Understanding Residential Customer Response to Demand Charges: Present and Future

PRESENTED TO

EUCI Residential Demand Charge Conference, Chicago IL

PRESENTED BY

Sanem Sergici, Ph.D.
(with contributions from Ahmad Faruqui and Ryan Hledik)

October 20, 2016

THE Brattle GROUP

Agenda

Understanding Residential Customer Response to Demand Charges

- Customer’s perspective
- Evidence from 1st generation pilots/programs
- Evidence from 2nd generation pilots/programs

PRISM Approach to Quantifying Response to Demand Charges

- Overview of approach
- Overview of findings

Transitional Mechanisms

Understanding Residential Customer Response to Demand Charges

Residential rate design is ripe for rethinking

Flat rate pricing is pervasive in residential rate design

The problem is not just a problem for the utility's shareholders

- The oversized volumetric rate can be avoided through investment in high-efficiency appliances and distributed generation
- Customers who don't (or can't) make these investments, particularly low income customers, subsidize those who do
- Therefore the cross-subsidy has significant implications with regard to equity and fairness – two important ratemaking criteria

Flat rate pricing persisted because of two reasons

- Lack of advanced metering
- A concern that residential customers are not ready for a change

Can residential customers understand demand charges?

Anyone who has purchased a light bulb has encountered watts; ditto for anyone who has purchased a hair dryer or an electric iron

Customers often introduced to kWh's by way of kWs; e.g., if you leave on a 100 watt bulb for 10 hours, it will use 1,000 watt-hours, or one kWh

Similarly, if you run your hair dryer at the same time that someone else is ironing their clothes and lights are on in both bathrooms, the circuit breaker may trip on you since you have exceeded its capacity, expressed in kVA's or kW's

Customers don't need to be electricity experts to understand a demand charge

Responding to a demand charge <u>does not require that the customers know exactly when their maximum demand will occur</u>

If customers know to avoid the simultaneous use of electricity-intensive appliances, they could easily reduce their maximum demand without ever knowing when it occurs

This simple message should be stressed in customer marketing and outreach initiatives associated with the demand rate

Examples from utility websites

- APS: "Limit the number of appliances you use at once during on-peak hours"
- Georgia Power: "Avoid simultaneous use of major appliances. If you can avoid running appliances at the same time, then your peak demand would be lower. This translates to less demand on Georgia Power Company, and savings for you!

Staggering the use of a few key appliances could lead to significant demand reductions

Avg. Demand Over 15 min

Appliance	Avg. Demand (kW)	
Clothes Dryer	4.0	Flexible Load (18.5 kW)
Oven	2.0	
Stove	1.0	
Hand iron	0.5	
Central air conditioner	5.0	
Spa heater and filter	6.0	
Misc. plug loads	0.2	Inflexible Load (1 kW)
Lighting	0.3	
Refrigerator	0.5	
Total	19.5	

Comments

- Use of some of the appliances is inflexible (1 kW)
- Use of other appliances could be easily staggered to reduce demand
- Simply delaying use of the clothes dryer, oven, stove, and hand iron would reduce the customer's maximum demand by 7.5 kW
- This would bring the customer's maximum demand down to 12 kW, **a roughly 38% reduction in demand**

Alternative Ways to Design a Demand Charge

There are many ways to design a demand charge

- Customer's maximum demand during month
- Max demand during peak hours of day (e.g. 2 pm to 6 pm)
- Demand during actual hour(s) of system peak
- Average of customer's highest X demand hours of month
- Average over interval of 15, 30, 60, even 120 minutes
- Others

Observations about existing demand rates

There is no one-size-fits-all approach across the 19 utility offerings

- 10 vary by season
- 8 combined with time-varying energy charge
- 6 based on demand during system peak period
- 2 measure demand over a 60 minute interval

Mostly offered on opt-in basis, occasionally mandatory for sub-classes

Emerging trend toward enhanced marketing

Low enrollment but not necessarily due to lack of interest

Typical enrollee at least 2x size of average customer

Observations about existing demand rates (cont'd)

Reasons for offering the rates have changed

- Older rates: Improve load factor (opt-in)
- Newer rates: More equitable cost recovery (opt-in)
- Future rates: Equity and fairness, (opt-out or mandatory)

Most utilities are vertically-integrated, not in RTOs

Rates typically recover distribution and generation capacity costs and sometimes transmission

Little empirical assessment of the rates' impacts has been conducted

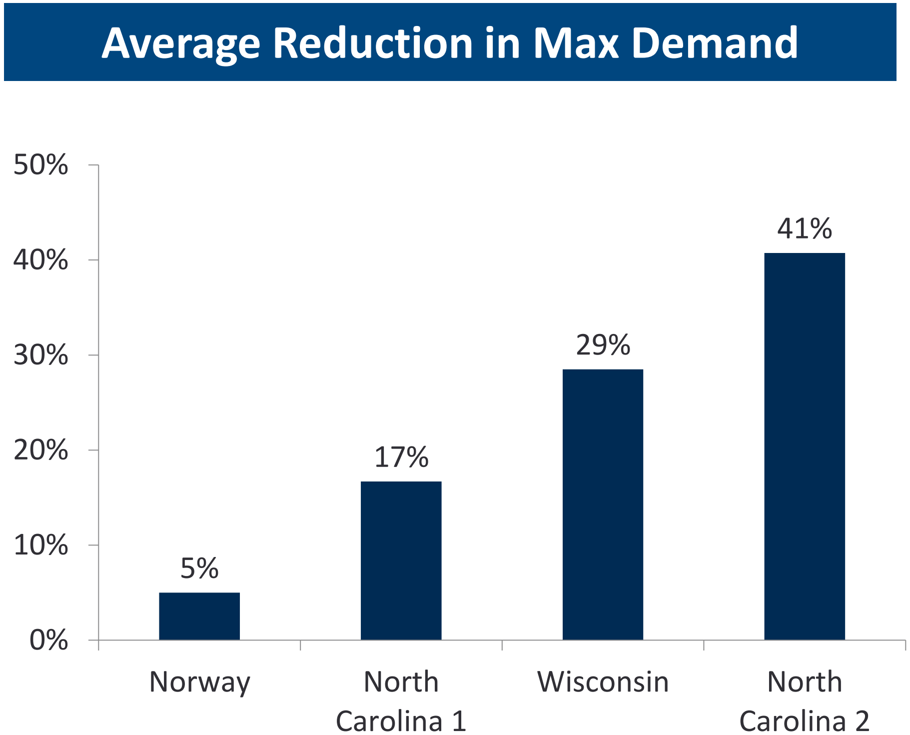
Do residential customers respond to demand charges?

Until recently, there were only three systematic studies that looked into this question

Study	Location	Utility	Year(s)	# of participants	Monthly demand charge ($/kW)	Energy charge (cents/kWh)	Fixed charge ($/month)	Timing of demand measurement	Interval of demand measurement	Peak period	Estimated avg reduction in peak period consumption
1	Norway	Istad Nett AS	2006	443	10.28	3.4	12.10	Peak coincident	60 mins	7 am to 4 pm	5%
2	North Carolina	Duke Power	1978 - 1983	178	10.80	6.4	35.49	Peak coincident	30 mins	1 pm to 7 pm	17%
3	Wisconsin	Wisconsin Public Service	1977-1978	40	10.13	5.8	0.00	Peak coincident	15 mins	8 am to 5 pm	29%

Notes:
All prices shown have been inflated to 2014 dollars
In the Norwegian pilot, demand is determined in winter months (the utility is winter peaking) and then applied on a monthly basis throughout the year.
The Norwegian demand rate has been offered since 2000 and roughly 5 percent of customers have chosen to enroll in the rate.
In the Duke pilot, roughly 10% of those invited to participate in the pilot agreed to enroll in the demand rate.
The Duke rate was not revenue neutral - it included an additional cost for demand metering.
The Wisconsin demand charge is seasonal; the summer charge is presented here because the utility is summer peaking.

Three experiments suggest that customers will respond



Note: The North Carolina pilot was analyzed through two separate studies using different methodologies; both results are presented here

However…

- Two of the pilots are old and the third is from a unique climate
- The impact estimates vary widely and based on small sample sizes
- No clear correlation between the demand charge level and participants' demand reduction
- New research is needed

Preliminary Conclusions and Limitations of First Generation Pilots

Preliminary Conclusions

- Customers do respond to demand charges
- Customers treat demand charges similar to TOU in terms of the everyday nature of their demand reduction
- Demand charges can potentially lead to overall energy savings
- Larger and wealthier homes are more likely to enroll in demand charges
- Demand charge impacts are trickier to estimate; modelling technique must be carefully considered

Limitations

- Two of the three pilots are very old (4 decades of changes in appliance stocks and customer attitude)
- Do not capture the role of smart grid technologies in managing demand
- Limited geographic coverage
- Range of estimates is too broad to draw conclusions
- None of them are based on billing demand; they measure demand during peak hours

Evidence from 2nd Generation Programs/Pilots

APS has more than 110,000 customers subscribed to utility's residential demand rate

- 3-parts (TOU energy, demand, and fixed charge)
- Both energy and demand components have seasonal variation
- Highest integrated one-hour kW read during peak hours
- Customers on a demand-based TOU rate shave peak demand by 5-15% more compared to customers on an energy only TOU rate

SRP is currently running a pilot program to understand the impact of demand charges on the non-DG residential customer usage

PRISM Approach to Quantifying Response to Demand Charges

New empirical research would improve our understanding of customer response

There are at least two viable approaches for reliably testing the impact of demand charges

Experimental pilot

- Scientific approach designed to provide statistically robust estimates
- Randomly selected treatment and control group to avoid bias
- Pre- and post-treatment data collection

"Test and learn" deployment

- Rates are deployed full scale and modified regularly to assess impacts
- "Before and after" data can still be collected
- A quasi-control group can be created from non-participants
- Less scientific, but facilitates faster deployment

However, sometimes pilots are not feasible

While some jurisdictions carefully study the implications of demand charges in the form of pilots, others have circumstances that prevent them from undertaking these pilots

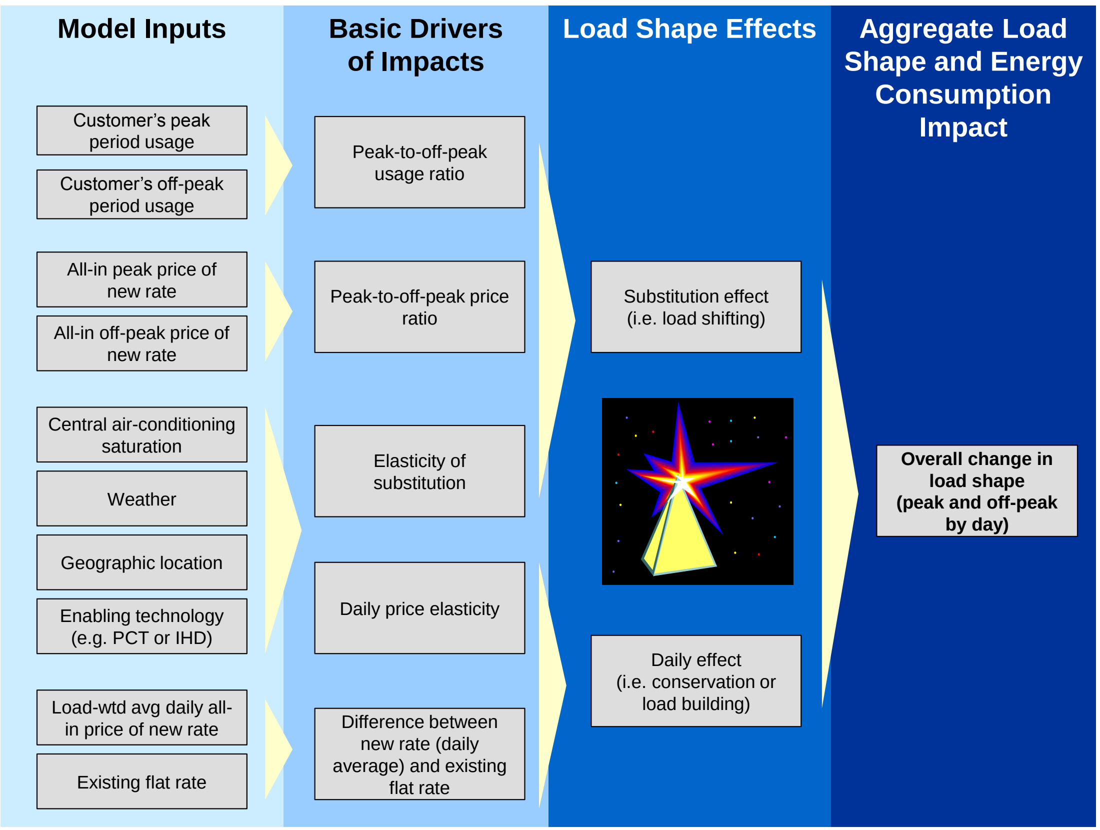
In the latter case, it might be useful to rely on an analytical tool to study:

- How does the demand change with different levels of demand charges?
- Does the impact vary for different customer types?
- How do the demand and peak impacts compare to each other under different pricing schemes?

We adapted the PRISM model to quantify the impact of demand charges

PRISM Applied to Demand Charges

Illustration of System-based Approach



Comments

- Load shifting effect and the average price effect can be represented through a single system of two simultaneous demand equations
- The system of equations includes an "elasticity of substitution" and a "daily price elasticity" to account for these two effects
- This modeling framework has been used to estimate customer response to time-varying rates in California, Connecticut, Florida, Maryland, and Michigan, among other jurisdictions
- In California and Maryland, the resulting estimates of peak demand reductions were used in utility AMI business cases that were ultimately approved by the respective state regulatory commissions

Our Approach

We model the impacts from two revenue neutral rates:

TOU vs. Demand Charge

- Demand charge is defined based on the highest one hour demand in the peak period
- Customer A is small but peaky
- Customer B is average
- Customer C is large and less peaky

	Current Pricing	Time of Use Pricing	Residential Demand
Customer Charge ($/month)	$10.00	$10.00	$10.00
Volumetric Charge ($/kWh)	$0.10		$0.05
Peak (4PM - 8PM)		$0.30	
Off-Peak		$0.07	
Demand Charge ($/kW)			$8.00

Sample Usage Patterns				
	Peak Usage	Off-Peak Usage	Demand	Total
Customer A	80	300	5	380
Customer B	150	850	4	1000
Customer C	250	2250	3	2500

Impact of Residential Demand Charge

Customer A	Time-of-Use	Residential Demand Charge
Total Usage	-0.6%	-1.5%
Peak Usage	-10.0%	
Demand		-16.6%

*Demand is measured in kW, all else in kWh.

Customer B	Time-of-Use	Residential Demand Charge
Total Usage	-0.2%	0.8%
Peak Usage	-11.3%	
Demand		-11.8%

*Demand is measured in kW, all else in kWh.

Customer C	Time-of-Use	Residential Demand Charge
Total Usage	0.3%	2.1%
Peak Usage	-12.0%	
Demand		-7.1%

*Demand is measured in kW, all else in kWh.

- For Customer A (small but peaky customer), the demand is lower by 16.6% after the implementation of RDC
- For Customer B (average customer), the demand is lower by 11.8%
- For Customer C (large and less peaky customer), the demand is lower by 7.1%

Impact of Demand Charge on Monthly Bills

Customer A	Current Rate	Time-of-Use	Residential Demand Charge
No Behavioral Change	$48.00	$55.00	$69.00
With Behavioral Response		$53.00	$62.06
No Behavioral Change (%)		15%	44%
With Behavioral Response (%)		10%	29%

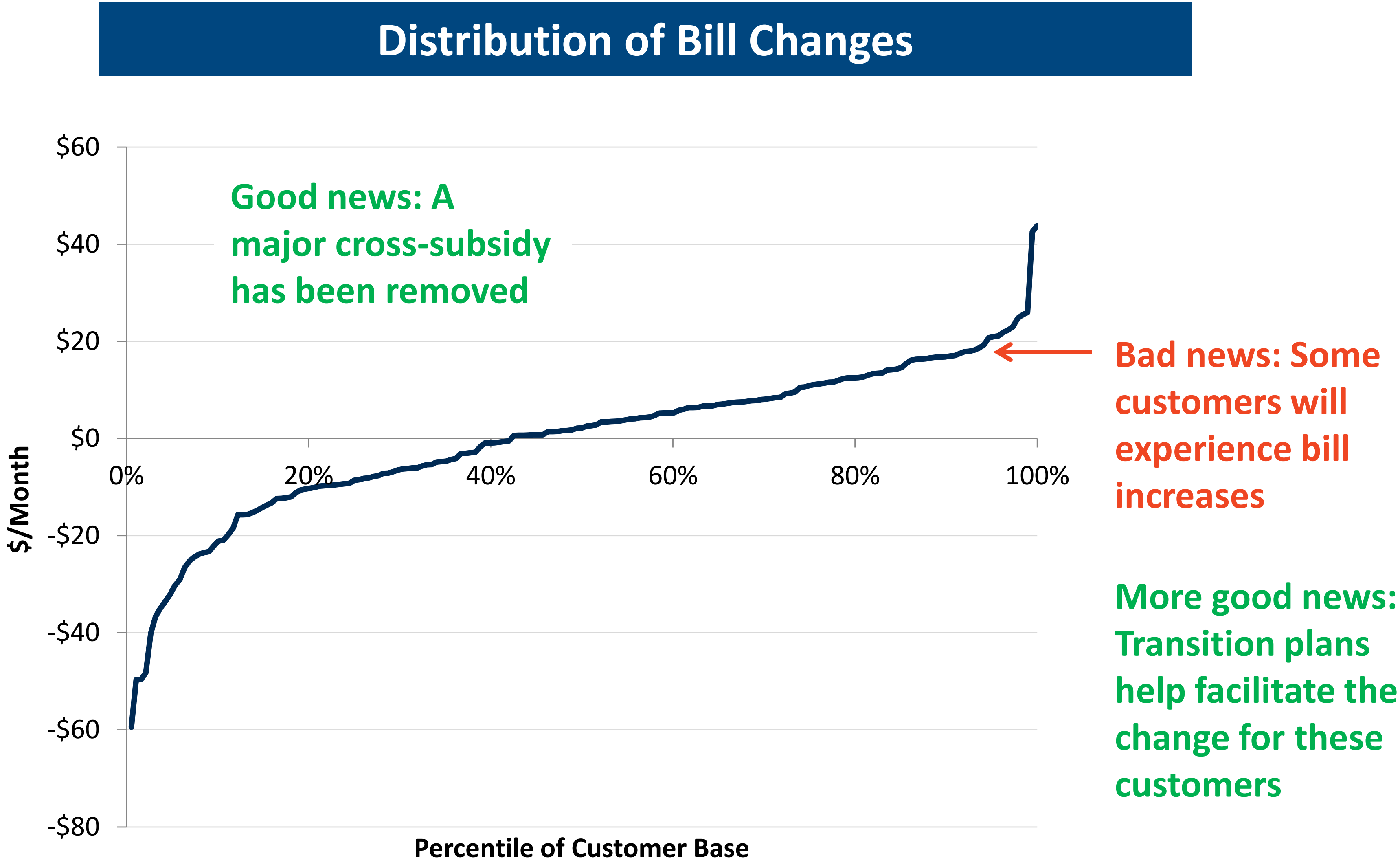
Customer B	Current Rate	Time-of-Use	Residential Demand Charge
No Behavioral Change	$110.00	$114.50	$92.00
With Behavioral Response		$110.47	$88.62
No Behavioral Change (%)		4%	-16%
With Behavioral Response (%)		0%	-19%

Customer C	Current Rate	Time-of-Use	Residential Demand Charge
No Behavioral Change	$260.00	$242.50	$159.00
With Behavioral Response		$236.14	$159.98
No Behavioral Change (%)		-7%	-39%
With Behavioral Response (%)		-9%	-38%

- Customer A’s monthly bill is higher by 29% after the implementation of RDC
- Customer B’s monthly bill is lower by 19% after the implementation of RDC
- Customer C’s monthly bill is lower by 38% after the implementation of RDC

Transitional Mechanisms

The rate change will affect each customer's bill differently



Common stakeholder concerns about demand charges

1. Demand charges will increase bills for low income customers
2. Residential customers will not understand demand charges
3. They will remove the incentive to invest in energy efficiency and rooftop solar PV
4. They will increase monthly bill volatility
5. Demand charges are not cost-based; TOU is a better option
6. They will require investment in expensive metering and billing infrastructure

New initiatives can address stakeholder concerns

1- Quantify bill impacts, particularly for low- and moderate-income customers

2- Assess customer understanding of demand charges through market research and identify the best way to communicate the concept

3- Assess customer response to demand charges through empirical analysis, pilots, and/or a test-and-learn approach

4- Establish a national conversation on residential demand charges

Initiatives to address stakeholder concerns (cont'd)

5- Consider innovative variations on conventional demand charge designs

6- Develop a customer education plan

7- Phase in the rate gradually

8- Develop protections for vulnerable customers

The transition will have to be tailored to the unique circumstances of each regulatory jurisdiction

Presenter Information

SANEM SERGICI

Senior Associate | Cambridge

Sanem.Sergici@brattle.com

+1.617.864.7900

Dr. Sanem Sergici is a Senior Associate in The Brattle Group's Cambridge, MA office with expertise in electricity markets and applied econometrics. At Brattle, the focus of Dr. Sergici's work has been on assisting electric utilities, regulators, market operators, and technology firms in their strategic questions related to energy efficiency, demand response, distributed generation, and understanding behavior of electricity prosumers. Dr. Sergici has been at the forefront of the design and analysis of dynamic pricing, enabling technology, and behavior-based energy efficiency programs in the North America. Dr. Sergici has completed numerous resource planning projects that involved development of scenarios and strategies for electric systems to meet long-range electric demand while considering the growth of renewable energy, energy efficiency, and other demand-side resources. 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 has been studying the incentives required for and the impacts of incorporating large quantities of Distributed Energy Resources (DERs) including energy efficiency, demand response, solar PVs, and energy storage in New York.She has spoken at several industry conferences and published in several industry journals.