

The Brattle Group

Energy Efficiency and Utility Demand-Side Management Programs

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The World Bank
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The Pre-DSM era (through the 1960s)

- Utilities built capacity to meet demand, relying on forecasts which were often made with a ruler and double-log paper
- Classic load management programs were used to preserve system reliability
 - These included direct load control of certain residential appliances such as water heaters and air conditioners and interruptible and curtailable rates for commercial and industrial customers

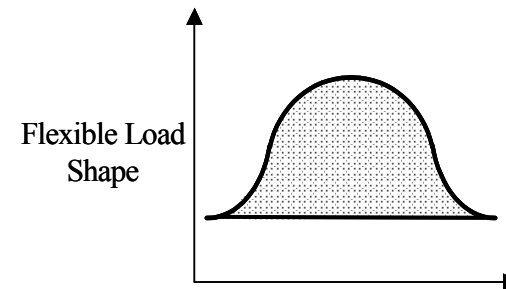
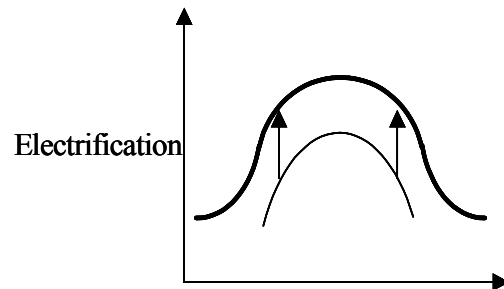
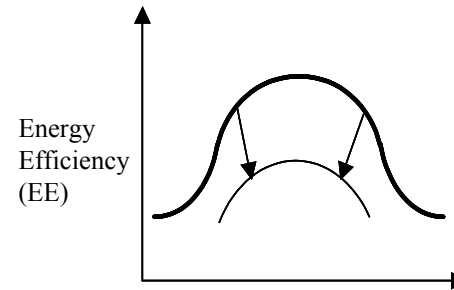
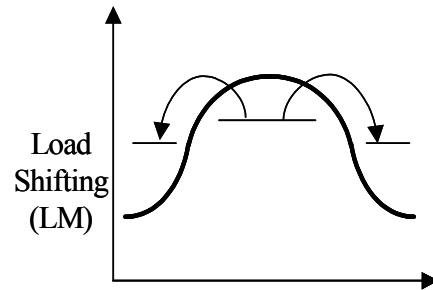
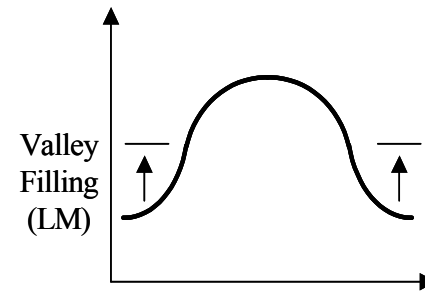
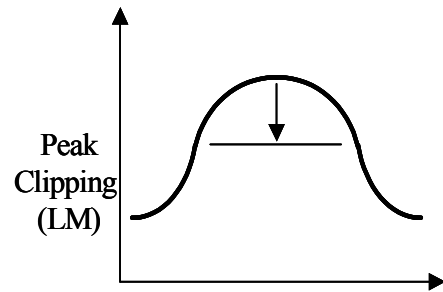
Then came the oil shocks of the 1970s

- Conservation programs were created in a hurry to minimize the use of imported oil
- They included informational messages, public appeals, energy audits, and home weatherization programs for residential customers and fuel switching programs for larger customers

“DSM” was born in 1983

- At a conference room in the O’Hare Hilton, Chicago, during an emergency meeting of senior managers from EEI and EPRI
- It was designed to encompass a variety of customer-side activities including energy efficiency and load management but also including beneficial electrification

“Six days to Sunday”



The first-generation programs (Mid-1980s to Mid-1990s)

- These programs emphasized cash rebates and low-interest financing to encourage customers to buy more efficient appliances and build more efficient buildings and industrial plants
- They were designed to change the demand-side of the electricity market in order to (a) better balance demand and supply, especially during critical times of the year, and (b) lower the customer's energy costs
- California developed a standard practice methodology for assessing the cost-effectiveness of DSM
- This approach was adopted rapidly in the developing world

Disenchantment with the “first-generation” programs

- These programs proved to be very cumbersome and not sustainable over the long haul
- They created cross-subsidies between participants and non-participants and required rate increases for all customers
- Utility shareholders were often left holding the bag as revenues and earnings fell
- Both in the developed and developing world, DSM began to fall by the wayside as the industry restructured into generation, transmission and distribution companies
- Programs were redesigned to focus on less costly market transformation activities involving incentives and education for equipment manufacturers and builders and the enactment of government codes and standards

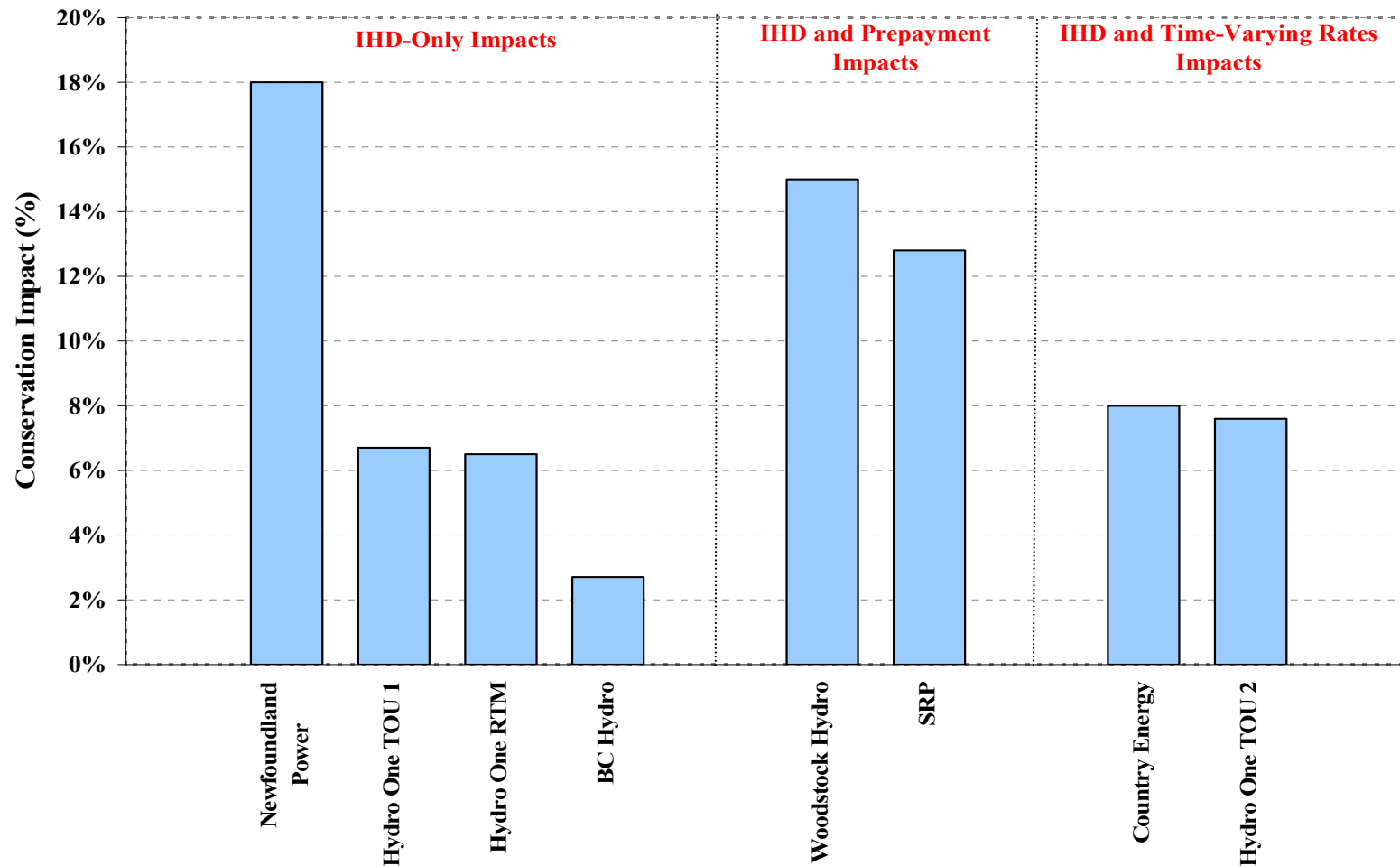
The “second-generation” programs

- The power crisis in the Western U.S. in 2000/01 spurred great interest in introducing “demand response” into electricity markets, to prevent wholesale prices from rising exponentially and ruining the financial solvency of electric utilities
- Even a small amount of demand response would have helped contain the energy crisis in California
 - If real-time pricing had been offered to large commercial and industrial customers, peak demand would have fallen by 2.5 percent, resulting in a drop of 18 percent in wholesale market prices
- The crisis spawned the “second-generation” of DSM programs, which emphasized reductions in customer loads during critical times of low reliability or rising wholesale prices
- This crop of programs included (a) programs that involved cash payments to customers for demand and energy reductions during critical time periods (load curtailment) and (b) programs that involved variations in the price of electricity during critical time periods (dynamic pricing)

In the “third-generation,” now underway, the foundations of DSM rest on five pillars

- One -- Customer awareness, interest and engagement
- Two -- Technological innovation
- Three -- Codes and standards for appliances, buildings and machines
- Four -- Energy price innovation
- Five -- Financial incentives

One: In-home displays can promote energy efficiency



Results derived from pilot programs carried out in North America

Other informational options

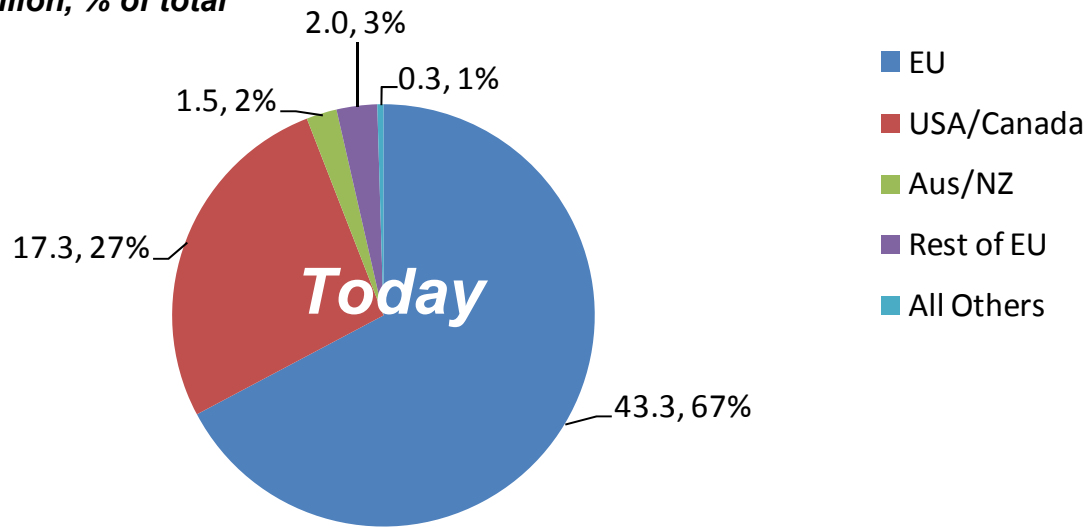
- Web-portals which require advanced metering infrastructure
- Social norming (Opower-type bill comparisons)
- Modlets

Two -- New technologies continue to be developed

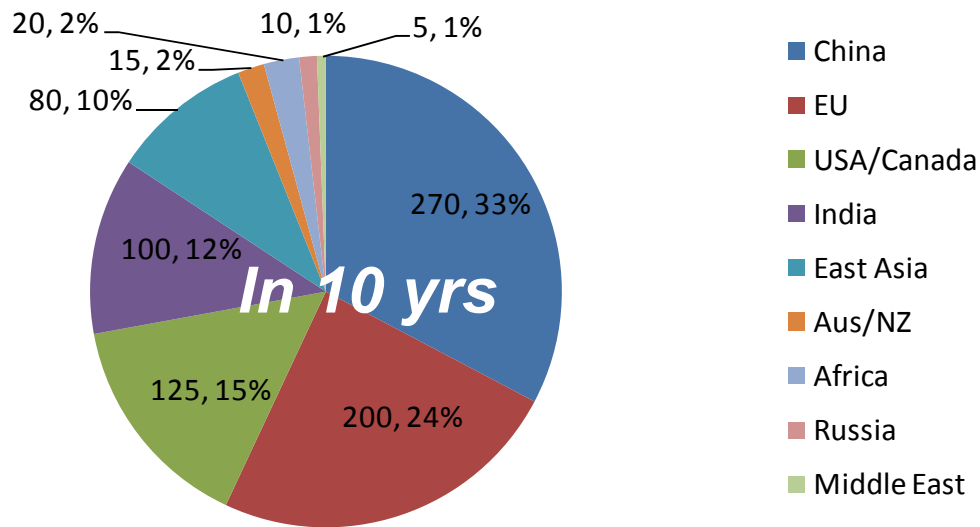
- SEER levels have reached 24 for central air conditioners
- Lennox is marketing a unit that comes with a PV-array
- CFLs are replacing incandescent and LEDs are beginning to emerge as commercially viable products in selected applications

Smart Meters are being deployed worldwide at a rapid clip (source – eMeter)

Million, % of total

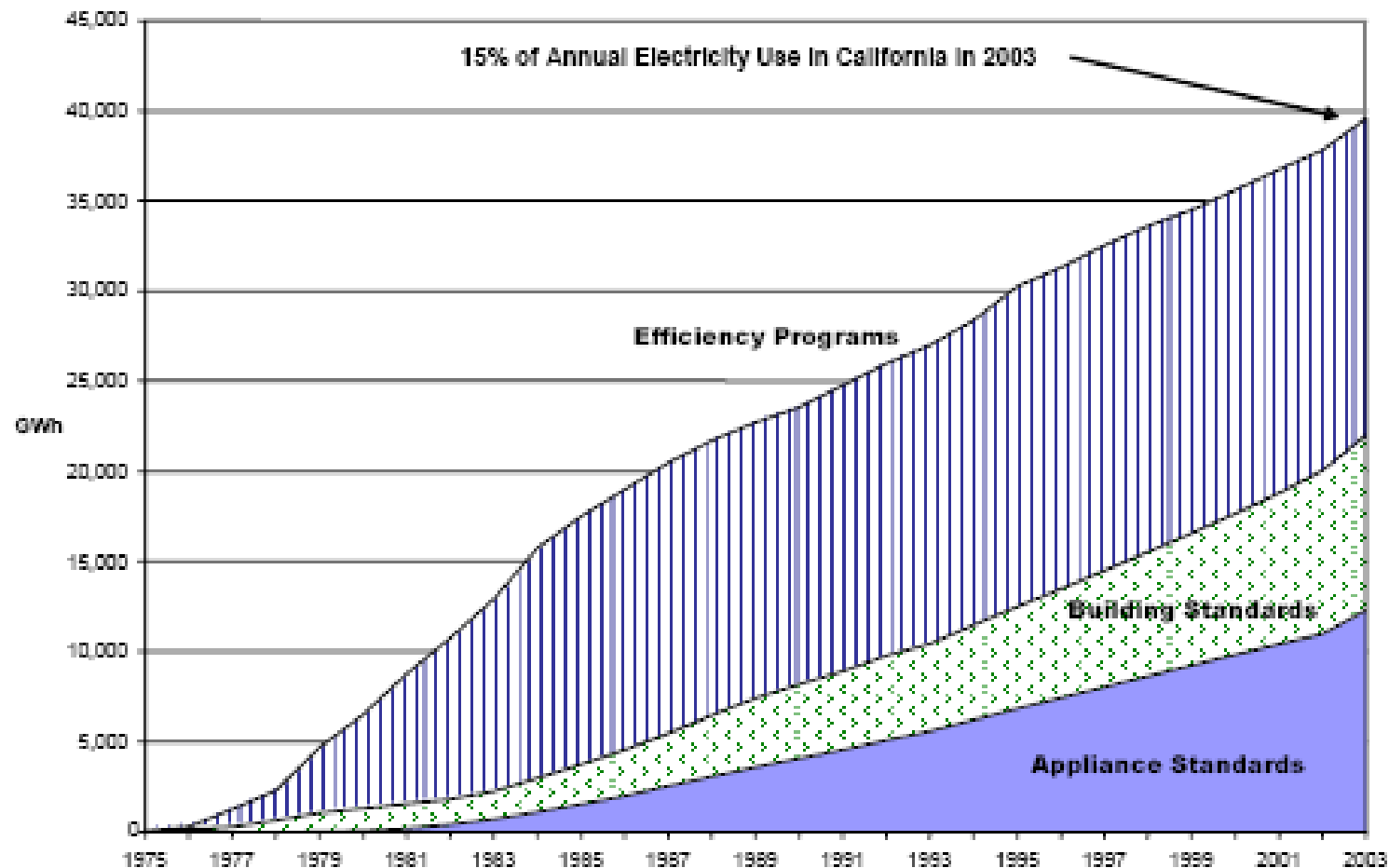


Over 64 million Smart Meters now in Place Worldwide



Over 825 million Smart Meters expected Worldwide in 10 years

Three -- Efficiency standards can play a major role, as in California



Four -- Pricing innovation

- Rate level
 - Energy price subsidies are beginning to be phased out
- Rate design
 - Inclining block rates are being deployed
 - Dynamic pricing rates are being considered for deployment wherever Smart Meters are present

Rate level innovation

- For political reasons, energy prices are subsidized in most developing countries (and for low income customers in some developed countries)
- Subsidized energy prices make it very difficult to get customers to participate in DSM programs
- If price subsidies could be transitioned to income subsidies, progress will take place

The Iranians seem to be doing this well

- Accepting the need to compensate consumers for raising prices closer to world levels, the Iranian government first proposed a monthly cash transfer aimed at poor families
- When defining the poor proved tricky, this was dropped in favor of blanket transfers to any family that applied for them (about 90% of the families did so)
- The government has set up a fund to administer receipts from the higher-priced goods, demarcating 50% to go towards families, 30% to help businesses affected by price rises and 20% to meet the state's own added costs
- The government doled out two months' worth of family cash transfers, amounting to some \$90 per person, before ending the price subsidy
- When the first tranche of price rises hit, quadrupling the cost of some kinds of bread and shooting diesel prices up by 2,000%, there was no hue and cry among the public

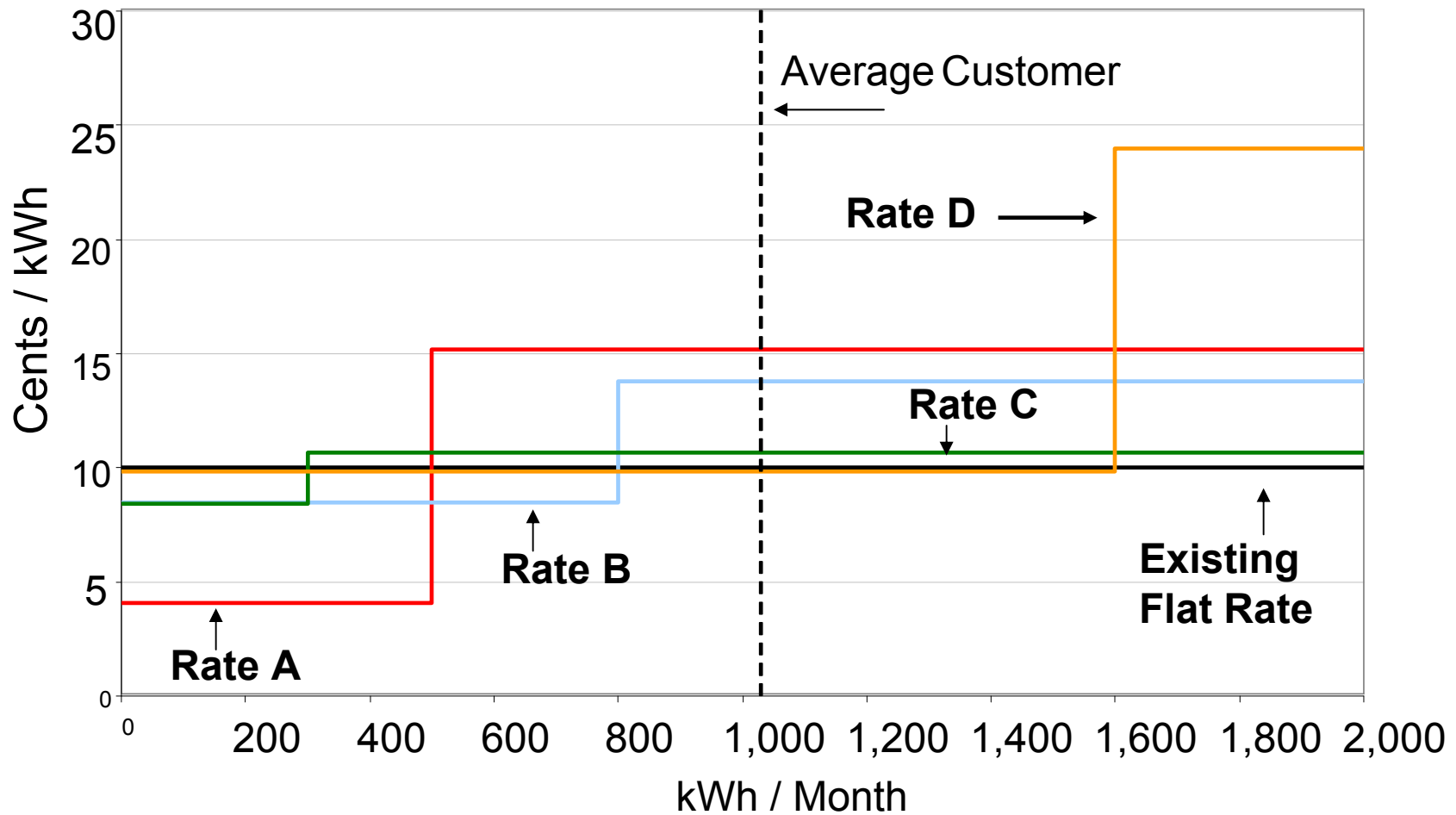
Exiting price subsidies (concluded)

- Iranians have rapidly got used both to paying a lot more for some things and to having more money to spend as they wish
- A family of five now pockets monthly sums close to Iran's minimum wage, enough to pull a big proportion of the 10% of Iranians who live on less than \$2 a day above that bar
- <http://www.economist.com/node/18867440>

There are several reasons for promoting energy efficiency through inclining block rates

- It is a low-cost option
 - Does not require Smart Meters or incentive/rebate payments
- It improves the economics of other efficiency technologies
 - Increased intrinsic value of in-home information displays
 - Faster payback on rooftop solar installations
- It is customer-friendly and can be universally deployed
 - Simplicity is key in generating customer response

Four types of IBRs are shown below



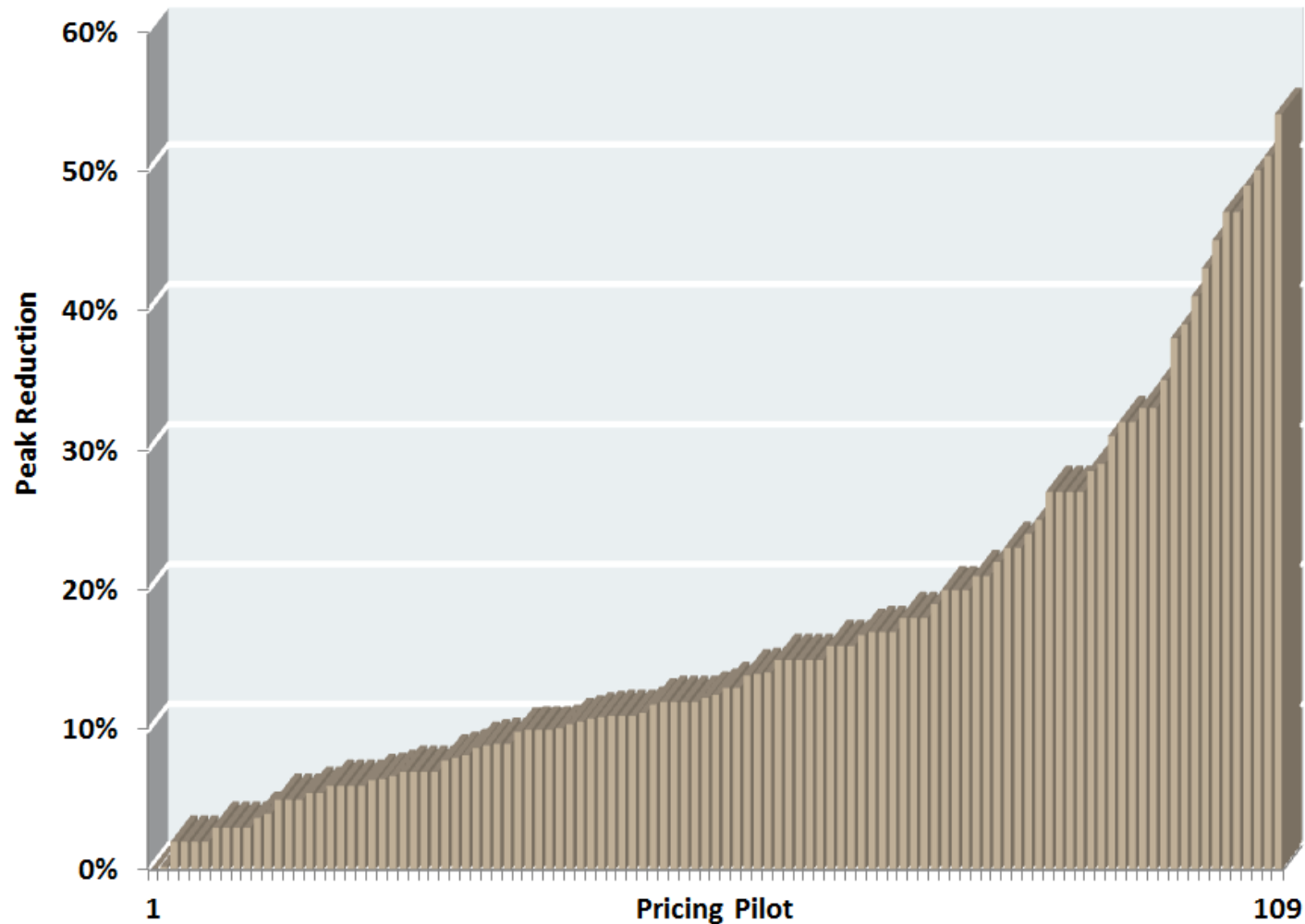
The impact will vary by rate design and methodology

Price Elasticity	Approach	Overall Change in Class Usage (%)			
		Rate A	Rate B	Rate C	Rate D
Short run	AP	-0.3%	-0.3%	0.0%	-0.2%
	TBMP	-3.6%	-1.4%	-0.6%	-0.3%
	MP	-12.8%	-8.0%	-1.6%	-4.3%

Price Elasticity	Approach	Overall Change in Class Revenue (%)			
		Rate A	Rate B	Rate C	Rate D
Short run	AP	-0.5%	-0.5%	0.0%	-0.9%
	TBMP	-5.6%	-2.0%	-0.6%	-0.9%
	MP	-19.6%	-11.1%	-1.7%	-6.2%

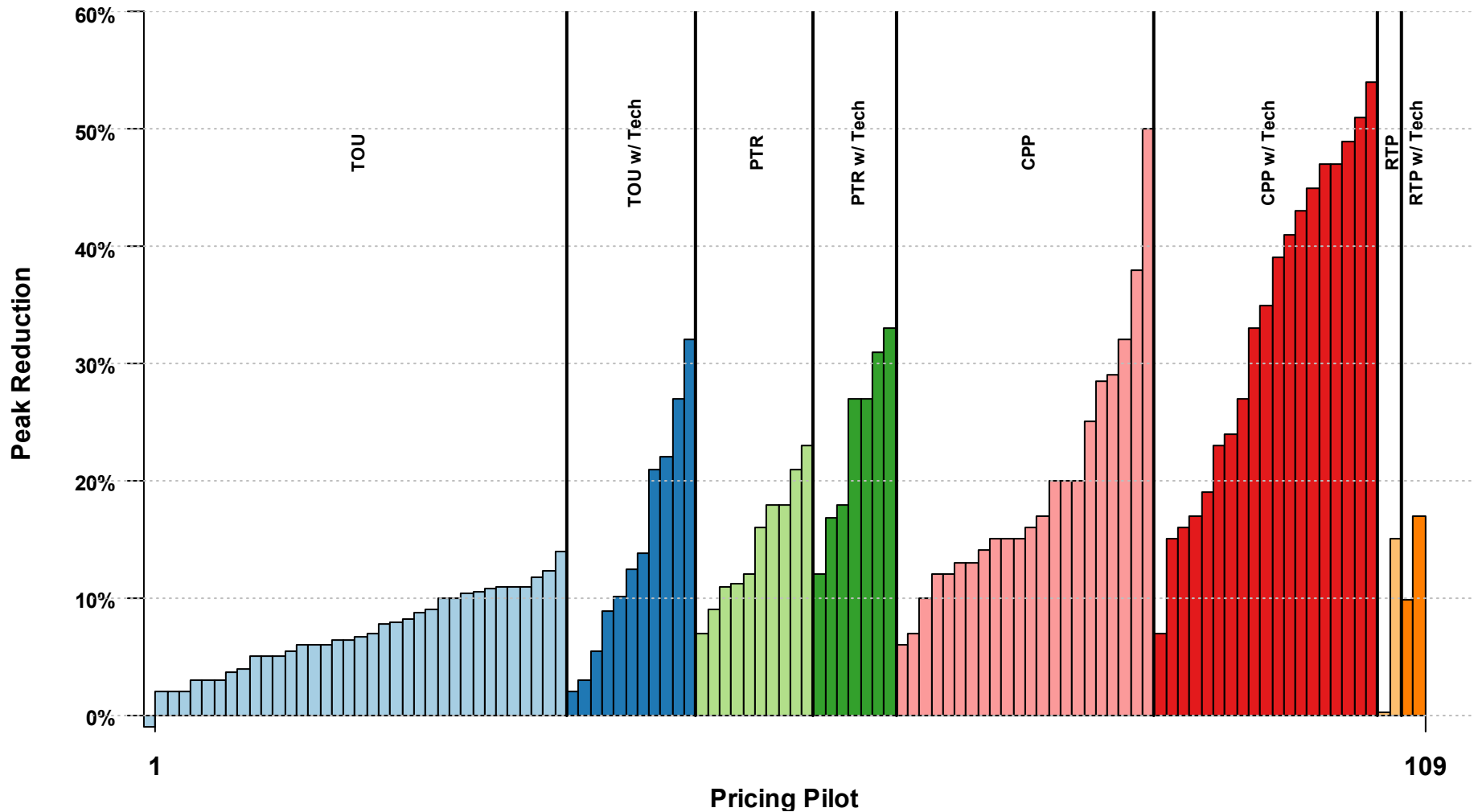
Dynamic pricing has been tested in three continents

Impacts from Residential Pricing Pilots



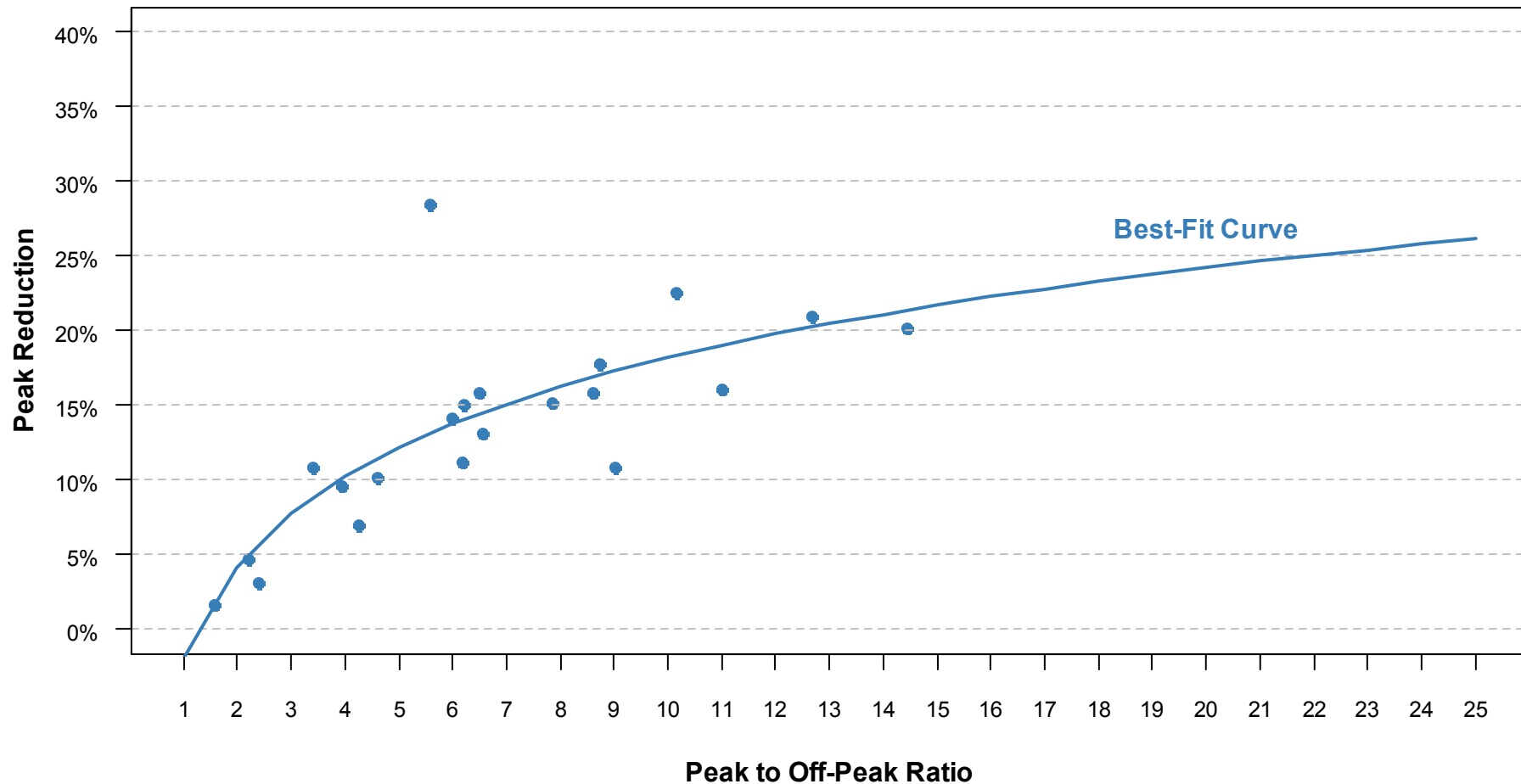
Dynamic pricing comes in many flavors

Peak Reductions by Rate and Technology



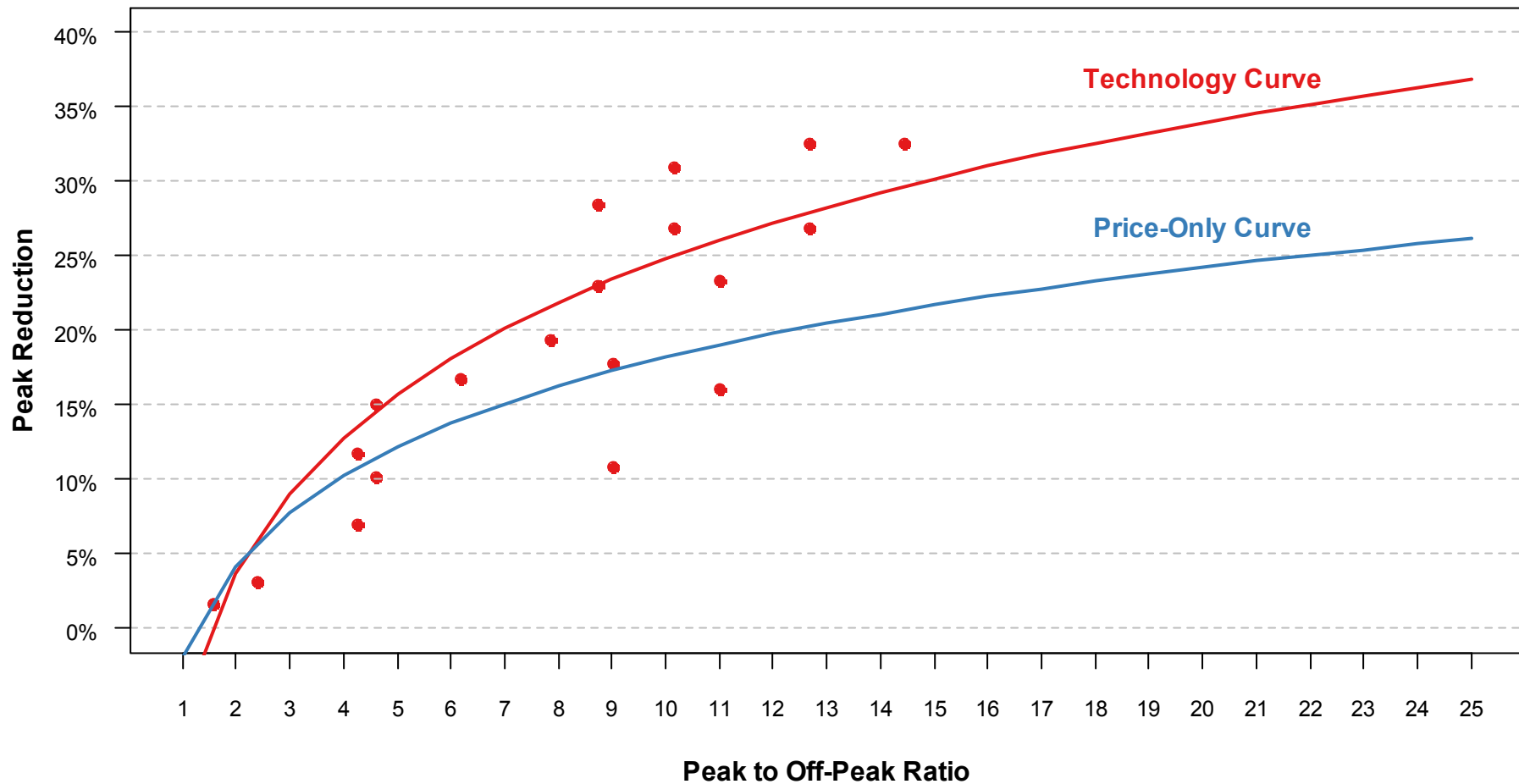
Demand response rises with price

Pilot Results by Peak to Off-Peak Ratio
Price-Only Results



Technology boosts price responsiveness

**Pilot Results by Peak to Off-Peak Ratio
Results with Enabling Technology**



Five -- Financial incentives play a dominant role in the United States

- In 2009, U.S. electric utilities budgeted over \$3.4 billion for energy efficiency (EE) programs (and an additional \$1.1 billion for load management and demand response programs)
- Average calculated cost/kWh saved in 2008 was 3.98 cents/kWh (4.05 cents/kWh in 2009)
- Capacity market payments and other market-based revenues contributed to the overall cost of the incentive programs but the largest funding source comes from ratepayers through either utilities or other centrally-administered programs

Other financing mechanisms

- White Tags
- Property Assessed Clean Energy (PACE)
- On-Bill Financing (OBF)
- Energy Efficiency Performance Contracting (EEPC) and Energy Service Companies (ESCOs)
- Utility ownership of customer-sited energy efficiency equipment
- Third-party energy efficiency entities (EEU)

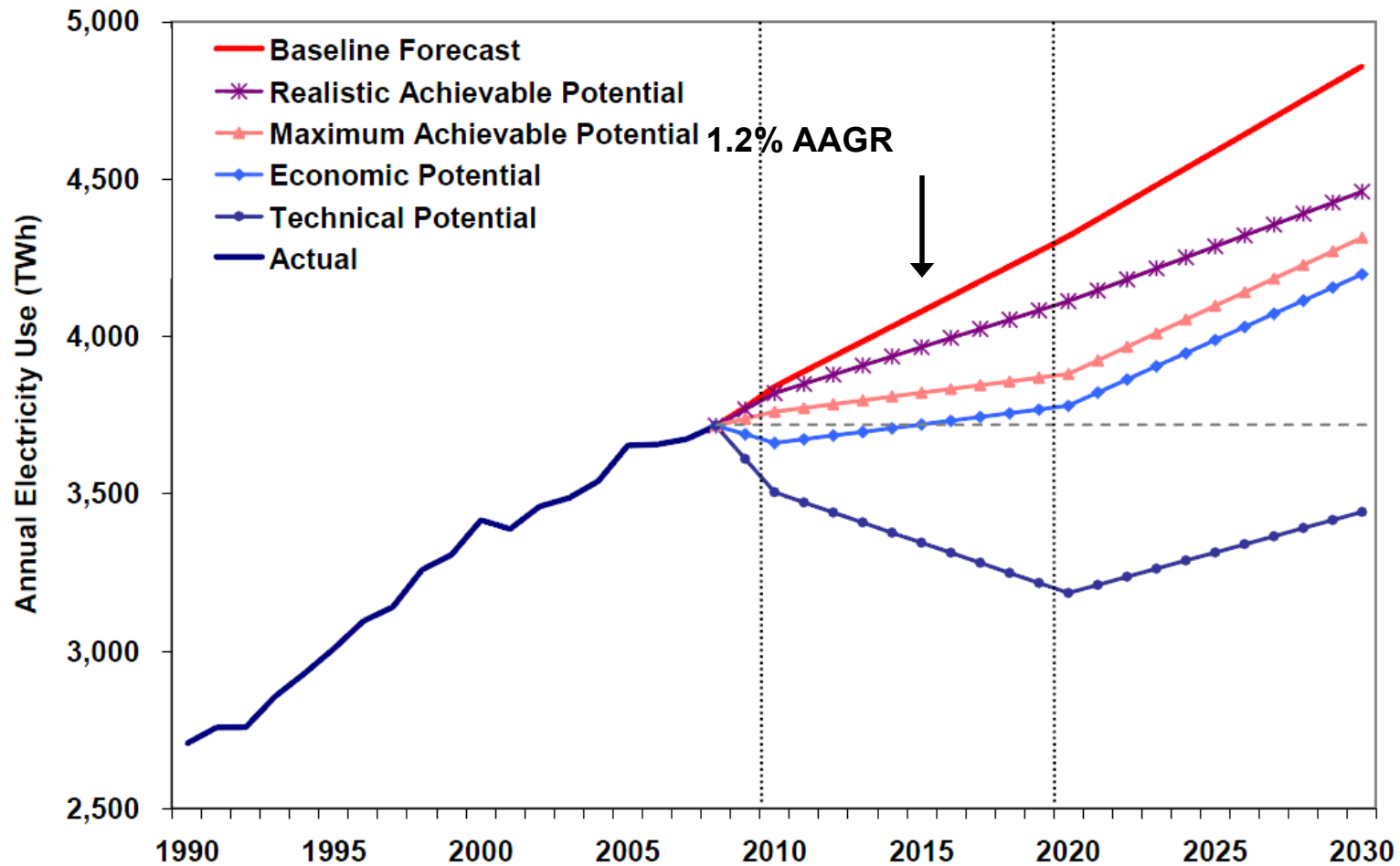
Summary assessment of other mechanisms

- There is little workable market experience with White Tags
 - They only work if the market size is large and there is price transparency
 - White tags don't address some of the barriers to EE deployment
- ESCOs have not lived up to their expectations
 - Have probably managed to pickup low hanging fruit in the public sector and with large C&I customers
 - Have not managed to support deeper, longer or more diffuse markets
- EEU
 - There seem to have been some initial success with EEUs
 - So far, focus on industrial and lighting, so too early to tell the ability to provide deep retrofits at residential level
 - Better at overcoming information hurdles and other transaction costs but do not directly address first cost barrier

Summary assessment (concluded)

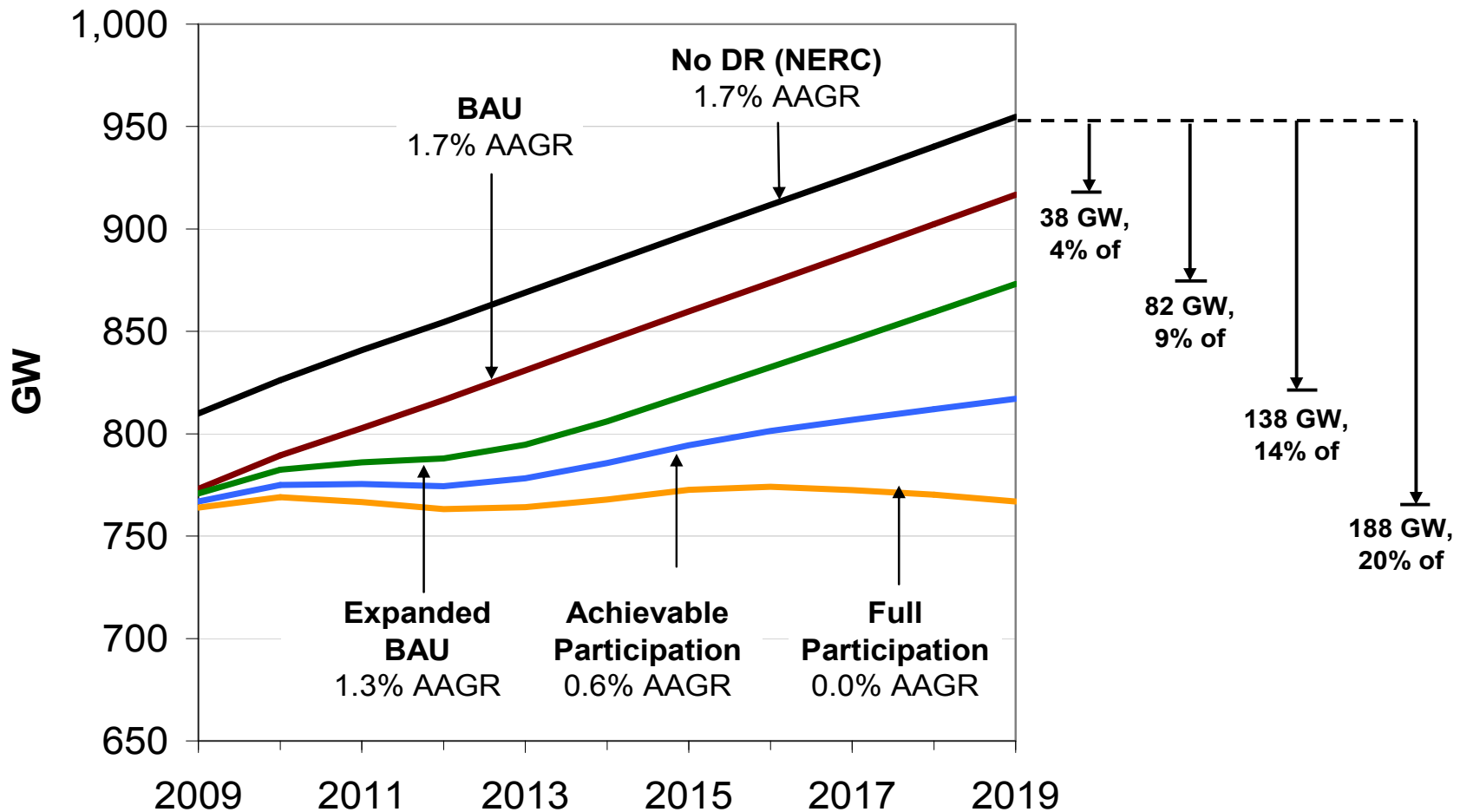
- PACE, OBF, Utility ownership are early experiments
 - Partially overcome important first cost hurdle
 - They do so at an interest rate that, given current laws regarding tax deductibility of home mortgage interest, are not typically advantageous
 - General reluctance to engage in deep retrofit measures with long lives
 - So far everything has been at a very small scale

Despite past gains, EPRI predicts a large potential for cost-effective energy efficiency



Source: EPRI Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.

The FERC predicts that demand response can reduce peak demand by up to 20% in 2019

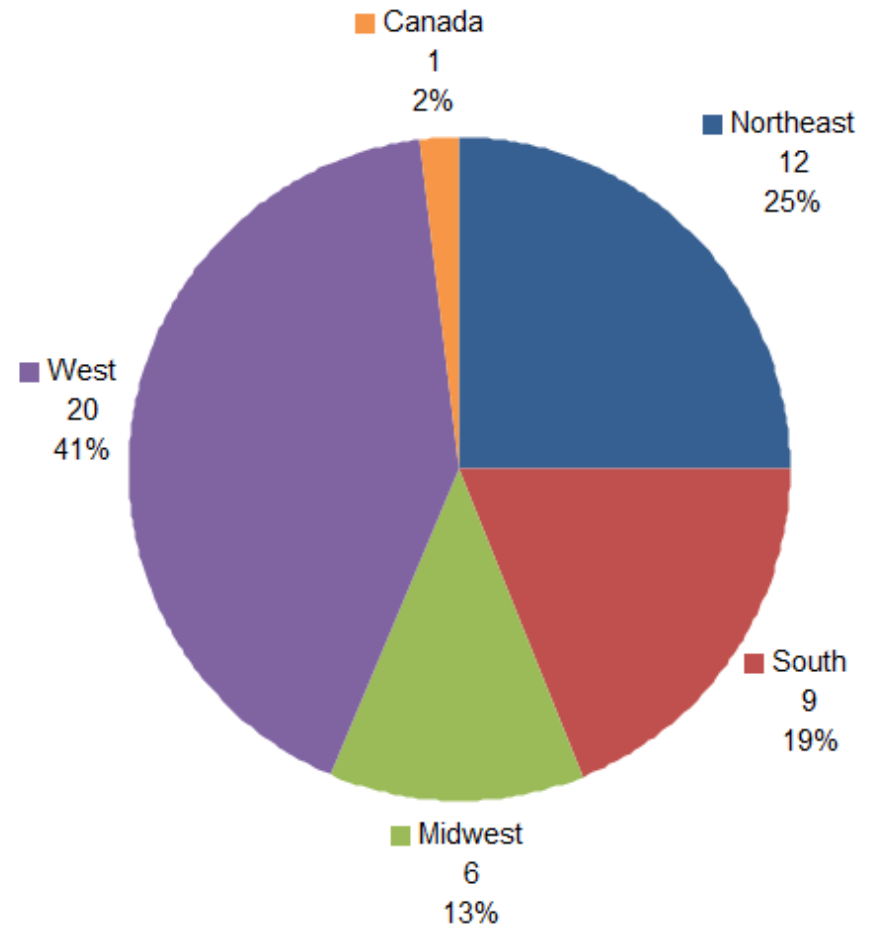


Source: FERC National Assessment of Demand Response Potential

Brattle has conducted an expert survey to gauge the potential of DSM

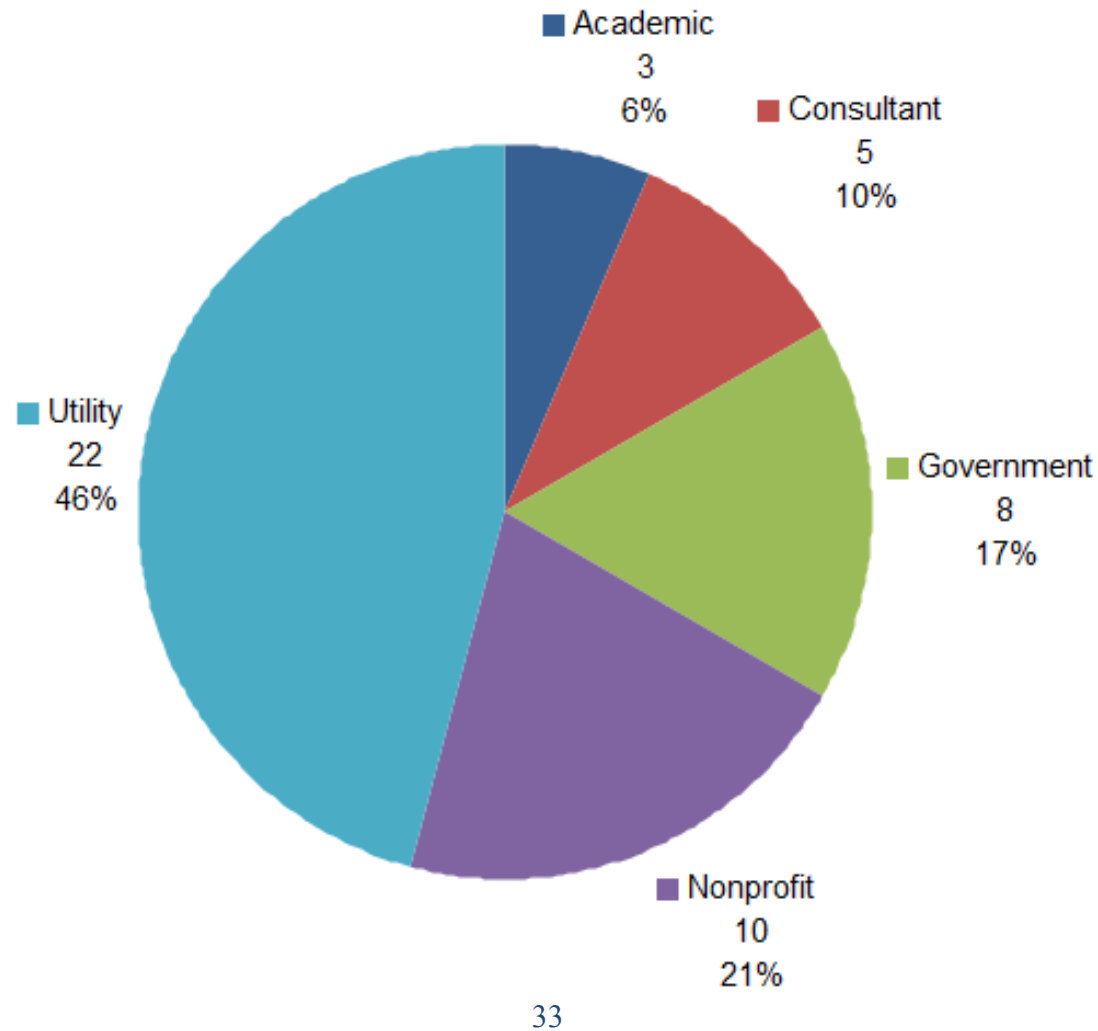
- The survey was mailed to 198 energy experts
- 50 experts responded (25% response rate)

Location of Survey Respondents



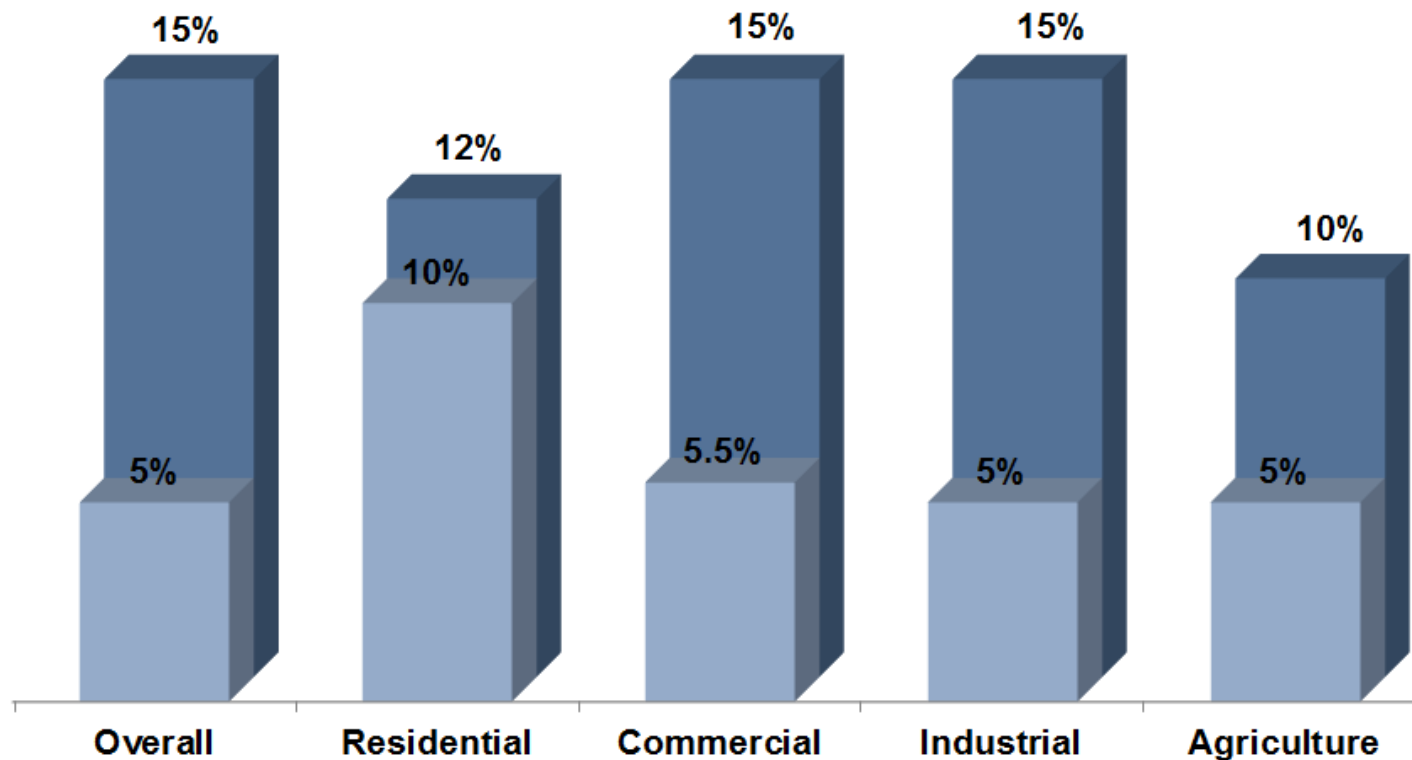
The responders spanned a range of affiliations

Profession of Survey



Electric energy efficiency savings range from 5% to 15%, with the highest savings in the Commercial and Industrial sectors

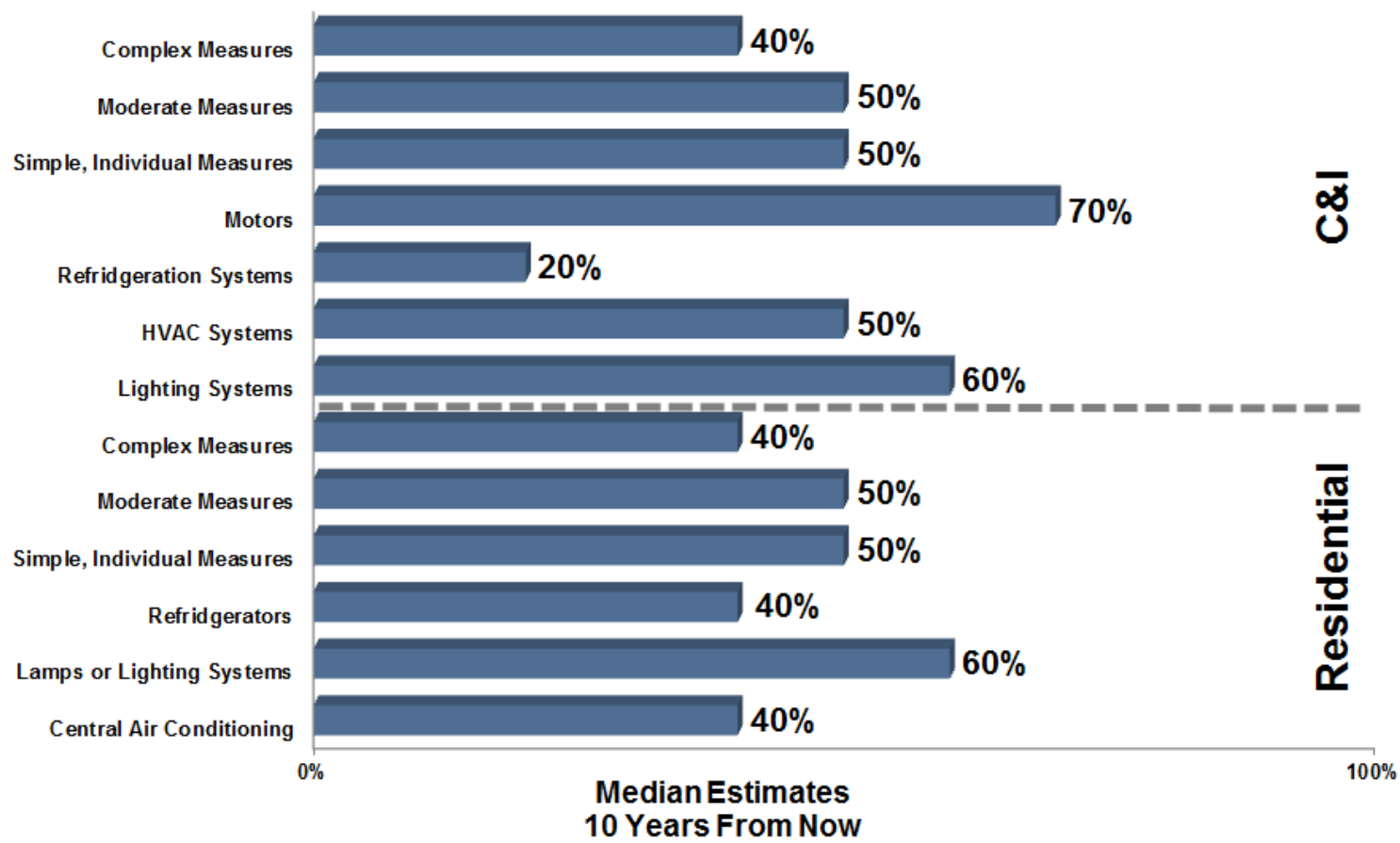
Electric Energy Efficiency Savings Forecast



Median Low and High Estimates
10 Years From Now

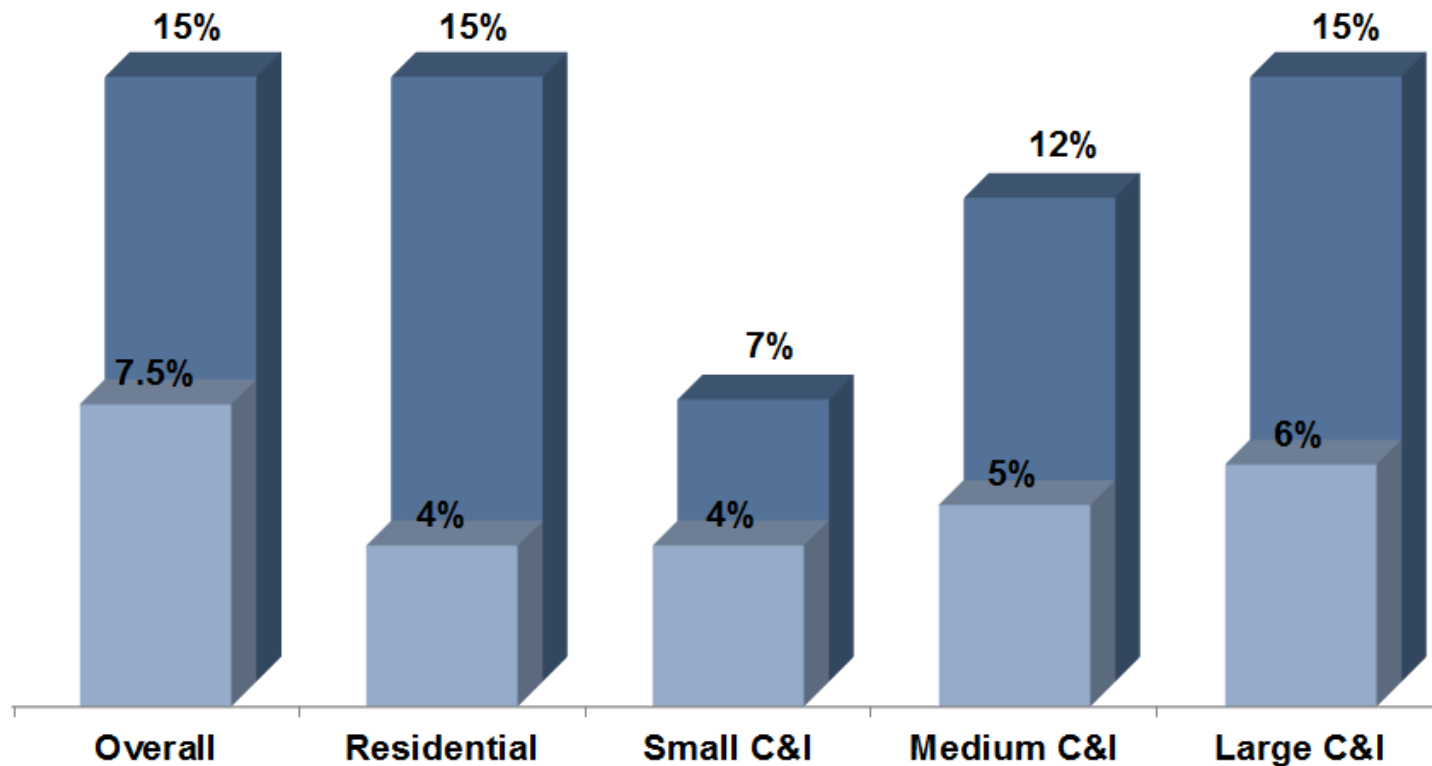
The options with the highest level of customer engagement are C&I motor replacement and residential lighting

**Electric Energy Efficiency
Percent of Customers Choosing High-Efficiency Options**



The potential for demand response ranges from 7.5 to 15 percent

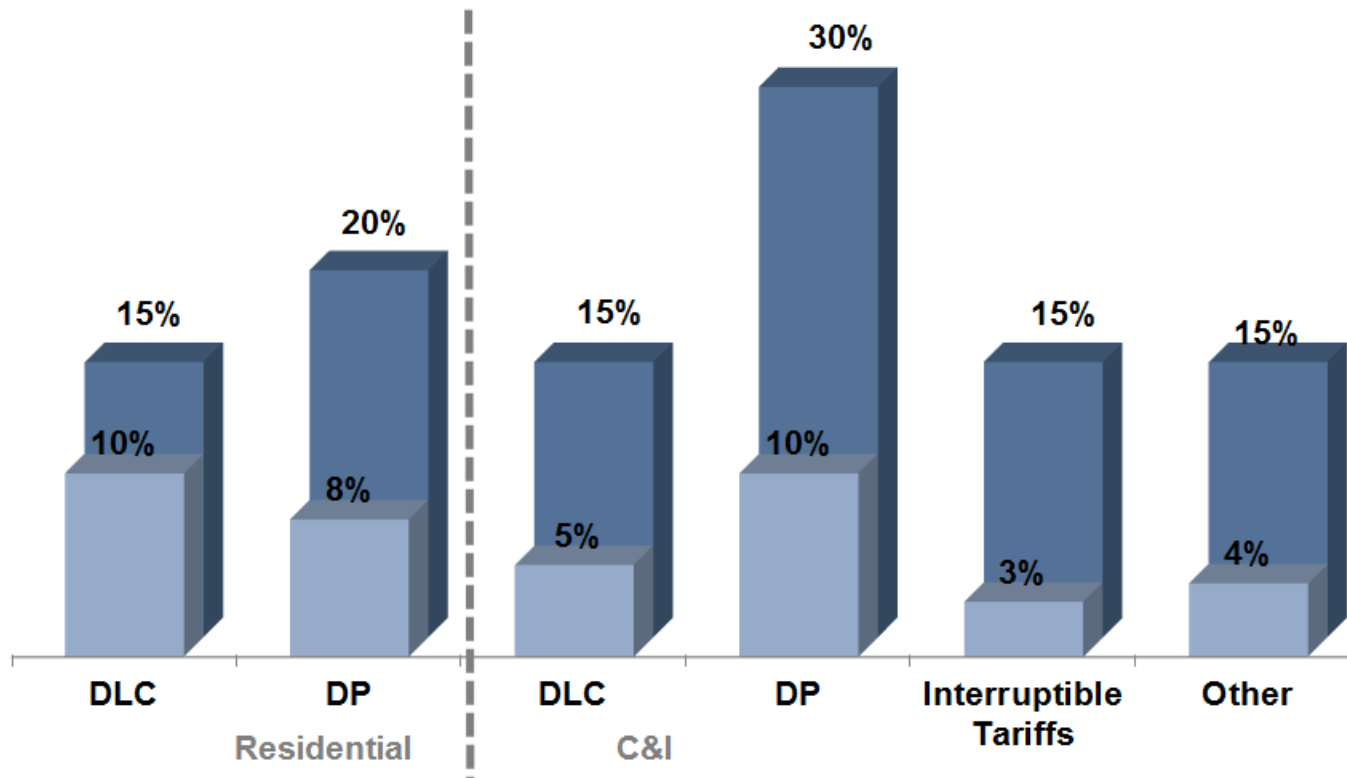
Forecasted Peak Demand Savings



Median Low and High Estimates
10 Years From Now

Dynamic pricing is expected to play a significant role in the future

Forecasted Customer Engagement in DR Programs



Median Low and High Estimates
10 Years From Now

Incentivizing the utilities to engage in DSM

- Provide rapid DSM cost recovery, which can become a major stumbling block
- Decouple sales from revenues, allowing fixed costs to be recovered
- Reward shareholders for engaging in a business that appears to be at counter-purposes with the core business

Shareholder reward mechanisms come in three flavors

- Utilities get a share of the savings created by the EE programs (CA, CO, OK, others)
- Utilities capitalize their DSM expenditures into the rate base and earn a bonus return-on-equity (NV had it but has changed)
- Utilities get a share of the avoided power plant costs (Duke, accepted constraints to gain approval)

The most popular one is shared savings

- Net benefits (measured by the TRC test) can be measured immediately after a program year is completed and installations are validated
 - Regulators choose a “share” for the utility, which is made contingent on the achievement of energy savings and peak demand reduction goals
 - The incentive can be collected in a succeeding year or spread over a longer collection period to allow for measurement and verification

The California example

- Utilities get a share of net TRC test savings
 - 9-12 percent depending on how close they come to meeting EE savings goals over 2006-08
 - If the utilities achieve 100 percent of the goals, the verified net benefits would be \$2.7 billion
 - Then \$2.4 billion of those net benefits will go to ratepayers and \$323 million to utility shareholders
- If utility portfolio performance falls below 65 percent of the savings goals, then financial penalties begin to accrue

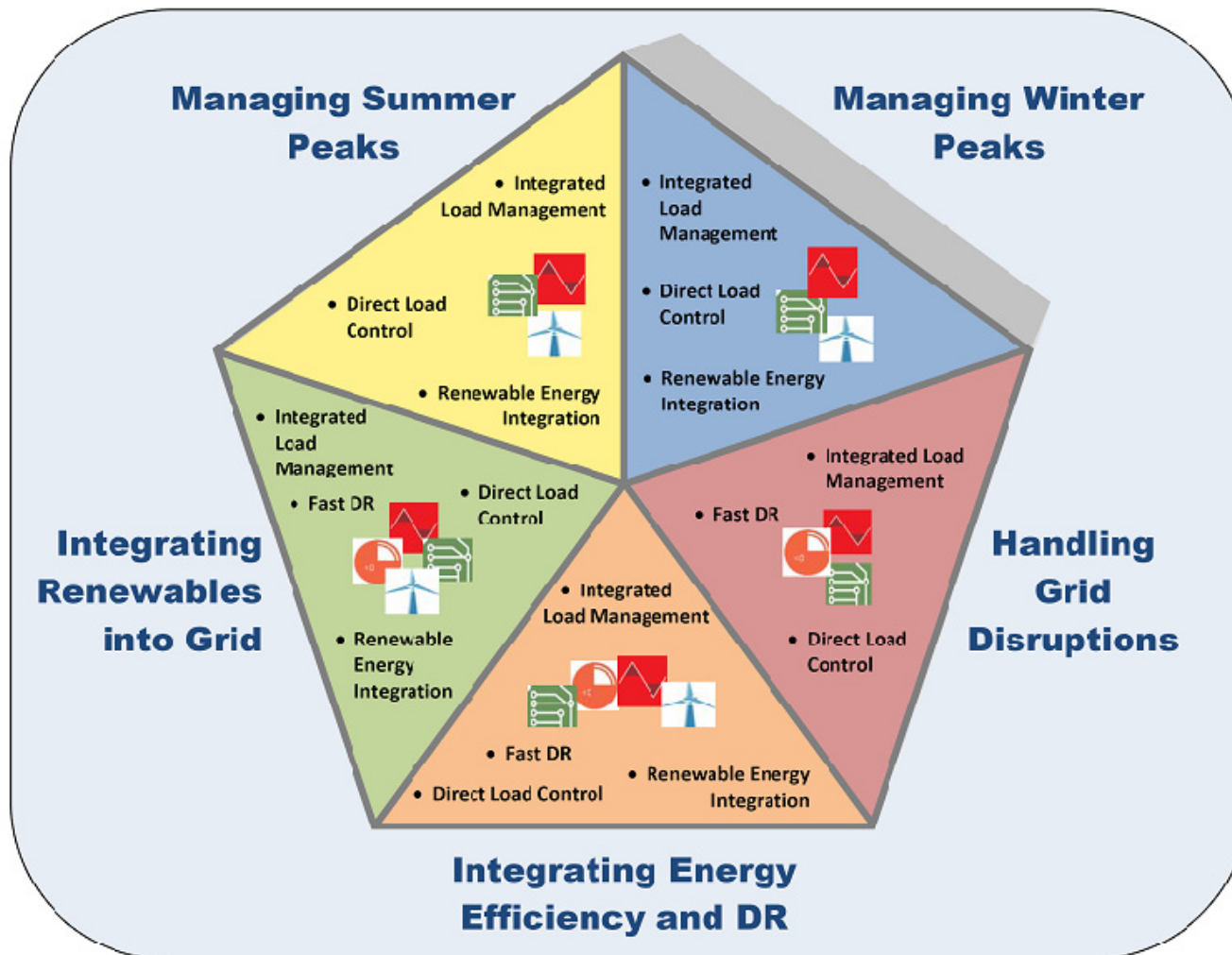
Capitalization is another model

- EE expenditures are capitalized as a regulatory asset, which earns the allowed return on equity (RoE)
- The regulatory asset is amortized just like a power plant, but over a shorter period set by the regulator
- This spreads the recovery of costs over time, but adds carrying costs
- Up to 2009, the PUC Nevada regularly approved RoE “adders” of 500 basis points on the equity portion
- However, NV has recently changed to expensing costs and allowing lost fixed revenue recovery

The “Save-a-Watt” model has evolved

- In return for doing a certain amount of EE, the utility “sells save-a-watts” at a price below the avoided costs of not building power plants, 50% - 75%
- No explicit cost recovery
- The utility proposed full control and risk of the EE programs but has accepted significant limits to gain approval
- In exchange, Save a Watt now includes lost fixed cost recovery, with a limit of three years for impacts of the EE measures

DSM is morphing into iDSM, encompassing renewables and distributed generation, as conceptualized here by the Bonneville Power Administration



International experiences

Country	Nature of demand response programs
Australia	Market reform intended to incorporate LM/DR into wholesale markets
Brazil	Temporary program to address shortages in hydro-dominated system, delays in construction of new generation
China	Recently initiated to address very rapid growth in peak demand and rolling blackouts
Italy	Leads the EU in smart metering deployment, rolling out mandatory TOU to all customers
South Korea	Little past experience with LM/DR; seeking to be a leader in the smart grid space
US (California)	Comprehensive portfolio driven by state policy that prioritizes demand-side options ahead of all other resources

The impact of demand response

Country	Predominant source of LM/DR	Known Impacts ¹
Australia	Interruptible power contracts, TOU pricing	350 MW participating in ancillary services market
Brazil	Power rationing program	20% reduction in total consumption ²
China	TOU pricing, interruptible power contracts	10,100 MW reduction (3,000 MW not from involuntary load shedding)
South Korea	Reliability-triggered DR (e.g. interruptible tariffs, DLC)	2,700 MW (4.5% of peak) ³
Italy	TOU pricing	10% of peak (expected) ⁴
U.S. (California)	Reliability-triggered DR (e.g. interruptible tariffs, DLC)	3,300 MW (6% of peak)

Notes:

(1) *These are reported impacts but may exclude impacts of some LM/DR programs*

(2) *This program was utilized in 2001-2002 but not on an ongoing basis*

(3) *Excludes impacts of DLC and emergency programs, which were not dispatched*

(4) *These are expected impacts based on mandatory TOU rollout*

DSM in Saudi Arabia

- Problems
 - Rapid peak demand growth (6% per year)
 - Capital-intensive grid expansion (SR 20 to 40 billion per year)
 - Low resource utilization
 - Mandatory load curtailment / blackouts in the summer
 - Lost revenue when oil is sold to electric utilities at a substantial loss
- Drivers of load growth
 - Very hot climate
 - Artificially low electricity rates
 - Low consumer awareness of energy efficiency
 - Ineffective enforcement of efficiency standards

Almost all of these problems can be addressed through the systematic application of Demand-Side Management (DSM)

A phased approach to DSM

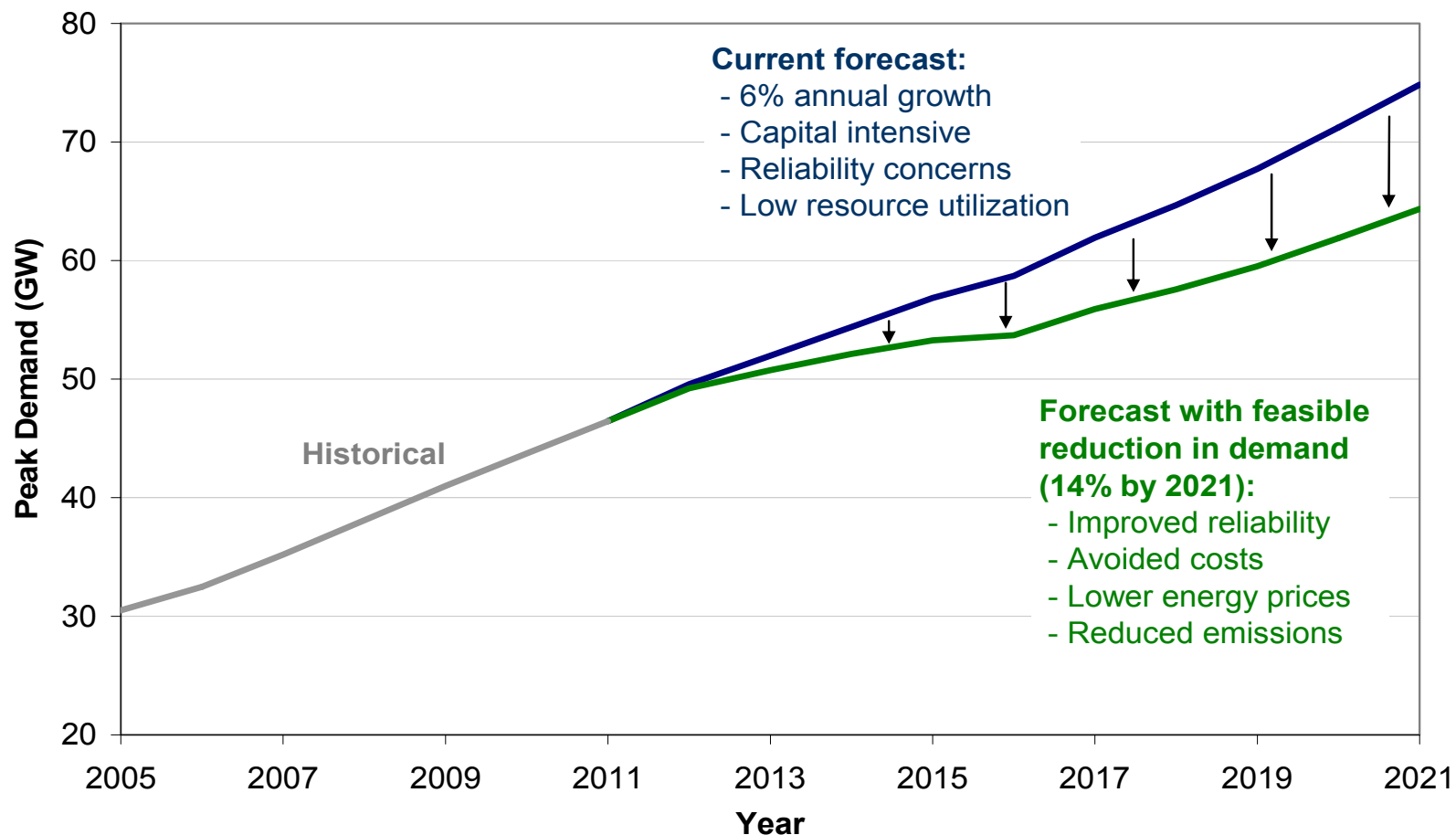
- The KSA is planning to launch five DSM programs starting next year
 - These programs should focus on the largest end use of energy (i.e., space cooling)
 - They should be designed to reduce energy use, peak demand and improve system load factor
- As a second step, pilots will be initiated on other topics in the years to come
 - New pricing mechanisms (i.e., TOU, dynamic pricing)
 - New innovative technologies (i.e., PCTs, auto DR, water pumping, A/C retro-commissioning)
 - New information delivery mechanisms (i.e., in-home displays, web portals)

The DSM Plan is structured around five programs

The DSM Plan	Description
EE Programs (Voluntary)	
1 Efficient Cooling	Encourage and assist customers in existing facilities to improve air-conditioning EE through incentives for replacement of a/c units
2 New Buildings Efficiency	Designed to accelerate the incorporation of EE in the design, construction, and operation of new, renovated or reconstructed homes and buildings in the KSA (mainly from insulation and a/c efficiency)
LM/DR Programs (Voluntary)	
3 Direct Load Control	A/C compressors are remotely cycled or shut down during times of high demand in return for incentive payments to participants (commercial, government and large residential sectors)
4 Interruptible Tariffs	Offer lower year-round rate in exchange for agreeing to reduce load to pre-specified level during a limited number of hours per year; Financial penalties for non-compliance (commercial and industrial sectors)
5 Curtailable Load Management	Customers receive a payment for each kilowatt of measured and verified demand reduction that they provide during load curtailment events (industrial sector only)

The DSM Plan will allow the KSA to manage unsustainable trends in peak demand growth

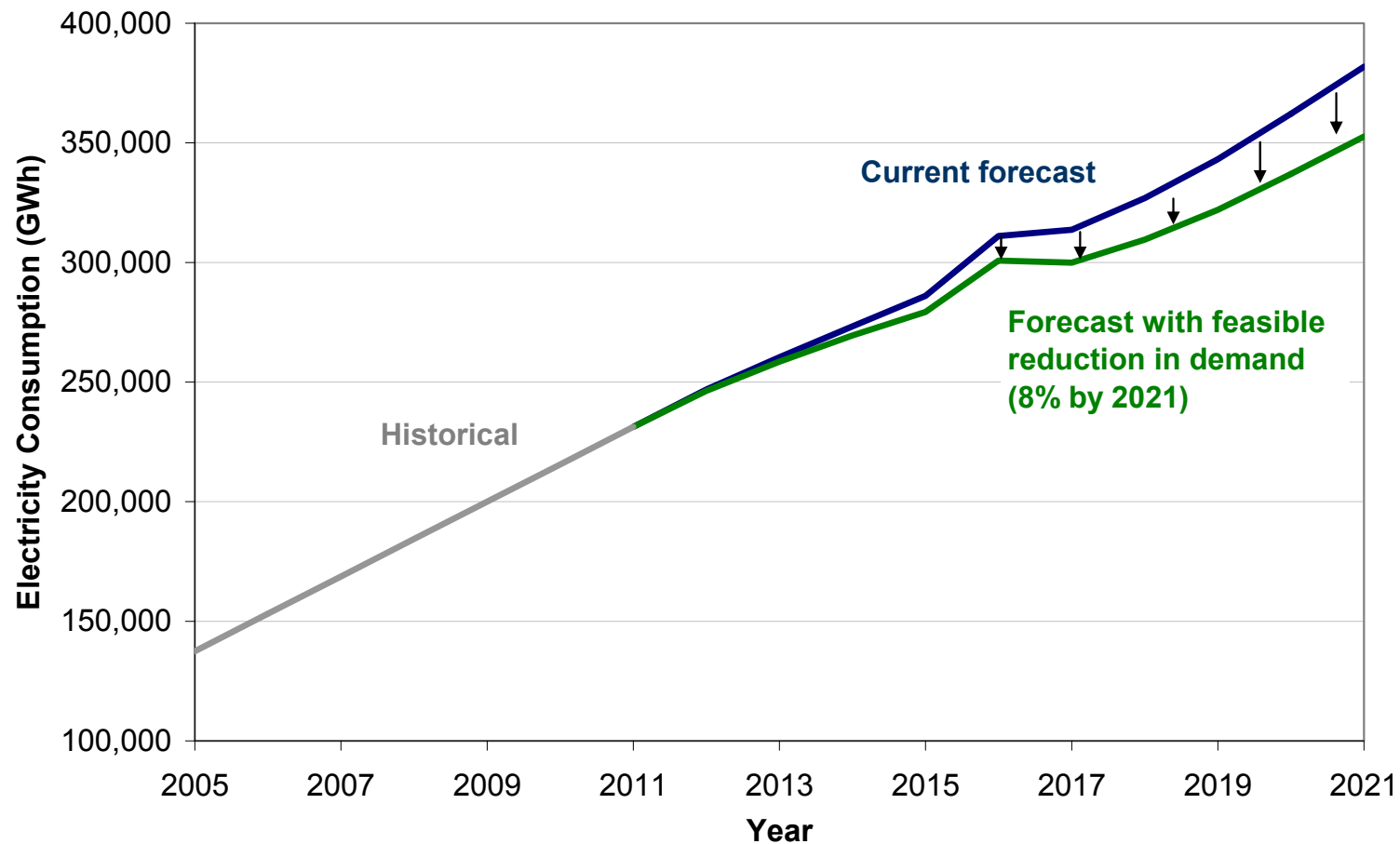
KSA System Peak Demand



Note: "Current forecast" projection provided by ECRA

It will also help to reduce unsustainable growth in electricity consumption

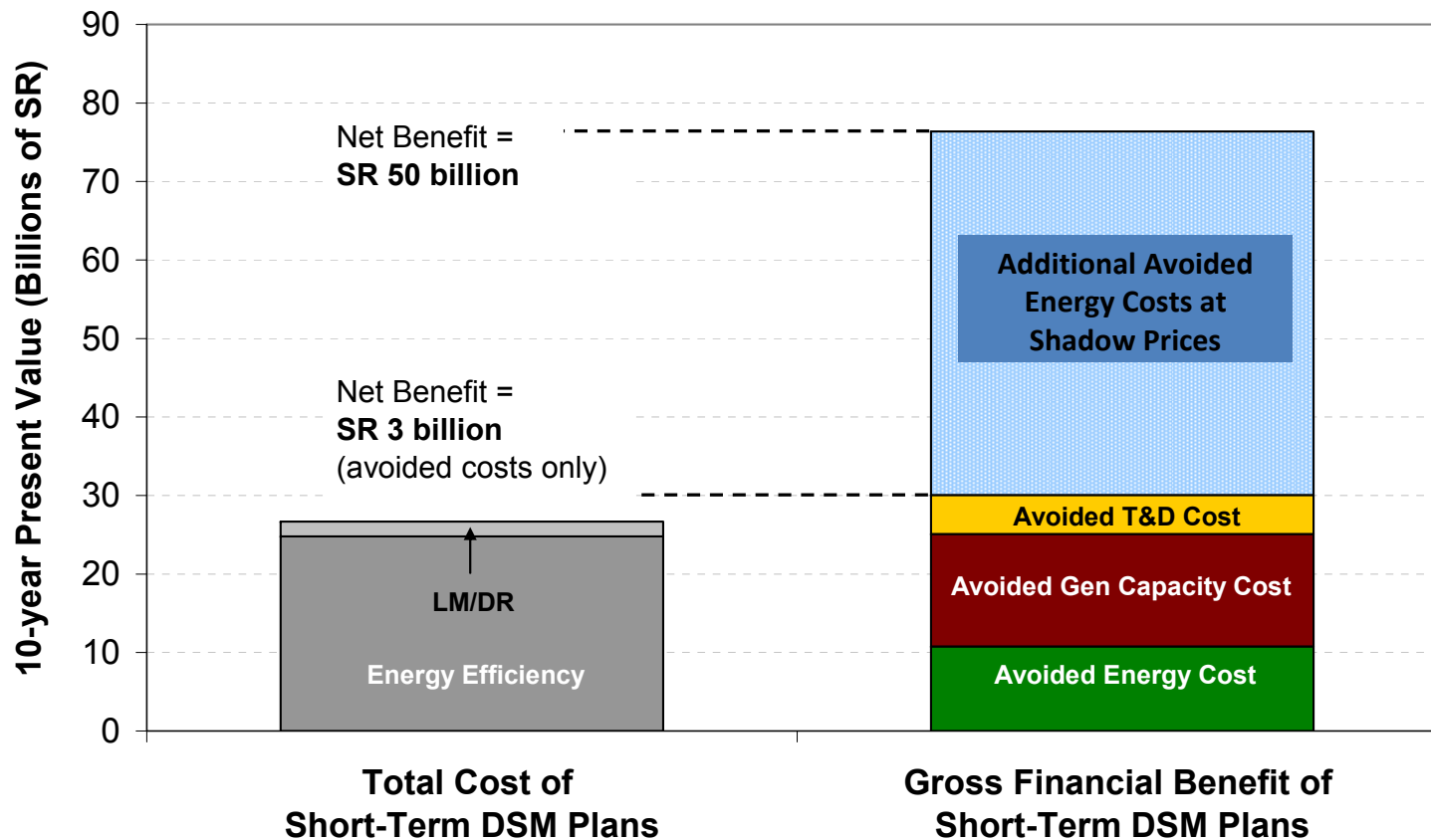
KSA Electricity Consumption



Note: "Current forecast" projection provided by ECRA. "Historical" extrapolated based on implied growth rate

DSM can yield significant net benefits to Saudi society over the next decade

Costs and Benefits of Recommended DSM Programs



Note: Shadow prices are a conservative approximation of energy prices based on near-market price of oil used for electric generation, provided by Ministry of Petroleum and Minerals

A phased approach is recommended

- Firstly, targeted energy awareness messages will be developed, leading to changes in customer behavior
 - Lower your energy bills
 - Cleaner air is good for your health
 - Being “green” is good and virtuous
 - Make the best use of the Kingdom’s precious natural resources
 - Invest in the future of your children and grand children
 - Do better in per capita energy consumption than your neighbors and with countries at similar levels of economic development
- Secondly, financial incentives will be used to bring about technological change by encouraging customers to buy efficient appliances and buildings
- Thirdly, in the long-term, raising electricity prices to reflect actual costs would turn DSM into a sustainable activity

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