Demand Response-ready or "Smart" Air Conditioning in India

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Outline

1. **Background**
2. **Motivation for Demand Response (DR) and DR standards**
3. **DR Potential and Types of DR**
4. **Considerations in developing standards for DR-ready ACs**
5. **International Standards Process**
6. **Opportunities to move forward** – discussion

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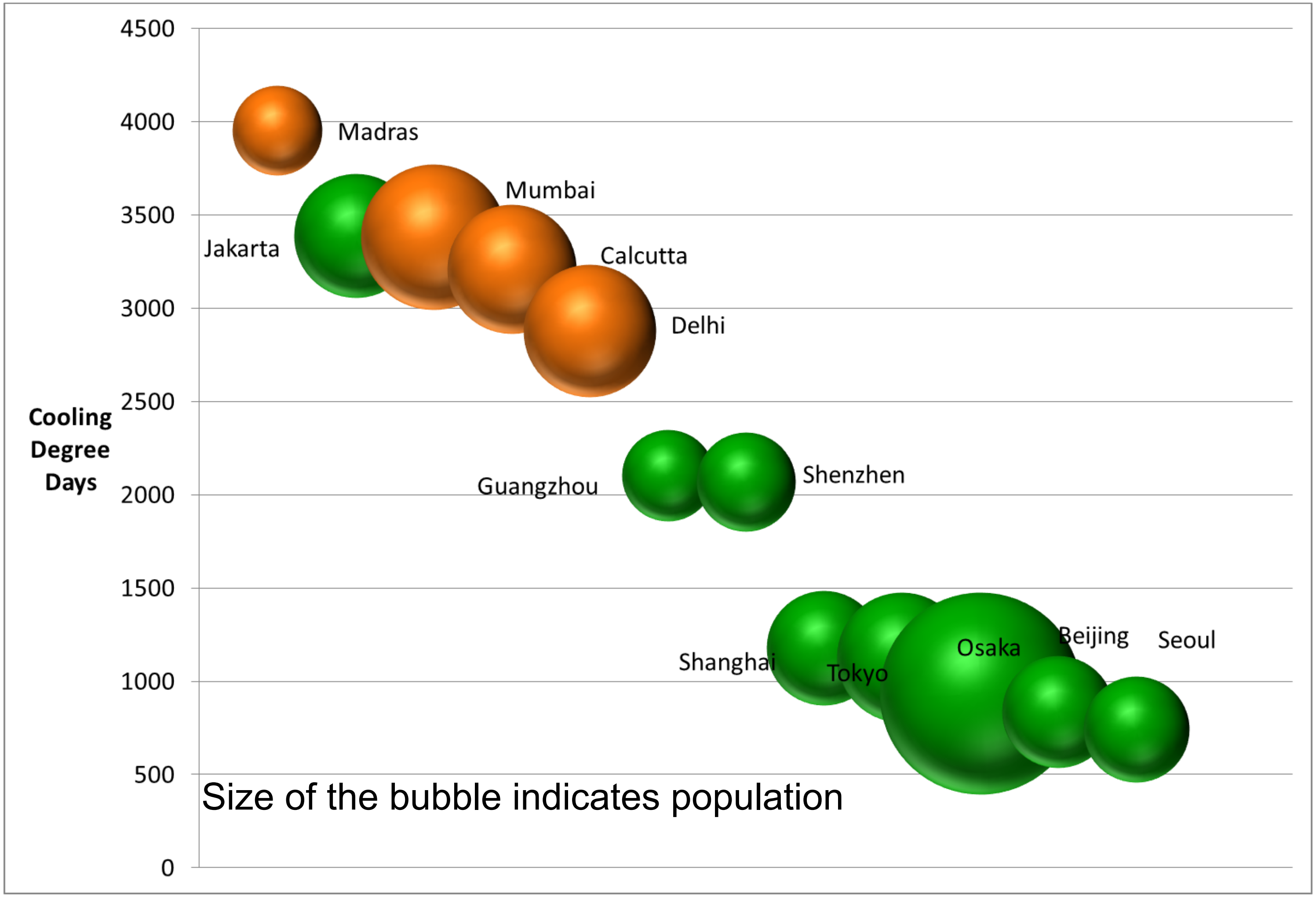
Definitions

Demand Response refers to changes in the operating mode of appliances or equipment in response to changes in electricity prices, the state of the electricity network, or external requests for load modification. The user may respond manually, or may willingly permit automated changes to lower energy costs and/or financial incentives.

Smart Appliance has been variously defined as: 1) "a product that uses electricity for its main power source which has the capability to receive, interpret and act on a signal received from a utility, third party energy service provider or home energy management device, and automatically adjust its operation depending on both the signal's contents and settings from the consumer" (AHAM/ACEEE, 2011), alternatively, 2) "the automated alteration of an electrical product's normal mode of operation in response to an initiating signal originating from or defined by a remote agent" (Standards Australia, 2012)

Indian cities are hot and populous



Source: Sivak, 2009

Compared to other regions, India has higher cooling requirements

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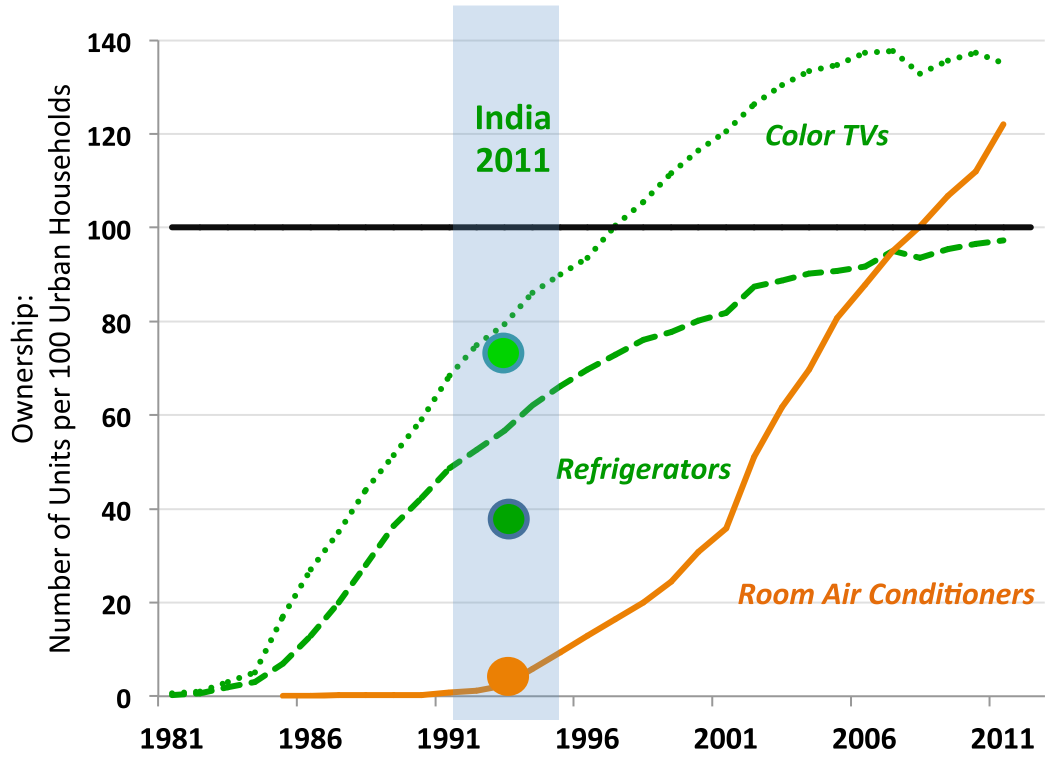
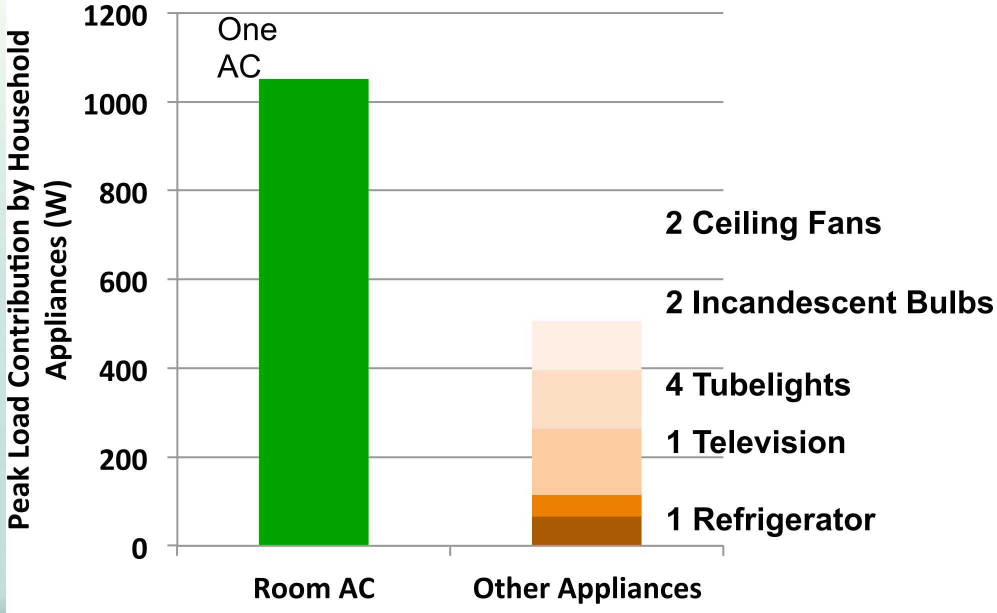
Example of High Cooling Demand Growth—China

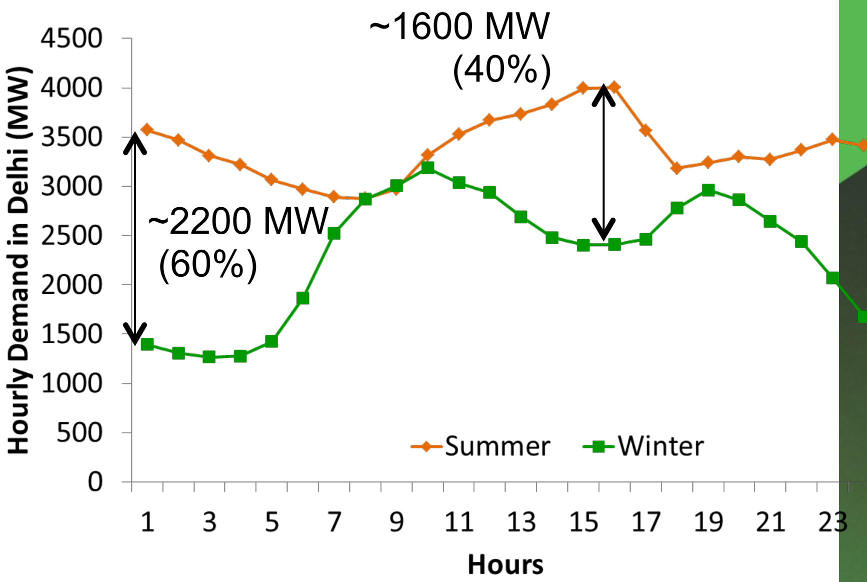


Source: NSSO, 2012, Fridley et al., 2012

- The AC ownership rate in urban China went from almost 0% in 1990 to over 100% in 25 years.
- AC sales in major emerging economies are growing at rates similar to China circa 1994–1995, e.g., India room AC sales growing at ~30%/year(Shah et al., 2013).

Room ACs have a large contribution to peak demand in India

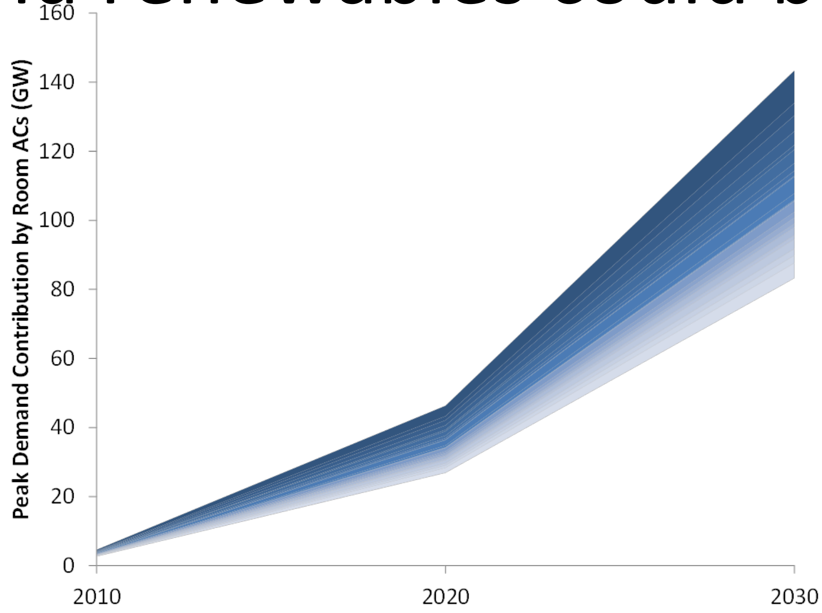




Cooling is the largest contributor to peak load on an appliance basis…

…and 40-60% of summer peak load in large metropolitan cities with hot climates like Delhi.

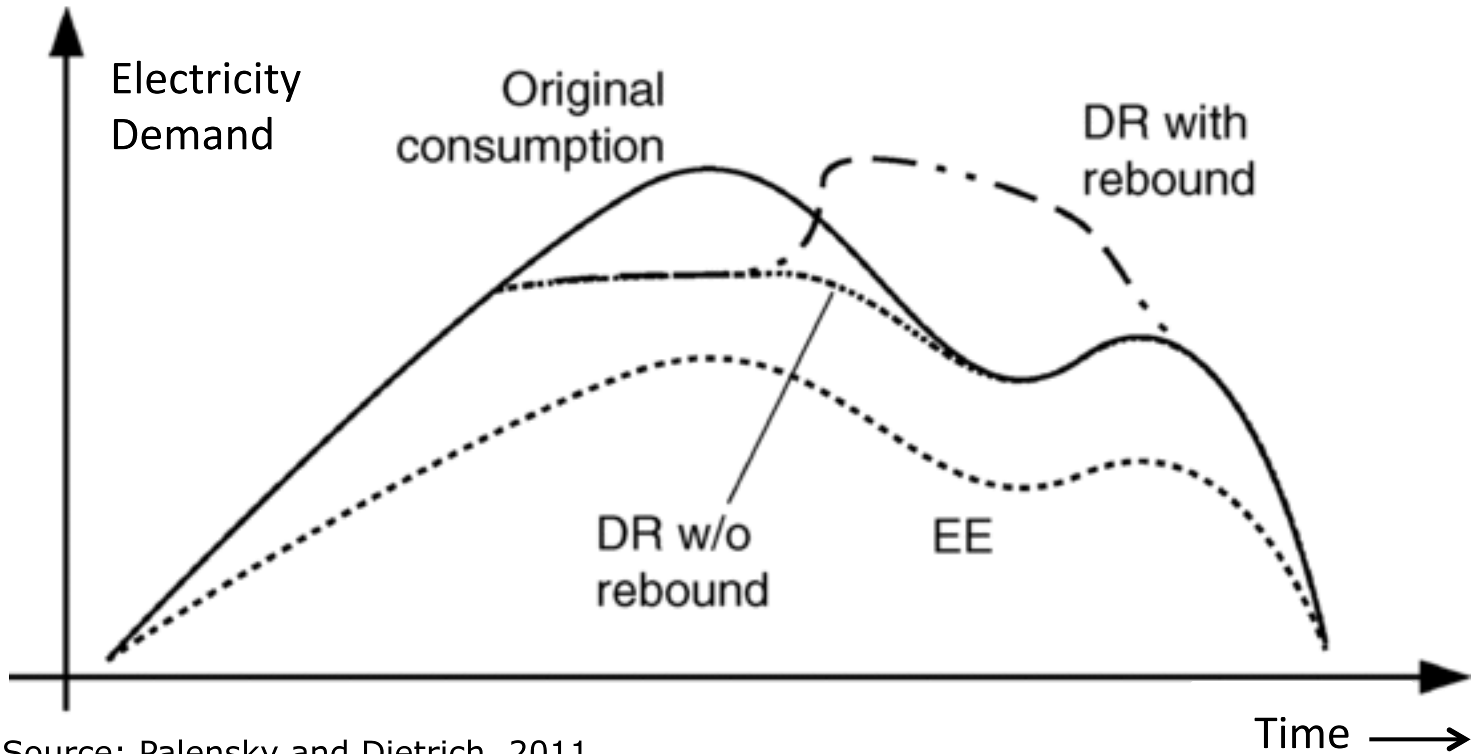
Cooling and renewables could both use DR



Source: Phadke et al (2013)

- Preliminary estimates show that the additional demand expected from room ACs in India is equivalent to 200-300 large (500 MW) power plants by 2030, needing:
  - Significant addition to generation capacity, OR
  - Shortages continue with diesel generators or inverters on the margin
- India is planning to add 160 GE of solar (100GW) and Wind (60GW) capacity by 2022.
- Integrating such RE would need ~15-20GW of additional flexible capacity (in addition to the existing and planned hydro and gas plants).
- Demand response could help with mitigating peak load(from ACs), and integrating renewables.

Energy Efficiency and Demand Response



Source: Palensky and Dietrich, 2011

- Energy efficiency (EE) reduces the original cooling demand uniformly and permanently.
- Demand response reduces the original cooling demand at the peak.
- Demand response with "rebound" shifts some of the original demand to a non-peak time as some, but not all, of the curtailed demand comes back online.

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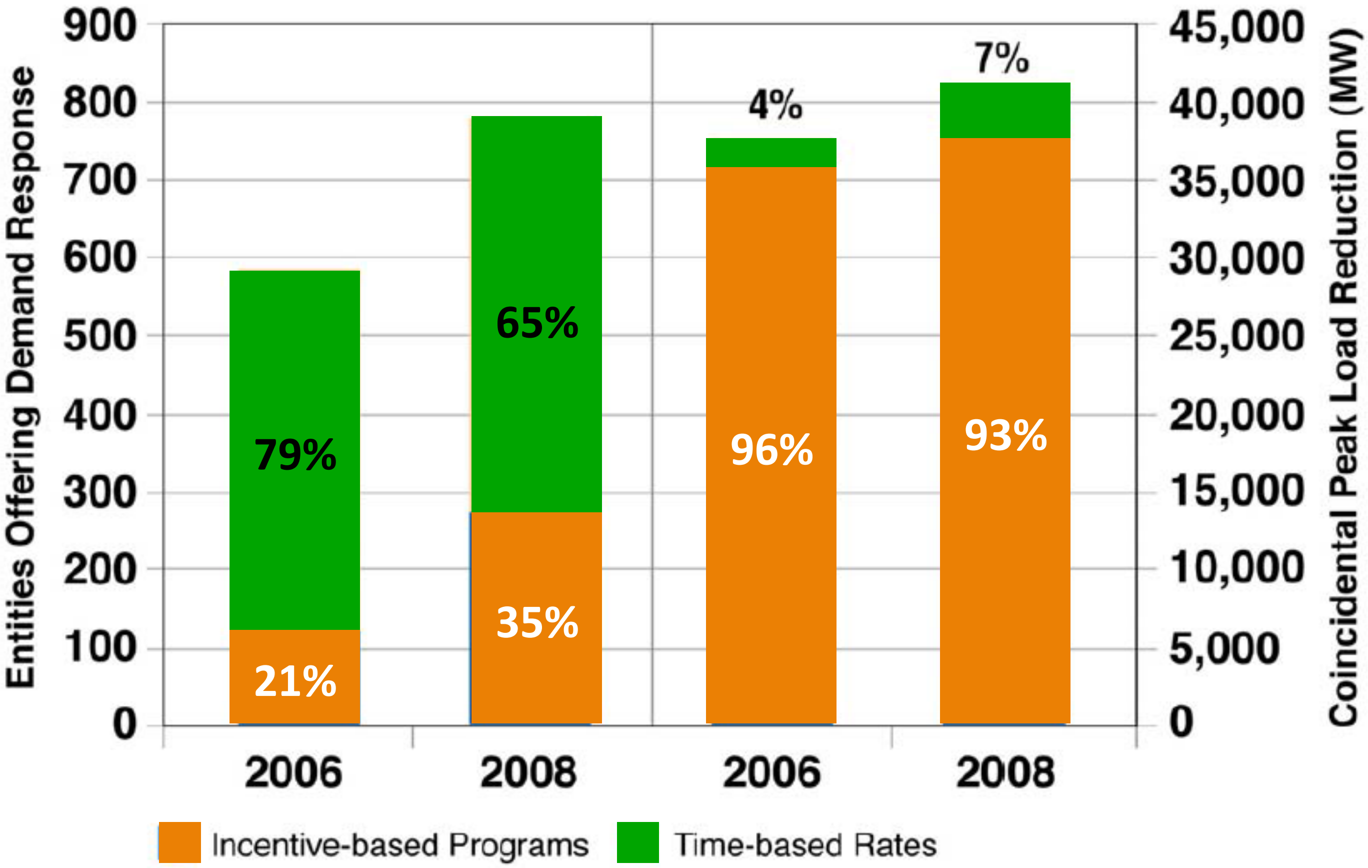
Demand Response Potential in the United States



Source: Cappers, Goldman, and Kathan, 2009

Demand response is a resource that is fast growing and has high potential, particularly for incentive-based programs.

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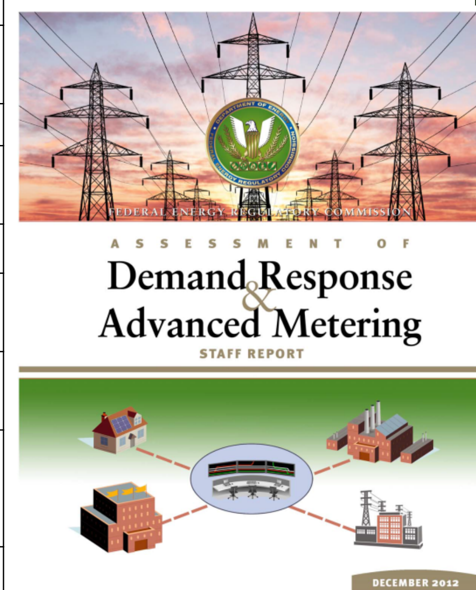
U.S. Demand Response Program Typology

2012 FERC Survey Program Classifications	Description
Direct Load Control (DLC)	Sponsor remotely shuts down or cycles equipment
Interruptible Load	Load subject to curtailment under tariff or contract
Load as Capacity Resource	Pre-specified load reductions during system contingency
Time-of-Use Pricing (TOU)	Average unit prices that vary by time period
Emergency Demand Response	Load reductions during an emergency event Combines direct load control with specified high price
Spinning Reserves	Load reductions synchronized and responsive within the first few minutes of an emergency event
Non-Spinning Reserves	Demand-side resources available within 10 minutes
Regulation Service	Increase or decrease load in response to real-time signal
Demand Bidding and Buyback	Customer offers load reductions at a price
Critical Peak Pricing (CPP)	Rate/price to encourage reduced usage during high wholesale prices or system contingencies
Critical Peak Pricing w/ Control	Combines direct load control with specified high price
Real-Time Pricing (RTP)	Retail price fluctuates hourly or more often to reflect changes in wholesale prices on day or hour ahead
Peak-Time Rebate (PTR)	Rebates paid on critical peak hours for reductions against a baseline
System Peak Response Transmission Tariff	Rates/prices to reduce peaks and transmission charges

Incentive-Based Program   Time-Based Program

80% of ISO participation occurs in these programs. (FERC, 2012)



http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf

Cooling Equipment Use and Latency

Customer Type	Equipment/ Building Component	Control Strategy	DR programs		
			Emergency or Energy Resource	Capacity Resource	Regulation Service or Reserves
Residential	Air conditioners	Cycling/forced demand shedding	✓	✓	✓
Commercial	Chillers	Demand limiting during on-peak period	✓	✓	
		Pre-cool building over night-storage		✓	
		Forced demand scheduling	✓	✓	
Industrial	Chillers	Demand limiting on time schedule		✓	

Source: Adapted from Walawalkar et al., 2010

Cooling equipment can be flexibly used in many DR programs, e.g.:

- as an "emergency" or "energy" resource during a time of high demand
- as pre-scheduled "capacity" that can reduce load according to a pre-planned schedule
- as a means of providing regulation services and reserves in real time or on short notice
- Demand response solutions need to be flexible with respect to response time(or latency)

Demand Response Specifications

Country/ Body	Standard/Committee	Technology/Appliances	Effective Dates
Japan	Echonet	Meters, appliances, home area networks (HANs)	various 1997-2014
USA	Energy Star criteria for connected appliances	Refrigerators & other appliances	2014
Australia	AS/NZS 4755	Air conditioners, pool pump controllers, water heaters, EV charge controllers	Various - 2008-2014
Korea	Korean labeling criteria for air conditioners and heat pumps	Air conditioners and heat pumps	October 2014
IEC	PC 118 Smart Grid User Interface	User interfaces	Began 2012
	TC 57 power systems management and associated information exchange	Power systems management	
	TC 59 WG15	Connection of household appliances to smart grids and appliances interaction	Draft expected mid-2015

- Many regions and economies are working on "smart" appliance standards.
- A single approach may not be feasible in the short term, but a unifying framework may be possible.
- Several unique requirements in India: e.g. cellphone penetration vs internet penetration, price sensitivity
- Public–private partnerships and collaboration can drive architecture and provide clear direction of needs of the electricity grid and of end-users.

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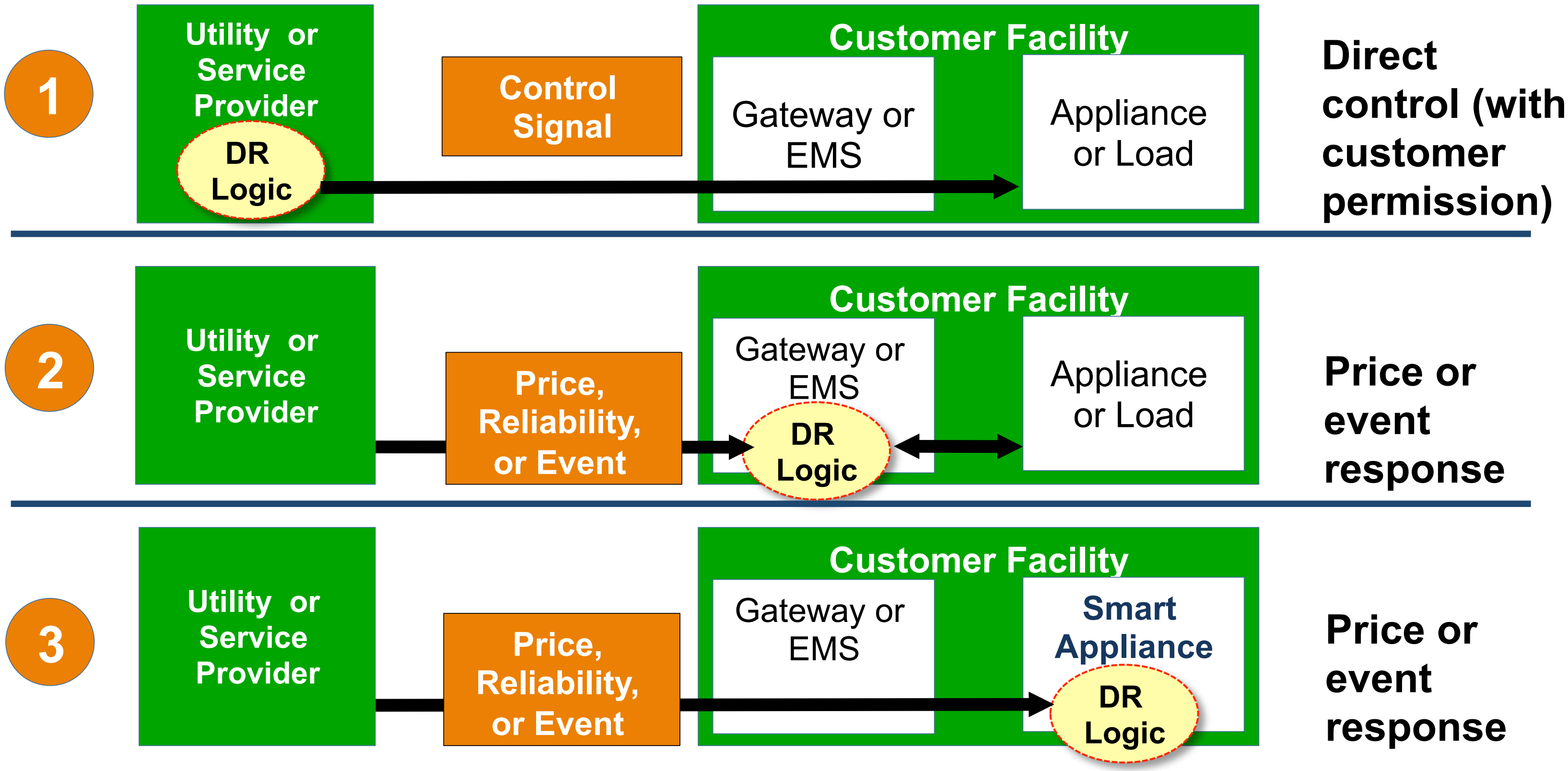
Utility vs. Customer Control in Demand Response

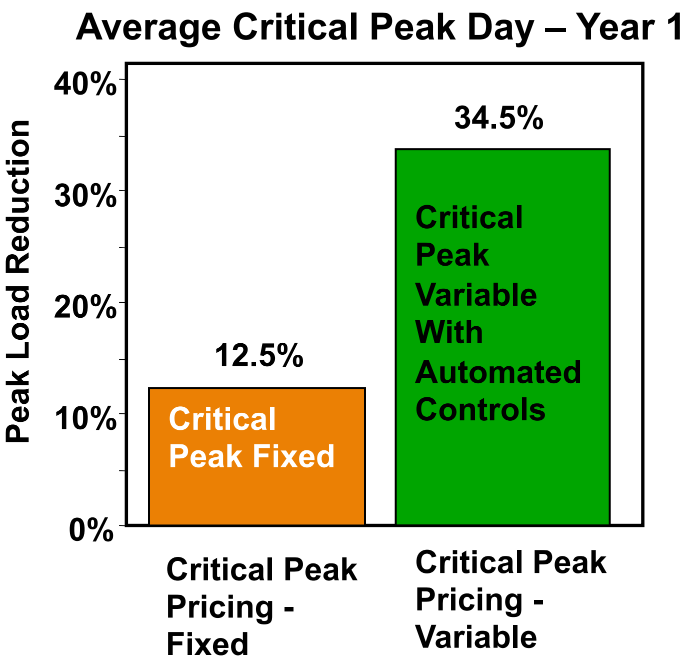


Adapted from: *Direct versus Facility Centric Load Control for Automated Demand Response, Grid Interop 2008*, E. Koch and M. Piette

- DR logic can be utility-centric, built into the building energy management system (EMS), or built into a "smart" appliance, depending on the type of DR.
- A clear and flexible DR specification is needed to allow multiple cost-effective interoperable solutions.

Automation: Necessary or Not?

- Automation increases load response as shown below (e.g., with smart thermostats or automated controls).
- Provides customers with "set and forget" it capability.
- Improves persistence of response over time.
- Provides faster and more reliable response; demand response can be integrated in electricity system planning.



Source: California SPP, 2003

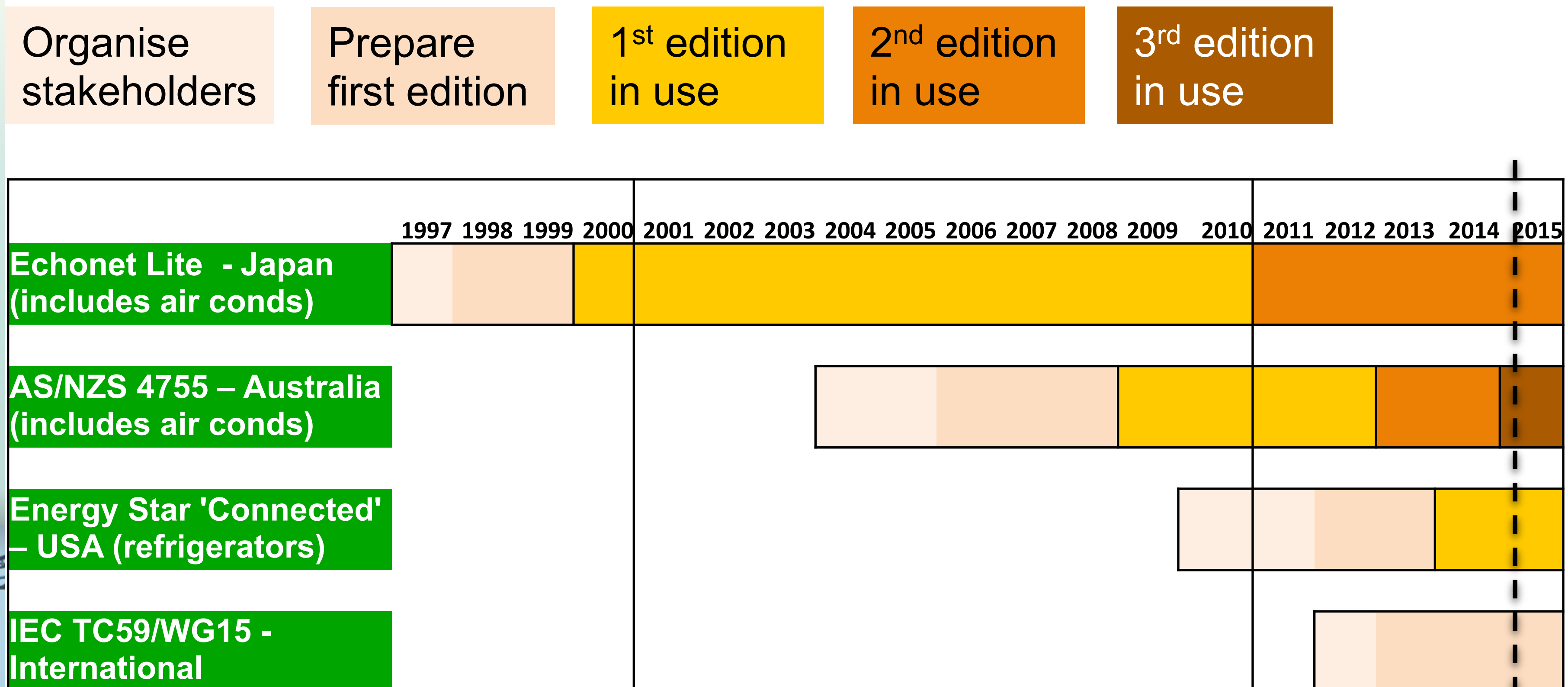
Rate Group	No Smart Thermostat	With Smart Thermostat
Residential – Critical Peak Pricing	29%	49%
Residential - Peak-Time Rebate	11%	17%
All Electric – Critical Peak Pricing	22%	51%
All Electric - Peak-Time Rebate	6%	24%

Source: PowerCents DC, 2010

Summary of Considerations in Standards process

- Reliability/bidirectionality
- Risk of under/overspecification
- Latency/response time
- Automated/manual
- Interoperable to allow cost-effective solutions

Standards Process



- The standards process takes time to build consensus
- Engagement in IEC process needed from Indian stakeholders

Now

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Recent Work and Next Steps

- BEE, India and US DOE organized a Space Cooling Efficiency Enhancement and Demand Response Workshop June 24-25, 2014- participation from utilities, grid operators, regulators and AC manufacturers
- Draft specification for DR-ready appliances being drafted by IEC TC59 WG15, first draft in mid- 2015
- Stakeholder engagement needed to shape the specifications for DR- ready appliances.
- BIS and BEE could participate in IEC standards process for DR-ready appliances.
- Simultaneous process of standards development and pilot demonstration projects could be undertaken.

Questions or Suggestions?

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