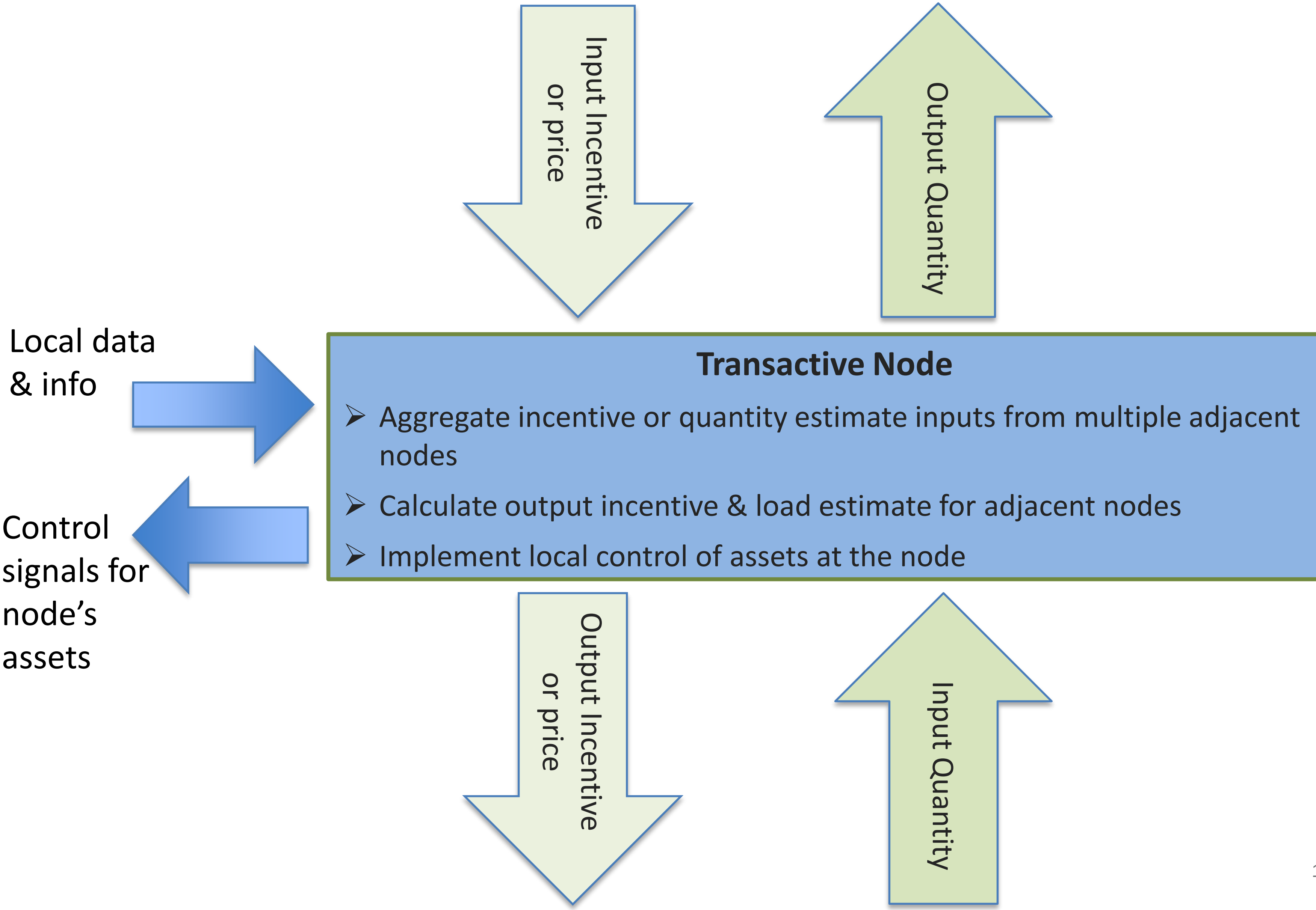
Operational objectives

- 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