Rate Reform in Evolving Energy Marketplace

PRESENTED BY
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May 30, 2019

EUCI Residential Demand Charges/TOU Summit

New Orleans, LA

THE Brattle GROUP

We face a new energy future

New technologies are changing the way customers interact with the grid

- **Smart homes:** Smart appliances, smart thermostats, and smart phones are becoming pervasive
- **Electric vehicles:** There is an opportunity to incentivize customers to charge during off-peak hours
- **Distributed generation:** Customers are increasingly meeting their own power needs, through rooftop solar panels, battery storage, and fuel cells; this requires the grid to be modified to accommodate two-way energy flows
- **Smart metering:** A new infrastructure is in place which will enable tariffs to be modernized

NEM introduced a cross-subsidy between customers that continues to grow

The problem arose because the residential rate structure was largely volumetric in nature and it did not mirror the cost structure of generating and delivering electricity to customers

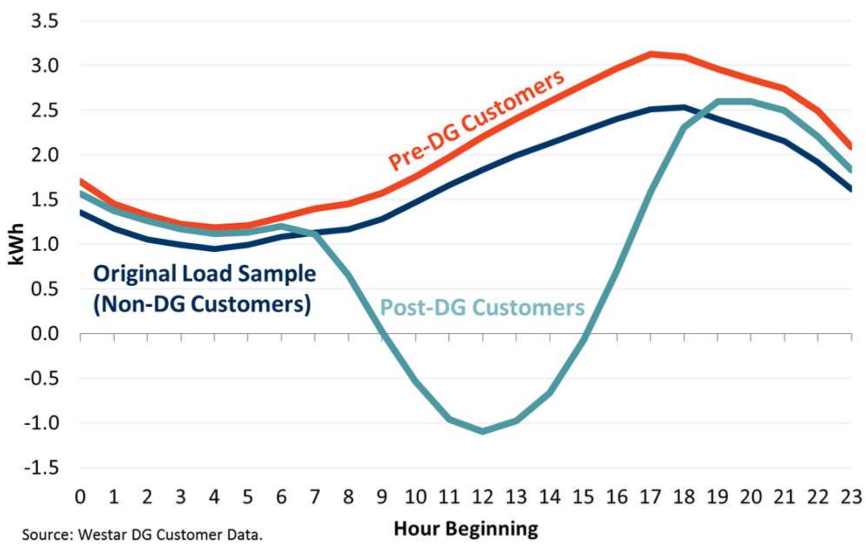
Typically, NEM customers reduced their energy consumption by 50% but did not lower their peak demand by very much

- And they remained connected to the grid 24/7
- The fixed cost to serve them did not go down

Thus, when NEM customers lowered their consumption by 50%, the recovery of costs to serve them went down by nearly 50%, but actual costs of serving them went down by a much lower percentage

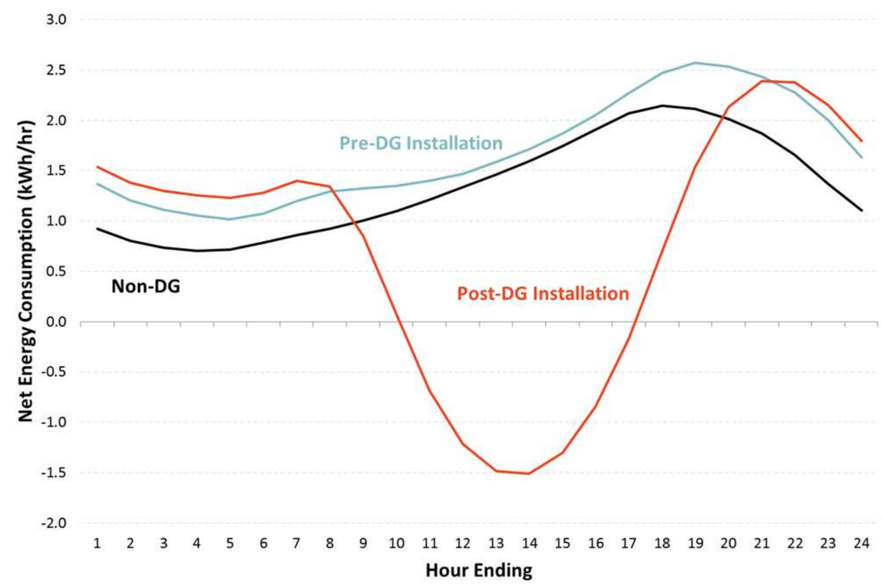
Load Shape Comparison
DG vs. Non-DG Customers

Summer Load Shape Comparison, Kansas



- We find DG reduces net energy consumption by half from **1060 kWh** to **530 kWh**
- However, average monthly peak demand is virtually unchanged

Summer Load Shape Comparison, Idaho



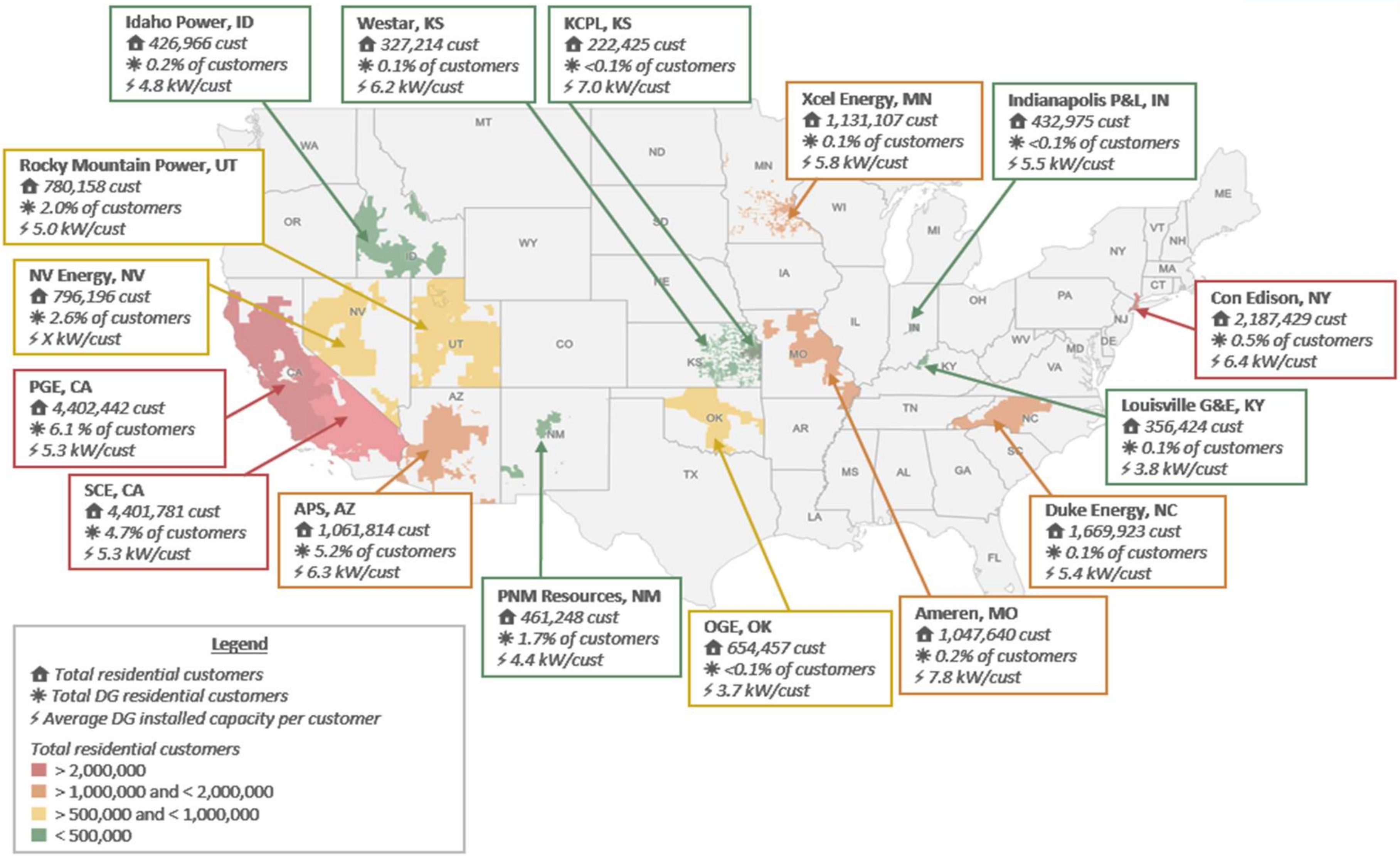
- We find DG reduces net energy consumption by over a third from **1190 kWh** to **770 kWh**
- As in Kansas, average monthly peak demand is virtually unchanged

Quantifying NEM cross-subsidies

We undertook a study to quantify the magnitude of these NEM cross-subsidies using data from a diverse group of sixteen U.S. utilities. Our study presents three enhancements to the previous studies with similar objectives

- We selected 16 utilities with varying geographic locations, size, distributed generation (DG) policy and rooftop PV penetration levels in order to achieve a broad representation of the utility landscape in the U.S.
- We developed a methodology to quantify the NEM subsidies and applied it consistently to all utilities included in the study enabling side-by-side comparisons of NEM subsidies
- Our methodology is based on a cost-of-service approach, rather than a cost-and-benefit approach, and explicitly identifies the costs avoided by NEM customers and is therefore more transparent

Study Scope (cont'd)
16 utilities in 14 states

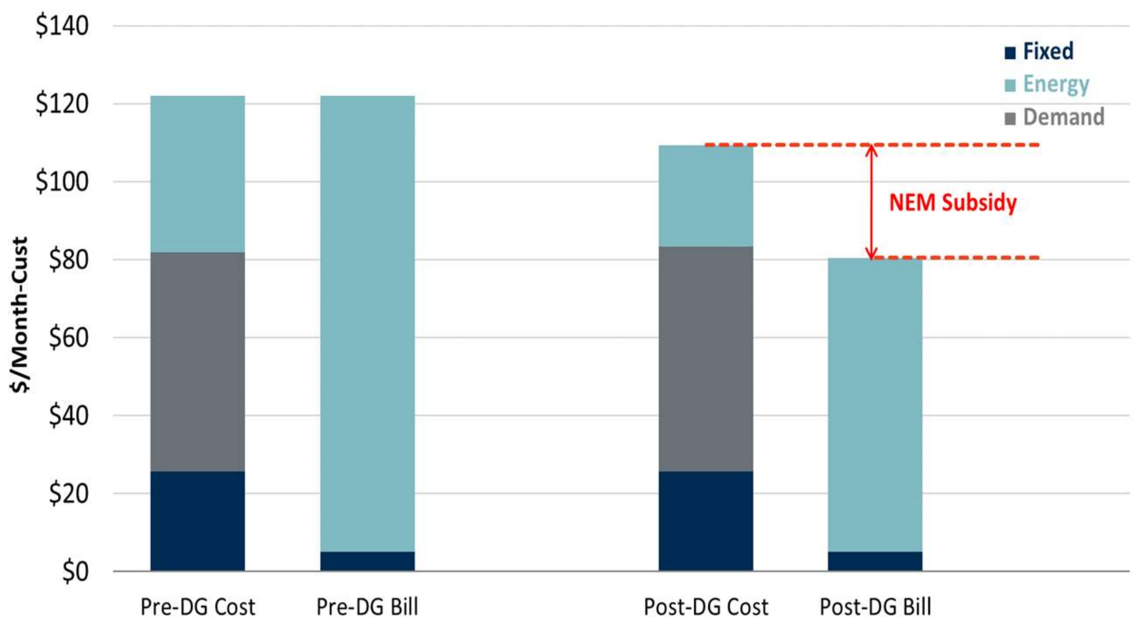


Study Methodology

We relied on the cost-of-service approach, which is reliable but very data intensive

We collected the required data from publicly available data sources and by reaching out to our contacts at the utilities studied

Illustration of the NEM subsidy calculation



Our methodology involves four main steps:

Step 1: Calculation of DG customers' electricity usage and peak demand

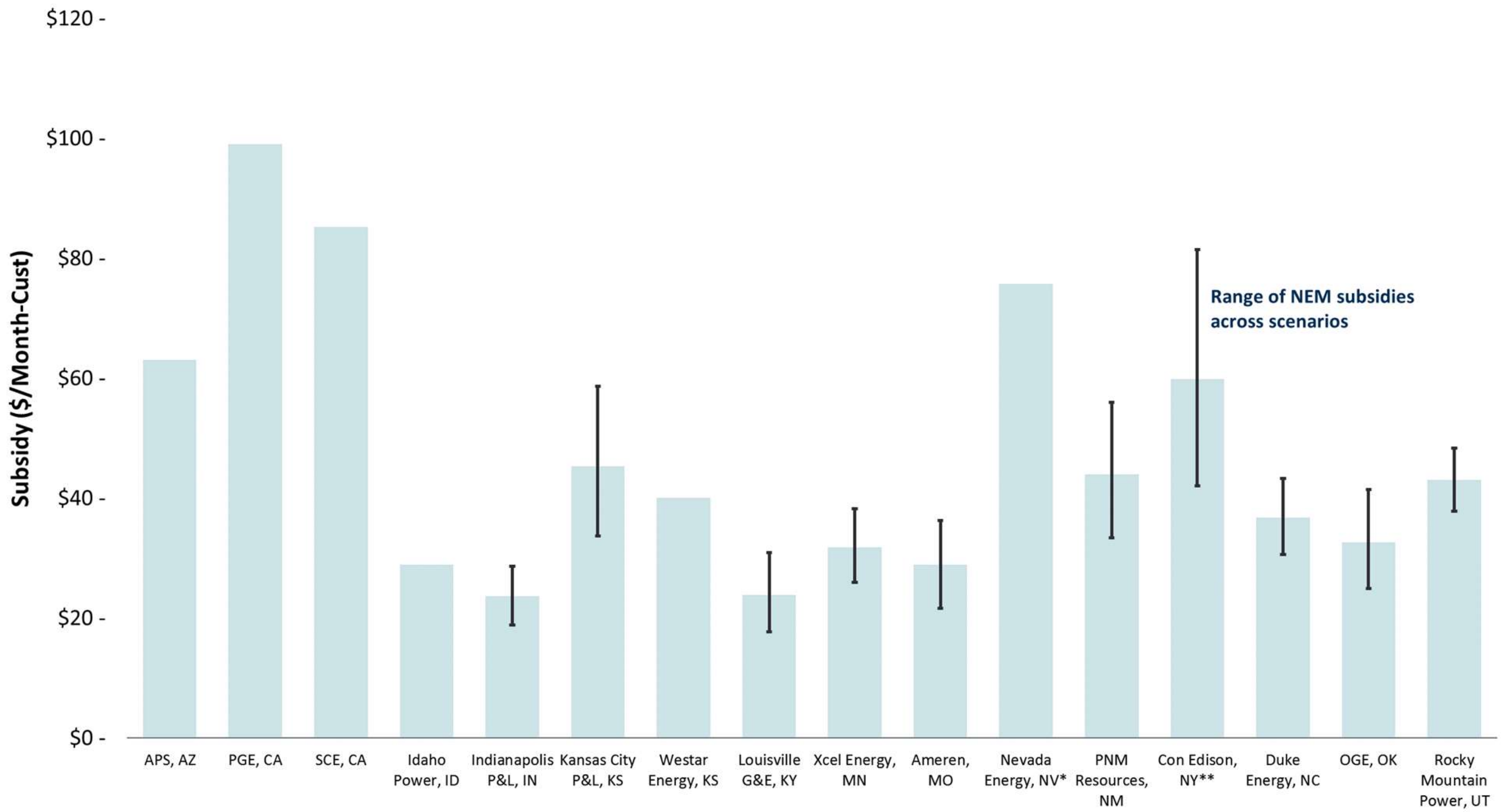
Step 2: Calculation of DG customer bills for pre- and post-DG

Step 3: Calculation of Cost of Serving DG customers for pre- and post- DG

Step 4: Calculation of NEM subsidy

The NEM subsidies range in $20-$100/customer/month, representing roughly 25%-200% of the monthly bills for residential DG customers of these utilities

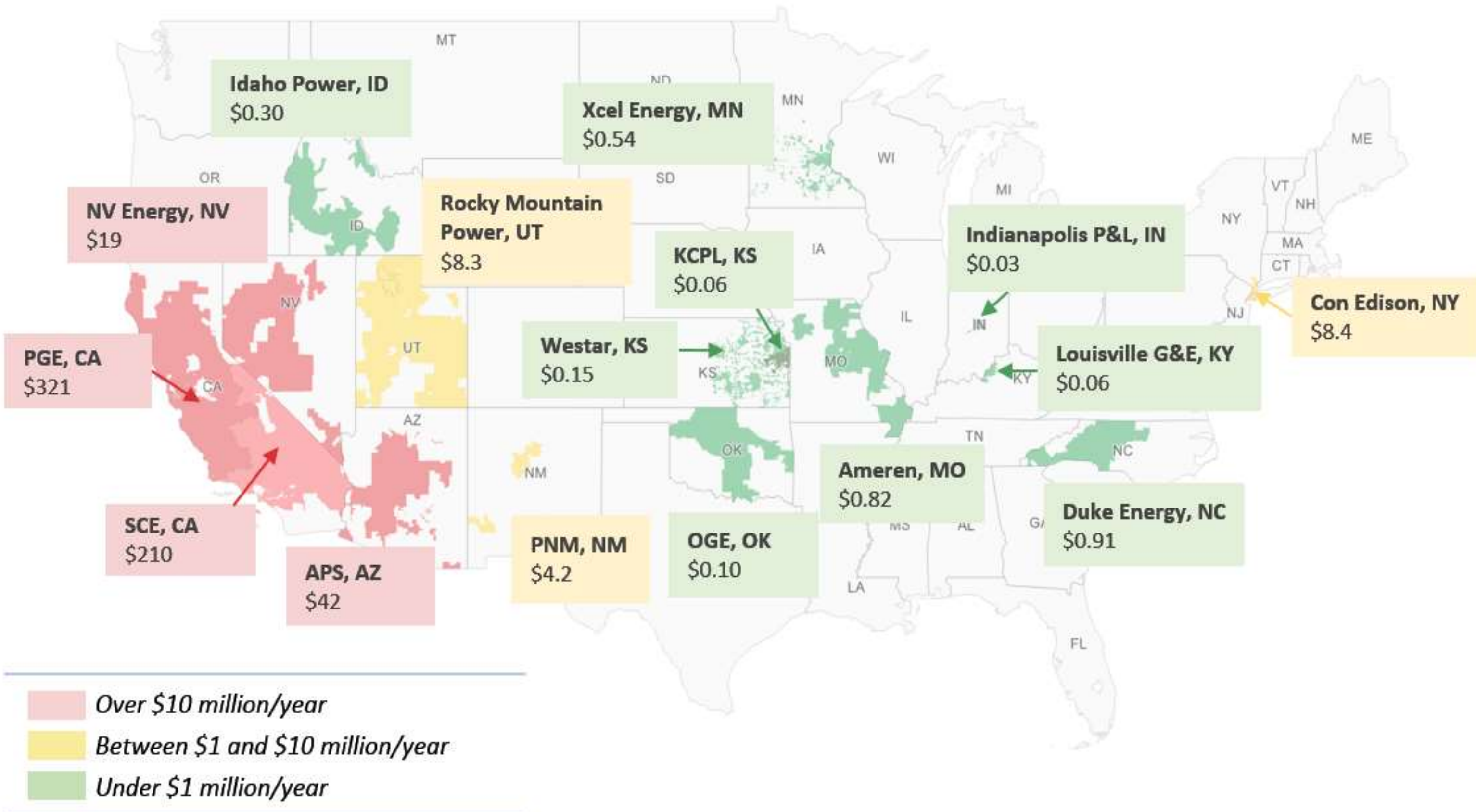
Source: "Quantifying Net Energy Metering Subsidies," Sanem Sergici, Yingxia Ying, Maria Castaner and Ahmad Faruqui, unpublished paper, April 2019.



*Note: *NEM subsidies exclude inter-class cross-subsidy except for Nevada Energy (NV). **NEM subsidy does not reflect the NY VDER tariff.*

NEM subsidies reach several hundred million dollars for utilities with high DG penetration

Aggregate NEM Subsidy ($million/year)



Note: For utilities who did not provide the DG customer profiles, the numbers are based on average NEM subsidies across the four scenarios.

How can the NEM cross-subsidies be minimized?

The most common way is to create a separate rate class for NEM customers

- This has been done in Arizona, California, Idaho, and Kansas
- It's being considered in Montana

For the new NEM class, introduce a separate rate that reflects the cost structure of generating and delivering electricity

This would typically be a three-part rate with a fixed charge, a demand charge, and a time-of-use energy charge

Such rates are commonly used for commercial and industrial customers and will probably become the norm for all customers in the future

Tariff design has multiple objectives

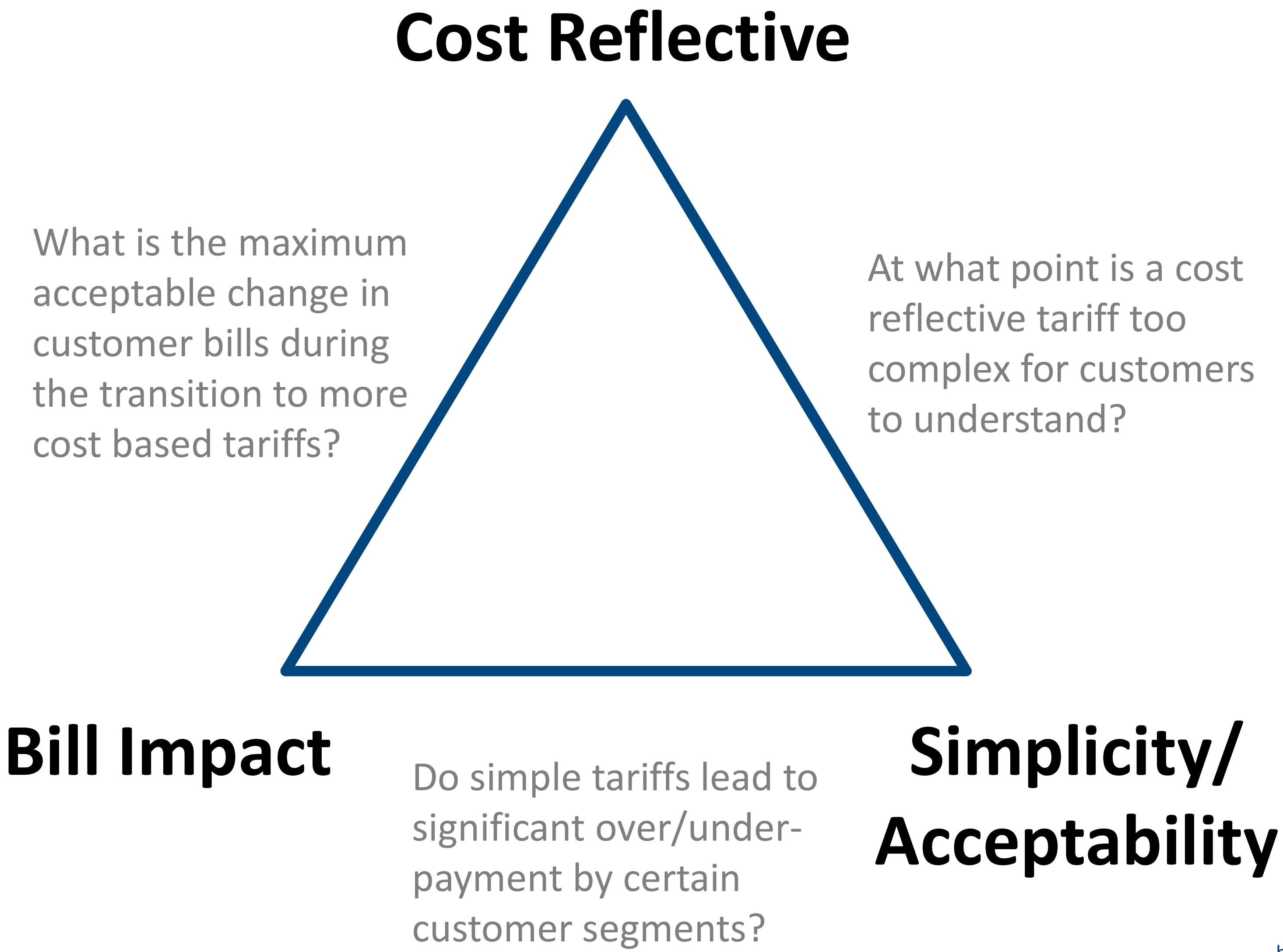
The pure economic theory of electricity pricing recommends adherence to the overarching principle of **cost-causation,** i.e. pricing should be cost-based and should lead to achievement of the following objectives

- Minimization of cross-subsidies
- Reduced long-run costs due to more efficient use of the network
- Efficient siting of distributed energy resources (DERs)

Customer considerations lead to deliberate adoption of tariffs designs that are not perfectly cost based

- Simplicity / understandability
- Customer acceptance / appeal/perceived fairness
- Mitigating large bill changes / volatility
- Protecting vulnerable customer segments

Thus, tariff design involves making trade-offs against three competing goals



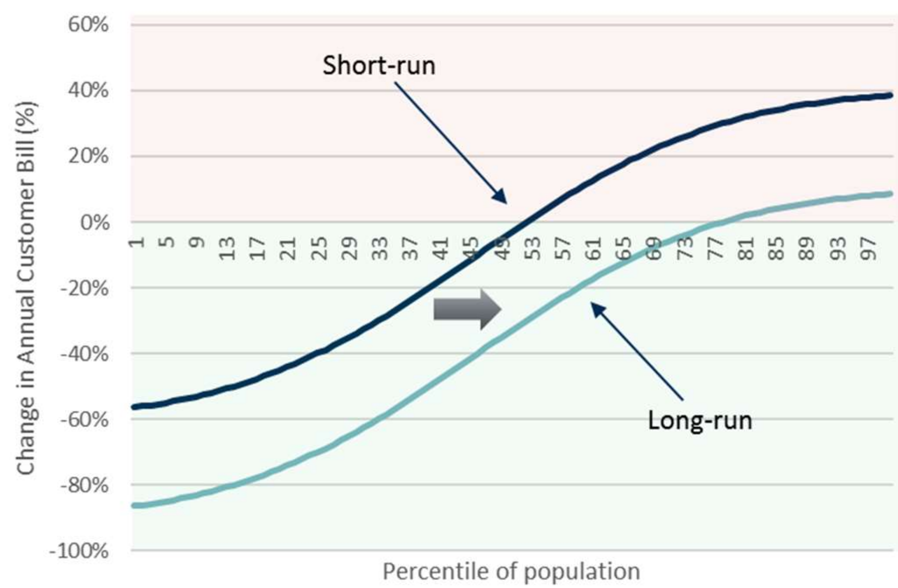
Tariff reform requires buy-in from stakeholders and, most importantly, from customers

Some of the benefits of the tariff transition, such as network cost reductions, will occur in the long-run, while impacts will be felt by customers immediately

Commonly cited stakeholder concerns about tariff changes

- Higher bills for (some) customers
- Changes to status quo are perceived to be "unfair"
- Bills for some vulnerable customers may increase, or they may be unable to respond to new price signals

Illustration of Bill Impacts due to Tariff Transition



It is important to ensure that customers understand why the transition is occurring and are aware of any opportunities to save on their bill

Examples of utility tariff offerings around the world and the U.S.

	Opt-in	Opt-out	Mandatory
Flat bill	Georgia Power, Oklahoma Gas & Electric		
Peak-time rebates	CPL (Hong Kong), UK Power Networks	Maryland, California, Illinois	
Demand charges	Arizona Public Service, Black Hills, Salt River Project, France, Italy, Spain		
Static TOU volumetric tariffs	Texas, France, Great Britain, Italy	SMUD (California) Ontario (Canada)	Fort Collins (Colorado)
Dynamic volumetric tariffs	Oklahoma, Illinois	California, Spain	

US Regions
Non-US Regions

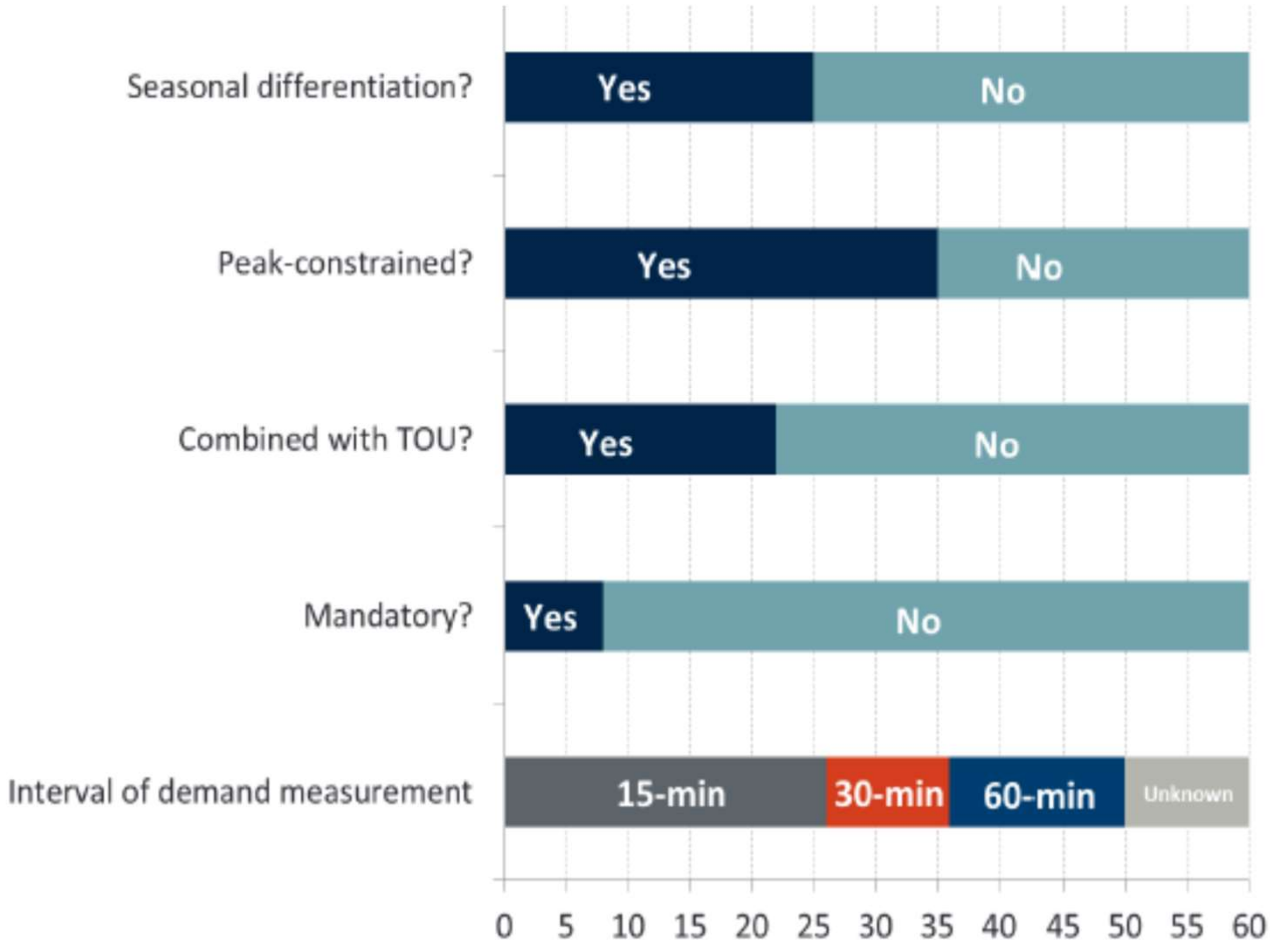
Residential demand charges are now being offered by at least 50 utilities in 24 states

#	Utility	Utility Ownership	State	Residential Customers Served	Fixed charge ($/month)	Demand Charge ($/kW-month) Summer	Demand Charge ($/kW-month) Winter	Timing of demand measurement	Demand interval	Combined with Energy TOU?	Applicable Residential Customer	Mandatory or Voluntary
[1]	Alabama Power	Investor Owned	AL	1,262,752	14.50	1.50	1.50	Any time	15 min	Yes	All	Voluntary
[2]	Alaska Electric Light and Power	Investor Owned	AK	14,466	11.13	6.51	10.76	Any time	Unknown	No	All	Voluntary
[3]	Albemarle Electric Membership Corp	Cooperative	NC	11,545	27.00	13.50	13.50	Peak Coincident	15 min	Yes	All	Voluntary
[4]	Alliant Energy (IPL)	Investor Owned	IA	402,199	11.50	17.40	11.62	Peak Coincident	60 min	Yes	All	Voluntary
[5]	Alliant Energy (WPL)	Investor Owned	WI	405,804	15.04	3.00	3.00	Peak Coincident	60 min	Yes	All	Voluntary
[6]	Arizona Public Service	Investor Owned	AZ	1,061,814	13.02	8.40	8.40	Peak Coincident	60 min	Yes	All	Voluntary
[7]	Arizona Public Service	Investor Owned	AZ	1,061,814	13.02	17.44	12.24	Peak Coincident	60 min	Yes	All	Voluntary
[8]	Black Hills Power	Investor Owned	SD	55,637	13.00	8.10	8.10	Any time	15 min	No	All	Voluntary
[9]	Black Hills Power	Investor Owned	WY	2,063	15.50	8.25	8.25	Any time	15 min	No	All	Voluntary
[10]	Butler Rural Electric Cooperative	Cooperative	KS	6,585	31.00	5.10	5.10	Peak Coincident	60 min	No	All	Mandatory
[11]	Butte Electric Cooperative	Cooperative	SD	4,910	45.00	9.50	9.50	Unknown	Unknown	No	All	Voluntary
[12]	Carteret-Craven Electric Cooperative	Cooperative	NC	35,805	30.00	11.95	9.95	Peak Coincident	15 min	No	All	Voluntary
[13]	Central Electric Membership Corp	Cooperative	NC	20,026	34.00	8.55	7.50	Peak Coincident	15 min	Yes	All	Voluntary
[14]	City of Fort Collins Utilities	Municipal	CO	62,770	6.16	2.60	2.60	Any time	Unknown	No	All	Voluntary
[15]	City of Glasgow	Municipal	KY	5,456	24.16	11.86	10.87	Peak Coincident	30 min	Yes	All	Voluntary
[16]	City of Kinston	Municipal	NC	9,702	14.95	9.35	9.35	Peak Coincident	15 min	No	All	Voluntary
[17]	City of Longmont	Municipal	CO	35,721	16.60	5.75	5.75	Any time	15 min	No	All	Voluntary
[18]	City of Templeton	Municipal	MA	3,500	3.00	8.00	8.00	Any time	15 min	No	All	Mandatory
[19]	Cobb Electric Membership Corporation	Cooperative	GA	182,132	28.00	5.55	5.55	Peak Coincident	60 min	No	All	Voluntary
[20]	Dakota Electric Association	Cooperative	MN	96,982	12.00	14.70	11.10	Any time	15 min	No	All	Voluntary
[21]	Dominion Energy	Investor Owned	NC	102,079	16.39	9.76	5.66	Peak Coincident	30 min	Yes	All	Voluntary
[22]	Dominion Energy	Investor Owned	VA	2,173,471	11.53	5.46	3.79	Peak Coincident	30 min	Yes	All	Voluntary
[23]	Duke Energy Carolinas, LLC	Investor Owned	NC	1,669,923	14.00	7.83	3.92	Peak Coincident	30 min	Yes	All	Voluntary
[24]	Duke Energy Carolinas, LLC	Investor Owned	SC	478,509	9.93	8.15	4.00	Peak Coincident	30 min	Yes	All	Voluntary
[25]	Edgecombe-Martin County EMC	Cooperative	NC	10,369	31.00	8.75	8.00	Peak Coincident	Unknown	No	All	Voluntary
[26]	Fort Morgan	Municipal	CO	4,989	8.17	10.22	10.22	Unknown	Unknown	No	All	Voluntary
[27]	Georgia Power	Investor Owned	GA	2,144,447	10.00	6.64	6.64	Any time	30 min	Yes	All	Voluntary
[28]	Kentucky Utilities Company	Investor Owned	KY	426,225	12.25	7.87	7.87	Peak Coincident	15 min	No	All	Voluntary
[29]	Lakeland Electric	Municipal	FL	105,937	9.50	5.60	5.60	Peak Coincident	30 min	No	All	Voluntary
[30]	Lincoln Electric Cooperative	Cooperative	MT	5,056	39.39	0.75	0.75	Any time	15 min	No	All	Voluntary

Cont'd

#	Utility	Utility Ownership	State	Residential Customers Served	Fixed charge ($/month)	Demand Charge ($/kW-month)		Timing of demand measurement	Demand interval	Combined with Energy TOU?	Applicable Residential Customer	Mandatory or Voluntary
						Summer	Winter					
[31]	Louisville Gas and Electric	Investor Owned	KY	356,424	12.25	7.68	7.68	Peak Coincident	15 min	No	All	Voluntary
[32]	Loveland Electric	Municipal	CO	31,458	23.50	9.80	7.35	Any time	15 min	No	All	Voluntary
[33]	Mid-Carolina Electric Cooperative	Cooperative	SC	48,265	24.00	12.00	12.00	Peak Coincident	60 min	No	All	Mandatory
[34]	Midwest Energy Inc	Cooperative	KS	29,976	22.00	6.40	6.40	Any time	15 min	No	All	Voluntary
[35]	NV Energy (SPP)	Investor Owned	NV	291,401	10.25	0.35 (daily)	0.35 (daily)	Peak Coincident	15 min	No	All	Voluntary
[36]	NV Energy (SPP)	Investor Owned	NV	291,401	15.25	0.26 (daily)	0.93 (daily)	Peak Coincident	15 min	Yes	All	Voluntary
[37]	Oklahoma Gas and Electric Company	Investor Owned	AR	55,190	9.75	1.00	1.00	Any time	15 min	No	All	Voluntary
[38]	Otter Tail Power Company	Investor Owned	MN	48,186	11.00	8.00	8.00	Any time	60 min	No	All	Voluntary
[39]	Otter Tail Power Company	Investor Owned	ND	45,790	18.38	6.52	2.63	Any time	60 min	No	All	Voluntary
[40]	Otter Tail Power Company	Investor Owned	SD	8,710	13.00	7.05	5.93	Any time	60 min	No	All	Voluntary
[41]	PacifiCorp	Investor Owned	OR	498,227	13.30	2.20	2.20	Unknown	Unknown	No	All	Voluntary
[42]	Pee Dee Electric Membership Cooperative	Cooperative	SC	28,754	34.40	8.50	7.00	Peak Coincident	Unknown	Yes	All	Voluntary
[43]	Platte-Clay Electric Cooperative	Cooperative	MO	21,070	25.38	2.50	2.50	Peak Coincident	60 min	No	All	Mandatory
[44]	Progress Energy Carolinas	Investor Owned	NC	1,162,473	16.85	4.88	3.90	Peak Coincident	15 min	Yes	All	Voluntary
[45]	Progress Energy Carolinas	Investor Owned	SC	136,294	11.91	5.38	4.14	Peak Coincident	15 min	Yes	All	Voluntary
[46]	Salt River Project	Political Subdivision	AZ	928,721	32.44	13.71	4.62	Peak Coincident	30 min	Yes	NEM Only	Mandatory
[47]	Santee Cooper Electric Cooperative	Cooperative	SC	32,829	50.00	6.00	6.00	Peak Coincident	30 min	Yes	NEM only	Mandatory
[48]	Smithfield	Municipal	NC	3,400	17.00	5.93	5.93	Peak Coincident	15 min	Yes	All	Voluntary
[49]	South Carolina Electric & Gas Company	Investor Owned	SC	605,717	14.00	12.04	8.60	Peak Coincident	15 min	Yes	All	Voluntary
[50]	Sun River Electric Cooperative	Cooperative	MT	4,460	32.00	4.00	4.00	Unknown	Unknown	No	All	Mandatory
[51]	Swanton Village Electric Department	Municipal	VT	3,236	11.33	9.17	9.17	Any time	15 min	No	All	Mandatory
[52]	Tideland Electric Member Corp	Cooperative	NC	18,540	31.00	10.35	9.40	Peak Coincident	15 min	No	All	Voluntary
[53]	Tri-County Electric Cooperative	Cooperative	FL	16,131	23.00	7.00	7.00	Any time	15 min	No	All	Voluntary
[54]	Traverse Electric Cooperative, Inc.	Cooperative	MN	1,819	76.00	18.65	18.65	Peak Coincident	Unknown	No	All	Voluntary
[55]	Tucson Electric Power	Investor Owned	AZ	378,992	10.00	8.85	8.85	Peak Coincident	60 min	Yes	All	Voluntary
[56]	Tucson Electric Power	Investor Owned	AZ	378,992	10.00	8.85	8.85	Peak Coincident	60 min	No	All	Voluntary
[57]	Vigilante Electric Cooperative	Cooperative	MT	8,273	26.00	0.50 per KVA	0.50 per KVA	Any time	Unknown	No	All	Mandatory
[58]	Westar Energy	Investor Owned	KS	327,214	16.50	6.91	2.13	Any time	30 min	No	All	Voluntary
[59]	Xcel Energy (PSCo)	Investor Owned	CO	1,228,305	19.31	10.08	7.76	Any time	15 min	No	All	Voluntary
[60]	Xcel Energy (PSCo)	Investor Owned	CO	1,228,305	6.54	13.38	10.46	Peak Coincident	60 min	No	All	Voluntary

Features of Residential Demand Charges



Source: The Brattle Group, May 2019.
Notes: Includes municipal utilities and cooperatives.

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Residential TOU Rates are undergoing a change

- Volumetric TOU rates are increasingly being proposed by environmental advocates to address grid cost recovery issues associated with rooftop PV adoption (as an alternative to higher fixed charges or new demand charges)
- To address solar PV integration challenges, new TOU rates are being introduced with a low mid-day price and a peak period that is delayed until later in the evening
- Several utilities are preparing to introduce TOU rates on a default (i.e., opt-out) basis for all residential customers
- TOU rates continue to be piloted in North America and internationally; the pilots consistently find that customers shift consumption from peak periods to off-peak periods

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Are TOU rates and demand charges substitutes?

Demand charges and time-of-use pricing are complements, not substitutes

- Volumetric TOU rates can fully recover generation and transmission capacity costs since they tend to be driven with the system peak. However, distribution capacity costs do not necessarily correlate well with the system peak
- Therefore, while a DER customer is reducing their usage in response to the TOU rates and reducing peak G&T requirements, it doesn't mean that they are also reducing D capacity requirements. It may in fact mean that they are underpaying for the distribution costs

Defining the TOU peak period to be consistent with the distribution peak brings TOU rates closer to demand charges, however the recovery of costs associated with 24/7 grid access service is still not guaranteed under this approach

- APS has revised its TOU design to shift the peak period from 12-7 pm to 3-8 pm
- SDG&E similarly delayed its peak period from 11 am – 6 pm to 4-9 pm

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A new TOU pilot will be deployed in Maryland in the Summer of 2019

The two-year TOU pilot is being developed as part of the Maryland PSC's Public Conference 44 (PC44) effort, and will be executed by BGE, Pepco and Delmarva Power, the "Joint Utilities" of Maryland

The primary objective of the pilot is to determine if TOU rates can help lower customer bills, especially for low to moderate income ("LMI") customers

The pilot is currently addressing customers taking Standard Offer Service (SOS), however there is also another one under consideration for customers receiving service from a retail supplier

The SOS pilot will feature cost-based TOU SOS rates and TOU delivery service rates

PC44 TOU Pilot Design

	Summer (June 1 – September 30)	Non-Summer (October 1 – May 31)
On-peak	2pm- 7pm on weekdays	6am- 9am
Off-peak	All other hours are off-peak, including holidays and weekends	All other hours are off-peak, including holidays and weekends

Example Rates as Listed in Final Work Group Report

Charges	Current (Flat)	On-Peak	Off-Peak	Ratio
BGE				
Delivery Service Charges	$0.03147	$0.10571	$0.02051	5.2
Supply Charges	$0.08255	$0.23874	$0.05948	4.0
Total	**$0.11402**	**$0.34445**	**$0.07999**	**4.3**
Pepco				
Delivery Service Charges	$0.04051	$0.16165	$0.01989	8.1
Supply Charges	$0.08258	$0.17707	$0.06650	~~2.7~~
Total	**$0.12309**	**$0.33871**	**$0.08639**	**3.9**
Delmarva Power				
Delivery Service Charges	$0.05402	$0.20785	$0.02404	8.6
Supply Charges	$0.08143	$0.16669	$0.06481	~~2.6~~
Total	**$0.13545**	**$0.37454**	**$0.08885**	**4.2**

Notes: Rates are subject to change before implementation of the pilot program. Totals may differ due to rounding.

- Targeted sample size for each utility is 4,020 of which 1,608 will be represented by LMI customers
- Sample sizes were determined using statistical power calculations

PC44 pilot will advance the state of our TOU knowledge

PC44 TOU pilot aims to answer a few unsettled questions and advance our state of knowledge by:

- Testing the impact of TOU on LMI customers on a sufficiently large sample size to yield conclusive results
- Applying TOU rates on <u>both the energy and delivery charges</u> with a sizable peak/off-peak ratio and increasing the portion of the bill that is subject to the TOU rate
- Understanding customer satisfaction with opt-in TOU rates

Default implementation of TOU rates are becoming more mainstream

Ontario, CA deployed a default TOU tariff in 2012 for all mass market customers for power supply

- Some 90% of Ontario's 4 million residential customers have been buying their energy through a regulated supply option, which features a three-period TOU rate

In Italy, default TOU pricing was extended to all 20 million plus households starting in 2010

CA IOUs will default all 10 million of their residential customers onto TOU rates in 2020, is currently piloting default TOU rates with less than 1% of the customers opting out

SMUD, APS, and Fort Collins residential customers are already on default TOU rates

TOU Implementation Best Practices

- TOU rates are not very useful for addressing specific events on the grid although they are useful for integrating variable renewable energy resources by reducing curtailments
- In determining the peak period, consider the change in load shape due to solar penetration
- Keep the peak period short
- Refrain from multiple periods, especially split mid-peak periods
  - Exception is the EV TOU rates, which are shown to be more successful if they include super offpeak periods
- Undertake billing analysis to determine winners and losers
- Target a peak/offpeak ratio > 3. A lower ratio will not lead to sizable savings for customers and will not motivate load shifting
- Educate customers on ways to change behavior; offer shadow bills
- Test impacts for the low and medium income (LMI) customers

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Concluding Thoughts I

Volumetric rates do not provide efficient or equitable price signals to residential customers

- They create cross-subsides between customers with different load factors and in particular between customers with DG and those without DG
- The problem will become more pronounced as DG penetration grows

For electric delivery service, the combination of a fixed customer charge and a demand charge best align revenues and costs and provide customers with the appropriate price signals. Demand charge can be:

- A combination of non-coincident peak and coincident peak demand charges; or
- Time-differentiated demand charges

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Concluding Thoughts II

Default time-of-use rates reflect the marginal cost of generation and transmission, but typically do a poor job of also reflecting the delivery system marginal cost

Choice of appropriate mass market rate design should not be decided solely on customer bill impacts

- Bill impacts can inform the pace of change
- The principles of cost causation and economic sustainability should be given priority

There are many ways in which to make the transition

- Phase in rate reform with initial focus on DG customers
- Seek stakeholder input
- Educate customers

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Dr. Sanem Sergici is a Principal in The Brattle Group's Boston, MA office specializing in program design, evaluation, and big data analytics in the areas of energy efficiency, demand response, smart grid and innovative pricing. She regularly supports electric utilities, regulators, law firms, and technology firms in their strategic and regulatory questions related to retail rate design and grid modernization investments.

Dr. Sergici has been at the forefront of the design and impact analysis of innovative retail pricing, enabling technology, and behavior-based energy efficiency pilots and programs in North America. She has led numerous studies in these areas that were instrumental in regulatory approvals of Advanced Metering Infrastructure (AMI) investments and smart rate offerings for electricity customers. She also has significant expertise in development of load forecasting models; ratemaking for electric utilities; and energy litigation. Most recently, in the context of the New York Reforming the Energy Vision (NYREV) Initiative, Dr. Sergici studied the incentives required for and the impacts of incorporating large quantities of Distributed Energy Resources (DERs) including energy efficiency, demand response, and solar PVs in New York.

Dr. Sergici is a frequent presenter on the economic analysis of DERs and regularly publishes in academic and industry journals. She received her Ph.D. in Applied Economics from Northeastern University in the fields of applied econometrics and industrial organization. She received her M.A. in Economics from Northeastern University, and B.S. in Economics from Middle East Technical University (METU), Ankara, Turkey.

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