Energy Technologies Area Lawrence Berkeley National Laboratory

Demand Response & Smart Grid Research from the Electricity Markets and Policy Group

November 2016

Informing Decision-Makers About the Experiences With and Opportunities for Demand Response Pricing and Programs

Core Demand Response & Smart Grid Staff: Electricity Markets and Policy Group

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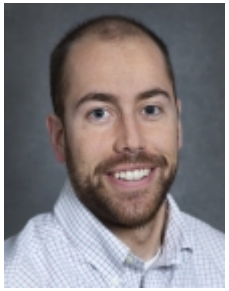

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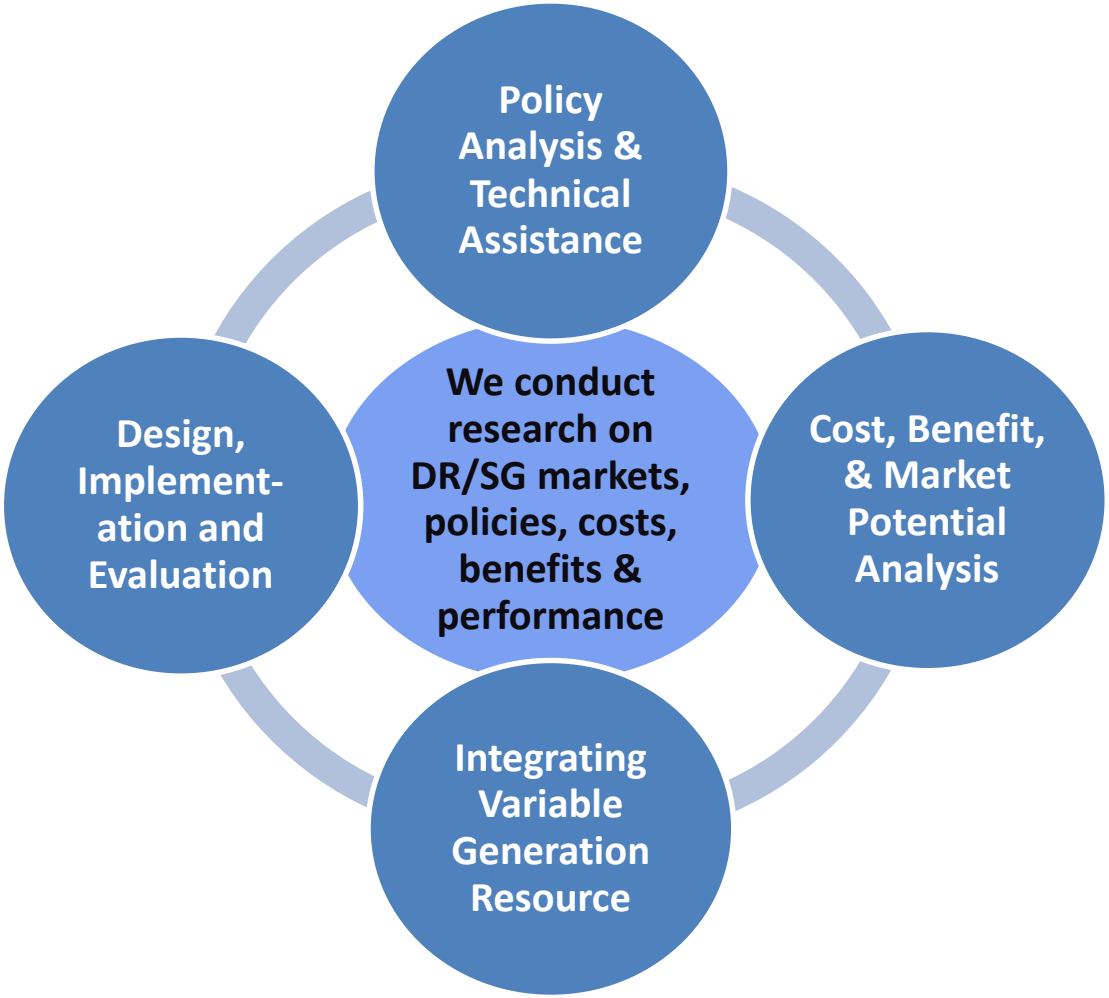
Office of Electricity Delivery and Energy Reliability and Office of Energy Efficiency and Renewable Energy

Emphasis of Demand Response and Smart Grid Research in Electricity Markets and Policy Group



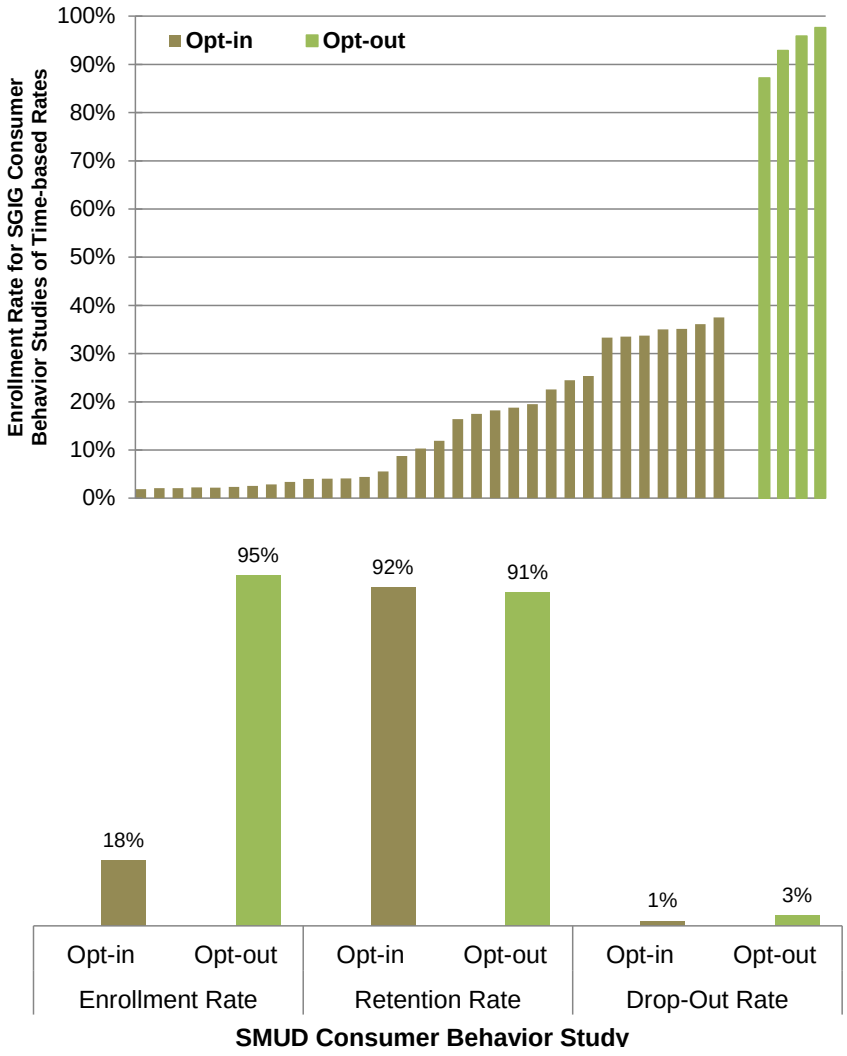
Our work in each of these areas focuses on demand response opportunities and smart grid enabled consumer data & programs

Topic 1. Primary Research on Design, Implementation and Evaluation Experience

Research seeking to better understand key elements of demand response rate and program opportunities as well as technologies enabled by advanced metering infrastructure

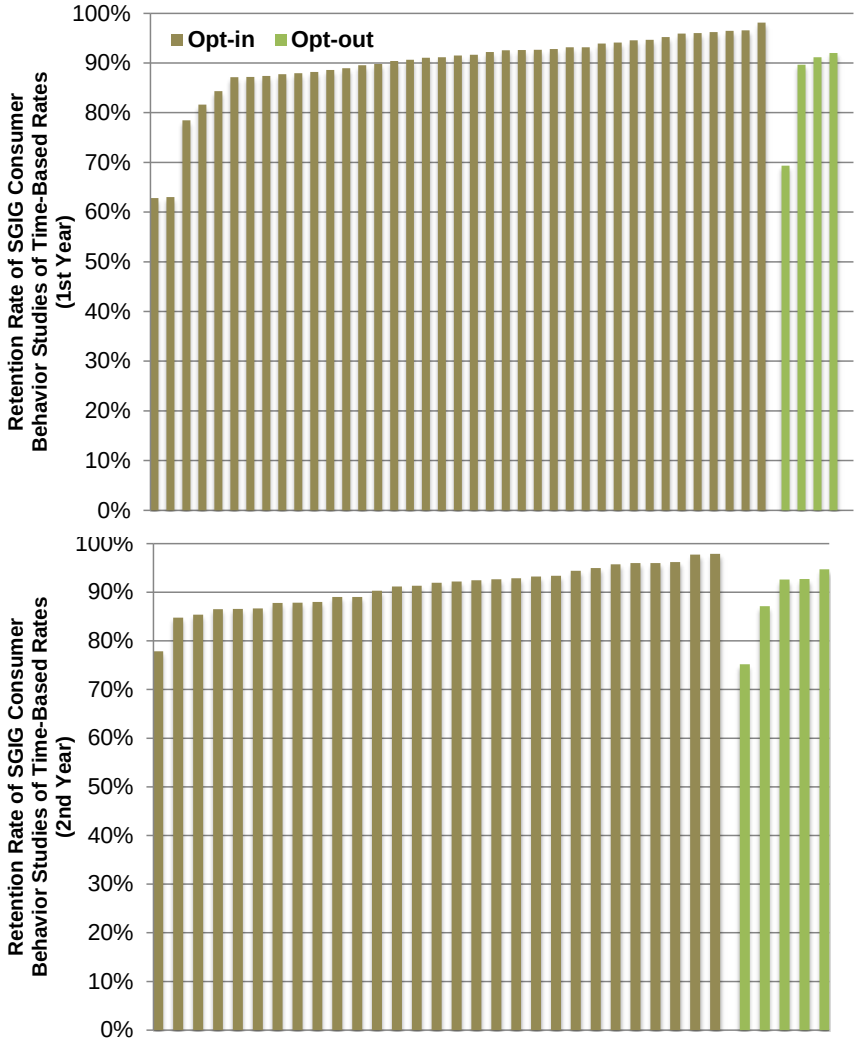
Residential Customers' Preferences for Time-Based Rates

ENROLLMENT



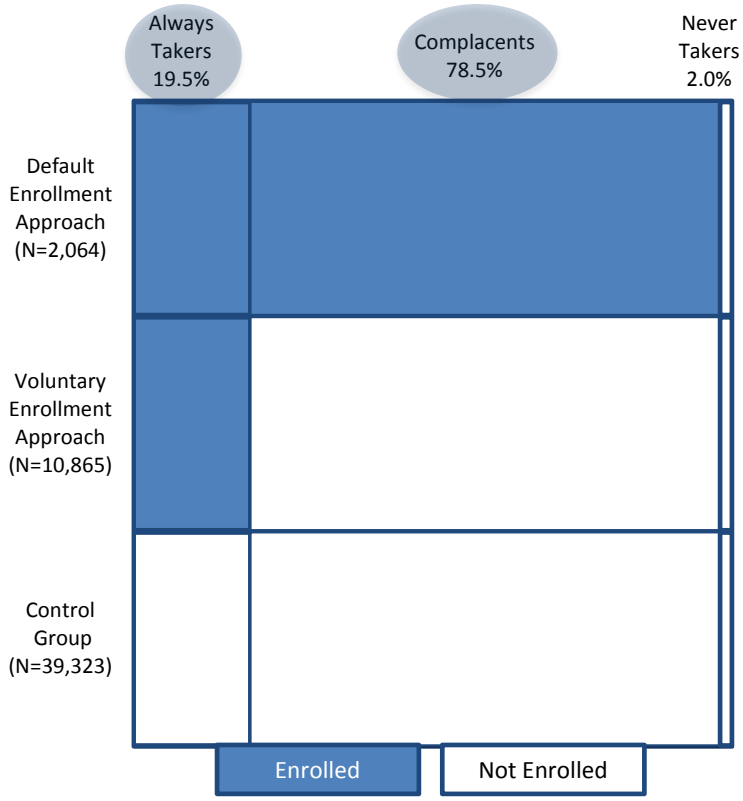
Source: Cappers et al. LBNL Report. 2016.

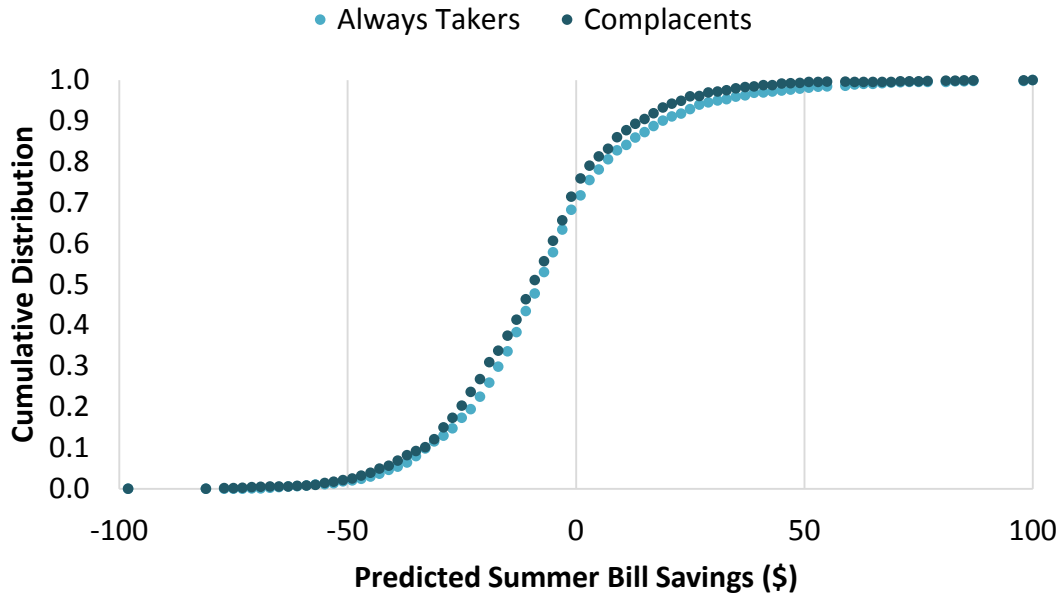
RETENTION

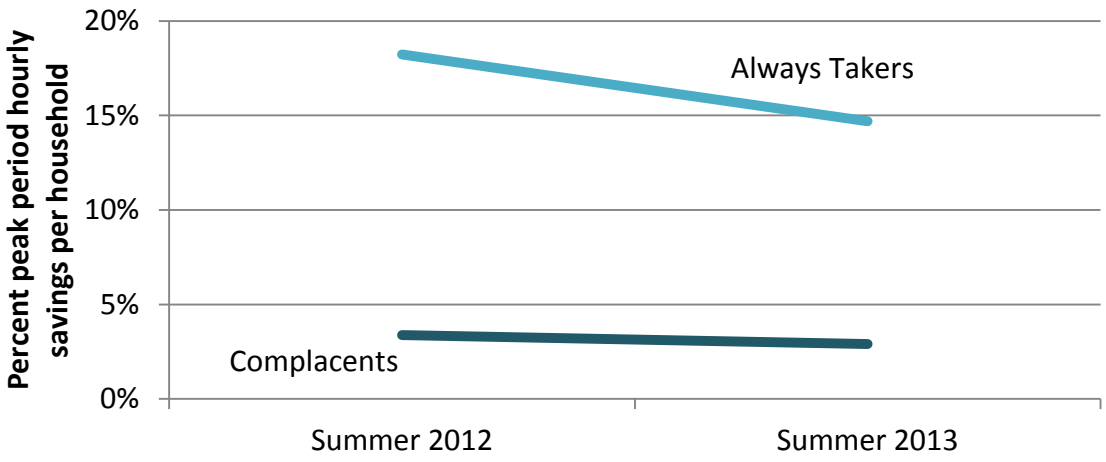


Sources: Cappers et al. LBNL Report. 2016.

Experiences of Customer Subpopulations on Voluntary vs. Default TOU

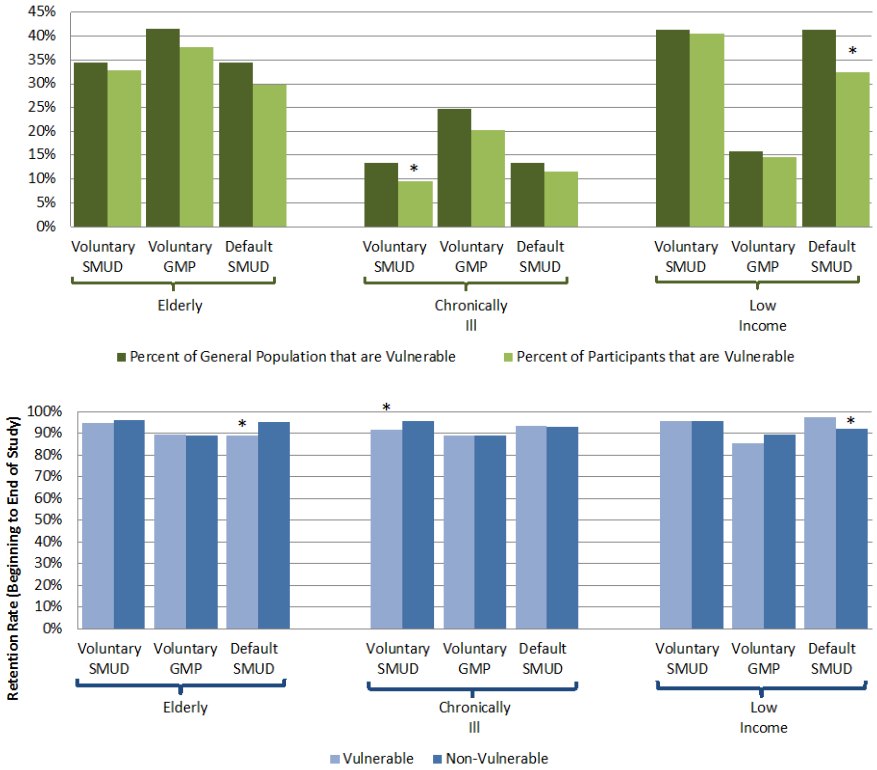




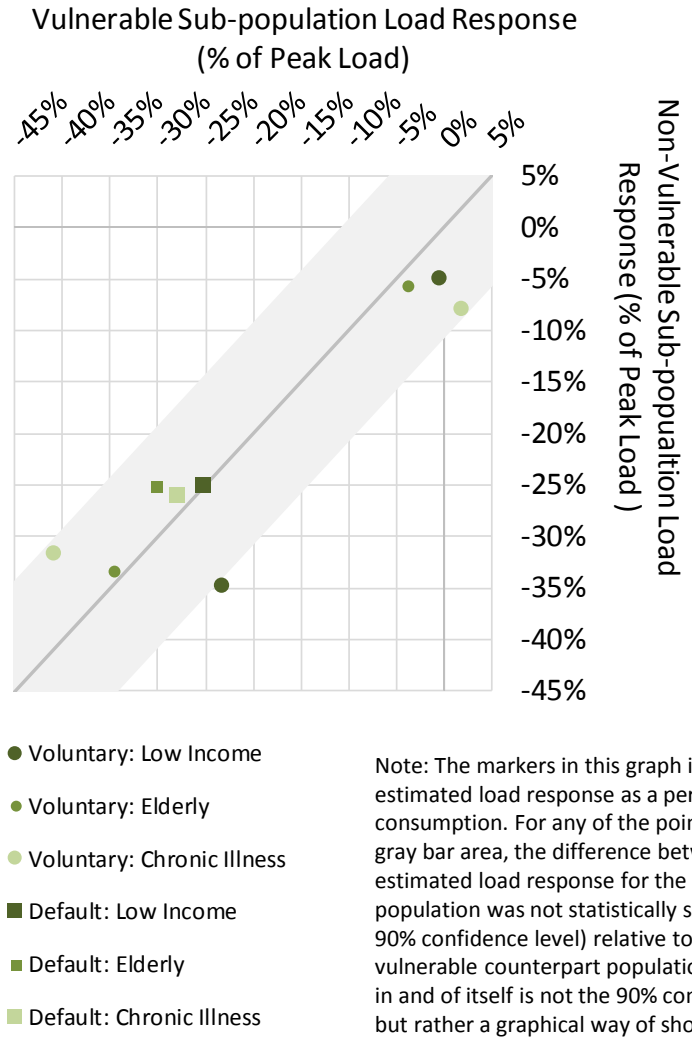


Source: Cappers et al. LBNL Report. 2016.

Experiences of Vulnerable Customer Subpopulations on CPP



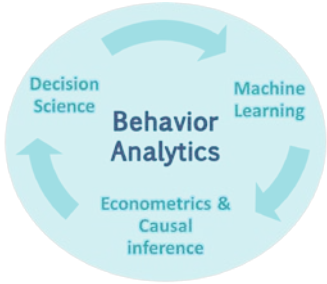
Note: These data are limited to those who responded to the survey. The percent of vulnerable households in the general population are based on those households from the control group that responded to the survey.
* indicates that the difference between the percent of study participants that are vulnerable versus the percent that are vulnerable in the general population are statistically significant at least at the 90% confidence level, all other differences are not statistically significant.



Note: The markers in this graph indicate the estimated load response as a percent of average consumption. For any of the points that lie in the gray bar area, the difference between the estimated load response for the vulnerable population was not statistically significant (at a 90% confidence level) relative to the non-vulnerable counterpart population. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimated differences are statistically significant at the 90% confidence level and which are not.

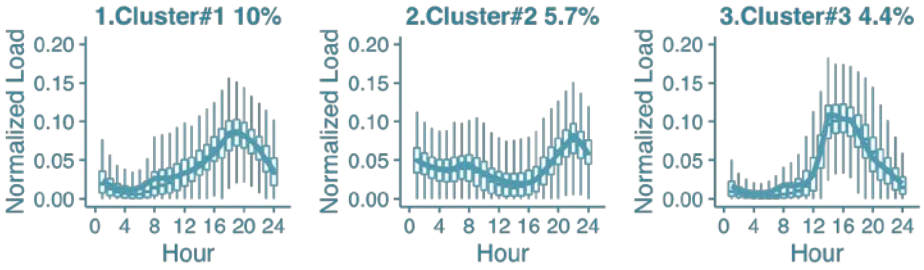
Source: Cappers et al. LBNL Report. 2016.

Behavior Analytics

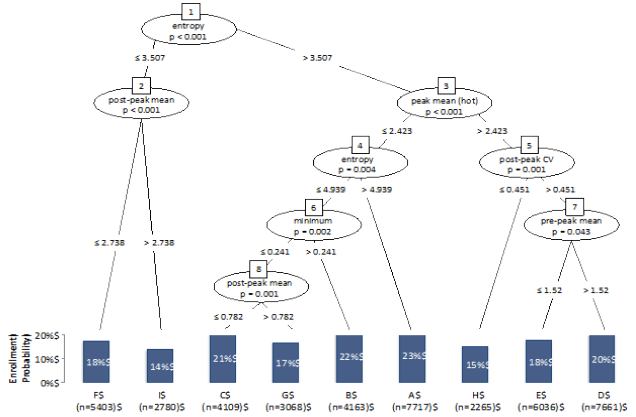


- Machine learning clustering algorithms to understand patterns of discretionary energy consumption.

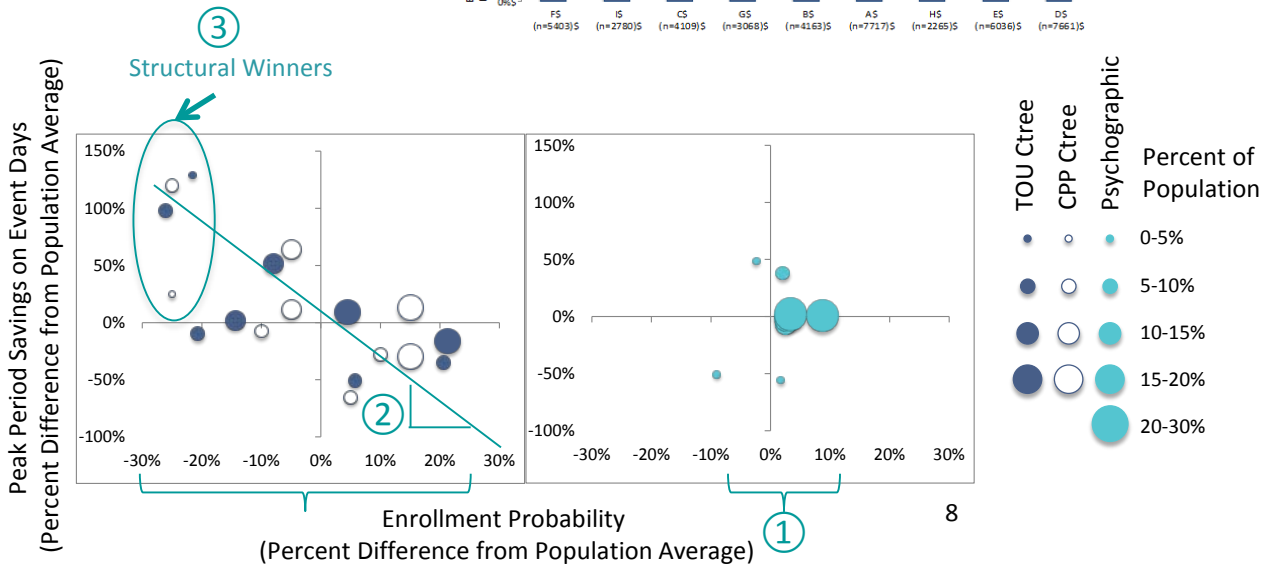
(Top 3 of 99 clusters)



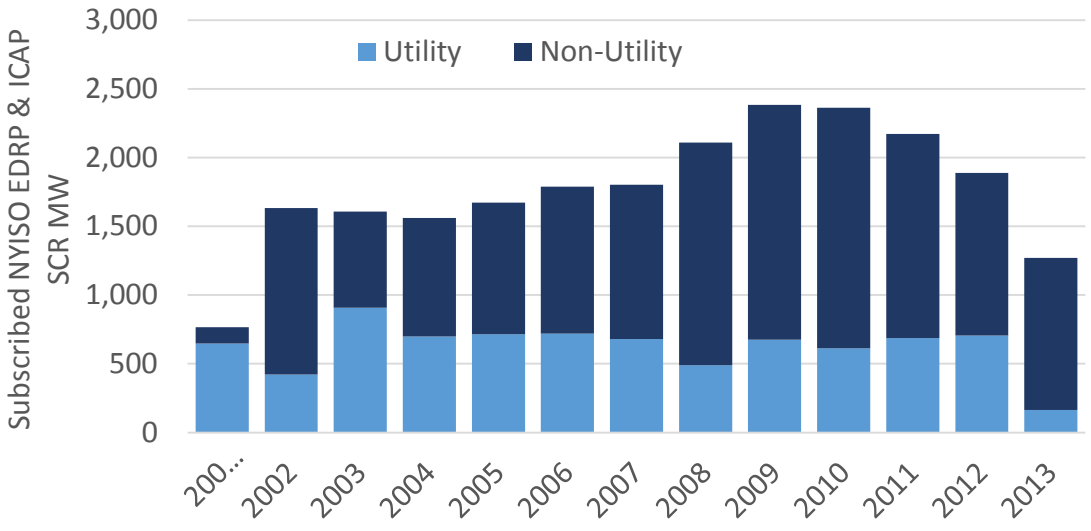
- C-tree algorithm to predict enrollment and create customer segments based only on pre-program energy use metrics.

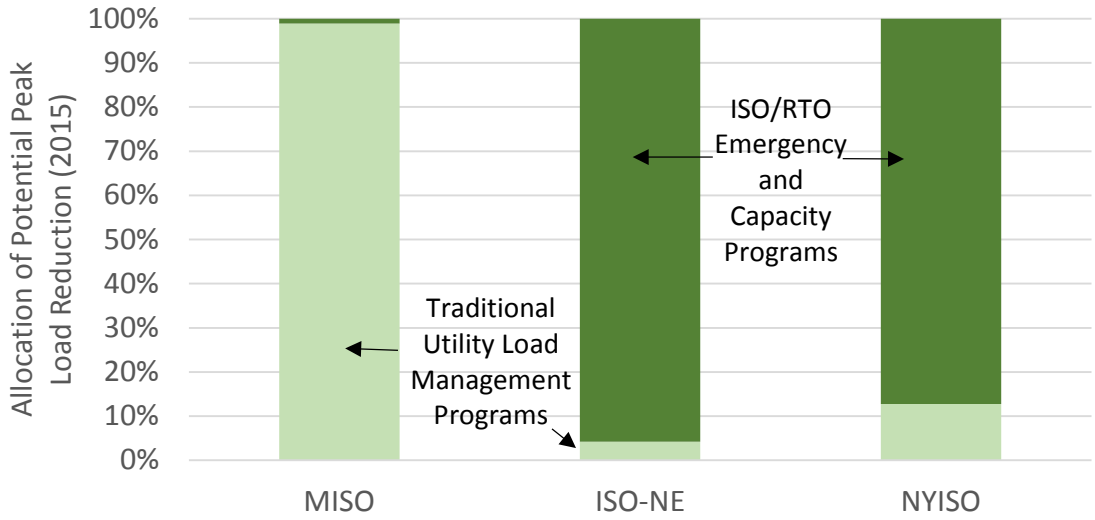


1. This analysis was better at differentiating customers based on their probability of enrolling than traditional psychographic marketing methods.
2. Those that saved the most once enrolled is the program were the least likely to enroll in the first place.
3. Those same groups that were the least likely to enroll were actually structural winners.



DR Experience in ISO/RTOs





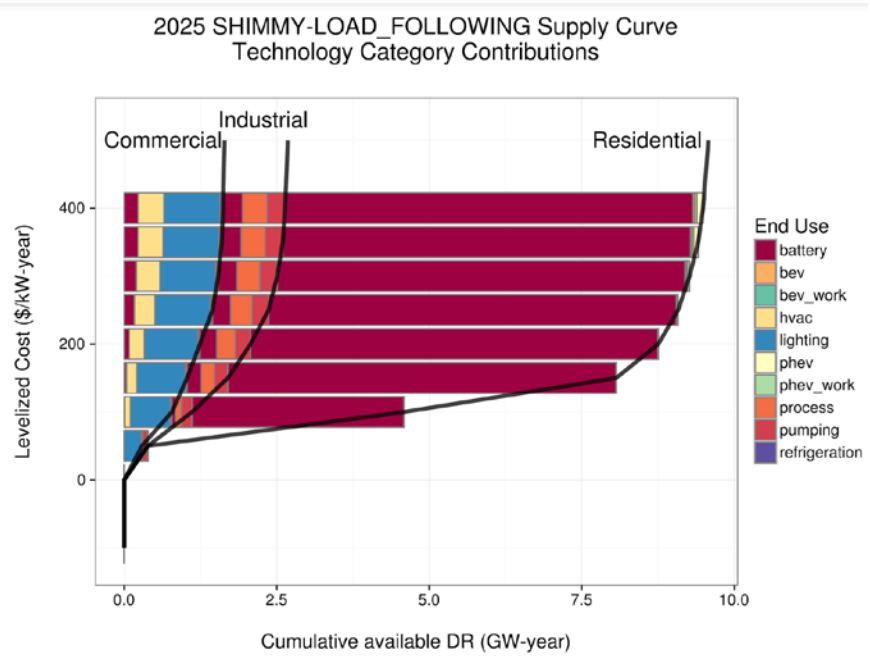
- Where ARCs are allowed to directly enroll customers in ISO/RTO DR programs, they have taken the majority of the market
- Where they are precluded, traditional utility programs still dictate enrollment opportunities
- This has implications for future DR opportunities and enrollment approaches

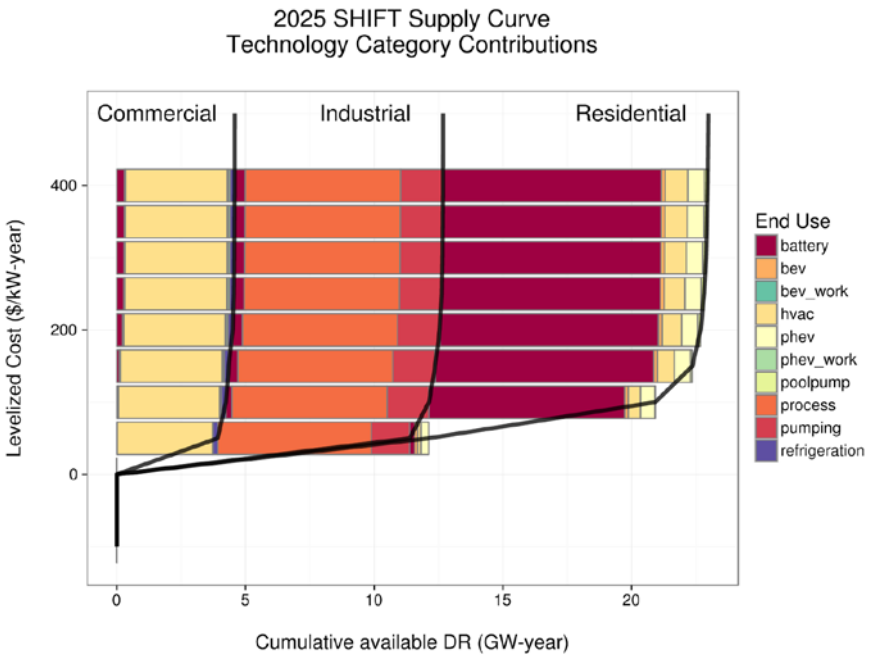
Source: Cappers and Satchwell. LBNL Report. 2015.

Topic 2. Cost, Benefit and Market Potential Analysis

Research seeking to quantify the costs, benefits and market potential of demand response rate and program opportunities as well as technologies enabled by advanced metering infrastructure

California Demand Response Potential

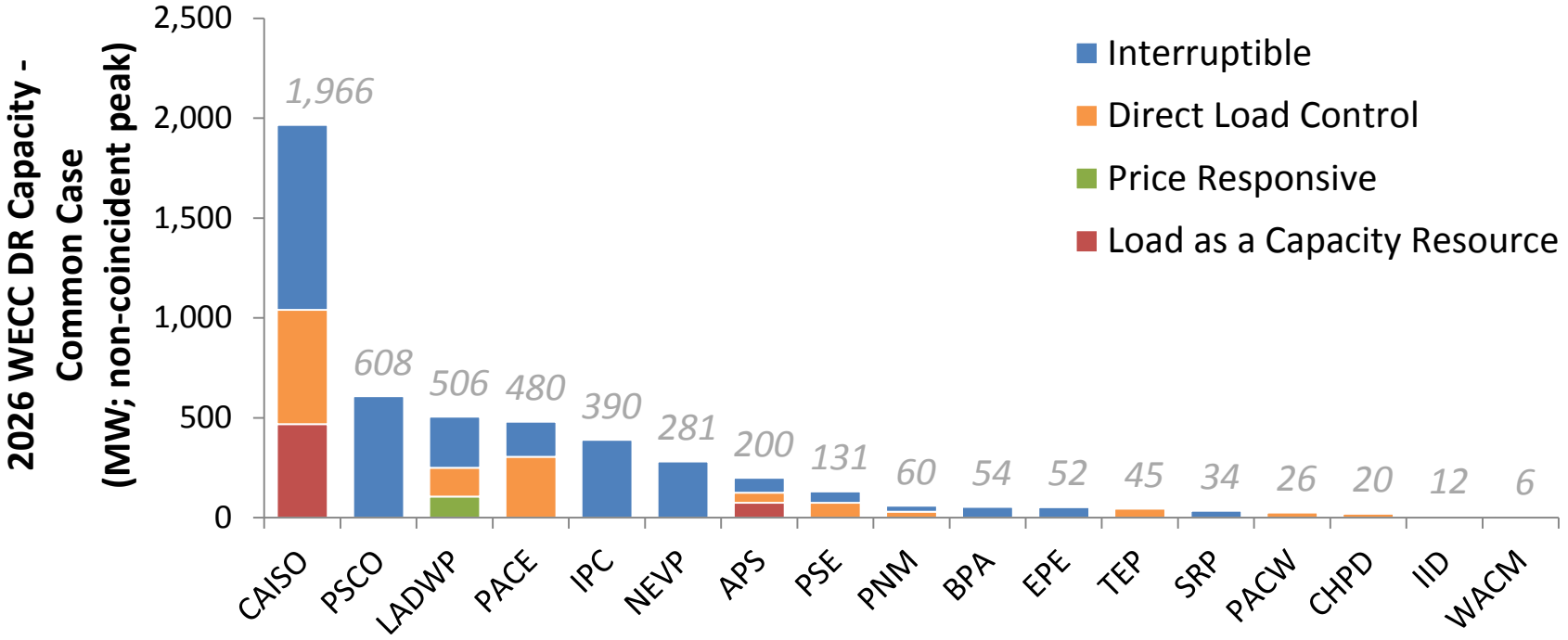




- Two year study conducted to evaluate DR in **bifurcated framework** for the California Public Utility Commission (CPUC)
- LBNL team developed "Demand Response Futures" Model that builds supply curves of DR service types- Shape, Shift, Shed & Shimmy- that provide service to the system
- Identified significant value to the CA system from DR technologies that can "Shift" hourly loads to address duck curve
- Developed extensive database of DR enabling technology costs and performance

Source: Alstone et al. LBNL Report. 2016.

DR in WECC Planning



- LBNL works with WECC staff and the State and Provincial Steering Committee (SPSC) to develop DR assumptions and modeling inputs for WECC's regional transmission planning studies
- Two types of DR modeling assumptions required for each study case:
  - **DR resource quantities**: How much DR is available to be dispatched in any given hour for each load zone?
  - **DR dispatch mechanics**: When is the DR dispatched and how does it affect hourly loads and peak demand?

Source: Satchwell et al. LBNL Report. 2013.

Topic 3. Integrating Variable Generation Resource

Research seeking to understand the role demand response rate and program opportunities can play in managing the integration of variable generation resources at the bulk and distribution system levels

Opportunities for DR to Provide Bulk Power System Services & Integrate VG Resources

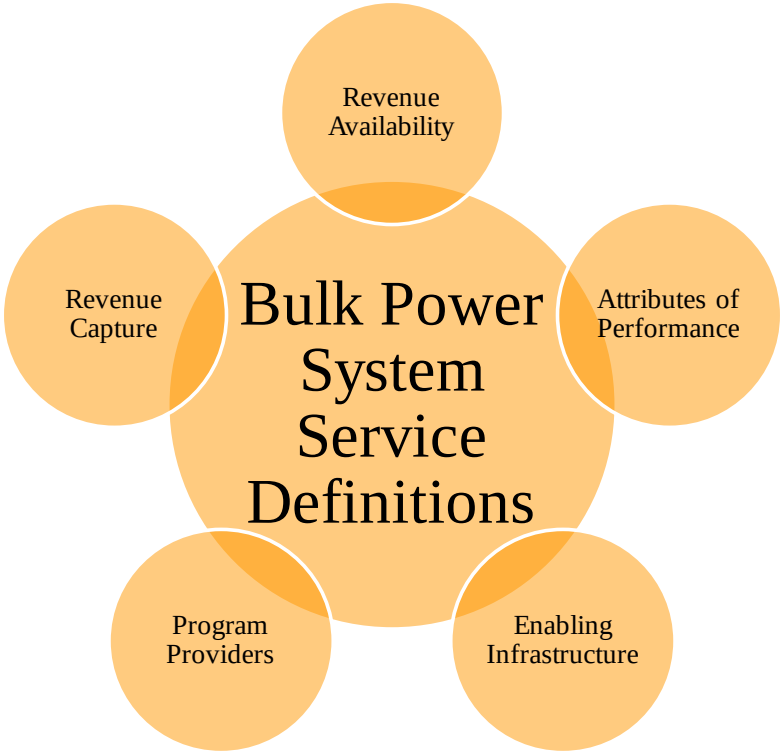
Bulk Power System Service	DLC	Emergency DR	Capacity	Energy	Ancillary Services	TOU	CPR	CPP	DA-RTP	RT-RTP
Spinning Reserves	○				○					
Supplemental Reserves	○	○			○					
Regulation Reserves					○					
Imbalance Energy	◉			○						○
Hour-ahead Energy	◉			○						○
Multi-hour Ramping	○								○	○
Day-ahead Energy	◉			○					○	○
Over-generation	○								○	○
Resource Adequacy	●		○			○	◉	◉	○	○

Variable Generation Integration Issue	DLC	Emergency DR	Capacity	Energy	Ancillary Services	TOU	CPR	CPP	DA-RTP	RT-RTP
1 Min. to 5 – 10 Min. Variability	○				○					
<2 hr Forecast Error	◉	○		○	○					○
Large Multi-hour Ramps	◉			○						○
>24 hr Forecast Error	○			○						○
Variation from Avg. Daily Energy Profile		○	○	○			◉	◉	○	○
Avg. Daily Energy Profile by Season						◉			○	○

	Currently not offered and unlikely to be offered in the future
○	Currently not offered or offered only on a very limited basis but could be offered more in the future
◉	Currently offered on a limited basis and could be expanded in the future
●	Currently offered on a wide-spread basis and likely to be continued in the future

Source: Cappers et al. Energy Policy. 2012.

Market and Policy Barriers for DR as Ancillary Service Provider



	Reliability Council	BA	IOU	ARC	Utility Regulator	End-use Customer
Bulk Power System Service Definitions	✸	✸,●	●	●		
Attributes of Performance		✸	●	●		●
Enabling Infrastructure Investments		✸	●	●		●
Revenue Availability		✸	●	●		
Revenue Capture		✸	●	●		●
Program Providers		✸	●	●	✸	●

✸ - Entity/Organization responsible for creating the barrier
● - Entity/Organization affected by the barrier

	Change Definition	Change Require-ment	Change Process	Reduce Costs	Increase Benefits
Bulk Power System Service Definitions	◆				
Attributes of Performance		◆			
Enabling Infrastructure Investments		◆		□	
Revenue Availability					◆
Revenue Capture		◆			
Program Providers			◆	□	□

◆ - Primary action to overcome barrier
□ - Secondary action to overcome barrier

Source: Cappers et al. Energy Policy. 2013.

Opportunities and Challenges with Using DR In Distribution System Planning and Operations

Current DR Signals Lack Geographic Specificity

Distribution System Service	Max Capacity Relief	Emergency Load Transfer	Voltage Management	Outage Recovery	Power Quality	Phase Balancing
TOU	•	•	•	•	•	•
CPP	•	•	•	•	•	•
DA-RTP	•	•	•	•		•
RT-RTP	•	•	•	•		•
Disconnectable	•	•	•	•		•
Configurable	•	•	•	•	•	•
Manual	•	•	•	•	•	•
Behavioral	•	•	•	•	•	•

Ineffective at providing distribution system service

Add Geographic Specificity to DR Signal

Distribution System Service	Max Capacity Relief	Emergency Load Transfer	Voltage Management	Outage Recovery	Power Quality	Phase Balancing
TOU	•		•	•	•	•
CPP	○		•	•		•
DA-RTP	○		•	•		•
RT-RTP	○	•	•	•	•	•
Disconnectable	●	◎	◎	◎	•	•
Configurable	○	•	•	•	•	•
Manual	○	•	•	•	•	•
Behavioral	•	•	•	•	•	•

Highly effective at providing distribution system service

Reasonably effective at providing distribution system service

Source: Cappers et al. LBNL Report. 2015.

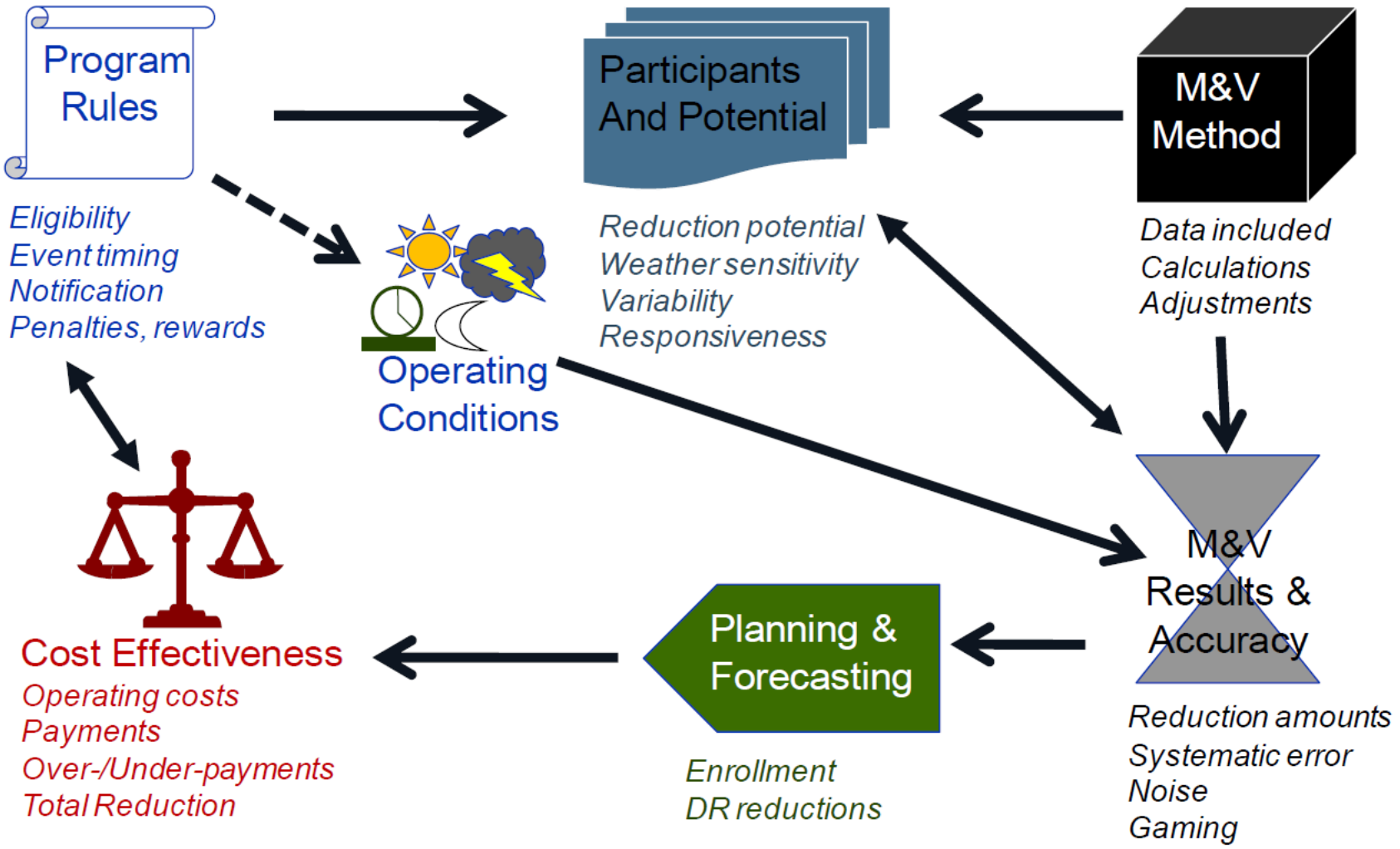
Topic 4. Policy Analysis and Technical Assistance

Research seeking to understand the role demand response rate and program opportunities can play in managing the integration of variable generation resources at the bulk and distribution system levels

State and Federal DR Policy Assistance

- LBNL conducts technical analysis & advises states and the federal government on DR rate and program design → typically linked to our research, as presented earlier
- Areas include: time-based rate and incentive-based program design, consumer engagement, AMI deployment and regulatory treatment of costs and benefits, and smart meter health effects
- Examples:
  - New York time-based rate pilots and consumer engagement
  - Michigan demand response potential studies
  - Ohio AMI and consumer engagement
- Regularly brief policy-makers on our work: e.g., NGA, OMB, CEA, CEQ

FERC-DOE National Forum on DR



Source: Goldberg and Agnew. FERC-DOE Report. 2013.

AMI Deployment Issues

Smart Metering

1. The cost effectiveness or business case for advanced meters is typically justified through reductions in system operating costs or expenses.
2. Internal utility meter reader labor issues have typically been resolved through well planned transition strategies.
3. Adverse customer acceptance issues typically result from inadequate advance customer education, notice, and data validation.
4. Advanced meters appear to be delivering reliable, accurate performance. Meter data applications are beginning to yield additional benefits not included in original business cases.
5. Smart meters with integrated home area networks (HANs) have technical and regulatory policy issues which challenge expectations.
6. Technical options are available to support demand response, pricing, and renewable integration.

Consumer Engagement

1. Customer engagement in regulated environments is not well understood primarily because "benefits" are typically derived from policy and technology decisions directed at the utility system, rather than the customer.
2. Customer engagement and education are inseparable long-term propositions. There is no single solution or quick fix.
3. Energy savings and educational expectations for in-home displays (IHDs) and access to near real-time meter data are not necessarily supported by existing research

Security and Privacy

1. Cyber security is an unresolved complex, evolving multi-jurisdictional effort to protect the electric system physical assets.
2. Privacy is a complex effort to protect the information gathered in support of electric service delivery.
3. Cyber security risks can impact all grid-related technology and communication options.

Source: Levy. LBNL Presentation. 2013.

Conclusions

The Value of and Audiences for Our Work Are Multifaceted

- Diverse product types
  - Direct assistance to policymakers, on request
  - Foundational data collection
  - Rigorous analysis of underlying data
  - Other selected research efforts where a need exists
- Diverse audiences: from international regulators to local policymakers, and from utility managers to academics
- Three over-riding goals
  - Stay nimble to be responsive to emerging issues
  - Maintain a mix of “foundational” and “intellectual” work
  - Emphasize rigor, objectivity, and independence

Questions?

Peter Cappers

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To hear more about our work:

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- Sign up to our email list: https://emp.lbl.gov/join-our-mailing-list

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