
U.S. Department of Energy's Smart Grid Investment Grant Program: Dynamic Pricing & Consumer Behavior Studies Webinar *Day 2*

April 22, 2010



Agenda – Day 2

- **Introductions and webinar objectives (5 min.)**
- **Considerations for well-designed consumer behavior studies (90 min.)**
- **Technical advisory groups (10 min.)**
- **Consumer behavior study plan (10 min.)**
- **Reporting requirements (10 min.)**
- **Final comments (5 minutes)**



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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**



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Overview

- **What are the benefits of random assignment?**
- **How should the experiment be designed?**
 - **Mandatory Participation**
 - **Optional Participation**
- **How can I design my experiment to minimize selection bias and other biases?**
- **How large of a sample do I need?**
- **What kinds of recruitment efforts should I consider?**
- **What are my data requirements and collection methods that I should employ?**
- **What should be included in my analysis plan?**



Benefits of Randomization

- The ideal approach for making a causal inference about a treatment's impact on an outcome of interest.
- With randomization over a large sample, the treatment group is statistically equivalent to the control group in every facet but one: the treatment group gets the treatment.
- Since the groups are *not* statistically different, estimates of treatment effects obtained from *randomized trials have no bias*.
- Randomized trials are transparent, simple to explain, and highly credible.



Mandatory vs. Optional Participation

Most recipients are considering one of two different forms of experimental design:

- 1. With *mandatory* participation (SGIG FOA preference), all customers in a geographic area are in the experiment and cannot opt-out or leave during the experiment.**
- 2. With *optional* participation, customers have the choice to be in or out of the experiment and may have the ability to leave during the experiment.**

Whether you use mandatory or optional participation depends on which situation you want to learn about.



Randomization Can Be Used For Both

- Randomization works with *both* mandatory and optional participation.
- With mandatory participation, the treatment is assigned to a randomly selected subset of the total population of interest.
- With optional participation, randomization can be done at different levels (i.e., offer or within the group of volunteers) depending upon what research questions are being asked.



Treatment and Control Groups

- In both cases, the group is randomly divided into customers who receive the treatment (the “treatment group”) and customers who do not (the “control group”).
- Same holds for multiple treatments.
- The *effect* of the treatment is measured by comparing outcomes between the treatment group(s) and control group.

Isolating Treatments

- It will be interesting to learn about the interactions between different treatments (e.g. CPP plus programmable thermostats).
- To identify whether the effect measured is truly an *interaction* effect, it is important also to run treatments with each of the factors separately (e.g. CPP only and programmable thermostats only).

CPP and PCT (Both Treatments)	CPP without PCT (One treatment)
PCT without CPP (One Treatment)	No CPP; No PCT (Control Group)

- This permits us to answer the following types of questions:
 - Do programmable thermostats have different effects when consumers are on OR not on dynamic pricing?
 - What would be the effects of installing programmable thermostats without dynamic pricing?



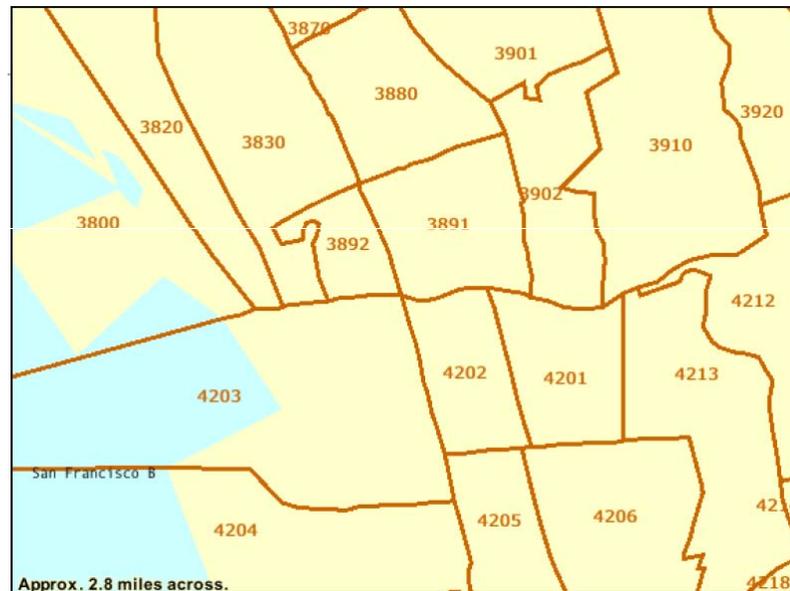
Smart Meter Saturation

- Smart meters should first be installed for *all customers*, including both the treatment and control groups.
- Program evaluation depends on comparing outcomes between these two groups, so complete data is needed from both.



Customer Level Randomization

- Randomization should be done at the customer level, not at the neighborhood level



- Every customer in the sampling frame should be equally likely to be assigned to treatment groups

Attrition and Selection Bias

- Attrition can undermine the initial random assignment by introducing selection bias
- Experiments can be designed to minimize attrition, consider offering:
 - First-year bill protection
 - Shadow bills during the first year
 - Customer education regarding how to benefit
 - Subscription/retention bonus
- *If your goal is to study attrition behavior, do not employ attrition reduction measures that you would not use in actual operation*
- Customers initially assigned to the control group should not be allowed to switch to the treatment group.

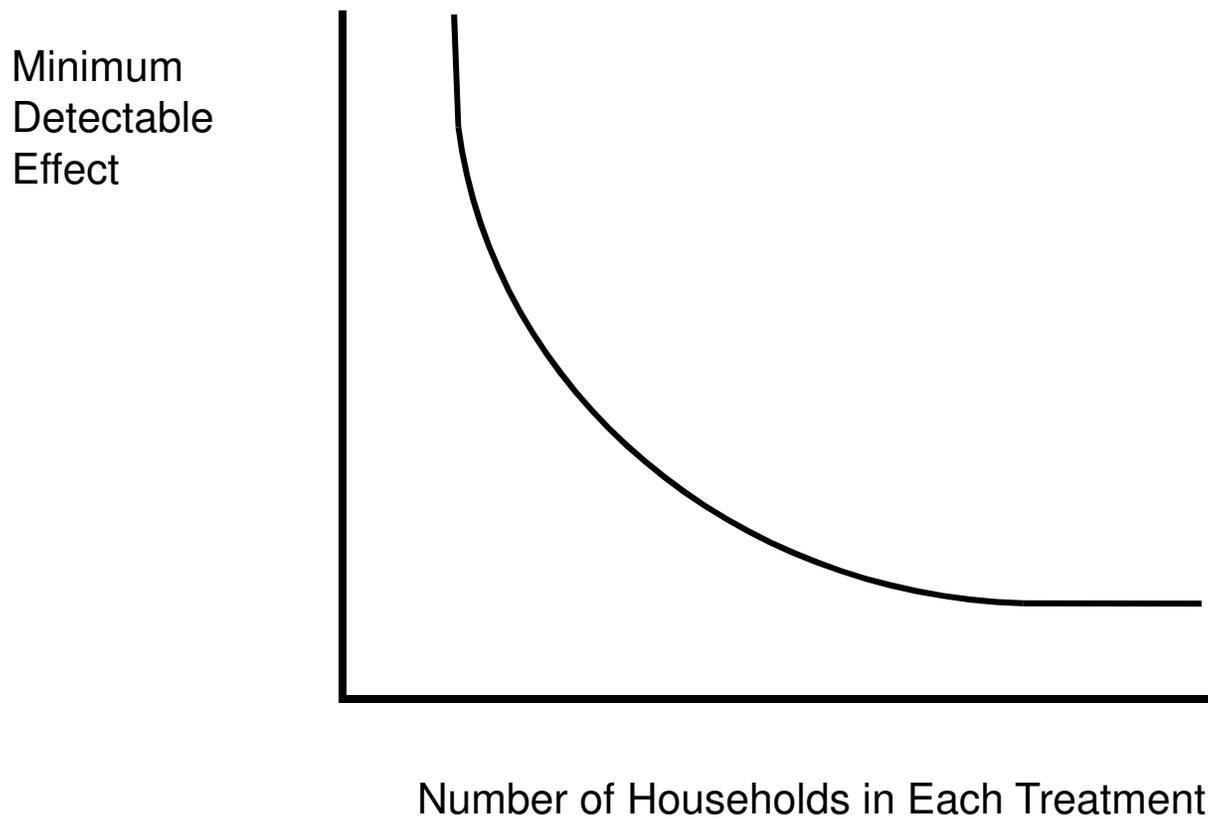


Statistical Power

- Even the best experimental designs can be undermined by a small sample size.
- Some of the effects we are interested in are important, but small in magnitude.
- *It is vital to employ sample sizes within experimental cells that are large enough to detect meaningful differences*
- The ability of a sample to detect a certain minimum difference is called its **statistical power**.
- A sampling statistician can help you identify sample sizes required to achieve reasonable statistical power.
- There is a tension between the *number* of treatments and statistical precision.



Minimum Detectable Effect



Recruitment Strategies

- **Recruitment consists of the enrollment process and, for voluntary options, the marketing/retention strategies employed**
- **Three basic enrollment models**
 - **Mandatory assignment (in theory, 100% enrollment)**
 - **Opt-out enrollment (>50% enrollment is feasible)**
 - **Opt-in enrollment (could range from very low up to 30-40%)**
- **Selection and attrition are threats to validity in all voluntary enrollment models**
 - **Selection refers to customer decisions to opt-in or not opt-out when an offer is made**
 - **Attrition refers to customers who drop out after experiencing a treatment for some period of time**
 - Conscious decisions to leave based on treatment experience
 - Customers who drop out for other reasons (e.g., normal churn, loss of eligibility)



Mandatory Enrollment

- Treatment and control groups randomly assigned
- No recruiting required—customers are not given a choice
- For technology options, it may not be possible to achieve mandatory enrollment
 - You can't force someone to have a PCT installed and installation/communication barriers often exist
 - Not everyone may be eligible for the technology of interest
- Interesting issues remain unresolved
 - Impact of first year bill protection on customer satisfaction and future performance
 - Impacts of information and support on customers' willingness and ability to respond
 - Impacts of enabling technologies on customer response



Opt-Out Enrollment

- **Customers randomly assigned to treatment and control groups**
- **Treatment group customers are told they are enrolled in the tariff unless they proactively opt-out**
 - **A significant percentage of customers may/will opt out— therefore, you must control for both selection and attrition**
- **Approaches to minimizing opt-outs are controversial and there is a significant opportunity to advance the state of the art by testing them**
 - **First-year bill protection**
 - **Shadow bills during the first year**
 - **Customer education regarding how to benefit**
 - **Subscription/retention bonus**
- **A key guideline is to not do something during the pilot that:**
 - **Adversely and substantially influences customers' incentives to respond**
 - **Significantly affects your ability to extrapolate the results after the pilot**



Opt Out Enrollment (2)

- **Planning for, and addressing, selection and attrition bias is a critical element of experimental design**
- **One way of maintaining internal and external validity in the presence of selection/attrition is through “intention-to-treat” analysis**
 - **Include loads for customers who opt out in the treatment group when estimating impacts—the average impact represents all customers who were offered treatment, not just those who accepted treatment**
 - **If treatment effect is small and opt out rate is large, impact may get lost in the “noise” but evidence to date suggests this shouldn’t be a problem when estimating rate impacts for residential customers**



Opt-in Enrollment

- **Customers randomly assigned to treatment and control groups**
- **A significant percentage of customers will not opt in, and some of those who do will later opt out, so selection and attrition must both be addressed**
- **Approaches to minimizing opt-outs are controversial and there is a significant opportunity to advance the state of the art by testing them**
 - **First-year bill protection**
 - **Shadow bills during the first year**
 - **Customer education regarding how to benefit**
 - **Subscription/retention bonus**
- **A key guideline is to not do something during the pilot that:**
 - **Adversely and substantially influences customers' incentives to respond**
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Opt-in Enrollment (2)

- **Suitable control groups can be developed by withholding treatments from randomly selected volunteers**
 - Create an oversubscription
 - Delay treatment for control group by one year
 - Assign to treatment and control groups using an instrumental variable and employ regression discontinuity analysis
- **Intention-to-treat analysis may be a less likely possibility because the impact is more likely to get lost in the noise if enrollment rates are small**



Marketing Strategy

- **Marketing strategy can significantly impact enrollment rates for opt-in enrollment**
- **Marketing strategy can be an important treatment factor to be tested**
- **New information has recently become available concerning the relative effectiveness of various marketing features**
- **If you are not planning to test different marketing options, at least consider using features that will maximize opt in enrollment based on what is currently known and on what you would consider doing if you were to roll out the tariffs to all customers**
 - **It is quite realistic to expect 10 to 20% enrollment rates for opt-in even using direct mail and ~30% enrollment may be possible if you are willing to consider non-traditional (for utilities) methods such as telemarketing or in-person recruitment**



Key Marketing Decisions

- **Direct mail, telemarketing, in-person marketing**
- **Sign up incentives**
 - **Modest marketing incentives; not paying customers to be in the experiment**
- **Message**
 - **Bill savings, environment, etc.**
- **First year bill protection**
- **Multiple touches**
- **Format of marketing material**
 - **Glossy brochures versus business letter**
- **Targeting strategy**
 - **Analysis designed to identify high use or a/c households so as to maximize enrollment rates and/or minimize marketing costs**
 - **Targeting households that are on other programs (e.g., DLC) that have higher propensities to enroll**
- **Timing**
 - **Take rates may be higher pre-summer than in late summer**



Data Requirements Vary With Research Objectives

- **Impact estimation requires**
 - **Usage data, weather data, customers characteristics information**
- **Understanding changes in customer behavior requires**
 - **Data on behavioral patterns before and after treatments are in effect**
- **Understanding variation in customer acceptance requires**
 - **Tracking options and marketing features offered and take rates**
 - **Characteristics of customers who enroll as well as those who are offered treatments and decline**



Data Required for Almost All Studies

- A population file containing the complete population of customers who are eligible for test
 - This file should contain readily obtainable information describing each customer (e.g., customer segment, building type, usage, location, current tariff)
- A sample file containing the customers who were sampled along with an indicator of the treatment groups to which they were assigned
- Hourly interval measurements of kWh for at least one year or season (for seasonal rates) **before and after treatments** are in effect
- Hourly weather station measurements
- Customer surveys to determine characteristics of treatment and control customers
- Operations data (i.e., the details of the price changes that customers experienced, event timing, number and type of notification options for each customer, successful notifications, etc.)



Hourly Interval Measurements

- Two major applications for hourly interval measurements:
 - Sample design and sampling
 - Impact analysis
- Hourly interval data has a pooled cross **sections** and time series structure (it is a panel measured over time)
 - Sampling for repeated measures should be assumed and prior measurements of hourly loads are required to do this
 - Sample design and sampling also require hourly data on a representative sample of customers to estimate variations within and among customer groups, which influence required sample sizes
 - Pre- and post-measurements of hourly loads for one year or one season prior to and after treatments are in effect



Hourly Interval Measurements (2)

- **Do not assume that hourly interval data is automatically being recovered and stored during the pre-test period. Assume the opposite.**
 - **Make certain that systems are recovering interval data**
 - **Do quality assurance checks on this data as it is being retrieved**
 - **Provide feedback to operations as required.**



Weather

- **Peak period loads are usually weather sensitive and variations in ambient temperature (and in many locations, humidity) must be taken into account in analyzing customer responses to dynamic pricing**
 - **Hourly NOAA weather station measurements**
 - **For the closest weather station to each customer**
 - **For all time periods involved in the test (i.e., pre and post)**
- **If load impacts are to be estimated for “normal” or “extreme” weather conditions, a long time series of weather data will be required to determine what weather should be used to represent these conditions**



Customer Survey Data

- **Survey data is needed for several purposes**
 - Obtaining information on customer characteristics
 - Controlling for selection and attrition in treatment enrollment
 - Measuring changes in customer behavior (if of interest)
- **Survey response bias is a serious problem that must be addressed**
 - It is as important to good experimental design as is addressing selection and attrition bias among treatment customers
 - Even with mandatory treatment, you can't force people to answer surveys; experimental validity can easily be threatened through survey response bias



Customer Survey Data (2)

- **Response rates in excess of 90% are required to safely ignore response bias**
 - **Typically achievable only through in person surveying (going door to door)**
 - **When response rates are less than 90%, selection must be affirmatively ruled out—that is, you must take steps to determine if response bias exists**
 - Assess bias from other available data
 - Conduct in person surveys on small sample to assess bias
 - **Incentives to respond to surveys should be considered**
 - **Well designed mail surveys typically have higher response rates than telephone surveys —poorly designed mail surveys can have very low response rates and high potential for significant bias**



Operations Data

- **When events occur (dates, times if variable, etc.)**
- **Number and type of notification options for each customer**
 - **Recent data shows that impacts are much higher for customers that are provided multiple notification options**
- **Success rates for each notification option for each event**
- **For RTP options, hourly prices for each day**



Marketing Data

- **Marketing offers made to each customer**
 - **Treatment offered**
 - **Marketing features used (message, incentives, etc.)**
 - **Touch (e.g., did customer accept on first offer, second offer, etc. if multiple offers made)**
 - **Each customer's decision (and overall take rates)**



Issues Affected By Analysis Plan

- **Key research design activities are influenced by the analysis plan**
 - **Statistical precision obtainable from sampling**
 - **Ability to detect differences -- power**
 - **Sample design**
 - **Design of experimental conditions**
 - **Survey sample design and survey content**
 - **Data collection requirements**
- **The analysis plan should both determine and take account of other aspects of the study design**
- **It should be thought about up front, not after the fact**



Key Issues in Analysis Plan

- **How will changes in consumer behavior be analyzed?**
- **How will changes in consumption be detected and described?**
- **How will the effects of selection and attrition be identified and controlled?**
- **How will impacts of marketing efforts be analyzed?**



Impacts on Electricity Consumption

- **All experiments anticipated under this program will study consumer responses to time varying pricing measured by smart meters**
 - **Hourly (or sub-hourly) usage data (kWh)**
 - **Most designs require data for both the treatment period and prior to the treatment period for both control and treatment customers**
 - Lack of pretreatment data can significantly increase required sample sizes for the same level of precision
 - **Regression analysis is the standard approach to impact estimation**



Impacts on Electricity Consumption

The analysis plan should specify:

- **The basic statistical or econometric approach that will be used to quantify differences in electricity consumption between experimental conditions**
 - For example, panel regression models with fixed effects for time and variable effects for the treatment and weather
- **The variables that will be analytically controlled for**
 - Weather, customer characteristics, seasonal/day-of-week/time-of-day effects, etc.
- **Whether or not selection and attrition are expected to occur and how possible biases induced by these problems will be observed or controlled.**
For example --
 - Intention to treat analysis (including treatment customers who opt out in the “treatment group” for estimation purposes so impact reflects the average of those who stay on the treatment and those who opt out)
 - Randomized exposure to treatment within volunteer groups to assess the impacts within the volunteer population
- **How interactions between pricing designs, marketing strategies and enabling technologies will be quantified**



Impacts of Marketing Strategies

- **Marketing details can dramatically affect enrollment**
 - For example, empirical results from recent studies indicate that modest marketing sign up incentives can more than double enrollment rates
 - Other recent results have found dramatically different enrollment rates from direct mail (3 to 5%), telemarketing (20%) and in person sales (37%)
- **If variations in marketing strategy are part of the study, how will differences in customer response be described?**
 - Raw difference in response rates
 - Econometric analysis of the impacts of offer and customer characteristics on the likelihood of enrollment (e.g., logit regression)
- **The analysis plan should indicate the statistical or econometric models that will be used to assess the effects of alternative marketing strategies**



Impacts on Consumer Behavior

Analysis plan should specify:

- The consumer behaviors that will be observed
- If surveys, diaries or other invasive techniques are used, how panel conditioning effects will be avoided
 - Panel conditioning effects refer to behavioral changes resulting from the fact that people know they are being observed or because of frequent reminders that result from the process of data gathering
- The types of questions that will be asked
 - It is much better to ask customers what they are doing before and after a treatment goes into effect, than to ask them what changed
- The basic statistical or econometric approach that will be used to quantify changes in consumer behavior (e.g., multinomial logit model)
- The variables that will be analytically controlled for if any (e.g., housing type, occupancy patterns, household income, etc.)
- Whether or not selection and attrition are expected to occur and how possible biases induced by these problems will be observed or controlled (e.g., regression analysis, synthetic control groups, other)
- How interactions between pricing designs, marketing strategies and enabling technologies will be quantified.



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Technical Advisory Group

Roles and Responsibilities

- **Each SGIG recipient will have a TAG assigned to:**
 - **Review the technical details, provide constructive feedback and offer targeted suggestions for improvement of the Consumer Behavior Study Plan**
 - **Work collaboratively to ensure final Consumer Behavior Study plan is acceptable to both the recipient, DOE and (to the degree possible) the recipient's authorized regulatory authority**
 - **Meet periodically throughout the consumer behavior study to review progress, discuss issues or concerns, and brainstorm with recipients on ways to address these issues or concerns**
 - **Review and provide feedback on interim and final evaluation reports**



Technical Advisory Group

Organization and Members

- **TAGs will be comprised of 3-4 individuals**
 - 1 Coordinator – Main liaison between TAG and recipient
 - 2-3 Members – Individuals with specialized skills in statistics, experimental design, economics, rate making, Smart Grid technology, information feedback, etc.
- **We have engaged a team of industry experts with national reputations in their respective fields**
 - **Consultants**: FSC Group, The Brattle Group, KEMA, Regulatory Assistance Project, Theresa Flaim, Roger Levy
 - **Academics**: UC Berkeley Energy Institute at Haas, Dr. Ben Hobbs (John Hopkins), Dr. Richard Feinberg (Purdue University)
 - **National Lab**: LBNL



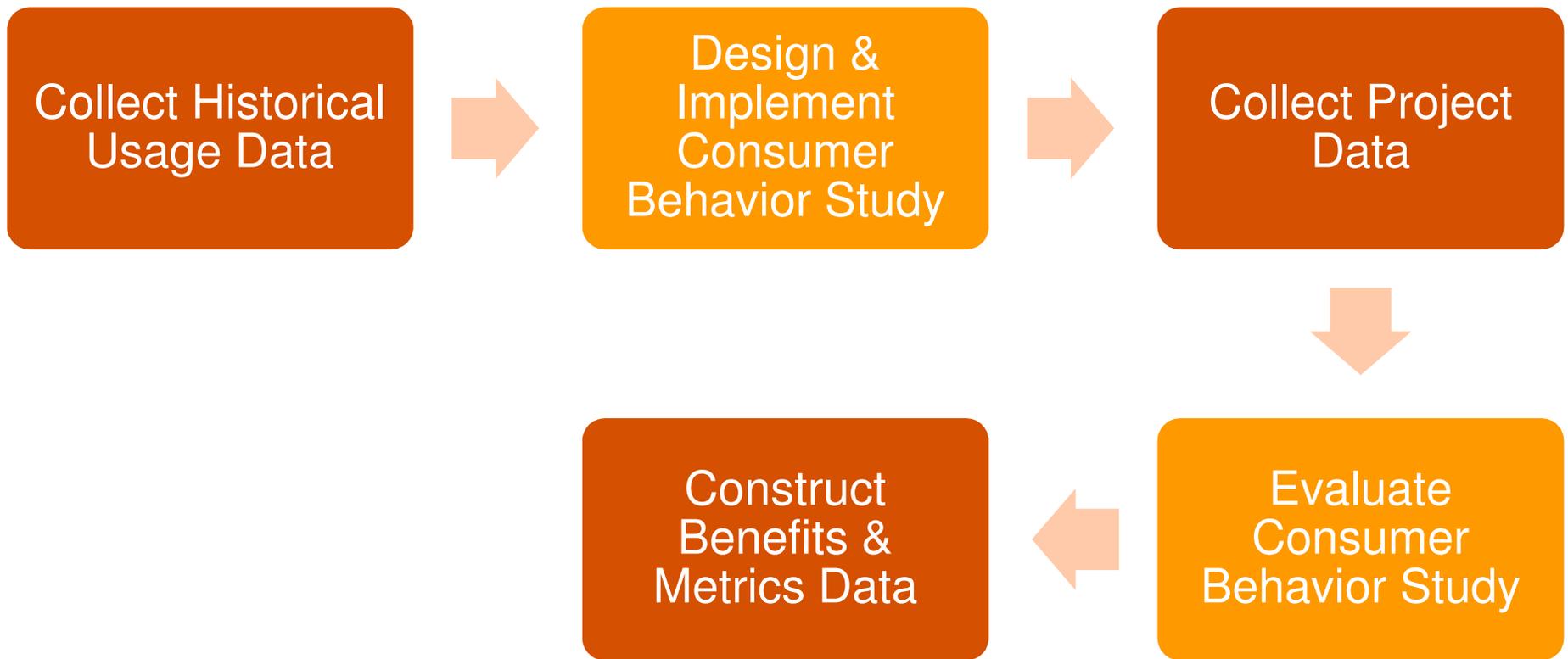
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Consumer Behavior Study Project

General Process Flow



Consumer Behavior Study Plan

Development

- **Each Project Team that agrees to pursue a consumer behavior study of dynamic pricing will be expected to produce a **Consumer Behavior Study Plan****

 - **Identifies key project design components**
 - **Describes how the project will be implemented**
 - **Indicates how the project will be evaluated**
 - **Provides a detailed assessment of how data reporting will take place**



Consumer Behavior Study Plan

Content: Key Program Design Elements

- **Identify specific research questions and hypotheses**
- **Describe the target population and sample and how this sample will be developed**
- **Describe how customers will participate (e.g., opt-in, opt-out, randomly assigned) and be assigned to control and treatment groups that will be represented**
- **Describe the specific rate design(s), enabling technologies, and information feedback approaches if any, that will be tested and controlled for**



Consumer Behavior Study Plan

Content: Project Implementation

- **Provide a milestone schedule for the implementation phase of the project, including expected dates for obtaining regulatory approval and for submitting the draft Evaluation Report**
- **Describe how the target sample will be maintained throughout the duration of the project**
- **Describe the data collection process that will be required for the subsequent evaluation**



Consumer Behavior Study Plan

Content: Program Evaluation

- **Describe the methodology that will be used to evaluate the key research questions**
- **Describe the data requirements to complete the evaluation**
- **Describe what kinds of information will be reported as an output from the evaluation**



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Reporting Requirements

Overview

- **Each SGIG recipient will be responsible for providing the following information to DOE:**
 - **Interim and Final Evaluation Reports**
 - **Project Data (primary data)**
 - This is a comprehensive data set that serves as the foundation for the evaluation effort and is used to construct the Benefits & Metrics data
 - **Benefits & Metrics Data (secondary data)**
 - Metrics **specific to the consumer behavior studies** are being requested of each Project Team to be reported
 - Outputs from the program evaluation effort



Interim and Final Evaluation Reports

- **Two different evaluation reports should be provided to DOE**
 - **Interim (~12 months into study)**
 - Provided to illustrate what has been learned thus far
 - Indicate if any changes in design are required to address observed issues
 - **Final (Upon completion of study)**
 - Provided to summarize overall key findings and lessons learned

- **The Evaluation Reports should contain at a minimum:**
 - **Overview of the project and its goals**
 - **Description of how the project was designed and implemented to achieve these goals**
 - **Synopsis of the evaluation framework and methodology**
 - **Summary of the results and lessons learned**



Data Reporting Requirements

Overview

- **DOE has a desire to make available to the public as much data as possible, especially **the primary data** used by project teams to evaluate their own consumer behavior studies**
 - **Allows for analysis by outside entities (e.g., academics, utilities, consultants)**
 - **Enables cross-sectional (inter-project team) analysis of trends (e.g., understanding what drives common results across projects and unique results of individual projects)**
 - **Provides an opportunity to ask new and different questions of the data**



Data Reporting Requirements Process

The screenshot displays the SmartGrid.gov website interface. At the top, there is a navigation bar with links for 'About Smart Grid', 'Task Force', 'Stakeholders', 'Books', 'Resources', 'News/Events', and 'Contacts'. Below this, a breadcrumb trail reads 'Home > Information for Smart Grid Project Teams'. The main heading is 'Information for Smart Grid Project Teams'. A paragraph of text explains that the website provides reporting requirements, project development resources, and data management tools, funded by the DOE's Smart Grid Investment Grant and Demonstration programs. The page is organized into three main columns: 'Project Reporting' (containing links for Data Hub, FederalReporting.gov, VIPERS, and SIPRIS), 'Projects' (featuring a map of the United States with project locations and lists for Investment Grant Programs and Demonstration Projects), and 'Project Resources' (listing various PDF guides, forms, and reports, along with a 'Webinars' section).

- **SmartGrid.gov will serve as the portal to the data hub**
- **More detailed information will be provided as the capabilities are fully developed**
 - **File formats**
 - **Security protocols**
 - **Data transfer methods**

Data Reporting Requirements

Content

- **Project Data**

- **Customer-level hourly interval data**
 - Electricity usage
 - Tariff pricing (i.e., retail rate level in effect)
 - Weather (e.g., dry bulb, wet bulb, THI)
- **Customer characteristics**
 - Demographic
 - Structural

- **Historical Usage Data**

- **Hourly (or monthly) customer-level data**
- **Ideally covers period 12-18 months prior to commencement of study**
- **Ideally similar content as Project Data**



Data Reporting Requirements

Content (2)

- **Benefits & Metrics Data**
 - **Customer-level (or customer-cohort level) Impact Metrics**
 - Elasticity measurements
 - Effects on peak demand
 - Effects on annual consumption
 - **Customer (or customer-cohort) characteristics**
 - Retail electricity rate
 - Demographic
 - Structural



Data Reporting Requirements

Timing

- **Historical Usage Data**
 - Ideally, this would be submitted early in the study
 - Timing will be limited by when the system gets up and running

- **Project Data**
 - At completion of preliminary evaluation effort and final evaluation effort

- **Benefits and Metrics Data**
 - At completion of preliminary evaluation effort and final evaluation effort



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THANK YOU!

