U.S. Department of Energy's Smart Grid Investment Grant Program: Dynamic Pricing & Consumer Behavior Studies Webinar

Day 1

April 20, 2010

Agenda – Day 1

- Introductions and webinar objectives (10 min.)
- DOE interest in consumer behavior studies (20 min.)
- Defining the research objectives (40 min.)
- Methodological approaches (50 min.)

Agenda – Day 1

- **Introductions and webinar objectives (10 min.)**
- DOE interest in consumer behavior studies (20 min.)
- Defining the research objectives (40 min.)
- Methodological approaches (50 min.)

Introductions

- **Team of people will be presenting materials**
  - Joe Paladino (DOE)
  - Chuck Goldman and Peter Cappers (LBNL)
  - Michael Sullivan and Steve George (FSC Group)
  - Catherine Wolfram, Meredith Fowlie and Lucas Davis (UC Berkeley)
- **Presentation Audience**
  - Comprised exclusively of SGIG recipients who will be undertaking a consumer behavior study of dynamic pricing
  - A follow-up to this series of webinars will be provided to a broader audience of stakeholders, regulators, etc. in the coming weeks

Webinar objectives

- **Day 1**
  - **Discuss DOE's interest in consumer behavior studies with dynamic pricing**
  - **Identify key research questions that are priorities for DOE**
  - **Provide an overview of principles of sound research design**
- Day 2
  - Considerations for well-designed consumer behavior studies
  - Outline process and reporting requirements

Agenda – Day 1

- Introductions and webinar objectives (10 min.)
- **DOE interest in consumer behavior studies (20 min.)**
- Defining the research objectives (40 min.)
- Methodological approaches (50 min.)

Past experience with dynamic pricing pilots

- **Collectively, most past dynamic pricing studies have focused on answering a limited set of questions**
  - **How much, if any, peak demand savings occurs?**
  - **How much, if any, net energy savings occurs?**
  - **What role does enabling technology play in increasing energy and/or peak demand savings?**
  - **How satisfied are customers with the particular rate design?**
- **Previous pilots have produced a wide array of answers to these questions, in part due to experimental designs of varying quality and differing objectives (e.g., technology trials, customer acceptance of rates)**

Deeper questions remain unanswered about the transforming capabilities of AMI

New studies should investigate the power of AMI in seamlessly integrating pricing, technology, and information feedback to induce a change in behavior

Pricing

- Customer acceptance
- Market segmentation
- Character of response
- Rate design

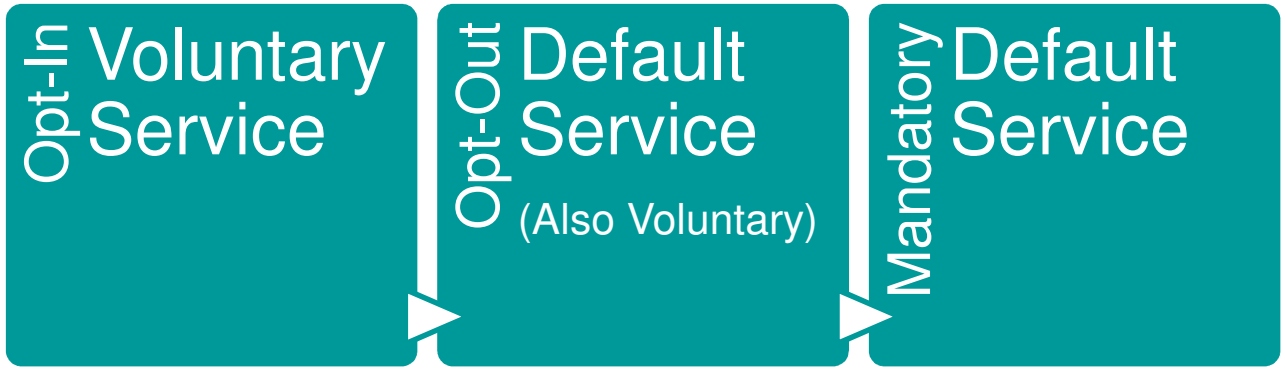
Technology

- Customer acceptance
- Market segmentation
- Character of response

Information Feedback

- Market segmentation
- Delivery mechanisms
- Persistence

Role of dynamic pricing in retail service offerings



- **Without changes in retail pricing, there is limited value in the technology and information feedback AMI enables**
- **FOA clearly states preference for making dynamic pricing the required default service offering**
  - **Not all jurisdictions will immediately embrace this strategy**
  - **DOE expects the results of these studies will help make the case for transitioning there over time**
  - **Approaches to rate offerings such as "opt-in" or "opt-out" are viable alternatives that will require a different experimental design than those prescribed in the FOA**

Opportunity for SGIG to advance the industry's understanding

- **Results from prior studies are difficult to extrapolate to other jurisdictions or circumstances, and/or viewed skeptically by external observers and stakeholders**
- **DOE approach: Include technical advisory groups comprised of highly skilled and well-trained academics and practitioners to work with utilities in a collaborative process to ensure that SGIG studies will be designed, administered, and evaluated in the most methodologically sound approach possible**

Agenda – Day 1

- Introductions and webinar objectives (10 min.)
- DOE interest in consumer behavior studies (15 min.)
- **Defining the research objectives (40 min.)**
- Methodological approaches (50 min.)

Defining research objectives

If you don't know where you are going, you might wind up someplace else.

-- Yogi Berra

Put another way, "If you don't decide up front what you want to know, you might end up answering some other question (knowingly or, worse, unknowingly)."

Three high level questions

- **What do you want to test—that is, what treatments do you want to know something about?**
- **What populations do you want to test the treatments on?**
- **What do you want to know about the effect of the treatments?**

What do you want to test?

- At a high level, the treatments of interest involve combinations of the following four categories
  - Pricing option
  - Enabling technology
  - Enrollment process
  - Marketing strategy
- In your research design proposals, DOE wants to see the treatments described precisely
  - To assess the extent to which variation in treatments will be tested across the experiments
  - To assess whether the proposed research design will, in fact, produce valid estimates of the effects of treatments of interest
- It is not sufficient to say, "I'm going to test a CPP rate" or "I want to see what technology does"

Pricing options

- TOU—time of use
  - Prices vary by rate period and day of week, but do not change based on system conditions (technically, not a dynamic rate option)
- CPP—critical peak pricing
  - Prices vary by time of day on selected days that are not known until the day before or day-of
- PTR—peak time rebate
  - Similar to CPP, but instead of higher prices during peak periods on selected days, customers are paid to reduce load (Technically, not a rate, but a pay-for-performance program)
- RTP—real time pricing
  - Prices vary hourly (typically either day-ahead hourly pricing or real-time pricing based on wholesale energy market)
- Combinations
  - CPP/TOU, PTR layered on top of TOU, RTP with CPP overlay to capture avoided capacity costs

Additional pricing features

- **Each pricing option must be defined according to the following attributes**
  - **Price levels by rate period**
  - **Number of rate periods (two, three, more?)**
  - **Length of peak period**
  - **Timing of rate period**
  - **Changes across seasons (simplicity versus relevance)**
  - **Seasonal revenue neutrality versus annual revenue neutrality**
  - **Overlays on existing pricing tiers**

Examples of pricing questions to consider during research design phase

- **Do you know what the pricing attributes should be or do you want to determine the best set of attributes as part of the research?**
  - **If you test a single rate with specific attributes, you won't know if that is the best rate or what the impact would be for a tariff with different attributes**
    - Would shorter peak periods produce larger impacts?
    - Would higher peak period prices produce larger average impacts?
    - Would high peak period prices produce larger aggregate impacts (as higher prices might mean lower enrollment rates)?
  - **Which is better—CPP, TOU, RTP, or some combination?**
  - **What do you mean by better (greater average impacts, greater aggregate impacts, more equitable allocation of costs, etc.)?**

Enabling technologies

- **Another type of treatment variable involves technology**
- **DOE has a keen interest in the incremental effect of enabling technology combined with time-varying pricing**
- **Technology can be used for several purposes**
  - **Appliance control**
    - Switches (e.g., direct load control—DLC)
    - Programmable communicating thermostats (PCTs)
    - Home area networks (HAN) for controlling multiple end uses
  - **Notification**
    - Orbs (or other devices) for indicating when high prices are in effect
    - Messaging through phone, email, paging, text messaging, etc.
  - **Information feedback**
    - Real time information delivered to dedicated in-home displays (IHDs) or information provision to personal computers or other display options
    - Day late information feedback through web portals

Examples of technology questions to consider during research design phase

- What technologies will be tested?
- Do you want to know the impact of one technology versus another, or is technology being provided as an integral part of the pricing option being offered (in which case you would not be able to separate out the price effects from the technology effects)?
- Can the technology produce benefits in the absence of time-varying prices, or only in conjunction with pricing?
- Are all customers eligible for a technology (and if not, how will you address eligibility concerns)?
- Will you charge for the technology (and if so, full price or subsidized)?
- How will installation barriers be addressed?
- If you are looking at load control, will you test both PCTs and DLC switches?
  - If not, on what basis have you/will you choose one over the other?

Retail pricing enrollment options

- **Mandatory**
  - Customers are assigned to a tariff with no option to refuse
- **Opt out**
  - Customers are assigned to a tariff
  - Customers make an affirmative action to refuse
- **Opt in**
  - Participants are offered a tariff
  - Customers make an affirmative action to accept

Examples of enrollment questions to consider during research design phase

- Do you want to study customer acceptance or just study load impacts for customers assigned to various tariffs?
- What type of enrollment model will you use (or definitely not use) if the results of the pilot lead to full scale role out of a tariff?
- What type of opt out attrition mitigation measures will you consider incorporating into a full-scale roll out (e.g., bill protection)?
- How will selection/attrition be addressed during the trial?

Marketing strategies

- **For opt in enrollment, how you market each treatment can significantly affect enrollment rates**
- **Features of the marketing offer include:**
  - **Message (e.g., savings, social responsibility, environment)**
  - **Mode — direct mail vs. telemarketing vs. in person**
  - **Sign up incentives (not payments to be in program, but something to overcome inertia)**
    - Evidence from PG&E's SmartRate tariff shows that a $25 incentive will more than double enrollment using direct mail
  - **Number of "touches"—that is, the # of times you contact a customer**
  - **Type of marketing package (glossy brochure vs. #10 envelope with business letter)**
  - **Enabling technology**
    - For PG&E's SmartRate tariff, enrollment rates are 3 times higher for customers on direct load control compared with Greenfield customers

Examples of marketing questions to consider during research design phase

- **Do you want to know the relative importance of different marketing features?**
  - **Sign up incentives, different messaging, etc.**
- **If not, how will you know the best way to achieve high enrollment during the trial?**
- **Is it possible to vary the marketing mix across customers (e.g., offer one customer an incentive but not another customer)?**
- **Will you consider unconventional (for utilities) marketing methods if they are much more affective (e.g., telemarketing, direct sales, social networks, etc.)?**

What populations are of interest?

- **In addition to deciding what treatments you will test, you must decide who you will test them on**
- **Dynamic pricing may have very different impacts on different sub-populations**
  - **Residential customers**
    - Low income
    - Customers with and without central air conditioning
    - Owned vs. rented housing
  - **Commercial customers**
    - Owned vs. rented facilities
    - Business types
    - Size

What do you want to know?

- Carefully defining what you want to know about the treatments and populations of interest is the key to sound research design
- If you don't know what questions are of most interest, you may not be able to answer them millions of dollars later
- What you may want to know typically falls into the following categories:
  - Changes in energy use by time period
  - Differential acceptance/enrollment/attrition rates for each treatment option and population of interest
  - Understanding changes in consumer behavior underlying the changes in energy use
  - Understanding why customers do or don't accept or change their usage behavior in response to various treatments

Changes in energy use

- This has been the primary focus of nearly all past studies and it is an essential part of all studies
  - But we already know that customers can and will respond to time varying pricing, so what new findings will your study provide in this area?
- Proper experimental design is essential to developing unbiased estimates of load impacts
  - The methodological discussion will focus on this
- While average impacts are interesting, often more interesting and useful is understanding how impacts vary across populations and even across individuals
  - Knowing that 80% of impacts come from 20% of customers is useful
  - More useful is knowing the characteristics of those 20%
  - Answering these types of questions impacts the data needs, evaluation approaches and, potentially, sample sizes and sample design

Customer acceptance/enrollment/attrition

- DOE has a keen interest in understanding how enrollment varies across
  - Rate options
  - Enrollment models (opt out vs. opt in)
  - Different marketing methods
  - Different groups of customers
- Studying customer acceptance/enrollment/attrition requires a different design than if you are only interested in understanding what the load impact is for customers who are on a particular price/technology treatment
- Understanding, not avoiding, selection and attrition are critical requirements in studies involving these enrollment mechanisms

Understanding changes in behavior underlying changes in usage

- Understanding the change in energy use from a treatment is much easier than understanding what caused that change
- The latter requires detailed surveys or observations of consumer behavior before and after treatments go into effect
  - It is much more accurate to observe behavior before and after a treatment goes into effect than to ask people how they changed their behavior after the fact
- Potential questions of interest include
  - What end uses are people changing?
  - Are the changes primarily the result of reductions in use or changes in the timing of use?
  - Are the treatments impacting purchase decisions or just usage decisions?

Understanding why customers do or don't accept treatments or change behavior

- Agency Problems
- Lifestyle constraints
- Inability to measure and understand the timing and magnitude of electricity consumption by end uses
- Insufficient perceived monetary benefit
- Technical inability to adjust electricity consumption for specific end uses
- Lack of awareness of change in electricity cost

Agenda – Day 1

- Introductions and webinar objectives (10 min.)
- DOE interest in consumer behavior studies (15 min.)
- Defining the research objectives (40 min.)
- **Methodological approaches (50 min.)**

Overview of this section

- **How does randomization enhance the internal and external validity of the estimates you ultimately obtain?**

- **What are some of the ways that randomization can be incorporated into program evaluation?**

A review of the very basics

Main objective: estimate the impact of a proposed program/ intervention on an outcome of interest in a particular population/sub-population.

- ***Intervention of interest:*** **Examples include CPP, CPP + TOU, CPP + information provision, CPP + enabling technology, etc.**
- ***Outcome of interest*****: Examples include peak consumption of participating households, enrollment in different kinds of dynamic pricing rate designs, etc.**
- ***Population of interest*****: Examples: All program participants, households who opt into voluntary programs, specific demographic groups.**

Properties of a well designed pilot

The quality/usefulness of a pilot is typically assessed in terms of internal and external validity.

***Internal validity*: Confidence with which we can state that the impact we estimate was *caused* by the treatment being evaluated (versus some other factors).**

***External validity*: The extent to which a study's results can be generalized/applied to other subjects or settings.**

In theory, evaluations employing random assignment and random sampling will possess higher internal and external validity as compared to studies that do not use random selection/assignment.

The empirical challenge:

- **In order to estimate the causal effect of an *intervention of interest* on the *outcome of interest* in a *population of interest*, we need credible, unbiased estimates of what the *outcome of interest* would have been in the absence of the *intervention of interest*.**
- **Since the counterfactual is not observable, the key goal is to construct or "mimic" the counterfactual.**

Problem: How to construct a credible and precise estimate of outcomes we cannot observe?

Constructing the counterfactual

The counterfactual is often constructed by selecting a group not affected by the program

***Observational approaches*: Argue that a certain excluded group accurately mimics the counterfactual.**

***Randomization approaches*: Use random sampling from the population of interest and random assignment of the treatment of interest to create a control group to mimic the counterfactual.**

Observational Approaches:
Non-experimental, retrospective studies

- **Observe outcomes at households participating in the program and observationally similar households who do not participate.**
- **An estimate of the unobservable counterfactual among participants is obtained via econometric manipulation of outcomes among non-participants.**
- **The critical assumption: when outcomes at apparently similar households are compared, differences are either purely by chance or caused by program participation.**
- **If this assumption is violated, this has important implications for both the estimated impacts and the assumed precision of these estimates.**

Standard randomized control trial:

- Households are randomly selected from the larger population of interest group.
- Sample is randomly divided across treatment and control group.
- The treatment group participates in the program being evaluated. The control group remains in status quo state.
- Post-treatment outcomes are compared across groups.
- Statistical methods are used to estimated how likely it is that observed differences in outcomes are caused by the intervention (versus random chance)

Examples to illustrate internal and external validity concerns

- **Suppose the population is equally divided between two "types" of observationally equivalent households (i.e., Type A and Type B)**
- **In 2010 both sets of households are on the same "base" rate.**
- **In 2011, when offered the opportunity to move to a CPP rate, Type A households opt in, whereas Type B households opt out.**
- **Ideally we would observe both types of households in both states of the world.**
- **The estimate of the treatment effect can only take into consideration information that is *observed.***

Household Treatment Effect

(Treatment Usage - Base Usage)

observed for Type A in 2011

observed for Type B in 2011

Internal validity: Observational approach

- **Type A households opt for the treatment CPP rate and Type B households choose to remain on thee control base rate.**

	Household peak demand in 2010 on base rate	Household peak demand in 2011 on CPP	Household peak demand in 2011 on base rate
Type A Households	100	105 (observed)	120 (counterfactual)
Type B Households	100	115 (counterfactual)	118 (observed)

- **Estimated treatment effect**
  - **Households were observationally equivalent in 2010, so assume the Type A household counterfactual is equivalent to Type B household observed usage in 2011**

$$((105 - 100) - (118 - 100)) = (105 - 118) = -13$$

- **True average treatment effect:**
  - **Usage in 2011 would NOW differ by household on similar rates**

$$((105 - 120) - (115 - 118)) / 2 = -9$$

Randomization with mandatory assignment

- **Suppose 50% of Type A and Type B households are instead randomly assigned to the treatment CPP rate group.**

	Household peak demand in 2010 on base rate	Household peak demand in 2011 on CPP	Household peak demand in 2011 on base rate
Households assigned to CPP	100	0.5(105)+0.5(115) (observed)	
Households assigned to control	100		0.5(120)+0.5(118) (observed)

- **Estimated average treatment effect**
  - **Now all options by rate service and household type are observed**

((0.5(105))+(0.5(115))) - ((0.5(120))+(0.5(118))) = -9

- **True average treatment effect:**

((105 – 120) – (115 – 118)) / 2 = -9

Randomization with opt-in

- **Suppose that only opt-in (Type A) households are randomly assigned to treatment and control groups, but opt-out (Type B) households are not.**

	Household peak demand in 2010 on base rate	Household peak demand in 2011 on CPP	Household peak demand in 2011 on base rate
Type A Households	100	105 (observed)	120 (observed)
Type B Households	100	115 (counterfactual)	118 (observed)

- **Estimated treatment effect:** *(105 – 120) = -15*
- **True treatment effect in entire population :** *((105-120) + (115-118)/2 = -9*
- **True treatment effect in opt-in sub-population:** *(105 – 120) = -15*
- **True treatment effect in opt-out sub-population:** *(115 – 118) = -3*

Random assignment enhances internal validity

- **Absent random assignment, there is greater risk that systematic differences might be responsible for some/all of the observed differences in the outcome of interest.**
- **Several within study comparisons of experiments and non-experiments have assessed the internal validity of retrospective, non-experimental program evaluations (*e.g.* Bloom, 2002; Cook *et al.*, 2006; Glazerman *et al.*, 2003).**
- **Punch line (Bloom, 2002):**

"The answer to the question, 'Do the best (observational) methods work well enough to replace random assignment?' is probably, 'No.'"

Random selection enhances external validity

- **Absent random selection from the larger population, there is greater risk that the study sample differs systematically from the population you are interested in learning about.**

Attrition issues: Come back to this on day 2

- **Every effort should be made to adhere to randomized design principles to ensure that results are not misleading.**
- **The act of randomly assigning customers to treatment and control conditions does not guarantee that they will comply with their assignment.**
- **Non-random attrition can undermine validity.**
- **Selection and attrition issues need to be managed carefully.**

Alternative approaches to incorporating randomization

- There are alternative ways to build in randomization to reduce bias associated with self-selected trials.

- Assuming the population of interest is those customers who volunteer for the treatment, alternative approaches include:
  - Oversubscription methods
  - Random assignment of volunteers to start dates or treatment phases.

Another alternative: Randomized encouragement designs

- Rather than randomize over the intervention itself, randomly manipulate encouragement to participate (or discouragement from dropping out).
- REDs are particularly useful when the effects of both participation and outreach are of policy interest.
- Effectiveness of this design depends critically on the effectiveness of the encouragement.
- Population of interest: households who participate in the program when encouraged.

WE LOOK FORWARD TO SEEING YOU BACK HERE ON THURSDAY APRIL 22 FOR THE 2ND DAY OF THIS WEBINAR