Grid Interactive Water Heaters and Beyond

WORKSHOP ON INNOVATION IN RELATION TO BUILDING ENERGY DEMAND IN IAMS – EC FP7 ADVANCE PROJECT

Eutrecht
20-21 January 2015

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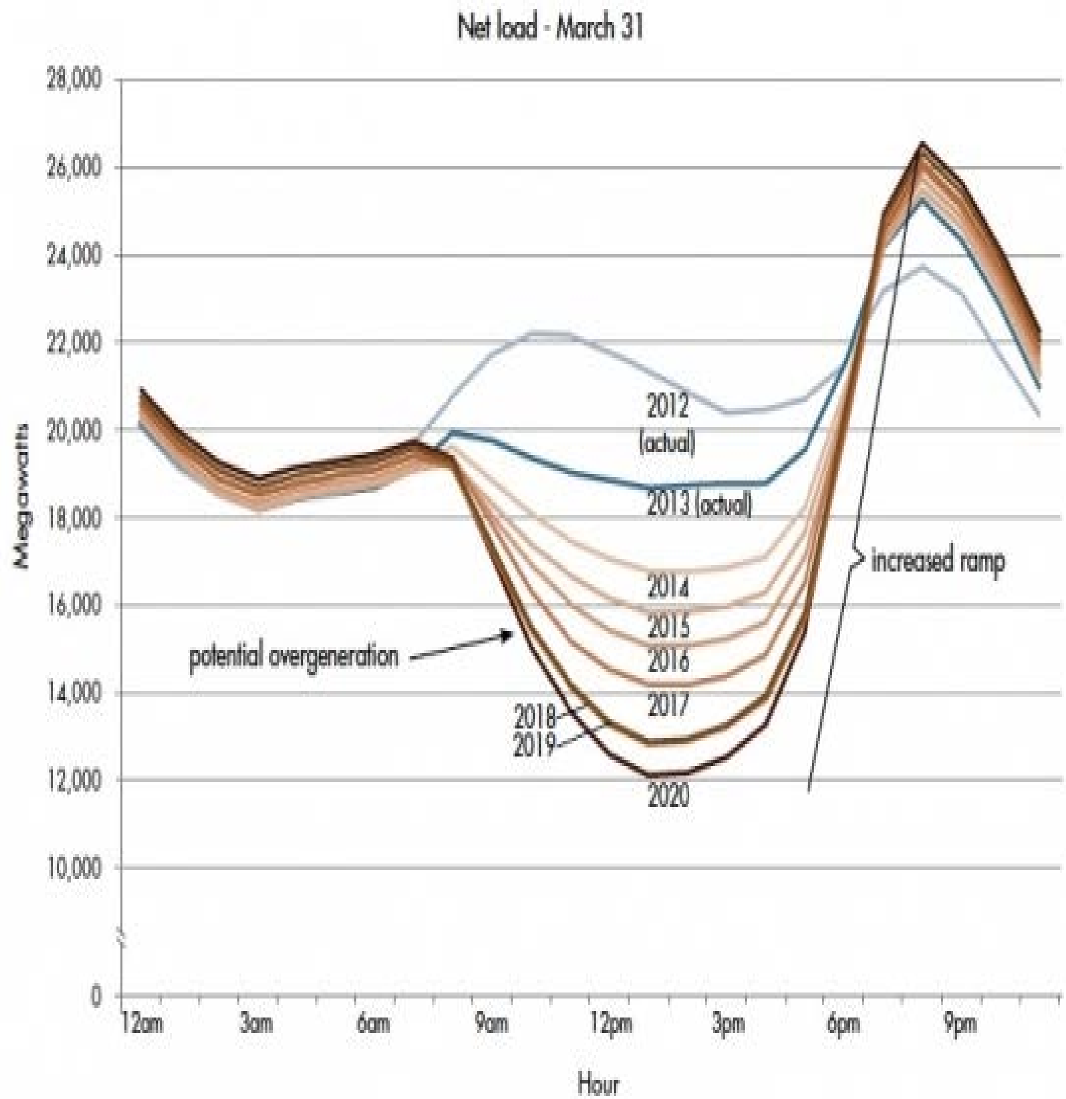
NRDC
THE EARTH'S BEST DEFENSE

Topics

- Interest in **grid-interactive** and controlled appliances
- **Why water heaters** deserve attention
- Water heater **types** and **control approaches**
- Current U.S. **policy problem** for water heaters
- Looking **beyond**

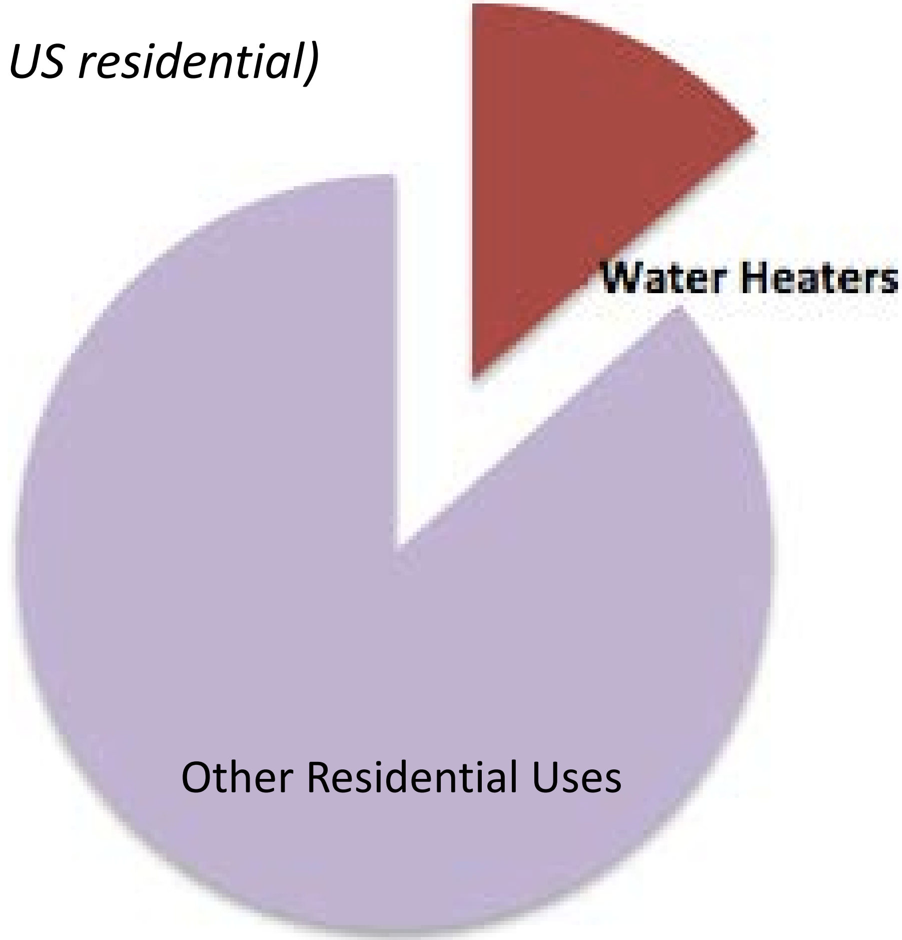
Why Grid-Interactive Appliances?

- ***Decarbonizing*** grid
- ***Renewable generation***
  - – ***variable output*** often
    - …***daily/seasonal*** patterns
    - …***no ancillary*** services
    - …***poor fit*** with demand
  - – *CAISO* **duck curve**
    - May overstate, but ***raises real issues***
- Grid interactivity can help system ***flexibility and economy***



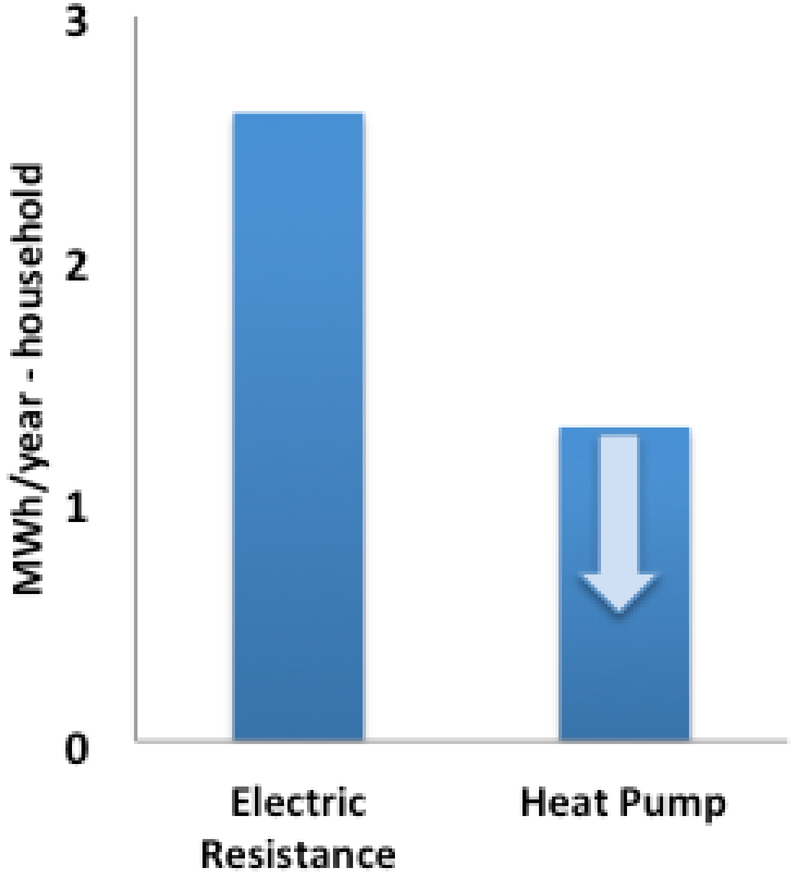
Why water heaters?

- ***Large energy use*** *(~14% US residential)*



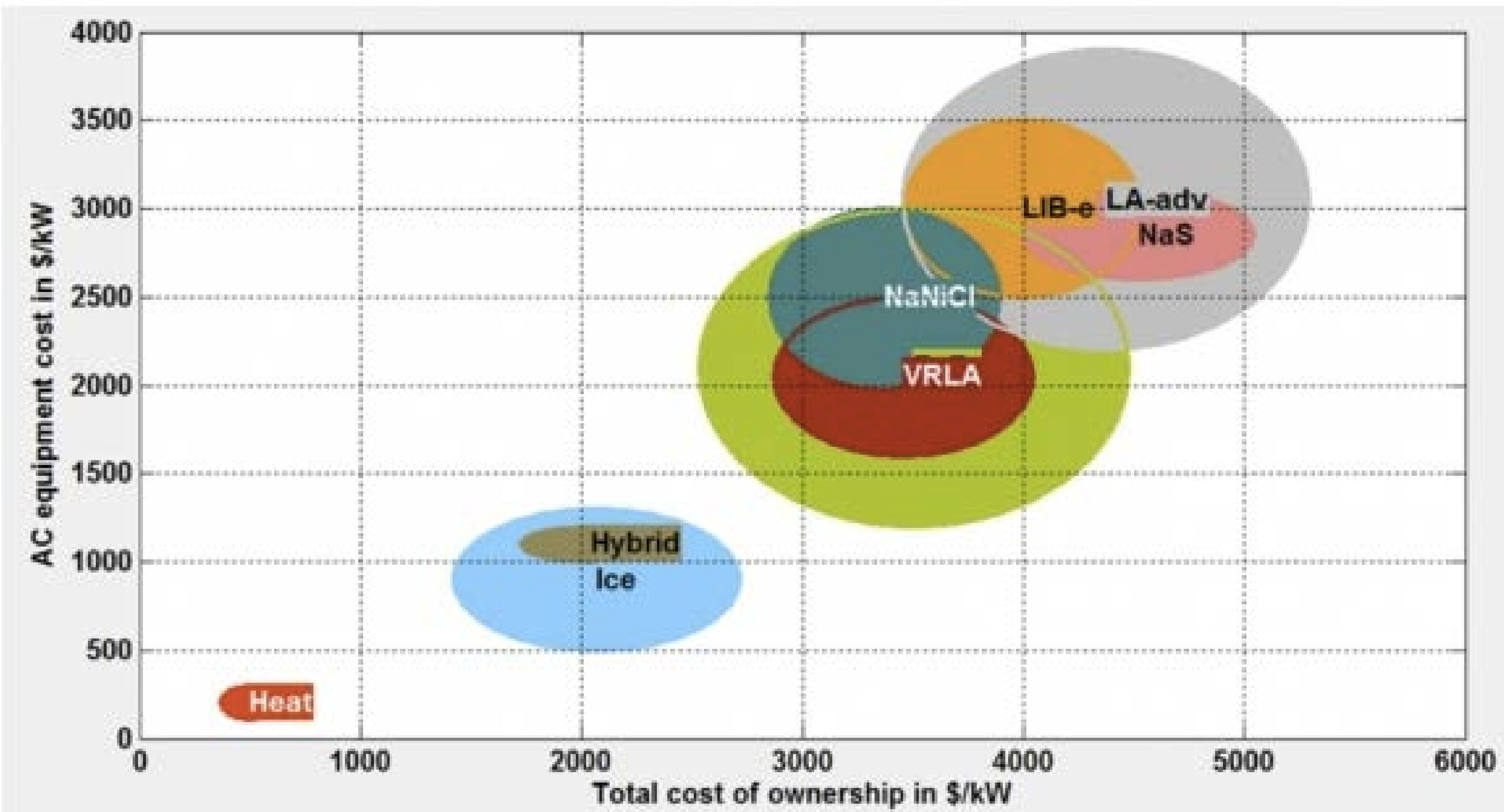
Why water heaters?

- ***Large efficiency opportunity*** *using heat pumps*



Why water heaters?

- ***Low-cost storage*** *potential*
- *Experience with millions of controlled units in operation*



Source: Sandia National Laboratory

Why water heaters?

- ***Ancillary services*** *potentially*

Grid Service Requirements	Response Speed* (Mainland)	Response Speed* (Hawaii)	Response Duration	Potential for DR?
Capacity				
Capacity Used to meet demand plus reserve margin; supplied by on-line and off-line resources, including interruptible load	Minutes	scheduled in advance by system operator	If called, must be available for at least 3 hours	✓
Ancillary Services				
Contingency Reserve** Reserves to replace the sudden loss of the single largest on-line generator; supplied from online generation, storage or DR	Seconds to <10 min	Within 7 cycles of contingency event	Up to 2 hours	✓
Regulating Reserve Maintain system frequency; supplied from on-line capacity that is not loaded	<1 min	2 seconds, controllable within a resolution of 0.1 MW	Up to 30 min	✓
Non-Spinning Reserve Used to restore regulating reserves and contingency reserves; supplied by off-line fast start resources or DR	10-30 min	<30 min	2 hours	✓
Non-AGC Ramping Resources that can be available prior to quick start generation and can add to system ramping capability	N/A	<2 min	Up to 2 hours	

Source: Hawaiian Electric Company

Why water heaters?

- ***A successful example***

Managing constraints with connected, responsive customer assets

- The submarine cable service to Fox Island, WA failed in November 2010
- The Fox Island Bridge Cable was also at risk, failing whenever the temperature drops below 20F
- Peninsula Light worked with 400 customer water heater load control units to avoid service blackouts to Fox Island

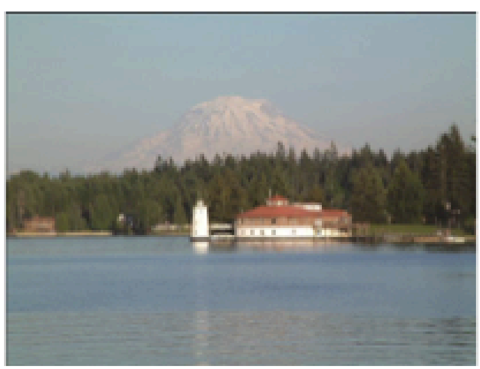


Photo: John Ohlson, Dragonwyck Design LLC

Why water heaters?

- High-level US ***policy attention***

ACEEE AHRI AO Smith APPA American Public Power Association
EEI Edison Electric Institute
GE imagination at work
HTP
neea
NRDC
National Rural Electric Cooperative Association
pjm
PVI
Rheem
STEFFES CORPORATION
Vaughn Water Heaters Controllers
ZODIAC POOL SYSTEMS, INC.

September 12, 2013

The Honorable Jeanne Shaheen

...lding

...n

...Building

...Portman:

...consideration of The Energy Savings and Industrial Competitiveness ...ned parties jointly propose the attached amendment to Section 325(e) of ...ervation Act (42 U.S.C. 6295(e)) to mitigate the concerns of some ...potential impact of the April 2010 energy efficiency standard for water heaters by allowing for the manufacture of certain large-volume grid-enabled electric resistance water heaters. We appreciate your consideration of this amendment.

Sincerely,

A.O. Smith Corporation
Air-Conditioning Heating and Refrigeration Institute
American Council for an Energy-Efficient Economy
American Public Power Association
Edison Electric Institute
General Electric Company
HTP, Inc.
National Rural Electric Cooperative Association
Natural Resources Defense Council
Northwest Energy Efficiency Alliance
PJM Interconnection, L.L.C.
PVI Industries, LLC
Rheem Manufacturing Company
Steffes Corporation
Vaughn Thermal Corporation
Zodiac Pool Systems, Inc.

Cc: The Hon. Ron Wyden
The Hon. Lisa Murkowski
The Hon. John Hoeven
The Hon. Mark Pryor

IN THE SENATE OF THE UNITED STATES—113th Cong., 1st Sess.

S. 1392

To promote energy savings in residential buildings and industry, and for other purposes.

Water Heater Types and Control Benefits

WH Type	Control & Communication	Experience	Grid Benefits	Analysis
Electric resistance	None	Large	None	NA
Electric resistance	One-way comm, slow control	Millions installed	**Capacity** (load-shifting, energy storage)	Limited public assessment
Electric resistance	Grid Interactive: Fast two-way	Hundreds installed	Above, plus **ancillary services**	Nascent, case-specific
Heat pump	None	Modest and growing	**Energy savings**	Nascent
Heat pump	Slow control	Very few installed	**Capacity and energy savings**	Very limited
Heat pump	Fast control; two-way	None	Capacity and energy savings; **ancillary services**?	Theoretical

Current Policy Problems for Water Heaters

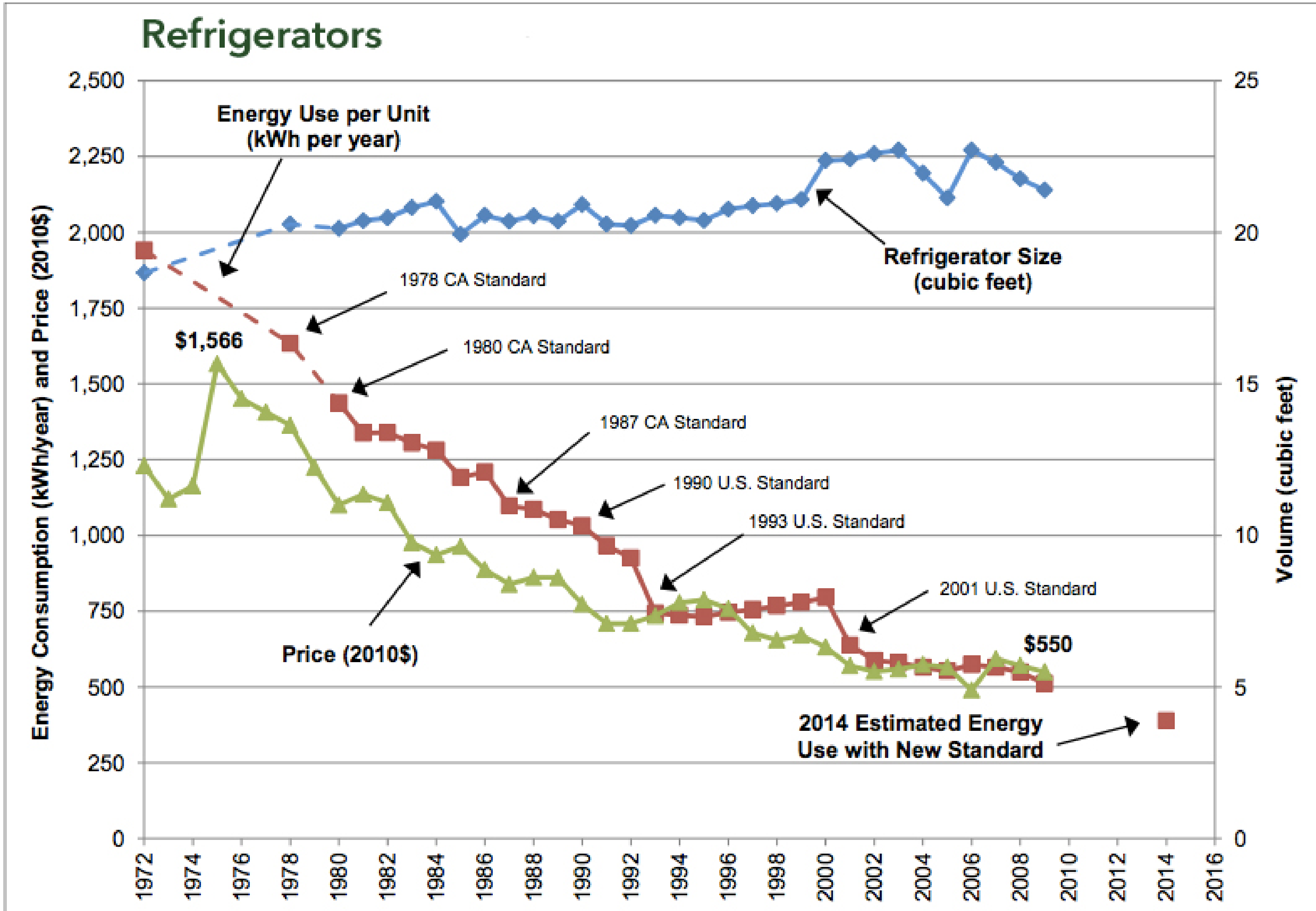
Standards

- New large electric resistance water heaters ***banned after April 2015*** by energy efficiency standards
- Standards-setting process ***didn't envision grid-interactive*** applications
- ***'Anti-backsliding'*** provision in law

Utility policy

- Gas and **electric rate designs** and policies often favor gas…
- … and often don't encourage grid interaction

Efficiency Standards: A History of Success



Source: Appliance Standards Awareness Project

US Energy Efficiency Standards: A Good, Open Analytically-Based Process

"…designed to achieve the ***maximum*** *improvement in* ***energy efficiency****… which the Secretary determines is* ***technologically feasible and economically justified…."***

- Secretary of Energy must ***consider everything relevant****:*
  - Economic impact on consumers and manufacturers
  - Life cycle costs
  - Energy savings, and the need for national energy savings
  - Performance and competition impacts
  - Anything else relevant
- Extensive ***public input***
- ***Rigorous analyses*** published in draft and final form
- ***Exceptions and exemptions*** to prevent 'special hardship, inequity, or unfair burdens'

Great Savings From Current US Standards

- ***$1.1 trillion*** cumulative savings of purchases through 2035
- ***500 million tons CO2/yr*** in 2035
- ~***250 GW*** in 2035
- ~***800 million MWh/yr*** in 2035

DOE’s Options

- Broad ***waiver rulemaking*** for GIWH

  …***stuck*** at DOE since Feb 2013

- ***OHA ‘exception’*** for individual GIWH requests

  …***denied*** for first application

- Wait for ***legislation***
- Wait for ***next rulemaking review***, losing current potential
- *Develop* ***system efficiency analysis, not just isolated appliance efficiency*** *for future work*

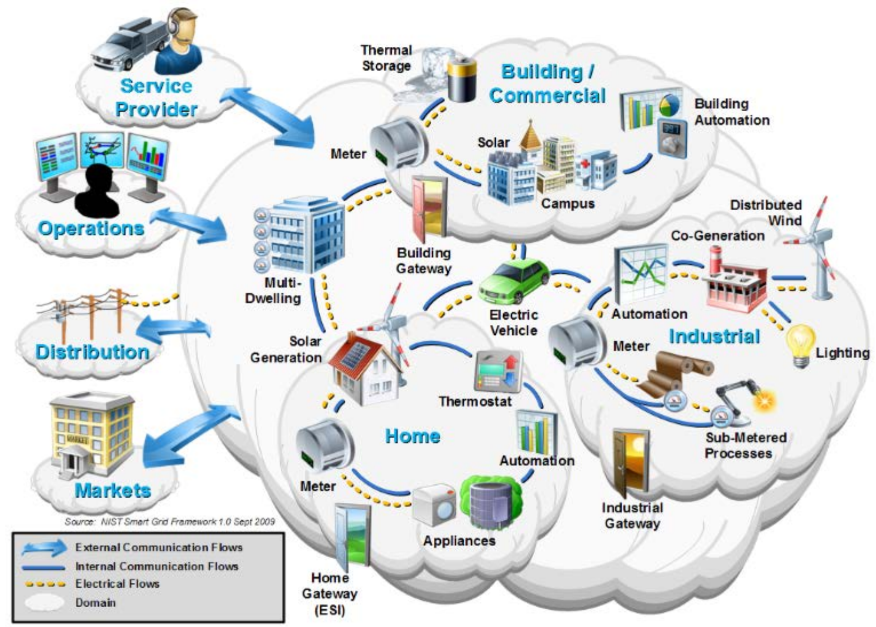
Looking Beyond

- Which ***other products*** should be on the grid-interactive radar?
- ***DOE building-to-grid*** and other integration efforts
- ***"Transactive controls"***

Smart buildings lead to better utilization of energy at all scales

- Buildings need to be smart to participate in transactions within the building, with other buildings, and with grid entities.

- Sensors and controls at the whole building level and at the component level are fundamental to optimize DER and the grid.
  - Hypothesis: *The financial viability of building efficiency may be sub optimized since margins are th)*
    alone is not financially viable i
    instances, BUT… a model with multiple transactions within an energy ecosystem enhances the value propositio



- All BTO Sensors and Controls projects are designed to improv building performance and incorporate the broader transaction capability.

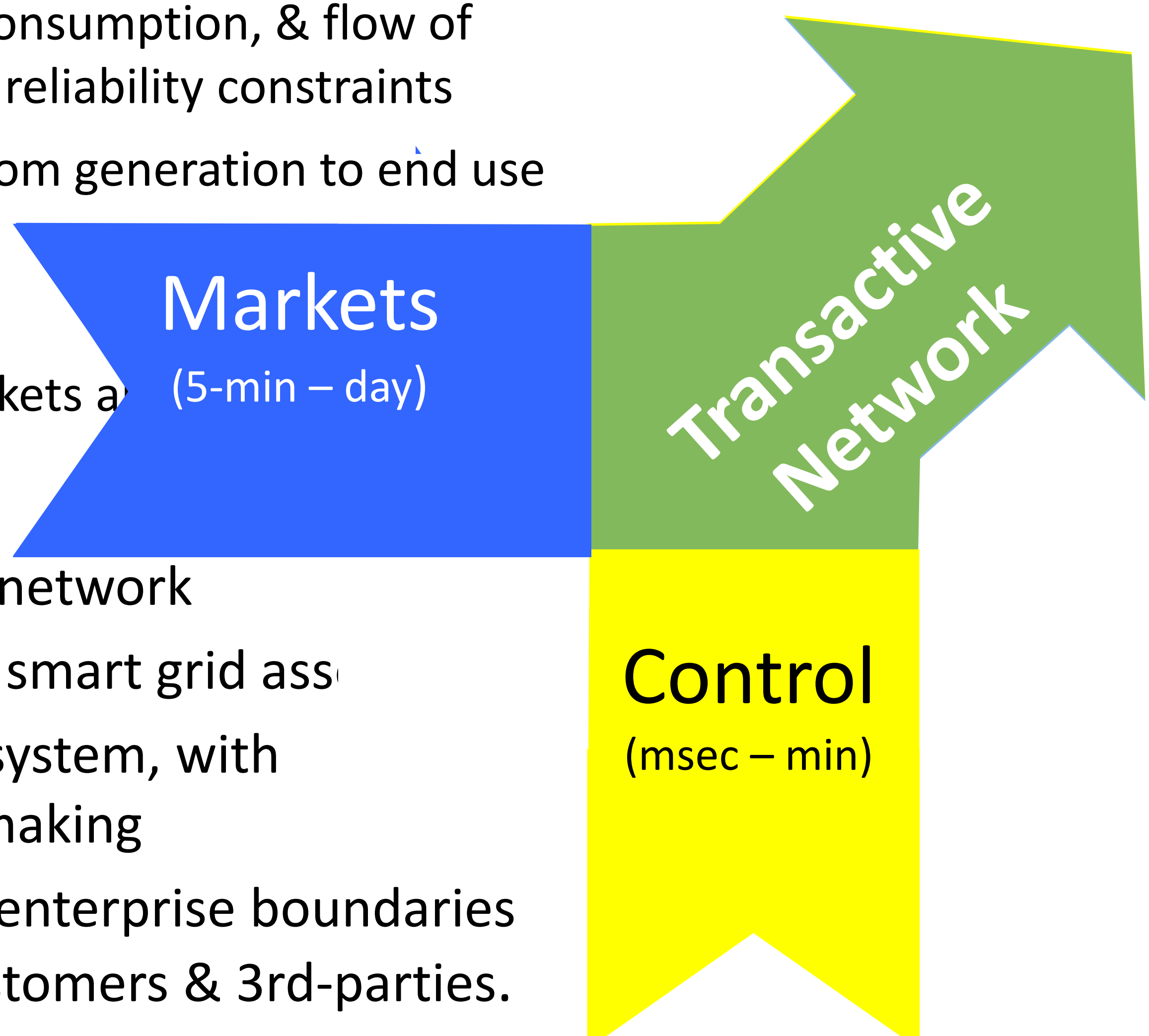
Definition of Transactive Control & Coordination

Uses economic or market-like constructs

- to manage generation, consumption, & flow of electric power, including reliability constraints
- by coordinating assets from generation to end use <u>with precision</u>.

Blends elements of power markets a
energy control systems

- to form a transactive network
- organizing millions of smart grid ass
- into a virtual control system, with distributed decision making
- that respects natural enterprise boundaries between the grid, customers & 3rd-parties.



Source: PNNL