The Brattle Group

Direct Load Control of Residential Air Conditioners in Texas

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Austin, TX

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Outline

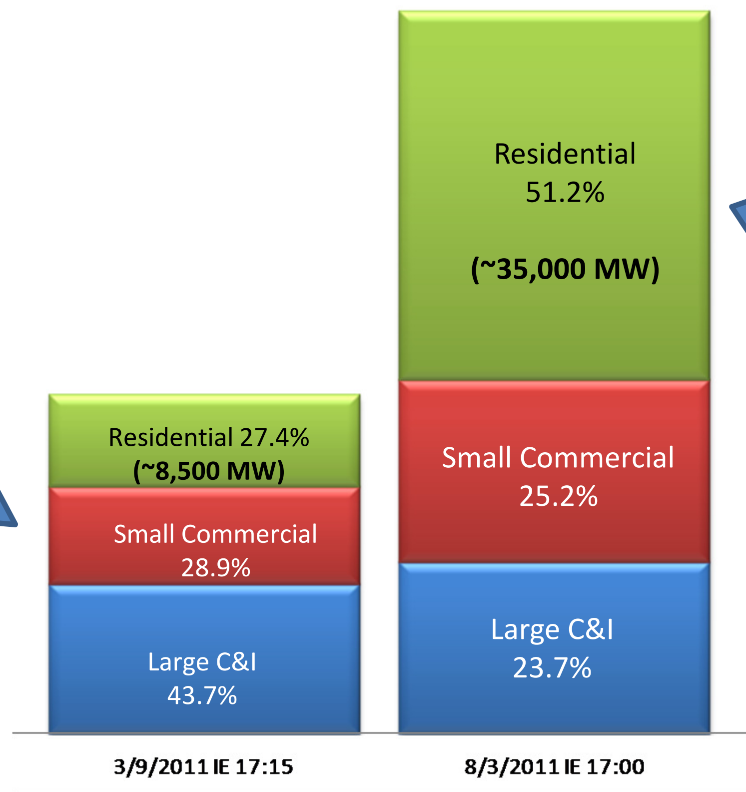
- DR for the Texas mass market
- The national DLC landscape
- DLC in Texas - today
- DLC in Texas - 3 years out
- The way forward - alternative pathways

DR for the Texas mass market

During summer peak times, the mass market can account for over 75% of ERCOT's electricity demand

ERCOT Electricity Demand

During cool months, the mass market is less than 60% of ERCOT's demand



During summer peak hours, A/C load pushes the mass market to over 75% of ERCOT's 68,000 MW of demand (and residential customers represent more than half of the total)

Source: ERCOT

Notes:
Customer class breakdown is for competitive choice areas; percentages are extrapolated for munis and co-ops to achieve region-wide estimate
Large C&I are IDR Meter Required (>700kW)

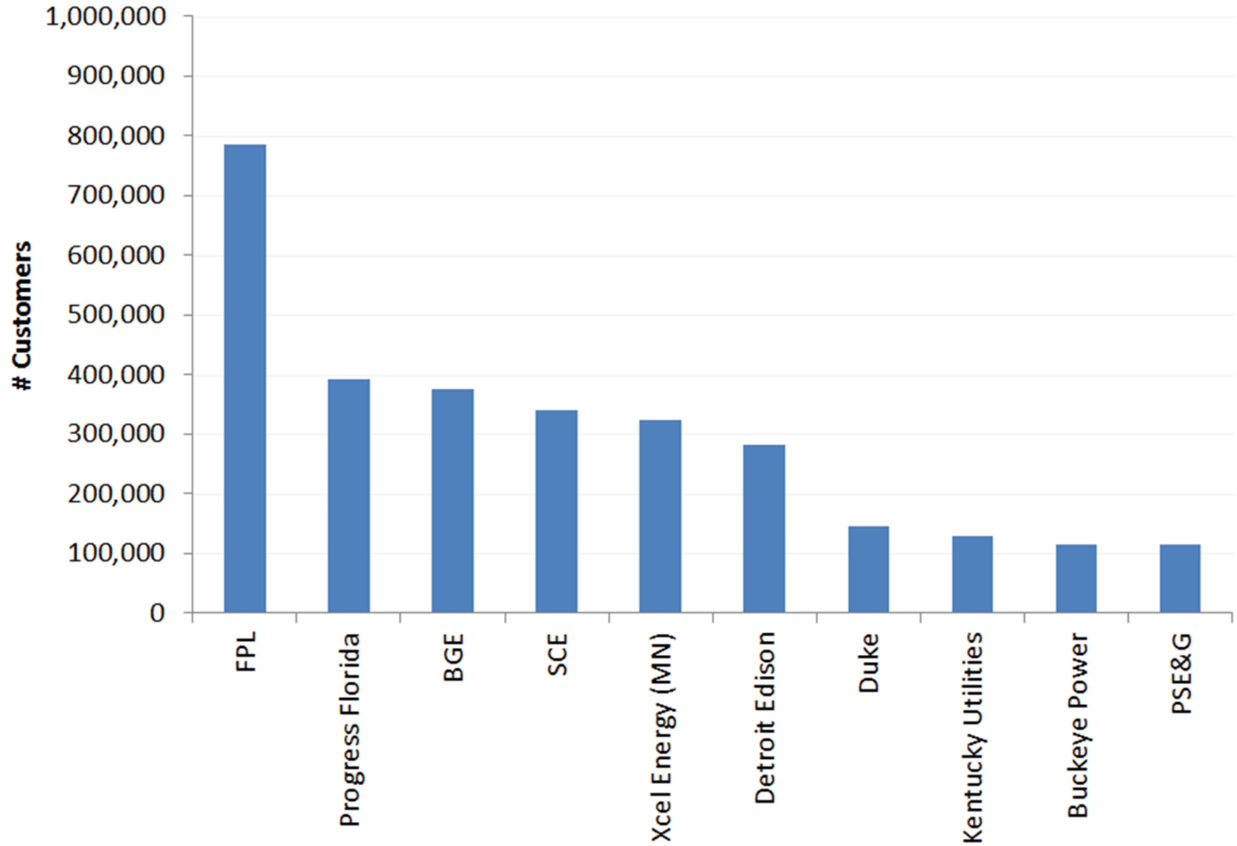
Direct load control (DLC) can help to address ERCOT's residential air-conditioning-driven peak

- Central air conditioners (CACs) would be controlled through a switch on the compressor or smart thermostat
- The CACs would be cycled on and off or the smart thermostat would be set back by a few degrees
- Participants would be told that this would happen up to 10 times a year and for no more than 4 hours per event
- Participation incentives would range from a free smart thermostat to monthly payments
- The DLC program would be offered on a voluntary (opt-in) basis
- When aggregated across all participants, the DLC program would lower peak demand substantially and avoid or defer new generation and network capacity investments

The national DLC landscape

The largest residential DLC programs in the U.S. have enrolled hundreds of thousands of participants

Enrollment in the 10 Largest Residential DLC Programs

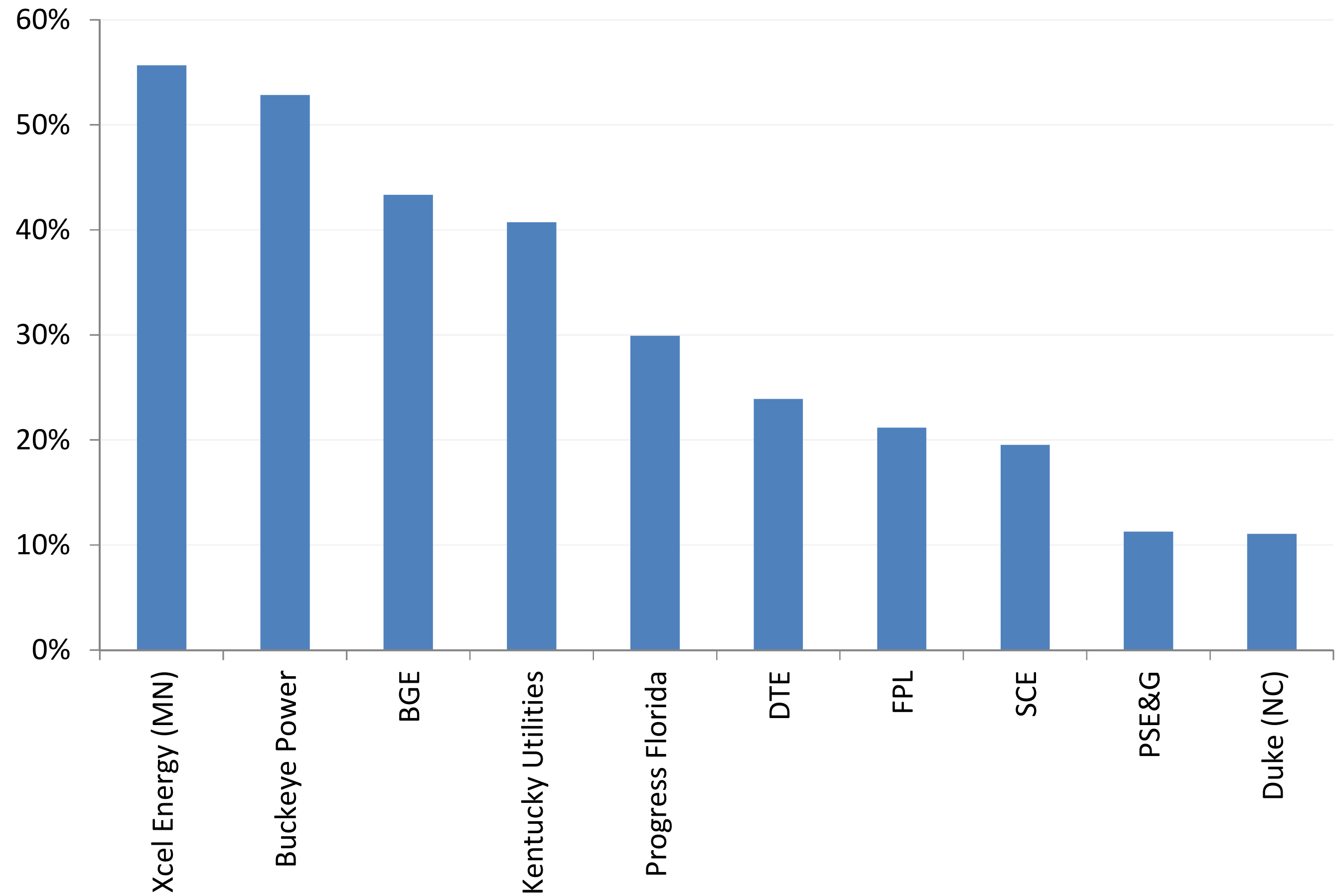


FERC has identified over 300 residential DLC programs being offered around the country, with more than 5 million total participants

Source: FERC 2010 Assessment of Demand Response & Advanced Metering
Note: KU appears to be mischaracterized as C&I in FERC database, assumed to be residential

These large residential DLC programs have achieved at least 10% to 30% enrollment rates

Enrollment (% of Eligible) in 10 Largest Residential DLC Programs

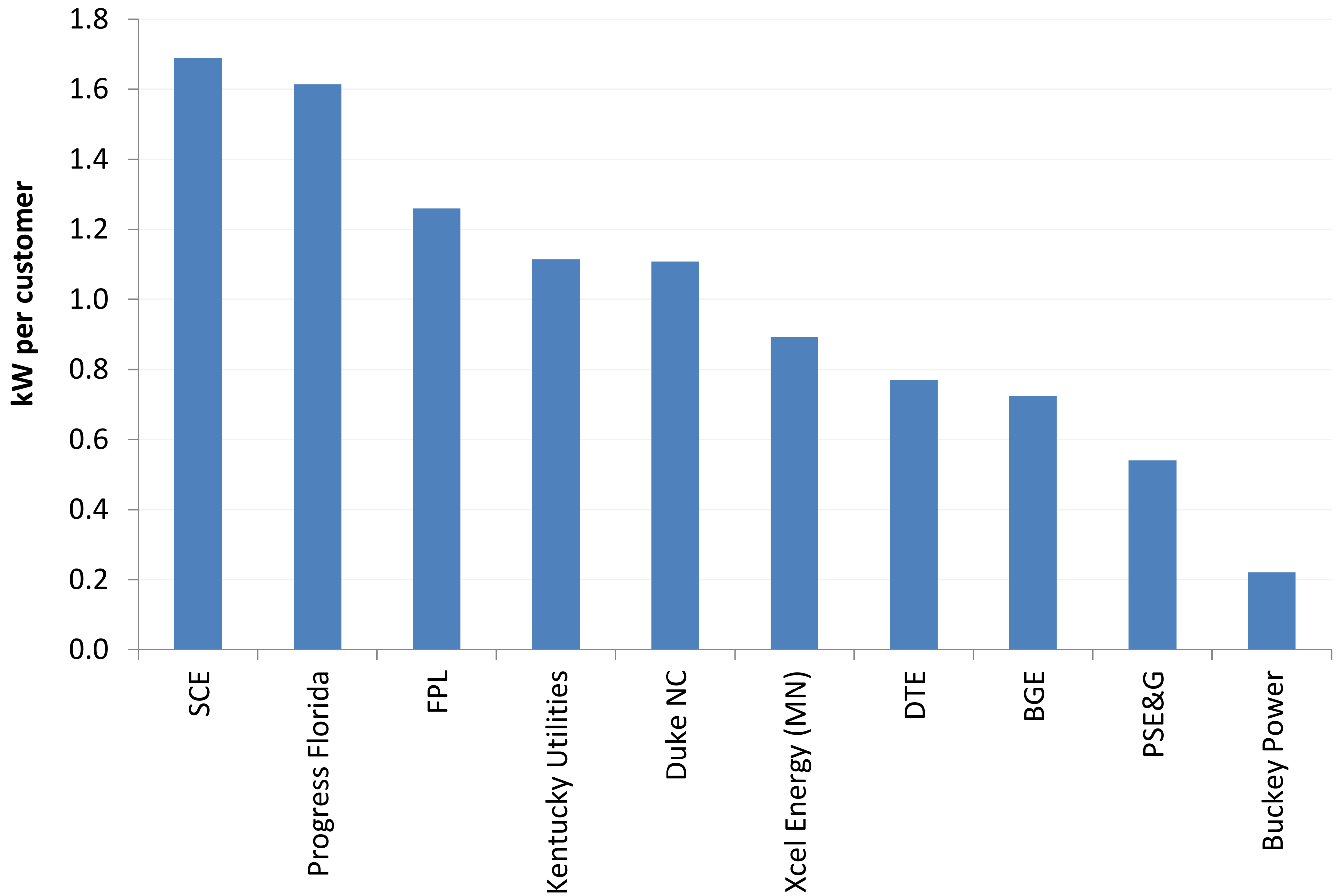


Source: FERC 2010 Assessment of Demand Response & Advanced Metering

Note: Utility-level CAC saturations were used where available. Otherwise, state-level estimates were taken from FERC's 2010 Assessment of DR Potential

An average impact of between 0.8 and 1.5 kW is achievable for residential DLC programs

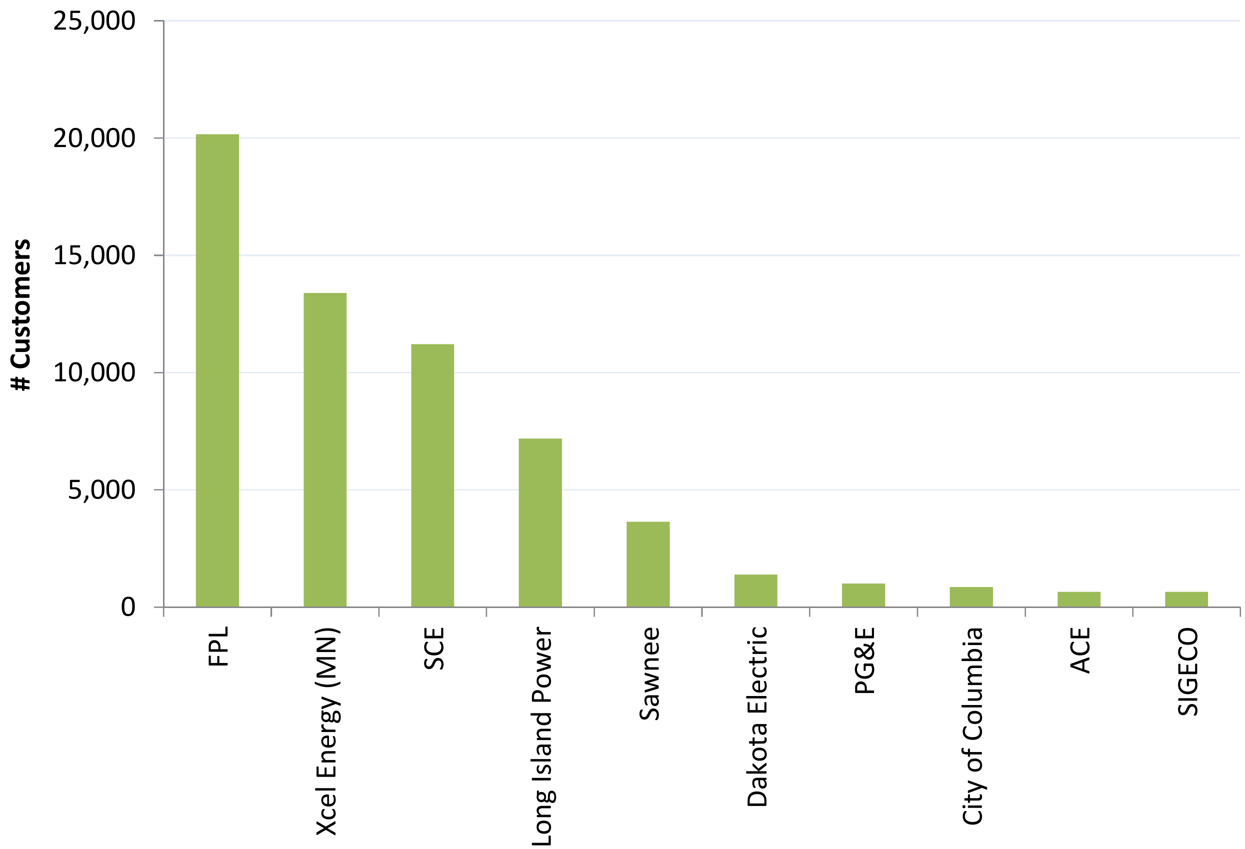
Per-customer Load Drop in 10 Largest Residential DLC Programs



Source: FERC 2010 Assessment of Demand Response & Advanced Metering

Small C&I customers are also enrolled in DLC programs, although to a lesser extent

Enrollment in 10 Largest C&I DLC Programs

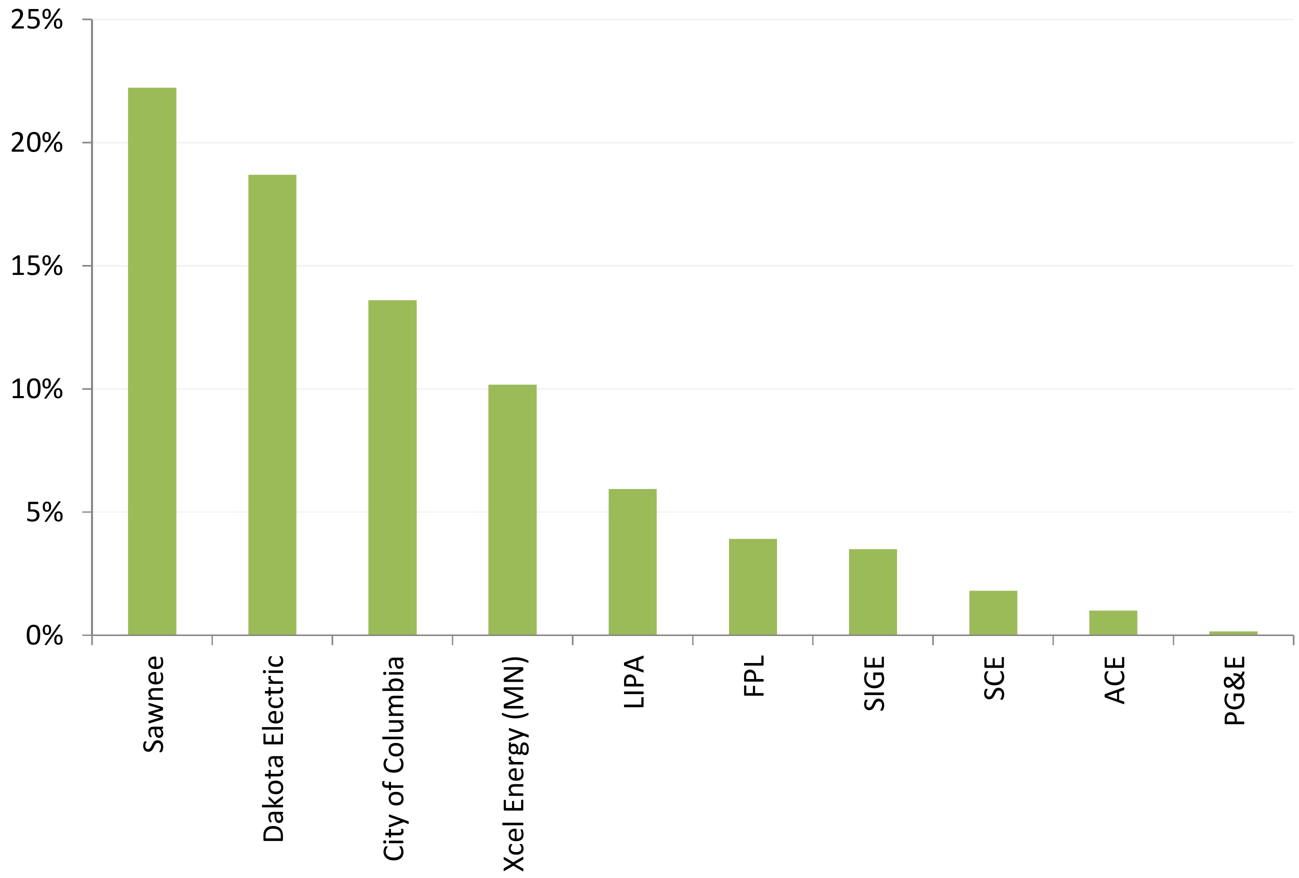


FERC has identified over 100 C&I DLC programs being offered around the country, with more than 75,000 total participants

Source: FERC 2010 Assessment of Demand Response & Advanced Metering; excludes irrigation control

Enrollment of 5% to 10% is achievable for small C&I DLC programs

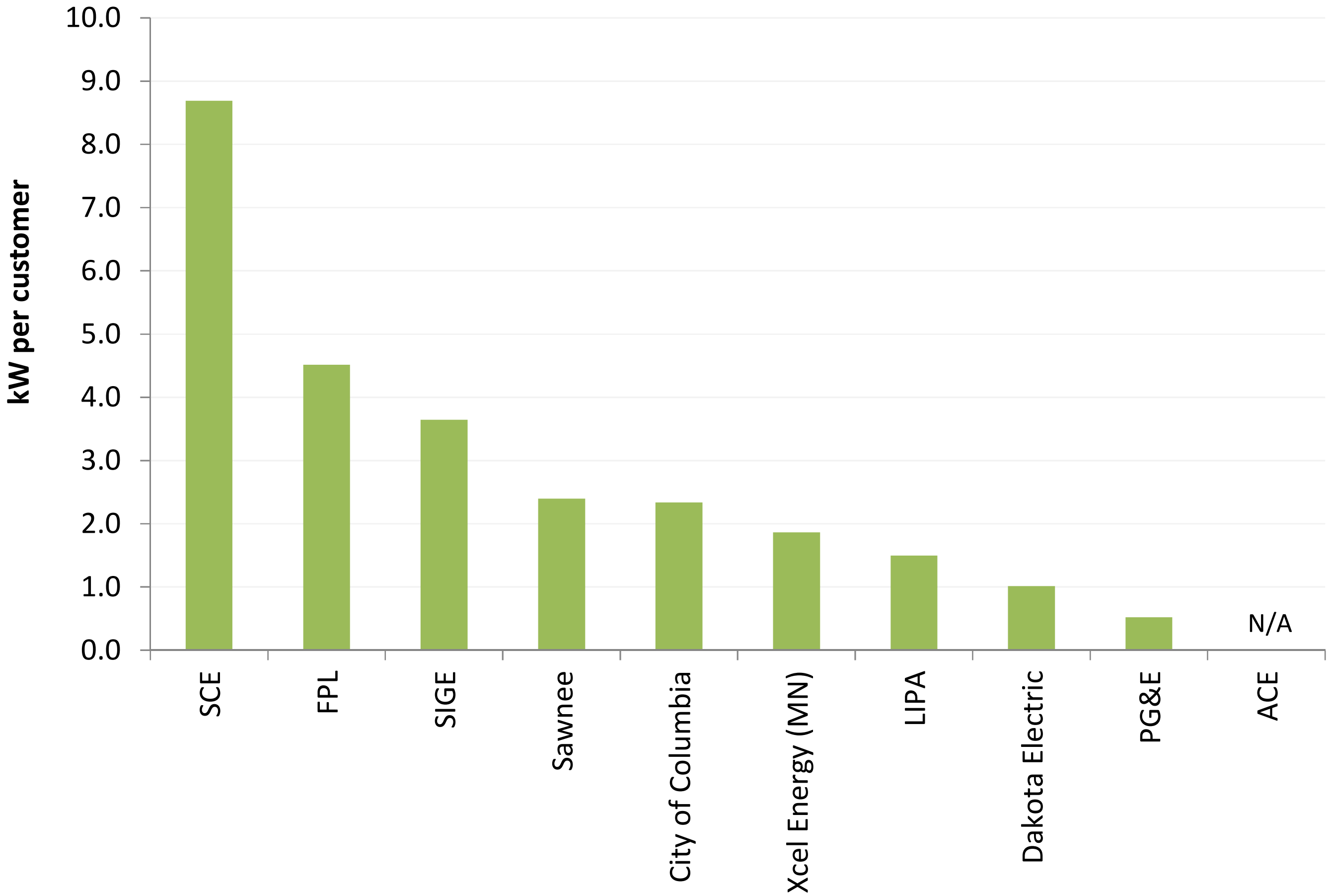
Enrollment (% of Eligible) in 10 Largest C&I DLC Programs



Source: FERC 2010 Assessment of Demand Response & Advanced Metering

An average impact of between 2 kW and 4 kW is achievable in small C&I DLC programs

Per-customer Impact in 10 Largest C&I DLC Programs

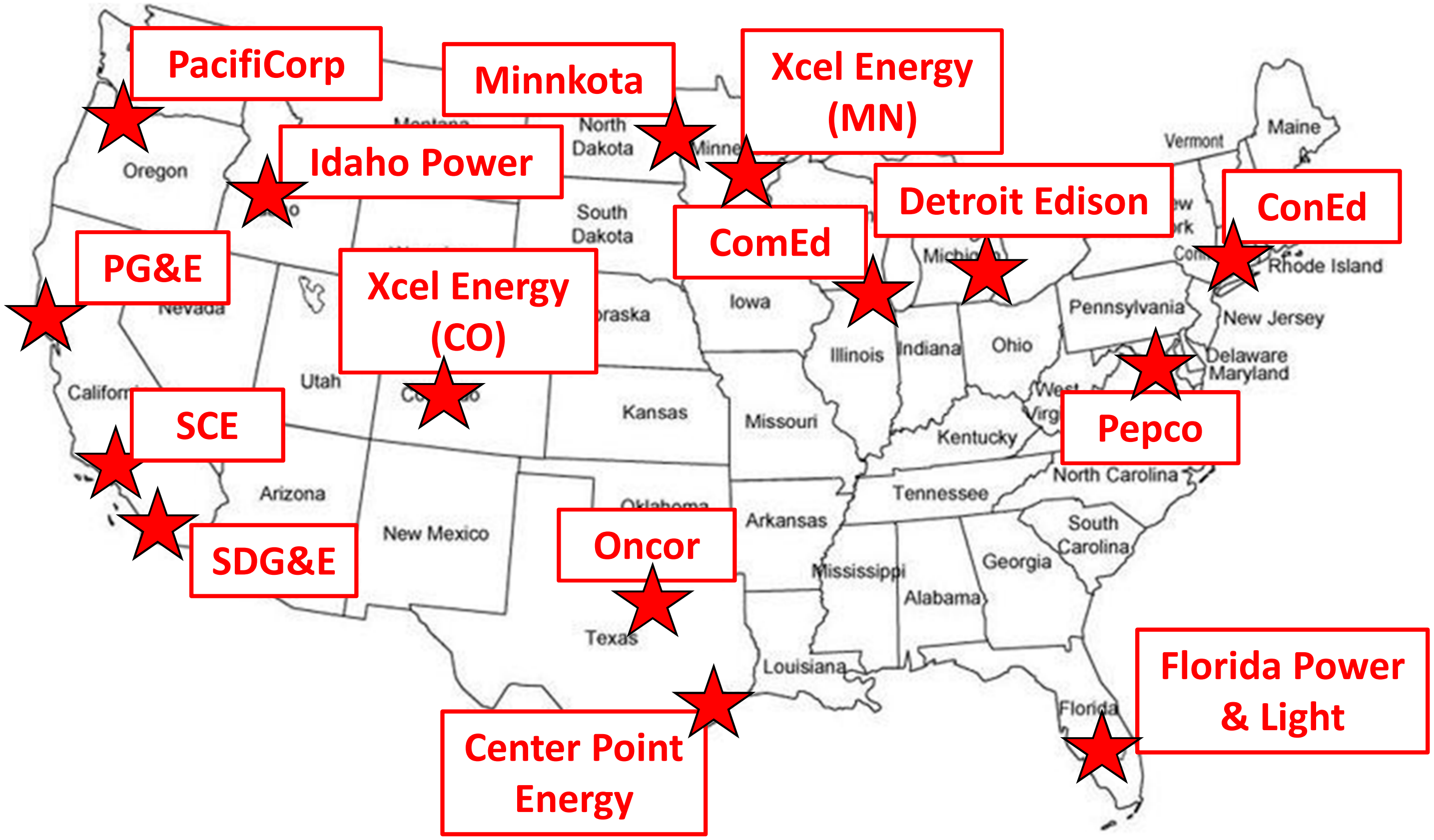


Source: FERC 2010 Assessment of Demand Response & Advanced Metering

Note: Impact data not available for Atlantic City Electric

To obtain additional information about the DLC landscape, we surveyed several utilities and other stakeholders

Utilities Surveyed by Brattle



Other Stakeholders

- Centerpoint
- Comverge
- Consert
- ERCOT Staff
- Honeywell
- Oncor

Our survey was designed to assess several key mass market DLC issues

- Program objectives
- Operational characteristics
- Adoption rates and system impacts
- Incentives
- Marketing strategy
- Barriers to greater adoption
- Participant fatigue
- Lessons learned in implementation
- Plans to expand the program, combine it with dynamic pricing, or further promote flexible demand

Findings of the survey (I)

- DLC is widespread throughout the US and exists in both organized markets and regulated markets
- DLC is mostly being used for reliability purposes
  - In some cases it is being repurposed for economic dispatch purposes
- Recruitment incentives take a variety of forms including a one-time sign-up payment, free hardware installation and a recurring annual payment
  - Some programs are considering switching to a pay-for-performance mode
  - Participation rates in the 10-30% range can be expected if well designed programs are also well executed

Findings of the survey (II)

- Compensation becomes increasingly important in hotter climates
- Compensation package should include
  - Equipment installation at no cost to customer (for external cycling devices estimated equipment & installation cost is $300/unit)
  - One-time payments vary across surveyed programs--$50/year is the most likely lower bound to attract sufficient attention from ERCOT customers
  - Per-event compensation and other performance-based payments can also be considered given adequate M&V capabilities
  - Opt-out penalties should reflect program impacts

Findings of the survey (III)

- DLC is commonly offered as on opt-in voluntary program
- At least one state agency in California considered making it mandatory in new dwellings by invoking its load management standard setting authority
- DLC can be combined with dynamic pricing for optimum impact
  - OGE in Oklahoma is deploying smart thermostats with dynamic pricing and hopes to reach 20 percent of its residential customers in three years

Findings of the survey (IV)

- DLC can be deployed through compressor switches or smart thermostats
- DLC with AMI can ensure two-way communication and improve the measurement and verification of impacts and the identification of dead units

DLC in Texas - today

Two of the municipal utilities in Texas are running mass market DLC programs today

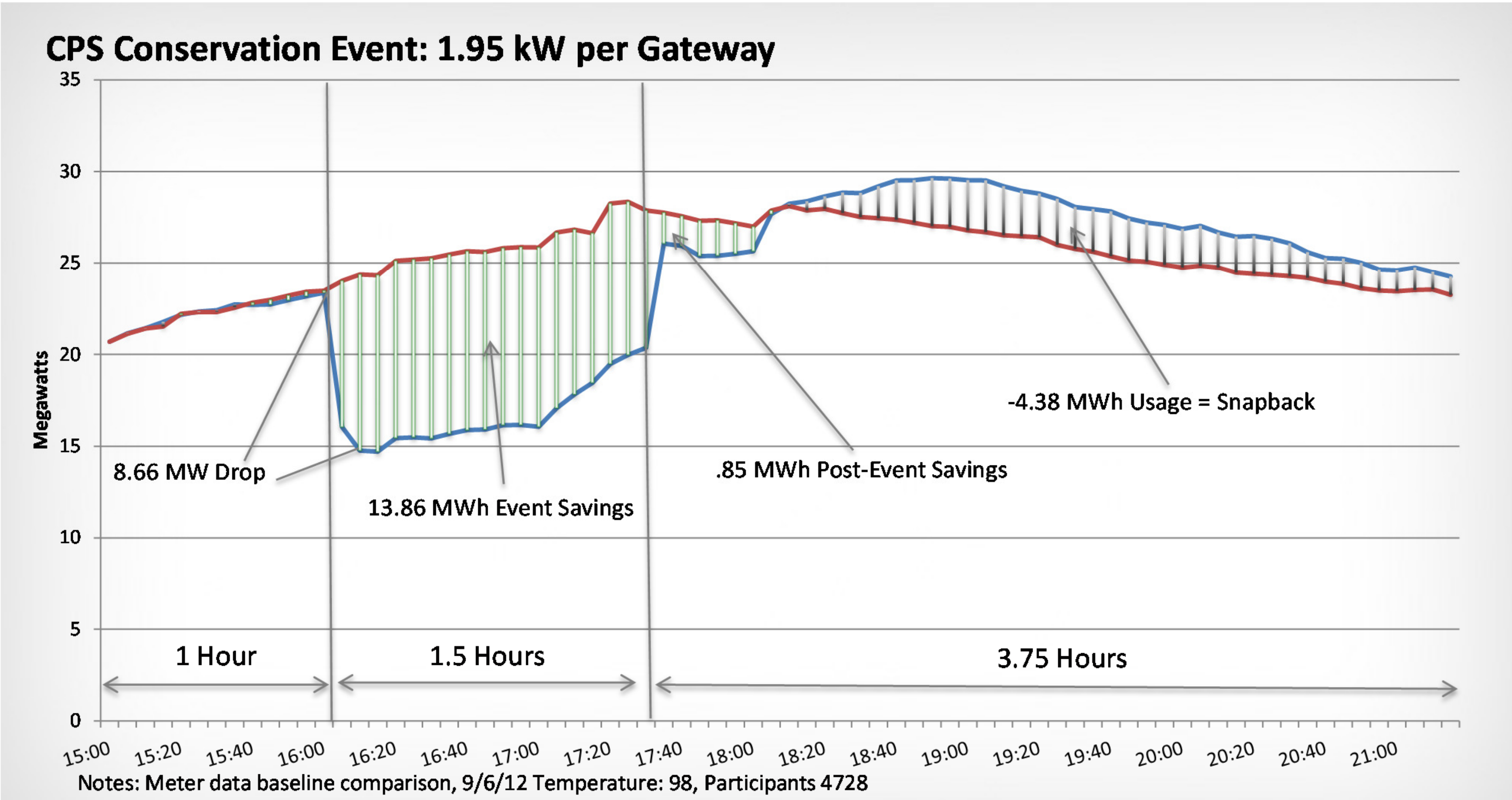
Austin Energy

- **Size**: 90,000 thermostats installed since 2001
- **Technology**: Thermostats with one-way Radio Frequency (RF) technology
- **Incentive**: Customer is provided with free thermostat
- **Impact**: ~1.4 kW load reduction per installation per event

CPS Energy

- **Size**: About 65,000 thermostats have been installed in a variety of residential dwellings and small businesses
- **Technology**: Thermostats are used to cycle a/c loads
- **Incentive**: Thermostat provided for free with 33% cycling and an additional $30 annual bill credit with 50% cycling
- **Impact**: 0.4 kW load reduction per installation per event
- New program initiated with Home Management System, yielding higher impacts per customer

DLC works to shift load away from peak hours – a real example from a program in Texas



Source: Consert

DLC in Texas – three years out

In 3 years, a residential DLC program in Texas could achieve between 520 and 2,925 MW of peak load reduction

Key assumptions

- 6.5 million eligible customers
  - 8.2 million customers and 80% air-conditioning saturation
- Realistic adoption levels: **10% to 30%**
  - Based on a review of existing DLC programs in other regions and interviews with DR providers
- Typical residential load drop: **0.8 kW to 1.5 kW per event**
  - Based on a review of existing DLC programs in other regions and interviews with DR providers

Range of achievable residential DLC impacts

- Range of nominal DR capacity: **520 to 2,925 MW**
  - 6.5 million meters **x** [10%] **x** [0.8 kW] = 520 MW
  - 6.5 million meters **x** [30%] **x** [1.5 kW] = 2,925 MW

Note: These impacts are at the meter level – a discussion of adjustments to estimate avoided generation capacity are discussed later in the presentation

In 3 years, a small C&I DLC program in Texas could achieve between 140 and 560 MW of peak load reduction

Key assumptions

- 1.4 million eligible small C&I customers (<250 kW)
  - Market size derived from EIA and FERC data
- Realistic adoption levels: **5% to 10%**
  - Based on a review of existing DLC programs in other regions and interviews with DR providers
- Typical business load drop: **2 to 4 kW per event**
  - Based on a review of existing DLC programs in other regions and interviews with DR providers

Range of achievable small C&I DLC impacts

- Range of nominal DR capacity is **140 to 560 MW**
  - 1.4 million meters x [5%] x [2 kW] = 140 MW
  - 1.4 million meters x [10%] x [4 kW] = 560 MW

Note: These impacts are at the meter level – a discussion of adjustments to estimate avoided generation capacity are discussed later in the presentation

Adjustments should be made to convert the meter-level impacts to avoided generation capacity

Adjustments for operational constraints of DR programs

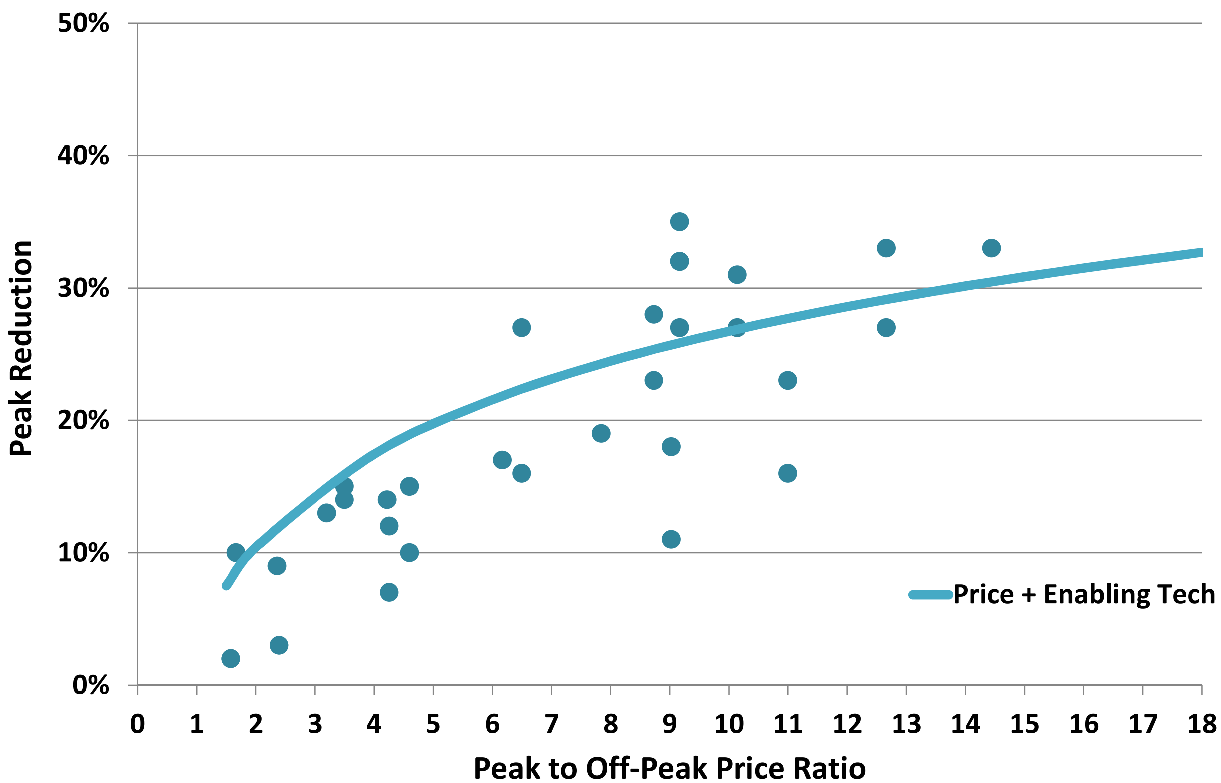
- In some states, DR impacts are derated to account for operational constraints of the programs
- For example, the system peak may occur outside of the window of hours during which the DLC program can be dispatched
- There is considerable range in the level of the derate that is applied, as it is dependent on market conditions, the DR program, and the calculation methodology being used

Adjustments to convert from meter to generator

- Meter-level peak reduction estimates must also be increased to account for reserve margin requirements and line losses
- For example, the impacts may be grossed up 15% for the reserve margin and 9% for line losses

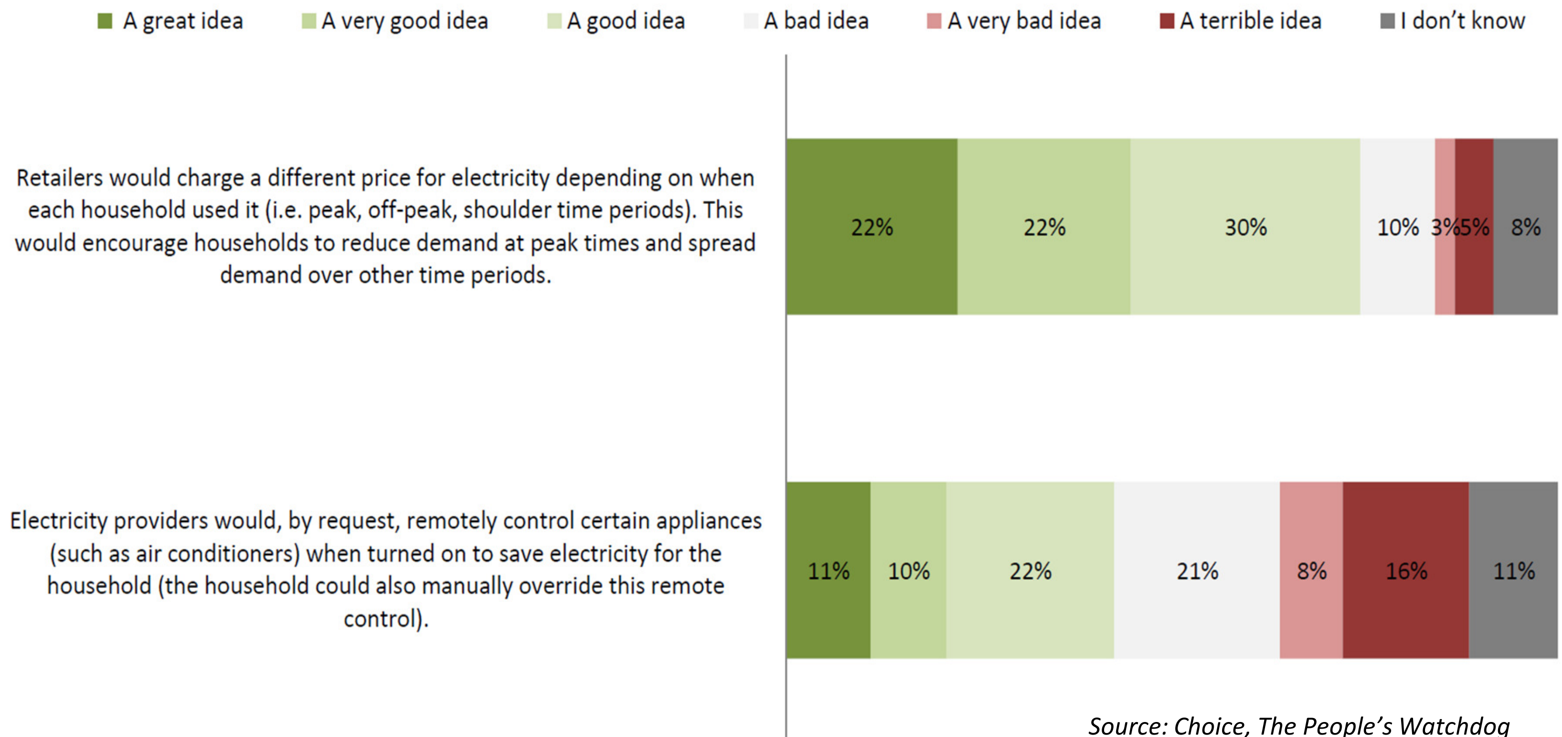
Impacts may increase further if DLC programs are offered with dynamic pricing (for the T&D portion of the retail rate)

Impacts of Technology-enabled Dynamic Pricing Pilots



When combined with DLC technology, dynamic pricing has been shown to incentivize additional load reductions from end-uses other than air-conditioning

A survey of customer preferences for DLC and dynamic pricing could help to refine estimates of likely adoption



Source: Choice, The People's Watchdog

In this Australian survey, 74% of customers expressed interest in dynamic pricing and 43% expressed interest in DLC

The way forward – alternative pathways

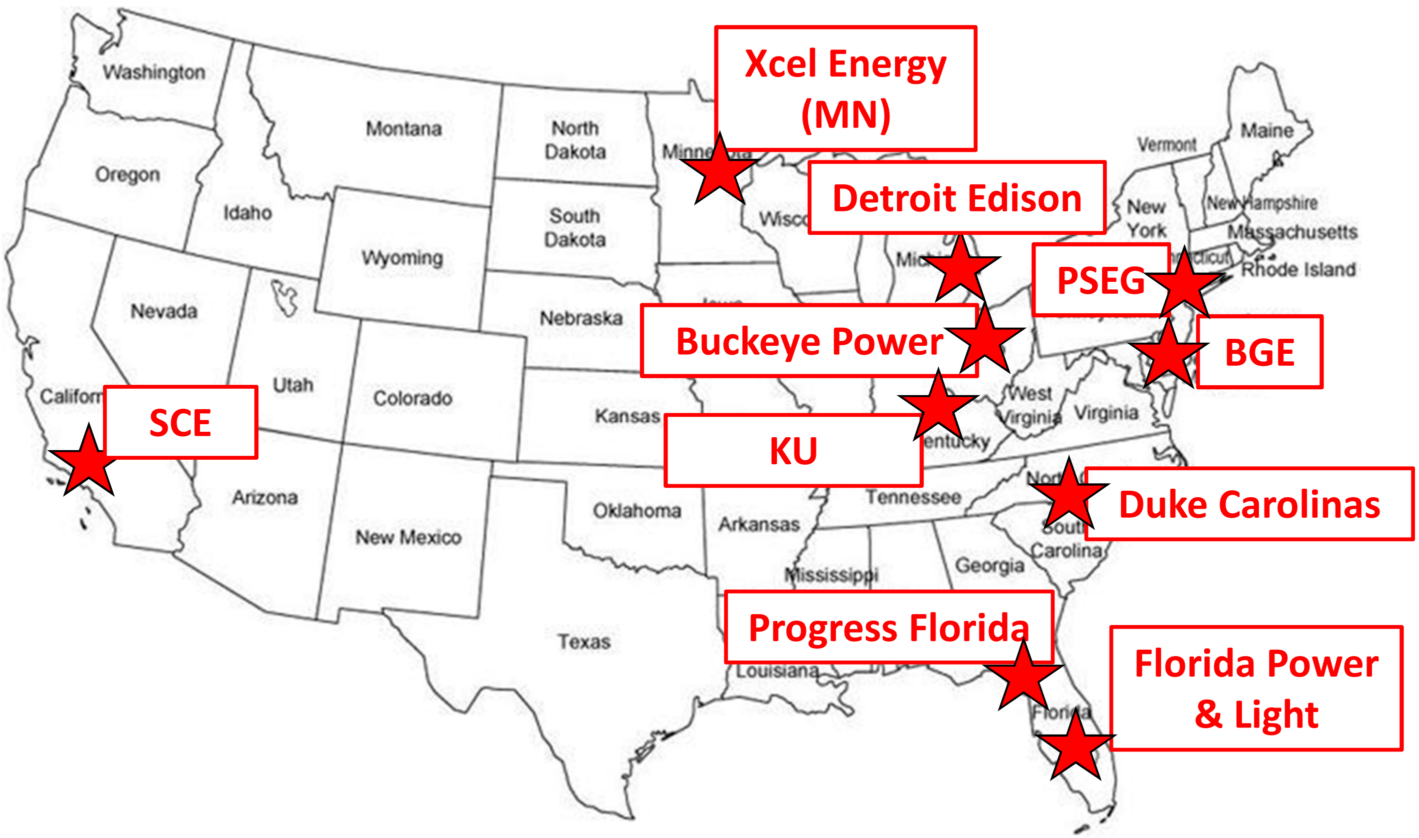
The path forward for DLC will involve many important decisions

- What is a realistic MW goal for the program and by when would it be realistic to achieve it?
- Who should offer the program?
- Should the program include a financial incentive?
- Who should pay the incentive?
- How should the program benefits be shared?
- Should the program technology be a compressor switch or a smart thermostat?
- Who should own the DLC technology?
- Are there supply chain issues that need addressing?
- Should DLC be coupled with dynamic pricing?

Appendix

There is geographic diversity among the largest DLC programs

The 10 Largest Utility DLC Programs



Top 10 Residential DLC Programs

Utility Name	Entity Type	Region	State	Number of Customers	Potential Peak Reduction	Per-customer Potential Impact (kW)
FPL	Investor Owned Utility	Florida Reliability	FL	784,965	989.0	1.3
Progress Florida	Investor Owned Utility	Florida Reliability	FL	392,763	634.0	1.6
BGE	Investor Owned Utility	ReliabilityFirst Cor	MD	375,836	272.0	0.7
SCE	Investor Owned Utility	Western Electricity	CA	340,547	575.5	1.7
Xcel Energy (MN)	Investor Owned Utility	Midwest Reliability	MN	325,503	291.0	0.9
Detroit Edison	Investor Owned Utility	ReliabilityFirst Cor	MI	281,384	217.0	0.8
Duke	Investor Owned Utility	SERC Reliability Cor	NC	146,958	163.0	1.1
Kentucky Utilities	Investor Owned Utility	SERC Reliability Cor	KY	130,000	145.0	1.1
Buckeye Power	Cooperatively Owned Utility	ReliabilityFirst Cor	OH	116,319	25.7	0.2
PSE&G	Investor Owned Utility	ReliabilityFirst Cor	NJ	114,708	62.0	0.5

Source: FERC 2010 Assessment of Demand Response & Advanced Metering

Top 10 Small C&I DLC Programs

Utility	Entity Type	Region	State	Number of Customers	Potential Peak Reduction	Per-customer Potential Impact (kW)
FPL	Investor Owned Utility	Florida Reliability	FL	20,165	91.0	4.5
Xcel Energy (MN)	Investor Owned Utility	Midwest Reliability	MN	13,397	25.0	1.9
SCE	Investor Owned Utility	Western Electricity	CA	11,210	97.4	8.7
Long Island Power	Municipal Power Agency	Northeast Power Coor	NY	7,185	10.8	1.5
SEM	Cooperatively Owned Utility	SERC Reliability Cor	GA	3,643	8.7	2.4
Dakota Electric	Cooperatively Owned Utility	Midwest Reliability	MN	1,383	1.4	1.0
PG&E	Investor Owned Utility	Western Electricity	CA	1,001	0.5	0.5
City of Columbia	Municipally Owned Utility	SERC Reliability Cor	MO	857	2.0	2.3
ACE	Investor Owned Utility	ReliabilityFirst Cor	NJ	659	-	-
SIGECO	Investor Owned Utility	ReliabilityFirst Cor	IN	650	2.4	3.6

Source: FERC 2010 Assessment of Demand Response & Advanced Metering

Note: Peak reduction data for ACE is incomplete

Brattle impact estimate assumptions

- PUCT-supported roll-out of cycling & communication equipment
- 40-50% adaptive algorithm AC cycling
- 10 events during summer only
- Maximum of 4 hours per event (as few as 2 hours)
- Near real-time/instantaneous event dispatch
- One-time annual payment to customer of $50 (not linked to capacity)
- AC cycling device installation outside the residence
- Over ride
  - Possible for individual events or program as a whole—requires contacting program operator
  - No customer-side override capabilities (other than opt-out procedure)
- No major supply-chain and large-scale installation challenges

Best Practices and Insights from *Brattle* Industry Survey

- AC Cycling
- Essential Program Terms
  - Compensation
  - Call frequency and duration
- Effective Marketing Approaches
- Performance Factors
- Measurement & Verification Issues
- Forward-Looking Technology Choices
- Program Ramp-Up and Scale Challenges
  - Installation quality and count verification
  - Potential supply chain issues

Insights on AC Cycling

Efficient cycling outcomes are achieved using adaptive-cycling algorithms:

- AC unit cycling times are determined using customer-specific baseline usage data collected on site
- Adaptive-cycling requires hardware and software equipment solutions that are already available on the market and in use in a number of programs nation-wide
- “Snap-Back” should not be ignored:
  - Occurs when cycling procedures rely solely on chronological algorithms that ignore customer-specific usage
  - Time-based cycling will result in zero kW reduction from some customers and weaker cumulative outcomes for other customers—undersized AC units will work harder during “on” cycle in an attempt to compensate for ambient temperature increases. As a result, final load reductions are lower than optimal.
- Any DR penetration estimate should reflect the underlying cycling technology to be deployed

Essential Program Terms: Call Frequency & Duration

- Frequency and duration of program calls are crucial characteristics:
  - Resource adequacy value declines with limited calls and duration constraints
  - Survey results indicate that the maximum realistic call duration for ERCOT is 4 hours and frequency should be no greater than 10 events/year
- Consistent outreach and communication with customers on how the program works is essential
- Additional attrition should be expected if events are clustered

Effective Marketing Approaches

- Ingredients of a successful marketing effort
  - Joint outreach by program operators, public authorities, and HVAC equipment service providers
  - Reliance on multiple media channels
  - Door-to-door advertising
  - Market segmentation
  - Cite environmental, societal and personal benefits
- Program evolution affects marketing success —advertising approaches should adjust accordingly

Performance Factors

- Opt-out opportunities for participants should be limited and well-defined:
  - Customer should be able to opt out via phone/internet contact with program operator
  - Device shut off actually performed (remotely) by program operator
  - No opt-out switch on customer premises
  - Compensation should reflect opt-out history

Performance Factors (Cont.)

- Instantaneous calls are most valuable to resource adequacy
- Adaptive cycling algorithms hold the best promise for optimal realized load reductions—they also avoid negative system side-effects (returning all AC load to cycling at once may place non-trivial burdens on the system)
- Targeting the most valuable customer profiles should be a priority at program inception (AMI data might be available to analyze for this purpose)
- Multi-family occupancy patterns may affect realized reductions

Measurement & Verification Issues

One-way communication

- Currently, most affordable
- Devices can be repeatedly programmed in various geographical, transmission, and chronological configurations
- M&V is based on statistical sampling methods: a subset of cycling devices are equipped with additional measuring equipment—results are extrapolated to the universe of participants
- Devices can be targeted individually by program operator for cycling, opt-out or reconfiguration
- Several communication protocols—paging, cellular, or wi-fi

Two-way communication

- More expensive than one-way
- Holds greater potential for enhanced program features and additional demand-side management programs

AMI Infrastructure for Demand Response

- Potential bandwidth issues if trying to send signal through AMI devices
- Signal latency issues are also likely (in addition to bandwidth shortage)
- No comprehensive testing has been done
- Currently, operates on a different network than AC cycling devices

Forward-Looking Technology Choices

- Policy goals will greatly effect infrastructure investment decisions
  - One-way paging communication network will be cheaper and likely faster to deploy
  - Two-way is more expensive but holds promise for even greater DSM penetration and contribution in the long-run
  - Issues with newer technologies might prove detrimental to program ramp-up but provide enhanced benefits later
- Technology choices have to be made carefully
  - Consider existing program experience from other jurisdictions
  - Recognize likely trends in technological development
  - Contemplate a base deployment using one-way communication and allow for two-way upgrades by interested customer segments/providers

Program Ramp-Up and Scale Challenges: Installation quality and count verification

Rapid program ramp-up requires that a number of logistical issues are addressed:

- **Skilled Labor:** Additional qualified installation providers might need to be trained and staff retention could be an issue since installations are seasonal and so is employment
- **Quality Control:** Need to ensure each installation meets program quality standards—this might increase program roll-out costs
- **Penetration Verification:** Experience in other jurisdictions cautions against large program outlays without proper installation verification structure in place—installers' work has to be independently monitored

Program Ramp-Up and Scale Challenges: Potential Supply Chain Issues

Large-scale program ramp-up might be subject to potential supply chain constraints and difficulties:

- Emerging device technologies are more susceptible to production bottle necks
- Supplier pool should be diversified accordingly
- Contingency plans should be developed in anticipation
- Large scale deployments will naturally attract many bidders: quality and timely performance requirements should be carefully negotiated
- Different technologies might be associated with varying lead times for deployment and non-trivial differences in installation skills & requirements

Biographical Information

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Dr. Faruqui has advised more than 50 clients on demand response issues, including utilities, transmission system operators, regulatory agencies, governments and international lending agencies.

He has testified or appeared before a dozen state and provincial commissions and legislative bodies in the United States and Canada.

He co-authored “A National Assessment of Demand Response Potential” for the FERC Staff and co-authored a whitepaper on demand-side options for the Australia Energy Market Commission.

He has been cited in The Economist, The New York Times, and USA Today and he has appeared on Fox News and National Public Radio. The author, co-author or editor of four books and more than 150 articles, papers and reports on energy efficiency, he holds a Ph.D. in economics from The University of California at Davis and bachelors and masters degrees from The University of Karachi.

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