Dynamic Pricing in a Smart Grid World

NARUC Webinar

January 26, 2010

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Webinar Objectives

Can you have a Smart Grid without "smart pricing"?
What is "smart pricing"?

1. **Understand the relationship between rates, prices, and smart grid.**
2. **Identify and explore key rate related policy issues.**
3. **Review customer response.**
4. **Identify potential implementation and transition options.**

Presentation Outline

I. Background
II. Rate Design Issues
III. Experience to Date
IV. Where do we go from here?
V. References

I. Background

A. **What is a Smart Grid?**

B. **What rate features would help maximize the benefits of a Smart Grid?**

Definition of a Smart Grid

Smart Grid is a system of information and communication applications integrated with electric generation, transmission, distribution, and end use technologies that:

Promote Customer Choice	1	**enables consumers** to manage their usage and choose the most **economically** efficient offerings
Improve Reliability	2	uses **automation** and alternative resources to maintain delivery system **reliability** and **stability**, and
Integrate Renewables	3	integrates **renewable**, **storage**, and **generation alternatives**.

Are "smart rates" necessary to achieve the benefits of Smart Grid?

- Yes, especially to achieve the potential benefits for consumers:
  - Rate structures provide price signals.
  - Price signals link the utility system and customer.
  - Price establishes the customer value function.
  - Price enables the benefits of smart grid to be achieved.
- Rate design for regulated service is the domain of state regulatory commissions - it is not being addressed by NIST*.

*NIST = National Institute of Standards and Technology

"Smart pricing" – Ideal features from a Smart Grid perspective

- **Provide meaningful customer information**
  - Easy to understand use-cost relationship
  - Signals customers can and are willing to respond to
- **Digital price signals that can be:**
  - Communicated or broadcast electronically
  - Acted upon by customer controls, smart appliances, and energy management systems
- **Prices that integrate efficiency, demand response, distributed generation alternatives, and renewables.**

II. Rate Design Issues

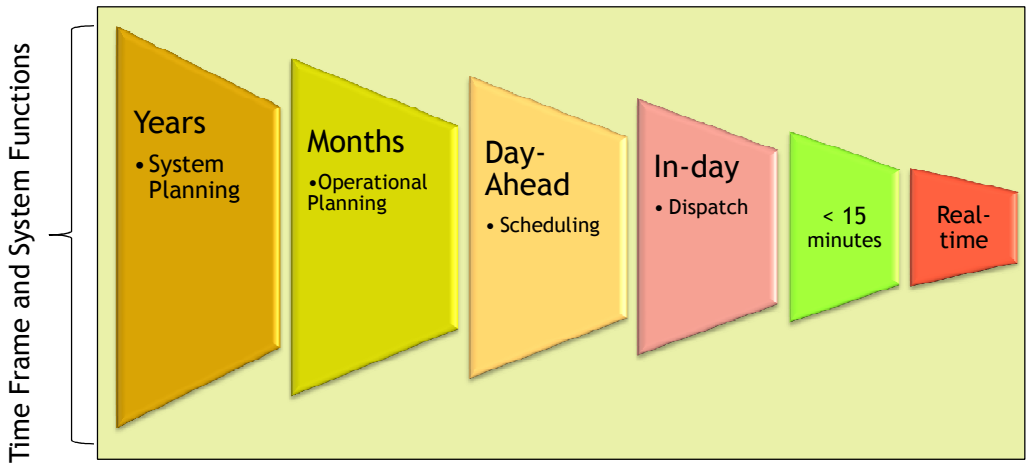
A. Market context

B. Defining Dynamic Pricing

1. Taxonomy of Products
2. Rate Structures for Firm Service
3. Pricing Product Overlays

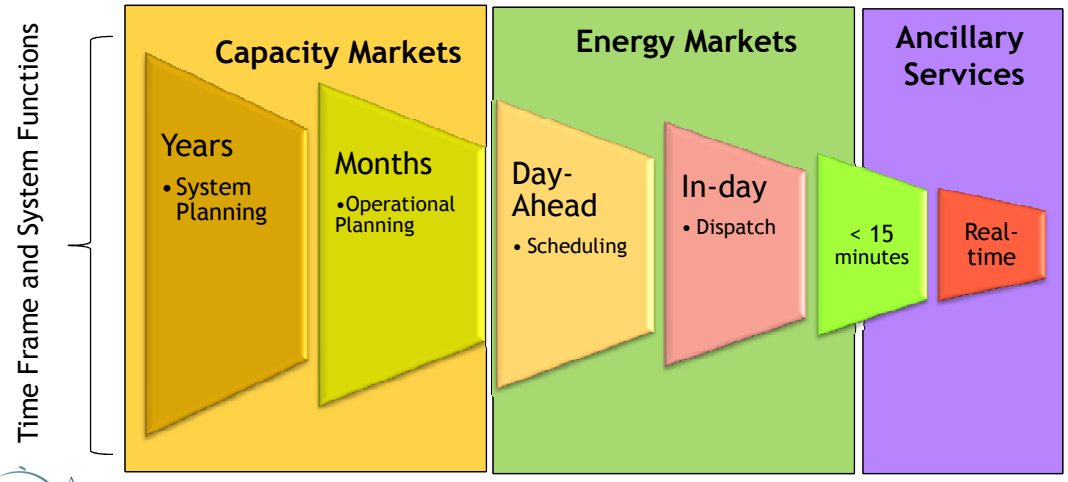
Market Context: Regulated Monopoly

Under the vertically integrated model, engineering, economic planning, system operations are closely linked over time.



Market Context: Competitive Markets

Markets perform the same functions through a series of markets which operate over different time horizons, creating new product opportunities for retail customers and new opportunities for efficiency gains.



II. Rate Design Issues

A. Market context

B. Defining Dynamic Pricing

1. Taxonomy of Products

2. Rate Structures for Firm Service

3. Pricing Product Overlays

Defining Dynamic Pricing – Taxonomy of Products

Traditional Retail View

Customer Choice and Control

- Customer decides when and how much to consume
- Fully hedged service*
  - Flat, uniform price
  - Tiered (inclining or declining) rates
  - Time of use rates

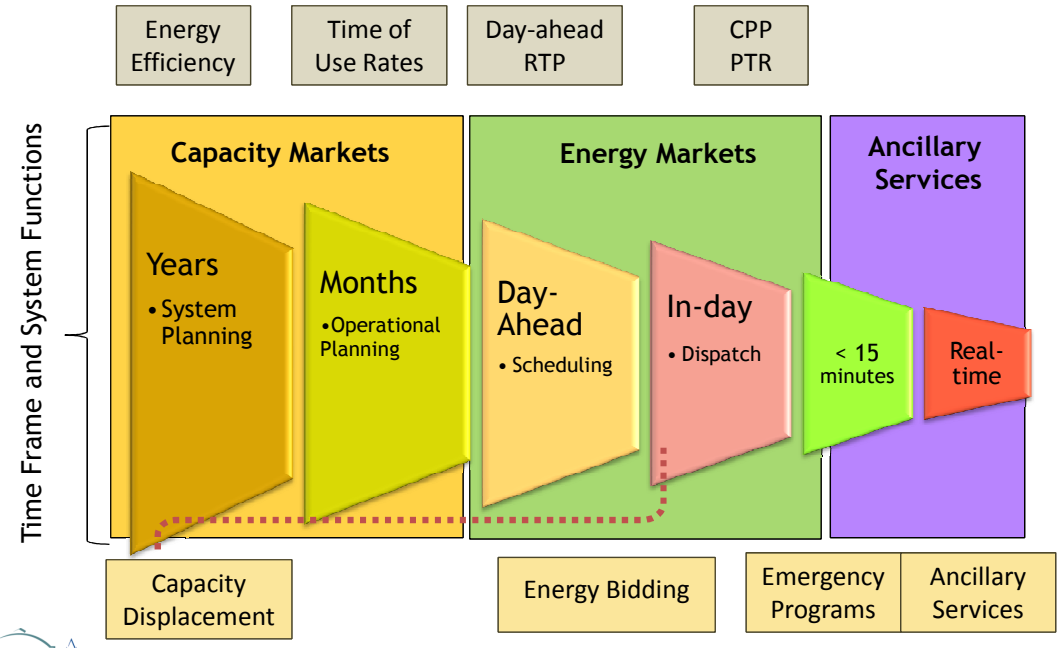
Wholesale View "Load as Resource"

Customers Bid to Supply

- Economic products - customers bid to curtail at a given price
  - Day-ahead energy market
  - Real-time energy market
- Reliability products
  - Capacity
  - Emergency
  - Ancillary services

*Prices are set prospectively, but may be subject to adjustment through mechanisms such as fuel cost adjustment riders.

How Products Align with Market Time Frames



Focus of This Presentation: Traditional Retail View

- **Two types of products:**
  - Regulated rates for basic firm or default service
  - Product overlays – rate options that are designed to overlay the underlying firm service rate
- **Wholesale demand response programs**
  - ISOs are also developing demand response programs whose benefits would be enabled by Smart Grid and AMI infrastructure
  - A detailed discussion of DR program design in wholesale markets is beyond the scope of this presentation

Defining Dynamic Pricing: Six Basic Structures for Firm or Default Service*

- ❑ Flat energy rates
- ❑ Flat demand/energy rates
- ❑ Tiered rates (inclining or declining blocks)
- ❑ Time of use (TOU) rates
- ❑ Variable peak pricing (VPP) rates
- ❑ Real time pricing (RTP) rates

*Most rate structures also include a customer or access charge.

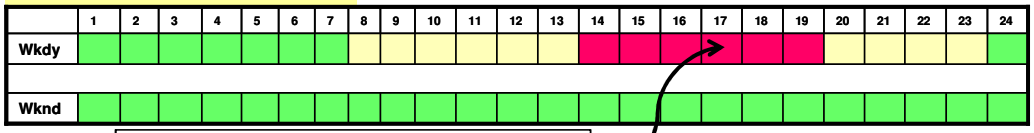
Time-Varying Rate Structures (typical designs)

- **Time of Use**
  - Prices for peak, shoulder and off-peak periods established a year in advance
- **Variable Peak Pricing (VPP)***
  - A hybrid of TOU and RTP
  - The on-peak ***period*** (hours and seasons) is defined in advance
  - Peak period ***prices*** for the next day are established based on the day-ahead forecast of wholesale market prices
- **Real-time Pricing (RTP)**
  - Hourly prices change based on system or market conditions on a day-ahead, hour-ahead or real-time basis

*There is also a product overlay known as variable peak pricing which is a variant of critical peak pricing.

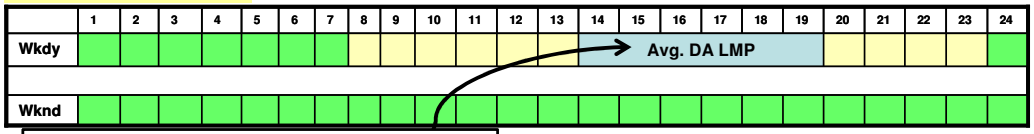
Comparison of TOU and Variable Peak Pricing

Proposed 3-Part TOU

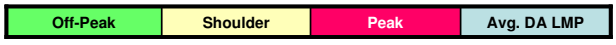


Under traditional TOU, the peak, shoulder and off-peak price would typically be established a year in advance.

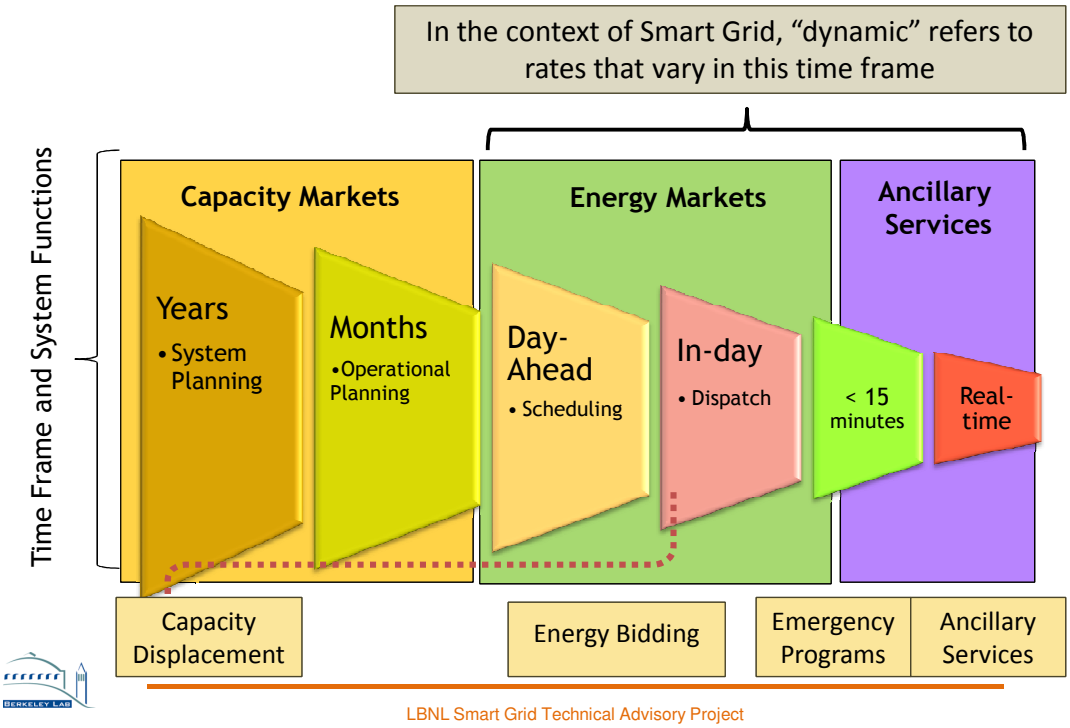
Proposed VPP



Under VPP, the on peak price is set equal to the average day-ahead wholesale market price for the on-peak hours



What is "dynamic" when time is a continuum?



Defining Dynamic Pricing: Product Overlays

- A product overlay can simply be layered on top of the existing firm rate under specified conditions, with no (or minimal) adjustments to the underlying basic firm rate.
- Examples:
  - Interruptible/curtailable (I/C) rates
  - Direct load control (DLC)
  - Critical peak pricing (CPP)
  - Peak time rebate (PTR)
  - 2-part real time pricing (2-Part RTP)

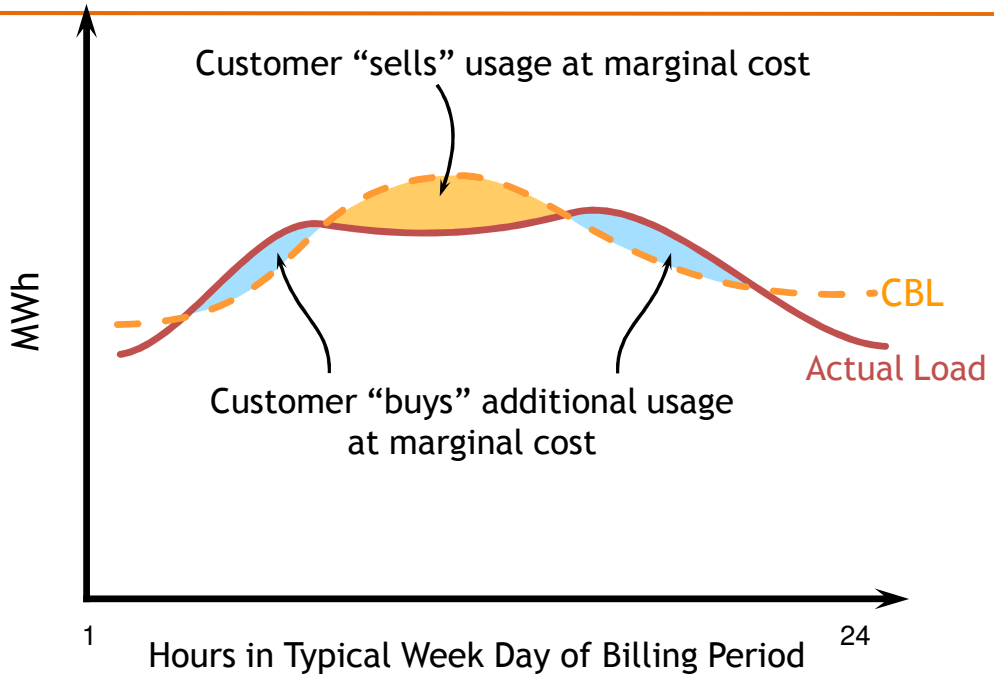
Pricing Product Overlays: CPP & PTR (Typical Designs)

Design Feature	Critical Peak Pricing	Peak Time Rebate
Resource goal	Peak load reductions	Same
Critical Peak Period Definitions	Typically defined in advance	Same
Event Price	Typically defined in advance	Same
Revenue Neutrality (relative to base case)	Firm rate + CPP rate designed to be revenue neutral ▪ Can create windfall gains & losses ▪ May need revenue adjustments if all events are not called in order to recover required revenue	PTR not designed to be revenue neutral (requires initial rate increase to cover rebates) ▪ Can create windfall gains due to how the CBL is defined ▪ Can be called only as needed
Customer-specific baseline load (CBL)	Not required	Required – a major implementation issue

Pricing Product Overlays: Two-Part RTP Overlay

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

Pricing Product Overlays: Two-Part RTP Overlay



III. Experience to Date

A. What do we know?

B. What don't we know?

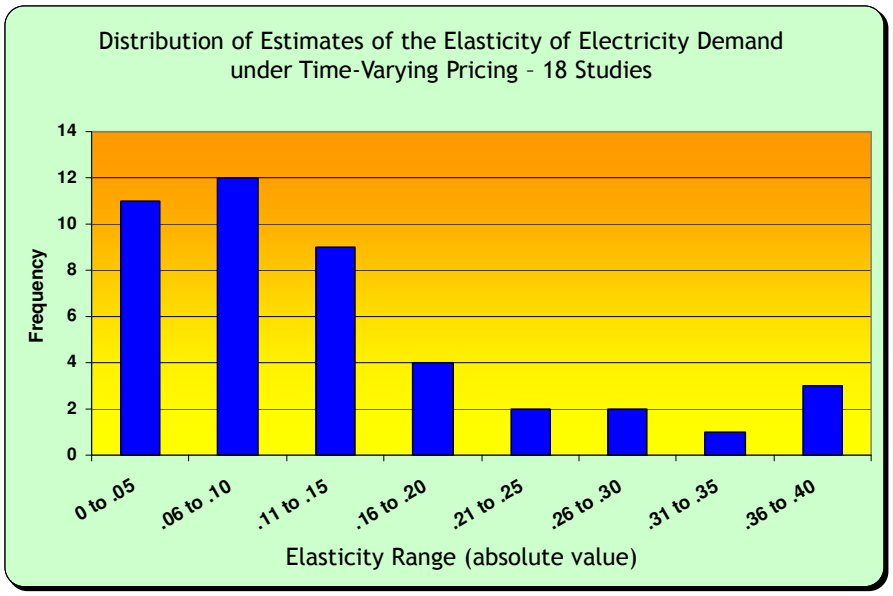
C. What are we still arguing about?

What do we know? Many customers respond to price; some more than others (1)

- **Customers *in aggregate* do respond to prices**
  - Response varies by:
    - Customer class (residential, commercial, industrial)
    - Income/state of the economy
    - Energy intensity (appliance/equipment mix; industrial process)
    - Weather
  - Individually, some customers respond very little; others are much more responsive. Large users provide larger load reductions. Automation increases response and improves customer satisfaction.
- **Size** (of the load response) **matters, but doesn't tell the whole story**
- **Need elasticities to understand and normalize effects**

  Overall, price response is relatively inelastic (A ***10% increase*** in electricity prices for residential customers results in a ***3% reduction*** in consumption, based on past studies)

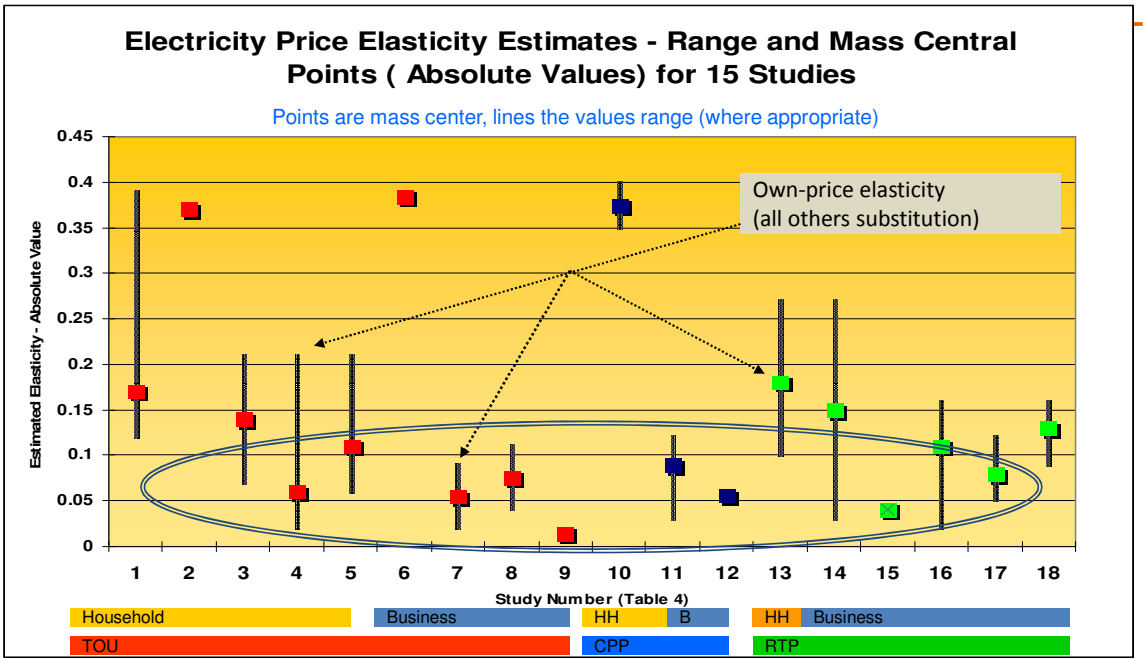
What do we know? Price Elasticities for Time-Varying Rates (2)



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

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

What do we know? Price Elasticity Estimates for Time-Varying Rates (by sector and type of rate) (3)



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

What do we know? Big rate changes create big bill impacts (4)

- Size and distribution of bill impacts depend on:
  - The difference between the existing rate structure and the new rate structure
  - Differences among customer load profiles
    - If all customers have the identical load shape and the new rate is revenue neutral, there would be no bill impacts from a change in rate design
    - Differences will be relatively larger for rate classes that are very heterogeneous (i.e., industrial compared to residential)
- Many people are much more averse to losses than they are happy with gains of equal amounts

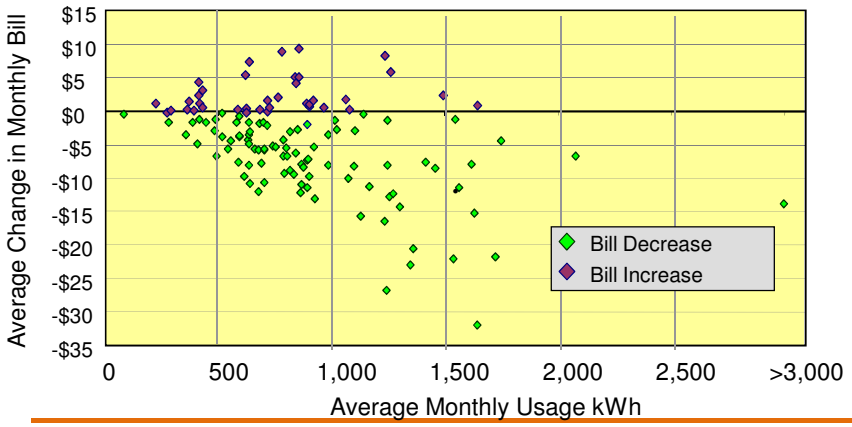
What do we know? Rate changes create bill impacts (5)

(Residential Pilot Example from California Statewide Pricing Pilot)

- Bill impacts vary depending upon customer load shapes, and differences between the base rate and new rate structure.
- Under voluntary subscription (like the pilot illustrated below), we expect to see more winners than losers.

Distribution of Participating Customer Bill Impacts

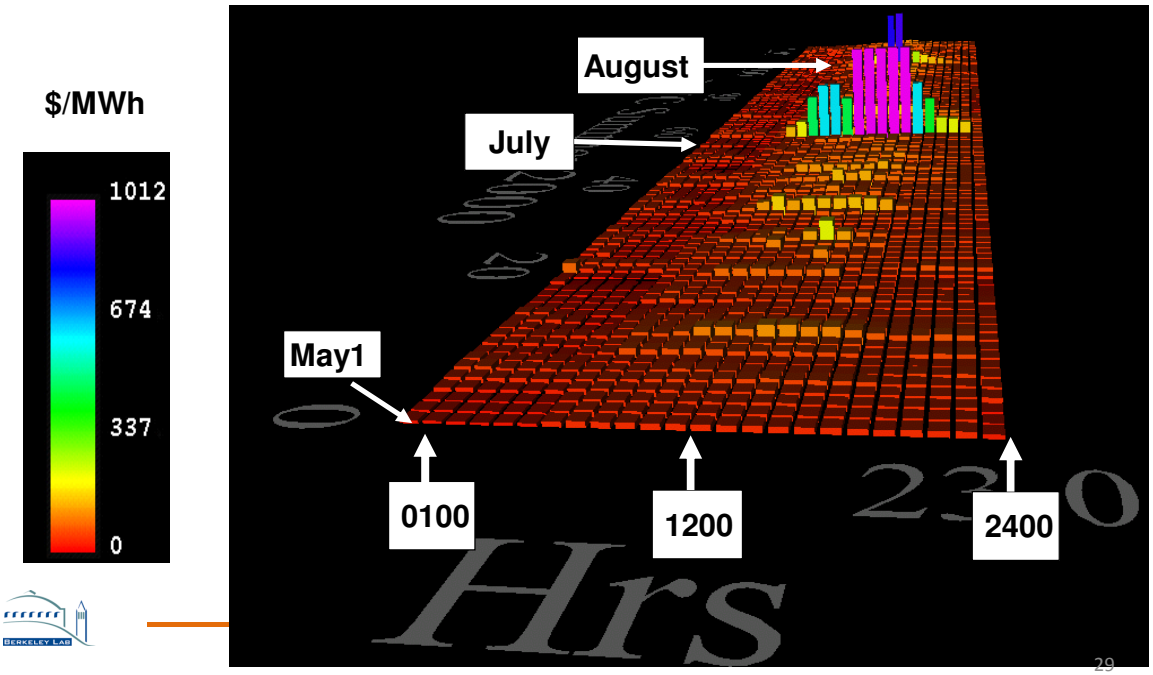
(SDGE CPP-V Example, July 2003 thru May 2004)



Source: CEC analysis of SPP billing data, August 2004 (SDG&E).

What do we know: Value of product overlays depends on price volatility and ability of customers to respond

NYISO Day-Ahead Prices: May–Dec 2001



II. Experience to Date

A. What do we know?

B. What don't we know?

C. What are we still arguing about?

What don't we know or need to understand better?

- ❑ We understand something about how and why some customers respond, but less about others
- ❑ Will response behavior persist or erode over time?
- ❑ How can the results from one utility be extrapolated to other regions with different:
  - Climate
  - Customer characteristics (demographics, income)
  - Appliance/equipment mix
  - Electricity prices and rate structures
- ❑ What basic types of education, communication and enabling technology will work best to improve customer response?
- ❑ More pilots with rigorous experimental designs will help

II. Experience to Date

A. What do we know?
B. What don't we know?
C. What are we still arguing about?

What is demand response really worth?

- Is a negawatt really the same thing as a kilowatt? How can you "sell" a product (kWh reduction) you haven't purchased?
- One issue: if you pay customers a price to reduce load that exceeds the actual avoided costs, it can create negative social welfare impacts
- ISOs have adopted different approaches for paying DR resources:
  - Pay full LMP (CA)
  - Establish a price floor for DR bids (NY and NE)
  - Subtract the generation and transmission portion of the retail rate from LMP to avoid over-payment (PJM)
- FERC issued a NOPR in March 2010 to establish consistent pricing across ISOs for DR resources participating in day-ahead and real-time energy markets (Docket No. RM10-17-000)
- Issue also applies to the design of retail rate programs (CPP and PTR)

IV. Where do we go from here?

A. **Wait and See**

B. Consider Design Choices – what are the tradeoffs?

C. Plan for a transition

Wait and See

- **Do nothing – let others resolve the uncertainties**
  - Observe how FERC resolves certain design issues that affect participation by and/or payments to DR resources
  - Let the wholesale ISO/RTO define DR products for retail customers
  - Support and observe rigorous consumer behavior study plans (e.g., DOE SGIG projects, but results won't be available until late 2013)
- **When to begin planning – Factors to consider:**
  - Are there state mandates (e.g., renewable portfolio standards) that will have to be addressed?
  - Do you want your customers to be able to take advantage of smart appliances?
  - Do you anticipate a growing penetration of electric vehicles in your region?
  - Earlier preparation and planning might mitigate potential problems and minimize lost opportunities

IV. Where do we go from here?

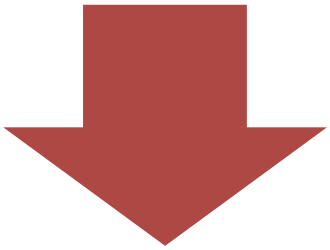
A. Wait and See

B. Consider Design Choices – what are the tradeoffs?

1. **Basic firm service or product overlay?**
2. **Mandatory vs. voluntary participation?**

C. Plan for a transition

Tradeoffs: Basic Service or Product Overlay?

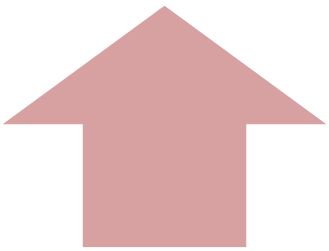


Basic Service

- Pros: Offers greatest potential for economic efficiency gains
- Cons: Will be more difficult due to conflicting regulatory goals (bill impacts)

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 economic efficiency



Economic Potential, Bill Impacts and Smart Grid Benefits of Different Rates (compared to flat rates)

Rate Structure	Economic Efficiency Potential	Initial Bill Impacts (assumes no response)	Potential to Maximize Smart Grid Benefits
Flat Rates + PTR or CPP Overlay			
Flat + PTR	Low/moderate	Low	Moderate
Flat + CPP	Low/moderate	Moderate	Moderate
TOU + PTR or CPP Overlay			
TOU + PTR	Moderate/high	Moderate/high	Moderate
TOU + CPP	Moderate/high	Moderate/high	Moderate
Dynamic Base Rates			
Two-Part RTP	High/higher w/ technology	Low	High/very high
TOU-VPP	High/very high	High	Moderate/high
Real Time Pricing	High/higher w/ technology	Very high	Very high

Tradeoffs: Mandatory vs. Voluntary Participation (1)

- **Mandatory Rates (changes in firm or default rate structure)**
  - **Pros:** Likely to achieve the largest overall economic benefits
  - **Cons:** Can result in large windfall gains and losses, leading to strong customer opposition
- **Mandatory Assignment with an Opt-out provision**
  - **Pros:**
    - Uses customer inertia to "nudge" people onto more efficient rate structure
    - Preserves customer choice
    - Creates larger potential market to enable smart appliances, energy management options and competitive pricing
  - **Cons:** might have customers migrate in larger numbers if prices change

Tradeoffs: Mandatory vs. Voluntary Participation (2)

❑ Voluntary rate structures – offered to all

- **Pros:** Customers get to decide whether they want to be on the new rate (preserves customer choice)
- **Cons:**
  - Potential for windfall losses to the utility due to adverse selection; encourages utilities to design rates in a way to minimize potential losses (ex: TOU rates with very long on-peak periods, low peak/off peak price differentials, etc.)
  - Imposes need for expensive marketing and creates a "pull" environment
  - Makes it difficult to achieve demand response saturations necessary to help manage congestion in specific locations (load pockets)

Tradeoffs: Mandatory vs. Voluntary Participation (3)

- **Voluntary rate structures – targeted recruitment**
  - **Pros:**
    - Allows marketing to be targeted to those customers most likely to respond or to areas (load pockets) where demand response could have greatest value
    - Would help reduce marketing costs and increase resulting impacts
  - **Cons:**
    - Could be perceived as discriminatory

IV. Where do we go from here?

A. Wait and See
B. Consider Design Choices – what are the tradeoffs?
C. Plan for a transition

Plan for a Transition: What are the issues?

1. How do we transition customers from existing flat and tiered rates to a dynamic rate?
2. How do we educate customers regarding both the opportunities and risks?
3. Will technologies be available so customers can automate their response?
4. What can we do to identify and mitigate potential adverse bill impacts before they create problems?

Plan for a Transition: Technology issues

3 **Will technologies be available so customers can automate their response?**

- **Utility provided programs**
  - Can be implemented in 1-2 years
  - Limits technology options, customer choice, cost
  - May require subsidies, incentives on top of rate
- **Non-utility competitive market options**
  - Will require 3-5 years to seed the market
  - Will encourage multiple technology, service, cost, and customer choice options
  - May require subsidies or incentives to facilitate implementation and accelerate customer purchase

Plan for a Transition: Rate Transition Options

1 **How do we transition customers from existing flat and tiered rates to a dynamic rate?**

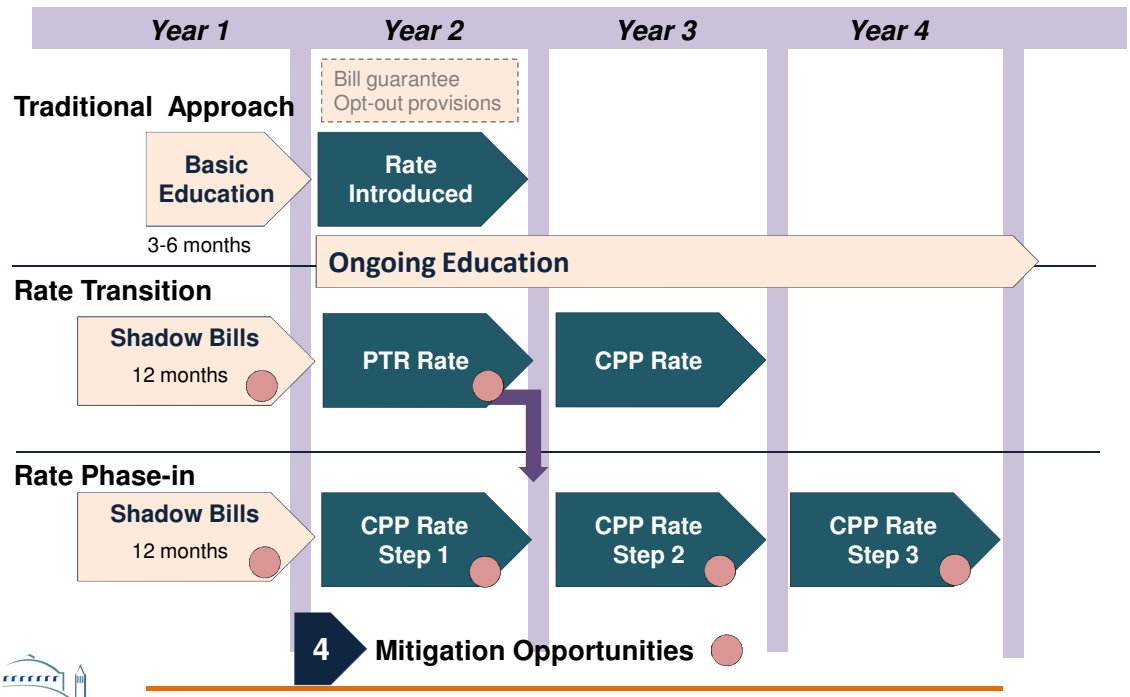
- **Time Frame Issues:**
  - Education: [Virtual Participation] familiarize customers with rate structure and prices before rate introduction – minimum 6-12 months.
  - Education: need to provide continuing information on adaptation methods and technologies – ongoing.
  - Technologies: 3-5 year minimum acquisition cycle for low cost adaptation options
  - Technologies: 4-9 year minimum acquisition cycle for major appliance and infrastructure options
- **Rate Design considerations / options**
  - Transition from "safe" PTR to dynamic CPP.
  - Phase in dynamic rate price differentials over a 3-5 year period.
  - Opt-out options to hedged flat or TOU rate.

Plan for a Transition: Education Transition Options

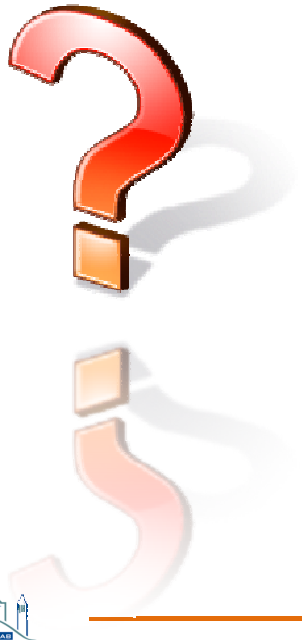
2 **How do we educate customers regarding both the opportunities and risks?**

- **Pre-Rate Introduction - Shadow Bills [Virtual Participation]**
  - Provides customers with side-by-side comparison of potential bill impacts
  - Can be supplemented with adaptation and technology information to address opportunities and mitigation
- **Post-Rate Introduction (ongoing)**
  - Web-based tools and information
  - Case studies to illustrate adaptation
  - Technology reviews, case studies, incentives
  - Shadow bills, cumulative accruing impacts to provide post implementation (purchase) confirmation

4 Plan for a Transition: Mitigation Options



Contact Information



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