The Brattle Group

Tutorial: Theory and Practice of Cost-Reflective Rates

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Rate Design Principles – The Bonbright Criteria

1. Effectiveness in yielding total revenue requirements under the fair-return standard without any socially undesirable expansion of the rate base or socially undesirable level of product quality and safety
2. Revenue stability and predictability, with a minimum of unexpected changes that are seriously adverse to utility companies
3. Stability and predictability of the rates themselves, with a minimum of unexpected changes that are seriously adverse to utility customers and that are intended to provide historical continuity
4. Static efficiency, *i.e.,* discouraging wasteful use of electricity in the aggregate as well as by time of use
5. Reflect all present and future private and social costs in the provision of electricity (*i.e.*, the internalization of all externalities)
6. Fairness in the allocation of costs among customers so that equals are treated equally
7. Avoidance of undue discrimination in rate relationships so as to be, if possible, compensatory (free of subsidies)
8. Dynamic efficiency in promoting innovation and responding to changing demand-supply patterns
9. Simplicity, certainty, convenience of payment, economy in collection, understandability, public acceptability, and feasibility of application
10. Freedom from controversies as to proper interpretation

The Bonbright Criteria Collapse into 5 Key Criteria

1. Economic Efficiency

2. Equity

3. Revenue Stability

4. Bill Stability

5. Customer Satisfaction

Economic Efficiency

Price acts as a signal

If price is set to the incremental cost of providing a kWh

- Consumers who value the kWh more than the cost will use it
- Consumers who value it less will not

Ensures resources are not wasted

May not meet other social goals such as protecting vulnerable consumers

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Equity

No consumer should unintentionally subsidize another consumer

Different load profiles mean that “peaky” consumers are using electricity when it is most expensive

They are subsidized by “less-peaky” consumers who overpay for cheap off-peak electricity

In the US we estimate that under flat rate pricing, inter-customer subsidies may amount to $3 billion per year

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Risks

Revenue Stability

- Risk faced by retailer in moving away from flat rate
- Theoretically, all pricing schemes can be implemented to be revenue neutral
  - More difficult to achieve with consumer price response.

Bill Risk

- Risk faced by consumer of large increases in bill
- Pricing schemes can be designed to be neutral for the average customer
- May not be neutral for all customers – winners and losers

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Customer Satisfaction

Need customer "buy in" for a rate to work

Rates need to be:

- Simple:
  - Electricity is not customers' number one priority
  - Rates need to be simple to understand
  - AND simple to respond to
- Choice
  - Customers have different needs and risk tolerances
  - Choice of rates may allow them to optimize for their own preferences
  - Choice may alleviate political concerns

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Developing Inclining Block Rates

Agenda

1. Why the renewed interest in inclining block rates?
2. The art and science of designing an inclining block rate
3. Understanding the impacts
4. Inclining block rates in action
5. Frequently asked questions

Utilities have rediscovered the demand side of the equation

Energy efficiency can play a vital role in meeting future energy needs

- It reduces resource costs
- It can control rising bills (by managing rate shock)
- It is a tool that any utility can employ to lower emissions
- And it is a value-added service for customers

Recent policy has recognized this importance by promoting energy efficiency

- Removal of financial disincentives for energy efficiency
- Approval of additional incentives
- Legislative goals and targets

What is the best way to pursue energy efficiency?

There is no single solution to energy efficiency

Information

- About energy costs as they are incurred and ideas on how to manage those costs

Codes and standards

- For new appliances, buildings and industrial processes

Enabling technologies

- For controlling costs in real-time conditions through price-sensitive thermostats and appliances

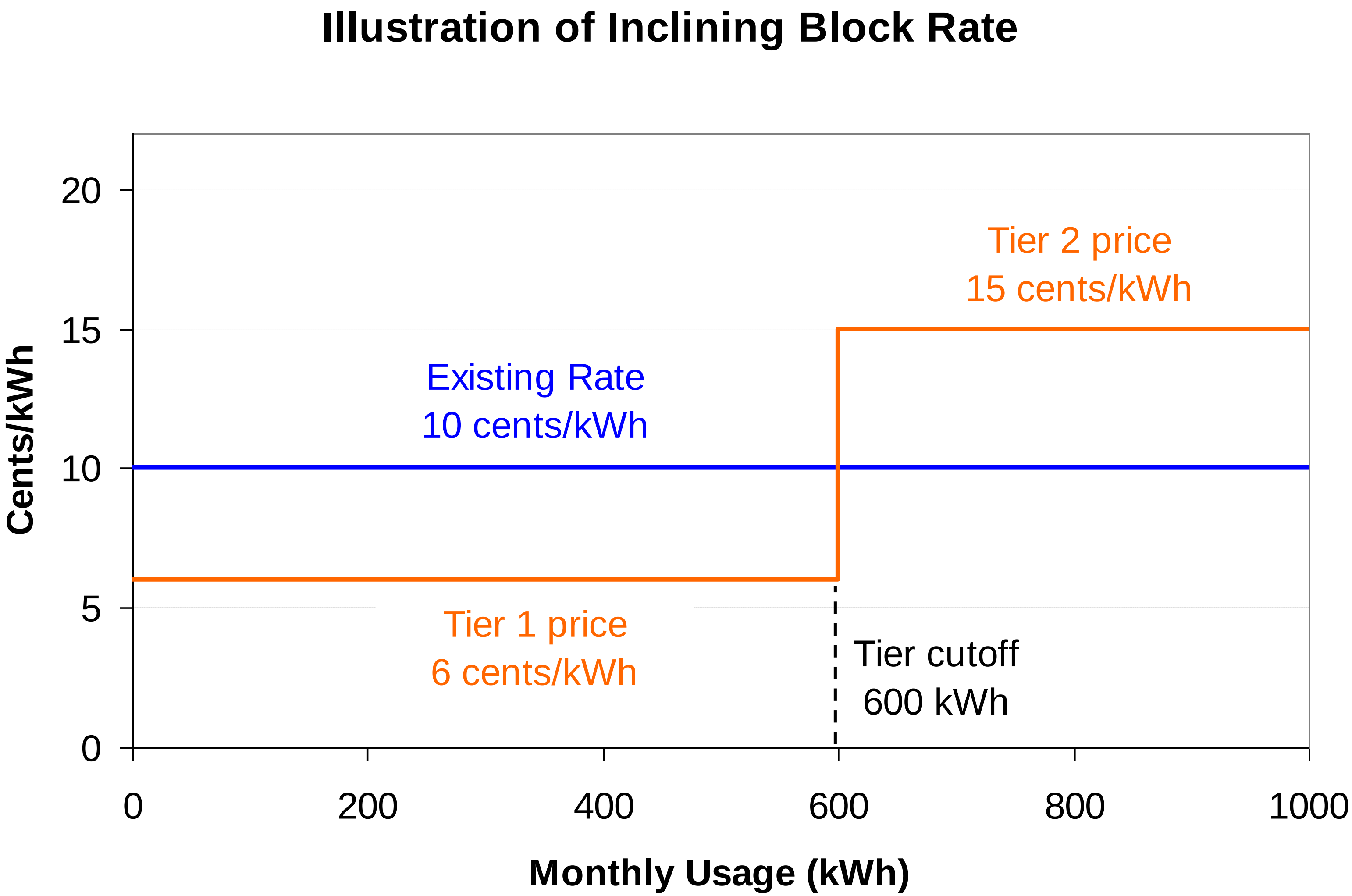
Rebates and financing

- Accelerating the adoption of smart end-use technologies

Smart rate design

- Inclining block rates for energy efficiency and dynamic pricing rates for peak load management

Illustration of an energy efficiency-inducing inclining block rate (IBR)



There are good reasons for promoting energy efficiency through rate design

It is a low-cost option

- Does not require smart meters or incentive/rebate payments

It improves the economics of other efficiency technologies

- Increased intrinsic value of in-home information displays
- Faster payback on rooftop solar installations

It reflects system costs more accurately than a flat rate

- This applies in an increasing marginal cost environment

It is customer-friendly and can be universally deployed

- Simplicity is key in generating customer response

However, there are also challenges

Recovering fixed costs

- Does decoupling apply to lost revenues due to rate structure changes?
- Without decoupling, how is the lost revenue issue addressed?

Designing an effective rate

- Will the rate induce customer response?
- Will it satisfy important criteria for sound ratemaking?

Managing bill impacts

- By how much will customers' bills change?
- Will the rate hurt specific customer segments?
- What are options for mitigating these impacts?

These issues will be addressed throughout the presentation

Designing an inclining block rate is both an *art* and a *science*

Some aspects of IBR design are more "science" than "art"

- Aligning prices with system costs

Other aspects require subjective judgment

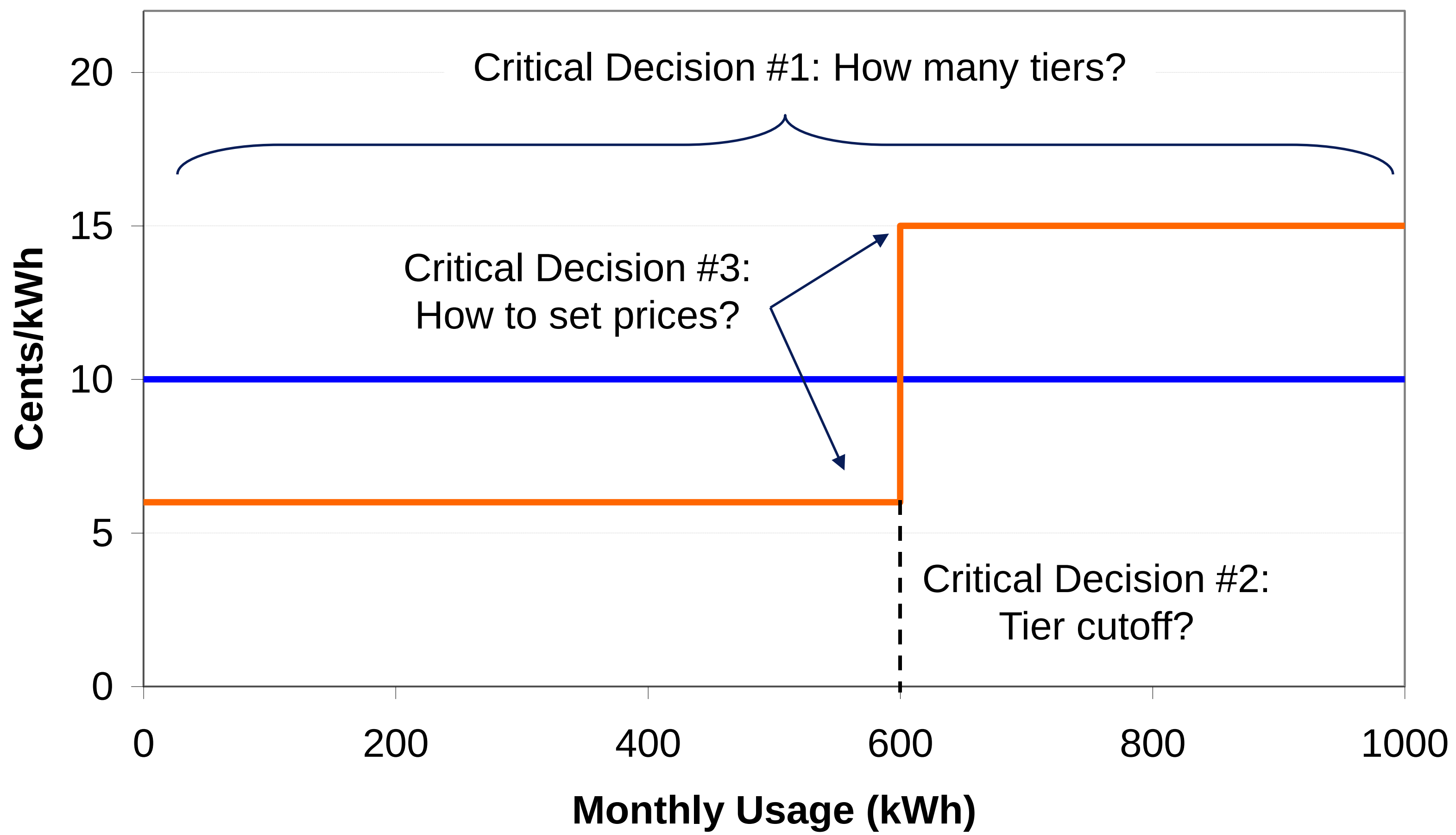
- Establishing the number of tiers
- Determining cutoff points

The exercise requires tradeoffs among often conflicting objectives

- Encouraging more efficient energy consumption
- More accurately reflecting system costs
- Promoting social objectives (e.g., income re-distribution)
- Ensuring bill stability or rate continuity

There are three critical decisions to be made when designing an inclining block rate

Illustration of Inclining Block Rate



Critical Decision #1: How many tiers?

The simplest IBR has two tiers

- Provides simplicity for customer
- Provides simplicity for utility

A three-tiered rate is another approach

- Provides more customers with a conservation incentive
- Still fairly easy to explain

Today's IBRs include as many as five tiers

- Most granular reflection of increasing costs
- In theory, the concept could be extended to a "straight line"

Critical Decision #2: How to establish the cutoff point between tiers?

Lifeline
- First tier represents monthly usage level necessary to satisfy a basic standard of living

Baseload generation
- First tier represents share of class usage that is met through baseload generation

Average usage
- First tier represents average customer's monthly usage

Even allocation
- Cutoffs are set such that class usage is allocated evenly within the tiers

Energy efficiency target
- For example, establish cutoff at 80% of previous year's class usage

Function of individual customer usage
- Specify tiers as percentage of usage on an individual customer basis

Critical Decision #3: How to set the prices?

Set based on system costs

- ♦ Final tier as peak marginal energy and capacity cost
- ♦ First tier as off-peak marginal cost

Set based on policy goals

- ♦ Reverse-engineer the target level of customer response and price accordingly
- ♦ Build rate increase only into outer tiers
- ♦ Satisfy mandated rate caps (e.g. California)
- ♦ Constrain price range to limit distribution of bill changes

The prices could be based on a combination of these options

The are multiple methods for measuring customer response to inclining block rates

How do customers respond to an inclining block rate?

- Marginal price
  - Customers observe the price paid for the "last" kWh of electricity, which is the price per kWh the customer considers
  - Economic theory suggests marginal customer response
- Average price
  - Customers divide their total bill by the total number of kWh consumed; the resulting price per kWh is the price customers consider

***Brattle* uses an approach between these extremes**

- Tier-based marginal price
  - Customers respond to the marginal price paid in each tier

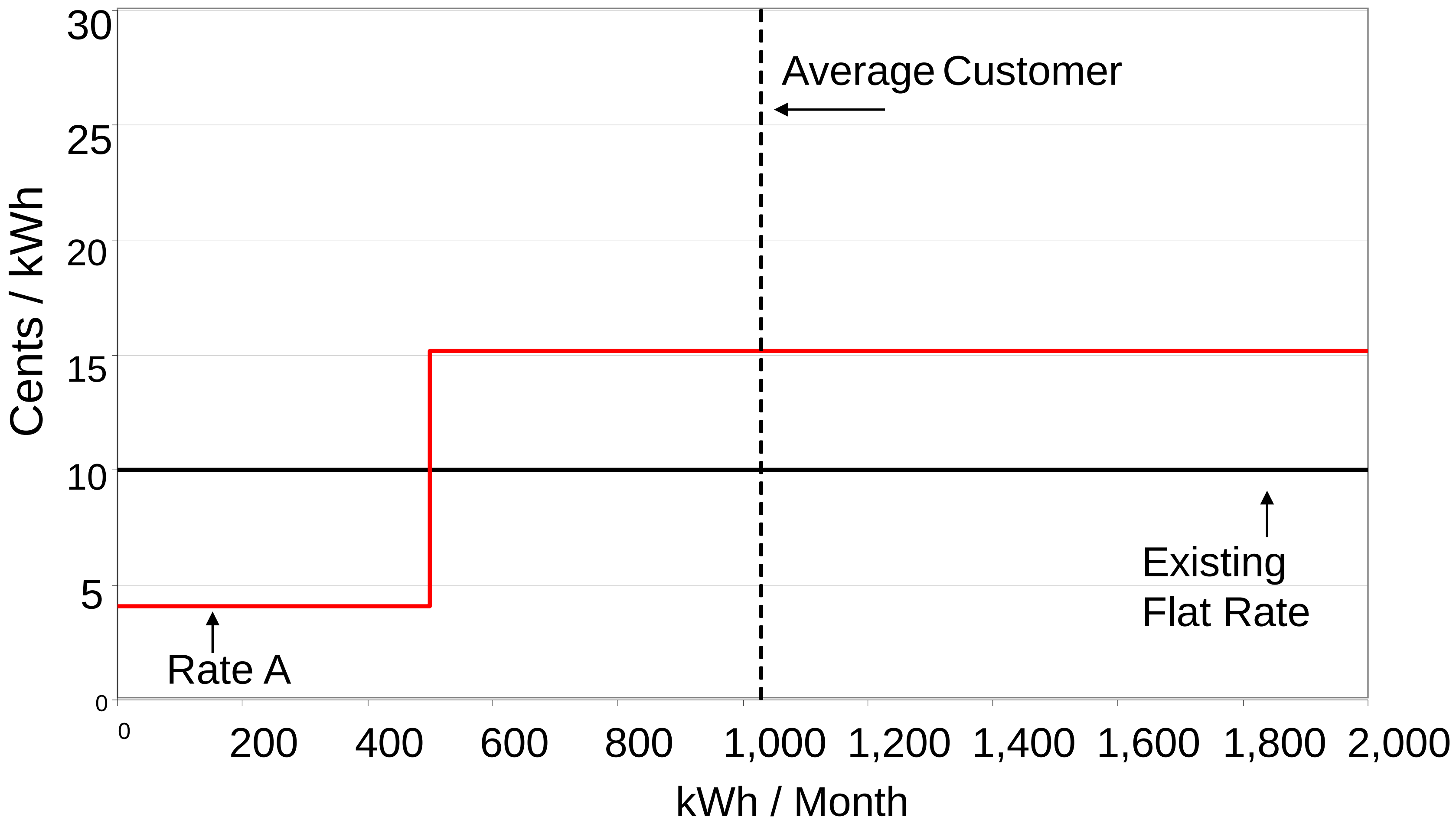
The analysis is driven by assumptions about customer short-run price elasticity

We assume a 1st tier short-run elasticity of -0.13 and a 2nd tier short-run elasticity of -0.26

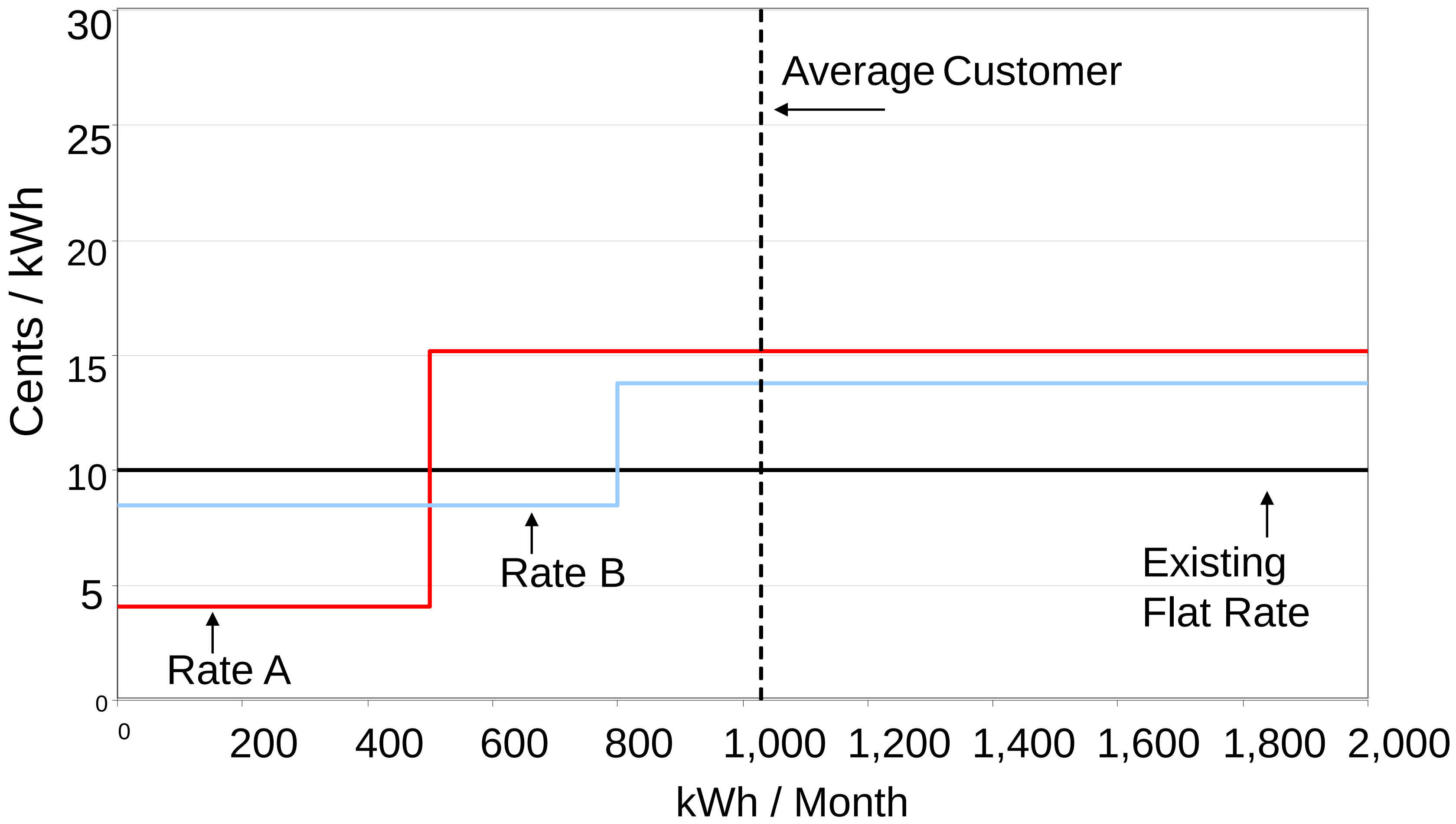
- 1st tier consumption is generally considered to be less elastic than 2nd tier consumption
- Several sources were surveyed to determine the price elasticity
  - Short run elasticities were estimated by EPRI at -0.3 and RAND at -0.24
  - Study of California households found that residential electric price elasticity could range anywhere from 0 to -1.08
  - According to a paper by Severin Borenstein, elasticities ranged from -0.1 to -0.2
- To be conservative, our assumptions are at the low end of this range

Long-run price elasticities are significantly larger and would change the results of the analysis

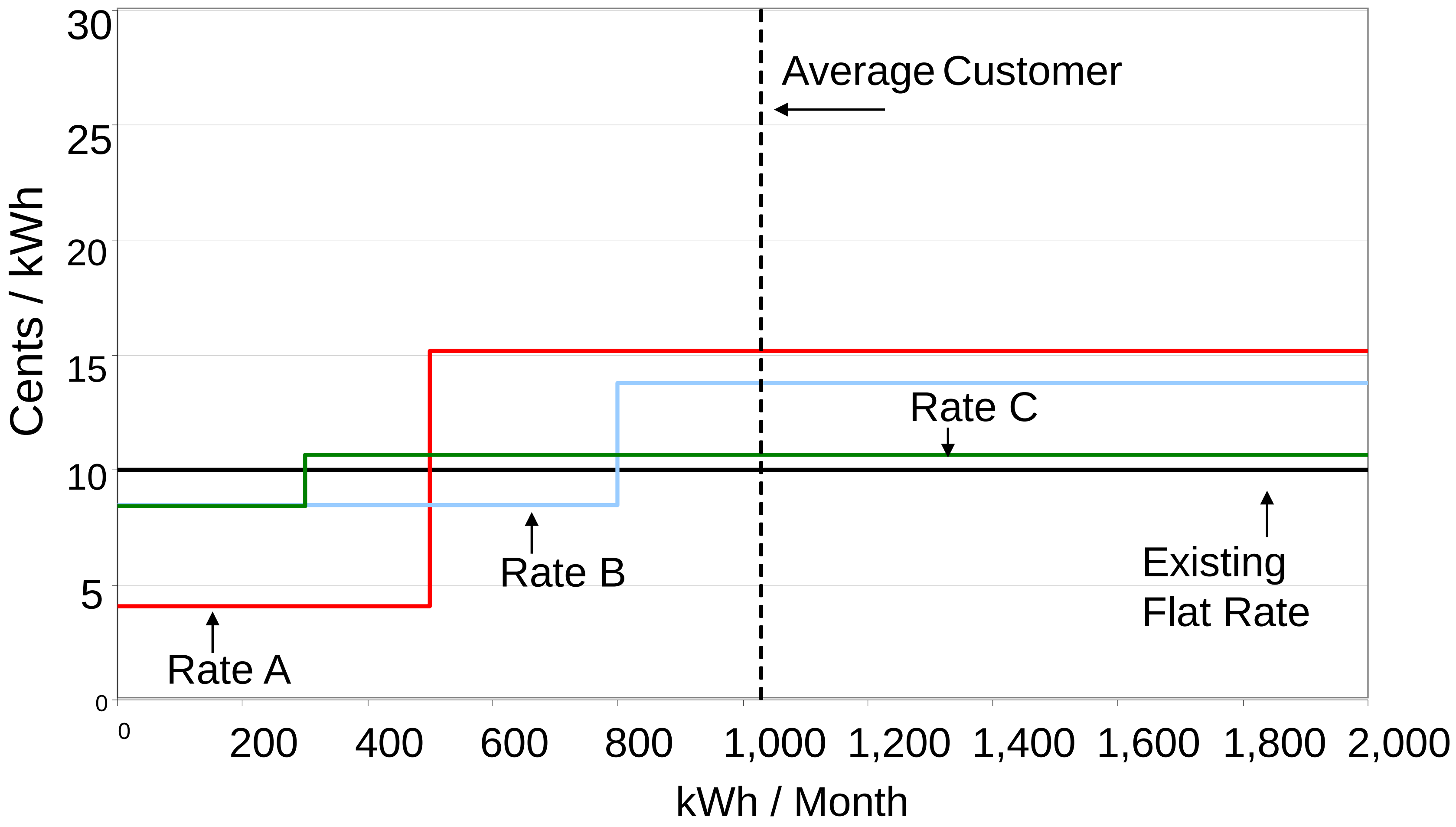
Introducing revenue neutral inclining block rates



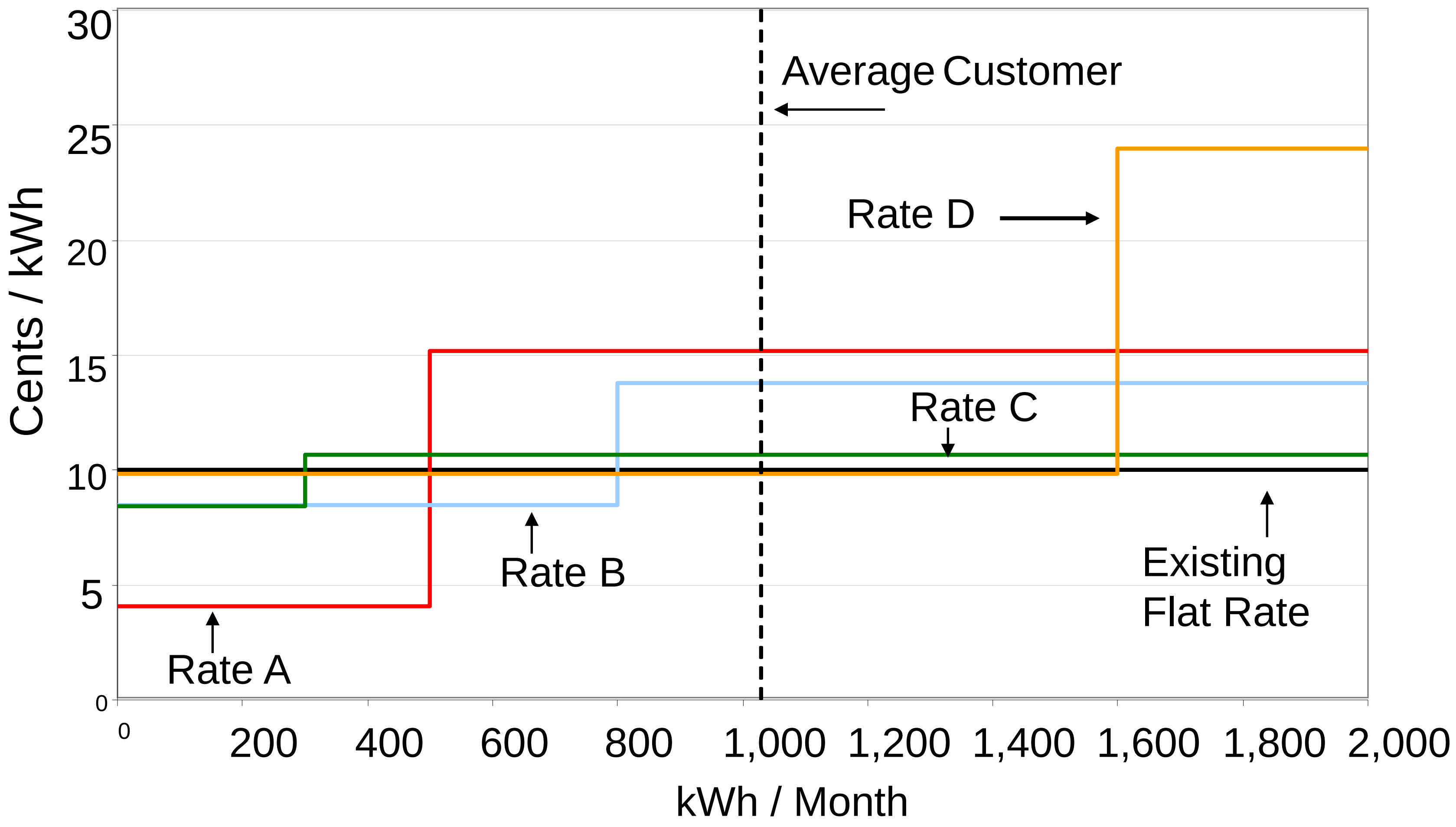
Rate B has a wider first block than Rate A



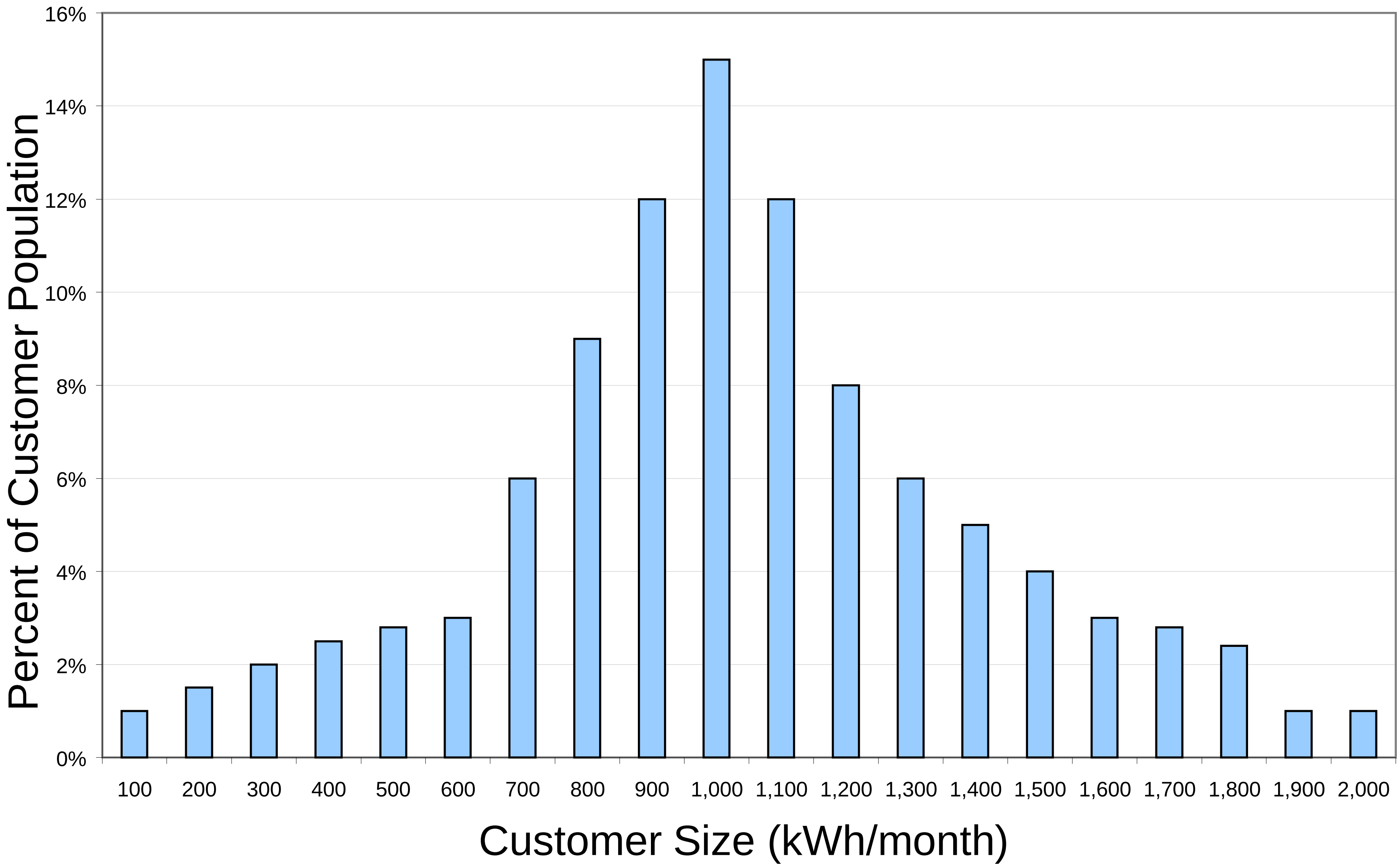
Rate C is a very mild inclining block rate



Rate D focuses on the largest users



Representative customer billing distribution

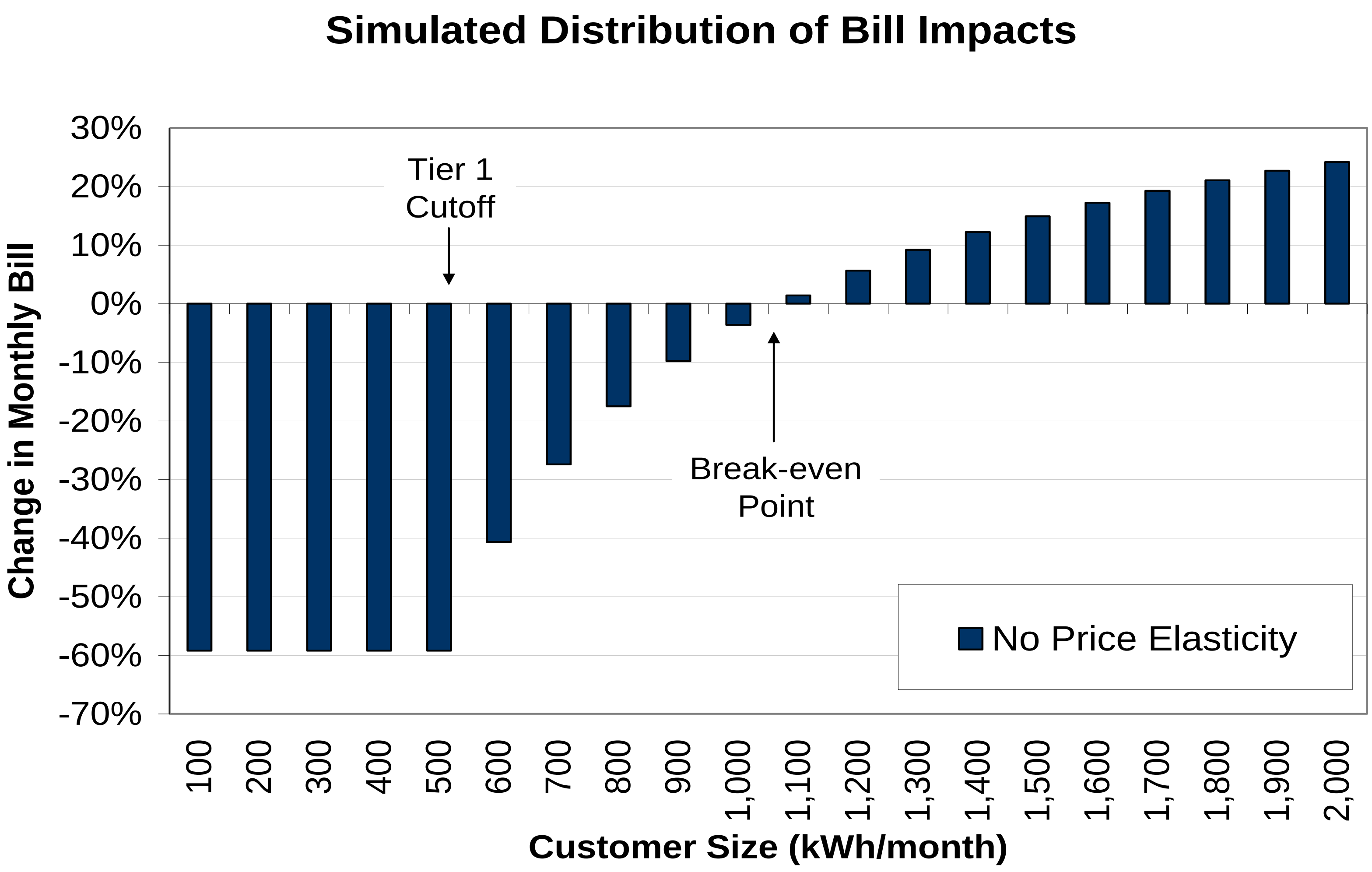


Energy use could decline by up to 5.9 percent & Customer bills could decline by up to 9.1 percent

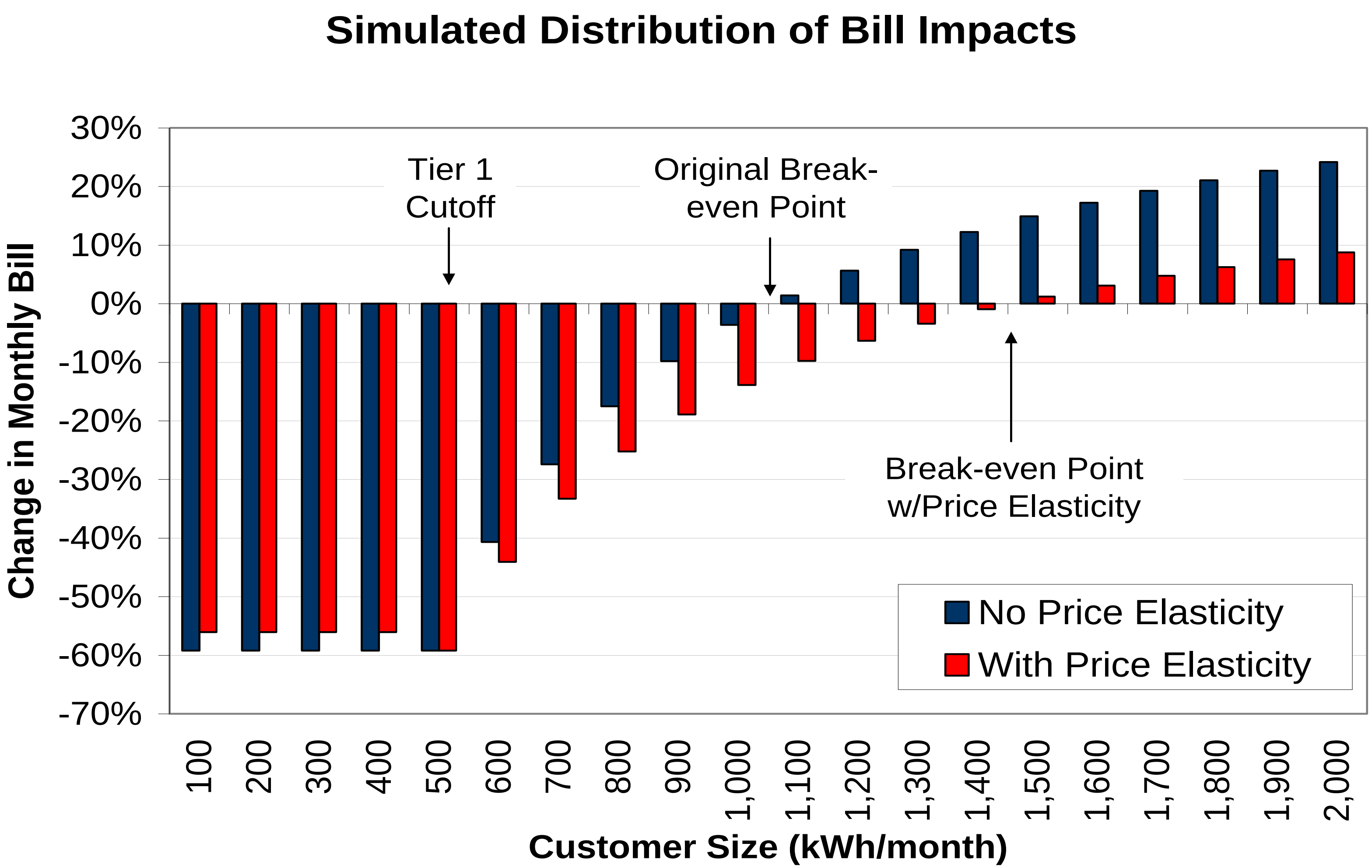
Price Elasticity		Avg Percent Change in Usage Rate A	Rate B	Rate C	Rate D
Short Run	**Mean**	**-5.9%**	**-2.2%**	**-1.0%**	**-0.5%**
	Std Dev	2.0%	0.8%	0.3%	0.2%
Long Run	**Mean**	**-18.4%**	**-6.7%**	**-3.1%**	**-0.7%**
	Std Dev	6.5%	2.4%	1.1%	0.4%

Price Elasticity	Avg Percent Change in Customer Bills Rate A	Rate B	Rate C	Rate D
Short Run	**-9.1%**	**-3.1%**	**-1.0%**	**-1.4%**
	3.1%	1.1%	0.4%	0.5%
Long Run	**-28.4%**	**-9.4%**	**-3.3%**	**-2.6%**
	9.9%	3.4%	1.1%	1.0%

Bill savings are largest for the smallest customers



Price response mitigates the impact on high use customers



Inclining block rates are used all over the world, and not only by electric utilities

BC Hydro conducted an IBR survey in 2008 of 88 utilities in North America, Europe, and Asia

Table C-1 Number of Utilities Offering a Particular Default Residential Tariff

Tariff Structure	Canada	US	Europe	Asia	Total
Inclining block year round	3	18	1	2	24
Summer inclining block but winter declining block	0	5	0	0	5
Inclining summer flat winter	0	2	0	0	2
Flat summer declining winter	0	3	0	0	3
Declining block year round	3	2	1	0	6
Flat rate year around	11	31	5	0	47
TOU	0	0	1	0	1
Total	**17**	**61**	**8**	**2**	**88**

Water utilities also use IBRs

San Francisco Public Utilities Commission's water IBR

Block	Charge per 100 Cubic Feet				
	Effective 7/1/09	Effective 7/1/10	Effective 7/1/11	Effective 7/1/12	Effective 7/1/13
For the first 300 cubic feet	$2.61	$3.09	$3.50	$3.90	$4.20
All additional cubic feet	$3.48	$4.12	$4.60	$5.20	$5.50

Updated analysis of BC Hydro’s 2008 IBR survey shows 22 of 61 U.S. utilities (36%) use IBRs sometime during the year

Survey of Inclining Block Rates (Three, Four, and Five Tiers)

State	Utility	Tier 1 ($/kWh)	Tier 2 ($/kWh)	Tier 3 ($/kWh)	Tier 4 ($/kWh)	Tier 5 ($/kWh)
CA	**Pacific Gas & Electric ***	**0.11877**	**0.13502**	**0.29062**	**0.40029**	
	Cutoff (% of baseline)	100%	130%	200%		
	Differential ($/kWh)	0.01625	0.15560	0.10967		
	Percent Change (%)	13.7%	115.2%	37.7%		
CA	**Southern California Edison**	**0.12462**	**0.14453**	**0.23775**	**0.27275**	**0.30775**
	Cutoff (% of baseline)	100%	130%	200%	300%	
	Differential ($/kWh)	0.09322	0.03500	0.03500	-0.30775	
	Percent Change (%)	64.5%	14.7%	12.8%	-100.0%	
AZ	**Arizona Public Service**	**0.19342**	**0.27478**	**0.32562**	**0.34716**	
	Cutoff (kWh/month)	400	800	3000		
	Differential ($/kWh)	0.08136	0.05084	0.02154		
	Percent Change (%)	42.1%	18.5%	6.6%		
CA	**San Diego Gas & Electric**	**0.13412**	**0.15489**	**0.27985**	**0.29985**	
	Cutoff (% of baseline)	100%	130%	200%		
	Differential ($/kWh)	0.02077	0.12496	0.02000		
	Percent Change (%)	15.5%	80.7%	7.1%		
GA	**Georgia Power**	**0.04599**	**0.07645**	**0.07877**		
	Cutoff (kWh/month)	350	1000			
	Differential ($/kWh)	0.03046	0.00232			
	Percent Change (%)	66.2%	3.0%			
ID	**Idaho Power**	**0.06099**	**0.07431**	**0.08918**		
	Cutoff (kWh/month)	800	2000			
	Differential ($/kWh)	0.01332	0.01486			
	Percent Change (%)	21.8%	20.0%			
OR	**Pacific Power ***	**0.07563**	**0.08280**	**0.09354**		
	Cutoff (kWh/month)	500	1000			
	Differential ($/kWh)	0.00717	0.01074			
	Percent Change (%)	9.5%	13.0%			
WA	**Avista Utilities ***	**0.06103**	**0.07101**	**0.08324**		
	Cutoff (kWh/month)	600	1300			
	Differential ($/kWh)	0.00998	0.01223			
	Percent Change (%)	16.4%	17.2%			

Notes
*** Denotes year-round rates, otherwise rates are summer-only**
Rates include all kWh-varying portions of tariff available in the rate filing

The price in each tier can change tens of percent to hundreds of percent

Survey of Inclining Block Rates (Two Tiers)

State	Utility	Tier 1 ($/kWh)		Tier 2 ($/kWh)
MI	**Indiana Michigan Power Co. ***	**0.04758**		**0.05257**
	Cutoff (kWh/month)		500	
	Differential ($/kWh)		0.00499	
	Percent Change (%)		10.5%	
FL	**Florida Power and Light ***	**0.13354**		**0.16558**
	Cutoff (kWh/month)		1000	
	Differential ($/kWh)		0.03204	
	Percent Change (%)		24.0%	
PA	**PECO Energy**	**0.11850**		**0.13410**
	Cutoff (kWh/month)		500	
	Differential ($/kWh)		0.0156	
	Percent Change (%)		13.2%	
FL	**Progress Energy ***	**0.11497**		**0.13588**
	Cutoff (kWh/month)		1000	
	Differential ($/kWh)		0.02091	
	Percent Change (%)		18.2%	
MI	**Consumers Energy Company**	**0.09848**		**0.15866**
	Cutoff (kWh/month)		600	
	Differential ($/kWh)		0.06018	
	Percent Change (%)		61.1%	
NJ	**Jersey Central Power and Light ***	**0.02124**		**0.06938**
	Cutoff (kWh/month)		600	
	Differential ($/kWh)		0.04814	
	Percent Change (%)		226.6%	
NJ	**Public Service Electricity and Gas Co.**	**0.02859**		**0.03241**
	Cutoff (kWh/month)		600	
	Differential ($/kWh)		0.00382	
	Percent Change (%)		13.4%	

Notes

1. Duke Energy Corp. has an IBR in Ohio, not North Carolina as stated

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in the BC Hydro report

Rates include all kWh-varying portions of tariff available in the rate filing

Tier thresholds vary from 250 to 1,000 kWh per month

Survey of Inclining Block Rates (Two Tiers)

State	Utility	Tier 1 ($/kWh)		Tier 2 ($/kWh)
CA	**Sacramento Municipal Utility District**	**0.10220**		**0.18180**
	Cutoff (kWh/month)		600	
	Differential ($/kWh)		0.07960	
	Percent Change (%)		77.9%	
AL	**Alabama Power Company**	**0.07924**		**0.08177**
	Cutoff (kWh/month)		1000	
	Differential ($/kWh)		0.00253	
	Percent Change (%)		3.2%	
NY	**Consolidated Edison**	**0.06674**		**0.07511**
	Cutoff (kWh/month)		250	
	Differential ($/kWh)		0.00837	
	Percent Change (%)		12.5%	
VA	**Dominion Virginia**	**0.06507**		**0.07583**
	Cutoff (kWh/month)		800	
	Differential ($/kWh)		0.01076	
	Percent Change (%)		16.5%	
NY	**Long Island Power Authority**	**0.08570**		**0.09750**
	Cutoff (kWh/month)		250	
	Differential ($/kWh)		0.01180	
	Percent Change (%)		13.8%	
WA	**Puget Sound Energy ***	**0.08423**		**0.10204**
	Cutoff (kWh/month)		600	
	Differential ($/kWh)		0.01781	
	Percent Change (%)		21.1%	
OH	**Duke Energy Corp.[1]**	**0.04235**		**0.05627**
	Cutoff (kWh/month)		1000	
	Differential ($/kWh)		0.01392	
	Percent Change (%)		32.9%	

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in the BC Hydro report
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Frequently asked questions

Do customers respond to inclining block rates?

- Yes, based on many studies of customer price responsiveness over the past three decades
- However, this requires an easy-to-understand and well-marketed rate

How should these rates be marketed to customers?

- Simplicity is key
- Customers should be made aware of the price in all tiers
- Historical usage can be benchmarked against the tier cutoffs
- Customers have demonstrated that they conserve with increased access to usage information
- Bill protection as optional transition tool

Will IBRs cause revenue erosion?

- The conservation effect from IBRs should be treated the same way the impact of DSM programs is treated

Frequently asked questions (continued)

Do IBRs require smart meters?

- No, but smart meters may enhance a utility's ability to provide customers with useful information for responding to the new rates

Are the rates cost-based?

- Yes, in an environment of increasing marginal costs
- However, the link is less transparent than with time-varying pricing

Can IBRs be combined with dynamic pricing?

- Yes, using surcharges and credits; this is the approach taken in California

Will IBRs work for utilities with declining block rates?

- Yes, but they should first consider moving to a flat rate

Does a large DSM budget make these rates redundant?

- In the near term the two are complementary since these rates make DSM programs more attractive by shortening the payback period

The Brattle Group

Developing Dynamic Pricing Rates

www.brattle.com

Antitrust/Competition Commercial Damages Environmental Litigation and Regulation Forensic Economics Intellectual Property International Arbitration
International Trade Product Liability Regulatory Finance and Accounting Risk Management Securities Tax Utility Regulatory Policy and Ratemaking Valuation
Electric Power Financial Institutions Natural Gas Petroleum Pharmaceuticals, Medical Devices, and Biotechnology Telecommunications and Media Transportation

The rationale for dynamic pricing

Providing electricity at peak times is very expensive

For most utilities the annual load factor is under 60%

The top 1% of the hours account for 8-18% of the annual peak load

- Generation and network capacity to meet the peak load sits idle for most of the 8,760 hours of the year

This puts significant upward pressure on costs and every customer pays higher rates

Dynamic pricing rates can lower growth in peak loads, improve load factors and lower average costs

What is dynamic pricing?

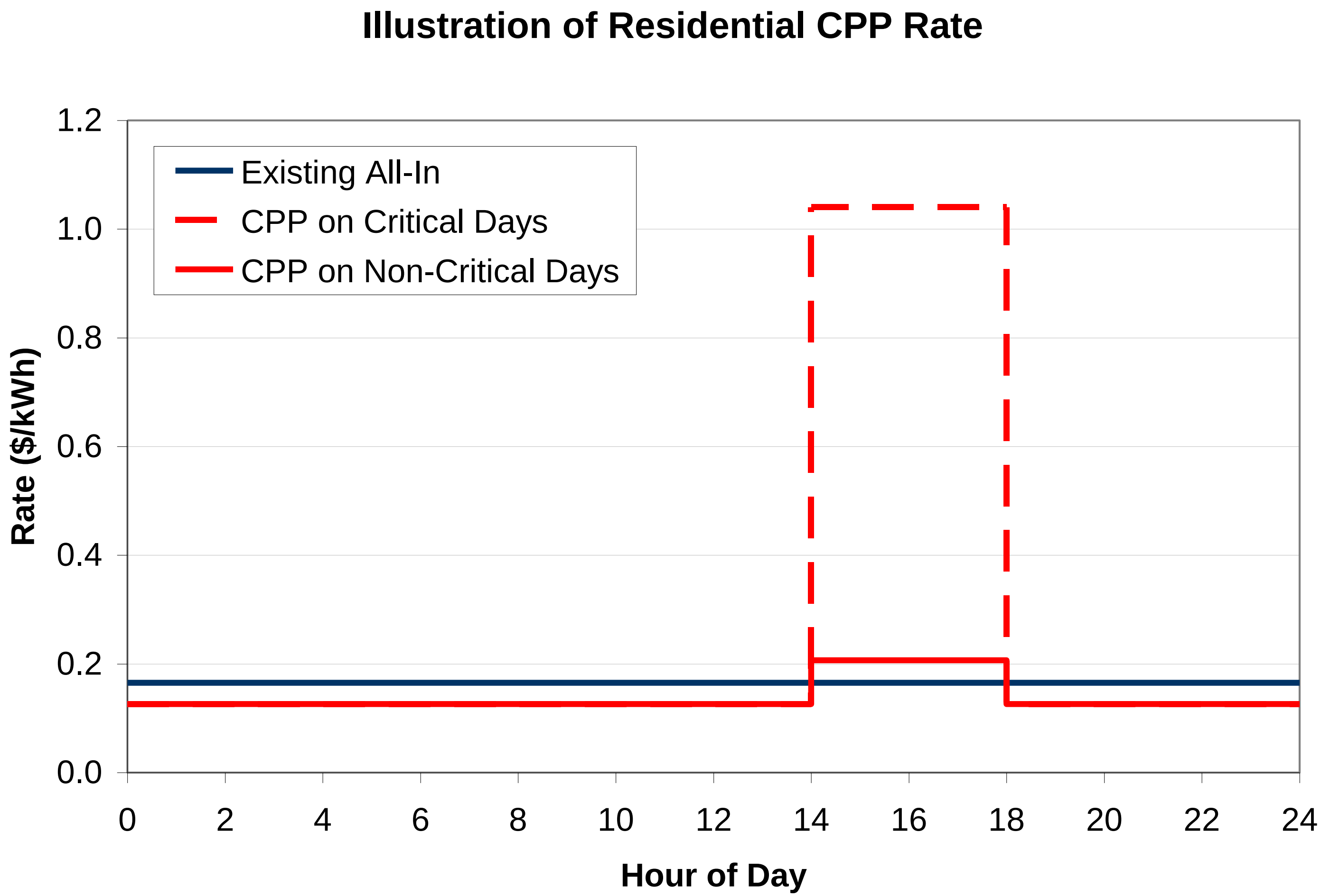
There are many flavors

- Time variant rates (or time-of-use rates, TOU)
- Critical-peak pricing (CPP)
- Peak-time rebates (PTR)
- Variable-peak pricing (VPP)
- Real-time pricing (RTP)

These can be combined to yield hybrid forms of dynamic pricing

Rate Design: Critical Peak Price *and* Time-of-Use

The CPP/TOU consists of a higher price during critical peak events and peak periods, and a discounted price during the off peak hours



Steps in calculating the residential CPP/TOU rate

1. **Determine period lengths**
   - Number and duration of critical peak events
   - Duration of peak period and seasonal variation

2. **Determine all-in rate in critical peak period:**
   - Existing all-in rate + capacity price

3. **Determine all-in rate in off-peak period:**
   - Set based on off-peak energy and delivery costs

4. **Determine all-in rate in peak period:**
   - Solve for peak rate such that the CPP is revenue neutral

Steps in calculating the C&I CPP/TOU rate

Slightly different due to the presence of demand charges

1. **Determine period lengths**
   - Number and duration of critical peak events
   - Duration of peak period

2. **Determine generation rate in critical peak period:**
   - Existing peak generation rate + capacity price

3. **Determine off-peak and mid-peak generation rates:**
   - Both are set equal to existing rates

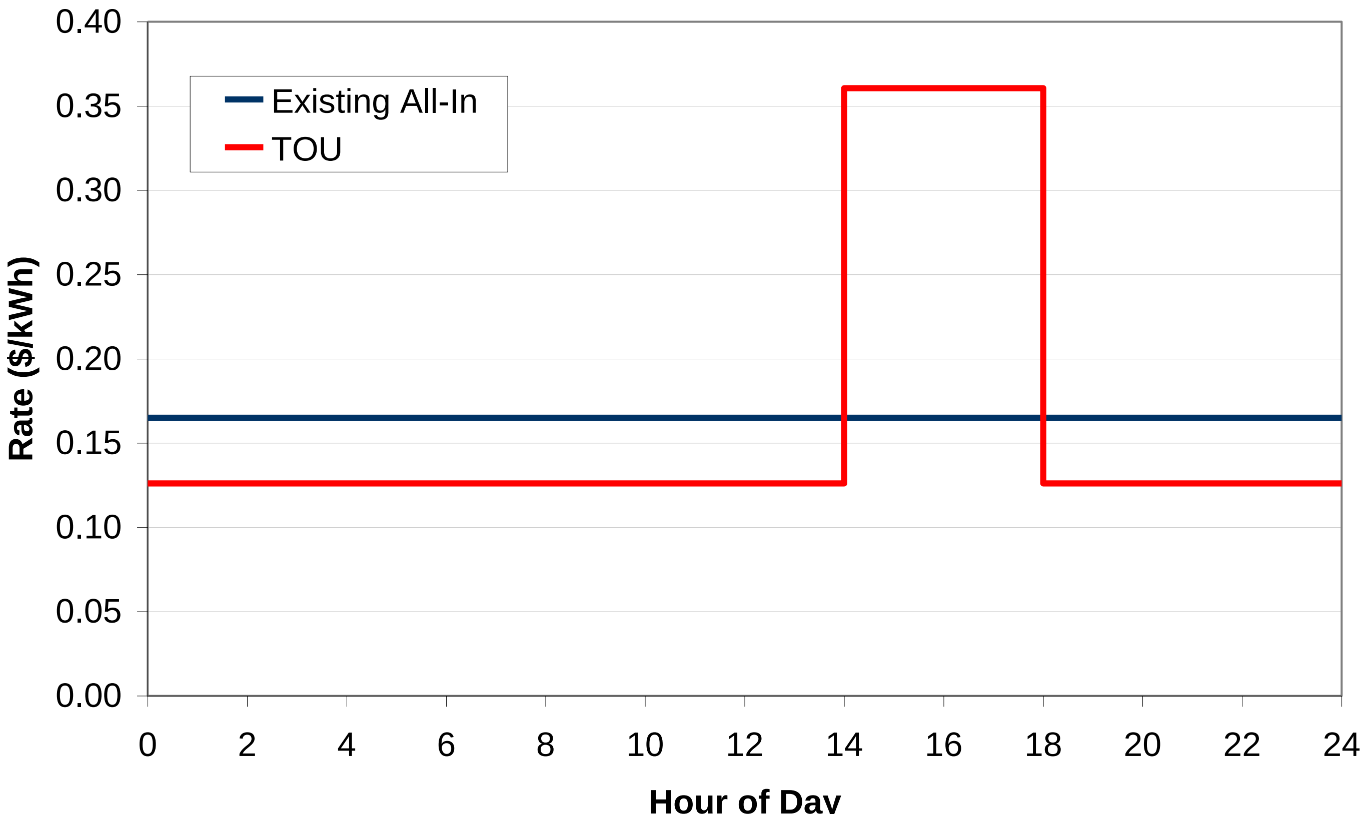
4. **Determine peak generation rate:**
   - Solve for peak rate such that the CPP/TOU rate is revenue neutral without the addition of the generation demand charge (i.e., the new CPP/TOU rate eliminates generation demand charges)

5. **Create an all-in CPP/TOU by converting all remaining charges (such as customer charges and delivery charges, but excluding generation demand charges) to $/kWh rates and adding them to the generation rates**

Rate Design: Time of Use

The TOU consists of a higher price during the peak period and a discounted price during the remaining hours

Illustration of TOU Rate on Weekday



Steps in calculating the TOU rate

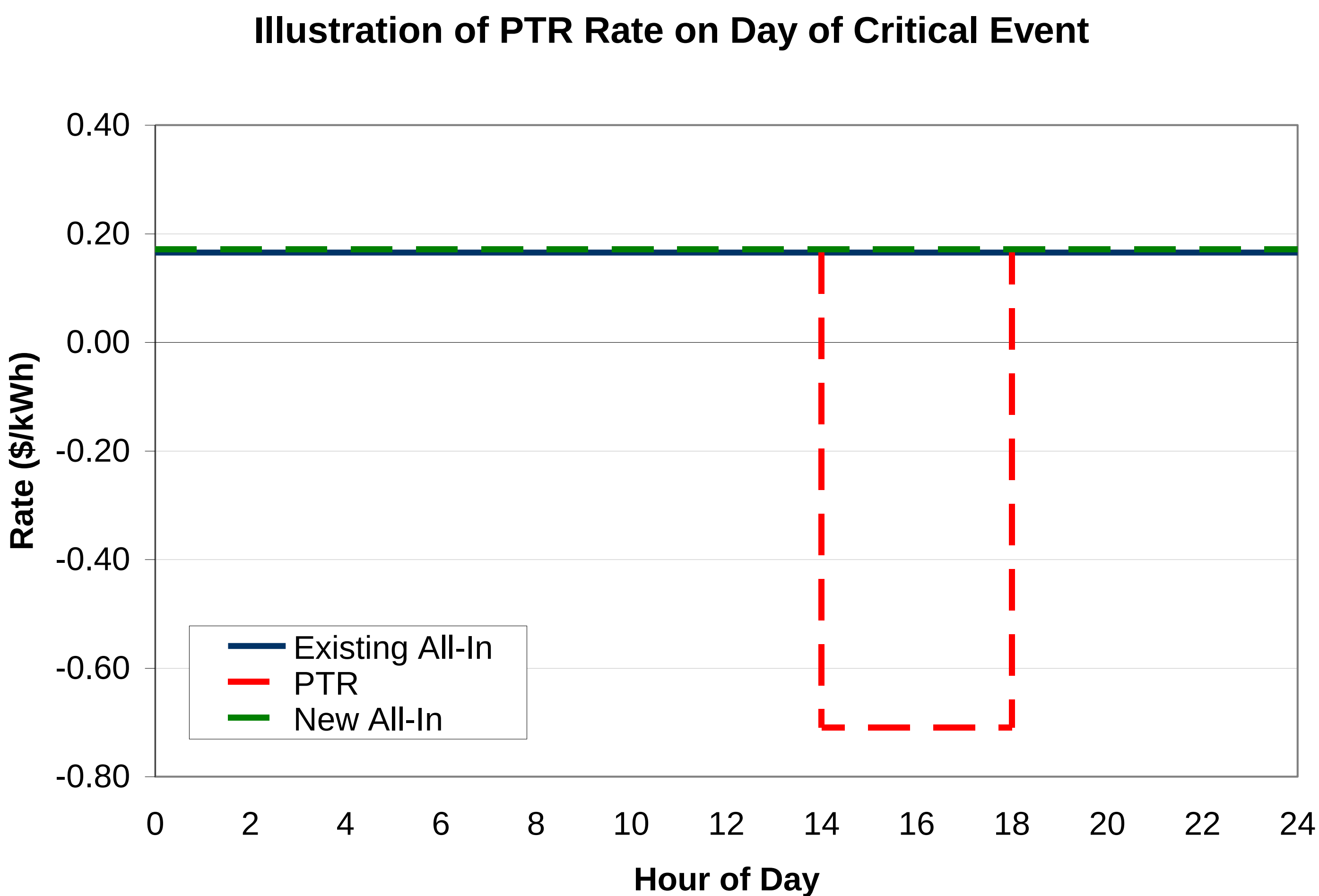
1. **Determine period lengths**
   - Duration of peak period
   - Seasonal variation in peak period

2. **Determine all-in rate for off-peak period:**
   - Set equal to all-in off-peak rate determined in the CPP/TOU calculation

3. **Determine all-in rate for peak period:**
   - Solve for peak rate to maintain revenue neutrality

Rate Design: Peak Time Rebate

The PTR consists of a credit during critical peak events that mirrors the CPP surcharge



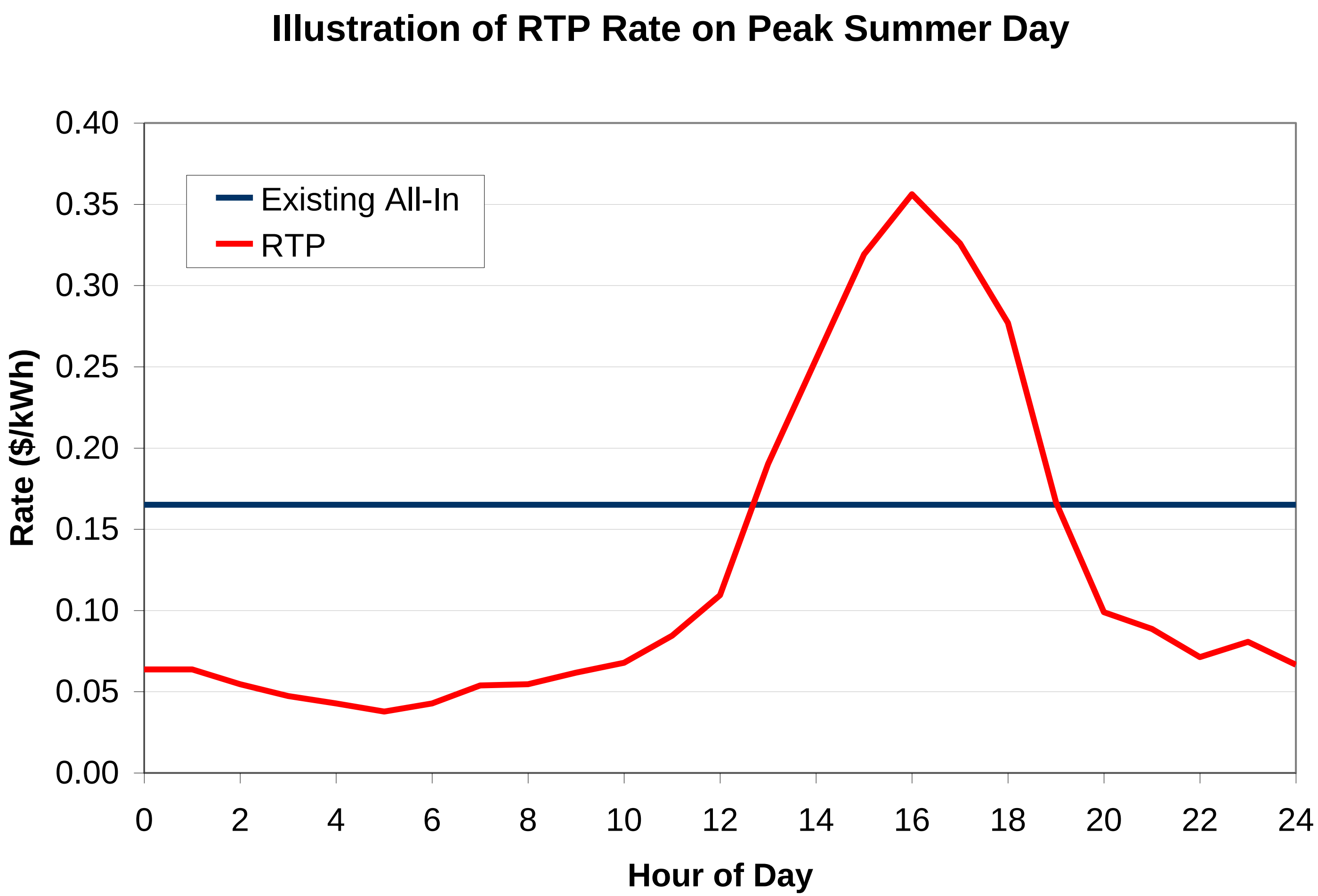
Steps in calculating the PTR

1. **Determine the level of rebate provided during the critical event**
   - This is usually set equal to the surcharge that was calculated for the CPP rate.

2. **Raise the all-in rate to reflect the amount of the rebate**

Rate Design: Real-time Price

The RTP varies with each hour of the day



Note: We have developed a one-part RTP for this project.

Steps in calculating the RTP rate

1. **Determine the ratio of the average historical hourly market price to the existing average customer's generation charge (energy portion only)**

2. **Apply the ratio of the bill from step 1 to the hourly market price to calculate the customer's new generation charge**

3. **Leave the non-generation portion of the customer's bill, including demand charges, unchanged**

Comparing dynamic rates…

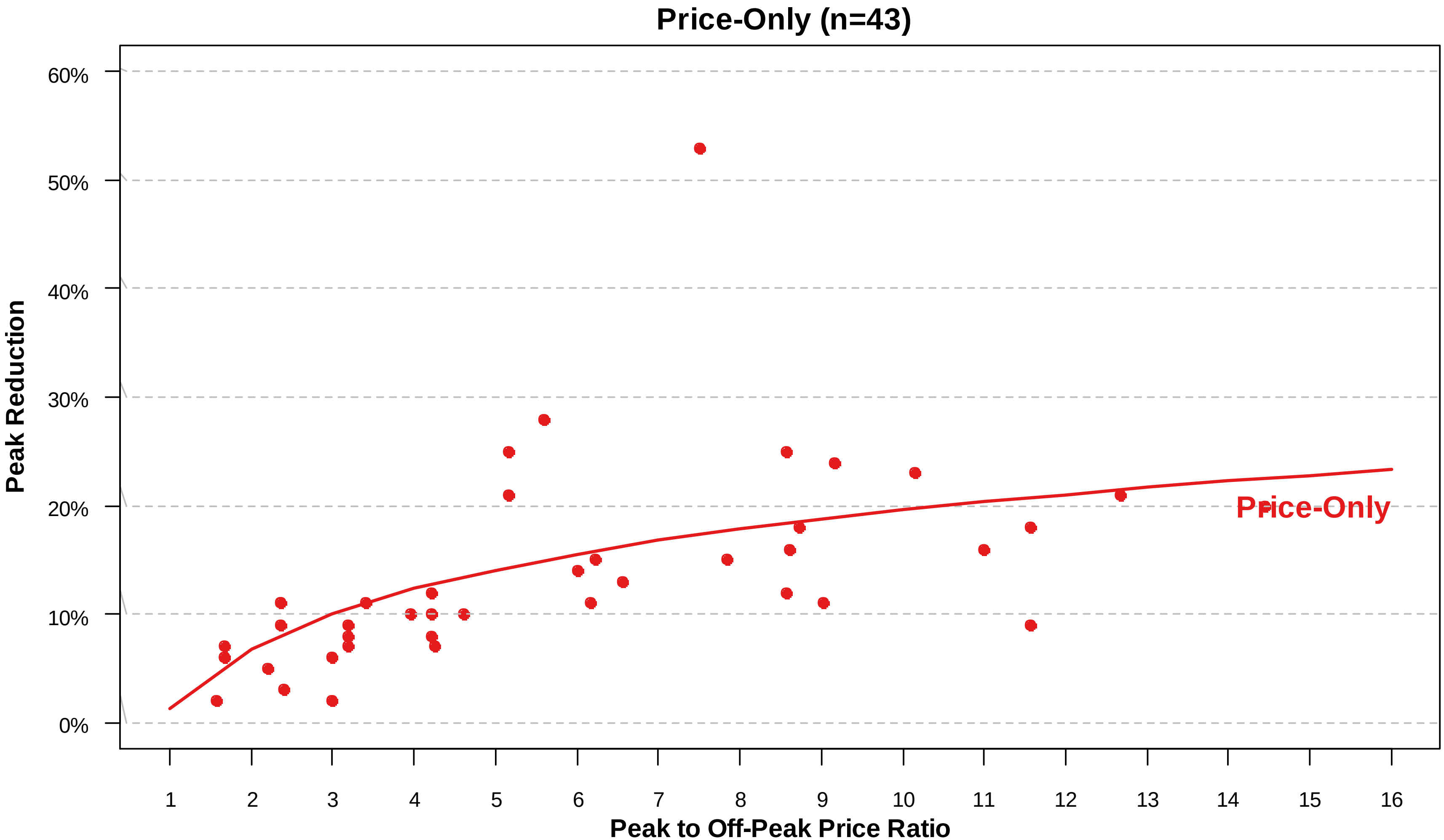
Policy	Economic Efficiency	Equity	Bill Stability	Revenue Stability	Simplicity
Flat rate	--	--	++	-	++
PTR	+	-	++	--	o
CPP	+	o	o	+	o
TOU	+	+	o	o	+
One-Part RTP	++	++	--	+	-
Two-Part RTP	++	++	-	++	--

Key:

+ + : very good
+ : good
o : average
- : poor
- - : very poor

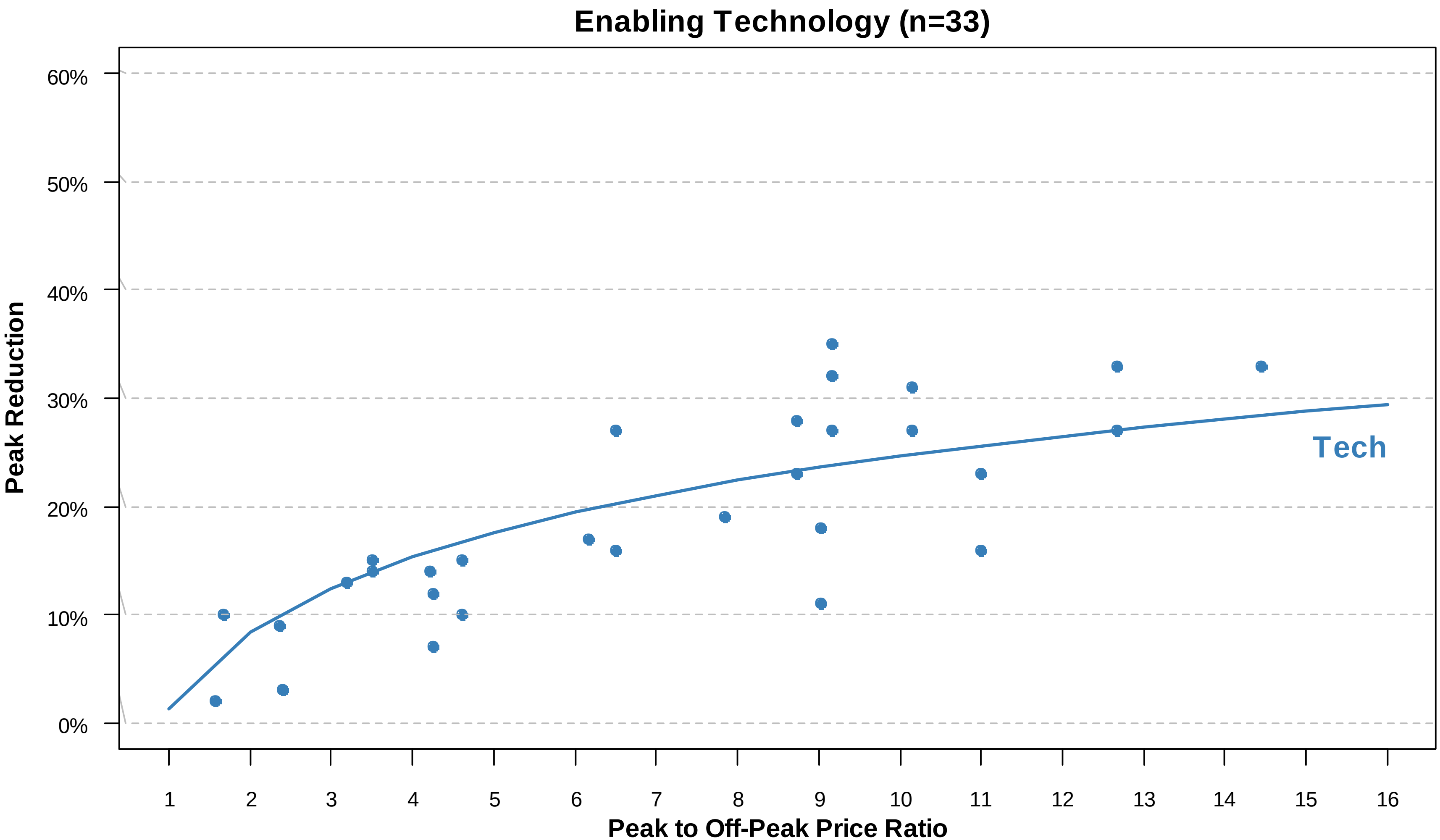
Customers do respond to price signals

The Arc of Price Responsiveness

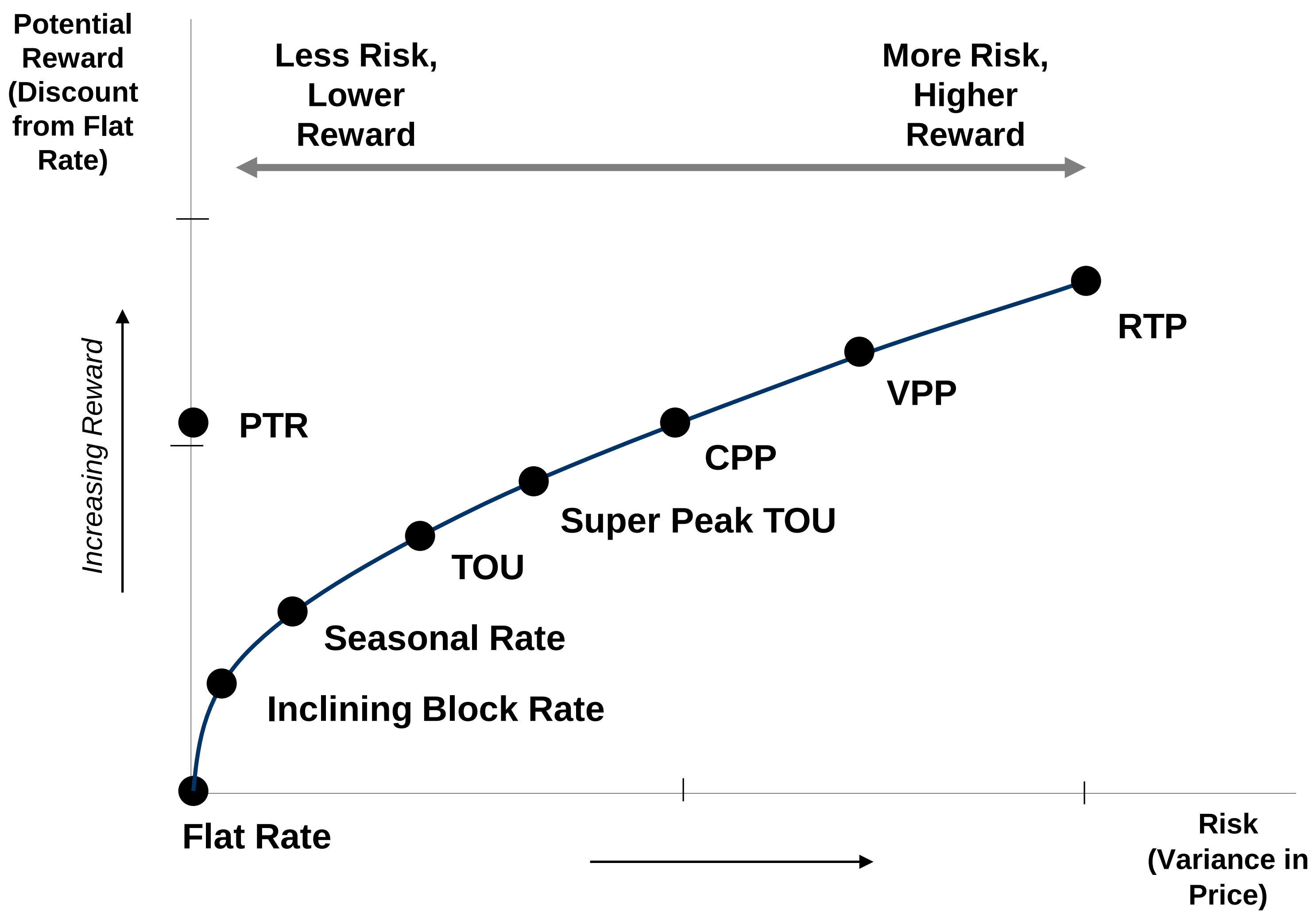


Enabling technology further enhances price responsiveness

The Arc of Price Responsiveness



All customers face a risk-reward trade-off, including vulnerable customers



Making the transition—Opt-in

Opt-in participation rates tend to be quite low

- The rate is 1% in the US for time-varying rates and 1% of that 1% for dynamic pricing rates

However, if the hedging premium that is embedded in flat rates is removed from the dynamic pricing rate, making it less expensive than the flat rate, higher participation rates can be expected

- For example in Arizona: time-varying rates have been selected by 51% of the customers for one utility and by 29% for another

Making the transition—Opt-out

If dynamic pricing is offered on an opt-out basis, societal benefits will be maximized but some customers may see higher bills

- They could be allowed to opt-out and moved to flat rates that embody the full hedging premium
- Bill protection could be provided for the first few years
- Two-part pricing could be offered

A mixed deployment approach is probably the best way to move forward

Opt-in for low income consumers and those with medical conditions requiring special uses of electricity

Mandatory for consumers above a certain size

Opt-out for all other consumers

- And if they do opt-out, they can pick a new flat rate which reflects the full cost of hedging

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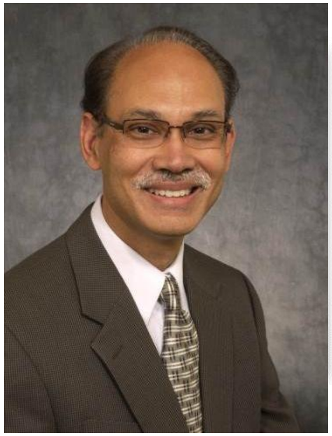
Speaker Bio and Contact Information



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Ahmad Faruqui is a principal with *The Brattle Group* who specializes in the analysis, design and evaluation of smart grid strategies involving the consumer. He has consulted with more than 50 utilities and transmission system operators around the globe and testified or appeared before a dozen state and provincial commissions and legislative bodies in the United States and Canada.

He has also advised the Alberta Utilities Commission, the Edison Electric Institute, the Electric Power Research Institute, the Federal Energy Regulatory Commission, the Institute for Electric Efficiency, the Ontario Energy Board, the Saudi Electricity and Co-Generation Regulatory Authority, and the World Bank.

Dr. Faruqui has managed the design and evaluation of large-scale dynamic pricing experiments in California, Connecticut, Florida, Illinois, Maryland and Michigan. This work involved the estimation of a variety of econometric models for estimating customer response to prices that varied by time of day.

His work has been cited in publications such as 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 efficient energy use, he holds a Ph.D. in economics and an M.A. in agricultural economics from The University of California at Davis, where he was a Regents Fellow, and B.A. and M.A. degrees in economics from The University of Karachi with the highest honors.

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