This paper discusses the major applications of customer surveys in the electric utility setting. We also discuss sampling methods for customer surveys, because these methods can impact the effectiveness of the various survey applications. We compare some of the advantages and disadvantages of the most popular sampling methods. The figure below shows the survey applications discussed in this paper.

1 Jeff Smith can be contacted at smithj@powersystem.org, Steve Fenrick at fenricks@powersystem.org, and Chris Ivanov at ivanovc@powersystem.org.
1. **Energy Efficiency and Demand Response**

Survey data can be used assist with the investigation, evaluation, and optimization of energy efficiency (EE) and/or demand response (DR) programs.

**EE/DR Investigation**

The number and vintage of end-use appliances on an electric system is a key element affecting a given program’s potential to reduce energy sales or peak demand. Residential end-use appliance surveys can be used to determine this data, as well as gauge consumer willingness to participate in EE and DR programs.

Because household attributes and customer attitudes will impact the performance of any EE or DR effort, surveys are a key input into determining the potential of any contemplated program. This potential is typically broken down into three categories.

1) **Technical potential** is the maximum amount of energy or demand response that DR/EE programs could provide, regardless of the benefits and costs of each program. For this category, we assume that all customers who could enroll in the programs do in fact enroll.

2) **Economic potential** shows how much DR/EE potential is achieved if we implement all programs which have monetary benefits that outweigh costs, and only such programs.

3) **Achievable potential** displays how much DR/EE benefit is reasonably achievable within a given time frame (given such practical factors as consumer participations rates, etc.).

![Figure 1: Demand Response Program Potential](image-url)
One possible example of the role of a survey is when an electric utility is investigating the demand reduction potential of a direct load control program. To determine the technical potential of this program, the number of appliance units on the system would need to be estimated through a representative survey. *The better the survey data, the more accurate the cost-benefit models will be.* These surveys will also show how different programs will have different impacts on the utility’s finances.

**EE/DR Evaluation**

Surveys are also valuable in the evaluation and optimization of DR/EE programs. For example, PSE has researched demand response programs involving dynamic pricing arrangements (e.g., peak time rebates, critical peak pricing). We have found that the more a consumer is predisposed to having environmental and “green” concerns, the larger their demand impact will be (on average). This has implications not only on the potential impacts of the program, but also on optimizing program value, by allowing more aggressive marketing to those customers with these attitudes.²

**EE/DR Optimization**

Surveys can be used to gauge the customer satisfaction with a certain DR/EE program and provide the utility with insights on system-wide acceptance and overall reaction to the program. Such a survey will identify strengths, and it can also help identify cost-efficient modifications that will enhance the program’s value and consumer experience.

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² PSE has written a separate white paper on how this type of analysis can improve a utility’s ROI for their DSM program Steve Fenrick, Jeff Smith, and Chris Ivanov. “Demand Response Pricing Programs: Maximizing Value of a System Roll-out.” Power System Engineering White Paper, August 2011. Please contact us if you are interested in obtaining a copy.
II. Load Research & Load Forecasting

One of the key factors for engineering and financial planning is an understanding of the underlying conditions that drive electric loads. This understanding can be broken into two pieces: load research (understanding historically how loads have performed), and load forecasting (a prediction of how loads will behave in the future).

Load Research

Load research has historically relied on customer survey data to inform placement of end-use meters. Although this is still a useful application, more and more utilities are installing AMI systems, which make end-use meters unnecessary. Utilities can then combine residential survey data with AMI data. When used to inform econometric models, utilities can produce load shapes for end-use appliances (e.g. AC, electric water heaters) without directly metering those appliances. Furthermore, these models can be applied to produce coincidence factors for appliances, by rate classes and by geography. This is a valuable tool for both load research and distribution and transmission planning.3

Additionally, surveys are important to load research from the rate making perspective. They are important to developing meter placement locations by stratified class, which will inform demand estimates. These estimates affect every rate class because the aggregate pool of utility costs will be spread among all customers. This allocation will be dependent on estimating all billing determinates fairly and accurately.

Load Forecasting

Typically, load forecasts for a utility will take one of two forms: econometric or end-use. Both kinds of forecasts represent a sales forecast, which will be improved if a utility can understand its historical data. This will impact both the finances of the utility and its capacity planning for the future. Both the econometric and end-use approaches rely on surveys to improve their accuracy.

The econometric approach uses survey data in its models, through the creation of independent variables. These variables could represent the effects of appliance saturation or energy efficiency measures. For example, rather than using only Cooling Degree Days (CDDs) as a proxy for the weather impacts on air conditioner use, a utility can use econometric models and survey data to determine saturation rates of various appliances (such as AC units, dehumidifiers, electric heat or electric water heaters). Forecasts can then combine CDD and saturation data in composite variables and these models will generally be more accurate than those using proxies such as CDDs.

End-use models also rely heavily on surveys. These models take the end-uses of electricity of a rate class and sum them to arrive at the total sales for that class. Survey data provides the correct end-use figures to include for each class. As government mandates and appliance standards change, the easiest and most straightforward way to capture potential changes in a load forecast is to develop end-use models.

III. Customer Satisfaction & ACSI Scoring

Surveys can also facilitate and increase customer satisfaction and loyalty. ACSI scores are an easy way to gauge customer satisfaction. With just four questions answered by a few hundred of your customers, you will have a quantified value of your utility’s customer satisfaction. ACSI scores are unique in that they can be used to compare your utility both to your industry peers and to other companies outside the electric utility industry.

More importantly, ACSI scores can measure customer satisfaction trends. This information can be used to continue and reinforce an upward trend, or reverse a downward one. In the end, utility management wants happy and satisfied customers. Quantifying customer satisfaction can provide management with a key metric that staff and managers can utilize.

In a broader business environment, the utility customers’ experience is manifested in three distinct ways: Through the electricity bill they pay (rates), through the reliability they experience, and through the customer service they receive. All of these elements will impact their satisfaction with their electric utility. To properly evaluate your customer service programs and your customer satisfaction, it is important to identify the impact that rates and reliability changes have had on the customer satisfaction scores. This knowledge will allow your utility to maximize value for the customers, which will in turn build customer good will.
IV. T&D Planning

Survey data can be useful to transmission and distribution (T&D) planning in a couple of ways. The first is through spatial load forecasting. Spatial load forecasting predicts the future loads on a utility’s substations and feeders. Spatial load forecasting uses end-use appliances to inform the models (just as system-wide load forecasting does). This end-use information provides T&D planners with knowledge of subsystem attributes and trends that are driving future capacity needs.

The second important use of survey data for electric utilities is determining the value of reliability through a “Value of Service” study. End-use customers demand a low cost but highly reliable system. These conflicting demands require the T&D planner to make trade-offs between reliability and cost. Properly designed surveys can provide estimates of where the extra costs of increasing reliability equal the value placed on it by customers.

For example, say a survey is conducted and, on average, a utility’s customers were found to be “willing to pay” $10 per year to reduce outages by 10 minutes. When evaluating an investment (e.g. smart feeder switching) or a process change (e.g. tree trimming or pole inspection cycles), the costs and anticipated benefits of the investment/process change should not exceed the ratio of $10 per 10 minutes of duration time avoided. Obviously, every system’s customers will be different, which will cause the demand for reliable service to vary from one utility to the next. Surveys help capture how much value your customers place on reliable service.
Why Choose an Expert to Design your Survey?

One aspect of survey design that requires expert attention is the sampling method. Proper sample methodology will minimize data collection and analysis costs, as well as potential bias. A properly designed survey with questions phrased and ordered correctly will allow the utility to develop accurate conclusions that can be confidently applied to the entire system.

**Sampling methods**

If the sample selected is biased and not reflective of your system, the findings cannot be applied to your entire population, thus nullifying your efforts. Decisions made using inaccurate findings can have serious negative impacts, so accurately reflecting your population is the primary concern in drawing any sample. Below is a brief description of several popular methods.

- **Simple or systematic random samples** are the simplest methods in many cases. These methods select samples by picking observations at random, or by picking every \( n \)th observation. In order to adequately capture all variance and be representative of that population, random samples are comparatively large. While easy to implement, their increased size adds costs to data collection efforts.

- **Stratified random samples** are an effort to minimize the sample size (cost) and maximize the representation of a population (efficiency). The population is broken into several groups, or strata, based on a known dimension (e.g., annual usage in kWh). Unlike random sampling, stratified sampling represents the variance within the population (rather than the population itself) and requires adjustment prior to interpretation - increasing administrative costs. While more complicated and costly to put together and interpret than simpler methods, this is the most efficient option and results in the smallest available sample size for any given level of acceptable error. Therefore, this method has the lowest data collection costs.

- **Cluster samples** break the population of interest into groups based on physical location. Ideally, each cluster is a miniature representation of the entire population, and a random selection of one or more clusters is made for the sample. For studies where data collection costs are high (such as where one-on-one interviews are required, or where equipment must be installed within a sprawling service area), this method offers a potentially lower cost alternative than random, systematic or stratified sampling, with the tradeoff of low efficiency.

**Bias & Collection**

Question order and phrasing can influence how a respondent completes an answer. Careful ordering and wording of questions is necessary to minimize bias and allow for accurate modeling that can be applied to your system. Another source of potential bias is the method chosen to collect data. While mail surveys can be less costly, they are accompanied by a lower response rate. Phone surveys, on the other hand, while having a higher response rate, are more expensive to administer. Compounding the downside of phone surveys is the current trend away from land-line phones, rendering a large section of many utilities’ customers impossible to reach by phone.\(^4\)

\(^4\) The Center for Disease Control (CDC) released survey results in May 2010 where they found 24.5% of all households lack a landline telephone. This distribution is heavily skewed toward homes below the poverty line (36%), renters (40%), and the 25-29 year-old demographic (50%), making these groups the toughest to reach by
### Table 1: Sampling Method Advantages

<table>
<thead>
<tr>
<th>Survey Method Advantages &amp; Disadvantages</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phone Survey</strong></td>
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<td></td>
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<tr>
<td></td>
<td>- Quicker than mail</td>
<td>- More expensive than mail</td>
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<tr>
<td></td>
<td>- Can clarify questionable responses</td>
<td>- Question clarification can lead to measurement bias</td>
</tr>
<tr>
<td></td>
<td>- 40-80% response rate which is higher than mail surveys</td>
<td>- Older customers and women more likely to respond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Recent collapse in presence of landline phones in households, as well as the establishment of “do-not-call” lists, makes contact of certain household impossible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The Department of Energy recommends telephone survey methods be avoided unless accurate telephone contact information is available for all participants during enrollment 5</td>
</tr>
<tr>
<td><strong>Mail Survey</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cheaper than phone</td>
<td>- Slower than phone</td>
</tr>
<tr>
<td></td>
<td>- More private &amp; discreet than phone surveys, leading to higher response rates and more accurate responses to personal questions</td>
<td>- 25-40% response rate lower than phone surveys</td>
</tr>
<tr>
<td></td>
<td>- Easier for a utility to contact any given account than by phone</td>
<td>- Respondents tend to be at the extremes of extremely satisfied/dis-satisfied, under-representing the more neutral respondents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Older customers and women more likely to respond</td>
</tr>
</tbody>
</table>

These factors generally mean mail surveys are a favored source of information for companies such as energy utilities that have comprehensive billing address information on their customers. The Department of Energy recommends that information not be collected by means of phone in most circumstances.6

**Sample Selection Comparison**

To present an idea of the tradeoff between a random and stratified sample, an illustrative example is presented below. The example assumes a population of 15,000 customers, with energy usage between 1,000 kWh and 120,000 kWh per year. This kWh usage, as in most utility examples, is heavily skewed to the lower usage end.

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6. IBID
Table 2: Sample Size Comparison

<table>
<thead>
<tr>
<th>Sample Size Required by Various Sampling Methods</th>
<th>Hypothetical example with Population = 15,000; Range = 1,000-120,000 kWh; Mean = 18,850 at 5% error at the 95% confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Required Sample Size</td>
<td>Simple or Systematic Random Sample</td>
</tr>
<tr>
<td>Sample Mean</td>
<td>375</td>
</tr>
<tr>
<td>Sample Standard Deviation</td>
<td>18,850</td>
</tr>
<tr>
<td>14,952</td>
<td>3,651</td>
</tr>
</tbody>
</table>

Any method should be carefully chosen with consideration to the balance of accurately reflecting the population (efficiency) while at the same time minimizing the costs of data collection. As can be seen, the stratified sample is substantially more efficient as compared to the random samples.

**Data Collection Costs**

The table below expands this example to offer a general idea of the difference in data collection costs based on the sampling method chosen. Assuming that mailed surveys cost $5 per participant (includes printing, mailing, follow-up post card, and labor) and have a 25 percent response rate, while phone interviews cost $20 and have a 40 percent response rate, it can be seen that the stratified sample is significantly less costly.

Table 3: Sample Size and Cost Comparison

<table>
<thead>
<tr>
<th>Sample Size Required by Various Sampling Methods</th>
<th>Hypothetical example with Population = 15,000; Range = 1,000-120,000 kWh; Mean = 18,850 at 5% error at the 95% confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Required Sample Size</td>
<td>Simple or Systematic Random Sample</td>
</tr>
<tr>
<td>Data collection costs at $5 per participant and 25% response rate</td>
<td>375</td>
</tr>
<tr>
<td>Data collection costs at $20 per participant and 40% response rate</td>
<td>$7,500</td>
</tr>
<tr>
<td>$18,750</td>
<td>$2,700</td>
</tr>
</tbody>
</table>

7 This value is allocated precisely across strata, is different for every population, and is dependent upon the variance within each stratum. In this generalization, while each stratum owns an equal share of the total population kWh variance, the higher variance strata represent smaller portions of the overall population (for example, in this example the fifth stratum accounts for 20 percent of the kWh variance but only 3.5 percent of the population - this is reflective of most utility systems). Observations are distributed via Neyman Allocation to the Delanius Hodges stratification method, providing maximum efficiency.
PSE can team with you to design and implement a survey that represents your system and provides your management team with valuable information to support your decisions. With a PSE-implemented survey, you have a powerful tool to help gain a deeper understanding of your system in the most cost-effective way. As shown above, our team can help implement surveys designed to measure specific questions involving energy efficiency, demand response, load forecasting, load research, customer satisfaction, and T&D planning activities.

PSE combines our expert market research capabilities with experts who regularly work with electric utilities on these same issues. Our team is comprised of market research experts, economists, T&D planning professionals, power supply planners, rate/financial experts, and Smart Grid technology experts.

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