Fundamentals of Dynamic Pricing

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Presentation to the Public Utilities Commission of Ohio

December 8, 2009

*Energy Resource Economics, LLC. Work was sponsored by the Lawrence Berkeley Laboratory under Contract No. 6898299. Support and advice also provided by Bernie Neenan and Christopher Holmes.

Outline of Presentation

I. Why Dynamic Pricing?

II. Pricing under Regulation vs. Markets

III. Design Principles for Regulated Pricing

IV. Wholesale Products (Supply & Demand)

V. Retail Product Features and Rate Structures

VI. Experience to Date with Dynamic Pricing

VII. Lessons in Program Evaluation: NMPC Default RTP Program

VIII. Design Example 1: Seasonal TOU Rate

IX. Design Example 2: Interruptible Rate

I. Why Dynamic Pricing?

What is dynamic pricing?

- In broad terms, dynamic pricing refers to rates that better reflect electricity costs which vary over time
  - Electricity cannot be stored economically
  - Supply must equal demand at all times to maintain reliability and stability of the power system
  - Dynamic prices reflect cost changes that can vary dramatically in real time, by hour of the day or over seasons of the year
- Dynamic pricing vs. demand response
  - Sometimes terms are used interchangeably (anything that will encourage overall efficiency by providing better price information)
  - Demand response can mean products that are:
    - Aimed at specific load-shape goals (i.e., peak shifting or peak reduction)
    - Controlled by the system operator not the customer

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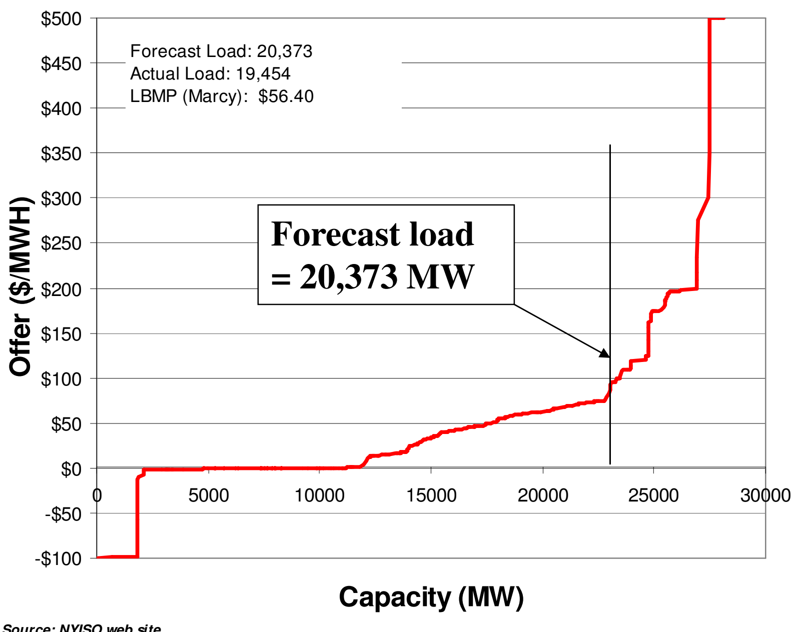
Why do we care about dynamic pricing?

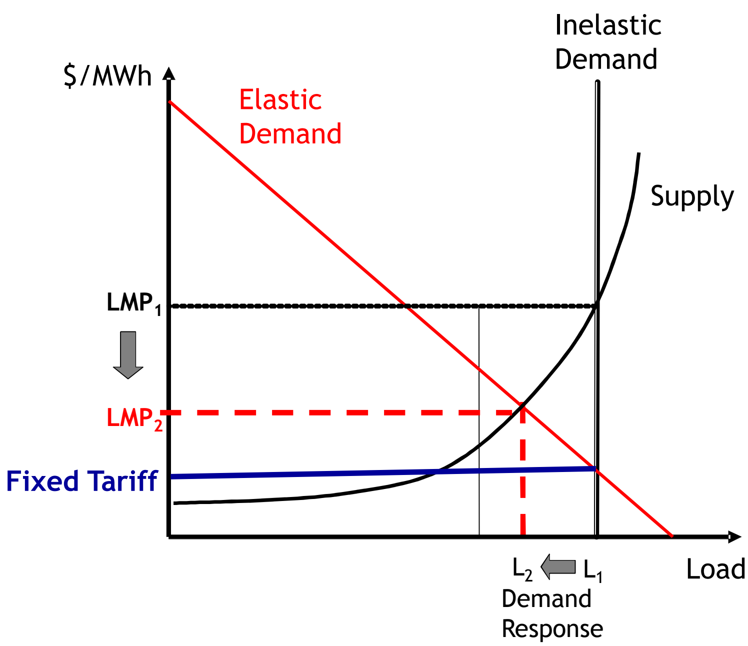
- Why do we care?
  - Electricity consumption is inefficient if we consume more or less than we would if we paid what it actually costs
  - Potential for cost savings is enormous
  - Improvements in metering and telecommunications (AMI) have greatly reduced implementation costs

When supplies are tight, both the supply and demand curve can be vertical, leading to price spikes when supplies are short



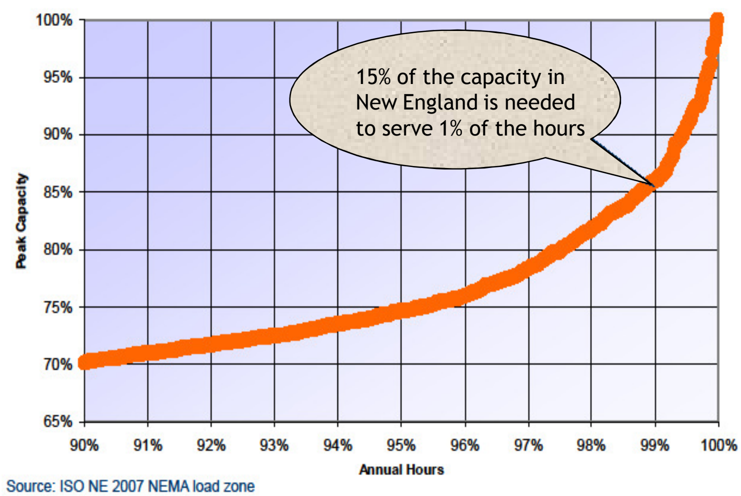
Data are price bids in the NY ISO Day-Ahead Market for Feb. 7, 2000, Hour 8.

How a Load Reduction Impacts Market Energy Prices (LMP)



Source: Bernie Neenan, "Design and Implementation of Efficient Basic Service Pricing Plans in Massachusetts," Presentation to ISO-NE, Boston, MA, November 15, 2006.

Demand Response – Enormous Potential but Costs are Still Uncertain



If demand could be reduced 15% during only 1% of the hours, the savings would be significant.

Source: Philip Giudice, Massachusetts Department of Energy Resources, "Perspectives on Transmission Needs," Harvard Electricity Policy Group, Oct. 2, 2009.

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Benefits of Dynamic Pricing (1)

- Participant savings relative to regulated service:
  - Avoid paying the hedged service risk premium
  - Savings from demand response behaviors
    - Savings from shifting away from high prices
    - Consumer surplus from expanded load at low prices
- Benefits to all Electricity Consumers
  - Reduced demand can lead to:
    - Lower market energy prices or LMPs (locational marginal prices)
    - Lower capacity costs
  - Lower market prices can also reduce bilateral market prices and lower the cost of default service
- Market Performance Benefits - Improvement in the efficient allocation of societal resources

Benefits of Dynamic Pricing (2)

- Other often-cited benefits
  - Improved reliability
  - Market power mitigation
  - Reduced emissions
  - More choices
  - Portfolio risk reduction
  - Vertical market development (enabling technologies)

II. Pricing Under Regulation vs. Markets

Market vs. Regulated Pricing

- Market Prices
  - Forward-looking, based on marginal cost
  - Don't reflect sunk costs
- Regulated Prices
  - Based on average, historic costs.
  - Only reflect marginal costs to the extent they impact the average

$$\text{Regulated Price (¢/kWh)} = \frac{\text{Fixed Costs} + \text{Fuel Costs} + \text{O\&M Costs}}{\text{Energy Sales (kWh)}}$$

Fixed Costs = Depreciation of original investment & maintenance capital, fixed price contracts, financing costs, etc.

Regulated vs. Market Prices – Mid 1990s

What happens to prices when there is:	Regulated monopoly	Competitive markets
Excess generating capacity	↑	↓
Declining natural gas costs	↓ Depends on capacity mix & fuel contracts	↓
New capacity **cheaper** than old capacity	↓ or ↔	↓

On the eve of deregulation, average embedded generation costs were 6 ¢/kWh in upstate New York. Average market prices were 2 – 3 ¢/kWh.

Regulated vs. Market Prices – 2008

What happens to prices when there is:	Regulated monopoly	Competitive markets
A shortage of generating capacity	↓	↑
Increasing natural gas costs	↑ Depends on capacity & contract mix	↑
New capacity more expensive than old capacity	↑ or ↔	↑

When natural gas prices are $10-15/MMBtu, electricity prices can be in the range of 10-15¢/kWh due to fuel costs alone.

Implications for Dynamic Pricing Design

- Market prices are based on *marginal* (forward looking) costs
- Regulated rates are based on *average* (historic) costs
- Marginal costs and average costs move in opposite directions and are almost never equal
- The fact that Ohio has regulated service ***and*** customer choice will need to be considered in the design of both basic service and product overlays.

III. Design Principles for Regulated Service Pricing

Design Principles and Issues

Design Principle	What it means	Issues and hard spots
1. Revenues in aggregate should recover total costs	• Regulated industry should be financially self-sufficient (no outside subsidies) • Cost standard is embedded (depreciated) cost	• Defining prudence • Allowed rate of return on equity • Rate shock (nuclear phase-ins; expiration of price freezes)
2. Costs should be allocated fairly	• Total revenue collected from each class should reflect the cost of serving that class • Similarly situated customers should be charged the same	• Typically based on embedded costs • Subsidies to residential (voters) and industrial (jobs) classes are common
3. Prices should encourage efficient consumption	• Rate ***structure*** should encourage efficient energy use • Marginal costs should be used to design rate components	• Rates designed on average costs are more common than marginal • Time-differentiation is rare; dynamic pricing even rarer

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Design Principles and Issues

Design Principle	What it means	Issues and hard spots
4. Prices should be equitable or fair	• To some, prices that reflect costs are fair • To others, it can mean protection for low income customers, the elderly, farms, churches, VFW, etc.)	• Equity is in the eye of the beholder
5. Price/revenue stability	• Avoiding undue bill impacts for customers and providing stable revenue to utilities	• Gradualism in rate changes can severely hamper progress towards efficient pricing if costs are changing rapidly
6. Other goals & special interests	• Competition & choice • Energy efficiency • Environmental quality	• These goals would be better served with higher prices for regulated service

The more special considerations that must be addressed, the fewer degrees of freedom you have in designing efficient rates

Other Design Choices and Decisions

- What types of product are we designing?
  - Rates for basic commodity service?
    - Default or POLR service
    - Full requirements (traditional service)
  - Overlay/Optional products?
- What rate classes?
  - Residential/commercial/industrial?
  - All sizes?
  - Only > 1MW?
- What resource goals (if any) are we trying to achieve?
  - Reduce the peak demand by X%
  - Defer the need for certain types of capacity for a certain period?
  - Improve environmental performance, i.e., reduce carbon emissions?

Product Choices – Basic Service or Product Overlay?

Basic Service

- Pros: Offers greatest potential for efficiency gains
- Cons: Will be more difficult due to conflicting regulatory goals

Product Overlays

- Pros: Can design the overlay without having to re-design the underlying rate for basic service
- Cons: Will have more limited potential for improving overall energy efficiency

IV. Wholesale Products

A. Capacity
B. Energy
C. Ancillary Services

Definition sources: North American Reliability Council, "Data Collection for Demand-Side Management for Quantifying its Influence on Reliability, Results and Recommendations, NERC, Princeton, NJ, December 2007; NERC Glossary of Terms Used in Reliability Standards, Adopted by NERC Board of Trustees Feb. 12, 2008; Task Force on Electric System Reliability, Secretary of Energy Advisory Board, U.S. Department of Energy, "Maintaining Reliability in a Competitive U.S. Electricity Industry," Washington, DC, September 29, 1998; Edison Electric Institute, "Glossary of Electric Utility Terms," Washington, DC, 1995.

Capacity

Supply Options

- The ability to generate electricity, measured in megawatts (MW)

Demand Resources

- Load reductions displace or augment generation for planning and/or operating resource adequacy
- Load commits to pre-specified load reductions when system contingencies arise
- Penalties are assessed for nonperformance

Energy

Supply Options

- The generation or use of electric power over a period, expressed in kilowatt hours (kWh)

Demand Resources

- Energy-Price
  - Demand-side resource bids to curtail load for scheduling or dispatch and displaces generation resources
  - Penalties are assessed for nonperformance
- Energy-Voluntary
  - Demand-side resource curtails voluntarily when offered the opportunity to do so for compensation
  - Nonperformance is not penalized

Ancillary Services

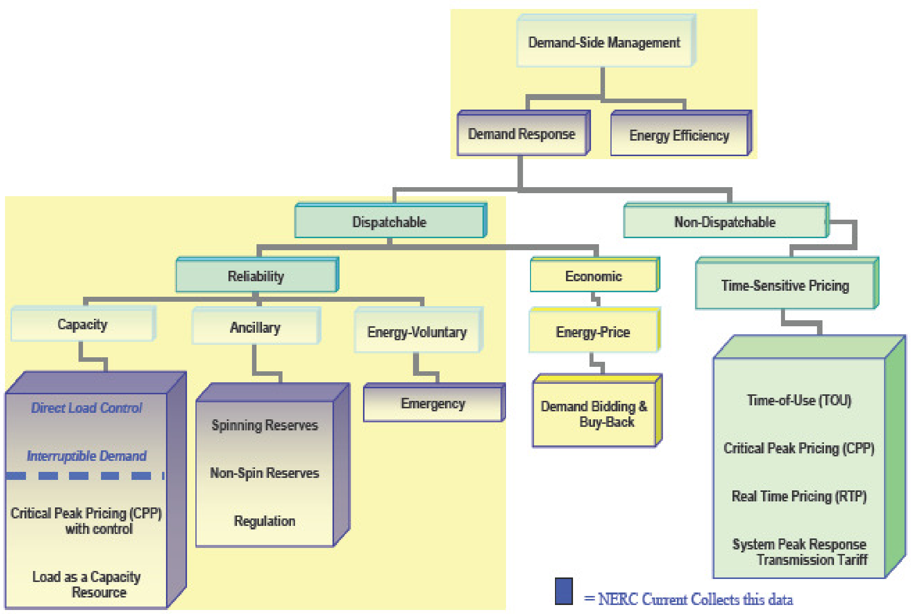
Supply Options

- Services necessary to support the transmission of electric energy from resources to loads while maintaining the reliable operation of the transmission system
  - ***Operating reserves, spinning & supplemental*** – generation synchronized to the system and fully available to serve load within the disturbance recovery period
  - ***Regulation*** – generation that is subject to automatic generation control to follow minute-to-minute fluctuations in load

Demand Resources

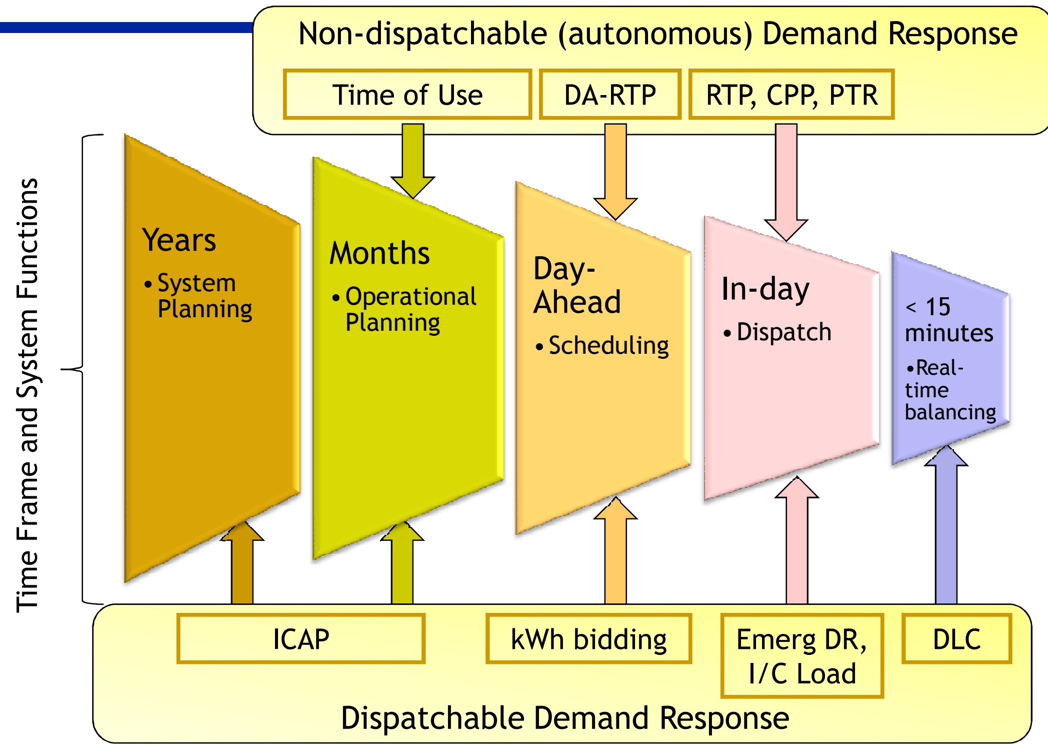
- Demand-side resource displaces generation deployed as operating reserves and/or regulation
- Penalties are assessed for nonperformance

Demand Response Programs Viewed from the Wholesale Perspective – Load as a Resource



Source: North American Electric Reliability Corporation (NERC). December 2007. Data Collection for Demand-Side Management for Quantifying its Influence on Reliability, Results and Recommendations. Princeton, NJ. NERC_DSMTF_Report_040308.pdf.

Integrating Demand Response into Wholesale Markets



Source: USDOE, The Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them, Feb. 2006.

V. Retail Product Features and Rate Structures

A. Basic Service

i. Type of service
ii. Quantity options & risks
iii. Rate structures
iv. Time differentiation

B. Product Overlays

Product Features – Type of Service

- Firm
- Interruptible
  - for reliability
  - for economics

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Product Features – Quantity Options & Risks

- **Unlimited** – Customer has right to unspecified and unlimited quantities (traditional utility service).
- **Nominated** – Customer nominates a particular quantity of consumption (more common in markets).
- **Ability to resell** (restricted or allowed)
- **Compliance**
  - Utility controlled (ex: direct load control)
  - Customer controlled (ex: customer can decide whether to curtail or buy through certain interruptible events)

Product Features – Types of Structures

- Billing determinants
  - Energy
  - Demand
  - Customer or access charges
- Types of structures
  - Flat
  - Tiered (declining or inclining block)
  - Two-part

Product Features – Time Differentiation

- Annual
- Quarterly (ex: fuel cost adjustments)
- Seasonal /monthly
- Daily (ex: day-ahead)
- Hourly (ex: hour-ahead)
- Real time

Typical Rate Structures for Basic Firm Service

Structure*	Annual	Seasonal	Time of Day	Hourly
All energy	✓	✓	✓	✓
Demand/energy	✓	✓	✓	
Time of use	✓	✓	✓	
Two-part RTP			✓	✓
Inclining block	✓			

*Most rate structures also include a customer or access charge, not shown here.

V. Retail Product Features and Rate Structures

A. Basic Service

i. Type of service

ii. Quantity options & risks

iii. Rate structures

iv. Time differentiation

B. Product Overlays

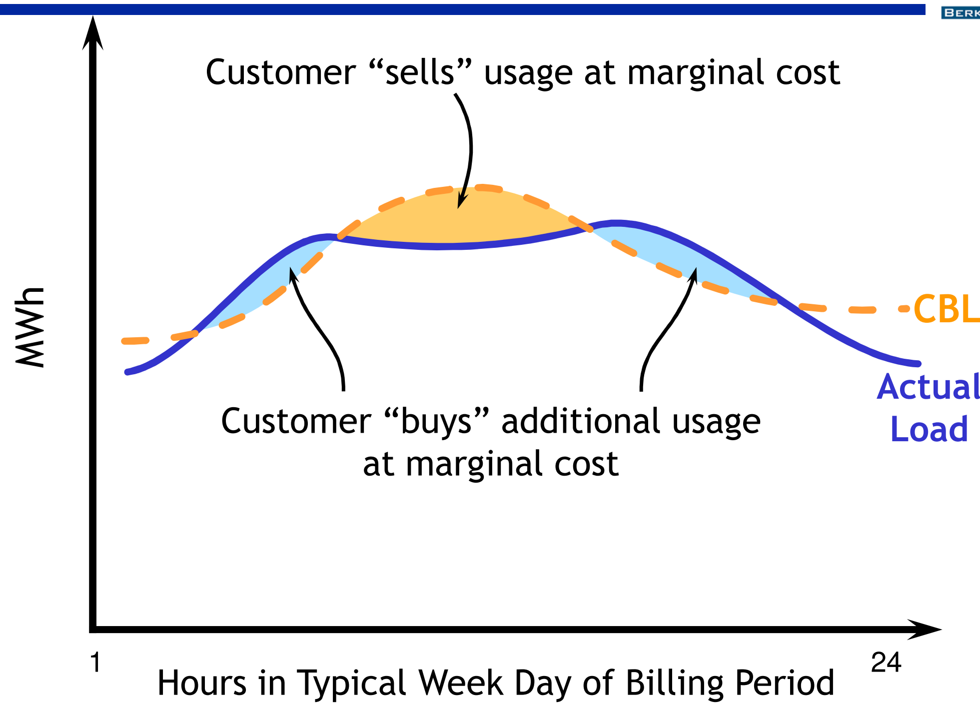
Product Overlays

- These are products that can overlay an underlying rate for basic service. Overlays include:
  - 2-part Real Time Pricing (2-Part RTP)
  - Interruptible/curtailable
  - Direct load control
  - Critical peak pricing
  - Peak time rebate

Two-Part Pricing Overlay

- Part 1:
  - Retains the price hedge embedded in the customer's basic service rate
  - Requires setting a customer baseline load (CBL), usually defined the historical hourly load profile
- Part 2:
  - Changes in usage from the CBL would be priced at utility's marginal cost (or market price)

2-Part RTP Overlay



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2-Part RTP – Design Issues

- How to set the energy rate
  - Day-ahead hourly forecast
  - Real time energy prices
  - Seasonal/time of use
- How to reflect short-term “capacity” costs in the energy rate (scarcity pricing as in PJM’s proposed operating reserve demand curve)
- How to set the customer baseline load
- How to design price protection products for customers who later want more or less exposure to the market

Interruptible/Curtailable Rates (1)

- These plans offer usually offer upfront incentive payments or rate discounts to customers if they agree to reduce their load to a pre-defined level (or by a pre-defined amount) under specific conditions
- Participants who do not meet their obligations can face penalties

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I/C Rates – Design Issues (2)

- Measuring sources of value
  - Reliability (Capacity)
  - Economics (Energy)
- Product dimensions that affect value
  - Interruptions
    - Notice
    - Duration
    - Frequency
  - Length of contract (1 yr vs. 3)
- Measuring load reduction/assuring compliance
  - Real-time response at an instant in time
  - Assuring the load is down to firm level
  - Load level relative to a baseline

I/C Rates – Design Issues (3)

- Credits paid to participants
  - Participation credit
  - Event credit
  - Penalties for non-compliance
- Product interactions – can customers participate in more than one overlay product?
  - More than one type of interruptible program?
  - Other optional rates (i.e., interruptible rate plus 2-Part RTP?)

Direct Load Control (DLC)

- Utility has the ability to remotely shut down a participating customer's equipment (air conditioners, water heaters, etc.) on short notice
- Customer receives upfront payment or a rate discount
- Sources of value – same as I/C
- Product dimensions that affect value – same as I/C
- Measuring load reduction/assuring compliance
  - Compliance is usually deemed
  - Ability to override can reduce load reductions

Critical Peak Pricing (CPP)

- Base rate can be uniform, TOU or Day-ahead RTP rate
- Participating customer receives a rate discount or credit in exchange for being exposed to much higher prices during a pre-determined number of critical peak events per year
- Event conditions are pre-specified, such as:
  - Capacity shortfalls that jeopardize system or local reliability
  - High wholesale or equivalent energy prices
  - Event notice – typically a few hours ahead, but can be as short as 30 minutes or as long as day-ahead

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Critical Peak Pricing (2)

- Event credit can be set in advance to be a fixed amount or one of several levels
- CPP overlay + base rate are designed to be revenue neutral
  - Customers who respond save
  - Customers who do not respond are pay the same bill
- Don’t need a CBL to determine compliance – but measuring program performance is still an issue

Peak Time Rebate (PTR)

- **Most features the same as for CPP, except:**
  - Participant is paid an event credit for energy reductions
  - Base rate + PTR rebate is not designed to be revenue-neutral
  - Requires a customer baseline load to determine compliance (i.e., the amount of credit customer gets paid)

CPP/PTR Design Issues

- Measuring sources of value
  - Reliability (Capacity)
  - Economics (Energy)
- Product dimensions that affect value
  - Interruptions
    - Notice
    - Duration
    - Frequency
  - Length of contract (1 yr vs. 3)
- Measuring/estimating load reduction
  - Real-time response at an instant in time?
  - Load level relative to a baseline?

VI. Experience to Date with Dynamic Pricing

A. Price Response to Basic Rates
B. Time of Use Rates
C. Interruptible/Curtailable Rates
D. Price Elasticities for Time Varying Rates

A. Price Response to Basic (Average) Rates

Table shows the own price elasticity of demand for electricity (the change in demand associated with a 1% increase in the price of electricity) based on the results of nine studies, some dated

Own-price elasticities* of electricity demand

	Short Run			Long Run		
	Mean	Low	High	Mean	Low	High
Residential	-0.3	-0.2	-0.6	-0.9	-0.7	-1.4
Commercial	-0.3	-0.2	-0.7	-1.1	-0.8	-1.3
Industrial	-0.2	-0.1	-0.3	-1.2	-0.3	-1.4

*Percent change in demand associated with a 1% increase in the price of electricity. Residential estimates are from nine studies. Source: Neenan, B., Eom, J. January 2008. "Price Elasticity of Demand for Electricity: A Primer and Synthesis." Electric Power Research Institute, Palo Alto, CA: 2007, 1016264. Available at: www.epri.com

A. Price Response to Basic Rates (2)

- Impact of Time:
  - In the short-run demand is very inelastic, but still not zero!
  - In the long-run, demand is more elastic (reflecting the ability to change over stock of energy consuming durable goods)
- Impact of Income
  - As incomes rise, so does electricity consumption
  - True of industrial as well as residential customers
- Impact of Energy Intensity
  - Energy intensive industries (paper & allied products, chemicals, primary metals, etc.) are more than twice as responsive to price over the long-term as non-intensive industries (tobacco, apparel, leather, miscellaneous manufacturing, etc.)

B. Experience with TOU Rates

- There are numerous surveys of utility TOU Programs* especially following PURPA standards in the Energy Policy Act of 2005
- An overwhelming majority of utilities offer TOU rates, most of which are voluntary. Fewer than 1% of customers have subscribed to these voluntary rates

*A summary of various surveys can be found in: Tennessee Valley Authority, "Adoption & Implementation of PURPA Standards in the Energy Policy Act of 2005 Regarding Time-Based Metering and Communications (Smart Metering and Time-Based Rates), Staff Recommendations, Draft for Review," March 1, 2007. Available at www.tva.gov.

B. Experience with TOU Rates (2)

- Some utilities implemented mandatory TOU programs for customers above a certain size, following PURPA legislation in 1978.
  - In New York, the following customers were placed on a TOU rate:
    - In the late 80s, all customers > 1MW
    - In the early 90's, residential customers > 30,000 kWh
  - Salt River Project also put its largest customers on mandatory TOU rates
- "Utilities that have implemented mandatory TOU rates have realized realized significant system benefits." (See list of studies cited in TVA 2007)

B. Experience with TOU Rates (3)

- Challenges with mandatory changes in rate structure
  - If the new rate is substantially different than the old, it can result in large windfall gains and losses
  - Strong customer can be a problem (duh)
- Challenges with voluntary rate structures
  - If designed to be revenue-neutral to the base rate, a voluntary rate offering:
    - Creates the potential for windfall gains and losses to customers and revenue losses to the utility
    - Winners jump on, losers stay off, utility loses money
  - To mitigate the potential revenue erosion problem, a utility might:
    - Design a rate that minimizes that potential (very long on-peak periods, low peak/off peak price differentials, etc.)
    - Minimize marketing and promotion of optional rate
  - When this happens, the results are discouraging

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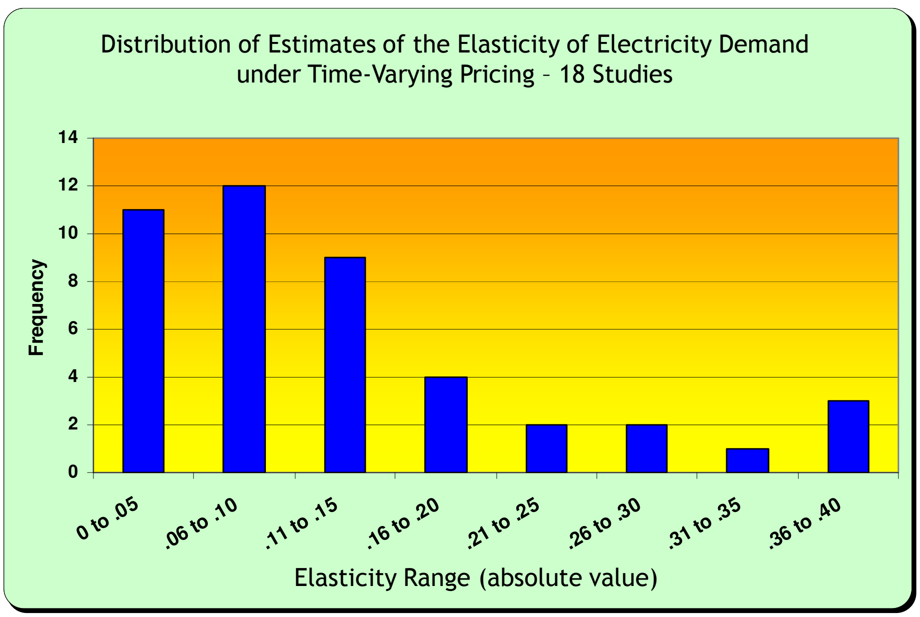
B. Experience with TOU Rates (4)

- Two design lessons from the TOU experience:
  - **<u>Price differential matters</u>**: Response is greatest when the difference between the peak and off-peak prices is largest
  - **<u>Fatigue matters</u>**: The longer the on-peak period is, the lower the response to price differentials. (*However, since the longer the on-peak period, the lower the peak to off-peak differential will be, the two effects are likely to be related.)*

C. Experience with Traditional Interruptible/Curtailable (I/C) Rates

- Traditional utility I/C rates were designed to achieve two objectives:
  - Promote economic development
  - Provide interruptible load for use in system emergencies
- Existing tariffs are not transparent as to:
  - Underlying basis for design (value of interruptibility vs. economic development discount)
  - Extent to which tariff rights are exercised (conditions under which interruptions are actually called)
- Measurement of available peak load reduction is also highly problematic due to differences in how credits are paid (more on this in the design example)

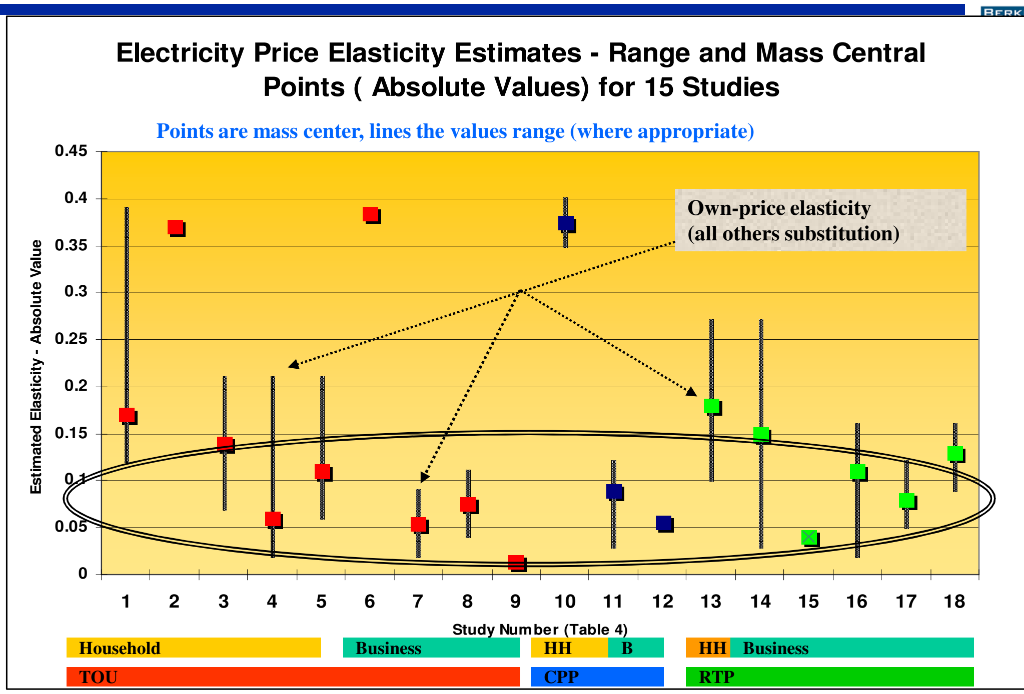
D. Price Elasticities for Time-Varying Rates



Results vary by sector, income, price differential, rate design, general economic conditions and other factors.

Source: Neenan, B., Eom, J. January 2008, p. 23.

D. Price Elasticity Estimates for Time-Varying Rates (by sector and type of rate)



Source: Neenan, B., Eom, J. January 2008, p. 27.

VII. Example Program Evaluation: NMPC RTP Default Service RTP*

Source: Based on work funded by the California Energy Commission through LBNL.

Key Policy Questions

- Are customers satisfied with RTP as default service tariff?
  - Did they switch and are they hedged?
- What are the key barriers to customers being price responsive?
  - What is the role and impact of enabling technologies?
- Do real time prices deliver demand response?
  - What was the magnitude of price response at the customer level?
  - Does price response change at different price levels?
- How do RTP and NYISO DR programs interact?

NMPC RTP Tariff: Market Situation

- RTP is the default tariff for the "SC-3A" Class (Customers > 1MW) since late 1998
- Unbundled charges for transmission and distribution costs
- Customer choices for electric commodity service:
  - NMPC Option 1 (Default): RTP indexed to NYISO Day-Ahead Market price
  - NMPC Option 2: fixed rate contract – one-time availability at program inception (now expired)
  - Competitive retail supplier (ESCO)
- NYISO also offers several DR programs
  - Emergency Demand Response Program (EDRP)
    - pay-for performance
  - Installed Capacity/Special Case Resources (ICAP/SCR):
    - up-front reservation payment
  - Day-Ahead Demand Response Program

SC-3A Customers: Market Segments

Business Class	All SC-3A Customers: # of Accounts	All SC-3A Customers: Peak Demand (MW)	Customers Facing Hourly Prices: # of Accounts	Customers Facing Hourly Prices: Peak Demand (MW)	Survey Respondents: # of Accounts
Commercial / Retail	17	55	17	49	11%
Gov't / Education	44	206	34	166	30%
Health Care	17	78	8	38	13%
Manufacturing	46	233	44	221	33%
Public Works	22	70	16	40	13%
Totals	146	642	119	514	76

- NMPC billing system and customer surveys used to determine whether customers exposed to hourly varying prices
- 119 (of 146) customers saw SC-3A or comparable hourly-varying prices at some point during the study period (Summers 2000 – 2004)

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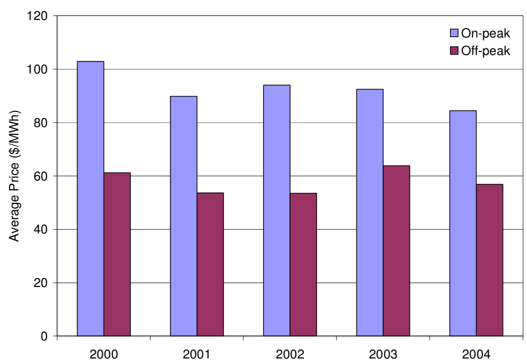
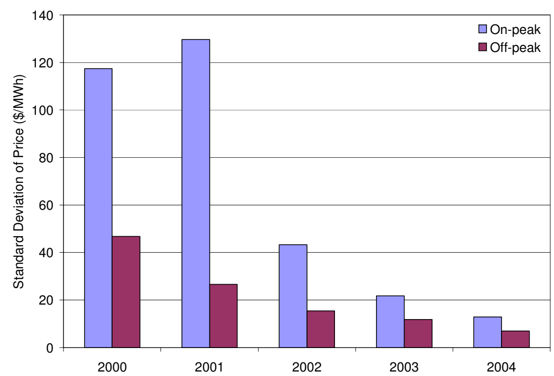
Trends in Day-Ahead Market Prices:
Summer, Eastern New York

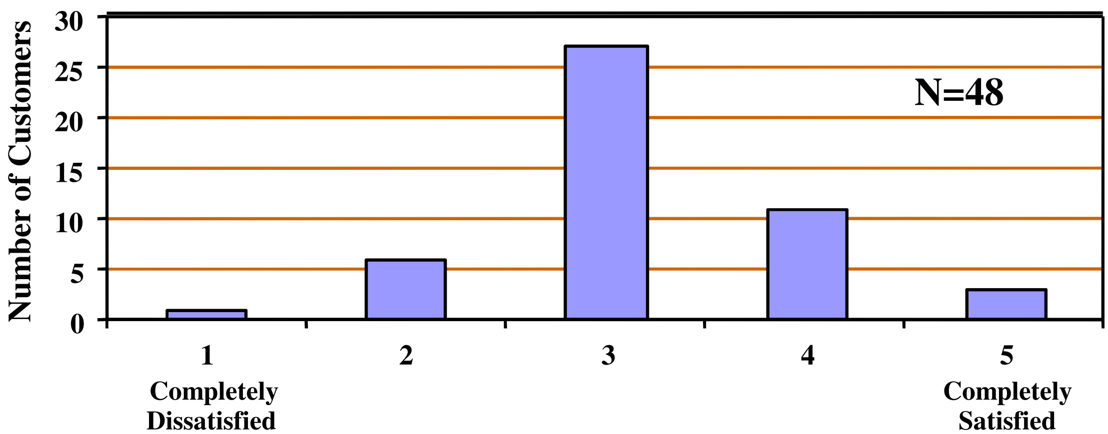




- Less price volatility since 2002 compared to summers of 2000 and 2001
- Average hourly prices for summer period are relatively stable over 5 years

*On-Peak defined as 2pm-5pm on weekdays

How Satisfied Were Customers with the NMPC RTP Tariff?



- Customers are relatively satisfied
- Interviews reveal greater disappointment with limited offerings by competitive retailers

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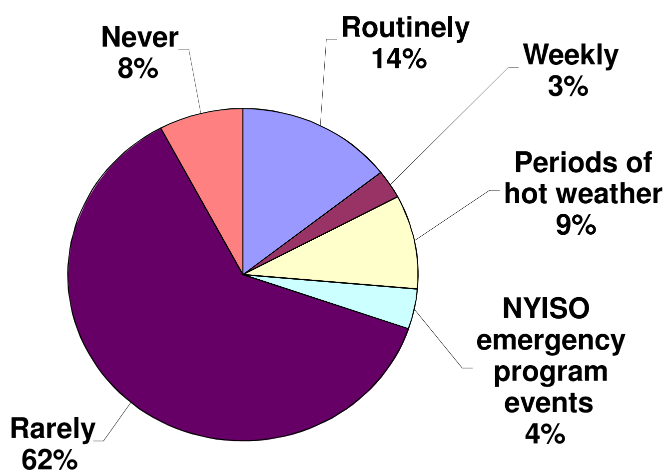
How Often Do Customer's Monitor the Next Day's Hourly Prices?



N = 76

- ~30% of customers monitor day-ahead hourly prices routinely or during hot weather/system emergencies
- ~70% rarely or never monitor prices

What Barriers to Responding to High Hourly Electricity Prices Were Identified?

Survey Results

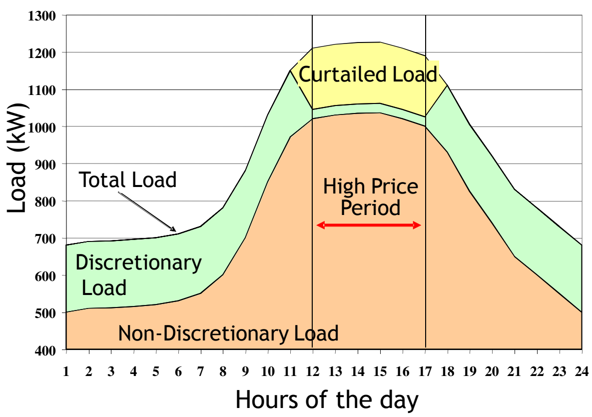
(N=76)	Frequency
No Barriers Encountered	9
Barriers	
Organization/Business Practices	
• Insufficient time or resources to pay attention to hourly prices	39
• Institutional barriers in my organization make responding difficult	23
• Inflexible labor schedule	16
Inadequate Incentives	
• Managing electricity use is not a priority	17
• The cost/inconvenience of responding outweighs the savings	17
Risk Averse/Hedged	
• My organization's management views these efforts as too risky	10
• Flat-rate or time-of-use contract makes responding unimportant	9

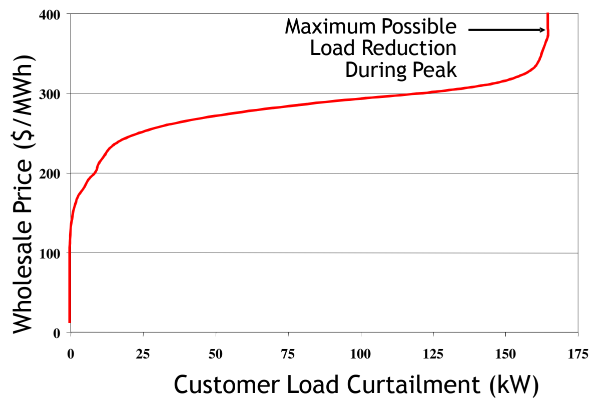
How Did Customers Use Enabling Technologies?

	EMCS or Peak Load Mgmt Devices (N = 37)	Energy Information Systems (EIS) (N = 31)	Onsite generation (N = 42)
To respond to high hourly prices	6	7	3
To reduce overall electricity bills	24	14	2
To reduce peak-demand charges	15	12	1
Facility/process control automation	28	11	-
Monitoring and analysis*	-	9	-
Emergency backup/reliability	-	-	40
Cogeneration	-	-	2

Only 15-20% of customers use DR enabling technologies to respond to high hourly prices. Technologies were used primarily for facility/process automation control and to reduce overall utility bills and peak demand charges.

What were Customer Response Strategies?
Forego vs. Load Shift vs. Onsite Generation

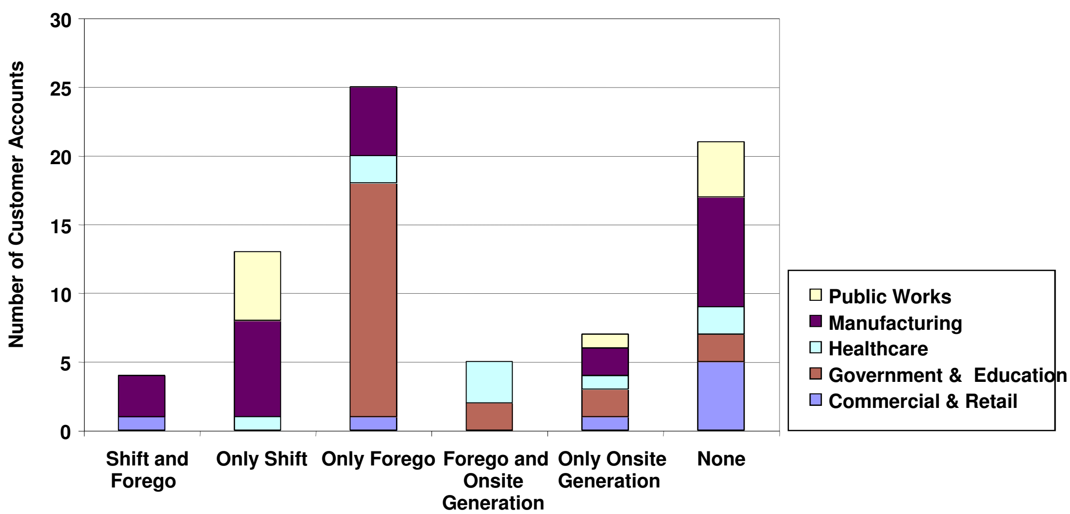




- Customers assess their DR potential: discretionary vs. non-discretionary usage
- Many customers have a minimum price threshold to curtail (or shift) usage
- Customer's maximum load curtailment is often limited to discretionary loads; unwilling to curtail more even if prices rise further.

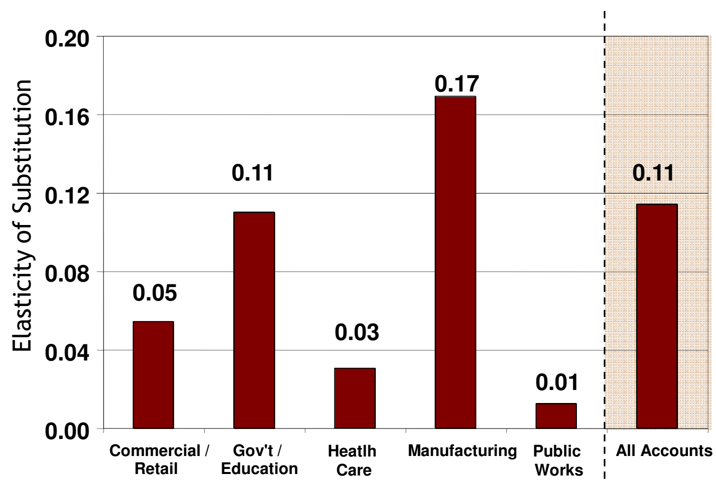
What Did Customers Say Tell Us About Their Price Response Capability?

N = 76



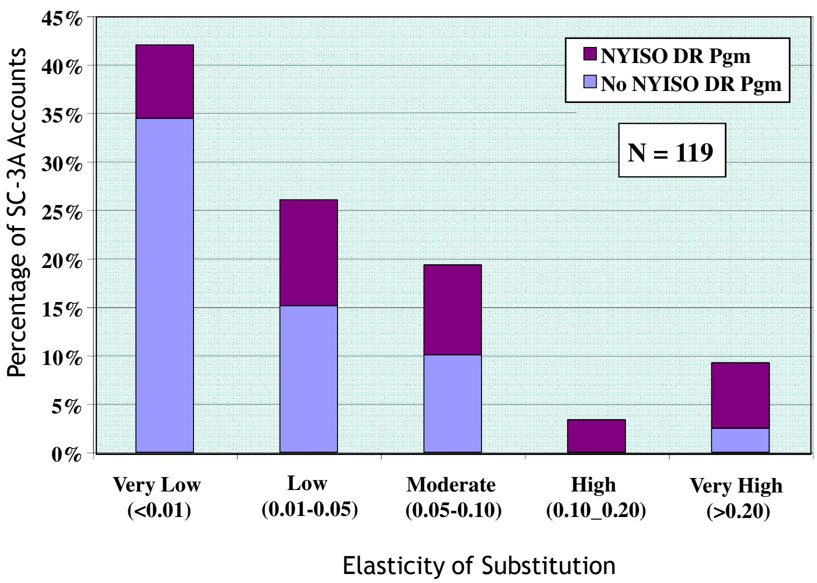
- ~30% of customers say they are unable to curtail load
- ~70% can either forego or shift load or utilize onsite generation
  - Government/education customers forego usage as their curtailment strategy
  - Manufacturing customers can shift or forego load, or both

How Did Price Responsiveness Vary by Market Segment? Significantly.



- Manufacturing customers are most price responsive on average (0.17), followed by government/education customers (0.11)
- On average, other three market segments are much less price responsive

How Did Price Elasticities Vary Across Individual Customers? Widely.



- ~12% of customers are most price-responsive (>0.10)
- ~20% are moderately price-responsive (0.05-0.10)
- 42% of the customers are unresponsive
- NYISO DR Participants tend to be more price responsive than non-participants

What were the key findings?

- NMPC large customers are generally satisfied with day-ahead, hourly pricing as default service RTP
  - ~33% remain on default service RTP
  - Another ~20-25% of customers served by competitive retailers are partially or fully exposed to day-ahead, hourly prices
- Price response is modest overall (0.11)
  - Manufacturing and government/educational customers are most responsive
  - 20% of customers account for 80% of price response
  - Aggregate DR potential is ~50 MW (11% of customer summer peak demand)

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Key Findings: Policy & Program Design Implications

- RTP is best implemented as part of a portfolio of DR option
  - ISO/Utility DR programs can complement RTP
    - Easier to sell because of public duty aspect of ISO-declared events
    - Limited, voluntary exposure is a big plus to many customers
  - Ensure adequate hedging options exist, at least initially
- It will take time to develop price-responsive load
  - Significant number of non-price responsive customers
  - Initial response for most customers is discretionary curtailment (not shifting)
- Targeted education and technical assistance needed to realize customers' inherent price response potential
  - Even more important if RTP is extended to smaller customers

VIII. Pricing Design Example 1: Designing a Seasonal TOU Rate

Overview of Design Process

1. Develop initial rate design using forecasts of marginal energy costs and marginal capacity costs
2. Simulate customer response to initial design
3. Calculate production cost and capacity savings (old rate vs. new)
4. Modify design, repeat analysis, to identify optimal design (greatest savings)

1. Develop Initial Design Using Supply Cost Data

- Define initial seasons and costing periods
  - Want some time (cost) differentiation that doesn't go all the way to hourly pricing
  - Seasons are generally combinations of similar weather months and can include peak seasons, off-peak seasons, and transition seasons
  - Costing periods are generally hourly time periods defined across a week and can include on, off and shoulder periods
- What kind of data & analysis?
  - Forecast marginal energy costs (or spot market prices)
  - Forecast loss of load probability or loss of load hours, by time period
  - Analysis – use regression to see how different seasonal/hourly definitions "fit" the cost data

1. Develop Initial Design . . . (2)

- Identify initial design based on best fit with supply data
- Allocate capacity costs to on-peak hours within seasons based on their share of loss of load energy; set capacity costs (demand or energy charge) equal to:
  - Levelized cost of a peaker or
  - The forecast market price of capacity
- Set seasonal/hourly energy prices based on the average marginal energy costs for each time period
- Using class billing determinants (energy kWh, kW, customer charges) to calculate total revenue
- Compare revenue to than embedded revenue requirements target. Adjust rates:
  - Equi-proportionately (up or down) to maintain cost-based differential between peak and off-peak marginal costs, or
  - To maintain fixed peak to off-peak cost differential

Illustrative TOU Period & Rates

Hour Beginning	Summer	Winter	Transition
12:00 AM	Off-Peak	Off-Peak	Off-Peak
1:00 AM	Off-Peak	Off-Peak	Off-Peak
2:00 AM	Off-Peak	Off-Peak	Off-Peak
3:00 AM	Off-Peak	Off-Peak	Off-Peak
4:00 AM	Off-Peak	Off-Peak	Off-Peak
5:00 AM	Off-Peak	On-Peak	Off-Peak
6:00 AM	Off-Peak	On-Peak	Off-Peak
7:00 AM	Off-Peak	On-Peak	Off-Peak
8:00 AM	Off-Peak	On-Peak	Off-Peak
9:00 AM	Off-Peak	On-Peak	Off-Peak
10:00 AM	Off-Peak	On-Peak	Off-Peak
11:00 AM	Off-Peak	Off-Peak	Off-Peak
12:00 PM	On-Peak	Off-Peak	Off-Peak
1:00 PM	On-Peak	Off-Peak	Off-Peak
2:00 PM	On-Peak	Off-Peak	Off-Peak
3:00 PM	On-Peak	Off-Peak	Off-Peak
4:00 PM	On-Peak	Off-Peak	Off-Peak
5:00 PM	On-Peak	Off-Peak	Off-Peak
6:00 PM	On-Peak	Off-Peak	Off-Peak
7:00 PM	On-Peak	Off-Peak	Off-Peak
8:00 PM	Off-Peak	Off-Peak	Off-Peak
9:00 PM	Off-Peak	Off-Peak	Off-Peak
10:00 PM	Off-Peak	Off-Peak	Off-Peak
11:00 PM	Off-Peak	Off-Peak	Off-Peak

Winter: Dec through Mar

Summer: Jun through Sep

Transition: Four remaining months

On-Peak Summer Season: Monday through Sunday

On-Peak Winter Season: Monday through Friday only

Illustrative Rates (¢/kWh)

Summer	On-Peak	11
	Off-peak	3
Winter	On-Peak	7
	Off-peak	3
Transition	All Off-peak	3

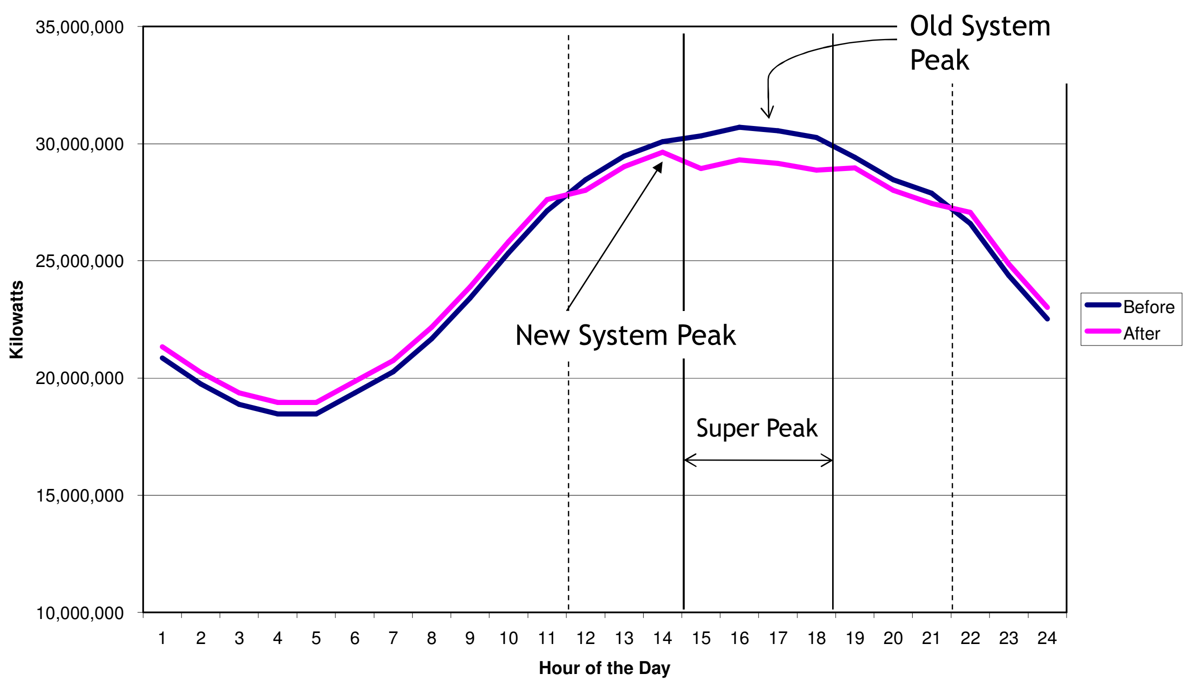
2. Simulate Customer Response to Initial Design

- Modeling inputs:
  - Customer class load shapes
  - Elasticities of substitution which reflect how a percentage change in the ratio of peak to off-peak prices results in a change in the ratio of customers' peak and off-peak usage
  - Assumption is that the main impact is a shift in demand, not a reduction
- Can use industry estimates if utility-specific estimates are not available

Customer Class	**TOU/CPP**				**Day Ahead RTP**			
	Low	**Med**	**High**	**Case**	**Low**	**Med**	**High**	**Case**
Residential	0.04	NA	0.21	**0.10**	NA	NA	NA	NA
Commercial	0.04	NA	0.21	**0.10**	NA	NA	NA	NA
Industrial	NA	NA	NA	NA	0.02	NA	0.27	**0.13**

*Source: U.S. Department of Energy, *Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them*, A Report to the United States Contress Pursuant to Section 1252 of the Energy Policy Act of 2005, February 2006, Appendix C: Intensity of Customer Demand Response, Table C-1. Demand Response Program and Pricing Studies: Estimated Price Elasticity of Demand, p. 88.

Why Simulating Customer Response is Important – peak load can shift



3 & 4. Calculating savings; iterate to identify best design

3. Calculate production cost and capacity savings (old rate vs. new)
4. Modify design, repeat analysis, to identify optimal design (greatest savings)
   - Multiple iterations of analysis are common
   - Can also explore other design modifications, i.e., effect of a super or critical peak period, etc.

IX. Pricing Design Example 2: Designing an Interruptible Rate

Designing an Interruptible Rate

- What's interruptible load worth?
  - Capacity value – levelized cost of a peaking unit, the cheapest form of capacity
  - The market price of capacity?
  - Value of lost load if there's a shortage?
  - Value of energy savings if load is interruptible for economics?
- Appropriate measure will depend in part on the supply situation and in part on the actual program design

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Designing an Interruptible Rate (2)

Product Feature	Greatest Value to the System	Greatest Appeal to Customers
Interruption Features		
▪ Notice	Short	Long
▪ Duration	Long	Short
▪ Frequency	High	Low
Length of Contract	Long	Short

Features that have the greatest value to the wholesale market have the lowest appeal to customers who will be interrupted.

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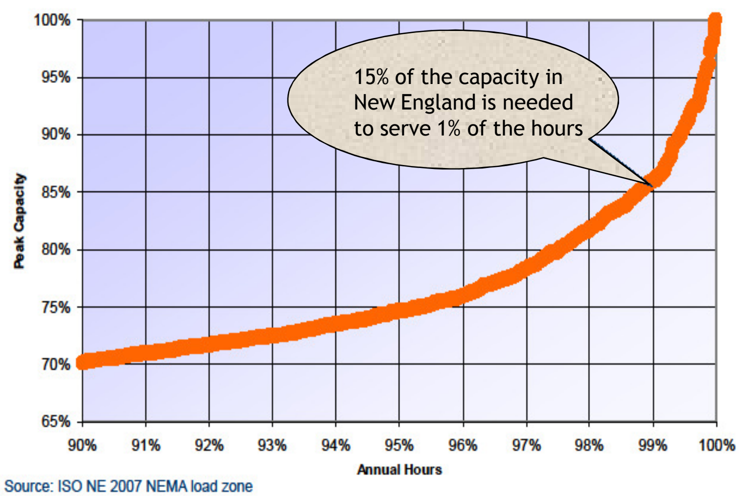
Designing an Interruptible Rate (3)



- What will it cost to be able to reduce peak demand 15% during 1% of the hours of the year?
  - 1% of the hours is 88 hours per year.
  - If each customer could be interrupted for only 44 hours per year, twice as many would have to be recruited.
  - If each customer could be interrupted for only 22 hours per year, four times as many customers would have to be recruited.

Source: Philip Giudice, Massachusetts Department of Energy Resources, “Perspectives on Transmission Needs,” Harvard Electricity Policy Group, Oct. 2, 2009.

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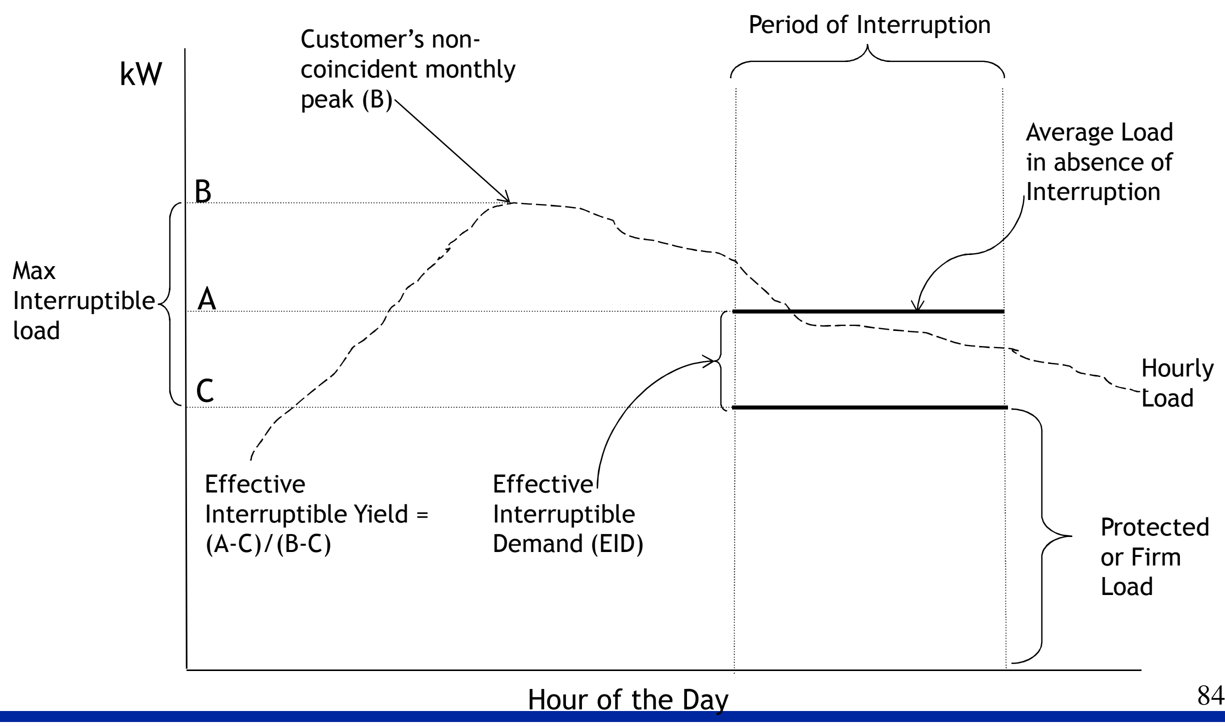
Designing an Interruptible Rate (4)

- Measuring load reduction/assuring compliance
  - Real-time response at an instant in time?
  - Assuring the load is down to firm level?
  - Load level relative to a baseline?
  - A deemed value, such as difference between customer's non-coincident peak and his firm power level (protected load)?
- No method is perfect. The difficult is that you cannot directly observe the "but for" load. What would the customer's load have been, but for the interruption?
- In the example on the next page, a very common measure of load reduction is actually 2X larger than the actual load reduction at the time of peak

Designing an Interruptible Rate (5)

Illustration of Effective Interruptible Yield



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Designing an Interruptible Rate (6)

- Credits paid to participants
  - Participation credit
  - Event credit
  - Penalties for non-compliance
- Product interactions – can customers participate in more than one overlay product?
  - More than one type of interruptible program?
  - Other optional rates (i.e., interruptible rate plus 2-Part RTP?)

Potential Next Steps

- Work with PUCO to further refine potential policy goals
- Assess rate options and products against those goals
- Determine information gaps, if any
- Suggest topics for evaluation through on-going or future pilots

Questions or comments?
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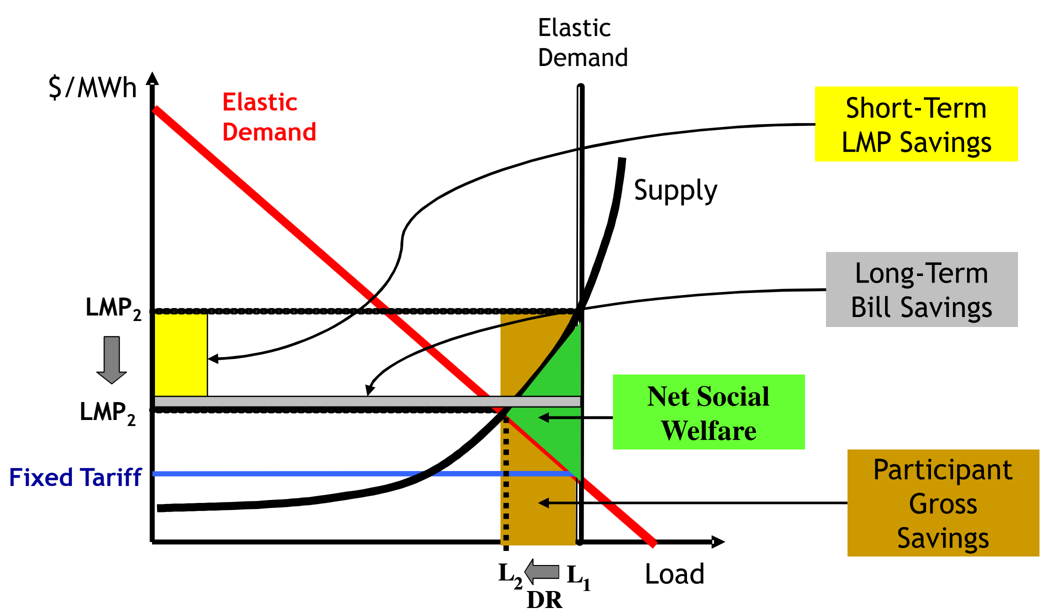
Phone: 865-909-0535

Appendix – Net Social Welfare of Reduction in LMP

Impact of LPM Change on Consumers



Source: Bernie Neenan, "Design and Implementation of Efficient Basic Service Pricing Plans in Massachusetts, Boston, MA, November 15, 2006.

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