



# DR Trends & Issues in US: Moving Toward St. Fred's Dream

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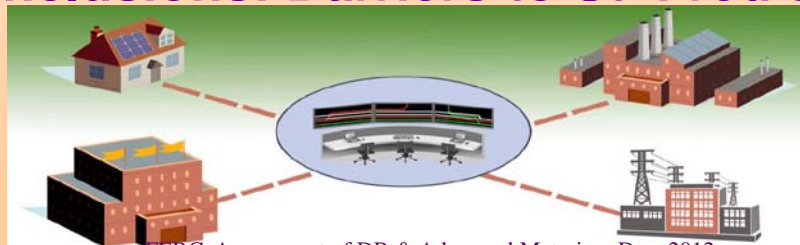
*Thanks to Beibei Wang (Southeast University), US NSF, Cheryl Hindes (BGE), Andy Satchwell (LBNL), John Goodin & Jeff McDonald (CAISO), Skipping Stone, Ahmad Faruqi (Brattle), Joe Bowring (Monitoring Analytics), & St. Fred (MIT)*



JHU E2SHI

## Outline

1. St. Fred's Dream
2. What DR is Hot-or Not?
  - Types
  - Growth
  - Why?
3. DR for peaks: Successes – and Struggles
  - Baltimore Gas & Electric
  - California
4. DR to manage wind variability
5. Conclusions: Barriers to St. Fred's Dream



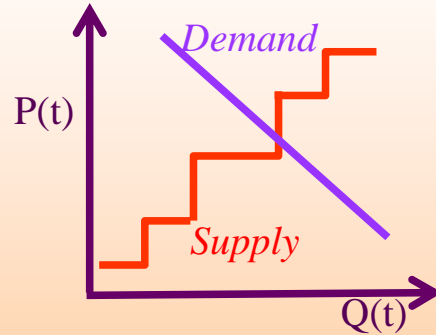
FERC, Assessment of DR & Advanced Metering, Dec. 2012



# 1. The Dream of St. Fred of MIT



- Fred Schewepe's 1978 vision of a market with real-time demand-response ("Power Systems 2000", *IEEE Spectrum*, July)
  - Prices  $P(t)$  send in real-time to consumers, who choose when & how much  $Q(t)$  to buy
  - Shape load to system capacity & other constraints (transmission, gen), optimally balancing:
    - Value to consumers
    - Cost of generation



- Late (1984): St. Fred dreamed of coordinating unregulated generation (Bohn, Caramanis, Schewepe, 'Optimal pricing in electrical networks over space and time', *Rand J Econ*)
  - Price spikes optimally fund capacity investment
- US Power Markets still (mainly) half a market
  - "Dumb meters/grid" (average cost pricing, uninformed consumers)
    - Missing demand side → More cost & pollution



# 2. Demand Response in the U.S.

**"Demand Response (DR): Changes in electric use by demand-side resources from their normal consumption patterns...  
 ... in response to changes in the price of electricity, or to incentive payments,  
 .....designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."**  
 (FERC, *Assessment of Demand Response & Advanced Metering*, Dec. 2012, p. 21)

**Is FERC its own worst enemy?** (Bushnell, Hobbs, Wolak, *Electricity J.*, Aug. 2009)

Figure 2-1. Estimated advanced metering penetration nationwide reported in FERC Surveys 2006, 2008, 2010, and 2012

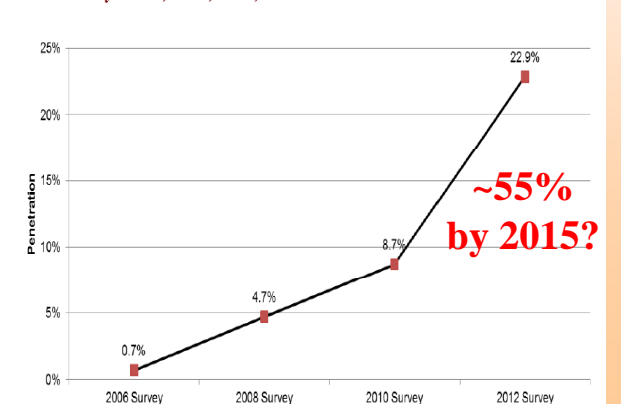
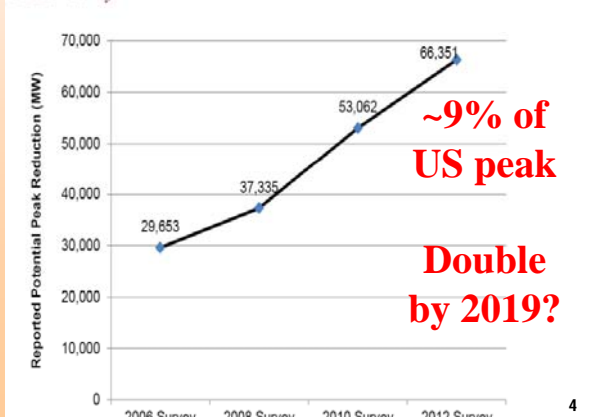
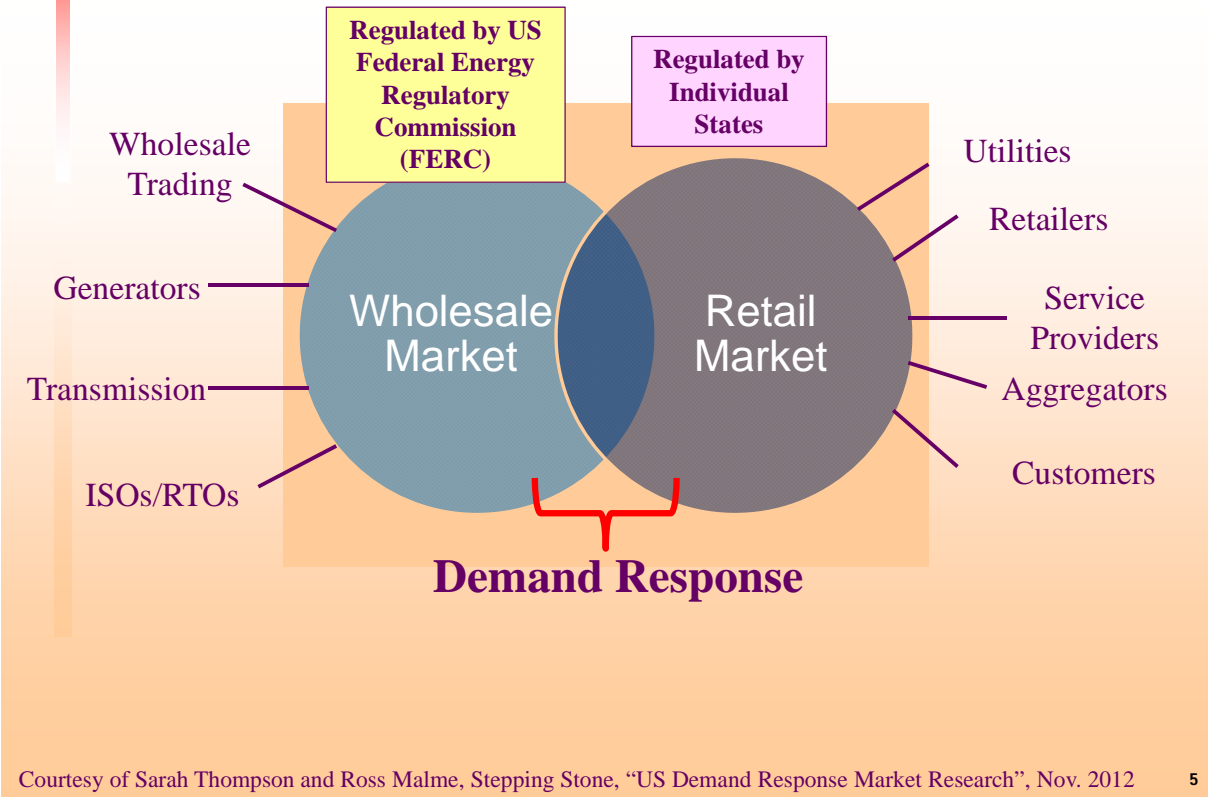


Figure 3-1. Total reported potential peak reduction in the 2006 through 2012 FERC Surveys





# North American Power Market Structure

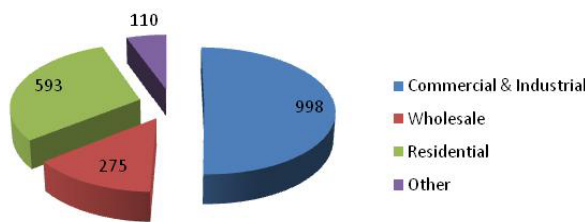


Courtesy of Sarah Thompson and Ross Malme, Stepping Stone, "US Demand Response Market Research", Nov. 2012

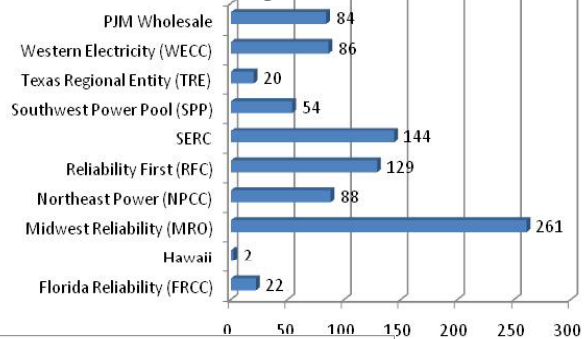


# Distribution of U.S. DR Programs (Numbers)

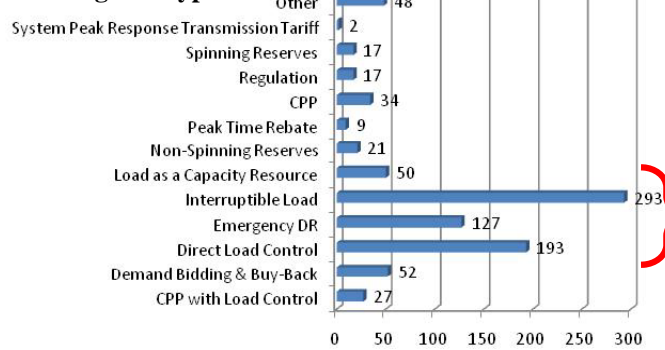
Utility *Retail* DR Programs



ISO *Wholesale* DR Programs



DR Program Types



Most are peak, or emergency programs—*Far from St. Fred's dream!*

Source:

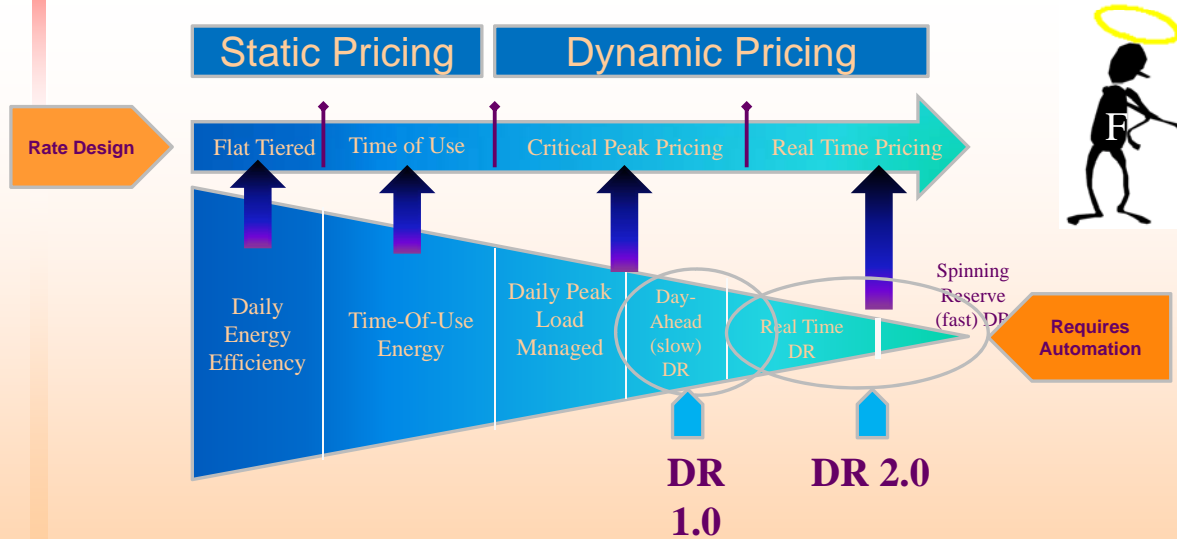
**Demand Response Directory**

[www.DemandResponseDirectory.com](http://www.DemandResponseDirectory.com)

Courtesy of Sarah Thompson and Ross Malme, Stepping Stone, "US Demand Response Market Research", Nov. 2012



## DR Evolution from 1.0 to 2.0



Source: M. Piette, S. Kiliccote, G. Ghatikar, *Linking Continuous Energy Management and Open Automated Demand Response*, Nov. 2008, LBNL-1361E.  
 Courtesy of Sarah Thompson and Ross Malme, Stepping Stone, "US Demand Response Market Research", Nov. 2012

### Main drivers now:

- **Regulation:** Federal (FERC) & state (17 states reviewing rate cases)
- **Profit** from generation capacity markets



## 3. Examples of Evolution: Baltimore G&E (1)



**Air Conditioner Load Controller**  
 (CAISO Participating Load Pilot Project Report, Southern California Edison, 2010)

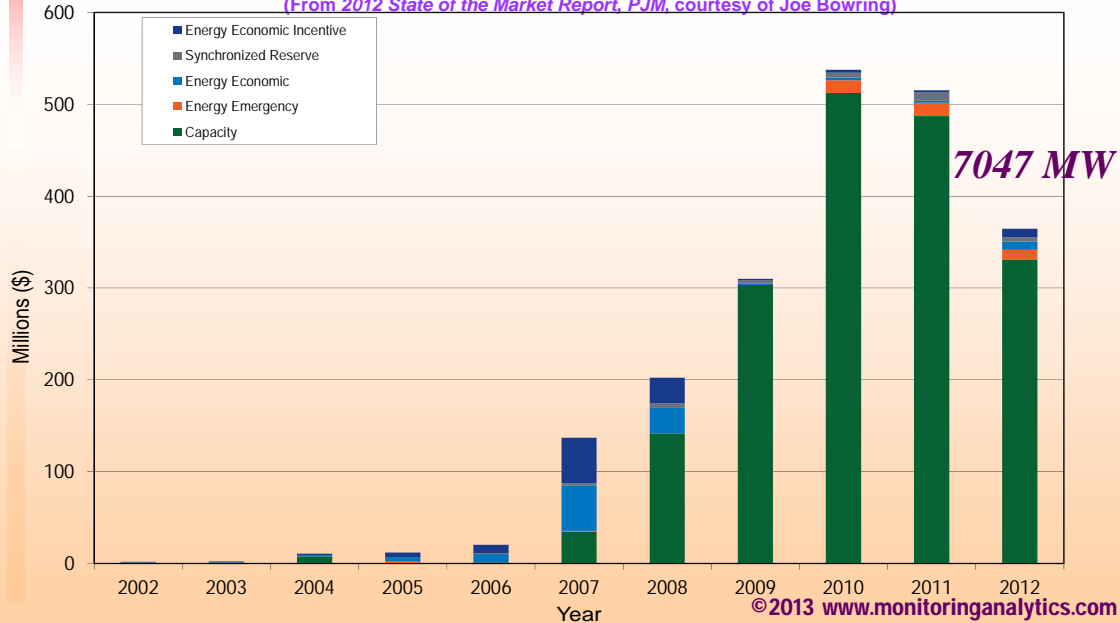
- **In place: Reliability programs**
  - One of largest load control programs in US: residential air conditioners
  - \$ rebate on bill
  - 350,000 customers
  - 600 MW peak reduction
- **Transition to price-based (DR 1.0)**
  - \$500M advanced meter roll-out (\$200M from Obama stimulus)
  - Peak pricing—all 1.3M residential customers by 2014.
  - Pilots 2008-2012. Should it be:
    - *Critical Peak-Pricing?* or
    - *Peak Rebate?*
- **Motivator:**
  - High capacity prices (PJM "Reliability Pricing Model")



# BG&E (2): DR Dominates PJM Capacity Market

## Demand Response revenue by market: 2002 through 2012

(From 2012 State of the Market Report, PJM, courtesy of Joe Bowring)



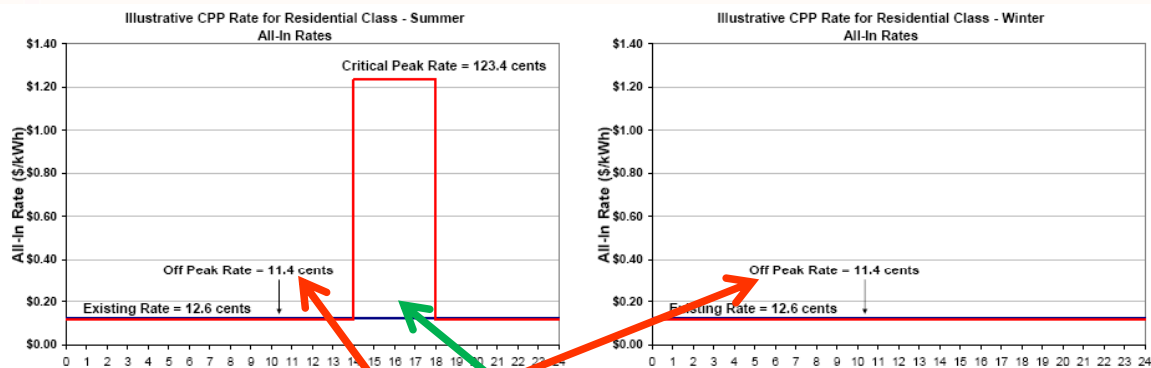
- Little new generation in PJM: *Is capacity market a failure?*
- **NO!** "Level playing field" → much cheaper DR (and gen refurbishment)
  - 14,832 MW cleared in 2015/16 capacity market



# BGE(3): Pilot comparison of two types of DR

(Source: A. Faruqi, Shaping Our Energy Future Through Dynamic Pricing, Brattle Group)

## Type 1: Critical Peak Pricing (CPP)



- Customers get a discount on all hours except a few critical hours of the year
- On a few critical days, customers pay a substantially higher price equal to the cost of capacity plus the average critical peak locational marginal price

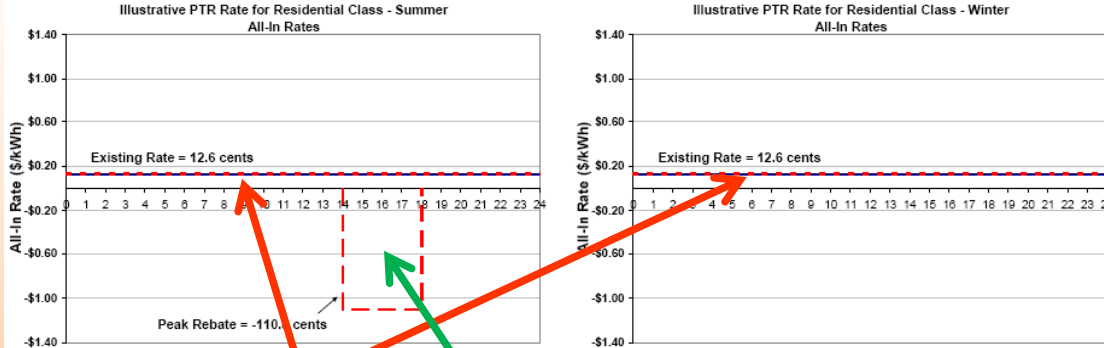


# BGE(4): Pilot Comparison

(Source: A. Faruqui, Shaping Our Energy Future Through Dynamic Pricing, Brattle Group)

## Type 2: Peak-Time Rebate (PTR) provides incentive to reduce peak, but leaves the flat rate unchanged

### Baltimore Gas & Electric's Choice



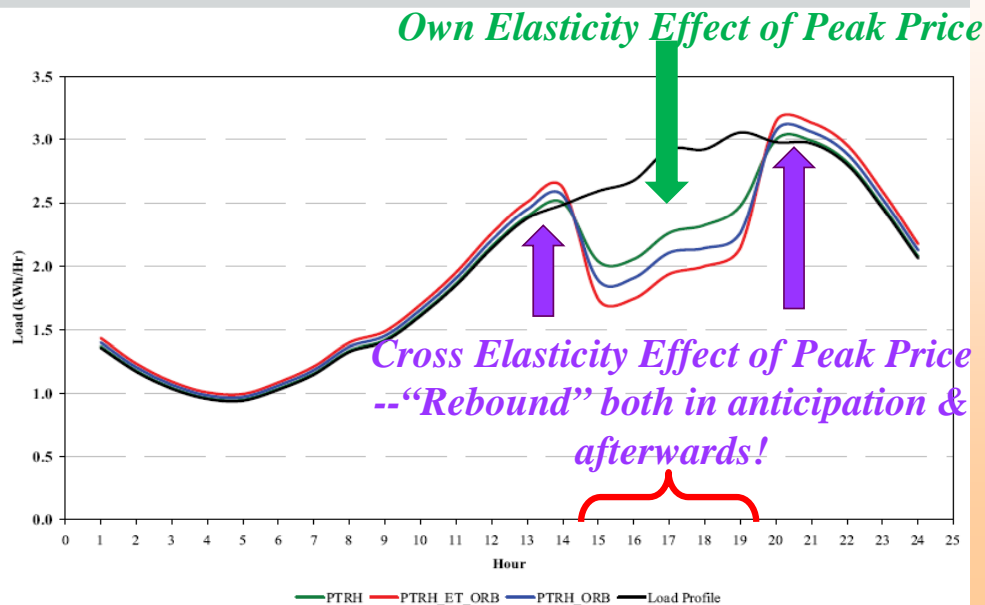
- Customers pay the default rate for all kWh used; if they make no changes in their usage they continue to pay the default rate with no extra costs (“carrot only” approach)
- On critical days customers can earn a rebate reductions in usage below an estimate of what they otherwise would have consumed (their “baseline” calculation)



# BGE(5): Impacts of PTR Program

Source: C. Hinds, BGE, Introducing the Smart Grid, Nov. 5, 2009, before the California Public Utilities Commission

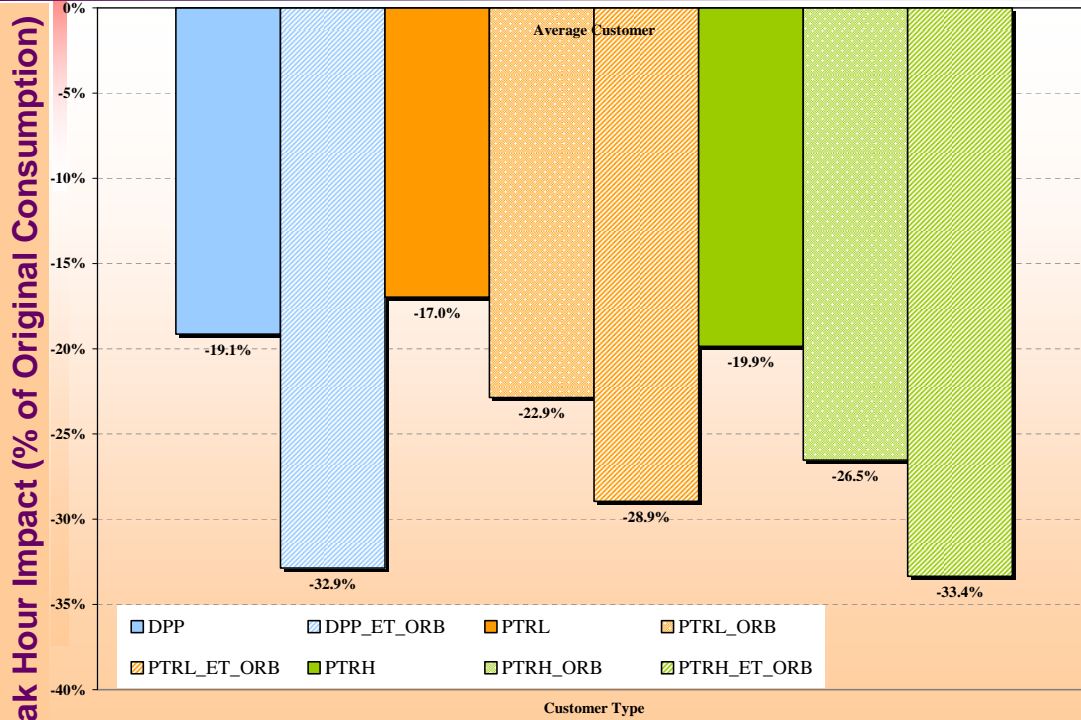
## Summer 2008 Pilot Actual Load Shapes for Participants and Control Group on July 17, 2008 Critical Peak Event







# BGE (6) 2008 DR Impact Summary



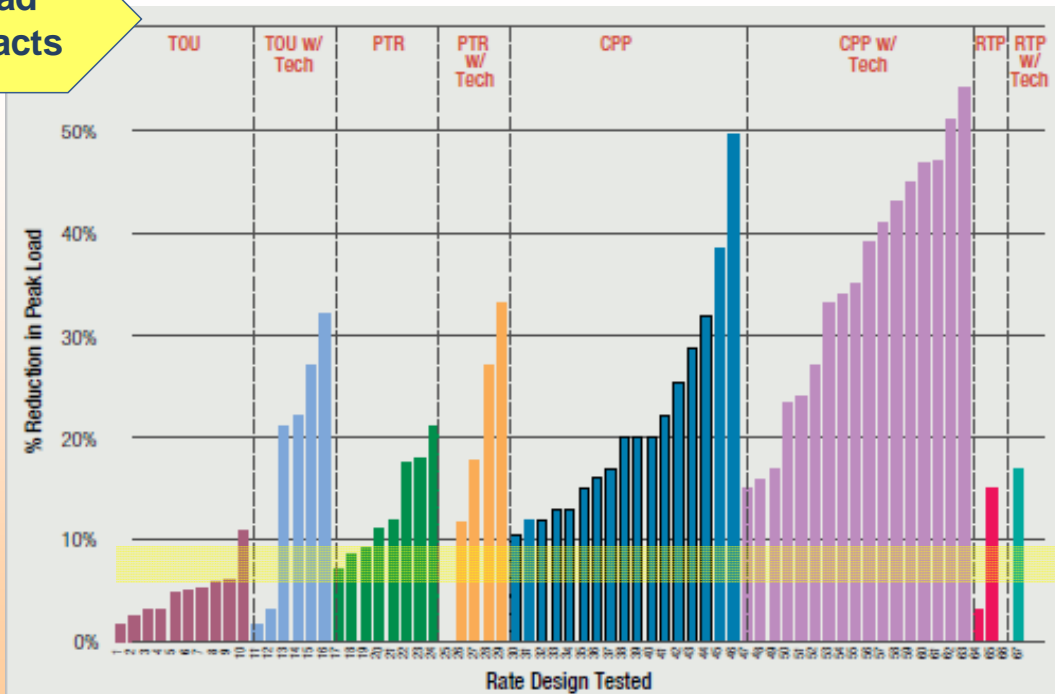
**Plus: 97-99% of Pilot Participants Want to Re-enroll!**

Courtesy of Cheryl Hindes, BGE 13



# National Peak Pricing Pilot Summary

Load Impacts

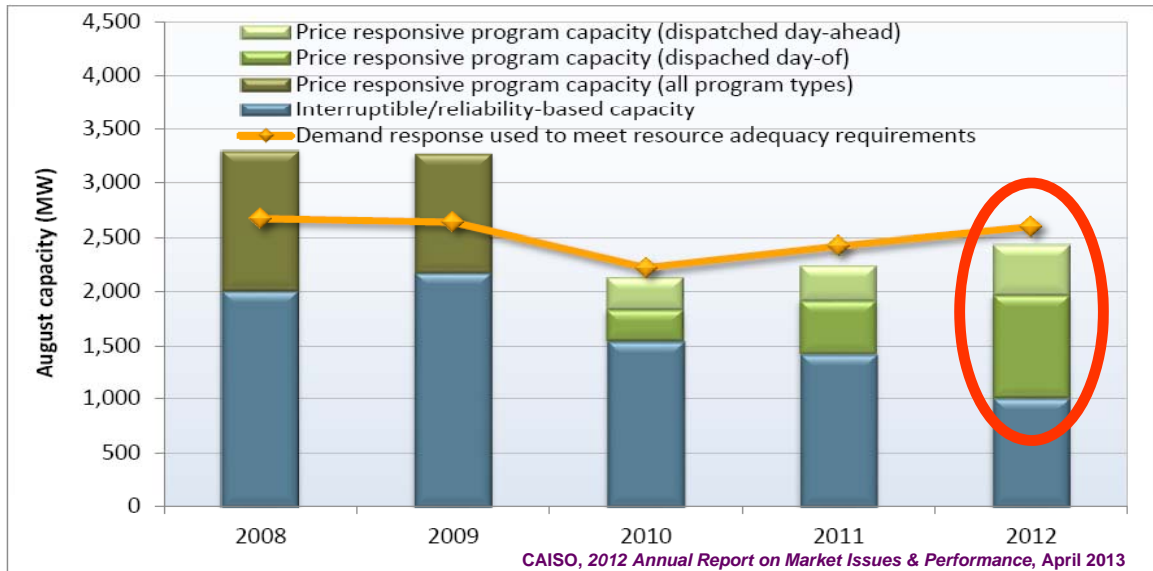


\* "Rethinking Prices", Ahmad Faruqi, Ryan Hledik, Sanem Sergici, *Public Utilities Fortnightly*, January 2010, p. 35 [http://www.fortnightly.com/uploads/01012010\\_RethinkingPrices.pdf](http://www.fortnightly.com/uploads/01012010_RethinkingPrices.pdf).



# Improving DR 1.0; Moving towards 2.0

## California ISO: Utility operated demand response programs (2008-2012)



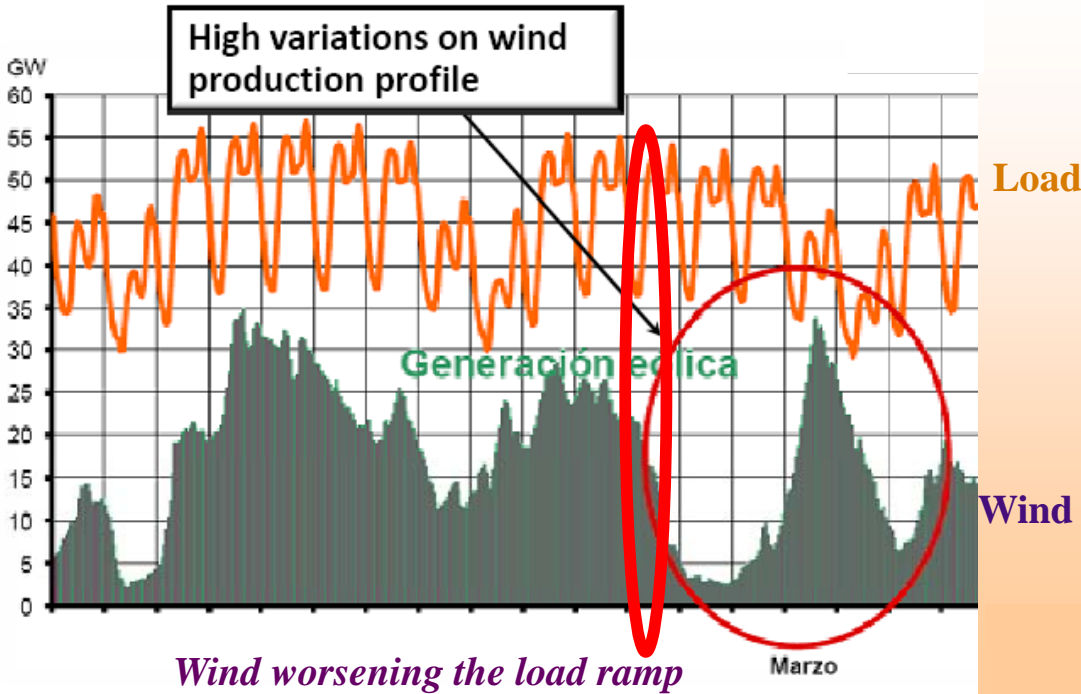
- Moving from:
  - day-ahead (1.0) to real-time (2.0)
- Low growth (state paid for meters, then prohibited having DR as default for residential consumers!)



## 4. DR 2.0: To Manage Variability

### 2020 Spanish Wind Profile Relative to Load

(de la Torre & Paradas, 2010)



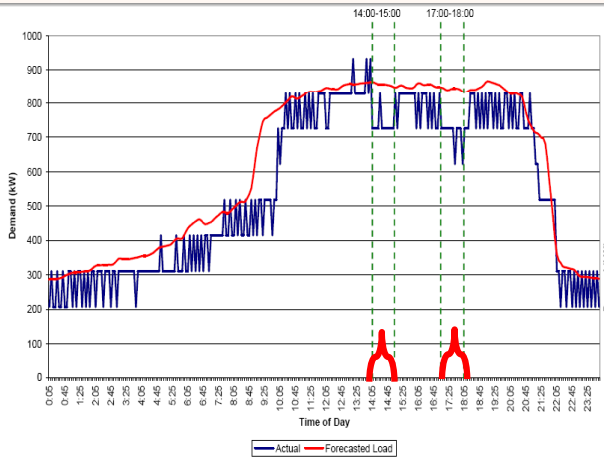




# DR 1.0: For Ancillary Services

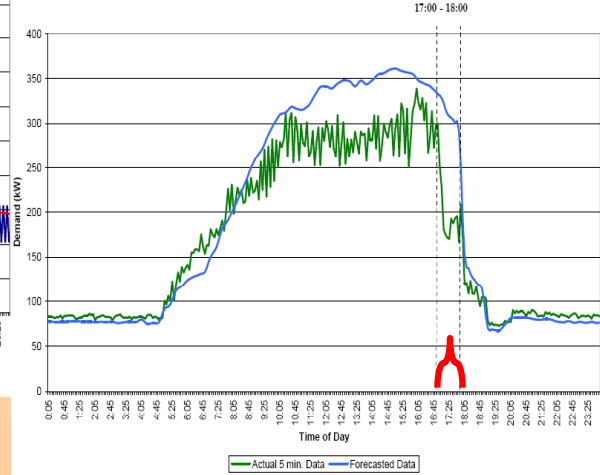
## Can DR respond fast & reliably enough to provide "ramp" and spinning reserve?

### California Pilot Projects say "Yes"!



Measured & forecast loads for Retail Store on 10/19/2009

Measured & forecast loads for Local Government Office on 8/26/2009



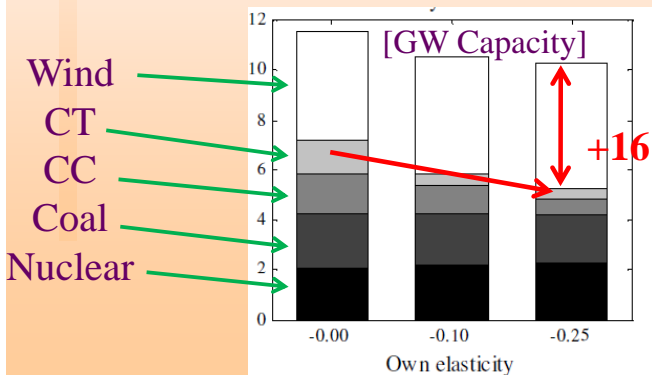
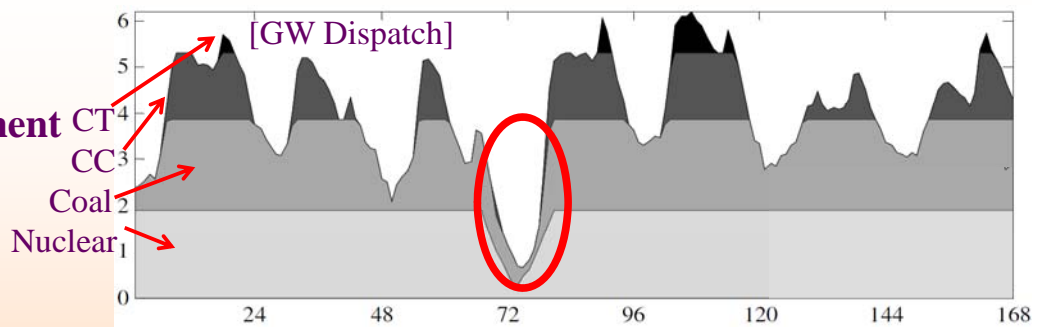
Air Conditioner Load Controller (CAISO Participating Load Pilot Project Report, Southern California Edison, 2010)



# DR for Ramp & Peaks → Better Long-run Wind Economics

C. deJonghe, B. Hobbs, & R. Bellman, IEEE Transactions on Power Systems, May 2012

Example Dispatch & Investment Mix



Effect of DR (price elasticity) on optimal gen mix

- Less cycling capacity
- More wind

Net economic benefits of DR: +1%/3% , as % of supply cost (for price elasticity = -0.1/ -0.25)



## 5. Conclusion:

### Why DR is Still More Dream than Reality



- Focus on a few peak hours, rather than entire load shape
- Public opposition to Smart Meters:
  - *Privacy, electromagnetic field concerns*
  - *Fears of rate increases → retain “average cost rates” to “protect” consumers*
  - *Luckily, “Opt-out” programs have few takers*
- Most state commissions indifferent or hostile
- Utility (retail) DR often poorly integrated with ISO operations
  - *Poor forecasts at wrong times*
  - *Not economically dispatched against gen*
- Inadequate quantification of effects & benefits