The Tariffs of Tomorrow

PRESENTED TO
Energy Efficiency Center
UC Davis

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Tomorrow has arrived

Wi-Fi thermostats are ubiquitous

Wi-Fi enabled appliances are here

So are home energy management systems

It is possible to finally get “prices to device”
Consumers are turning into prosumers

Rooftop solar panels are appearing on homes and businesses

Micro grids are being installed at universities and military bases

Self-generation at large C&I customers is receiving increasing interest

Battery storage is within reach
The future awaits

Self-driving cars are being tested based on “deep learning” and may be safer than driven cars

Ride sharing has gone global

Electric cars are making their appearance felt on the road
The organic generation is here

Consumers are turning “green and organic”

They want low prices, high reliability and ultimately grid-independence

They are very diverse in their preferences

Barring the electrification of the transportation sector, annual sales growth is expected to remain below 1% for the indefinite future
The Grid has to be reinvented

In her new book, “The Grid,” Dr. Gretchen Bakke, says that the current move toward more sustainable energy solutions will require “a serious re-imagination of the grid. The more we invest in ‘green’ energy, the more fragile our grid becomes.”

Bakke says that “the grid is worn down, it’s patched up, and every hoped-for improvement is expensive and bureaucratically bemired.”
Utilities are trapped in an existential dilemma

The business model built by Samuel Insull was premised on continuing electrification of the economy

- There were economies of scale in power plants. Bigger power plants produced electricity at lower costs than smaller plants. Falling costs meant falling prices which meant rising electricity sales and higher earnings for the utilities.

Now that cycle has run out of steam

- Smaller decentralized power plants are emerging on residential and commercial rooftops and larger consumers are engaging in co-generation.

Notes Bakke, “The utilities don’t know how to upgrade existing technology without putting themselves out of business. Nor do they know how to continue with the existing infrastructure without going out of business.”
An uncertainties about sales growth loom large, it is time to move ahead with rate reform

The bedrock principles of rate design find their best expression in the writings of Professor James Bonbright

These assert that cost-causation should be the overriding principle in order to promote equity between consumers and efficiency in the utilization of scarce capital and fuel resources
Rates should reflect costs

Bonbright argued that a purely volumetric rate assumes that the total costs of the utility vary directly with the changes in the kWh output of energy.

- He calls this “a grossly false assumption” and says such a rate “violates the most widely accepted canon of fair pricing, the principle of service at cost.”

And, while discussing the Hopkinson rate, he said that such a “rate distinguishes between the two most important cost functions of an electric-utility system: between those costs that vary with changes in the system’s output of energy, and these costs that vary with plant capacity and hence with the maximum demands on the system (and subsystems) that the company must be prepared to meet in planning its construction program.”
Bonbright cited the earlier work of the British engineer, D.J. Bolton

“More accurate costing has shown that, on the average, only one-quarter of the total costs of electricity supply are represented by coal or items proportional to energy, while three-quarters are represented by fixed costs or items proportional to power, etc. If therefore only one rate is to be levied it would appear more logical to charge for power and neglect the energy.”
Commercial and industrial (C&I) rates conform with Bonbright

These rates are comprised of 3 elements

- A fixed service charge to cover the costs of billing, metering and costumer care;
- A demand charge to cover the costs of distribution grid and of transmission and generation capacity costs;
- And an energy charge to cover fuel costs; this often varies by time-of-day and is sometimes dynamic
Residential tariffs of today = the residential tariffs of yesterday

They consist of a volumetric energy charge and a fixed charge

- Capacity costs are buried in the volumetric charge, using the load factor of the class
- The fixed charge does not fully recover the fixed costs of serving the customer

In 98% of the cases, the energy charge is flat and does not vary with time-of-use or location

The 2-part rate creates subsidies between customers with different load factors; neither does it promote efficient use of energy
Two-parts rates do not reflect any utility’s cost structure

<table>
<thead>
<tr>
<th>Cost categories</th>
<th>Utility’s Costs</th>
<th>Customer’s Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong> ($/kWh)</td>
<td>Variable = $60</td>
<td>Variable = $115</td>
</tr>
<tr>
<td>- Fuel</td>
<td>Fixed = $10</td>
<td>Fixed = $5</td>
</tr>
<tr>
<td>- Operations &amp; maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fixed</strong> ($/customer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Metering &amp; billing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Overhead</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size-related</strong> ($/kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Transmission capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Distribution capacity</td>
<td>Demand = $50</td>
<td></td>
</tr>
<tr>
<td>- Generation capacity</td>
<td>Fixed = $5</td>
<td></td>
</tr>
</tbody>
</table>
It is time to change residential rates

Back in 1961, Professor Bonbright asked us to guard against the “tyranny of the status quo”

However, 2-part rates remain ubiquitous

They persist for two reasons

- Lack of advanced metering: but now about half the customers have smart meters
- A perception that residential customers are not ready for a change: yet they have welcomed change in every other walk of life
Energy costs should be recovered through time-varying rates

**Economic efficiency**
- The costs of supplying and delivering electricity vary by day, and by hours within a day; they also vary by location
- Unless consumers see this temporal-and-locational variation in prices, excess generation capacity will be built and kept on reserve to meet peak loads during a few hundred hours of the year

**Equity**
- Under flat energy rates, customers who consume relatively less power during peak periods subsidize those who consume relatively more power during peak periods
Grid capacity costs should be recovered through demand charges

Utilities should begin moving to a three-part rate, i.e., a monthly service charge, a demand charge and a time-varying energy charge

- Time-variation in energy rates does not eliminate the need for demand charges
- Georgia Power has ~2,200 C&I customers on real time pricing but these customers still face a demand charge for their use of the grid [https://www.georgiapower.com/docs/rates-schedules/marginally-priced/6.20_RTP-DA.pdf](https://www.georgiapower.com/docs/rates-schedules/marginally-priced/6.20_RTP-DA.pdf)
- Facility-based demand charges co-exist with dynamic pricing rates in California for C&I customers
It is déjà vu all over again

“It is hoped that at some future date the three-part will be the exclusive rate for residence consumers. Such a rate may some day be demanded by good load-factor consumers.”

- W.J. Greene, Electrical World, November 7, 1925.
How do we move into the future?

We have to address the concerns about winners and losers

We have to listen to customers and speak their language

But we can’t sit still
Beginning the transition

Offer 3-part rates as the default option and provide bill protection for the first three to five years

Make them opt-in for customers with special circumstances

Or get them to subscribe to a baseline load shape and buy deviations at spot
Many utilities have proposed to increase the fixed charge and stay with a two-part rate design.

### Recent Proposals to Increase Fixed Charge

<table>
<thead>
<tr>
<th>Utility #</th>
<th>Originally Proposed</th>
<th>Approved Increase</th>
<th>Previous Fixed Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$0</td>
<td>$5</td>
<td>$25</td>
</tr>
<tr>
<td>2</td>
<td>$10</td>
<td>$15</td>
<td>$30</td>
</tr>
<tr>
<td>3</td>
<td>$15</td>
<td>$20</td>
<td>$35</td>
</tr>
<tr>
<td>4</td>
<td>$20</td>
<td>$25</td>
<td>$40</td>
</tr>
</tbody>
</table>

Average increase = $2.71 (35%)

### Amount of Approved Increase

Fixed charges can help to address the “cost shift” problem

In the absence of advanced metering infrastructure (AMI), rate design options for addressing the cost-shift issues associated with DG adoption and volumetric rates are somewhat limited.

Fixed charges are one option for addressing the cost-shift issue and do not require metering upgrades.

Some costs, such as metering, billing, and general overhead are clearly fixed and vary with the number of customers, not with the amount of electricity consumed.
Some utilities already offer demand charges

19 utilities offer residential demand charges, 10 of which are IOUs

They have been proposed in Arizona, Kansas, Illinois, Nevada, and Oklahoma

Notes:
1) All rates are drawn from their respective utility tariff sheets, valid as of July 2015.
2) The SP rate listed and varies by season and amount of demand; we show the average summer demand charge for a 10 kW customer for illustrative purposes.
3) The SC Public Service Authority DG rate includes a peak rate of $11.34/kW·mo and an off-peak rate of $4.85/kW·mo. We present the sum for simplicity.
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 kW’s; 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

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

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Avg. Demand (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothes Dryer</td>
<td>4.0</td>
</tr>
<tr>
<td>Oven</td>
<td>2.0</td>
</tr>
<tr>
<td>Stove</td>
<td>1.0</td>
</tr>
<tr>
<td>Hand iron</td>
<td>0.5</td>
</tr>
<tr>
<td>Central air conditioner</td>
<td>5.0</td>
</tr>
<tr>
<td>Spa heater and filter</td>
<td>6.0</td>
</tr>
<tr>
<td>Misc. plug loads</td>
<td>0.2</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.3</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19.5</strong></td>
</tr>
</tbody>
</table>

- 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
Stakeholder concerns can be addressed through some new initiatives

Codify and learn from the experience of utilities that have deployed new rates in the US and in Europe

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

Assess customer understanding of the new rates through market research (interviews, focus groups and surveys) and identify the best way to communicate the concept and to design the rates
Stakeholder concerns can be addressed through some new initiatives (concluded)

Assess customer response to new rates through a new generation of experiments whose design builds on insights gleaned from prior work on time-of-use pricing experiments

Study ways in which to mitigate financial impact on vulnerable customers, maybe by excluding them initially from the new rates, or by phasing in the rates, or by providing them financial assistance for installing energy efficiency measures
Ahmad Faruqui is an economist whose consulting practice is focused on the efficient use of energy. His areas of expertise include rate design, 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 more than a hundred clients on five continents. These include electric and gas utilities, state and federal commissions, independent system operators, government agencies, trade associations, research institutes, and manufacturing companies. 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, ECRA (Saudi Arabia), and Texas. He has presented to the governments of Australia, Egypt, Ireland, Philippines, Thailand and the United Kingdom and given energy seminars on all six continents. His research on the energy behavior of consumers has been cited in Business Week, The Economist, Forbes, National Geographic, The New York Times, the San Francisco Chronicle, the San Jose Mercury News, the 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 four books and more than 150 articles, papers and reports on energy matters. His work has appeared in peer-reviewed journals such as Energy Economics, Energy Journal, Energy Efficiency, and the Journal of Regulatory Economics and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He holds bachelors and masters degrees from the University of Karachi and a doctorate in economics from The University of California at Davis.
References – I


References – II


References – 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): 6222-6231.

http://www.fortnightly.com/fortnightly/2014/08/smart-default?page=0%2C0&authkey=e5b59c3e26805e2c6b9e469cb9c1855a9b0f18c67bbe7d8d4ca08a8abd39c54d


http://www.ksg.harvard.edu/hepg/Papers/2015/HEPG%20June%202015%20rapporteur%20s%20report.pdf
References – V


References – VI


References – VII


Videos

Georgetown University’s CSIS. A 90-minute panel session on time-variant pricing. Washington, DC.
https://www.youtube.com/watch?v=0p6ZHаХszRQ

NYU School of Law. A day-long a conference on time-variation pricing as part of the REV Proceedings. New York, NY.
http://www.sallan.org/Sallan_In-the-Media/2015/04/rev_agenda_time_variant_p.php

Appendix
Back to the future of rate design
## Back to the future of rate design

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Contribution</th>
</tr>
</thead>
<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 Principles of Public Utility Rates</td>
</tr>
<tr>
<td>Year</td>
<td>Author</td>
<td>Contribution</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<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>
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