Dynamic Pricing –

The bridge to a smart energy future

PRESENTED TO

World Smart Grid Forum
Berlin, Germany

PRESENTED BY

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September 25, 2013

THE Brattle GROUP

Agenda

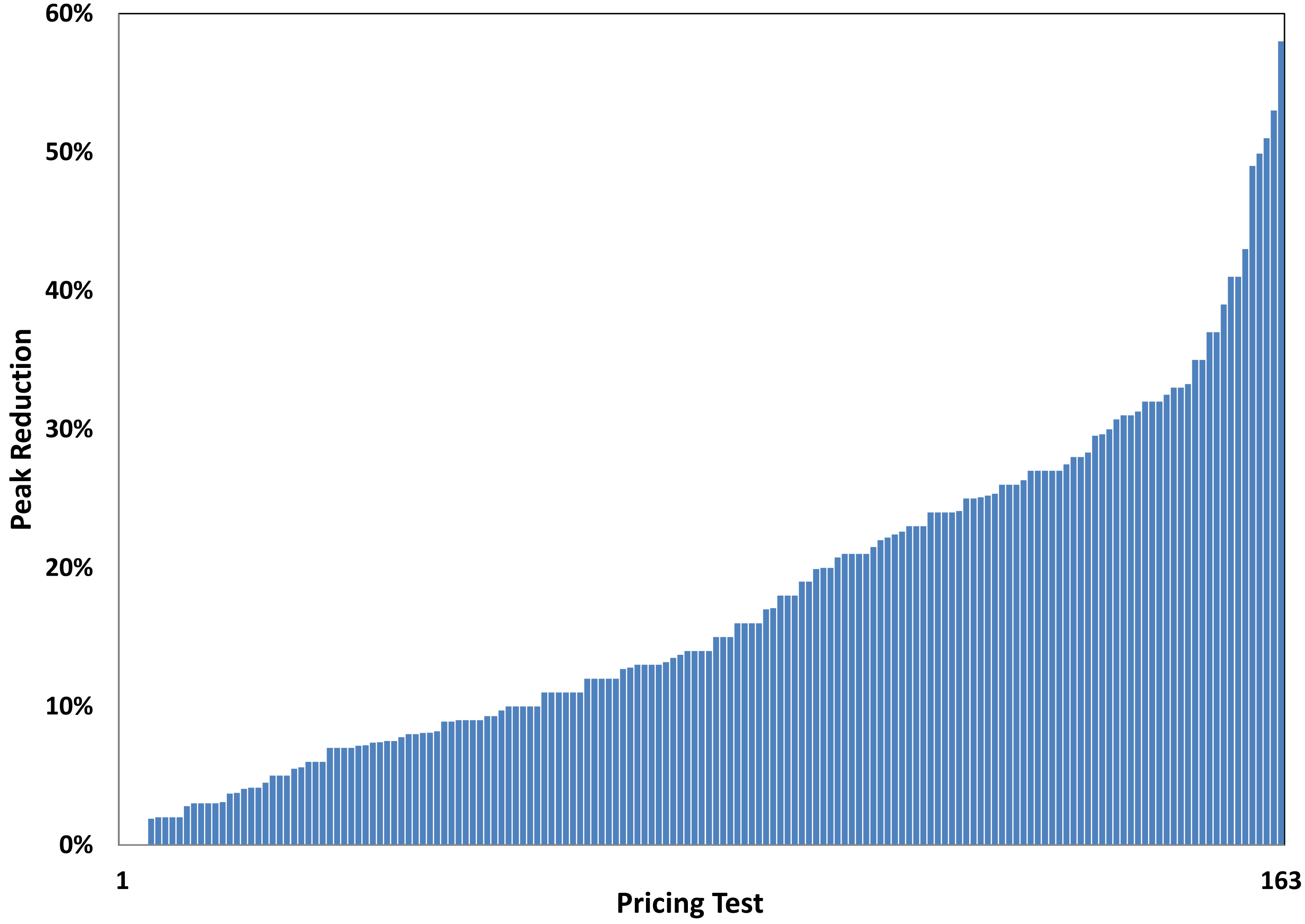
International Evidence on Dynamic Pricing

Using Dynamic Pricing for the Grid Integration of Renewables

Resolving the Crisis in Rate Design

International Evidence on Dynamic Pricing

There is no apparent consistency in 163 studies across 7 countries in 4 continents



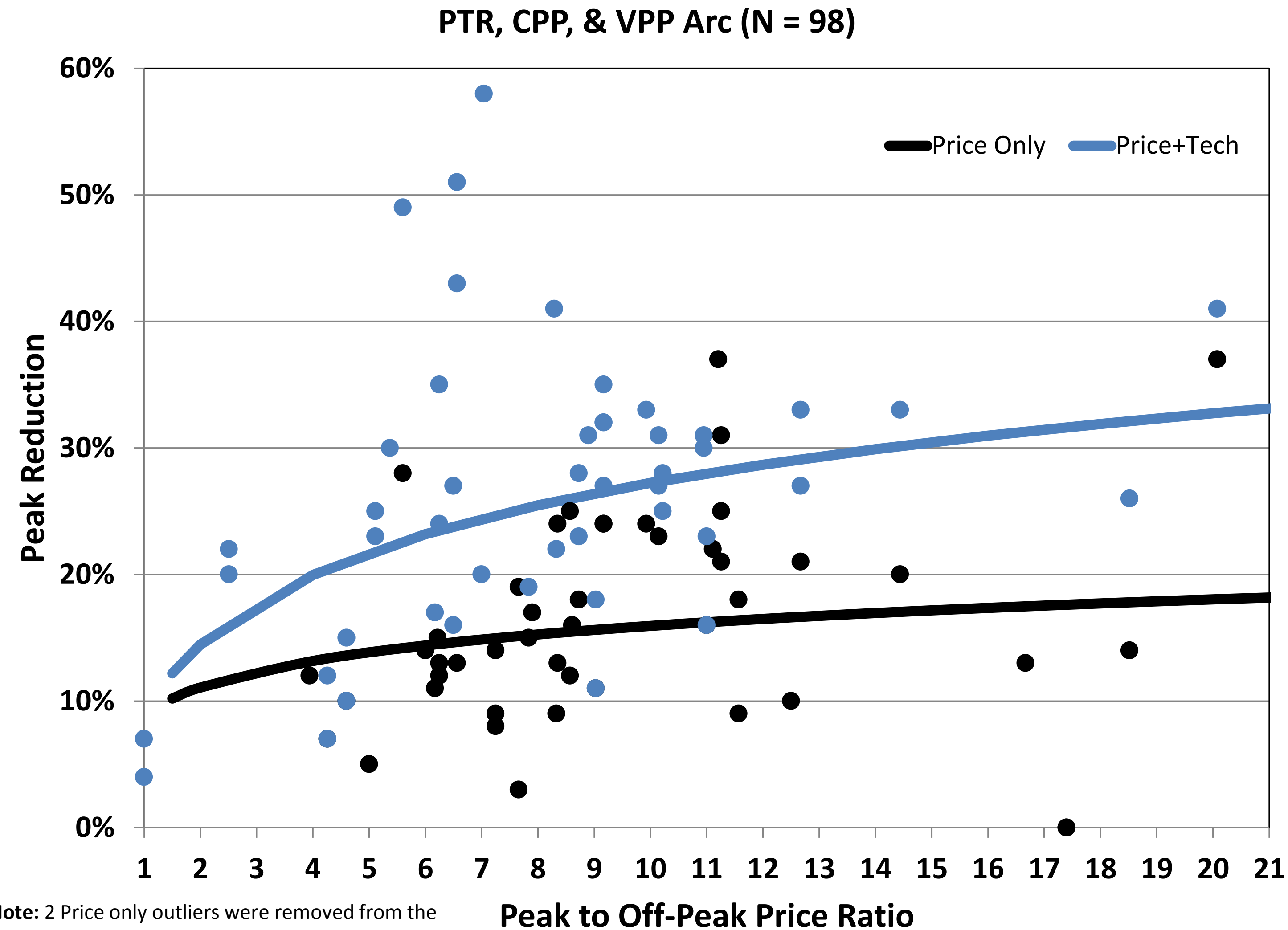
The issue needs further analysis

Several studies have published the peak to off-peak price ratio along with the associated impact on peak usage

In the slides that follow, I plot the reduction in peak usage against the peak to off-peak price ratio

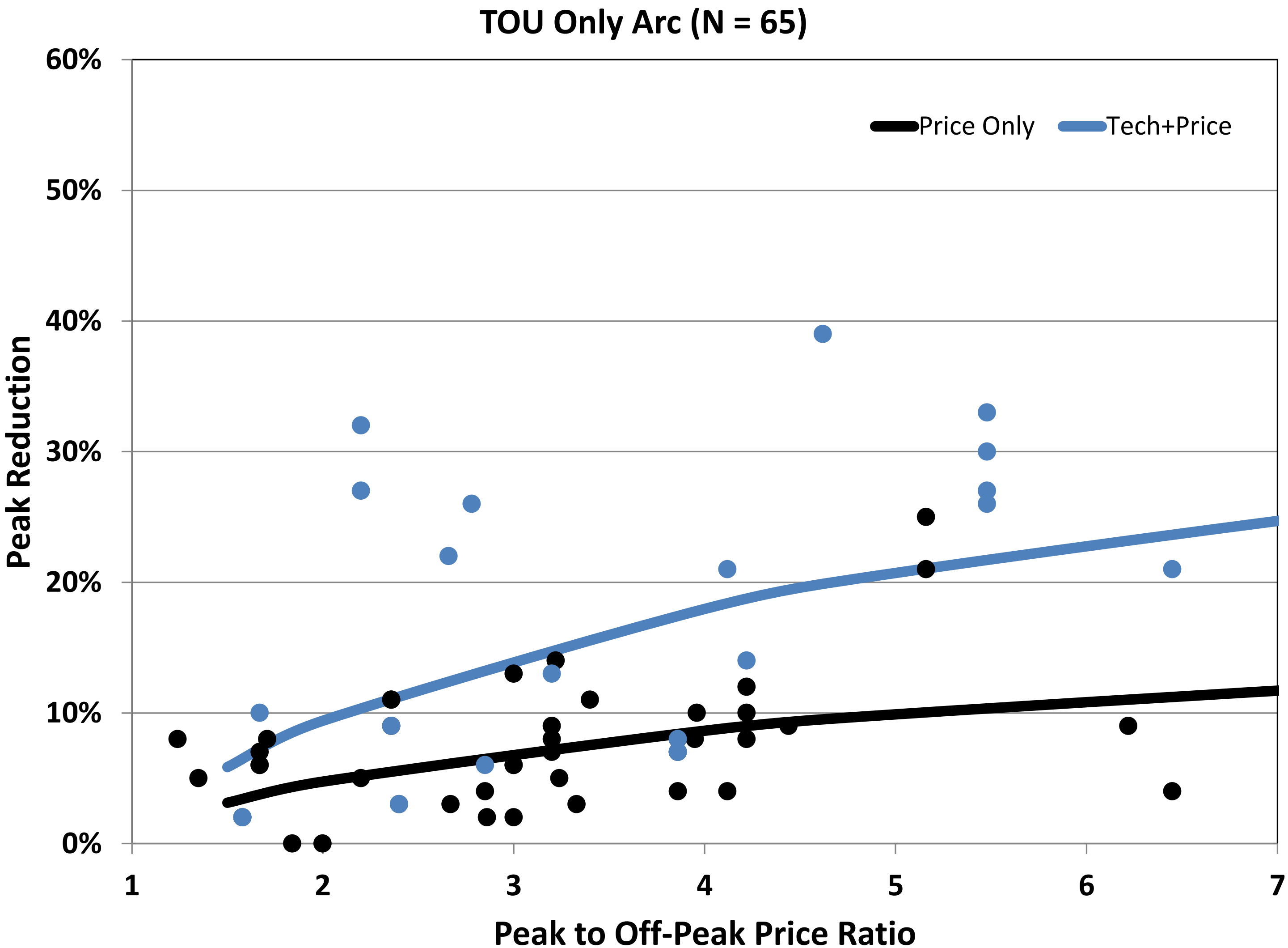
I group the results by pricing type (dynamic and simple time-of-use) and whether or not enabling technology (such as smart thermostats) was combined with pricing

The Arc of Price Responsiveness for Dynamic Pricing



Note: 2 Price only outliers were removed from the regression

The Arc of Price Responsiveness for TOU Pricing



The Arc of Dynamic Pricing can be used to make predictions about demand response

Peak to Off-Peak Price Ratio = 5

- Pricing-Only: ~13.8% peak reduction
- Pricing + Tech: ~21.7% peak reduction

Peak to Off-Peak Price Ratio = 10

- Pricing-Only: ~15.9% peak reduction
- Pricing + Tech: ~27.2% peak reduction

The results with the 5:1 price ratio are very similar to the results from the California Statewide Pricing Pilot in 2005; the experiment featured a CPP rate with a price ratio of 6.56, which resulted in a 13% peak reduction

The Arc of TOU Pricing can also be used to make predictions

Peak to Off-Peak Price Ratio = 5

- Pricing-Only: ~9.9% peak reduction
- Pricing + Tech: ~20.7% peak reduction

Peak to Off-Peak Price Ratio = 10

- Pricing-Only: ~13.8% peak reduction
- Pricing + Tech: ~29.3% peak reduction

The results with the 5:1 price ratio are very similar to the results from the California Statewide Pricing Pilot in 2005; the experiment also featured a TOU rate with a price ratio of 2:1, which resulted in a 4-5% peak reduction

Conclusions

The amount of demand response increases as the peak to off-peak price ratio increases but at a diminishing rate

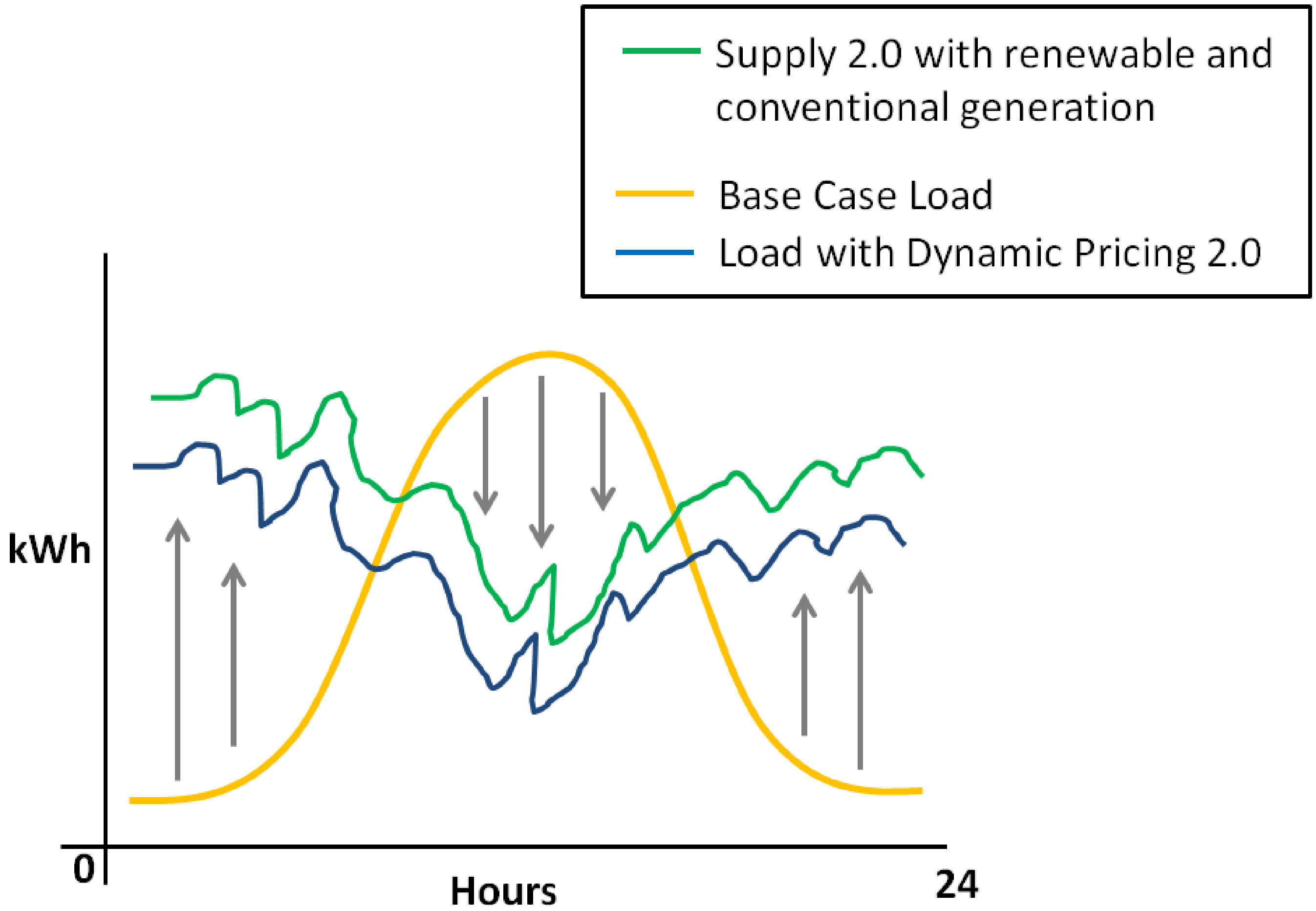
- Enabling technologies boost price responsiveness

Of course, there are many drivers of demand response besides the price ratio

- Length of peak period
- Number of pricing periods in a day
- Climate
- Appliance ownership
- How the rate was marketed to customers
- How customers were selected into the experiment

Using Dynamic Pricing for the Grid Integration of Renewables

RTP can help integrate renewables by creating load flexibility around the clock



Dynamic Pricing 2.0 = RTP + fast response technologies

- Fast response technologies include:
  - Advanced metering infrastructure
  - Smart appliances
  - Home energy controllers
  - Energy storage
  - Batteries
- Integration requires the provision of ancillary services which include:
  - Spinning reserves
  - Nonspinning reserves
  - Regulation up and regulation down

RTP can reduce the peak load in New York City by 13-16%

- **Base Case:** No technology; elasticities unchanged
- **Conservation Case:** Customers provided with in-home displays
- **High Capacity Price:** Capacity prices are increased to reflect higher cost of entry
- **High Elasticity:** Elasticities are twice as high as the base case to represent impact of enabling technology facilitating load shifting

Dynamic Pricing Scenario	Change in System Peak		Change in New York City Peak		Change in Long Island Peak		Change in Average Load			
	All Hours		*All Hours*		*All Hours*		*All Hours*		*150 Hours w/Max Δ Load*	
	(MW)	(%)	(MW)	(%)	(MW)	(%)	(MW)	(%)	(MW)	(%)
Base Case	(3,418)	(10%)	(1,514)	(13%)	(590)	(11%)	84	0.4%	(1,897)	(6%)
Conservation	(3,751)	(11%)	(1,514)	(13%)	(604)	(11%)	(288)	(1.5%)	(2,158)	(7%)
High Capacity Price	(4,282)	(13%)	(1,671)	(14%)	(776)	(14%)	176	1.0%	(3,147)	(11%)
High Elasticity	(4,603)	(14%)	(1,961)	(16%)	(779)	(14%)	130	0.7%	(3,606)	(12%)

Source: Potential Wholesale Market Benefits in New York State. ISO NY. Samuel Newell and Ahmad Faruqui. October 27, 2009.

Back to the future

- In 1981, MIT's Fred Schweppe published *Homeostatic Control: The Utility/Customer Marketplace for Electric Power*
- In Schweppe's formulation, *homeostatic control* is the ability to maintain internal equilibrium between electricity supply and electricity demand through technological and economic means
- It is based on two principles
  - Customer independence
  - Feedback between the customer and utility
- The idea of flexible load shapes was also discussed in Clark Gellings' 1982 paper on Demand-Side Planning

A Gedankenexperiment

6:00 am	Computer gets hot water ready for shower when consumer wakes up
7:00 am	Computer displays its energy use plan for next 24 hours based on predicted weather, spot price patterns and owner's average lifestyle, which computer has learned (think *Nest* thermostat)
10:00 am	Latest spot price and weather forecasts cause computer to pre-cool parts of the house so it can “coast” during the afternoon
12:00 pm	Consumer calls computer to say guests are spending the night. Computer incorporates air conditioning the guest room into its strategy
3:00 pm	A large quantity of supply is lost due to a storm. Computer reacts to very high spot prices by turning off everything except the refrigerator, freezer and itself

“The future, though imminent, is obscure” – Winston Churchill

The way forward

- While a few RTP pilots have been done, and while some have featured enabling technologies, they were not specifically focused on grid-integration of renewables

- We need a new generation of pilots focused on Dynamic Pricing 2.0 that will allow fast and flexible load shaping around the clock

- There is a lot we can learn from previous pilots with time-of-use and Dynamic Pricing 1.0; e.g., treatment and control groups should be selected randomly and be observed before-and-after the activation of pricing treatments to yield valid conclusions

Resolving the Crisis in Rate Design

Rate design has always been an unfailing source of argument

"There has never been any lack of interest in the subject of electricity tariffs. Like all charges upon the consumer, they are an unfailing source of annoyance to those who pay, and of argument in those who levy them. In fact, so great is the heat aroused whenever they are discussed at institutions or in the technical press, that it has been suggested there should be a "close season" for tariff discussions. Nor does this interest exaggerate their importance. There is general agreement that appropriate tariffs are essential to any rapid development of electricty supply, and there is complete disagreement as to what constitutes an appropriate tariff."

-D.J. Bolton, Costs and Tariffs in Electricity Supply, 1938

Sales growth has fallen by half and become a serious financial threat to utilities

When it's a problem…

- If fixed costs are recovered through volumetric rates, ability to make new investments and fully recover costs is compromised
- If a slow down in sales growth is coupled with higher costs, earnings are threatened
- Even with decoupling, sales reductions lead to upward pressure on rates

It might be less of a problem…

- If there are timely and frequent rate cases
- If there is an accompanying improvement in operational efficiency
- If a larger share of costs are recovered through fixed charges

Estimated intra-class subsidies for a utility in California

Caveat: The analysis was performed a few years ago and probably understates today's magnitudes

- **Overly inclining block rates =** $500 million per year paid from high-use customers to low-use customers
- **Lack of time-of-use rates =** $400 million per year paid from "flat" load profile customers to "peaky" load profile customers
- **Low income subsidy =** $300 million per year paid to low-income customers by all other customers

California's PUC has initiated a rate design reform proceeding

- A total of 18 proposals have been received and are under review
- Key topics in the debate include:
  - Tiered rates vs. Time-of-Use (TOU) rates vs. Flat rates, for the default rate
    - Dynamic pricing, such as PTR and CPP, as opt-in alternatives
  - Introduction of fixed charges
  - Introduction of demand charges
  - Resetting of low-income subsidies
  - Rethinking net energy metering tariffs
  - Developing transition strategies
  - Complementary programs that provide technology, consumer education or points-rewards systems to promote energy efficiency

Back to the future 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 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	• Laid out his famous Ten Principles of Public Utility Rates

Back to the future (concluded)

Year	Author	Contribution
1971	William Vickrey	• Fathered the concept of real-time-pricing (RTP) in *Responsive Pricing of Public Utility Services*
1976	California Legislature	• Added a baseline law to the Public Utilities Code in the *Warren-Miller Energy Lifeline Act*
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 *AB 1X,* 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 *Energy Policy Act of 2005*, which requires all electric utilities to offer net metering upon request

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 in which there is retail competition

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.

Net energy metering is yet another inter-customer subsidy, as seen in this example

Components of Electricity Retail Price (¢ / kWh)		
Generation	Fuel	3¢
	Capital	2¢
Transmission	Capital	3¢
Distribution	Capital	2¢
Retail Price = 10¢ / kWh		

- **Typical customer usage and bill**
  - 1,000 kWh @ 10¢ / kWh = $100
- **Solar customer producing 600 kWh with net energy metering (NEM)**
  - Net usage = 1,000 kWh – 600 kWh = 400 kWh
  - 400 kWh @ 10¢ / kWh = $40
- **However, the solar customer should actually pay $82**
  - (1,000 kWh @ 10¢ / kWh) – (600 kWh @ 3¢ / kWh) = $100 - $18 = $82
- **The non-solar customers are paying the difference of $42**

Toward the rate design of the future

- The rate design would be a two-part tariff, consistent with past writings on the subject, comprising a monthly fixed charge and a volumetric energy charge
- The fixed charge may be expressed as a single number that applies to all customers but it would be better expressed as a demand charge
- The volumetric charge would reflect the time-of-day and seasonal variation in the marginal cost of electricity but it would be better expressed as a real-time price, facilitating the grid-integration of renewables if home automation comes to pass
- With the advent of advanced metering infrastructure (AMI), which now reaches one-quarter of US households and continues to grow, the future seems to be within our grasp and home automation may not be too far behind

Other rate design features of the future

- **The rate design would not be encumbered with any subsides to address social issues**
  - Not only does that conflict with the equity principle, it often has unintended consequences as seen in California
  - Social issues are best addressed through the tax code

- **To promote customer choice, the ideal rate design would be put forward as the default rate and be accompanied with one or two options**
  - For example, if customers do not wish to face a time-varying rate, they should be offered a flat rate that reflects the full cost of hedging them from price volatility

Beginning the transition to the future

- Any change from the status quo creates winners and losers and this impedes movement to the future
- For the future to be reached, a way has to be found to cushion the impact on the losers
- A two-track approach is advisable
  - Manage expectations by making a strong case to the public as to why rates are being changed; this will involve a mass media and outreach campaign, not just an application to the PUC
  - Provide bill protection to the losers so they are held harmless in the first year and gradually exposed to the new rates over a three-to-five year transition period

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