Metrics and Benefits Guidance for the ARRA Smart Grid Programs

Guidance for ARRA Smart Grid Program Metrics and Benefits: Hourly Customer Electricity Usage

June 2011

Guidance for ARRA Smart Grid Program Metrics and Benefits		
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Overview of data to be collected and how it will be used

The U.S. Department of Energy (DOE) is collecting data from certain Smart Grid Investment Grant (SGIG) recipients and Smart Grid Demonstration Program (SGDP) participants about the electricity usage of the customers in their project. "Participants" refers to SGIG recipients and SGDP participants for the remainder of this document. DOE intends to use these data to estimate the impacts of the programs on electricity usage – specifically, to understand whether advanced metering infrastructure (AMI), smart-grid related customer systems, direct load control, and time-based rate programs lead to shifts in peak loads and reductions in overall electricity usage.

This document defines the required hourly electricity usage statistics which Participants are to report to DOE, and provides guidance on how to estimate these statistics. It also provides guidance on optional reporting of electricity usage data that has been normalized, whether for weather or other factors, which will be requested of Participants that have load research expertise. Participants engaged in "Consumer Behavior Studies" under the SGIG program are to report the statistics described in this guidance *in addition to, and separate from,* the data, load impacts, and reports that they have agreed to provide in their Consumer Behavior Study Plans.

Background

DOE issued "Hourly Customer Electricity Usage," Guidance Document - A001, on April 21, 2010. Since then, Participants requested that DOE provide additional guidance on the data DOE expects, including options for defining customer classes, treatment groups, and baseline groups. This document addresses these subjects and it supersedes the previous one. Participants should use this document to develop and catalog the steps and assumptions they use to estimate statistics on hourly customer electricity usage. Hourly customer electricity usage statistics are required of all projects reporting this impact metric, and optional normalized hourly customer electricity usage statistics reporting is requested of Participants that have load research expertise.

Glossary of terms

The following are impact metrics referenced and terms used in this document.

Table 1. Glossary of terms for hourly customer electricity usage statistics reporting

Customer class	DOE uses three basic customer classes (residential, industrial, commercial). A Participant may have one or more classes in its project and may define sub-classes within each class, for example, based on the size of the customers (large versus small commercial customers), households' demographic attributes, or geographic location. Projects should exercise care in defining sub-classes because there are trade-offs between the additional insights from studying the variability among sub-classes versus the limited statistical confidence one has in the analytical results from smaller sample sizes.
Hourly customer electricity usage	Amount of electricity used each hour (measured in kWh), by a given customer in the project. Over the course of one year, an AMI meter data management system (MDMS) records 8760 electricity usage data points (one for each hour of the year). This document provides guidance on the statistics required of all projects reporting this impact metric, as well as the optional data reporting requested of Participants that have load research expertise.
Hourly electricity-usage statistics	The statistics, which projects are to report, are the mean (i.e., average) and the standard deviation of hourly customer electricity usage, for each treatment and baseline group in each sub-class of customers.
Treatment	Program and/or technology designed to influence customers' energy consumption decisions, e.g., a time-based rate program, web portal with data on a household's hourly energy use, programmable controllable thermostat, or smart appliance.
Treatment group	The treatment group is a set of customers whom the Participant gives a particular treatment to such as a critical peak pricing tariff or a load control device (in addition to a smart meter). Analogous to the previous comment about defining sub-classes, projects should exercise care in defining treatment groups because there are trade-offs between the additional insights from studying different treatments versus the limited statistical confidence one has in the analytical results from smaller sample sizes.
Baseline	The baseline represents the counterfactual (i.e., what would have happened to those receiving treatment if they had not received it), which is the point of reference for evaluating the change brought about by the treatment.
Baseline group	The baseline group is a set of customers, or data about customers' electricity usage, used to measure or estimate the baseline (i.e., counterfactual). To evaluate change due to SGIG and SGDP AMI implementation, the baseline group may, for example, be a set of customers receiving a smart meter but not participating in a pricing program. In this same example, the treatment group is the group that receives a smart meter and participates in a time-based rate program. The change due to time-based rate program participation is the difference in electricity consumption patterns between the two groups.

Participants who are to report electricity usage statistics

All SGIG and SGDP Participants who install smart meters in their projects are to report the statistics on hourly electricity usage, as described below. Participants engaged in "Consumer Behavior Studies" under the SGIG program are to report the statistics described in this guidance *in addition to, and separate from,* their estimates of load impacts which their respective studies are planning to quantify.

Data to be reported

Raw and normalized data

To accommodate the various levels of load research expertise among Participants, while obtaining good-quality data on hourly electricity-usage statistics, DOE is requiring all Participants who are reporting to provide statistics about their "raw," unadjusted data; additionally, DOE is requesting that Participants with load research expertise also provide statistics about their "normalized" data, as follows:

> "Raw" statistics (Required): Participants will report the mean and standard deviation of the raw data (i.e., *unadjusted* for weather, seasonality, or any other factors) on individual customers' hourly electricity usage, by sub-class for each treatment and baseline group. DOE will normalize these statistics to account for weather, and possibly for other factors that affect variability in electricity usage, for subsequent analysis by DOE.

> "Normalized" statistics (Requested): In addition to reporting the "raw" statistics, Participants that have load research expertise, including those engaged in SGIG Consumer Behavior Studies, are invited to report the mean and standard deviation of normalized customers' hourly electricity usage. Participants may use their own methods to normalize customer hourly electricity usage data, or one of the options proposed later in this document. Regardless of method used, Participants reporting normalized hourly customer electricity usage should catalog and document their assumptions and method. Participants engaged in the SGIG Consumer Behavior Studies should use the same normalized usage data to calculate these statistics as the data they expect to use to estimate load impacts in their consumer behavior studies; these Participants should report the statistics requested in this guidance separately from their consumer behavior studies.

Participants will enter these statistics as arrays into their reporting template as shown in Figure 1.

	Hourly Usage Data (kWh) [The hour refers to the hour at the beginning of the interval]	Residential Sub-class 1 Mean of Load Data	Residential Sub-class 1 Standard Deviation of Load Data (of raw data)	Residential Sub-class 2 Mean of Load Data	Residential Sub-class 2 Standard Deviation of Load Data (of raw data)
27					
28	3/1/11 0:00				
29	3/1/11 1:00				
30	3/1/11 2:00				
31	3/1/11 3:00				
32	3/1/11 4:00				
33	3/1/11 5:00				
34	3/1/11 6:00				
35	3/1/11 7:00				
36	3/1/11 8:00				
37	3/1/11 9:00				
38	3/1/11 10:00				
39	3/1/11 11:00				
40	3/1/11 12:00				
41	3/1/11 13:00				
	3/1/11 14:00				

Participants are required to enter data by date and hour.

Participants are required to report mean and standard deviation per treatment sub-class.

Geographic Subregion Map | Hourly Customer Electricity Use | Baseline Hrly Cust Ele Use | Mnthly Customer Electricity Use | Ba

Figure 1. Excerpt of "Impact metric template for 8760 Data" to illustrate statistics reporting by customer sub-class. (The actual format of the template might differ from this preliminary version.)

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Defining customer sub-classes and treatment groups

Recommendations for defining customer sub-classes and treatment groups are summarized below. Definition of treatment groups is important. They define the precise types or combinations of AMI systems, customer systems and time-based rate programs in which the Participant has particular interest in evaluating their impacts on peak load and overall electricity usage.

The "RAW 8760 Metric Data" spreadsheet, which Participants are to use to report their electricity-usage statistics, queries the user for the number of customers in each sub-class. It also asks for information on: customers' access to data on their electricity usage, tools they have to control electricity usage, their direct load control systems, as well as information on enrollment in time-based rate programs. These treatments should be identified for each treatment group within each sub-class (Table 2).

Table 2. Recommendations for defining classes, sub-classes, and treatment groups

Definition	Description	Recommendations
Classes and Sub-classes = customers categorized on the basis of common attributes, irrespective of whether they have different smart-grid programs or technologies.	The residential class is comprised of all residential customers, commercial class is comprised of all commercial customers, and industrial class is comprised of all industrial customers. For each class, Participants may divide the customers into sub-classes (e.g., based on size such as number of employees at the facility, number of family members, type of industrial activity, or geographic location such as state or town).	Participants should define sub-classes if their projects have several different types of customers within a given class, or if the project extends over several states, and if the Participant wishes to evaluate whether a given treatment(s) has different impacts on different sub-classes.
Treatment groups = customers in a given class or sub-class, each of whom has been exposed to the same treatment. A treatment is a smart-grid related program and/or technology designed to influence customers' energy consumption decisions.	A treatment group consists of customers who are exposed to the same treatment. For example, Participants may have two treatment groups in the residential class: residential customers with time-of-use rates, and residential customers with time-of-use rates with critical peak pricing. There would also be a residential baseline group as well.	Participants should define multiple treatment groups if Participants are deploying different types of customer systems and/or offering different time-based rate programs, and have interest in evaluating whether different treatment combinations have different impacts on load.

Participants engaged in SGIG Consumer Behavior Studies should define their treatment groups following the same method prescribed by consumer behavior studies. |

Table 3 summarizes required statistics for the treatment groups, as well as optional normalized electricity usage statistics that are requested of Participants with load research expertise.

Table 3. Treatment group estimation methods

	Treatment group estimation methods	Description
Required of all Participants	Calculate "raw" statistics.	Mean and standard deviation are calculated for the treatment group (the formal definitions of these statistics are defined later in this document).
Requested of Participants with load research expertise	Calculate statistics of the normalized data.	The hourly electricity usage collected for the required statistical reporting is normalized; the mean and standard deviation are calculated and reported. Participants engaged in Consumer Behavior Studies may use the same normalized usage data, to calculate these statistics, as they are using in their consumer behavior studies.

Define baseline groups

Participants must define a baseline group for each sub-class of customers.

A baseline group is a set of customers whose hourly electricity usage patterns represent what would occur without treatment (i.e., the counterfactual). The baseline group's hourly electricity usage can be estimated using one of the three methods summarized in Table 4 and presented in order of preference.

Table 4. Baseline group estimation methods

	Baseline estimation methods	Description
Required of all Participants	Calculate "raw" statistics.	The baseline group is a set of customers who receive the same device (e.g., smart meter) as the treatment group, but who do not receive treatment (e.g., time-based rate program) during the same period. The selection method should be documented; baseline group selection methods include (presented in order of SGIG program and SGDP preference): 1. Propensity score matching: For each treatment customer, a baseline customer with similar demographic attributes is selected. 2. Random: For every treatment customer, a baseline customer is selected at random. The baseline group selection method may be further augmented to stratify customers based on geography, by defining geographic sub-classes, if it is believed that customers in various geographic locations that are exposed to treatment may react differently (i.e., due to very different weather patterns). Participants engaged in SGIG Consumer Behavior Studies should use the same control (i.e., baseline) groups, which Participants are using in those studies, as the baseline groups for the statistics they are reporting under this guidance. If the Participant cannot define a baseline group, the Participant should contact the metrics and benefits reporting team for additional guidance.
Requested of Participants with load research expertise	Option A. Estimate customer class load, in the absence of treatment, using industry standard load research methods.	The hourly electricity usage collected for the required statistical reporting of the baseline is normalized using industry standard load research methods; the mean and standard deviation of the normalized baseline data are calculated and reported. If this method is chosen, the method and assumptions used should be documented. Analogous to the above stipulation, Participants engaged in SGIG Consumer Behavior Studies should use the same normalized data on the same control groups, which Participants are using in those studies, to calculate the statistics they are reporting under this guidance.
	Option B. Estimate customer class load based on historical hourly data.	The treatment group could serve as its own baseline. Historical hourly electricity usage by the treatment customers, measured in a period just prior to the exposure to treatment, is used to estimate the mean and standard deviation of baseline hourly usage by regression methods in order to normalize for temporal weather fluctuations, economic factors and other influential effects. • Dates of historical data must be documented. • Independent variable categories, such as weather, must be documented. • Sources of historical and current data for independent variables, such as weather and pricing, must be documented. • Regression equation(s), statistical analysis and results must be documented.

Calculating statistics for treatment and baseline hourly customer electricity usage

Having defined customer sub-classes and the treatment and baseline groups, Participants are to calculate the mean and standard deviation of hourly customer electricity usage. The following equations apply to all groups – treatments and baselines. Mean and standard deviation can be calculated using default equations in data analysis software, such as Excel (though take note of Excel's row and column limitations).

Mean hourly customer electricity usage

The mean of customer electricity usage is calculated for each hour:

$$\mu_{C,g,h} = \frac{\sum_{n=1}^{N_{C,g}} U_{C,g,h,n}}{N_{C,g}}$$

Where

$\mu_{C,g,h}$ = Mean customer electricity usage for customer sub-class C, treatment or baseline group g, for hour h

C = Customer sub-class as defined above

g = A treatment group or baseline group

n = Individual customer in treatment or baseline group g, for customer sub-class C

h = Hours of recorded electricity usage data, h=1, … , m

m = Number of hours in the six-month reporting period

$N_{C,g}$ = Total number of customers in treatment or baseline group g for customer sub-class C

$U_{n,C,g,h}$ = Electricity usage for individual customer n in treatment or baseline group g, in customer sub-class C, for hour h – usage is either unadjusted for weather if the calculation is for the "raw statistic," or adjusted for weather and for possibly other factors if normalized data is being used

Standard deviation of hourly customer electricity usage

The standard deviation of customer electricity usage is calculated as:

$$\sigma_{C,g,h} = \sqrt{\frac{1}{N_{C,g}} \sum_{n=1}^{N_{C,g}} \left(U_{C,g,h,n} - \mu_{C,g,h} \right)^2}$$

Where

$\sigma_{C,g,h}$ = standard deviation customer electricity usage, for customer sub-class C, for treatment baseline group g, for hour h