Designing Politically-Correct Dynamic Pricing Plans to Realize the Benefits of Active Customer Participation in Wholesale Electricity Markets

Frank A. Wolak
Director, Program on Energy Sustainable Development (PESD)
Professor, Department of Economics
Stanford University
wolak@stanford.edu
http://www.stanford.edu/~wolak

The Marketing Challenge of Real-Time Pricing

What we say to customers about real-time pricing

Real-time pricing improves the efficiency of wholesale markets. Real-time pricing improves system reliability.

What they hear

Real-time pricing is just for dogs

Real-time pricing only available to the rich and beautiful

Real-time pricing is a way to get the rich people to pay more for electricity

Real-time price is default price

Paid for virtually all goods (except electricity)

What Happens to Supporters of Default Real-Time Pricing of Electricity?

Real-Time Price is Default Price
(Paid for Virtually All Goods (except electricity))
Real-Time Price is Default Price Paid for Virtually All Goods

- In all markets but electricity, the *real-time price* is the default price all consumers must pay and producers must receive
  - Price of oil changes on a daily basis
  - Price of gasoline can change on a daily basis
  - Price of coffee beans can change daily
  - Price of coffee can change daily
- Neither consumers or producers are required to pay or receive real-time price
  - Market participant can sign a hedging arrangement
- Widespread hedging activities to manage real-time price
  - Cell phone service (calling plan choice)

Example from airline industry
- Customers always have option to show up at airport and purchase ticket for flight they would like to travel on at real-time price
  - Default real-time price purchase strategy has significant price risk because flight can sell out (effectively an infinite price)
  - To hedge price risk, consumer purchases ticket in advance (fixed-price forward contract)
- Hedging arrangements benefit airlines and customers
  - Airlines can increase load factors (seats filled/seats flown)
  - Customers benefit with lower average fares

Why Is Electricity Different?

- Because of legacy of vertically integrated-monopoly market structure customers have “free” hedge against real-time price for unlimited quantity of electricity
  - In vertically-integrated monopoly regime, utility provided spot electricity price insurance to customer
  - Customer paid firm’s average cost for each KWh consumed and utility ensured supply was always available

Is Electricity Really Different?

- In wholesale market regime it is very risky to set a fixed retail price for unlimited quantity of energy that is guaranteed to always cover wholesale energy costs
  - Significant risk of bankruptcy of retailer
  - No secondary market activity in this kind of contract
- Wholesale electricity typically traded under standardized fixed price and fixed quantity contracts
  - Retail pricing must be adopted to this reality for consumers to benefit from wholesale markets
Important Point 1

- Fixed-retail price does not imply customers avoid paying real-time hourly wholesale prices in retail price
  - Retailers will go bankrupt if retail price does not satisfy equation given below on an annual basis
    - $P(\text{retail}) \geq P(\text{wholesale}) + P(\text{transmission}) + P(\text{distribution})$

important point 1

Default real-time pricing is nothing new:
Load-profile billing with customer’s actual hourly consumption

Important Point 2

- Real-time pricing is nothing more than load-profile billing with customer’s actual hourly consumption instead of “load profile” of monthly consumption in each hour
- Under load-profile billing, each customer is assigned weights, $w(t)$, giving share of monthly consumption customers with their load shape consumes in hour $t$
  - “Implied hourly consumption” is $w(t)Q(m)$, where $Q(m)$ is customer’s monthly consumption
  - If $p(t)$ is wholesale price in hour $t$, customer’s monthly wholesale energy costs are $\sum_{t=1}^{T} p(t)w(t)Q(m)$
- Default real-time pricing just substitutes customer’s actual consumption $q(t)$ in hour $t$, into above formula to yield $\sum_{t=1}^{T} p(t)q(t)$
Why Default Real-Time Pricing is the Endpoint

- Because it's what we do with every other product sold through a market mechanism
- Many states have ambitious renewable energy goals
- Renewables are often unavailable during peak periods
- Major factor driving need for dynamic pricing—High wholesale prices do not cause more wind or solar energy to be produced
  - As share of renewable energy grows final consumers must supply more “dispatchable negawatts” to maintain system balance

Hourly Metering is Required

- Lack of hourly metering of final demand makes it impossible to set hourly retail prices that pass-through hourly wholesale price
  - Customer reduces monthly bill by same amount by reducing consumption by 1 KWh during hour when wholesale price is $5000/MWh as he does when price is $0/MWh
- Economics of hourly meters is rapidly changing because of technological change
  - Major cost of monthly reading for conventional meters is labor cost
  - Modern hourly meters are read remotely by wireless or wireline technology

Day-Ahead versus Real-Time Dynamic Pricing

- All US wholesale markets are ideally suited for active participation of final consumers—Multiple settlement periods
  - Day-ahead forward market
    - Buy and sell energy for delivery and withdrawal during each hour of following day at fixed hourly price
  - Real-time imbalance market
    - Buy or sell imbalances relative to day-ahead schedules during each hour of day at hourly price
  - Day-ahead prices are substantially less volatile than real-time prices

Day-Ahead versus Real-Time Dynamic Pricing

- If default price that supplier receives and load pays is real-time price
  - Only if supplier sells in day-ahead forward market can it be paid the day-ahead price, but only for quantity sold in day-ahead market and not for actual production
  - Only if load buys in day-ahead forward can it be charged the day-ahead price, but only for quantity purchased in day-ahead market and not for actual consumption
  - Automated demand-side participation in wholesale market can help overcome regulatory barriers to symmetric treatment of load and generation
Day-Ahead versus Real-Time Dynamic Pricing

- In all US markets, there are a number of periods with very high real-time prices
  - With default real-time pricing, shifting demand away from certain periods can yield significant cost savings for consumer
  - Buy energy at $50/MWh in day-ahead market and sell it back at $2,000/MWh in real-time market
- Most volatile prices are near major load centers
  - California retailers are currently able to buy at Load Aggregation Point (LAP) prices averaged over large geographic areas covered by three investor-owned utilities
  - LAP pricing is likely to end in the near future
    - Wolak, Frank (2010) “Quantifying the Benefits of Spatial versus Temporal Granularity in Retail Electricity Pricing,” on web-site
    - Supply-side benefits of greater spatial granularity in pricing in California

Retail Competition

- If default price consumer must pay is real-time price, then competition among retailers can find optimal price for each customer
  - Customers switch to plan that suits them
- NY PSC may initially need to set default plan that all utilities must offer that “protects” consumers
  - Customers are welcome switch away from this plan to find what is optimal for them

Managing Price Risk

- Retail customer with interval meter purchases analogue to cellular telephone “calling plan” for electricity consumption
  - Fixed-price contract for fixed quantity of energy
    - Examples
      - 7x24 for 1.5 KWh at 10 cent/KWh
      - 6x16 for 0.5 KWh at 12 cents/KWh
      - 5x4 for 0.5 KWh at 15 cents/KWh
  - This yields a load shape that approximates customers actual consumption at average price of 10.5 cents/KWh
    - Customer only exposed to real-time price for deviations from this load shape, upward and downward
Managing Low Income Concerns

- Can give low-income customers the right to purchase load shape at reduced price
  - Examples
    - 7x24 for 1.0 KWh at 4 cent/KWh
    - 6x16 for 0.5 KWh at 6 cents/KWh
    - 5x4 for 0.25 KWh at 8 cents/KWh
  - This yields a load shape that approximates customer’s actual consumption at reduced average price of 4.5 cents/KWh to account for being low income
  - Customer only exposed to real-time price for deviations from this load shape, upward and downward

Conclusions 1

- Default real-time pricing for all consumers maximizes benefits of smart technologies
  - Makes day-ahead dynamic pricing, storage and automated load shifting technologies financially viable
  - No customer needs to pay real-time price for any consumption, only face it as a default price, just like in all other markets
- Consumers, or retailer on their behalf, purchases fixed load shape at a fixed prices
  - Consumers, or retailers on their behalf, buy and sell deviations from fixed load shapes in day-ahead and real-time markets to minimize bill risk
  - Similar to cell phone model
    - Purchase total monthly minutes at fixed price in advance
    - Real-time price per minute for consumption above total monthly minutes
    - Rollover of unused minutes similar to selling unconsumed contract quantity in day-ahead or real-time market
- Important note—Customer does not even need to know day-ahead or real-time price only have technology installed and follow instructions of retailer

Conclusions 2

- Whether default real-time pricing is implemented in most US states is still uncertain
  - Significant regulatory barriers in all but one state
  - Information provision is key to success
    - Kahn and Wolak (2013) “Using Information to Improve the Effectiveness of Nonlinear Pricing: Evidence from a Field Experiment” on web-site
    - Ongoing experiments at PESD on information provision
- Texas is test case for potential benefits of default real-time pricing
  - Large renewable energy share
    - Wind in west Texas
  - Interval meters are currently installed
  - Full retail competition allowed
  - Default price charged to retailer for consumption of each customer it serves is hourly real-time price
Questions/Comments
For more information:
http://wolak.stanford.edu/~wolak