

The Brattle Group

Load Shifting Effects and Impacts of AMI on the Load Forecast

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Presented by:
Philip Q Hanser
Principal
The Brattle Group

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In 2008, FERC surveyed more than 50 states to identify AMI penetration

- ◆ Based on FERC 2008 survey, AMI penetration in the U.S. has grown significantly from less than one percent to 4.7 percent between 2006 and 2008
- ◆ More utilities have announced plans to deploy AMI in the near future driven by federal legislations such as the EPA (2005) and the EISA (2007) and by individual state policies
- ◆ In the next five years, we will have AMI penetration among mass-market customers far beyond 4.7 percent as of 2008

AMI benefits can be collected under three groups

◆ **Customer Benefits**

- More accurate and prompt billing
- Better service due to faster detection of and response to power outages
- Improved convenience and privacy due to automated meter reading

◆ **Operational Benefits**

- Avoided meter reading costs
- Reduced customer support expenses
- Reduced energy theft and uncollectibles

◆ **Price Responsive Demand (through dynamic pricing)**

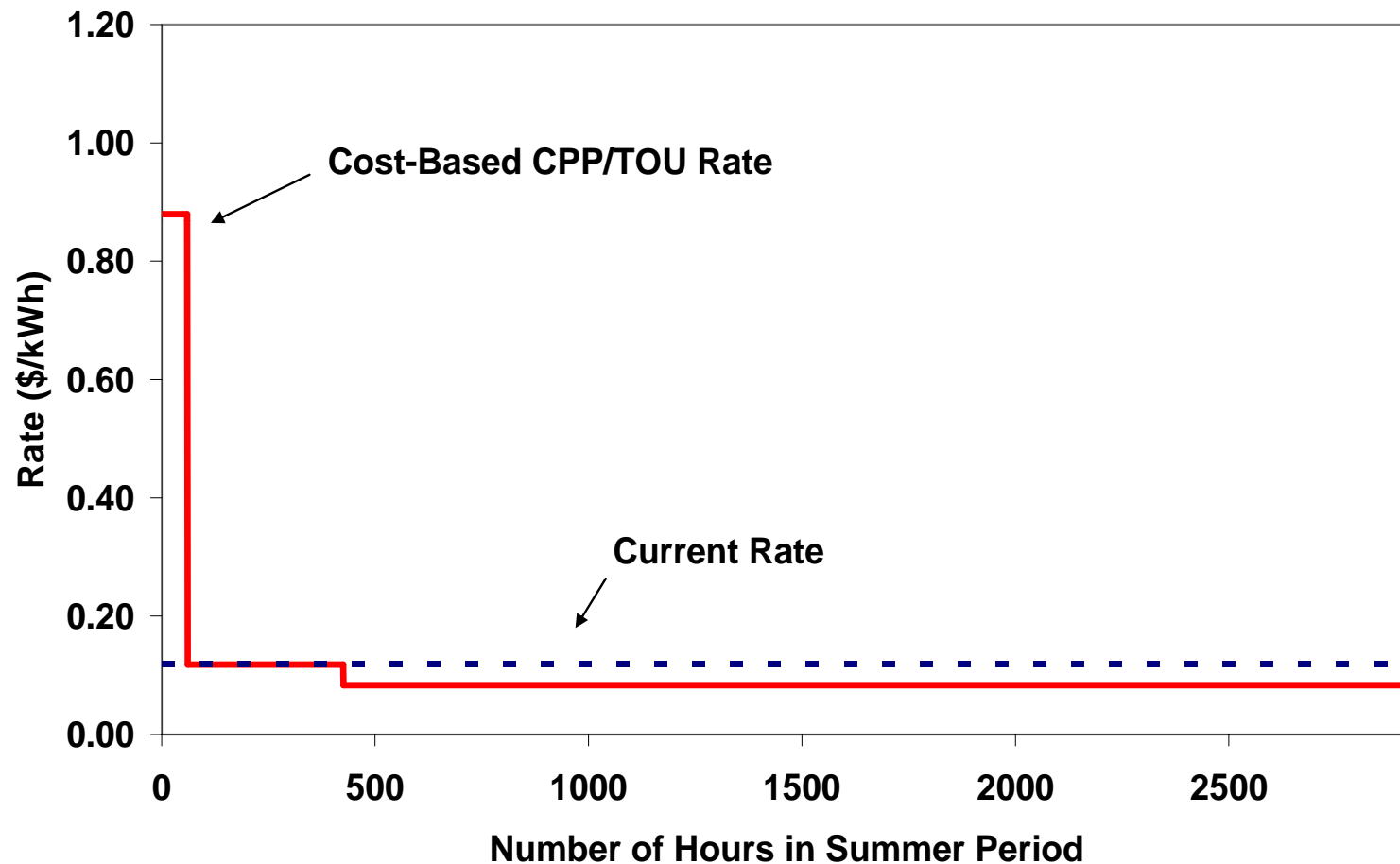
- Avoided capacity and energy costs
- Avoided incremental T&D investment costs
- Lower wholesale market prices

Dynamic pricing comes in many flavors

- ◆ **The list includes:**
 - Critical peak pricing (CPP)
 - Peak time rebates (PTR)
 - Variable peak pricing (VPP)
 - Real time pricing (RTP)
- ◆ **Any of these options can be combined with inclining block rate designs and/or standard TOU rates**
- ◆ **They can be combined with enabling technologies such as in-home displays and/or smart thermostats**
- ◆ **Finally, the rates can be offered on a day-ahead, day-of or hour-ahead basis**

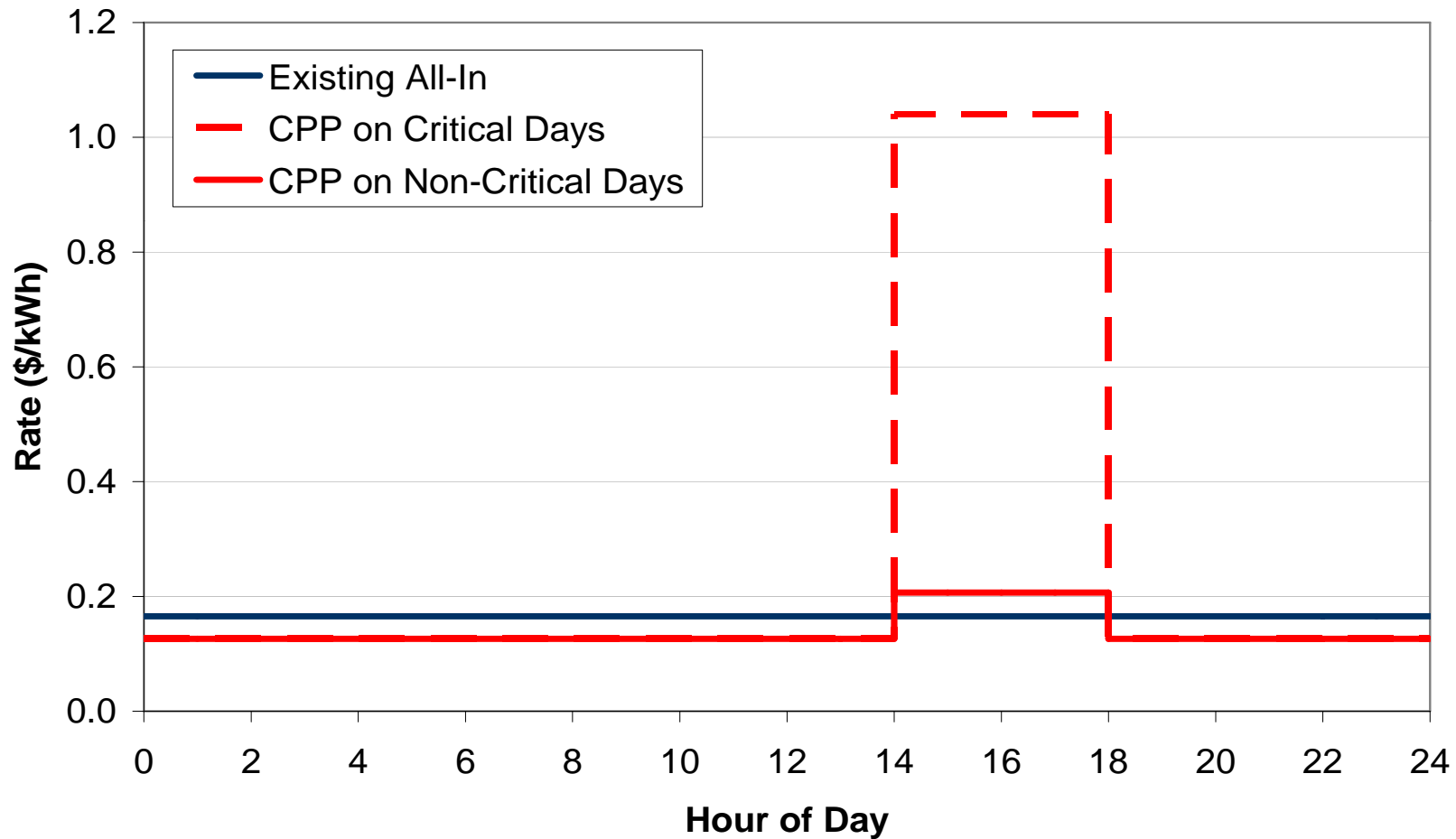
Customers get lower prices during thousands of hours if they agree to pay very high prices during a few

Price Duration Curve



Critical Peak Pricing

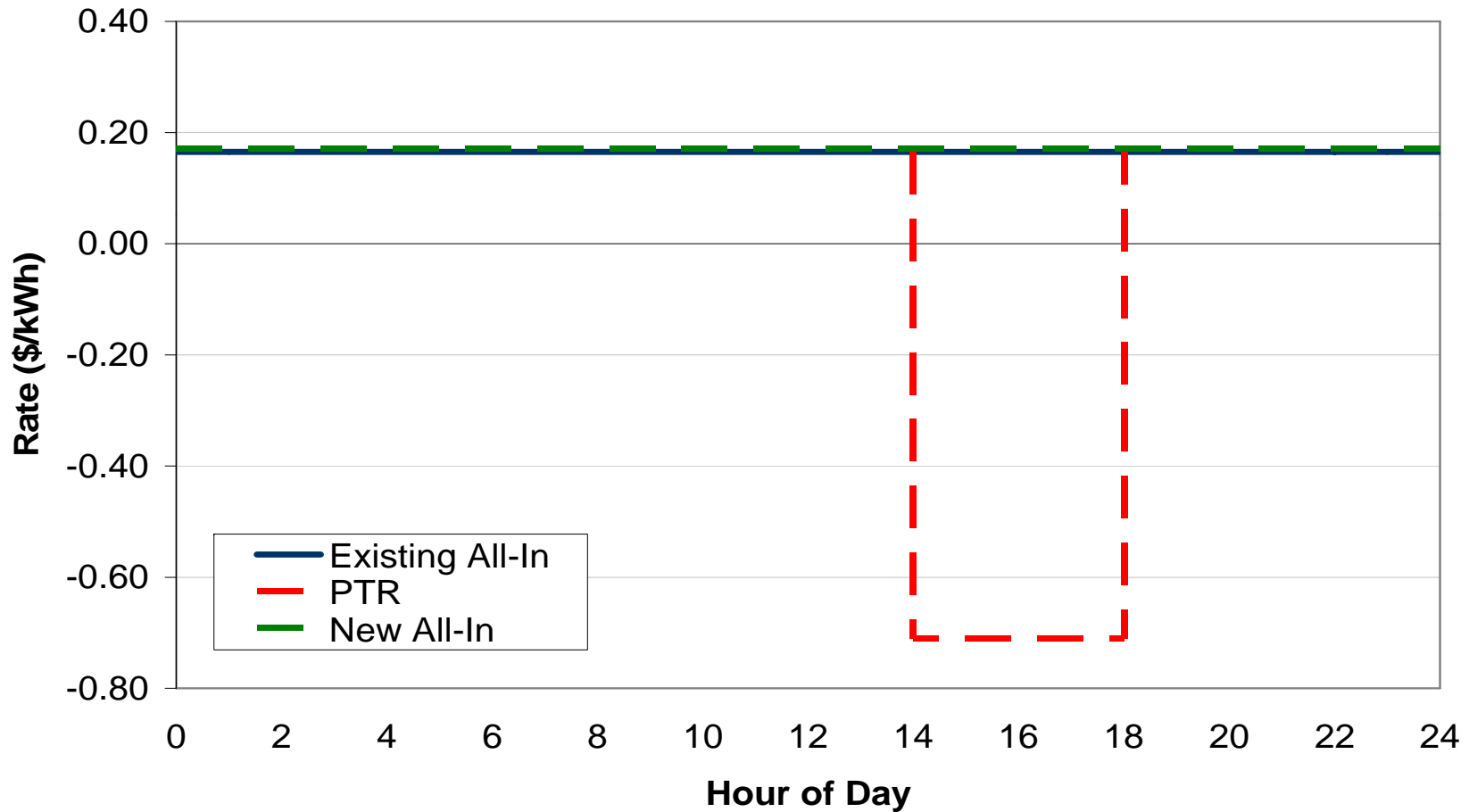
Illustration of Residential CPP Rate



Source: Faruqi and Wood (2008)

Peak Time Rebate

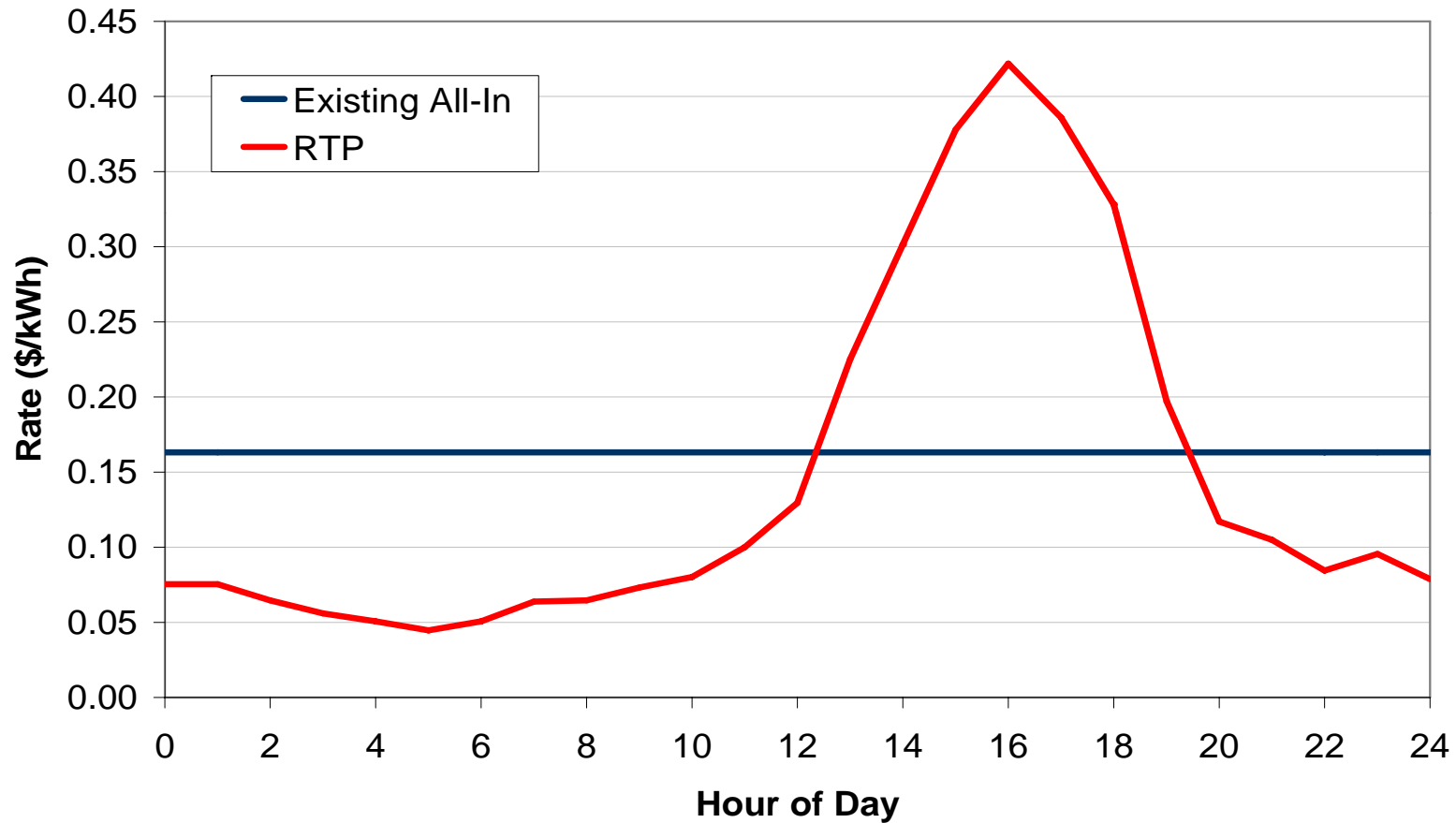
Illustration of PTR Rate on Day of Critical Event



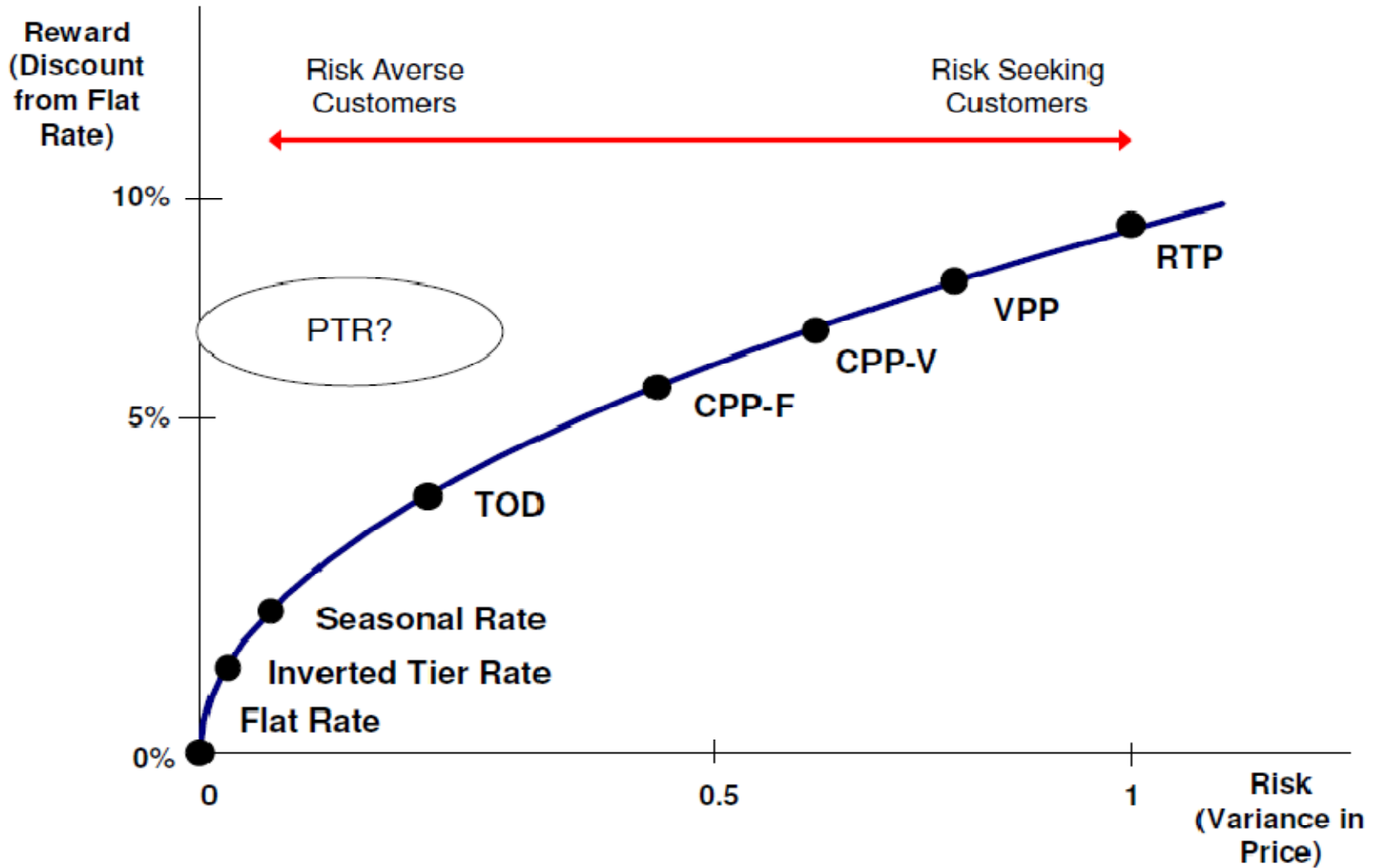
Source: Faruqui and Wood (2008)

Real Time Pricing

Illustration of RTP Rate on Peak Summer Day

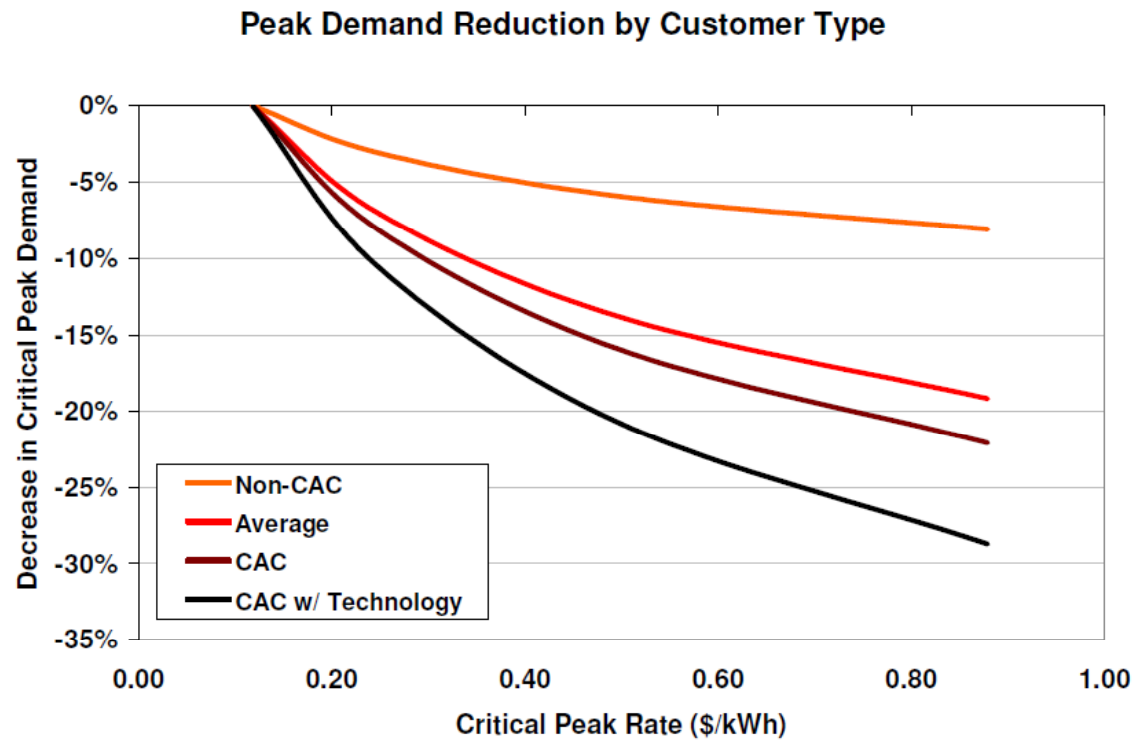


Dynamic pricing enables customer choice



Do customers respond to dynamic pricing?

- ◆ **Some don't, some respond marginally, some respond a lot**
 - Customer response varies by price and market segment

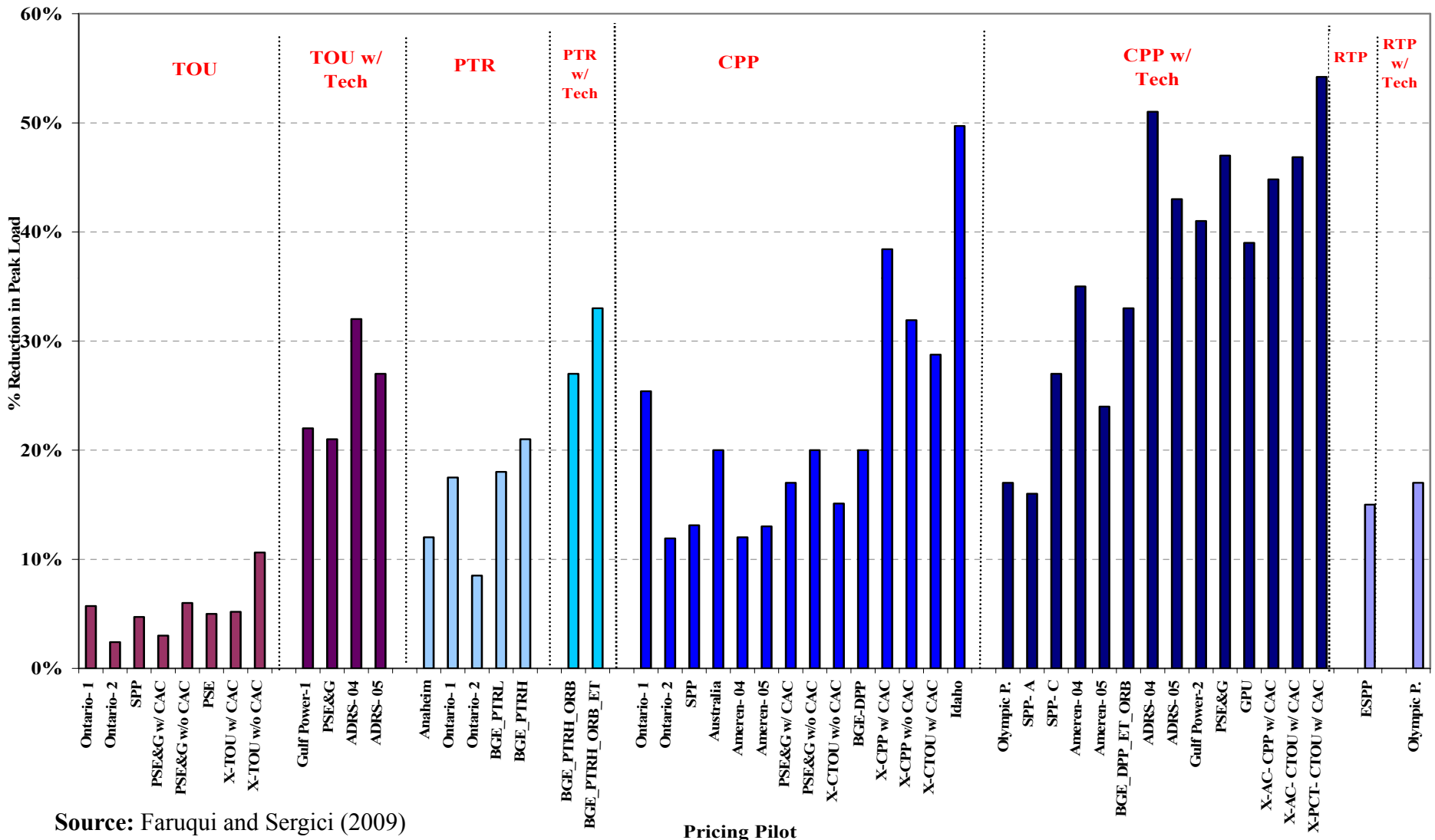


- ◆ **In the aggregate, they do respond quite a bit as evidenced by pricing experiments**

We reviewed 15 most recent experiments/programs with dynamic pricing of electricity

No	State/ Province	Experiment	Utility	Year	Number of Customers
1	California	Anaheim Critical Peak Pricing Experiment	Anaheim Public Utilities (APU)	2005	52 control, 71 treatment
2	California	California Automated Demand Response System Pilot (ADRS)	Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E)	2004-2005	In 2004: 104 control, 122 treatment In 2005: 101 control, 98 treatment
3	California	California Statewide Pricing Pilot (SPP)	Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E)	2003-2004	2,500 customers
4	Colorado	Xcel Experimental Residential Price Response Pilot Program	Xcel Energy	2006-2007	1350 control, 2349 treatment
5	Florida	The Gulf Power Select Program	Gulf Power	2000-2001	2300 customers participating in the RSVP program
6	France	Electricite de France (EDF) Tempo Program	Electricite de France (EDF)	Since 1996	400,000 customers
7	Idaho	Idaho Residential Pilot Program	Idaho Power Company	2005-2006	TOD Program- 420 control, 85 treatment EW Program- 355 control, 68 treatment
8	Illinois	The Community Energy Cooperative's Energy-Smart Pricing Plan (ESPP)	Commonwealth Edison	2003-2005	1,500 customers
9	Missouri	AmerenUE Residential TOU Pilot Study	AmerenUE	2004-2005	TOU - 89 control, 88 treatment TOU/CPP- 89 control , 85 treatment TOU/CPP w/ Technology- 117 control, 77 treatment
10	New Jersey	GPU Pilot	GPU	1997	Not Available
11	New Jersey	Public Service Electric and Gas (PSE&G) Residential Pilot Program	Public Service Electric and Gas Company (PSE&G)	2006-2007	450 control, 836 treatment
12	New South Wales (Australia)	Energy Australia's Network Tariff Reform	Energy Australia	2005	TOU program: 50,000 customers SPS: 1300 treatment
13	Ontario (Canada)	Ontario Energy Board Smart Price Pilot	Hydro Ottawa	2006-2007	125 control, 373 treatment
14	Washington	Puget Sound Energy (PSE)'s TOU Program	Puget Sound Energy	2001-2002	300,000 customers
15	Washington and Oregon	Olympic Peninsula Project	Bonneville Power Administration, Clallam County PUD, The City of Port Angeles, Portland General Electric, and PacifiCorp	2005	28 control, 84 treatment

Manhattan Skyline



Evidence shows that customers do respond to dynamic prices

- ◆ **Households respond to higher prices by lowering usage**
- ◆ **Demand response depends on several factors:**
 - Magnitude of the price increase
 - Presence of CAC
 - Availability of enabling technologies such as two-way PCTs and always-on gateway systems that allow multiple end-uses to be controlled remotely
- ◆ Across the range of experiments studied, TOU rates induce a drop in peak demand that ranges between **three to six percent**
- ◆ CPP tariffs induce a drop in peak demand that ranges between **13 to 20 percent**
- ◆ When accompanied with enabling technologies, CPP tariffs lead to a drop in peak demand in the **27 to 44 percent** range

How do we integrate price responsive demand to the load forecast?

There are three main approaches that could be considered to integrate PRD into an LSE's load forecast

◆ **Integrated Approach**

- Can be used when PRD is well-established

◆ **PRISM Approach**

- Can be used if a LSE has no PRD program in place or has recently introduced a PRD program so that the data requirements to implement the *Integrated Approach* are not fulfilled

◆ **Hybrid Approach**

- Can be used when a PRD program is well-established but the share of sales represented by customers on dynamic pricing rates is not large

1- Integrated Approach

Feasible when a PRD program is well-established

Two other conditions should also be fulfilled

- ◆ First, a significant share of customers should be on dynamic pricing rates
- ◆ Second, they should be on the rates long enough that their price responses can be estimated using conventional forecasting techniques

Under this approach, the hourly forecasting model would be modified to include an hourly price term and it would be estimated with the class level data

- ◆ This new forecasting model will produce the level of demand that incorporates PRD for a given hourly price.

2- PRISM Approach

Feasible if an LSE has no PRD program in place or has recently introduced a PRD program so that the data requirements to implement the *Integrated Approach* are not fulfilled

The PRISM model is used to estimate individual customer-level demand response

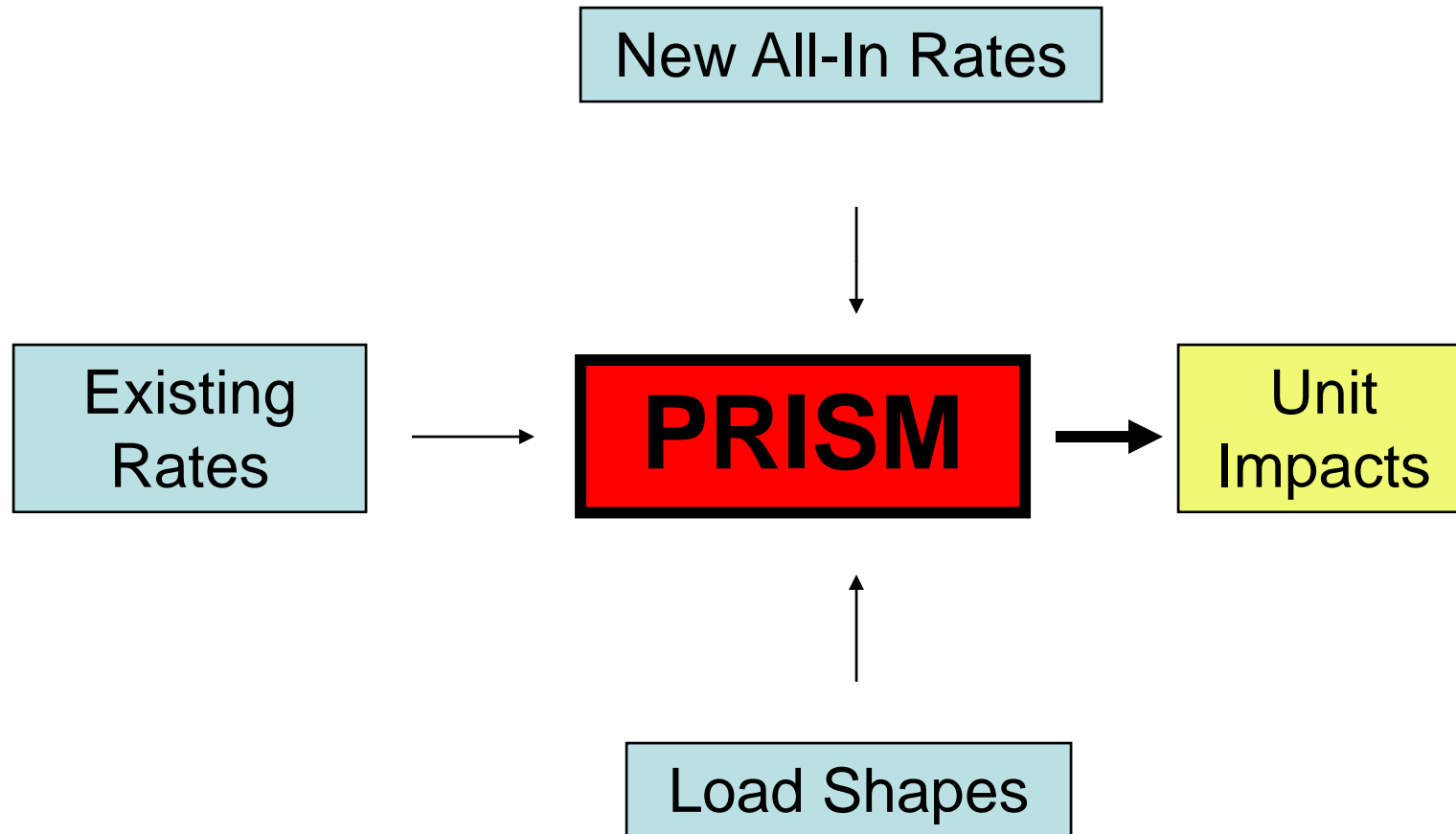
PRISM needs several types of inputs

- Weather data
- Existing and dynamic rate designs
- Customer load shapes
- Central Air Conditioning saturation

PRISM generates the change in the average customer's load shape

- This can be used to estimate the impacts of dynamic prices on the load forecast

What does PRISM do?



2- PRISM Approach (Cont'd)

The integration of PRD into the LSE's Forecast LSE Requirement can be accomplished through the following steps:

1. Calibrate PRISM to a LSE's conditions/participants and run PRISM to determine the average participating customer's response to various dynamic price series, expressed as a percentage reduction in hourly demand
2. Identify the amount of demand that is subject to the dynamic prices
3. Identify aggregate PRD
4. Subtract PRD from the total load forecast

3- Hybrid Approach

Feasible when a PRD program is well-established but the share of sales represented by customers on dynamic pricing rates is not large. In this situation, two options are available to incorporate the PRD from the dynamic pricing rate customers:

1. Customers on standard rates would be segregated from those on dynamic pricing rates. The hourly demand for the standard rate customers would be forecast separately from the demand for the dynamic pricing rate customers. For the dynamic pricing customers, a new forecasting model would be developed
2. The LSE could use its existing demand forecasting approach for forecasting the entire demand of the standard rate customers and for forecasting the non-price portion of the demand for the dynamic pricing rate customers. PRISM will be used to incorporate PRD to the LSE's Forecast LSE Requirement

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- ◆ **Faruqui, Ahmad and Sanem Sergici 2009. —Household Response to Dynamic Pricing of Electricity – A Survey of The Experimental Evidence, can be downloaded from: <http://www.hks.harvard.edu/hepg/>**
- ◆ **Faruqui, Ahmad, Sanem Sergici and Lisa Wood. 2009.- Moving Toward Utility-Scale Deployment of Dynamic Pricing in Mass Markets, *IEE Whitepaper*, June 2009**
- ◆ **Federal Energy Regulatory Commission. 2008. -Assessment of Demand Response and Advanced Metering. Staff Report.**
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