Best Practices in Utility Demand Response Programs

With Application to Hydro-Québec's 2017–2026 Supply Plan

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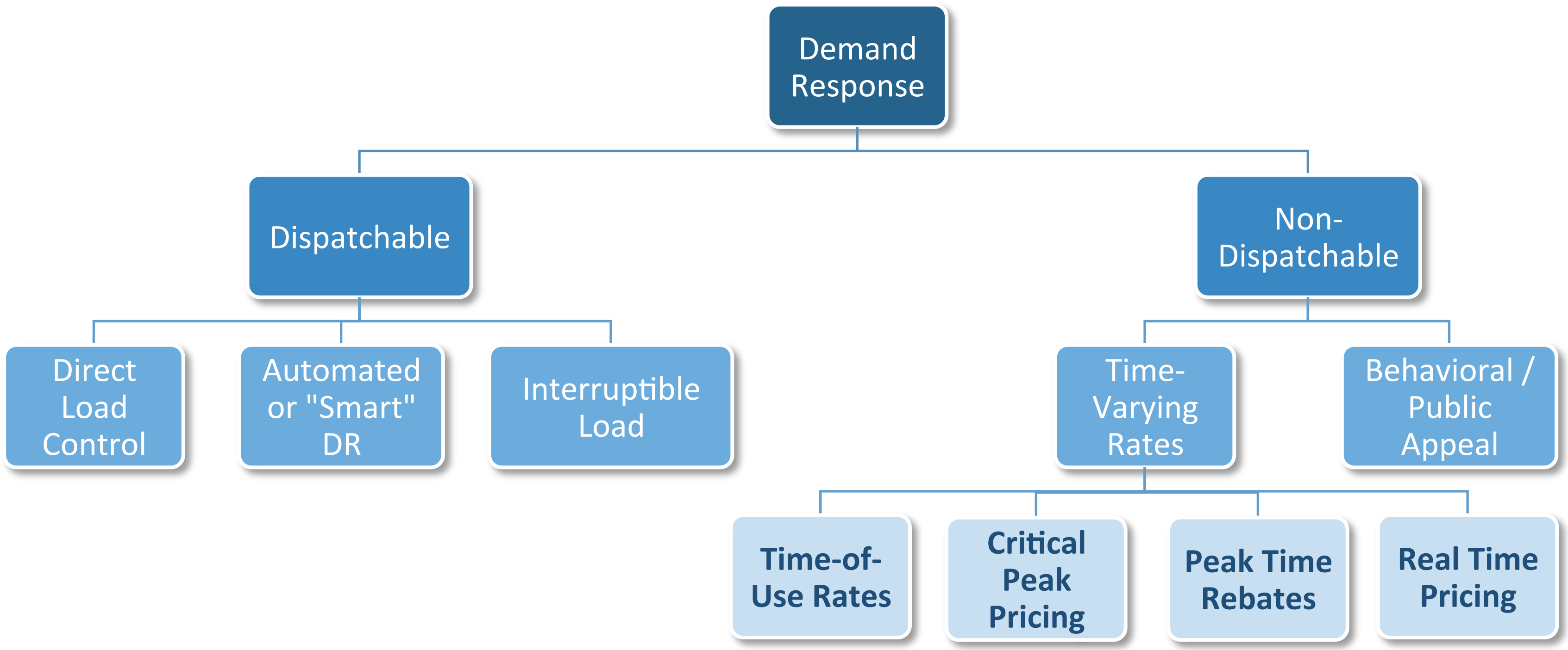
Sources of Value from DR

- Avoid peak capacity costs by reducing peak demand
- Avoid the need for transmission or distribution investments by reducing local peaks or responding to contingency situations
- Increase reliability during generator or line forced outages
- Match load to supply characteristics
- Enhance grid flexibility by providing ancillary services, such as frequency response or load following

Types of DR



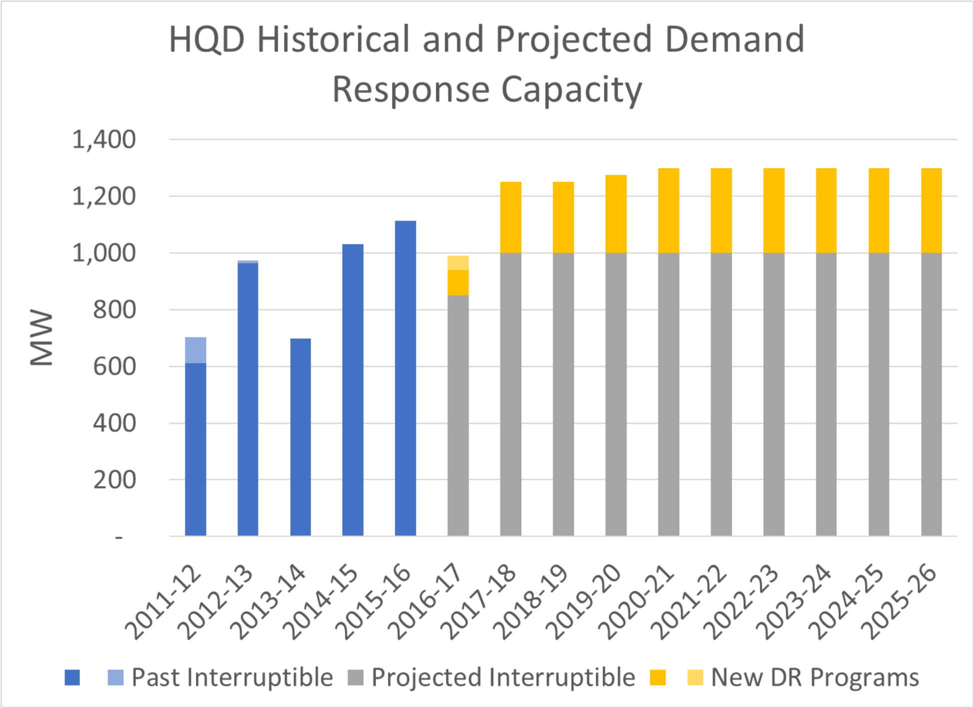
Demand Response
Dispatchable
Non-Dispatchable
Direct Load Control
Automated or "Smart" DR
Interruptible Load
Time-Varying Rates
Behavioral / Public Appeal
Time-of-Use Rates
Critical Peak Pricing
Peak Time Rebates
Real Time Pricing

Québec context for DR

- Supply cost is nearly invariant except during peak periods
- Electric grid built to handle these same peaks
- Peaks are driven by the coldest winter weather
- Relatively low electric rates have encouraged extensive use of electricity for space and water heating
- Advanced metering infrastructure (AMI) has been deployed
- Québec is committed to GHG reductions, including through electrification of transportation
  - EVs forecast to contribute 8% of growth in peak between 2017-2026

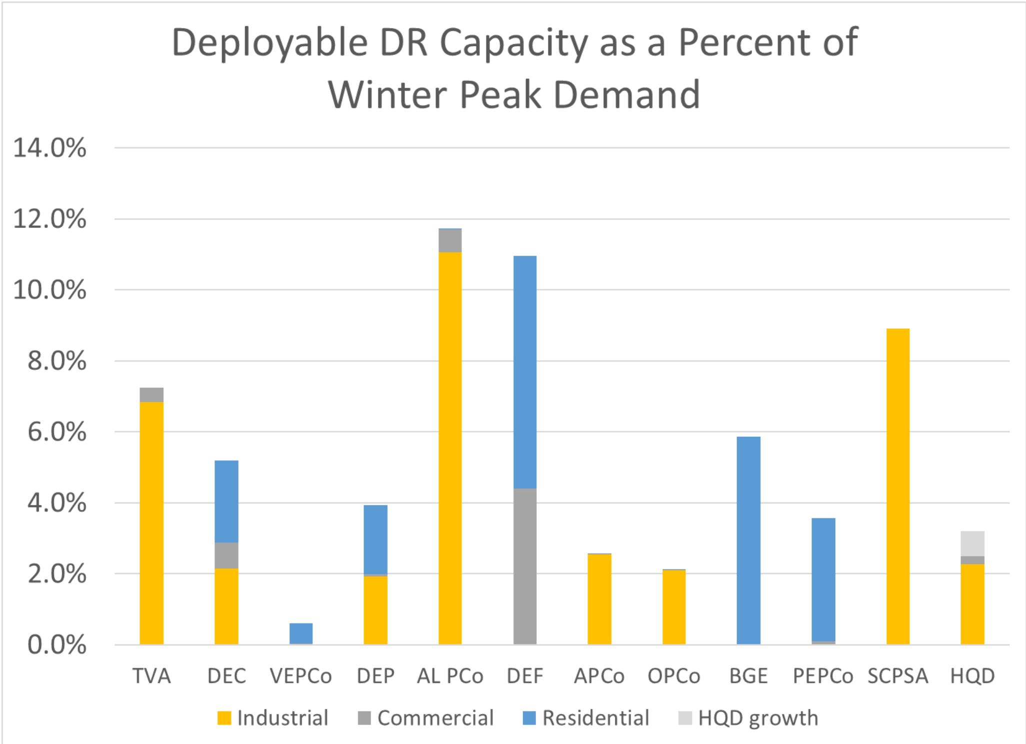
HQD DR: Today and projected

- Today and quantified in the Supply Plan
  - *Interruptible electricity*, for industrial customers
  - *GDP Affaires*, for commercial, institutional and small/medium industrial customers
- Other new DR programs in the plan include residential controlled or interruptible loads, but these have not been quantified and included in the projected resource



Comparison with other large utilities and markets

- 11 largest winter-peaking U.S. utilities have DR capacities between 0.6 percent and 11.7 percent of their winter peaks
- Utilities vary greatly in the sectors they address with DR programs
- Weighted average cost of DR capacity is $47/kW-year
- Wholesale market DR:
  - New England: 2.7% of winter
  - Ontario: 7% of winter



Best practices

Distributors and system operators implementing demand response programs should:	Design programs appropriate for the jurisdiction's context and objectives
	Quantify the cost-effective DR potential and develop a plan to meet it
	Take advantage of AMI, smart appliances, and other technologies
	Address a range of measures and sectors to identify and capture least-cost resources
	Effectively engage with customers and capture economies of scale with other customer engagement initiatives
	Continually assess costs and benefits and update both as circumstances change

Design for context

- Design DR programs to meet the system's particular needs
  - Weather driven peaks? Understand the relationship between weather and load
  - Vermont Weather Analytics Center combines next-gen weather forecasting with distributed energy resources (DER) and demand forecasts
- Understand what's cost-effective. Example:
  - Pennsylvania legislature required utility DR to address top 100 hours of load
  - But costs are really driven only by top 30 hours
  - 100-hour programs not cost-effective and risked exhausting customers
  - *Lesson:* Know the structure of avoided costs
  - Regulators changed the program

Cost-benefit analysis

- Reflect policy goals in design of cost-effectiveness screening test
  - Decide what components to include
  - Societal or utility perspective?
  - Include environmental externalities? Customer costs?
- Quantify benefits in detail
  - Benefits generally take the form of avoided costs
  - Resolve at different times
  - Reflect variation in cost/benefit structure over time or location
- Result: Ability to account for variation among DR program options

Potential and planning

- Why plan? Take a long-term perspective
  - Programs need time to ramp up
  - Programs should be relatively stable
    - Customers make investments based on a program design
- Best practice parallels the process used in leading energy efficiency programs:
  - Identify the *cost-effective* and *achievable* potential
  - Consider the resource in the context of supply planning
  - Engage stakeholders
  - Set an expectation and plan to achieve the necessary and cost-effective resource

Planning in the Pacific Northwest

- Northwest Power and Conservation Council (NWPCC) coordinates regional energy and water resource planning with a very open stakeholder process
- Objectives: Maximize use of hydro resource, integrate wind, and maintain healthy rivers
- 7th Power Plan (2015) process:
  - DR potential study (all sectors, "base" and "smart")
    - Potential is ~9% of winter peak
    - Takes program ramp times and market response into account
  - Stakeholders reviewed the potential study
    - Plan establishes a formal DR Advisory Committee
  - In stochastic regional supply planning, NWPCC identified that 600 MW of additional DR is needed for least-cost capacity needs by 2021 in nearly all futures
    - NWPCC plans for this amount
  - NWPCC has to use "soft power" approach to hold utilities accountable for progress toward this goal

Application to Québec: Planning

- HQD includes in the Supply Plan the expected growth in current programs.
- It falls short by not recognizing the impacts of additional programs over the coming decade.
- An improved planning approach could:
  - Conduct potential studies on a regular basis (e.g., every three years in preparation for the Supply Plan), including updated assessment of the *achievable* potential and of *avoided costs*.
  - Determine an appropriate fraction of the cost-effective DR resource to pursue in the long term, informed by the size of the utility's supply gap @ peak.
  - Identify a program portfolio that can cumulatively generate that amount of demand response, favoring programs that can ramp more quickly or whose impacts are more assured.
  - Taking into account the pace of program development and roll-out, map out the amount of demand response achievable in each year over the course of the Supply Plan and include that resource as the planned DR resource in the Supply Plan.
- The Régie should consider adopting a requirement for "all reasonably available cost-effective demand response," or a similar goal.

Application to Québec: Planning

- This planning approach would ensure consistency between load forecast and DR plan. Example:
  - Plan has 189 MW of new peak load from EVs by 2026, but no projection of DR using that resource
  - Instead:
    - Assess the potential and include cost-effective EV demand response in the Supply Plan
    - Commit to developing the tools necessary to achieve that savings over the coming decade
- Quantify impacts
  - Employ best practices in evaluation, measurement, and verification of programmatic impacts
  - Estimate the impacts of public appeals

Application to Québec: Avoided Costs

- Québec has a particularly complicated structure in which to calculate avoided costs.
  - DR and other load control could make the deviations from the patrimonial "bâtonnets" (plus other contracted supply) smaller and more predictable
  - Quantifying the benefits will be a fascinating challenge.
  - As load rises, the relationship between load and the patrimonial supply structure also changes, so avoided costs should be re-evaluated on a regular basis as part of the planning process.
- HQD should revise (and regularly update) its approach to calculating avoided costs
  - account for the differences in avoided costs in relation to HQD's peak hours
  - enable calculation of customized avoided costs for different DR interventions
- In order to best match DR potential with avoided costs, HQD may require more extensive data and models regarding the load shapes of different classes or sectors of customers than it currently possesses.

DR Measures: Water heating

- Thermal "battery" – time-shiftable load
- Range of dynamism:
  - Scheduled – planned load shape
  - One-way (individual or bulk)
  - Smart/two-way
- Millions of water heaters are used in utility programs in the U.S.
- Great River Energy (Minnesota cooperative)
  - 665k customers
  - 200k participate in load management of some sort and ~107k in water heater program
    - 67k in scheduled thermal storage: Electricity supplied only 11pm to 7am
    - 40k in peak shaving: Off for 5-7 hours when called
  - Four decades of consistent water heater programs
  - Two-way communication coming with AMI over the next decade
- Legionella has not been a concern for program implementers I talked to

Application to Québec: Pilots to programs

- Encourage HQD and the Régie to move the water heater program into implementation as quickly as possible, recognizing the role of other stakeholders.

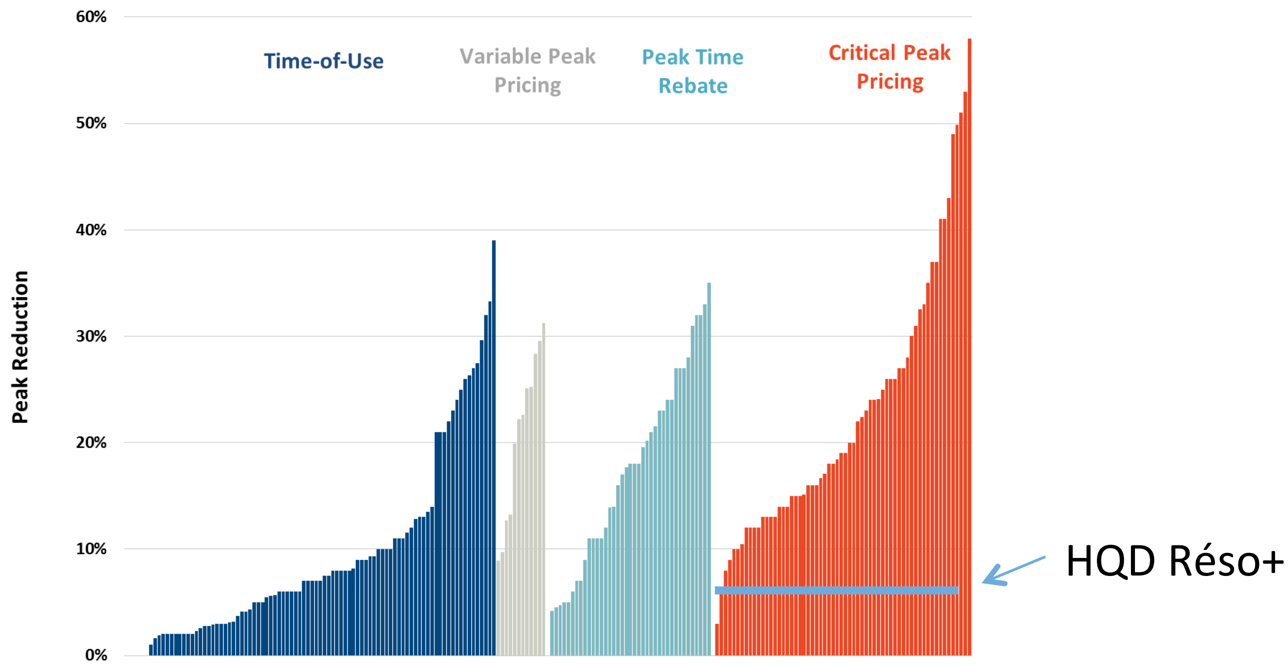
- HQD is also developing or piloting a number of promising avenues for new DR programs or technologies
- As these programs become ready to move from pilot to implementation, it is important that HQD move with all due haste to launch programs and capture the cost-effective potential.
- To grow the resource, HQD should consider enlisting the assistance of third-party DR experts and aggregators.

Application to Québec: Flexible program design

- More options for how to participate should increase participation
- HQD has experienced this recently, with changes in the interruptible load program driving increased participation and giving HQD confidence that this program can grow from 850 MW to 1,000 MW
- Encourage HQD to continue to diversify offerings or make them more flexible, especially for commercial and industrial customers
- Aggregators:
  - Provide greater flexibility for customers while providing a structured service to HQD
  - Can combine smaller loads, increasing the size of the participant population
- *GDP Affaires,* which has many of these characteristics, has been a success to date

"Non-dispatchable" DR:
Time-varying rates

Observed peak impacts vary by the kind of rate used and across different utilities.



Source: Faruqui, Ahmad. "Arcturus." The Brattle Group

Baltimore Gas and Electric has the most extensive peak time rebate (PTR) deployment. It is now the default for their 1 million+ customers, and BGE bids the resulting capacity into wholesale markets.

Application to Québec: Peak rates or rebates

- Interruptible load programs are effectively a kind of peak-time rebate.
  - Rates M, G-9, and L, as well as *GDP Affaires*
- Rate DT is a "temperature-peak" price rate, as a proxy for a "grid-peak" price rate.
  - HQD is piloting utility signal and behavioral approaches
- CPP pilot (Réso+) showed 6% effect. This would be a 1 GW resource if it scaled to all residential and agricultural customers.
- Peak-time rebate could harness the "behavioral" savings from the 2012 DR potential study and mitigate EV impacts.
- HQD should build on its 2008–2010 TOU and CPP pilot by testing new PTR or CPP programs.
  - If they prove promising and cost-effective, HQD should then introduce them as general opt-in or opt-out options to all customers.

Summary of Recommendations

- Re-orient DR planning to be based on achieving the cost-effective potential, rather than projecting only continuation of existing programs. Conduct regular DR potential studies.
- Revise approach to calculating avoided costs to account for the differences in avoided costs between HQD's peak and other hours. This would allow customized avoided costs for different kinds of DR interventions.
- Test new PTR or CPP programs. If promising and cost-effective, introduce them as general opt-in or opt-out options to all customers. Opt-out PTR program appears most promising.
- Move with all due haste to launch programs and capture the cost-effective potential. HQD's water heater program is particularly promising; continue to advocate for it.
- Incorporate the use of technical standards in its program design and implementation.
- Quantify the impacts of appeals for peak reduction, and use best practices for EM&V.
- Integrate DR into energy efficiency offerings where cost-effective opportunities exist.
- Continue to diversify DR program offerings or make them more flexible, especially for commercial and industrial customers. DR program designs should encompass aggregators.

Merci

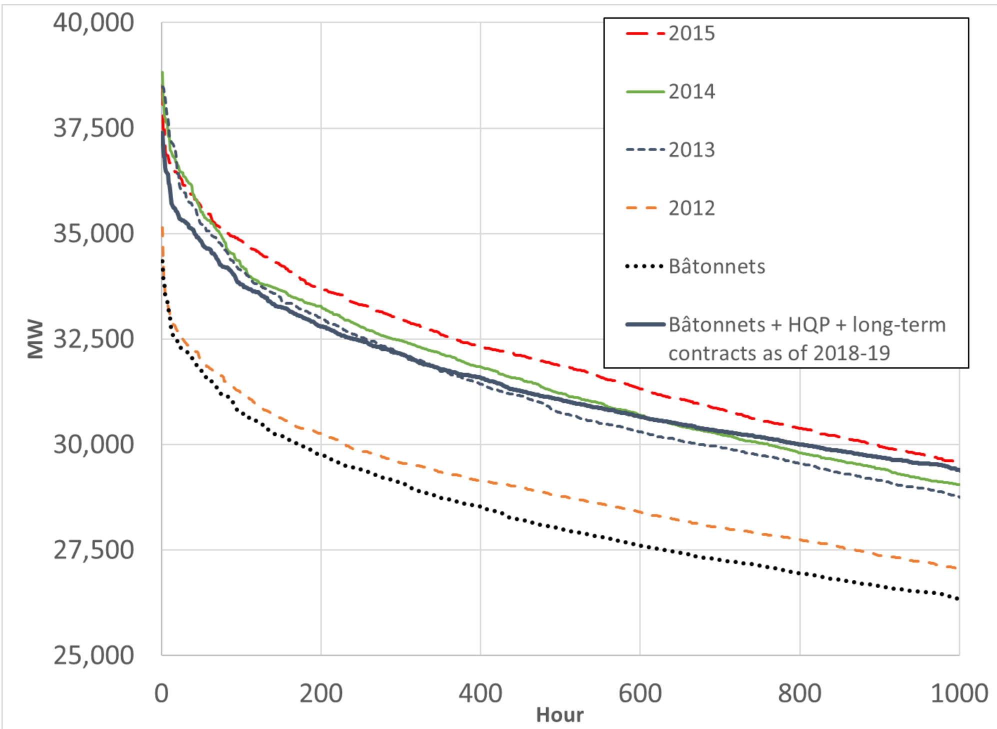
Backup Slides

Demand response taxonomy (California)

Shape captures DR that reshapes customer load profiles through price response or on behavioral campaigns—"load-modifying DR"—with advance notice of months to days.
Shift represents DR that encourages the movement of energy consumption from times of high demand to times of day when there is a surplus of renewable generation. Shift could smooth net load ramps associated with daily patterns of solar energy generation.
Shed describes loads that can be curtailed to provide peak capacity and support the system in emergency or contingency events—at the statewide level, in local areas of high load, and on the distribution system, with a range in dispatch advance notice times.
Shimmy involves using loads to dynamically adjust demand on the system to alleviate short-run ramps and disturbances at timescales ranging from seconds up to an hour.

Power supply

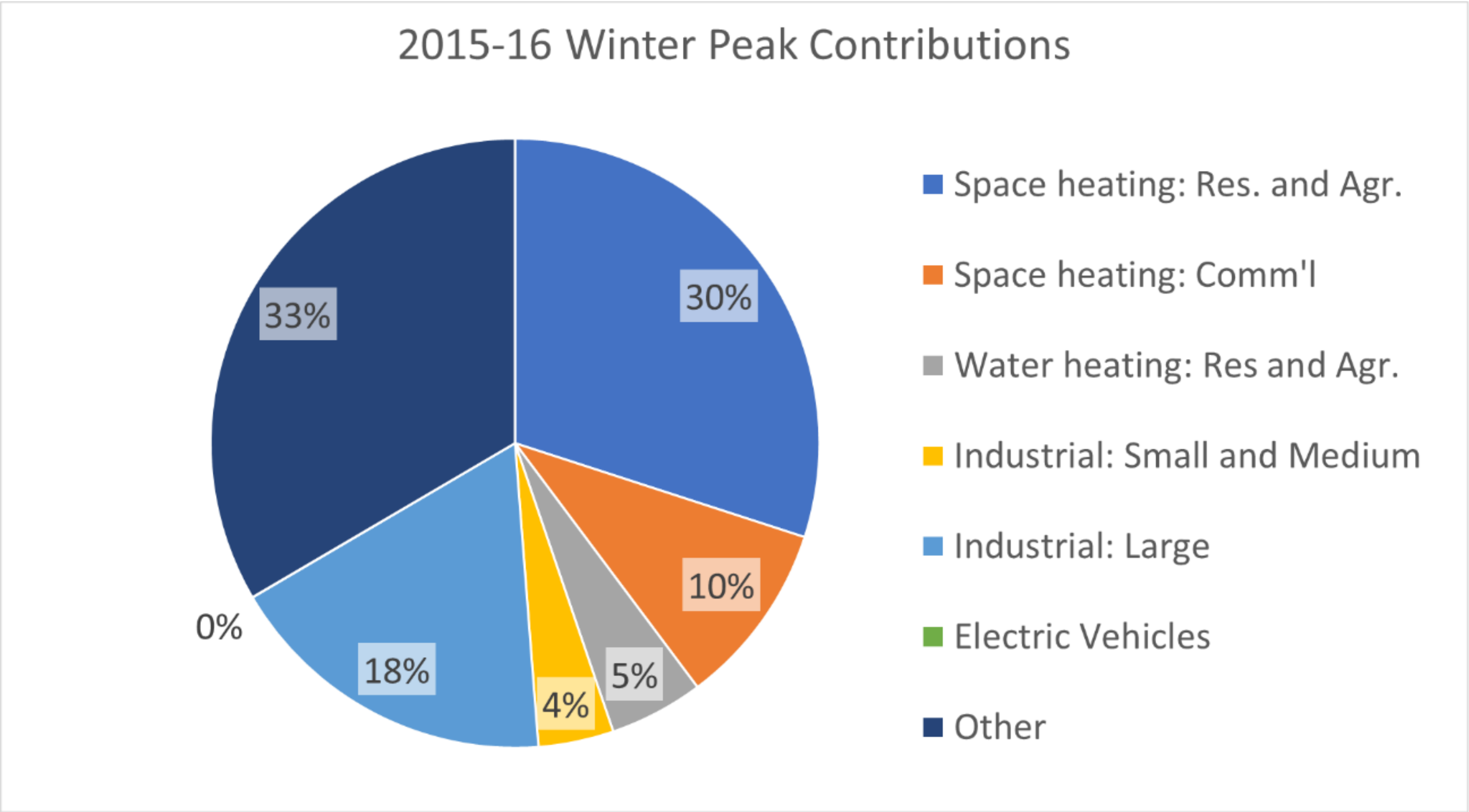
- Patrimonial supply plus long-term contracts (predominantly wind firmed with hydro)
- Exceeding the level of these long-term supplies can be expensive
- Load-duration curve for 2012-2015, along with patrimonial supply and long-term contracts:



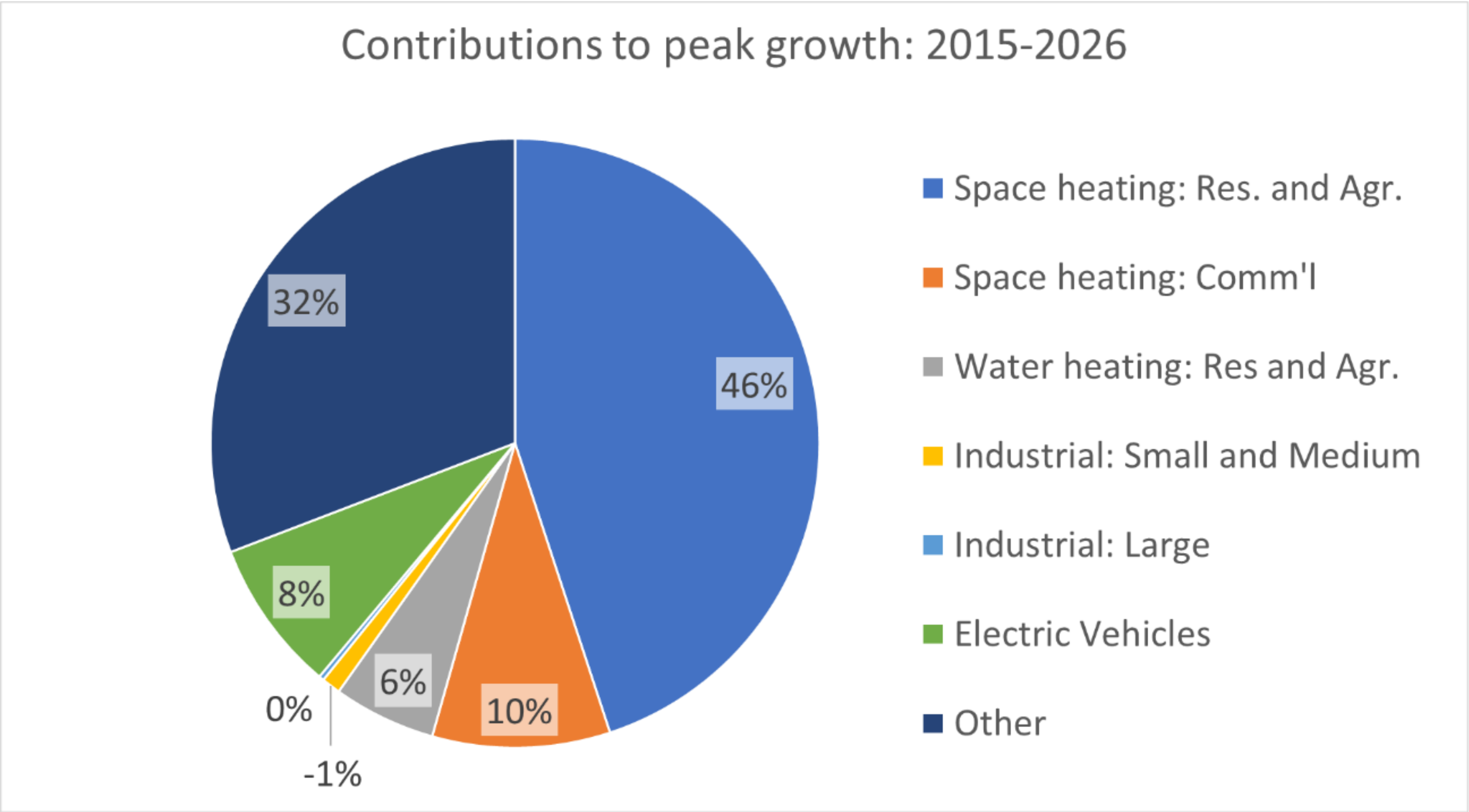
Wholesale market DR

- ISO New England:
  - Year-round resources required
  - Procured through Forward Capacity Market auction
  - 2.7 percent of winter peak from 2015-16 through 2019-20
- Ontario:
  - 478 MW of winter DR cleared market auction
  - About 1 GW of additional industrial DR
  - Nearly 7 percent of winter peak

End uses contributing to winter peak



HQD's forecast of winter peak growth, 2015-2026



Take advantage of technology

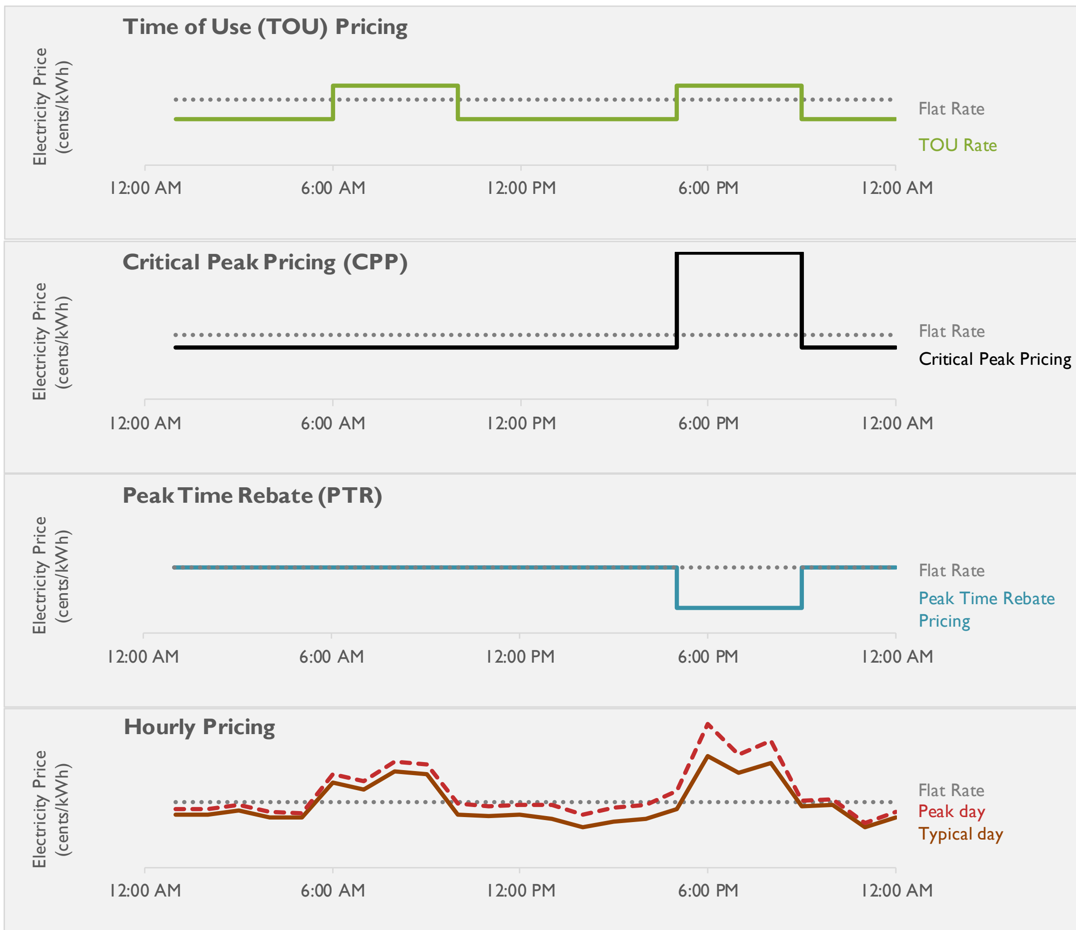
- Advanced metering infrastructure
  - Time-varying rates
  - Peak-reduction programs
- Networks and smart appliances/controls
- Technical standards
  - Universal Smart Network Access Port (USNAP)
  - OpenADR

Talking to smart appliances

- Home networks
  - Wifi thermostats can receive DR signals from the utility over the internet
  - Example: ConEd (New York City) offers rebate in exchange for two-year enrollment allowing utility thermostat control up to 10 times/year
- A standard for appliances: Universal Smart Network Access Port (USNAP)
  - Standard port with some market adoption
  - Vision: "USB for utility control of appliances"
  - Allows a manufacturer to build one appliance that can work with a variety of utility programs and technologies

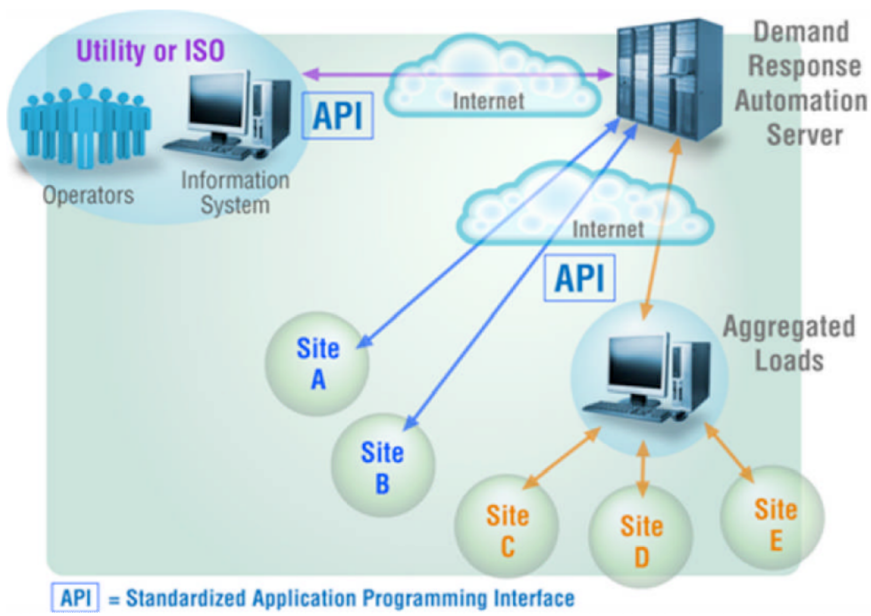
Time-varying rates

Some options enabled by AMI:



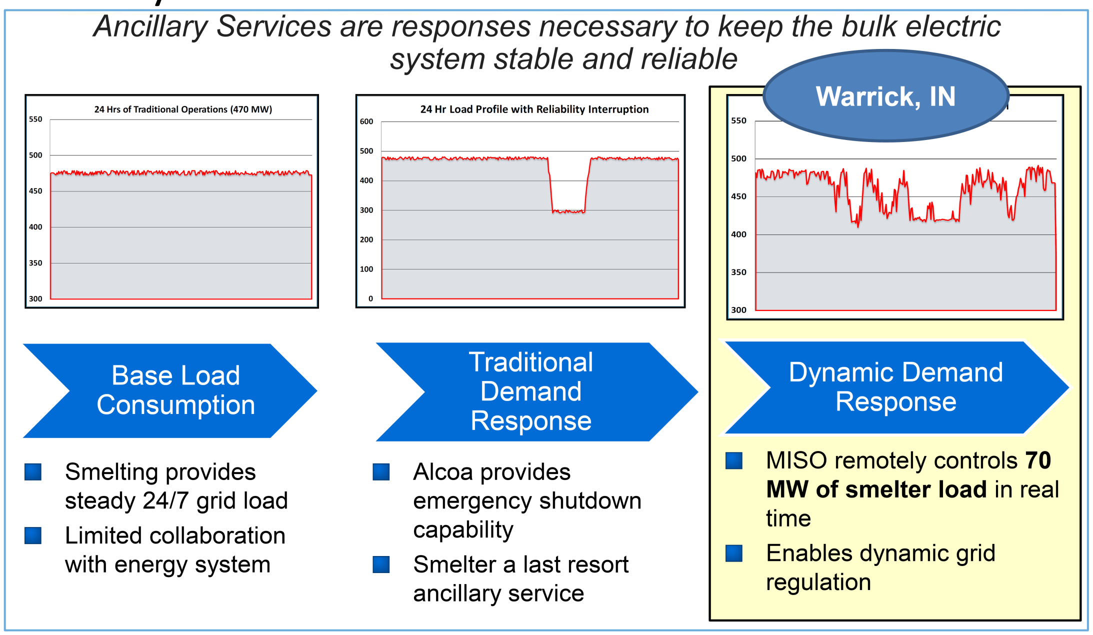
Automated DR communications

- OpenADR
  - Communication standard for automated demand response (Auto-DR)
  - Allows utility, aggregators, and loads to know they are all "talking the same language"
- Required for lighting and HVAC in large new construction in California



DR Measures

- Heating, ventilation, and air conditioning (HVAC)
  - Historically, utilities have relied on direct load control
  - Smart thermostat programs (incl. "bring your own thermostat" options) rising
  - Utility adjusts the temp. setting or limits the % of time the system can run
- Interruptible loads
  - Evolving from historical role (emergency and peak DR only) to dynamic loads supplying ancillary services
  - Alcoa:



DR Measures: Electric storage

- Provides multiple sources of value
  - Host: reliability
  - Grid: regulation, capacity, capital deferral
- Implementation options include:
  - Utility-scale at substation level
  - Distributed behind-the-meter
- Green Mountain Power (Vermont):
  - Utility-owned and controlled Tesla PowerWalls, available to customers for daily fee
    - Or customers can buy and receive a monthly credit for utility controllability
  - Located at residences
  - Customer gets uninterruptible power (and integration with solar PV)
  - Utility can control battery at monthly and annual peaks

DR Measures: Electric vehicles

- Small load now, but one of the few end uses that could significantly drive up electric demand over the coming decades
- Storage/flexibility inherent in hardware
- But human systems need to be designed to harness that flexibility
  - *Behavior*: Set the car not to charge the moment you get home
  - *Pricing*: Send a price signal to favor low-cost times (and avoid peaks)
  - *Control (V1G)*: Utility communication to car or charger to curtail load when asked
  - *Vehicle-to-grid (V2G)*: Injection from the car into the grid upon request or in exchange for a price
- Programs may address fleets differently from individual owners
- Generally in pilot stages in leading EV markets: California, Europe

Customer engagement

- Behavioral DR
  - AMI enables measuring the impact of individualized appeals for reductions on peak days
  - Opower saw 3.4 percent effect in Glendale, CA
- Working with energy efficiency programs
  - EE programs are often the conduit for utility engagement with customers on demand-related issues
  - Build DR into EE measure implementation (e.g., building or factory control systems)
- Aggregators
  - Can shift and customize the risk-reward balance for different customers
  - Have DR expertise that utilities may lack
  - Active in vertically integrated and wholesale market contexts

Application to Québec: Engage customers

- Couple with energy efficiency programs
  - HQD has improved its programs by including power management for winter peak as an eligible measure in its industrial retrofit EE program
  - HQD should build on this example and integrate DR into its other energy efficiency offerings where cost-effective opportunities exist