A global perspective on time-varying rates

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The coming revolution in rate design

Flat rate pricing (FRP) has been ubiquitous in residential rate design, not just in the US but globally.

FRP has persisted because of two reasons:

- Lack of advanced metering
- A concern that residential customers won’t understand either time-variant prices or demand charges.

The industry has begun moving to a three part rate, comprised of a monthly service charge, a demand charge and time-varying pricing (TVP):

- Such rates have a long history for commercial and industrial customers, backed up by a storied academic tradition dating back to Hopkinson and Wright.
The “house of the future” is about to enter the present

- Digital technology will be commonplace
  - Smart thermostats, smart appliances, smart light bulbs and smart plug loads
  - Home energy management systems will be pervasive
  - These will allow these households to manage their loads dynamically in real time

- If prices fall in the middle of the day, as renewable energy resources kick in, customer loads will rise automatically

- As prices rise later in the evening, loads will fall automatically
The “organic” consumer generation will facilitate the transition to TVP

- They are passionate about controlling their energy use not only to save money but also to lower greenhouse gas emissions.

- They are likely to be cognizant of the opportunities presented by dynamic pricing to lower energy bills and reduce emissions.
  - Their views may allow state commissions to rollout dynamic pricing as the default or universal tariff.

- Further support will come from the successful deployment of TVP as the default tariff to 4 million Ontarian households in and to all households in Italy.
The case for TVP rests on two pillars

**Economic efficiency**

- The costs of supplying and delivering electricity vary by day
- Unless consumers see this time variation in prices, they will have no incentive to modify their usage patterns
- Excess capacity will have to be built and kept on reserve to meet peak loads during a few hundred hours of the year

**Equity**

- Customers who consume relatively less power during peak periods subsidize those who consume relatively more power during peak periods
In the US, we lose $10 billion each year due to FRP

There are more than 50 million households with smart meters today but less than 2 million of them are on TVP

That prevents us from harnessing the benefits of universal dynamic pricing

- $7B/year in lower energy costs
- $3B/year in reduced cross-subsidies
So why are so few customers on TVP?

Over time, several concerns have been expressed about TVP by a variety of consumer organizations.

Some are associated with the rollout of smart meters, which are a pre-requisite for TVP, while others are associated with how TVP would affect customer well-being.

I focus on the latter and address seven often-cited concerns.
Concern #1: Customers won’t respond to TVP

Because results vary widely, some conclude that we have learned nothing about customer response.

60% of the tests have produced peak reductions of 10% or greater

Grouping results by tariff design helps explain some of the variation in impacts.
Of the 225 treatments, 37 are part of tests carried out with support from DOE funding.
The DOE treatments yield results that tend to be higher than those from other studies.

### Average Impacts Across Pilots

<table>
<thead>
<tr>
<th>Rate</th>
<th>Average Impacts Without DOE</th>
<th>Average Impacts of DOE</th>
<th>Number of DOE Treatments</th>
<th>Total Number of Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOU</td>
<td>8.0%</td>
<td>20.1%</td>
<td>10</td>
<td>92</td>
</tr>
<tr>
<td>VPP</td>
<td>11.1%</td>
<td>25.5%</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>PTR</td>
<td>17.2%</td>
<td>14.7%</td>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td>CPP</td>
<td>21.3%</td>
<td>28.0%</td>
<td>13</td>
<td>75</td>
</tr>
</tbody>
</table>
Concern #2: Customer response won’t vary with price

Not only do customers respond, but the magnitude of their response varies with the price incentive. The higher the incentive, the greater their demand response.

To study this relationship between price incentive and peak energy reduction, we have estimated the Arc of Price Responsiveness. The Arc is based on 210 time-varying pricing treatments from around the world.
We plot demand response against the peak to off-peak price ratio.

**TOU Impacts (price only)**

![Graph showing TOU Impacts (price only)](image)

**Dynamic Pricing Impacts (price only)**

![Graph showing Dynamic Pricing Impacts (price only)](image)

Note: 65 points.
Concern #3: Enabling technologies don’t boost demand response

The data shows that enabling technologies boost price responsiveness

TOU Impacts

Dynamic Pricing Impacts

Note: 92 points.

Note: 120 points.
Concern #4: Customer response won’t persist

Customer response has persisted in long-lived pilots
- California, Washington, D.C., Oklahoma for 2 years
- Maryland for 4 years

TOU programs have been in place for decades
- The French *tempo* tariff goes back to 1965
- Arizona’s TOU rates go back to 1980
Concern #5: TVP is unethical

In 2011, Mark Toney of TURN argued that dynamic pricing will hurt low income customers at the Kellogg Alumni Club in San Francisco. https://vimeo.com/20206833

In 2010, an entire conference was devoted to the “ethics of dynamic pricing” at Rutgers University. It was videotaped and the key papers published in The Electricity Journal.

In 1971, Columbia’s William Vickrey stated that people shared the medieval notion of a just price and regarded prices that varied with demand-supply imbalances as evil.
Concern #6: Customers have never encountered TVP

While that may have been true of that charming TV character, Archie Bunker, today’s consumers experience TVP in routine transactions every day, except when it comes to their purchase of electricity.

In the modern economy, TVP is pervasive. It is to be found in a wide range of industries: airlines, bridge tolls, freeway lanes, groceries, hotels, railroads, rental cars, sporting events, and theaters.

Even the ubiquitous parking meter displays a form of TVP.
Concern #7: Customers don’t want TVP

Customers have reported high levels of satisfaction with dozens of TVP pilots and programs in Australia, California, Canada, District of Columbia, Connecticut, Ireland, Japan, Michigan, Maryland, Oklahoma, just to name a few.

No one has to get up at 2 am to do their laundry.

Most customers value the opportunity to save money by making small adjustments in their energy lifestyle.
TVP is being practiced widely in the US

Arizona

- Over two decades, APS has enrolled 51% of its customers on an opt-in TOU rate and the SRP has enrolled about 30% of its customers on an opt-in TOU rate
- SRP has shown that the TOU rate has yielded a significant reduction in system peak demand
- Both utilities offer rate choices to customers as they sign up for service

Illinois

- Both Ameren and ComEd have enrolled about 25,000 customers on RTP in Illinois and are planning to roll-out Flat+PTR
TVP in the US (continued)

Massachusetts

- The DPU has issued a “straw” proposal that calls for default CPP+TOU pricing; customers could opt instead for a Flat+PTR

Mid-Atlantic Region

- BGE and PHI are rolling out Flat+PTR to some 2 million customers in Delaware and Maryland
- PJM is allowing price-responsive demand to be bid into its multi-state capacity markets, as AMI and dynamic pricing are rolled out in its footprint of 60 million customers
TVP in the US (concluded)

Oklahoma

- In three years, OG&E has 100,000+ customers enrolled on variable peak pricing (VPP) and/or TOU pricing and the number is expected to reach 20 percent of its customer base fairly soon
- The program is called Smart Hours
- About 60 percent of the participants are on Smart Hours Plus where they get smart thermostats installed for them by OG&E
- The program is part of a portfolio of programs designed to eliminate the need for a 600 MW coal plant
TVP (for distribution networks) in Australia

The regulatory scene

- The Productivity Commission showed that TVP would lower costs for all customers.
- The Australia Energy Market Commission recommended that TVP should be made mandatory for large customers, optional for vulnerable customers and default for everyone else.
- The last annual conference of the Australian Energy Regulator featured two sessions on TVP.

The businesses

- AusGrid (Sydney) has enrolled some 20 percent of its residential customers on TOU rates.
- Distribution network service providers in Queensland and Victoria have successfully completed pilots with TVP.
TVP in Canada

The province of Ontario has deployed AMI to 4.5 million households and small businesses

- The regulated retail rate plan replaced a two-tier inclining block rate with a TOU rate with on peak, intermediate and off-peak periods
- About 90% of residential customers have chosen to receive service on the TOU rate plan and about 10% have chosen flat rates being offered by retailers

The results from the first two years of deployment are very promising
TVP in Europe

A couple of years ago, Italy rolled out AMI to all 29 million households along with default TOU pricing

- About 23 million residential and small-medium enterprises are on TOU pricing
- A recent analysis of Italy’s default TOU concluded that more than half of customers have shifted consumption patterns in the first year
- The overall customer savings were €2.54 million in the first year

France began rolling out its *tempo* tariff a couple of decades ago

- The tariff features on-peak and off-peak rates that vary across three types of days
- About a third of EDF’s customers are on that tariff
TVP in Asia

Japan has been testing smart technologies and pricing in four cities

- Dr. Koichiro Ito of Boston University has evaluated these projects and concluded that customers *do* respond to hourly marginal prices
- Ito found that the various CPP treatments reduced peak demand by 11% on average

CLP Power in Hong Kong is running a two year pilot with PTR+TOU

- The first year results provided evidence of demand response
Canadian Case Study: Ontario’s Residential TOU Program

Besides Italy, Ontario is the only region in the world to deploy Time-of-Use (TOU) rates for generation charges to all customers who stay with regulated supply.

TOU rates were deployed in Ontario to incentivize customers to curtail electricity usage during the peak period and possibly to reduce overall electricity usage.

The Brattle Group was retained by Ontario Power Authority to undertake the impact evolution of the TOU program.

- Three year assignment; the 1\text{st} and 2\text{nd} Year Impact Evaluation results are presented here, the 3\text{rd} year study is underway.
TOU Seasons and Peak Periods

Note: The prices above are commodity only, the study uses the all-in prices that customers actually face.
Residential Summer TOU Peak Period Impacts

Residential Summer Peak Period: 11 AM – 5 PM

Note: Black bars indicate 95% confidence intervals for the impact

Time Period
- Pre-2012
- 2012
- 2013
Should TOU rates be rolled out as the default tariff?

The average TOU enrollment level is 28% under default flat rates. When TOUs are the default, the average enrollment rate rises to 85%.
The dynamic pricing enrollment levels are similar to those of the TOU offerings.

The average dynamic pricing enrollment is 20% under default flat rates and 84% when dynamic prices are the default.
Default time-variant rates (TVR) dominates opt-in TVR

Aggregate peak reduction impacts (MW) are calculated for a hypothetical utility with one million residential customers and a coincident residential peak demand of 2,000 MW.
No one said it would be easy

In 1939, the British economist Bolton wrote that changes in tariffs were guaranteed to be an unfailing source of argumentation

- There is general agreement that appropriate tariffs are essential to any rapid development of electricity supply
- Ad there is complete disagreement as to what constitutes an appropriate tariff
Ways to ease the pain

Any change in rate design will create winners and losers, and the key to success will lie in gradualism.

Choices in rate design should be offered, including a fully hedged flat rate.

Other options could include:
- Bill protection that is phased out over a few years
- Exempting vulnerable customers or providing them “energy stamps”
- Two-part rates in which only the second part is TVP
Source material – I


Source material –II


Source material –III

- Faruqui, Ahmad, Dan Harris and Ryan Hledik, “Unlocking the €53 billion savings from smart meters in the EU: How increasing the adoption of dynamic tariffs could make or break the EU’s smart grid investment,” *Energy Policy*, Volume 38, Issue 10, October 2010, pp. 6222-6231.


- Faruqui, Ahmad, Ryan Hledik, and Neil Lessem. “Smart by Default,” *Public Utilities Fortnightly*, August, 2014. [http://www.fortnightly.com/fortnightly/2014/08/smart-default?page=0%2C0&authkey=e5b59c3e26805e2c6b9e469cb9c1855a9b0f18c67bbe7d8d4ca08a8abd39c54d](http://www.fortnightly.com/fortnightly/2014/08/smart-default?page=0%2C0&authkey=e5b59c3e26805e2c6b9e469cb9c1855a9b0f18c67bbe7d8d4ca08a8abd39c54d)


Source material –IV


Source material – V

Dr. Faruqui leads the firm’s practice in understanding and managing the changing needs of energy consumers. This work encompasses rate design, distributed generation, energy efficiency, demand response, demand forecasting and cost-benefit analysis of emerging technologies. During his career, he has worked for more than 125 clients, including utilities, system operators, and regulatory commissions, in the US and in Australia, Canada, Egypt, Hong Kong, Jamaica, Philippines, Saudi Arabia and Thailand. He has filed testimony or appeared before state commissions, government agencies, or legislative bodies in Alberta (Canada), Arizona, Arkansas, California, District of Columbia, Illinois, Indiana, Kansas, Maryland, Michigan and Ontario (Canada). He has spoken at conferences in Australia, Bahrain, Brazil, Egypt, France, Germany, Ireland, Jamaica, and the United Kingdom. His work has been cited in publications such as *The Economist*, *The New York Times*, *USA Today*, *The Wall Street Journal* and *the Washington Post*. He has appeared on Fox Business News and National Public Radio. The author, co-author or editor of four books and more than 150 articles on energy economics, he holds bachelors and masters degrees from the University of Karachi and masters and doctoral degrees from the University of California, Davis.

The views expressed in this presentation are strictly those of the presenter and do not necessarily state or reflect the views of The Brattle Group, Inc.
Appendix
## Back to the future of rate design

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Contribution</th>
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<tbody>
<tr>
<td>1882</td>
<td>Thomas Edison</td>
<td>• Electric light was priced to match the competitive price from gas light and not based on the cost of generating electricity</td>
</tr>
<tr>
<td>1892</td>
<td>John Hopkinson</td>
<td>• Suggested a two–part tariff with the first part based on usage and the second part based on connected demand</td>
</tr>
<tr>
<td>1894</td>
<td>Arthur Wright</td>
<td>• Modified Hopkinson’s proposal so that the second part would be based on actual maximum demand</td>
</tr>
<tr>
<td>1897</td>
<td>Williams S. Barstow</td>
<td>• Proposed time-of-day pricing at the 1898 meeting of the AEIC, where his ideas were rejected in favor of the Wright system</td>
</tr>
<tr>
<td>1946</td>
<td>Ronald Coase</td>
<td>• 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</td>
</tr>
<tr>
<td>1951</td>
<td>Hendrik S. Houthakker</td>
<td>• 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</td>
</tr>
<tr>
<td>1961</td>
<td>James C. Bonbright</td>
<td>• Laid out his famous Ten Principles of Public Utility Rates</td>
</tr>
</tbody>
</table>
# Back to the future (concluded)

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<tr>
<td>1971</td>
<td>William Vickrey</td>
<td>• Fathered the concept of real-time-pricing (RTP) in <em>Responsive Pricing of Public Utility Services</em></td>
</tr>
<tr>
<td>1976</td>
<td>California Legislature</td>
<td>• Added a baseline law to the Public Utilities Code in the <em>Warren-Miller Energy Lifeline Act</em></td>
</tr>
<tr>
<td>1978</td>
<td>U.S. Congress</td>
<td>• Passed the <em>Public Utility Regulatory Act (PURPA)</em>, which called on all states to assess the cost-effectiveness of TOU rates</td>
</tr>
<tr>
<td>1981</td>
<td>Fred Schweppe</td>
<td>• Described a technology-enabled RTP future in <em>Homeostatic Control</em></td>
</tr>
<tr>
<td>2001</td>
<td>California Legislature</td>
<td>• Introduced <em>AB 1X</em>, 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</td>
</tr>
<tr>
<td>2001</td>
<td>California PUC</td>
<td>• Began rapid deployment of California Alternative Rates for Energy (CARE) to assist low-income customers during the energy crisis</td>
</tr>
<tr>
<td>2005</td>
<td>U.S. Congress</td>
<td>• Passed the <em>Energy Policy Act of 2005</em>, which requires all electric utilities to offer net metering upon request</td>
</tr>
</tbody>
</table>
James Bonbright's Ten Commandments

1. Effectiveness in yielding total revenue requirements under the fair-return standard
2. Revenue stability and predictability
3. Stability and predictability of the rates themselves
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
Bonbright Reloaded for the 21st century

The ideal rate design should promote economic efficiency, preserve inter-customer equity, promote the financial health of the utility, promote transparency to customers and enable customer choice.