The Smart Grid and its Role in a Carbon-Constrained World

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Information: The Virtual Electric Infrastructure

FACT:

In the next 20 years, the U.S. will spend $450B on electric infrastructure, just to meet load growth.

CHOICE:

Perpetuate a 20th Century solution

OR

Invest in a 21st Century system saving ratepayers $80B while increasing reliability and flexibility.

GRIDWISE™:

Revealing Values +
Communications +
Advanced Controls
≡ Electric infrastructure

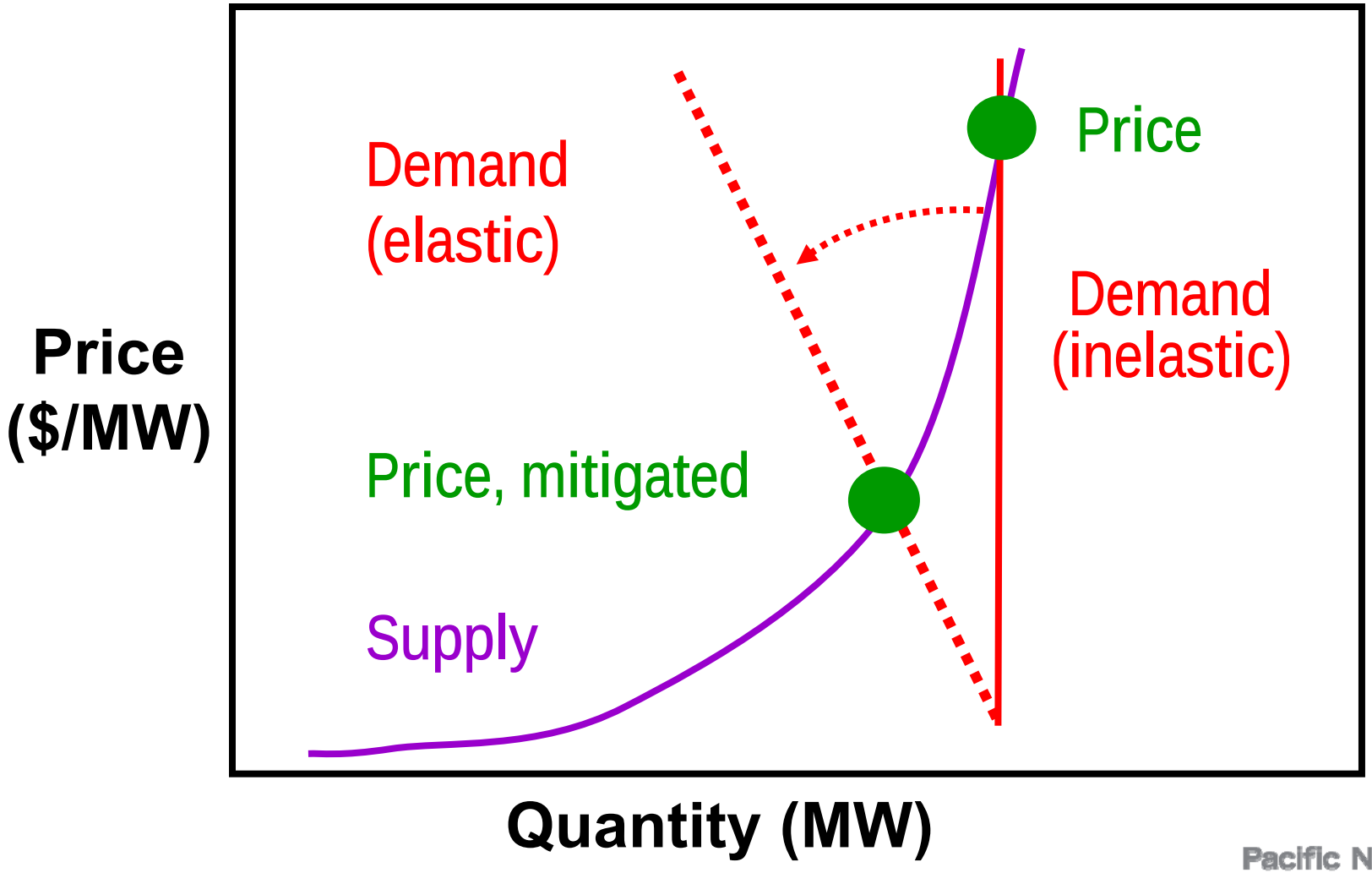
The choice is easy because…

$ bits << $ iron

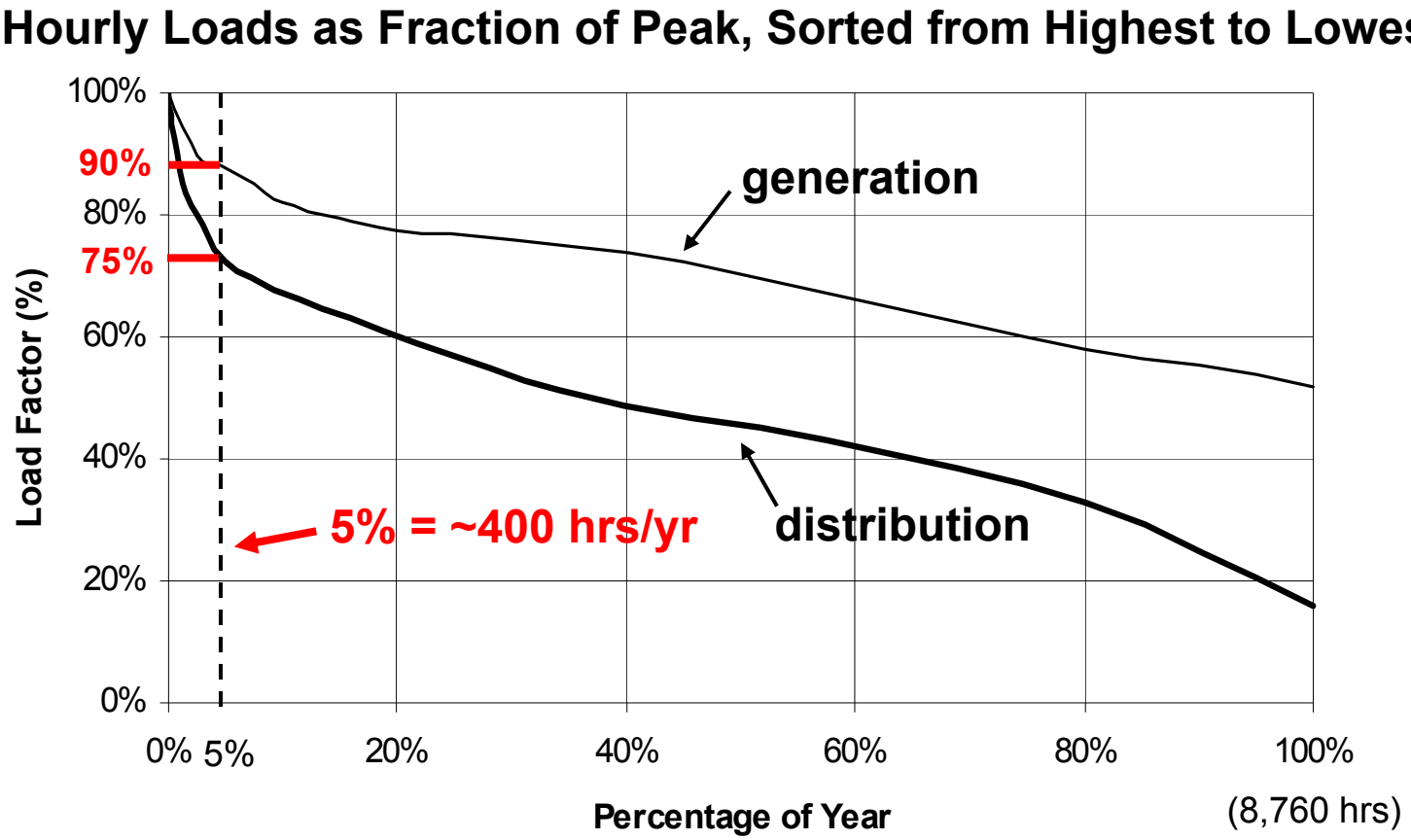
Some Key Smart Grid Technologies

- Communications
- Smart meters measure consumption at intervals (1 hour → 5 minutes)
- Demand response (to prices or other incentive signals)
- Distributed generation
- Distributed storage
- Distribution/feeder automation: smart switching of electric distribution system
- Advanced transmission visualization & control

Value of Demand Elasticity:
Lower Peak Demand & Stabilize Prices



Value of Demand Response: *Lower Peak Demand Reduces Infrastructure Investments*



25% of distribution & 10% of generation assets (transmission is similar), worth of 100s of billions of dollars, are needed less than 400 hrs/year!

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Fully Engaging Demand: What We've Learned from the Olympic Peninsula Demonstration

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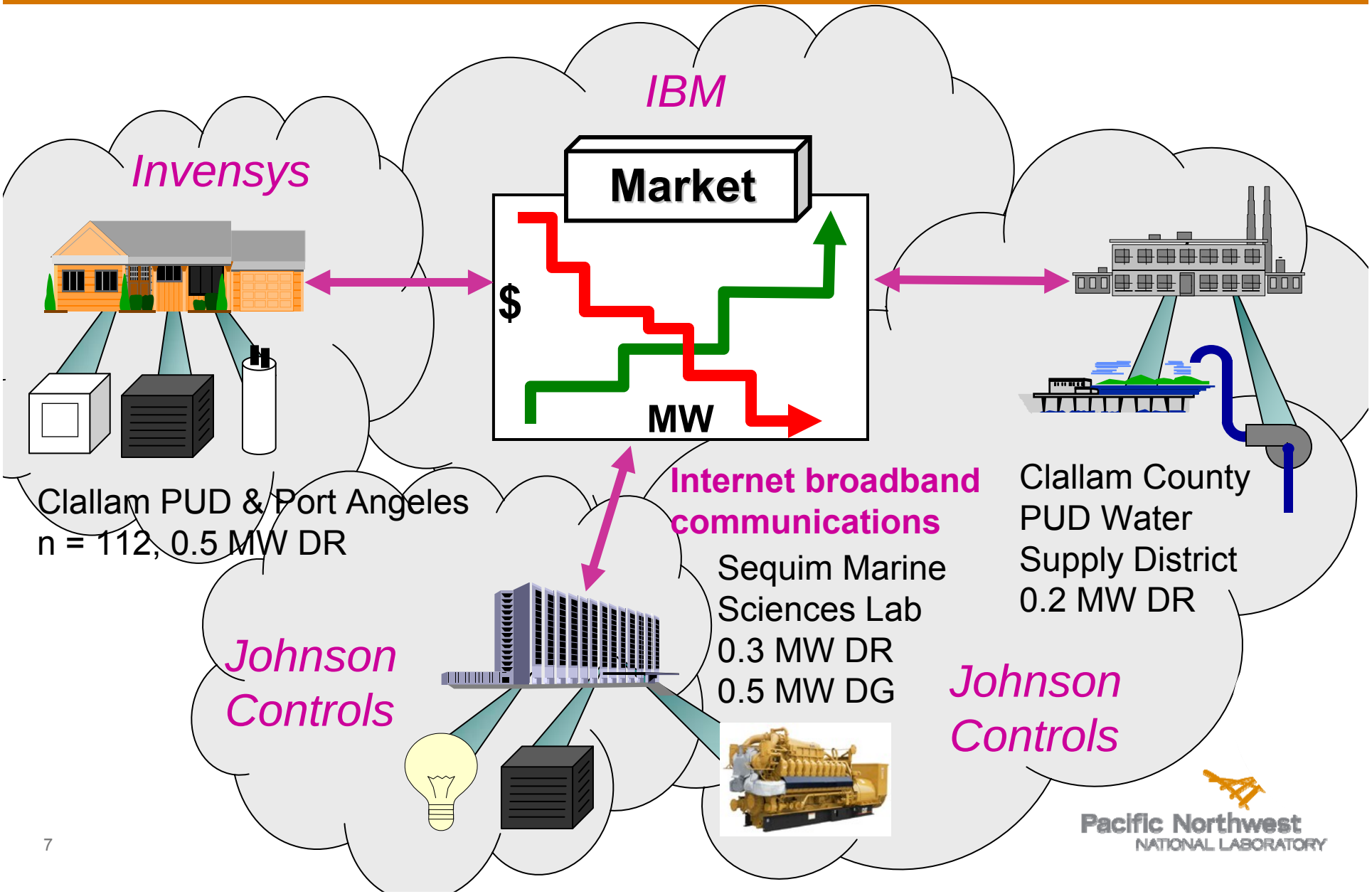
Olympic Peninsula Demonstration



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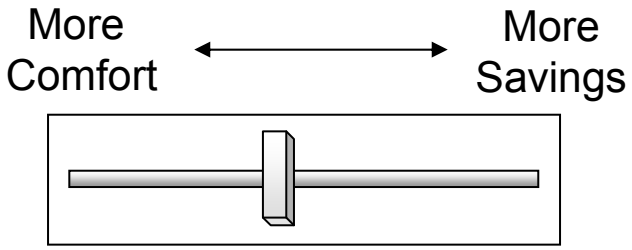
Olympic Peninsula Demo: Key Findings (1)

Customers can be recruited, retained, and will respond to *dynamic pricing* schemes **<u>if they are offered</u>**:

- 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 which end uses, and a 24-hour override
  - prevents fatigue: reduced participation if called upon too often
- Technology that automates their desired level of response
- A simple, intuitive, semantic interface to automate their response



Translates to control parameters:

K, T_{max}, T_{min} (see *Virtual Thermostat*)

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Olympic Peninsula Demo: Key Findings (2)

Significant demand response was obtained:

- 15% reduction of peak load
- Up to 50% reduction in total load for several days in a row during shoulder periods
- Response to wholesale prices + transmission congestion + distribution congestion
- Able to cap net demand at an arbitrary level to manage local distribution constraint
- Short-term response capability could provide regulation, other ancillary services adds significant value at very low impact and low cost)
- Same signals integrated commercial & institutional loads, distributed resources (backup generators)

The Smart Grid and Carbon

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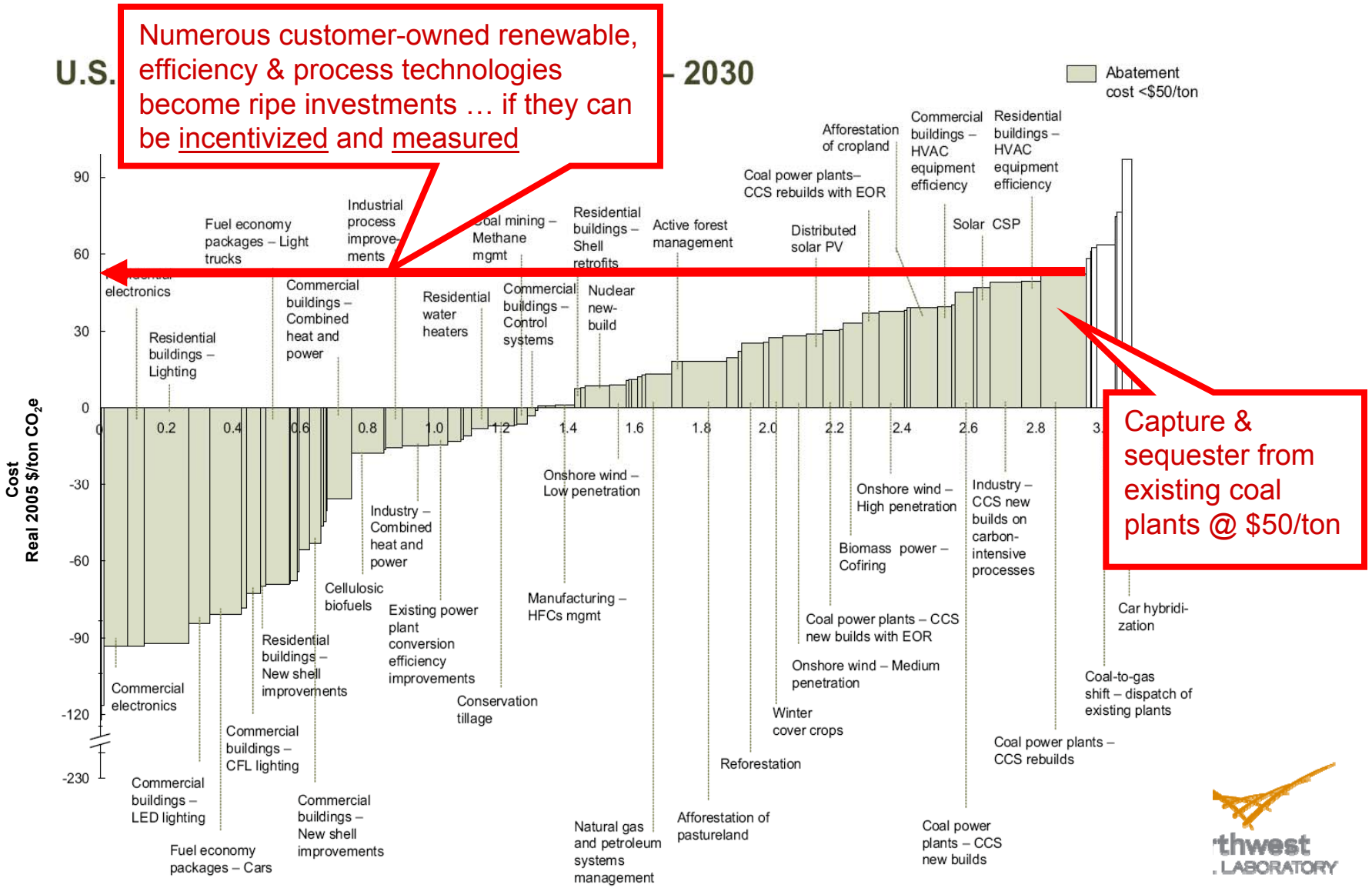
Carbon Supply Curve Suggests Massive Investment in Diverse Set of Resources is Coming



Source: McKinsey analysis

Smart Grid Can Deliver and Enable Carbon Savings – *A Sample of Mechanisms*

A *smart grid* can deliver carbon savings

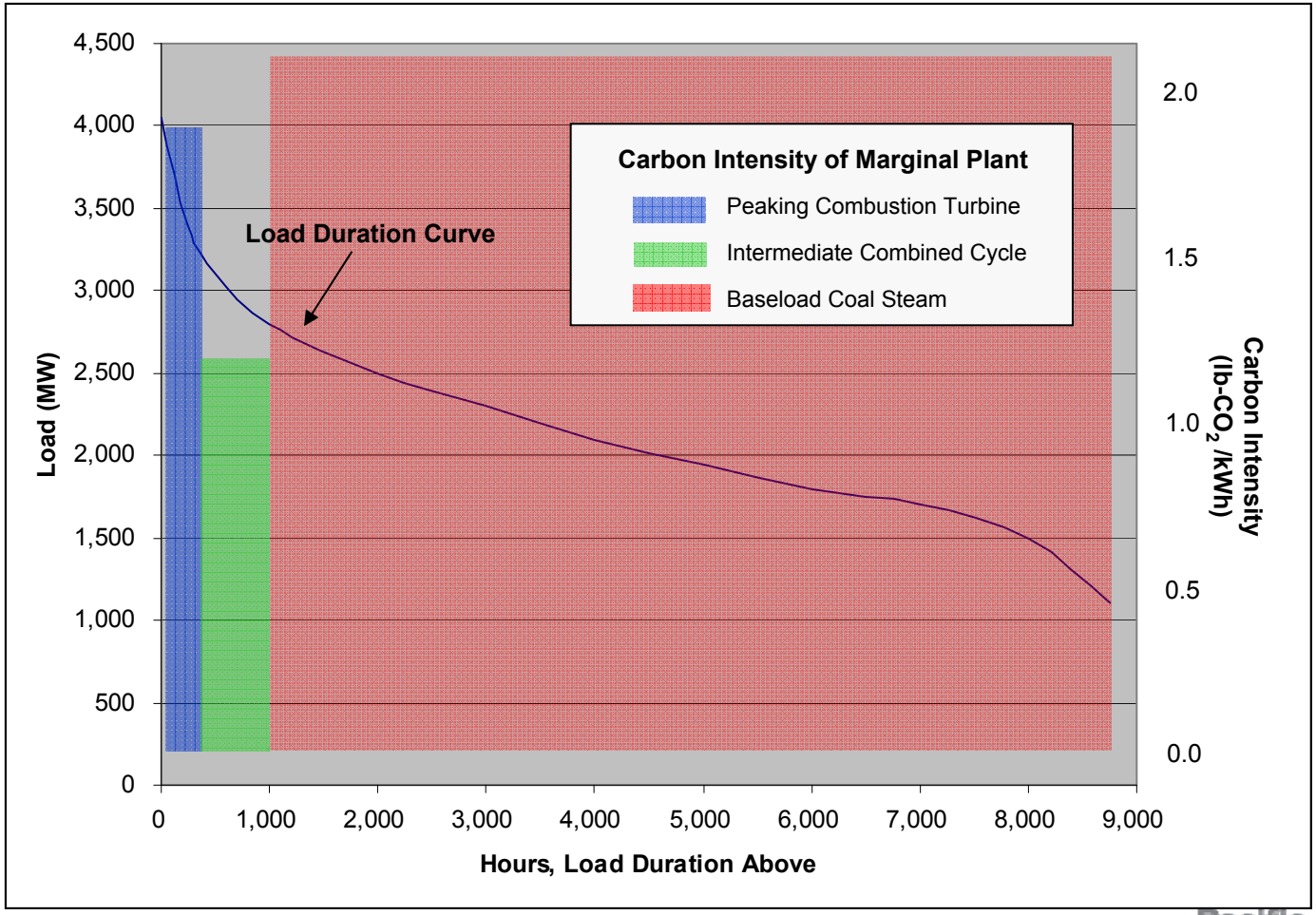
- End-use conservation & efficiency from demand response controls
- Carbon savings from peak load shifting
- Minimize losses & resistive loads by continually optimizing distribution voltage
- Cost effective & increasingly clean energy for electric vehicles
- Improve & sustain end-use efficiency by delivering continuous, remote diagnostic & commissioning services

A *smart grid* can enable more, lower cost carbon savings

- Lower net cost for wind power by regulating fluctuations with demand response
- Distribution grids capable of safely supporting high penetrations of PV solar
- Lower costs for efficiency programs by leveraging the demand response/AMI network to measure & verifying energy & cost savings – *for each customer, with unprecedented precision, in real-time*
    - Accurate accounting of actual carbon footprint of generation displaced by efficiency & renewables
    - Solid verification enhances value & tradability of carbon offsets (if allowed)

All kWh Are Not Created Equal – DR Load Shifting from Peaking to Intermediate Generation Can Save Carbon

Load Duration Curve and Carbon Dispatch of a Typical Coal-Based Utility



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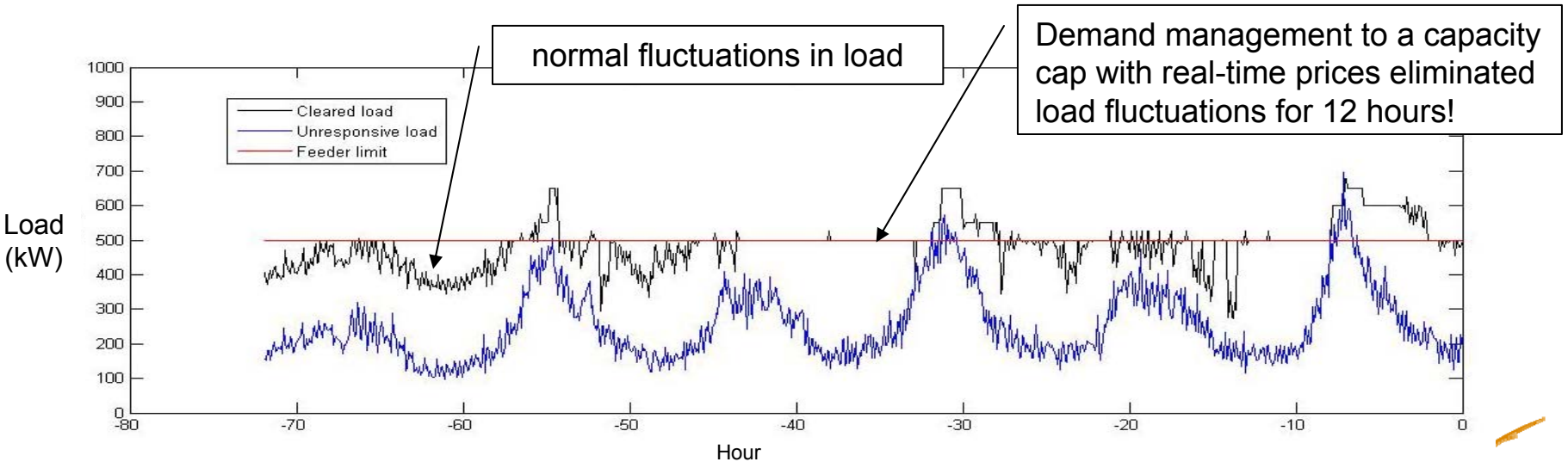
Potential for Demand Response to Help Manage the Large Infusion of Wind Power Implicit in a Carbon Strategy

Regulation: one or more fast-responding power plants continually throttle to match normal fluctuations in load

Highest cost generation in markets (zero energy sales, wear & tear, fuel consumption)

<u>Fluctuations in wind farm output greatly exacerbate need for regulation, reduce cost effectiveness of wind power at high penetrations</u>



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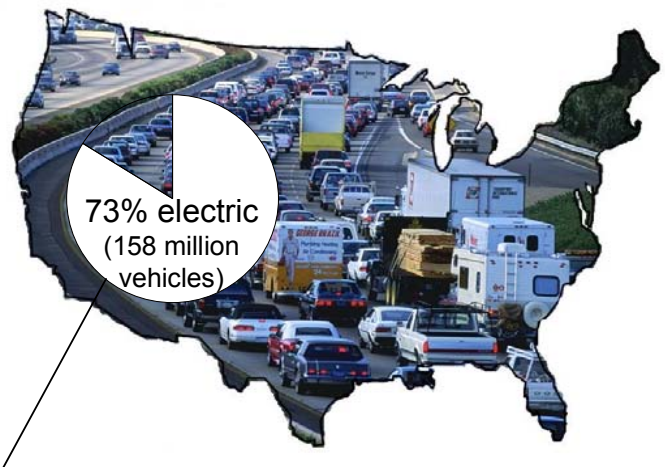
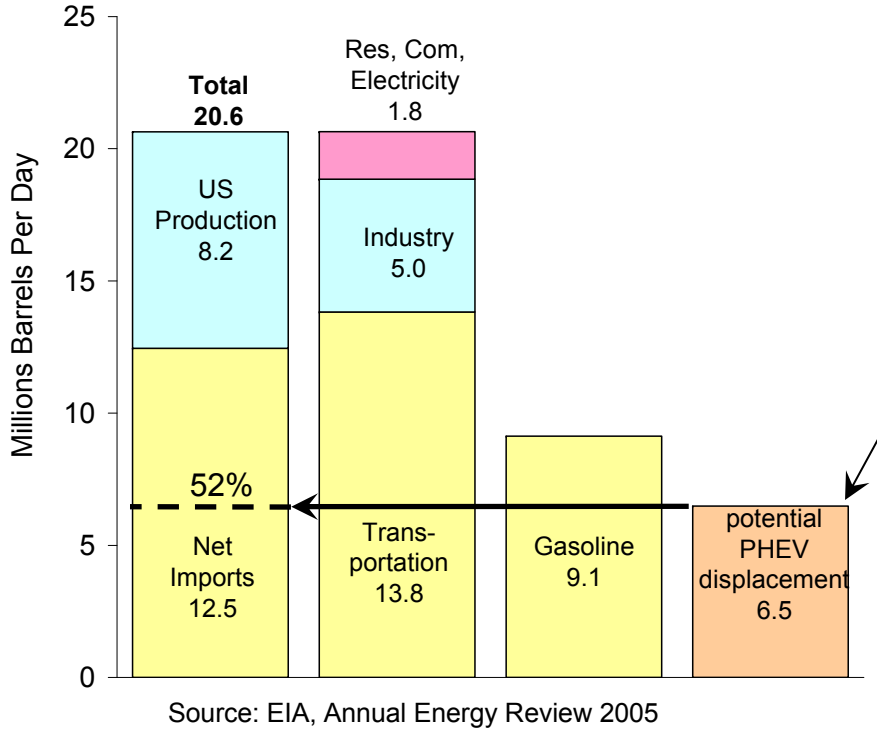
Potential Impacts of High Penetration of Plug-in Hybrid Vehicles (PHEVs) on the U.S. Power Grid*

** PNNL study for DOE Office of Electricity*

The idle capacity of today's U.S. grid **could supply 73%** of the energy needs of today's cars, SUVs, pickup trucks, and vans…

without adding generation or transmission
if vehicles are managed to charge off peak





Source: EIA, Annual Energy Review 2005

- Potential to displace 52% of net oil imports (6.7 MMbpd)
- More sales + same infrastructure = downward pressure on rates
- Reduces CO_2 emissions by 27%
- Emissions move from tailpipes to smokestacks (and base load plants) … cheaper to clean up
- Introduces vast electricity storage potential for the grid

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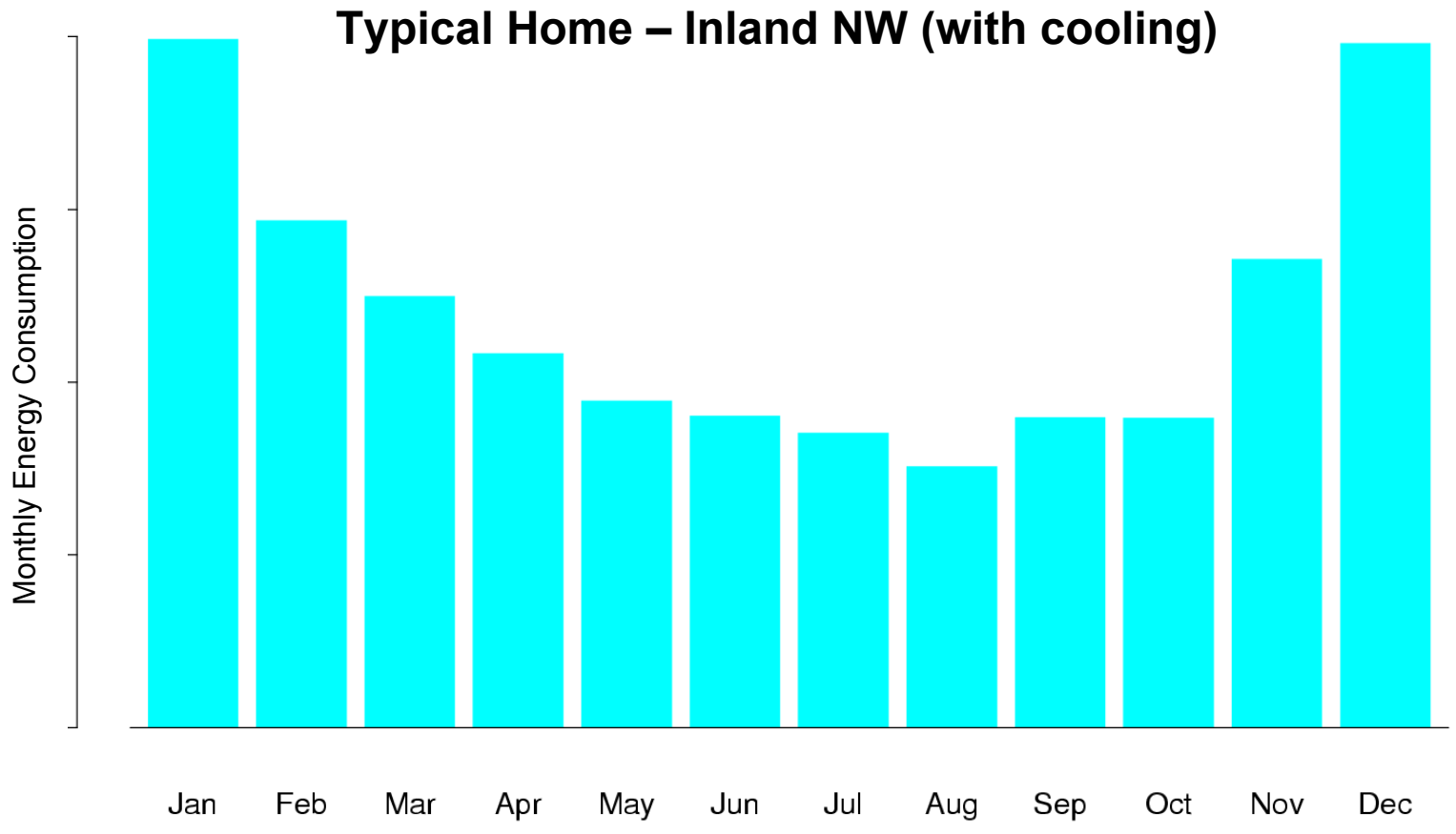
Measurement of Efficiency Savings Today: Basis is 12 Monthly Bills



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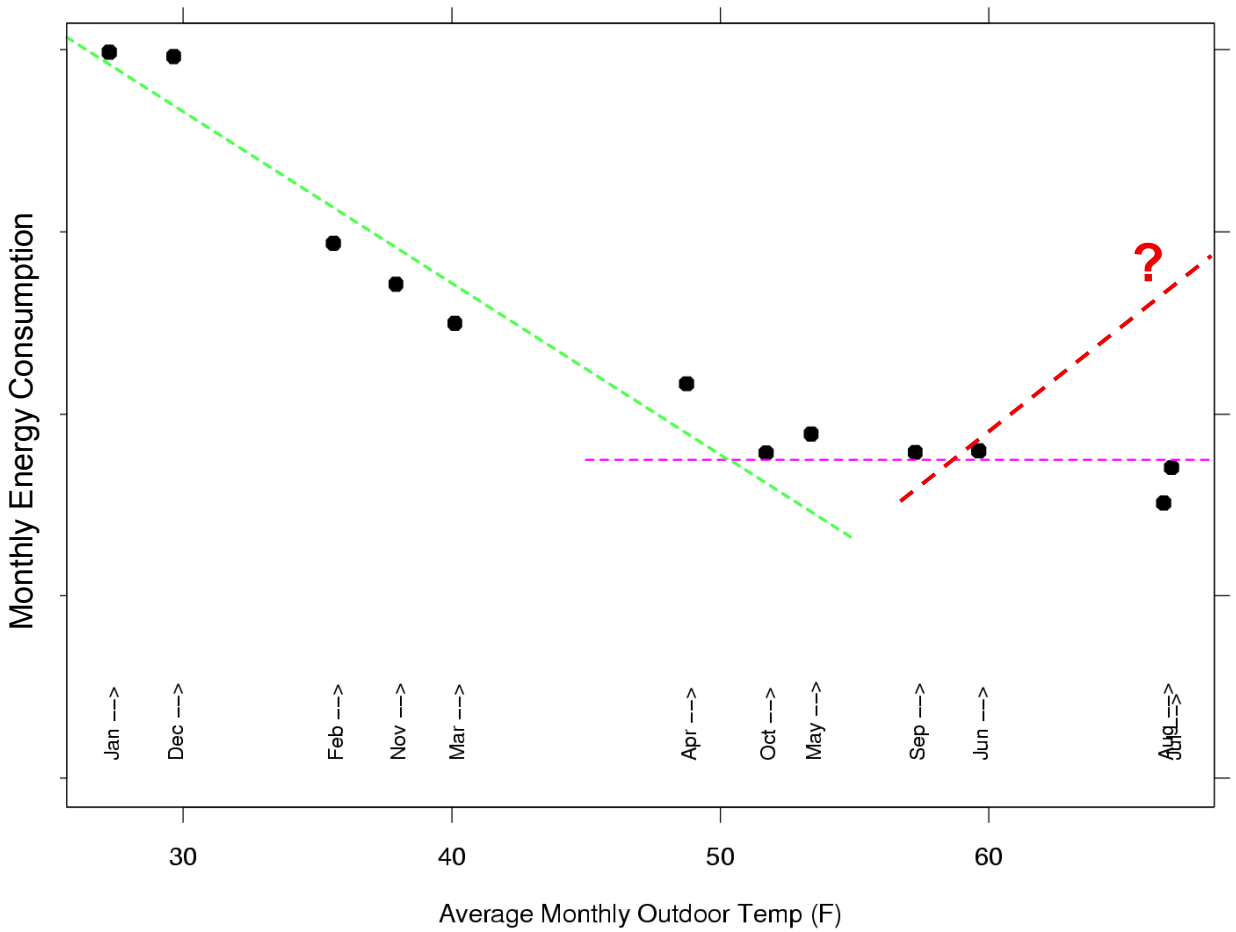
Analysis of Monthly Billing Data vs. Outside Temperature Yields Minimal Information



- State-of-the-art is 20-yr old PRISM billing data analysis
- Heating vs. base load is apparent, but with significant uncertainty
- Note AC is invisible

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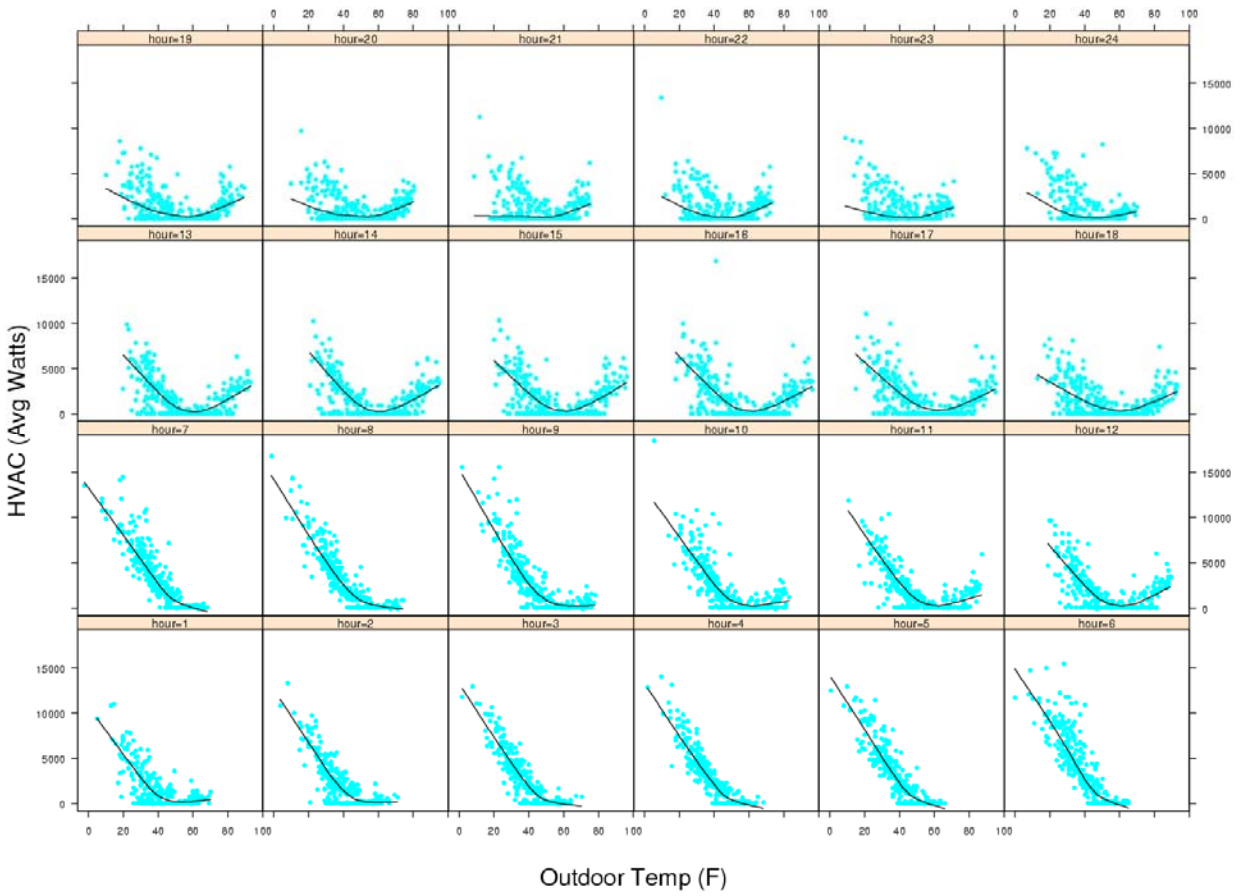
Smart Grid Provides Time-Series Data with End Use Resolution



- Vastly improved resolution allows detailed analysis of end-use savings
- Note AC load is now apparent

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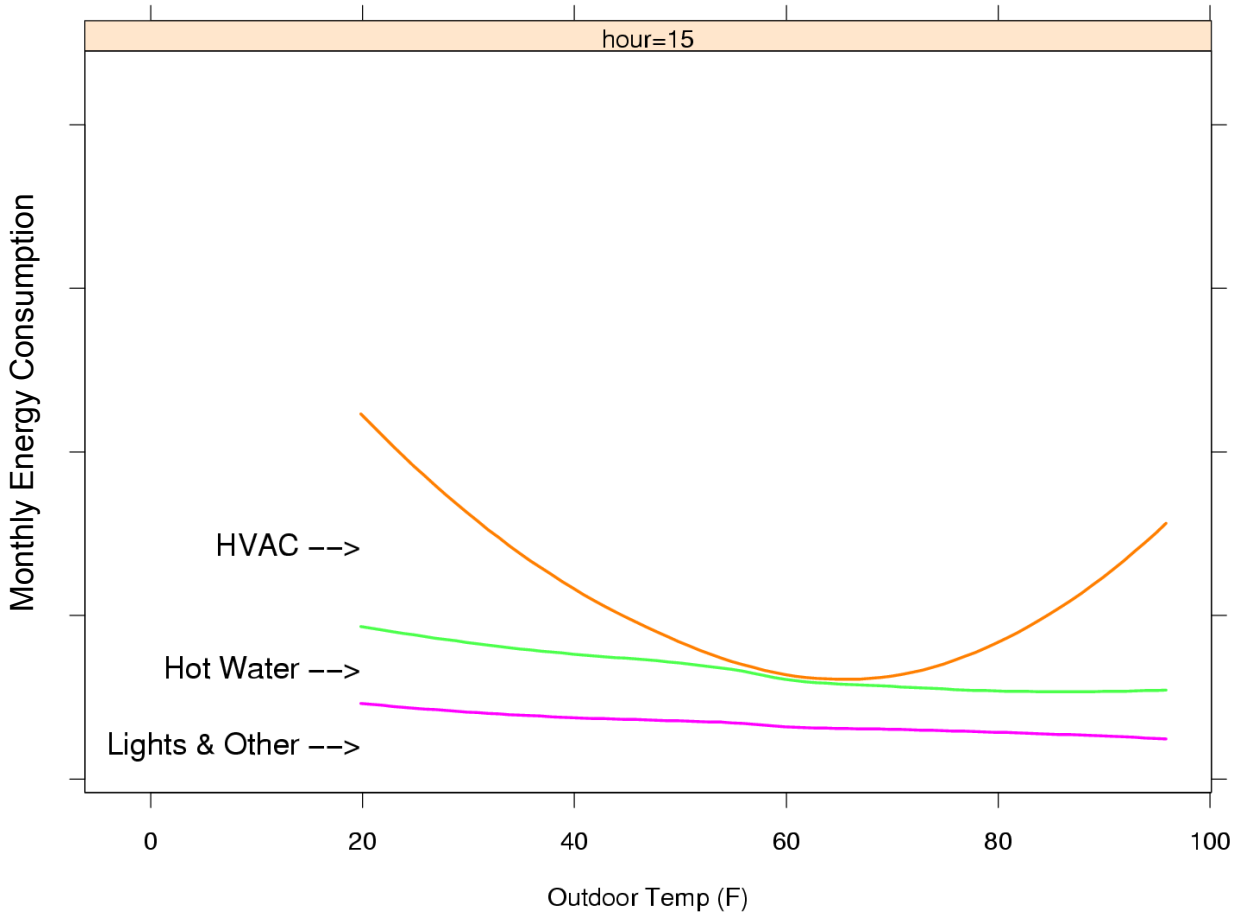
DR Networks Can Support Detailed Analysis of Most Types of Efficiency Savings



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