

Moving From Pilots to Full-Scale Deployments of Time-of-Use Rates

BRIDGING THE CHASM

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MI Power Grid: Energy Programs and
Technology Pilots Stakeholder
Meeting

April 16, 2020



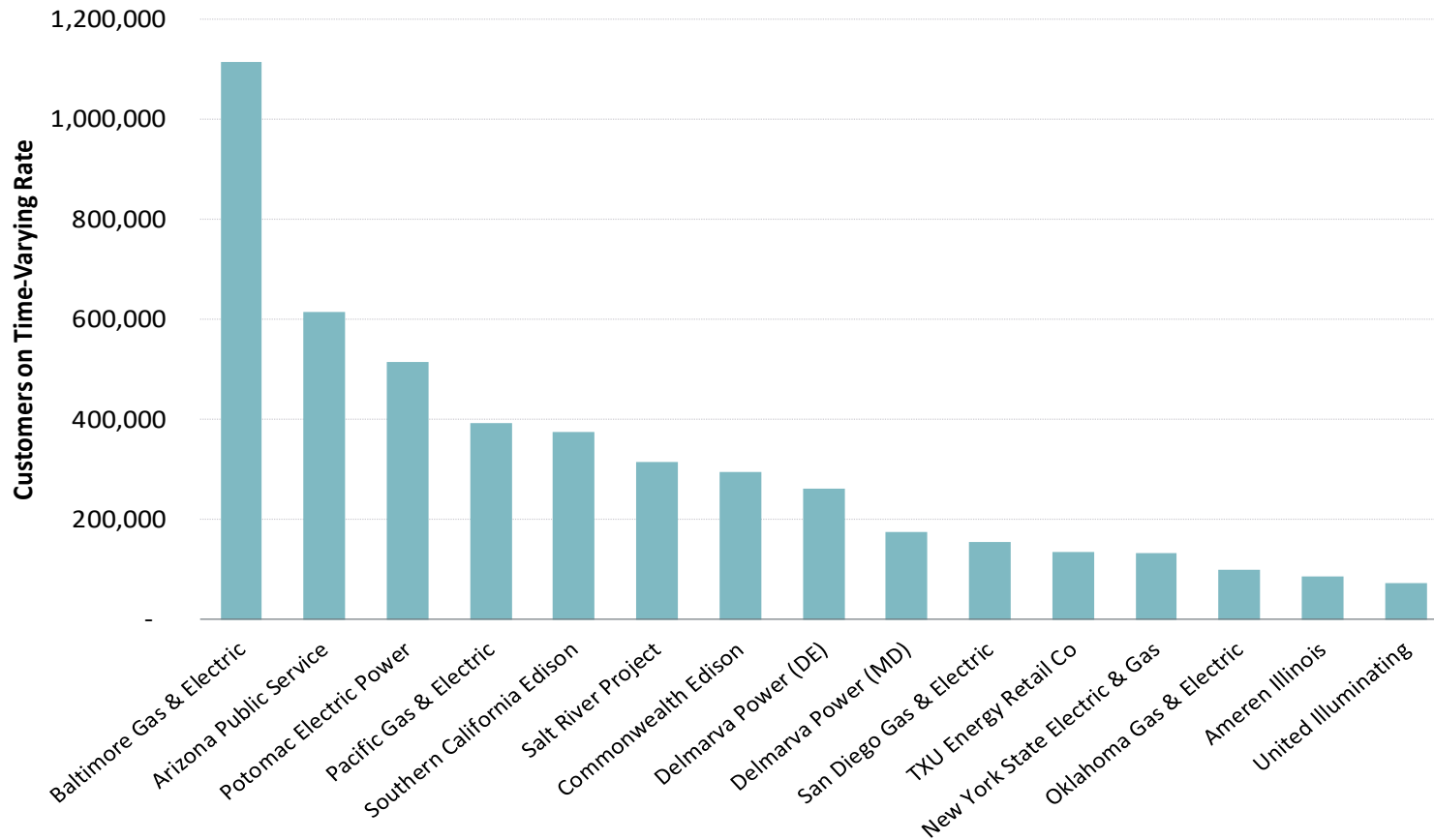
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Consumers encounter TOU pricing in many walks of life

ACTIVITY	EXAMPLES
Driving their car	Toll bridges, roads, parking meters
Entertainment	Movies, operas, plays, happy hour at restaurants
Ride sharing	Uber, Lyft, Kareem
Sporting events	Baseball, basketball, football
Vacation and business travel	Airlines, hotels, car rentals

But in 2018 only ~4% of residential electric customers were on TOU rates

15 utilities in 8 states and DC accounted for 86% of all TOU deployments



What will it take to get to 25%?

More pilots?

More deployments?

Both pilots and deployments?

Between 1975 and 2020, we have witnessed four generations of pilots with time-of-use (TOU) rates

Generation	Year
First Generation	1975 - 2002
Second Generation	2003 - 2009
Third Generation	2010 - 2016
Fourth Generation	2017 - Onwards

The first generation of TOU pilots: 1975-2002

The global energy crisis 1974 led to a dozen TOU pilots being funded in the US by the Federal Energy Administration (later subsumed into the US DOE)

The pilots were carried out in Arizona, Arkansas, California (LADWP and SCE), Connecticut, North Carolina, Ohio, Oklahoma, Puerto Rico, Rhode Island, and Wisconsin

With Dennis Aigner and Bob Howard, I reviewed the results for EPRI's Electric Utility Rate Design Study in 1981. Two years later, I co-authored a paper with Bob Malko

What happened next?

EPRI created a model for predicting customer response to TOU rates by drawing upon the five top experiments (RETOU)

PG&E did a TOU pilot which eventually led to the E7 rate which enrolled ~100,000 customers (I was on it for 10 years)

Yet TOU rates remained an exotic product since utilities were concerned about revenue loss with optional offerings and preferred mandatory deployments, which ran afoul of commission preferences

A few mandatory deployments took place for very large residential customers in the Mid-Atlantic region

Consequences of the global energy crises of 1974 and 1979

Oil prices rose and since generation was quite oil-dependent, electricity prices rose as well, slowing down load growth

As customer bills rose, utilities deployed DSM programs

Retail competition was introduced in the mid-to-late 1990s to further lower rates

Lack of smart meters posed a major barrier to deploying TOU rates

The second generation of TOU pilots: 2003-2009

California was rocked by an energy crisis in 2000-01, which was exacerbated by the absence of price-responsive demand

California carried out a landmark pricing pilot jointly with three investor-owned utilities in 2003-04. This was followed by pilots in Connecticut, District of Columbia, Michigan and Florida

In 2010, I co-authored an article with Sanem Sergici which summarized the results of several pilots

What happened next?

Smart meters began to be rolled out, since their presence was deemed to be a necessary condition to roll out TOU rates

Pennsylvania's PPL was the first utility to roll out smart meters, courtesy of a visionary CEO

California was the next state to roll them out, and its lead was followed by several others, including Alabama, Florida and Georgia

The third generation of TOU pilots: 2010-2016

The Great Recession of 2008-09 triggered the passage of the ARRA legislation which provided \$4.5B of funding for Smart Grid Investment Grants (SGIG), about half of which went to smart meter deployments

SGIG also funded 10 Customer Behavior Studies in California, Massachusetts, Michigan, Minnesota, Nevada, Ohio, Oklahoma, and Vermont

A summary report was published in November 2016

Several different rate designs were tested in DOE's Customer Behavior Studies

Table ES-1. Scope of the Consumer Behavior Studies

	CEIC	DTE	GMP	LE	MMLD	MP	NVE	OG&E	SMUD	VEC
Rate Treatments										
CPP		●	●		●	●	●	●	●	
TOU		●		●		●	●	●	●	
VPP								●		●
CPR	●		●							
Non-Rate Treatments										
IHD	●	●	●					●	●	
PCT	●	●					●	●		
Education							●			
Recruitment Approaches										
Opt-In	●	●	●	●	●	●	●	●	●	●
Opt-Out				●					●	

Utility Abbreviations: Cleveland Electric Illuminating Company (CEIC), DTE Energy (DTE), Green Mountain Power (GMP), Lakeland Electric (LE), Marblehead Municipal Light Department (MMLD), Minnesota Power (MP), NV Energy (NVE), Oklahoma Gas and Electric (OG&E), Sacramento Municipal Utility District (SMUD), Vermont Electric Cooperative (VEC)

The fourth generation of TOU pilots: 2017 onwards

Scores of pilots are underway throughout the globe, in places such as Australia, Hong Kong and New Zealand, in Canada and in California, Maryland, Michigan, North Carolina and other US states

We have been summarizing these results in a database called Arcturus

As of today, it contains information on nearly 350 deployments, mostly experimental, from many countries around the globe

While TOU rates were being piloted, a digital revolution transformed the globe ...

Generation	Year	Technology Development
First Generation	1975 - 2002	1975: IBM introduces the PC, Microsoft founded 1976: Apple founded 1984: Cisco founded 1994: Amazon, Yahoo founded 1997: Netflix founded 1998 : Google founded 1999: Salesforce founded
Second Generation	2003 - 2009	2003: Tesla founded 2005: YouTube founded 2006: Twitter, Solar City founded 2007: iPhone introduced
Third Generation	2010 - 2016	2011: Nest, Zoom introduced 2014: Google acquires Nest
Fourth Generation	2017 - Onwards	2017: iPhone X released 2019: iPhone 11 released

...and customers changed their energy lifestyles and the technologies in their homes

Today, smart thermostats are so widespread you cannot buy a plain old thermostat

LEDs lights are ubiquitous in homes and offices

2 million homes have PV panels on their roofs and the number is trending upwards at a fast rate; some customers are also installing battery storage

Some 1.4 million EVs are on the roads and the number is trending upwards

Have pilots always led to deployments of TOU rates?

In numerous cases, they have simply led to more pilots and in more than a few cases, they have led to nowhere

In at least one case, full-scale deployment took place without any pilots preceding it

In some cases, pilots led to full-scale deployment which was opt-in in some cases, opt-out (default) in others, and mandatory in at least one case

Ontario, Canada

Time-of-Use Rates

The Ontario Energy Board mandated the installation of smart meters for all customers to promote a culture of conservation. The C\$ 2 billion rollout of 4.7 million smart meters was complete by 2014

Alongside smart meters, without doing a pilot, Ontario introduced default TOU rates in 2011-12 for residential and small commercial customers

- 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
- The TOU rates only apply to the energy portion of the customer's bill
- Off-peak, mid-peak, and on-peak prices are defined by season
- A small number of customers without smart meters are on Tiered Pricing rates with seasonally differentiated tiers and prices
- Large commercial and industrial customers pay wholesale prices

California

TOU rates

Multiple pilots were carried out over two decades by the three-investor owned utilities and by SMUD

As of today, SMUD has 542,000 residential customers on default TOU rates, 98% of all its residential customers

SDGE has ~670,000 customers on default TOU rates; SCE has ~500,000 customers and PG&E 515,000 on opt-in TOU rates

The latter two utilities are expected to begin default deployments for new service connections in October, eventually encompassing all customers in a few years

Maryland

Peak Time Rebates

BG&E carried out pilots with TOU rates, critical-peak pricing rates and peak-time rebates over a four year period

Eventually it rolled out peak-time rebates on a default basis to all residential customers

Nearly 80% of customers are on these rebates today and most of them are saving money by earning them

Last year TOU pilots were initiated at BGE, Delmarva and Pepco under the sponsorship of the PSC; separate samples have been created for LMI and non-LMI customers and the pilots will run for two years

Oklahoma

Variable Peak Pricing

After conducting a pilot with TOU rates through the DOE/SGIG/CBS program, 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
- 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
- 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.
- 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

Colorado

Fort Collins carried out a one-year pilot with TOU rates and rolled out TOU rates last October on a mandatory basis

Xcel Energy carried out a two-year pilot with TOU rates and demand rates. It has proposed offering TOU rates to the Colorado PUC with an alternative being the demand rate

	Schedule R		Modified RE-TOU		
	Winter / Summer Tier 1	Summer Tier 2	Off-Peak	Shoulder	On-Peak
Time Periods	Winter All Sales		Summer Weekdays 10:00 pm - 11:00 am Summer Weekends & Holidays	Summer Weekdays 11:00 am -3:00 pm & 7:00 pm - 10:00 pm	Summer Weekdays 3:00 pm - 7:00 pm
% of Residential Sales	Summer 0kWh - 500kWh	Summer > 500kWh	All Winter Hours		
	85.1%	14.9%	84.8%	9.2%	6.0%
S&F Charge	\$5.41	\$5.41	\$5.41	\$5.41	\$5.41
Base Rates	\$0.05461	\$0.09902	\$0.05539	\$0.08309	\$0.11078
GRSA	-4.19%	-4.19%	-4.19%	-4.19%	-4.19%
ECA	\$0.02674	\$0.02674	43.66%	43.66%	43.66%
DSMCA	\$0.00162	\$0.00162	2.65%	2.65%	2.65%
PCCA	\$0.00401	\$0.00401	6.55%	6.55%	6.55%
TCA	\$0.00203	\$0.00203	3.31%	3.31%	3.31%
CACJA	\$0.00301	\$0.00301	4.92%	4.92%	4.92%
RESA	2%	2%	2%	2%	2%
Average Energy Rate	\$0.09153	\$0.13493	\$0.08865	\$0.13298	\$0.17729

As we look at the future, two new rationales have emerged for deploying TOU rates...

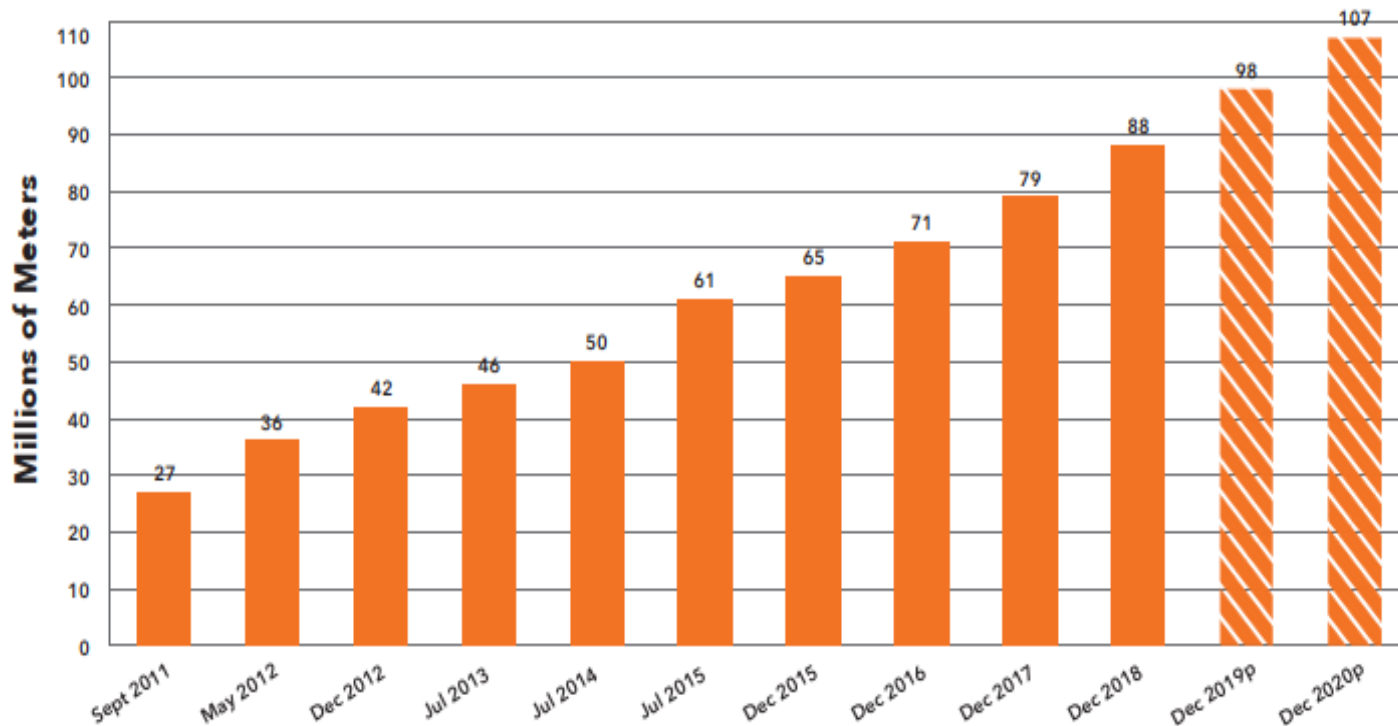
With increasing amounts of renewable energy resources coming into the grid, load flexibility enabled via TOU rates can preserve system reliability while ensuring lower costs for everyone

A new generation of customers has emerged with organic tastes; it wants to have better control over the impact of its energy life style on the climate of the planet

Many customers are acquiring EVs whose adoption and charging would benefit from the availability of TOU rates

...and a major barrier to TOU deployment has been lifted with the nationwide deployment of smart meters

Figure 1: U.S. Smart Meter Installations Approach 98 Million; Projected to Reach 107 Million by December 2020



Five steps for “bridging the chasm” between pilots and deployment

Step	Task
One	Design cost-reflective rates but make sure they are customer friendly; consider offering choices
Two	Learn how customers think and market the rates using the customer’s language
Three	Educate the customers on how to benefit from the rates
Four	Use enabling technologies and behavioral messaging to enhance the price signal
Five	Transition gradually and consider providing bill protection

The total number of customers on TOU rates is likely to triple by 2025 but it will still be <15% of the national total

California is likely to have more than 10 million customers on default TOU rates

Colorado may have some 1.5 million customers on default TOU rates

Michigan may have 2 to 3 million customers on default TOU rates

Other states such as Georgia, Maryland and Missouri may add a million or two customers on opt-in TOU rates

TOU rates will lay the foundation for the universal deployment of technology-enabled real-time pricing

Driven by legislation to decarbonize the grid, commissions are directing utilities to rapidly increase the share of renewable energy resources

As wind and solar begin to dominate the resource mix, the grid will face unprecedented reliability issues due to the intermittency of these resources

Load flexibility, enabled by technology-enabled real-time pricing, will become an imperative as will battery storage systems

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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.

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