Best Practices in Tariff Design

A GLOBAL SURVEY

PRESENTED BY Ahmad Faruqui Sylvia Tang

APRIL 5, 2021 NARUC STAFF SUBCOMMITTEES





Yesterday's customer is today's prosumer and tomorrow's prosumager





Time-Varying prices (TVPs) come in many shapes and forms

Rate	Definition
1- Time-of-Use (TOU)	The day is divided into peak and off-peak time periods. Prices are higher during the peak period hours to reflect the higher cost of supplying energy during that period
2- Critical Peak Pricing (CPP)	Customers pay higher prices during critical events when system costs are highest or when the power grid is severely stressed
3- Peak Time Rebates (PTR)	Customers are paid for load reductions on critical days, estimated relative to a forecast of what the customer would have otherwise consumed (their "baseline")
4- Variable Peak Pricing (VPP)	During alternative peak days, customers pay a rate that varies by day to reflect dynamic variations in the cost of electricity
5- Real-Time Pricing (RTP)	Customers pay prices that vary by the hour to reflect the actual cost of electricity
6- Two-part Real-Time Pricing(2- part RTP)	Customer's current rate applies to a baseline level of consumption. A second, marginal cost based, price applies to deviations from the baseline consumption
7- Three-part Rates (3-part Rates)	In addition to volumetric energy charge and fixed charge, customers are also charged based on peak demand, typically measured over a span of 15, 30, or 60 minutes
8- Fixed Bill with Incentives	Customers pay a fixed monthly bill accompanied with tools for lowering the bill (such as incentives for lowering peak usage)

Utilities are beginning to offer choices of tariffs to customers



Risk (Bill Volatility)

Agenda

- Benchmarking Survey
 - International Best Practices
 - Domestic Best Practices
- Conclusions



Agenda

- Benchmarking Survey
 - International Best Practices
 - Domestic Best Practices
- Conclusions



International Best Practices

- Africa: ESKOM in South Africa
- Asia: Taiwan Power Company, KEPCO, TEPCO and Mainland China
- Australia and New Zealand
- Europe: England, France, Ireland, Nordic countries and Spain
- South America: Brazil and Chile





ESKOM, a state-owned company in South Africa, is exploring dynamic tariffs to address short-term needs and increase short-term flexibility

- Transition residential customers to opt-in TOU rates, with a peak/off-peak price ratio as high as 4 in the winter (high demand season)
- Introduce mandatory TOU rates for customers with grid-tied generation, e.g., solar PV



KEPCO, a state-owned utility in Korea, offers two three-tier inclining block rates for both the demand charge and energy charge.

- Cutoffs at 200 and 400 kWh for low-voltage and high-voltage residential customers
- Opt-in three-period TOU are available to C&I customers but not residential customers due to the slowdown of AMI deployment

Taiwan Power Company introduced two Simple Residential and Commercial TOU Rate in 2016.

- Option 1: two periods with the peak/off-peak price ratio of 2.5 for the summer time. Option 2: three periods with price ratio of 3.4:2.3:1 for peak/shoulder/off-peak periods. The program enrolled 46,863 customers in 2019.
- Default TOU with demand charge for C&I customers

TPC also developed hourly RTP and CPP and plans for PTR for residential customers.

- In 2019, time-varying pricing pilot with 300 customers enrolling in hourly RTP rates
- Features three different pricing schedules: red, yellow, and green. The exact pricing schedule is triggered by the operating reserve conditions, and customers are notified one day in advance

Progress in Asia



TEPCO in Japan went down from 10 to 4 rate designs for residential customer after liberalization of electricity retailing.

- All plans including a demand charge
- Standard plan features a three-tier inclining block rate for energy; Premium plan has a two-part energy charge;
 Smart life features two-period TOU on energy charge
- Subscription on Aqua Energy 100 available for eco-friendly customers
- Bundled discount for customers who wish to sign up for both their gas and electric services

In mainland China, residential customers are defaulted to an Inclining Block Rate and C&I customers are defaulted to TOU rates. Some utilities (Shenzhen Power) also offered opt-in TOU on top of IBR for residential customers but only a very small numbers of customers are on the plan.

Progress in Australia and New Zealand

SA Power Networks in South Australia has proposed offering TOU rates on a default basis for residential customers from July 2020

- These rates will include a "solar sponge" component with a super off-peak period of 10 AM 3 PM when solar exports are high, an off-peak period of 1-6 AM, and a peak period consisting of all other hours
 - The "solar sponge" rate is 25% of the standard rate; off-peak prices are 50% of the standard rate and peak period rate is 125% of the standard rate
 - This is designed to respond to a change in the residential daily profile caused by an increase in solar PV adoption, which has caused a pattern of load peaks and troughs and shifted peak demand
 - Over 30% of customers have now installed solar on their rooftops

SAPN is also proposing to offer an optional, three-part "Prosumer" tariff for customers with interval meters

- The monthly demand charge is estimated using average demand over a four-hour period from 5-9 PM for November through March
- The TOU rates under the Prosumer tariff will be halved relative to those under the default TOU rate
- This rate structure accommodates customers who want to discharge energy storage systems during peak periods

Progress in Australia and New Zealand



In April 2020, Vector, the distribution utility that serves Auckland, expects to restructure its flat distribution charge as a TOU charge for Residential and General Consumer customers

- The TOU rates have a peak period of 7-11 AM and 5-9 PM weekdays, and a peak/off-peak ratio of approximately 2.5:1 for Low User customers and 5:1 for Standard customers
 - The Low User tariff represents a low fixed-charge option to assist low-use customers

Vector also conducted a PTR pilot program from June – August 2019 with 630 customers

- At the time, Vector served most residential customers on a two-part rate with a flat volumetric charge
- The peak time rebate was applied only to the distribution rate, with a peak to off-peak ratio of 5.4:1
- There were 7 event days with both a morning peak period (7-11 AM) and evening peak period (5-9 PM)
 - Event days were triggered by Vector staff when minimum peak temperature was expected to drop below 9 degrees

Octopus Energy in Great Britain offers two additional dynamic pricing programs as well as EV tariffs.

- Octopusgo: cheap super off-peak electricity price every night from 12:30AM-4:30AM
- *OutgoingOctopus* on a trial basis: targeting customers with rooftop solar and/or battery storage. can choose to sell their energy to the grid either at a fixed rate or at the real-time wholesale market rate.
- Beyond standard EV TOU tariff, it also partners with Tesla and offers *Tesla Energy Plan*.

Spain's default plan is the Voluntary Price for Small Customers.

- Customers whose contracted demand is below 10 kW pay an hourly market price for energy, in addition to regulated network charges and taxes.
- About half of Spain's total of 25.7 million of eligible customers are on the default tariff
- Two additional TOU options: Nocturnal tariff with two periods, and Super Off-Peak rate with three periods (designed for electric vehicle charging).
- Vulnerable customers are eligible for a 25 percent discount on their electricity bills.



Finland had completed its campaign to deploy smart meters universally by the end of 2018, reaching more than 99 percent of the country's 3.5 million electricity customers.

- About 17 percent of Finland's residential customers are on TOU rates
- A dynamic pricing program through retailers who purchase electricity in the wholesale market is also available to customers and about 9 percent of Finnish retail customers are on this program in 2018
 - Customers pay the hourly price, retailer's premium and a monthly fixed fee to the retailer

Similar to Finland, RTP tariff is available for customers in other Nordic countries. Nordic energy regulators have been working to integrate the retail electricity market for Finland, Denmark, Sweden, and Norway.

Progress in South America



Traditionally, Brazil offers two TOU tariff, blue and green and started to transition all residential customers to white tariff on an opt-in basis in 2018.

- Customers in Brazil purchase energy either through bilateral contracts or through regulated prices, which are based on supply-contract auctions.
- Blue and green rate design all include an energy component and a demand component
- The White divides the day into three periods peak, intermediate, and off-peak with peak/off-peak price ratio between 2 to 2.5, depending on the utility.
- Only about 48,000 customers are on the White

Agenda

- Benchmarking Summary
 - International Best Practices
 - Domestic Best Practices
- Conclusions



North America Overview

According to 2019 EIA Form-861, **365 U.S. utilities offer at least one form of time-varying rate** to residential customers

- 335 offer Time-of-Use (TOU)
- 31 offer Critical Peak Pricing (CPP)
- 13 offer Peak Time Rebate (PTR)
- 6 offer Variable Peak Pricing (VPP)
- 9 offer Real-Time Pricing (RTP)

Altogether, **6 million customers** (or 4.5% of all residential customers) are enrolled on one of these timevarying rates.



A few utilities dominate the provision of TOU rates in the US



Pacific Gas & Electric (PG&E) currently has ~400,000 customers on an optin time-varying rate. The other two California investor-owned utilities, Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E), have approximately 370,000 and 155,000 customers on opt-in time-varying rates respectively

- Almost 99% of customers that were moved to either SCE or SDG&E's TOU pilots chose to stay on a TOU plan

All three California investor-owned-utilities are planning the deployment of default TOU rates

- SDG&E began its rollout in March 2019, offering two TOU plans with a 4-9 PM peak period and a 2.1:1 peak/off-peak period, as well as an additional super off-peak period from 12-6 AM
- PG&E and SCE will transition customers in October 2020

The CPUC has ordered two customer guarantees as part of the rollout

- Customers will be provide an estimate of how their TOU bill compares with what their bill would have been on their old rate so they can see if they saved money or not
- A 12-month bill guarantee, such that customers whose first-year bill under the new TOU rate is higher than it would have been under their old rate will be credited the difference

Sacramento Municipal Utility District (SMUD) - TOU



Sacramento Municipal Utility District (SMUD), one of the largest U.S. municipalities, already transitioned in 2019 to default TOU rates for its 600,000 residential customers

- The rate has a peak period of 5-8 PM year around
 - Summer rates, which are higher than in non-summer, feature a peak rate of \$0.2941/kWh, an off-peak rate of \$0.1209, and an additional midpeak rate (for noon-5 PM and 8 PM-midnight) of \$0.1671/kWh
- Before filing for TOU, SMUD conducted a successful pilot program in 2012 and 2013 testing TOU, CPP, and TOU/CPP rates
 - The pilot found significant load shifting, customer preference for TOU over CPP, and ~50% higher average reductions with opt-in versus opt-out (which had 90% retention)

The Time-of-Day (TOU) results of the first summer in 2019 showed that:

- TOD supports carbon reduction goals set by the Board: carbon reduction of 12,800 tons,
- Customers shifted usage and willing to participate ~8% Residential peak load reduction, 96% of steady customers enrollment rate
- Customers had bill savings: saved about 2% or \$3 per month on their summer electric bill

Consumers Energy - TOU



- Summer Peak Rates charges a on-peak rate on weekdays 2-7 PM (June-September), that is about 1.5 times higher than the off-peak rate
- The off-peak rate is the regular rate from October-May

The plan was to default all residential customers to the TOU plan in June 2020, however this plan has been delayed until 2021

- The rollout is part of Consumers' "Clean Energy Plan", which commits to 90% clean energy by 2040
- As part of the default TOU rollout, Consumers Energy will deploy a bill impact tool so customers can see how their bill would differ under the new rate
- Consumers Energy is also deploying a massive outreach campaign (starting in mid-April) to help support customers during the transition, including customized clean energy program offers that can help them save on their bill



Fort Collins went to mandatory Time-of-Day Pricing in 2018 for all customers.

- Fixed charge at \$8 per month
- Off-peak hours cost approximately 30 percent less than current electric rates with higher prices during on-peak hours
- Summer On-peak hour (2 pm 7 pm) and Off-peak (all other hours) with peak/off-peak ratio of 3.6.
- Winter On-peak hour (5 pm 9 pm) and Off-peak (all other hours) with peak/off-peak ratio of 3.1.

Xcel Energy Colorado - TOU



- Pilot showed a 13.3% average reduction in on-peak consumption for all non-solar participants with Evs
- Three periods: Off-peak (9 pm 9 am), shoulder (9 am 2pm and 6 pm 9pm), peak (2 pm 6 pm) for non holidays
- Proposed moving customers to the new rate structure starting in 2021, as new smart meters are installed, a program that will run into 2024.

Ameren Missouri - TOU



Ameren Missouri offers a range of residential rate options, including four rates with time-varying components to their customers based on their needs and efforts.

- Evening/Morning Savers
 - Exposes customers to the idea of TOU with modest peak/off-peak ratio; involves a decline block rate design for winter rates
- Overnight Savers
 - Off-Peak 10 p.m. 6 a.m., 7 days a week (8 hours) with moderate peak/off-peak ratio
- Smart Savers
 - Involves a mid-peak price period and substantial peak/off-peak ratio. No on-peak period on weekends.
- Ultimate Savers
 - Only 4-5 hour window for on-peak periods and substantial peak/off-peak ratio
 - Has demand charge for both summer and winter

Ameren Missouri - TOU





Percent Savings in Monthly Bill by Rate

Notes: Monthly bill saving is calculated based on a typical customer summer and winter usage. % of on-peak hours is determined based on load characteristics. The estimated peak impact is produced by most recent models and data in Arcturus database.



Joint Utilities in Maryland - TOU



- Customers began transferring to the TOU rates beginning in April 2019 and will remain on rates through June 2022
- Unique Features
 - The TOU rates apply to charges for generation, transmission and distribution, and not just to the generation as is often the case with the prior TOU pilots
 - Include TOU rates with sizeable differentials between peak and off-peak periods, the ratio of peak to off-peak prices ranges from 4 to 6 across the three Jus
 - Customers who were randomly chosen for recruitment were provided with a personalized estimate of their potential savings under the TOU rate, based on their load profiles.
- Study Results
 - Summer peak impacts range from -10.2% to -14.8% and non-summer peak impacts range from -5.1% to -6.1% for all three JUs
 - LMI customers respond to the price signals just like the non-LMI customers, and in most cases in similar magnitudes
 - All JUs revealed larger conservation tendency during COVID months exhibited by large daily price elasticities
 - On average, all customers on the TOU rates (including LMI customers) enjoyed bill savings of 5% to 10%

Ontario Energy Board - TOU

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

- Opt-out basis as smart meters rollout was completed in 2014
- Off-peak, mid-peak, and on-peak prices are defined by season
- The TOU rates only apply to the energy portion of the customer's bill
- Analysis showed that load shifting impacts were lower in winter than in the summer period

Ontario's large power customers participate in the wholesale electricity market, and can participate in demand response auction programs.

Georgia Power – TOU (Residential) & RTP (C&I)

Georgia Power offers leading Real Time Pricing Rates on both hour- and day-ahead bases. Roughly 15,000 C&I customers are enrolled in Georgia Power's Real Time Pricing Rates (initially introduced as an economic development rate).

- day-ahead program is available for customers whose peak 30-minute demand is not less than 250 kW
- hour-ahead program is for customers with a peak demand of not less than 5,000 kW.
- Customers are notified of the price a day or an hour ahead of time
- With a real-time pricing rate, the customer is billed (or credited) for differences between actual load and established "baseline" load at real-time prices
- Customers may work with the utility to update their baseline load shapes, if the customer has been on RTP for over a year and is anticipating a significant change in load

In addition, Georgia Power also offers a variety of choices for residential customers, including Smart Usage (basic charge + demand charge + two period TOU for energy charge), Flat Bill, Plug-in Electric Vehicles (three period TOU plan), Night & Weekends (basic charge + two period TOU with substantial peak/off-peak ratio for energy charge).

Oklahoma Gas & Electric (OGE) - VPP

OGE rolled out a dynamic pricing rate coupled with a smart thermostat to its residential customers a few years ago

- "Smart Hours" features variable peak pricing, or four levels of peak pricing depending on what day type it happens to be (Low, Standard, High, Critical)
- There are fixed summer and winter peak hours
- The expectation is that there would be 10 Low price days, 30 Standard price days, 36 High price days, and 10 Critical price days in a typical year.
- Prices during peak hours vary depending on system conditions, and are communicated by 5:00 pm the previous day. Critical periods can be communicated with as little as two hours notice
- Is also offered to Small GS customers whose annual demand is less than 10 kW or less than 400 kW with a load factor of less than 25%

Some 130,000 customers out of 650,000 (20%) are on that rate today; they control their thermostat setting, not OGE

- Average peak load has dropped by ~40%
- Average bill savings amount to ~20% of the customer's bill

Holy Cross Energy - PTR



HCE offers a Peak Time Payback (PTP) program to both residential and commercialmembers.

- The baseline is calculated using historical hourly interval data to represent what a participant would have used in each hour during the event.
- Participants earn a bill credit of \$1 for each kWh reduced compared to their baseline usage during "critical events," and \$0.5 for each kWh reduced during "high events."
- Events typically occur between 4 and 9 PM on weekdays and typically last for two to three hours and the number of PTP event hours to be no more than 96 in a calendar year.
- No penalty for not reducing consumption when events are called.

Agenda

- Benchmarking Summary
 - International Best Practices
 - Domestic Best Practices
- Conclusions



CONCLUSIONS

What have we learned about customer behavior?

We have compiled information from 383 deployments of TOU, CPP, PTR and VPP rates in a database called *Arcturus*.

		Season			Recruitment		Technology	
Rate Design	Ν	Summer Only Rate	Winter Only Rate	Annual Rate	Opt-In	Opt-Out	With Tech	Without Tech
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
TOU	191	57%	25%	18%	79%	20%	62%	38%
CPP	108	69%	7%	24%	90%	10%	84%	16%
PTR	69	91%	4%	4%	91%	9%	91%	9%
VPP	15	87%	7%	7%	100%	0%	99%	1%
All	383	68%	16%	17%	85%	14%	36%	64%

Summary of Characteristics of Dynamic Pricing Experiences

CONCLUSIONS

The results resemble a Manhattan skyline



Source: Results from 383 pricing experiments in Arcturus database.

CONCLUSIONS

The "stars" form Arcturus, through which lie two "arcs of price response."



Arcs of Price Response

Rate Design

With Technology

Price Only



Events like the August blackouts in California and the February blackouts in Texas remind us that we need more price-responsive demand

Time-varying pricing will become more widely deployed around the globe

Real-time pricing will begin to be deployed to residential customers once prices are paired with devices

Subscription plans will also be offered, often paired with demand response programs to lower bills

DERs will begin to be integrated with innovative pricing designs

Presented By



Ahmad Faruqui

PRINCIPAL | SAN FRANCISCO

Ahmad.Faruqui@brattle.com

+1.925.408.0149

Ahmad Faruqui is an internationally recognized authority on the design, evaluation and benchmarking of tariffs. He has analyzed the efficacy of tariffs featuring fixed charges, demand charges, time-varying rates, inclining block structures, and guaranteed bills. He has also designed experiments to model the impact of these tariffs and organized focus groups to study customer acceptance. Besides tariffs, his areas of expertise include demand response, energy efficiency, distributed energy resources, advanced metering infrastructure, plug-in electric vehicles, energy storage, inter-fuel substitution, combined heat and power, microgrids, and demand forecasting. He has worked for nearly 150 clients on 5 continents, including electric and gas utilities, state and federal commissions, governments, independent system operators, trade associations, research institutes, and manufacturers.

Ahmad has testified or appeared before commissions in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, FERC, Illinois, Indiana, Kansas, Maryland, Minnesota, Nevada, Ohio, Oklahoma, Ontario (Canada), Pennsylvania, Saudi Arabia, and Texas. He has presented to governments in Australia, Egypt, Ireland, the Philippines, Thailand, New Zealand and the United Kingdom and given seminars on all 6 continents. He has also given lectures at Carnegie Mellon University, Harvard, Northwestern, Stanford, University of California at Berkeley, and University of California at Davis and taught economics at San Jose State, the University of California at Davis, and the University of Karachi.

His research been cited in Business Week, The Economist, Forbes, National Geographic, The New York Times, San Francisco Chronicle, San Jose Mercury News, Wall Street Journal and USA Today. He has appeared on Fox Business News, National Public Radio and Voice of America. He is the author, co-author or editor of 4 books and more than 150 articles, papers and reports on energy matters. He has published in peer-reviewed journals such as Energy Economics, Energy Journal, Energy Efficiency, Energy Policy, Journal of Regulatory Economics and Utilities Policy and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He is a member of the editorial board of The Electricity Journal. He holds BA and MA degrees from the University of Karachi, both with the highest honors, and an MA in agricultural economics and a PhD in economics from The University of California at Davis, where he was a research fellow.

Presented By



Sylvia Tang is a Research Analyst in The Brattle Group's San Francisco, CA office. She mainly supports utilities, energy companies, and government organization on rate design, cost of services analysis and cost benefit analysis. She received her bachelor degrees in Economics and Statistics from University of California Davis. She graduated from Yale University with Master of Science in Biostatistics.

Sylvia Tang

RESEARCH ANALYST | SAN FRANCISCO

Sylvia.Tang@brattle.com

+1.415.217.1074

Appendix A

ADDITIONAL READINGS





Selected papers on pricing and customer-centricity

"Refocusing on the consumer," *Regulation*, Spring 2020.

"Customer centricity: Lynchpin of strategy," Public Utilities Fortnightly, November 1, 2019.

"The Tariffs of Tomorrow: Innovations in Rate Designs," *IEEE Power and Energy Magazine*, vol. 18, no. 3, pp. 18-25, May-June 2020.

"2040: A Pricing Odyssey," Public Utilities Fortnightly, June 1, 2019.

"Rate Design 3.0 – Future of Rate Design," Public Utilities Fortnightly, May 2018.

"Innovations in Pricing: Giving Customers What They Want," *Electric Perspectives*, September/October 2017.

Appendix B

QUOTABLE QUOTES



APPENDIX B

Why do we have so little price-responsive demand?

"The greatest barriers [to price responsive demand] are legislative and regulatory, deriving from state efforts to protect retail customers from the vagaries of competitive markets." —Eric Hirst

"In electricity markets, as generating capacity constraints are reached, relatively little demand can be rationed by short-term price movements and, instead, must be rationed administratively with rolling blackouts. [This situation could be avoided if more demand-side instruments were available such as having] more customers who can see and respond to rapid changes in market prices and expanded use of pricecontingent priority rationing contracts. The demand response instruments that are available are poorly integrated with spot markets ... moreover, the prices that are paid ... are too low compared to the long-run cost of generating capacity." —Paul Joskow

Appendix C

A POCKET HISTORY OF RATE DESIGN



APPENDIX C

A Pocket History of Rate Design

Year	Author	Contribution
1882	Thomas Edison	 Electric light was priced to match the competitive price from gas light and not based on the cost of generating electricity
1892	John Hopkinson	 Suggested a two-part tariff with the first part based on usage and the second part based on connected kW demand
1894	Arthur Wright	 Modified Hopkinson's proposal so that the second part would be based on actual maximum demand
1897	Williams S. Barstow	 Proposed time-of-day pricing at the 1898 meeting of the AEIC, where his ideas were rejected in favor of the Wright system
1946	Ronald Coase	• Proposed a two-part tariff, where the first part was designed to recover fixed costs and the second part was designed to recover fuel and other costs that vary with the amount of kWh sold
1951	Hendrik S. Houthakker	• Argued that implementing a two-period TOU rate is better than a maximum demand tariff because the latter ignores the demand that is coincident with system peak
1961	James C. Bonbright	Published "Principles of Public Utility Rates" which would become a canon in the decades to come

APPENDIX C

A Pocket History of Rate Design (Concluded)

Year	Author	Contribution
1971	William Vickrey	• Proffered the concept of real-time-pricing (RTP) in <i>Responsive Pricing of</i> <i>Public Utility Services</i>
1976	California Legislature	 Added a baseline law to the Public Utilities Code in the Warren-Miller Energy Lifeline Act, creating a two-tiered inclining rate
1978	U.S. Congress	 Passed the Public Utility Regulatory Act (PURPA), which called on all states to assess the cost-effectiveness of TOU rates
1981	Fred Schweppe	• Described a technology-enabled RTP future in Homeostatic Control
2001	California Legislature	• Introduced <i>AB 1X</i> , which created the five-tier inclining block rate where the heights of the tiers bore no relationship to costs. By freezing the first two tiers, it ensured that the upper tiers would spiral out of control
2001	California PUC	 Began rapid deployment of California Alternative Rates for Energy (CARE) to assist low-income customers during the energy crisis
2005	U.S. Congress	• Passed the <i>Energy Policy Act of 2005</i> , which requires all electric utilities to offer net metering upon request

Clarity in the face of complexity

That's the Power of Economics



