End-Use Load Data Update Project Final Report

Phase 1: Cataloguing Available End-Use and Efficiency Measure Load Data

Prepared for Northwest Power and Conservation Council and Northeast Energy Efficiency Partnerships

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Table of Contents

Table of Contents

Table of Contents

1. Executive Summary

In recent decades, efforts to gather end-use load data appear to be scattered and minimal across the Pacific Northwest and East regions (the Regions). Although a significant amount of data was gathered through Bonneville Power Administration's End-Use Load and Consumer Assessment Program (ELCAP) in the mid-1980's through the early 1990's, confidence in the data has waned as technologies change and consumer behavior evolves. The overall objective of this project is to assess and catalog the more recently completed existing end-use and load shape data studies that may be useful to the Regions.

This phase of the load data update will identify gaps in and problems with the existing load shape data and establish priorities and study scopes for load shape improvements to support energy efficiency program planning, electricity markets and environmental policy. Elements of the work include:

- Research and inventory the existing load shape data available
- Determine what load shape data is necessary to meet utility energy efficiency program, ISO-New England and PJM Capacity Markets (CMs), and air quality regulatory needs
- Identify weaknesses in the existing data for use in efficiency programs, capacity markets, and air quality regulations
- Evaluate the transferability and applicability of existing load shape data to the Regions
- Provide a road map for meeting future short term and long term end-use metering needs.

Findings and recommendations are provided at a high level from a region-wide perspective. There were limitations that were not possible to capture in this study, including diverse data needs among program administrators. Therefore, we recognize that specific program administrators may have different priorities for data collection than what was identified.

This study is sponsored by the Northwest Power and Conservation Council's Regional Technical Forum (RTF) and the Northeast Energy Efficiency Partnerships (NEEP) Evaluation Measurement and Verification (EMV) Forum.

1.1 Methodology for Data Collection

One of the key challenges in the data collection effort was to cast the net wide enough to capture all potentially useful datasets, while collecting enough specific dataset characteristic information to ultimately assess its usability. Towards this end, KEMA utilized multiple channels and an iterative process for identifying potentially usable data sources, including:

- A web survey of 102 industry contacts to ask them to submit information on relevant studies from various regions of the country, but primarily focusing on the Northeast, Pacific Northwest and Mid-Atlantic regions
- Studies compiled for the 2006 California Load Shape Update Initiative, which also catalogued the usefulness of a list of load data studies from within the state
- Extensive follow up with industry contacts to further identify and collect dataset characteristics of studies that appeared "potentially useful."

For the purposes of this phase of the project, a list of end-uses and associated "Analysis Groups" were defined separately for the residential and non-residential sectors, as shown below in Table 1 and Table 2. These analysis groups form the framework for cataloguing useful datasets, performing the gap analysis and prioritizing efforts to develop and compile end use and measure specific load data. The end use analysis groups are intended to capture both measure savings shapes and end use consumption shapes.

Tables 1 and 2: End-Use Analysis Groups[1]

End Use	Residential Analysis Groups
Appliances	Appliances - Kitchen
Appliances	Appliances - Laundry
Appliances	Appliances -Refrigerators
Water Heating	Domestic Hot Water
HVAC	HVAC – Cooling
HVAC	HVAC – Fan Energy
HVAC	HVAC - Heating
HVAC	HVAC - Ventilation
HVAC	HVAC - Other
Lighting	Lighting - Exterior
Lighting	Lighting - Interior
Other	Plug Load (Electronics)
Other	Pool Pump

End Use	Non-Residential Analysis Groups
Agricultural	Agricultural - Process
Agricultural	Agricultural - Pumping
Appliances	Appliances - Laundry
Other	Clean Room
Other	Compressed Air
Other	Data Center Equipment
Other	Data Center Cooling
Other	Food Service Equipment
HVAC	HVAC - Cooling
HVAC	HVAC - Fan Energy
HVAC	HVAC - Heating
HVAC	HVAC - Other
HVAC	HVAC - Reheat
HVAC	HVAC - Ventilation Only
Process	Industrial - Process
Lighting	Lighting - Exterior
Lighting	Lighting - Interior
Process	Motors - Drives
Other	Plug Load (Electronics)
Process	Pump
Refrigeration	Refrigeration
Other	Water Heating

[1] "HVAC – Other" category includes measures such as controls, envelope (including insulation, window film, etc) and quality installation measures

In total, over 110 studies were identified as part of this effort, with the majority conducted in the New England or California regions. Through this data collection effort, it was found that most studies fell into one of three categories, based upon the general purpose of the study and the type of data collected:

- **Compilation Studies** – were studies that compiled primary interval data from other studies and used either DOE2 modeling or statistical modeling techniques to produce average end-use load shapes.
- **Load Research Studies** – were studies that utilized long term end-use power metering to develop average end-use load shapes. The samples were typically selected to define end-uses at the tariff class level with little or no customer specific data collected other than the interval power data.
- **Evaluation Studies** – were studies that primarily focused on evaluating savings impacts for energy efficiency measures or demand response programs. These studies were typically characterized by shorter term monitoring of program participants that only collected data about the specific program measures being evaluated.

1.2 Interviews with Users of Load Shape Data

To better understand the needs of the Pacific Northwest and East, KEMA conducted a number of interviews and convened two focus groups with three groups of users: energy efficiency program planners, capacity market representatives, and air quality regulators. These groups of users all utilize end-use and measure load shape data to better forecast the potential impacts related to energy efficiency programs, whether to estimate energy savings, demand reductions or reduced air emissions.

The interviews focused on what data users were currently using, including the sources of data they have available to them now and whether the load shapes are 8,760 annual hourly profiles or some other time period. Users were also asked about their confidence in existing load shapes and where they see the need for new metering studies.

In summary, it appears that the data collection related to end-use and measure load shapes is occurring on an ad-hoc basis within and between each region. Most energy efficiency planners and air quality analysts are utilizing whatever the best available data appears to be. The principal driver for hourly 8,760 is not for avoided cost calculations for energy efficiency program planners, but rather to support the forward-capacity market bid programs in both the ISO NE and PJM regions. Furthermore, New York is ramping up significant program activity, with a need to better understand the distribution of savings. There is an urgency related to the lack of consistency across programs and utilities in both regions and uneven information across the different states (including small versus large utilities).

The capacity markets have the most stringent requirements and urgent need for hourly 8,760 energy savings data. Some energy efficiency programs across the country are funding M&V of program impacts that could potentially support the development of end-use and measure load shapes that would be broadly useful. Although there are some protocols, such as the International Performance Measurement and Verification Protocol (IPVMP), the metering related to the evaluation of efficiency programs is not coordinated or conducted in a consistent manner between (or even within) regions. A first and significant hurdle to overcome this problem is the need for an M&V protocol designed specifically to support the collection of end-use data that can be usable and transferable across different regions.

The conclusion from interviews with users of the load-shape data is that capacity market requirements are the “gold standard” for end-use and measure load profiles. It appears that any data that is good enough for ISO-NE and PJM should certainly be adequate for energy efficiency program planners and air quality regulators.

1.3 Usability and Transferability of Datasets

Following the interviews with the users of the load shapes, KEMA assessed the usability of the identified datasets for load shapes. We first explored metrics for determining the general usability of studies, and then secondly examined the issues and requirements inherent in making a potentially useful study transferable to another region or customer population.

Studies were evaluated for usability based on the following criteria:

- **Accessibility** – The first and foremost indicator of usability is simply whether the underlying data is accessible, meaning that the study contact person has the ability to retrieve the relevant data. For this project, the accessibility rating is self-reported, with 1 being readily accessible and 5 being completely inaccessible. Studies that were completely inaccessible were not considered usable.

- **Statistical significance/Sample size** – In order to properly represent a specific customer population, the initial data must be collected with an appropriate sampling approach. The level of statistical significance is an important metric for assessing the usability of load shapes for the ISO-NE Forward Capacity Market (FCM). Over the years, program implementation and evaluation staffs have grown quite adept at estimating aggregate efficiency impacts from samples with ±10% relative precision at the 90%

confidence level. Load research was traditionally focused on 90/+/-10% as recommended in the Public Utilities Regulatory Policies Act (PURPA) of 1978.[2] This has been deemed the "PURPA Standard" or the "90/10 Rule" and has manifested itself through endless discussions among interval load data collectors primarily in the load research community and more recently among evaluators of energy efficiency and demand response. While annual kWh savings are relatively easy to quantify with reasonable accuracy, pursuit of accurate coincident peak demand impacts poses some challenges.

- **Vintage of Data** – KEMA considered more recently conducted studies to be more usable than older data collected. This is due to the fact that as data get older, users feel less and less comfortable with them, unsure that they represent today's loads. For the most part, these changes are not well understood, and some end-uses and measures have changed more significantly than others in recent years. For instance, we fundamentally rely on some of the same end-uses, such as heating and cooling our buildings, refrigerating our food and using lighting. In some cases, the load shape may still be the same, but the scale or magnitude of energy use may have changed.

- **Time Resolution/Granularity of Data** – The ISO-NE FCM requires at least a 15-minute sampling rate, and this concurs with the load research standard. It is worth noting that if users are interested in absolute peak values, then shorter time resolution may more accurately capture short term peak. Fifteen-minute peak values are almost always higher than hourly peak values due to load diversity factors. As data storage technology and communication speeds continue to improve, we will be able to easily handle data with one minute or even shorter integration periods. For the time being, we consider data collected at 15-minute intervals or less to be most usable. We also acknowledge that 1 hour data may be usable for energy efficiency and air quality regulators in many instances.

- **Geographic Location of Data** – Studies with data collection occurring within the Pacific Northwest and East are generally deemed to be more useful to those regions than studies based in other geographic locations. Some measures by their nature, however, might be expected to have relatively little variation by geographic region or customer type. Even within a specific region, however, studies that focus only on energy efficiency program participants may not represent the general population. This is related

[2] The accuracy level for collected information is addressed in the Code of Federal Requirements CFR 290.403 (b) which stated that "for loads during peak hours, sampling procedures must be designed with a statistically expected accuracy of ±10% at the 90% confidence level. A utility is not required to show that the resulting load curves have this same accuracy but is required to point out any significant deviations from expected accuracy.

to the issue of applying load shapes from one region to another region, and is explored further in the section below.

The question of whether a dataset from one region is usable in another hinges on the transferability of the data. In order to be transferred, the data must first be normalized properly so that it is portable. This requires that usage patterns be defined independent of efficiency and technology.

1.3.1 Transferability of Load Shapes between Regions

In general terms, the transferability of interval load data from a particular end-use analysis group is dictated primarily by the degree to which the power consumption of the equipment is impacted by the ambient weather conditions. The transferability rating looks at the general schedule variability of the analysis group as well as the variability of the end-use due to weather.

Table 3 and Table 4 summarize the general transferability ratings for each of the residential and non-residential end-use analysis groups utilized in the cataloguing effort. It is important to note that these tables assume that the C&I sector will be properly segmented and that data would be transferred across regions, but not within segments. For example the transferability of lighting data for the large office segment from one region would be rated for its transferability to the large office segment of another region and not the small office or retail segments.

Table 3: Residential Analysis Groups Transferability Ratings

Analysis Group	Schedule Variability	Weather Variability	Transferability Rating
Appliances - Kitchen	Medium	Low	High
Appliances - Laundry	Medium	Low	High
Appliances -Refrigerators	Low	Medium	High
Domestic Hot Water	Low	Medium	Medium
HVAC – Cooling	Medium	High	Low
HVAC – Fan Energy	Medium	High	Low
HVAC - Heating	Medium	High	Low
HVAC - Ventilation	Medium	Medium	Low
HVAC - Other	Medium	High	Low
Lighting - Exterior	Medium	Low	High
Lighting - Interior	Low	Low	High
Plug Load	Low	Low	High
Pool Pump	Low	Medium	Medium

Table 4: Non-Residential Analysis Groups Transferability Ratings

Analysis Group	Schedule Variability	Weather Variability	Transferability Rating
Agricultural - Process	Medium	Medium	Medium
Agricultural - Pumping	Medium	Medium	Medium
Appliances - Laundry	Low	Low	High
Clean Room	Low	High	Low
Compressed Air	Low	Low	High
Data Center Equipment	Low	Low	High
Data Center Cooling	Medium	High	Low
Food Service Equipment	Low	Low	High
HVAC - Cooling	Low	High	Low
HVAC - Fan Energy	Low	High	Low
HVAC - Heating	Low	High	Low
HVAC - Other	Low	High	Low
HVAC - Reheat	Medium	High	Low
HVAC - Ventilation Only	Low	High	Low
Industrial - Process	Medium	Medium	Medium
Lighting - Exterior	Low	Low	High
Lighting - Interior	Low	Low	High
Motors - Drives	Medium	Medium	Medium
Plug Load (Electronics)	Low	Medium	Medium
Pump	Low	Medium	Medium
Refrigeration	Low	High	Low
Water Heating	Low	Medium	Medium

Region-wide or even national protocols are needed to establish consistent methods and procedures for monitoring, such that the information can be transferable and useful to other regions and populations. Data from performance monitoring studies can then be used to satisfy diverse needs of energy suppliers and planners, energy end users, designers, researchers, equipment manufacturers, and regulators. The broad priority for the data protocol is transferability, and to enable several small studies from within a region (e.g. conducted for individual program evaluations) to be compiled into a larger dataset.

A wide number of data collection protocols have been established for energy efficiency monitoring and are outlined in the full report. These documents should be utilized as a starting point for a region-wide or national protocol.

1.4 Identification of Potentially Useful Studies and Gap Analysis

Of the 110 studies identified, KEMA focused on a subset of "potentially useful" studies for further analysis and data collection follow up. The selection criteria used for the initial screening of the "potentially useful" studies list was based on a high level review of each dataset.

The studies were reviewed using a variety of different evaluation criteria to determine which could be the most useful. Since there were not a lot of details about the work that was done, the studies were screened based upon the data that were provided consistently such as sample size and the date when the study was completed. The following criteria were used to establish usability criteria:

- Sample size
- Vintage of studies 2000 or more recent
- Studies that developed load profiles

After the initial screening effort, a phone survey was implemented to identify more details about the studies including:

- Types of ancillary data available
- Type of interval data collected (i.e., true power, current only, on/off transition data)[3]
- Whether the data was normalized and identification of normalization variables
- Inclusion of interval weather data or identification of interval weather data source
- Cost and/or level of effort to acquire the data

1.4.1 Summary of Potentially Useful Studies

As previously mentioned, the initial standard for determining potentially useful studies was set fairly low because of the urgent need to utilize end-use load shape data for the ISO/RTO capacity markets. As a result, 37 studies were deemed potentially useful enough to be evaluated for usability using a subjective ranking system as follows:

A – Meets capacity market standards (for defined region, measure(s)), and is usable as a stand alone study within a region

[3] True power refers to the measure of current, voltage and power factor to determine the integrated power usage and is the most accurate measurement. Current only measurement refers to a method that only measures the current in amps and then the voltage and power factor are assumed in order to calculate the demand. Finally on/off transition data typically measures a change of state either using a photocell in the case of lighting loggers or sensing electrical current in the case of CT loggers. These data typically carry a time stamp with each transition and can be converted to time series data, which provides a percent on value per fixed time interval (for example 15 – minutes). The time series data is then converted into interval load data by multiplying the electrical load of the device being monitored by the percent on. This type of metering is particularly efficient for devices that have fixed electrical load and variable operating schedules like lighting.

B – Meets efficiency planning standards (for defined region, measure(s)), and is usable as part of a compilation study

C – Has some issues (e.g. low sample size or data is a little old), but could be used as a last resort or to guide modeling efforts

D – Study should not be used (or data not available to be used)

IP – Study is currently in progress

The following series of tables (Table 5, Table 6, Table 7, and Table 8) present a summary of the useful studies organized by region along with the sponsoring entity, study name, study-end data, analysis groups evaluated, and usability rating. Studies which were rated a C or D were not included for follow up research.

Table 5: Potentially Useful Studies in the Pacific Northwest Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
Puget Sound Energy	Commercial & Industrial Lighting Savings Verification Study	2007	Lighting	B
BC Hydro	Load Monitoring Project (LMP)	1994 -2009	Appliance-Kitchen, Appliance Laundry Appliance Refrigerator, Water Heating	B
Seattle Cty Light	Space Heat Thermostat Metering Study	2006	HVAC - Heating	B
BPA	End-Use Load and Consumer Assessment Program (ELCAP)	mid 1980s - early 1990s	Water heating, HVAC - Cooling, HVAC - Heating, Lighting interior, Lighting exterior, Plug Load, HVAC - Fan Energy,	B
BC Hydro	Power Smart Residential End Use Study	Planning Stages	Appliance-Kitchen, Appliance Laundry Appliance Refrigerator, Water Heating	IP
NEEA	Ductless Heat Pump Pilot Evaluation	Not Completed	HVAC-Cooling, HVAC- Fan, HVAC-Heat HVAC-Other, Water Heating	IP
NEEA	Northwest Energy Star Homes Impact Evaluation	Not Completed	Lighting	IP

Table 6: Useful Studies in the Northeast Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
SPWG	SPWG Lighting Coincidence Factor Study	2007	Non-Residential Lighting Residential Lighting	A
NSTAR, N-Grid UI, CL&P	Residential Central AC Regional Evaluation	2009	HVAC - Cooling	B
UI	UI Water Heater Controller Study	2008	Water Heating	B
NSTAR, N-Grid NU,UI, VEIC	CFL Lighting Markdown Evaluation	2008	Lighting	B
NSTAR, N-Grid NU, UI	MA & CT Ductless Heat Pump Study	2008	HVAC- Cooling HVAC-Heating	B
NSTAR	BSCS lighting and Non-lighting Studies	2007 & 2008	HVAC-Cooling,HVAC-Other, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
MA Utilities	Mass SAVE Impact Study	2007	Lighting	B
Efficiency Maine	Maine Low Income Light and Appliance Study	2007	Lighting Appliances-Refrigeration	B
SPWG	Residential Room AC Impact Study	2007	HVAC- Cooling	B
UI, CL&P & WMECo	School Lighting Baseline Study	2006	Lighting	B
UI & CL&P for ECMB	CT Coincidence Factor Study	2005	HVAC-Cooling,Motors-Drives	B
NU	Custom Services	2005	HVAC-Cooling, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
NH Electric Coop	New Hampshire Small Business Lighting	2005	Lighting	B
NU	NU Municipal Program	2004	Lighting	B
NSTAR N-Grid	Small Business Solutions (SBS)	2003,2005, 2006	HVAC-Other, Lighting Motor - Drives, Refrigeration	B
N-Grid	Small C&I Unitary HVAC Pilot Impact Study	2003	HVAC-Cooling	B
NU & UI	NU & UI Energy Star Homes Evaluation	2002	Lighting	B
NSTAR	C&I New Construction and Retrofit	2001	HVAC-Other, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
NSTAR	C&I Retrofit	2003	HVAC-Cooling,HVAC-Other, Compressed Air, Motor - Drives, Refrigeration, Lighting	B

Table 7: Useful Studies in the Mid Atlantic Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
BGE	Demand Response Infrastructure Pilot Program	2007	HVAC - Cooling	B
BGE	Res. Water Heater, Residential and Commercial AC Control Evaluation	on going	Res. Water - Heating and HVAC-Cooling Non-Res HVAC-Cooling	B
BGE	Residential Water Heater Control (2001 - 2005)	2005	Res. Water - Heating	B
BGE	Residential AC Control (2001 - 2005)	2005	Res. HVAC - Cooling	B
BGE	Commercial AC Control Evaluation (2001 - 2006)	2006	C&I HVAC - Cooling	B

Table 8: Useful Studies in the California Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
PG&E and Others	Compressed Air Management Program	2006 - ongoing	Compressed Air	B
CPUC	Database of Energy Efficiency Resources (DEER) (Residential)	2001 - ongoing	All Residential Analysis Groups except HVAC - Ventilation Only & Other	A
CPUC	Database of Energy Efficiency Resources (DEER) (Non Res)	2001 - ongoing	All Non-Res Analysis Groups covered by catalogued studies except Water Heating	A
SDG&E	Express Efficiency Hours of Operation	2006	Lighting	B
CPUC	Industrial End Use Survey (IEUS)	In Progress	Industrial - Process	IP
SCE	Refrigerator Recycling Study	2005	Appliances-Refrigeration	A
SDG&E	Residential CFL Load Shapes by Room Type	2004	Lighting	A
SCE PG&E	Residential End Use Load Research Study	1996, 2001	Appliance-Kitchen,Laundry & Refrigerator, Water Heating HVAC - Cooling & Heating, Plug Load, Pool Pump	A
LBNL Ecos	Residential Plug Load Study	2006	Plug Load	B
SCE, PG&E CPUC	Savings By Design	2006, 2007 Ongoing	Industrial - Process, Refrigeration, Compressed Air, HVAC - Cooling, Heating&Ventilation Only, Lighting	B

1.4.2 Assessment of Data Availability

The severity of the end-use data gap issue is driven by the extent to which smaller studies of similar measures can be combined within one region, and data from other regions can be transferred and or combined to provide reasonably good load shapes.

Table 9: Summary of Gap Analysis by Region and Sector

Region	Sector	Summary of Gap Analysis
Pacific Northwest region	Residential	The residential customer sector has good coverage in this region as long as the BC Hydro Power Smart Residential End-use metering study is implemented with the large sample sizes that were indicated in the customer survey. If this study is not implemented or the sample sizes are significantly reduced then the coverage for these analysis groups gets thin rather quickly.
	Non-Residential	There was only one non-residential study identified in this region, and it was the Puget Sound Energy lighting study with 65 sample points. Therefore based on the available information **all non-residential analysis groups have a high need for end-use data.**
East region	Residential	Compared to the Pacific Northwest, the residential end-use analysis groups have significantly less coverage in the East. More than half (7 of the 13) analysis groups have no coverage by studies conducted in this region. Additionally only one (lighting interior) of the remaining six analysis groups has a low need for additional data.
	Non-Residential	Ten of the twenty-two analysis groups have no sample data at all. This was the same result as the overall non-residential gap analysis and the same analysis groups are involved and are rated as having a high need for additional data. Once again, the lighting - interior is the only analysis group that appears to have adequate coverage and a low need for additional data.

1.5 Prioritization of Near-term Activities

The gap analysis from the previous section was conducted to identify the promising studies for the various end-use analysis groups where data may be available. This step was necessary to identify where the option of compiling end-use data from groups of other studies may be a viable option. In order to allocate limited near term resources, a ranking of the relative importance of different end-use analysis groups was developed. The relative importance levels are based on a high-level assessment of the perceived and actual contribution of measures within the end-use analysis groups to overall savings within the two regions. The relative prioritization of end-use analysis groups for improvement is categorized as follows:

- **Tier 1** – Most Important. Highest contribution to savings and high need, per web survey
- **Tier 2** – Moderately Important. Moderate contribution to savings and/or need, per web survey
- **Tier 3** – Lower Importance. Lower contribution to savings.

The results from the web survey along with market potential study data from California and Connecticut were used to determine the prioritization rankings for end-use analysis groups.

Generally, there are five options that could be pursued to develop the end-use data sets as follows:

- **Option 1** – Combine existing end-use studies of common measure types into meta studies using data collected within a region (Regional Meta Study). This option is theoretically the most attractive and easiest to implement because there is no primary data collection effort (end-use metering) and there are no transferability issues since data from within one defined region is used. Of course there still are challenges when attempting to combine datasets that involve the format and content of the data. Typically the data were collected to support one evaluation effort and a combined dataset is reduced in detail to the lowest common denominator. One particularly challenging aspect is assigning weights to the observations within the combined dataset. These challenges could be mitigated by developing common data collection and storage procedures that are designed to support the combination of multiple datasets as they are developed.
- **Option 2** – Utilize all data from within the region as well as data from other regions to fill gaps in the regional data (Trans-Regional Meta Study). This option is also theoretically attractive because there is no primary data collection effort (end-use metering) involved. However, because data from multiple regions are to be combined, the issue of data transferability must be addressed. Analysis groups that have a high transferability rating should be the easiest to combine, however it is advisable to perform a statistical comparison of the datasets from each region to make sure that no significant bias is being introduced into the results. If there are no data from within the region than there really is no way to perform this bias analysis and justifying the transferability of the data becomes more problematic particular with respect to capacity market M&V requirements. This option also still has all of the data combination challenges discussed above for Option 1 along with the transferability issue. If a load shape is needed for a relatively unimportant measure that is not weather dependent, then the DEER database could be used directly to extract a load shape.

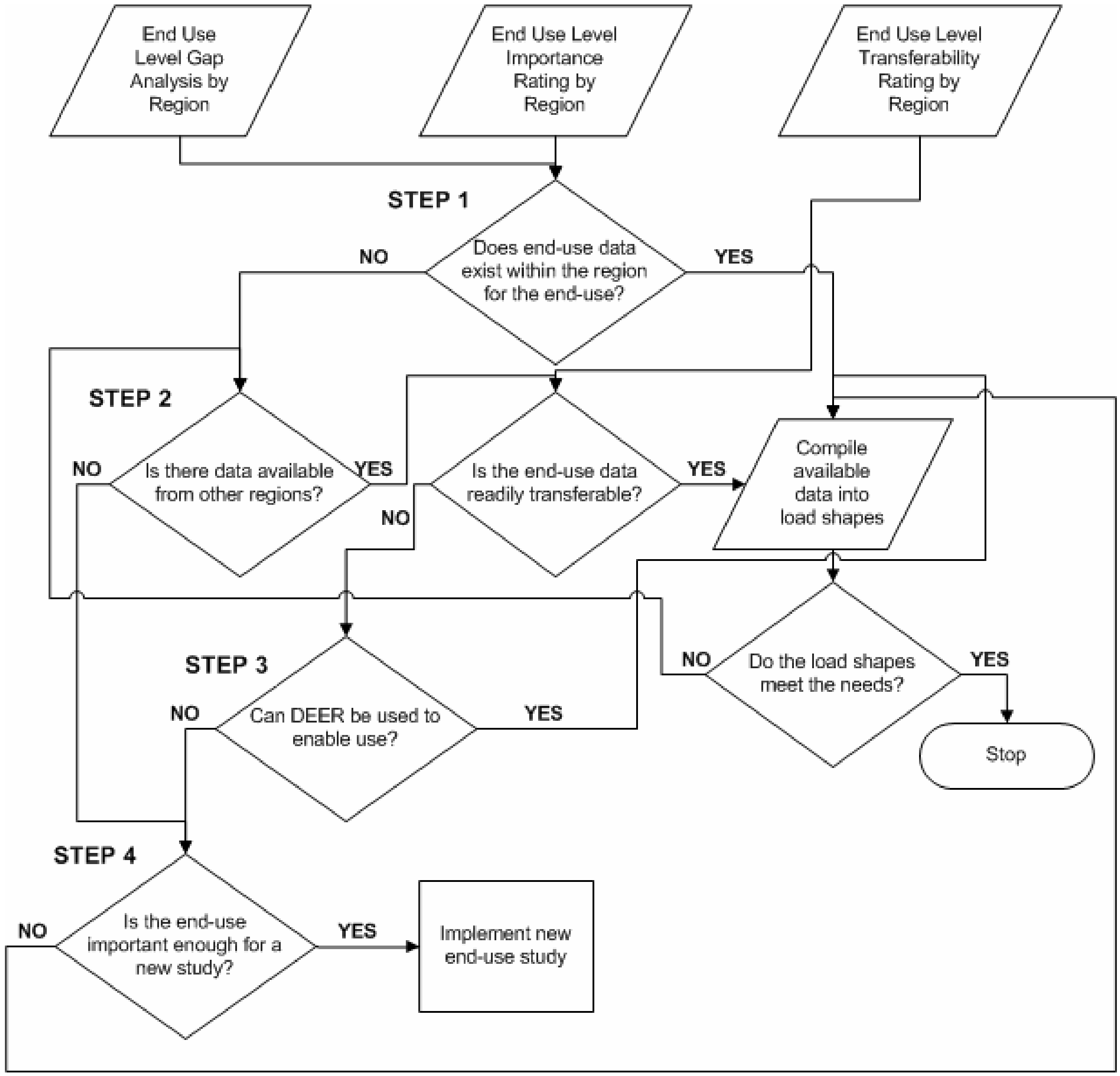
- **Option 3** – Develop database for regionally customized DOE2 models using California Database for Energy Efficient Resources (DEER) as a starting point. Once again this option is theoretically attractive because there is no primary data collection effort. However, customizing the DOE2 models used by DEER to reflect the conditions within a particular region will require a significant data collection effort to identify saturation data of energy efficiency equipment within both Residential and Non-residential customer sectors. DEER models consist of 29 C&I prototypes and 4 Residential prototypes and each provide about 10 different end-uses, excluding whole premise load. Additionally calibration of these models to system load is another process that should be undertaken and can be tremendously onerous depending on the level of rigor attempted.

- **Option 4** – Field new end-use data collection effort to evaluate the measure(s) within a particular region or across multiple regions. This option is attractive because it provides the flexibility to design and conduct the study to meet specific data needs for energy efficiency, air standards or capacity markets. Depending on the level of complexity involved in combining datasets (either from within a region or from multiple regions) or attempting to customize DEER DOE2 prototype models, this may be the easiest and cleanest option.

- **Option 5** – Do nothing because the end-use or measure is not important at this time.

Figure 16 provides a flowchart for the near-term action plan that details the general decision-making process for determining what the best course of action would be for the end-use analysis groups. The decision-making process utilizes the end-use analysis group level gap analysis, importance rating, and transferability rating to inform the decision-making process.

Figure 1: End-use Analysis Group Near-term Action Plan Flowchart



1.5.1 Pacific Northwest Region

Table 10 provides a summary of the near-term actions recommended for the residential sector analysis groups in the Pacific Northwest (PNW) region.

Table 10: End-Use and Measure Shape Improvement Strategies (PNW Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
HVAC - Cooling	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC - Heating	Option 1	Compile results from BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump (IP) and Seattle City Light Space Heat Thermostat Study.
Plug Load (Electronics)	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and consider leveraging LBNL/Ecos CA Residential Plug Load Study and SCE/PG&E Residential End Use Load Research study.
Tier 2 Importance		
Domestic Hot Water	Option 1	Compile results: BC Hydro LMP, BC Hydro Power Smart Residential End-Use Study (IP), and NEEA Ductless Heat Pump Pilot (IP).
Lighting - Exterior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
Appliances - Laundry	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
Appliances - Refrigerators	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
Tier 3 Importance		
HVAC - Fan Energy	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
Pool Pump	Option 1	Leverage BC Hydro Power Smart Res End-Use Study (IP)
HVAC - Other	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC-Ventilation Only	Option 5	The only data identified here is from ELCAP. We recommend that this data continue to be utilized.
Appliances - Kitchen	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.

One word of caution should be interjected about the using the existing regional studies as the primary method for developing end-use load shapes, since virtually all of the end-use analysis groups that have Option 1 as their near-term action plan rely almost exclusively on the BC Hydro Power Smart Residential End-use Metering Study for data. This study is still in the planning stages and currently looks to be targeting sample sizes of around 300 for most of the residential sector end-use analysis groups. If this study is not implemented or if sample sizes are significantly reduced, then the available data from within the region becomes very sparse and would probably require that data from other regions be utilized or additional metering efforts within the region. The PNW region should try to leverage (and potentially coordinate with) the BC Hydro study to minimize new metering costs.

The prognosis for the PNW non-residential sector is not good, because there has been no recent end-use interval data collection activity in the region that was identified through this cataloguing effort. The region will have to rely on newer studies that have been conducted in California and the East for borrowed data or launch a significant new metering effort within the region. Some level of new metering effort within the region is unavoidable and the scope of the effort could be managed effectively by looking at specific outside sources of data and considering the ability to leverage these data where practical. It could be that customization of the DEER DOE 2 prototype models is the most cost effective method for developing end-use and impact load shapes however, even this method would benefit from primary data collection from within the region to identify building stock characteristics and develop operating schedules.

Table 11 provides the near-term action plan for the 22 non-residential end-use analysis groups in the Pacific Northwest. There are a total of eight Tier 1 end-use groups identified as a high priority for action.

Table 11: End-Use and Measure Shape Improvement Strategies (PNW Non-Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

<table>
<tr><th>Non-Residential Analysis Groups</th><th>Importance Level</th><th>Near Term Action</th><th>Description</th></tr>
<tr><td>Lighting - Interior</td><td>Tier 1</td><td>Option 1/2</td><td rowspan="5">Since no studies were found within the region, except for the Puget Sound Energy lighting study, data from outside the region may be utilized, as these end use analysis groups are generally considered transferable (“high”). The Northeast region has good coverage for lighting data and CA DEER provides publicly available data for the other end use groups.</td></tr>
<tr><td>Lighting - Exterior</td><td>Tier 1</td><td>Option 2</td></tr>
<tr><td>Compressed Air</td><td>Tier 2</td><td>Option 2</td></tr>
<tr><td>Appliances - Laundry</td><td>Tier 3</td><td>Option 2</td></tr>
<tr><td>Food Service Equipment</td><td>Tier 3</td><td>Option 2</td></tr>
<tr><td>Motors - Drives</td><td>Tier 1</td><td>Option 4</td><td rowspan="5">The remainder of the end use analysis groups are recommended for new metering, due to low or medium transferability. The new metering studies may also be used to assess the extent which the ELCAP load shape data may still be usable.</td></tr>
<tr><td>Plug Load (Electronics)</td><td>Tier 1</td><td>Option 4</td></tr>
<tr><td>HVAC - Cooling</td><td>Tier 1</td><td>Option 4</td></tr>
<tr><td>HVAC - Fan Energy</td><td>Tier 1</td><td>Option 4</td></tr>
<tr><td>HVAC - Heating</td><td>Tier 1</td><td>Option 4</td></tr>
</table>

Refrigeration	Tier 1	Option 4	The remainder of the end use analysis groups are recommended for new metering, due to low or medium transferability. The new metering studies may also be used to assess the extent which the ELCAP load shape data may still be usable.
Industrial - Process	Tier 2	Option 4	
Water Heating	Tier 2	Option 4	
Pump	Tier 2	Option 4	
Data Center Equipment	Tier 2	Option 4	
Agricultural - Pumping*	Tier 2	Option 4	
Date Center Cooling	Tier 2	Option 4	
HVAC - Other	Tier 2	Option 4	
HVAC-Ventilation (Only)	Tier 2	Option 4	
HVAC-Reheat	Tier 2	Option 4	
Agricultural - Process	Tier 3	Option 4	
Clean Room	Tier 3	Option 4	

1.5.2 Eastern Region

The gap analysis for the East indicated that there were promising studies for both residential and non-residential customer sectors. There were some residential analysis groups that did not have good studies available.

Table 12 provides a listing of the recommended near-term activities for the East residential sector end use groups, which are ranked in order of importance. Of the four Tier 1 end use groups only the lighting – interior has sufficient data from within the region to compile load shapes. The others will require either the use of additional data from other regions, the customization of DEER DOE 2 models and/or the fielding of a new regional metering study. The plug load (electronics) end use will probably require a new metered data collection effort within the region as there is little available data from other regions. The Tier 2 end-use groups will also require the use of additional data from outside of the region, but most of the groups have high transferability ratings, so this does not appear to be a major issue.

Table 12: End-Use and Measure Shape Improvement Strategies (East Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1	There have been a number of high quality lighting studies completed in the Eastern Region. In particular, the region is recommended to utilize the SPWG Lighting Coincidence Factor Study.
HVAC - Cooling	Option 1/4	Compile results from the UI and CL&P 2005 Coincidence Factor Study (B), NGrid Residential Room AC Impact Study (B), and NSTAR/NGrid/UI/CL&P CAC Regional Evaluation (B) and conduct new metering.
HVAC - Heating	Option 1/4	Compile results from MACT Ductless heat pump study and conduct new metering.

Plug Load (Electronics)	Option 2/4	Utilize LBNL/Ecos CA Residential Plug Load Study and SCE/PG&E Residential End Use Load Research study. Otherwise, conduct new metering.
Tier 2 Importance		
Domestic Hot Water	Option 1/2	Utilize data from the UI Water Heater Controller Study, NYLE Heat Pump Water Heater Evaluation Study and leverage data from other regions such as the Mid-Atlantic (e.g. BGE Residential Water Heater Evaluation studies).
Lighting - Exterior	Option 1/2	Compile data from the SPWG Lighting Coincidence Factor and NU/CL&P CFL Markdown Impact study, and consider bringing in data from other regions (e.g. DEER) since the end use analysis group has a "high" transferability rating.
Appliances - Laundry	Option 2/4	Consider leveraging public data from other regions, such as DEER, or conduct new metering studies.
Appliances - Refrigerators	Option 1/2	Compile data from the Efficiency Maine Low Income Appliance Impact Study and consider leveraging data from other regions, such as DEER, or BC Hydro Power Smart Res End Use Study (IP).
Tier 3 Importance		
HVAC - Fan Energy	Option 4	Since no data was found, and end use group transferability is low, new metering is recommended.
Pool Pump	Option 5	Leverage BC Hydro Power Smart Res End-Use Study (IP) should it become available.
HVAC - Other	Option 3/4	Since no data was found, DOE modeling or new metering is recommended.
HVAC - Ventilation Only	Option 4/5	Since no studies were found, new metering is recommended, or no action, as the measure is considered low importance.
Appliances - Kitchen	Option 2/4	Due to high transferability, first consider leveraging data from other regions, such as simply utilizing DEER load shapes, or conduct new metering studies.

Table 13 provides a listing of the short-term activities recommended for the East non-residential end use analysis groups ranked in order of importance. Most of the Tier 1 end-use groups can develop load shapes by utilizing data collected within the region in conjunction with data collected from other regions. Once again the plug load (electronics) end-use group would require data provided from a new metering study and the HVAC heating end use may as well although DOE2 models may be used to develop profiles in the short term.

Table 13: End-Use and Measure Shape Improvement Strategies (East Non-Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Non-Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1/2	There have been a number of high quality lighting studies completed in the Eastern Region. In particular, the region is recommended to utilize the SPWG Lighting Coincidence Factor Study.
HVAC - Cooling	Option 1/4	Compile results of UI/CL&P 2005 Coincidence Factor Study, NGrid Small C&I Unitary HVAC Pilot Impact Study, NSTAR BSCS Non-Lighting M&V Impact Study and NSTAR CS Impact Study and conduct new metering.
Lighting - Exterior	Option 1/2/4	Compile results of UI/CL&P 2005 Lighting Coincidence Factor Study, NSTAR BSCS Impact Study and NSTAR CS Custom Impact Study and perhaps conduct some new metering.
HVAC - Fan Energy	Option 1/4	Compile UI/CL&P 2005 Coincidence Factor Study and conduct new metering.
Plug Load (Electronics)	Option 4	No studies were found related to non-residential plug load. New metering is recommended.
HVAC - Heating	Option 1/4	Compile UI/CL&P 2005 Coincidence Factor Study and conduct new metering.

Motors - Drives	Option 1/2/4	Compile data from UI/CL&P 2005 Coincidence Factor Study, CL&P Municipal Impact Study, NSTAR BSCS Non-Lighting M&V Impact Study, NSTAR C&I Retrofit Impact Study and conduct new metering.
Refrigeration	Option 1/4	Compile results from a number of studies that are available, including NSTAR BSCS Impact Studies, NSTAR SBS Impact Study, NSTAR CS Impact Study, NSTAR C&I Impact Study and NGrid SBS Customer Impact.
Tier 2 Importance		
Industrial - Process	Option 1/2/4	Compile data from NSTAR BSCS Non-Lighting Impact Study, NSTAR BSCS Impact Study, NSTAR C&I Retrofit Study and NSTAR C&I New Construction Retrofit Study.
Data Center Cooling	Option 4	No studies were found related to data center cooling. New metering is recommended.
HVAC - Other	Option 1/4	Compile results of NSTAR BSCS Non-Lighting M&V Impact Study, NSTAR C&I Retrofit Impact Study, and NGrid Custom HVAC Impact Study, and conduct new metering.
HVAC - Ventilation (Only)	Option 4	Since no studies were found, DOE modeling or new metering is recommended.
HVAC - Reheat	Option 4	Since no studies were found, DOE modeling or new metering is recommended.
Water Heating	Option 3/4	Since no non-residential water heating studies were found, DOE modeling or new metering is recommended.
Pump	Option 3/4	No studies found. DOE modeling or new metering recommended.
Compressed Air	Option 1/2/4	Compile results of NSTAR studies: BSCS Non-Lighting M&V Impact Study, CS Impact Study, C&I Retrofit Study, C&I New Construction Retrofit Impact Study, and conduct new metering.
Data Center Equipment	Option 4	No studies found. New metering recommended.
Tier 3 Importance		
Agricultural - Pumping	Option 5	Due to minimal contributions to efficiency program savings, no action is recommended at this time.
Appliances - Laundry	Option 5	
Food Service Equipment	Option 5	
Agricultural - Process	Option 5	
Clean Room	Option 5	

1.6 Future Regional End-Use Data Efforts

This study has shown that there is relatively little current end-use data being collected today with the exception of data collected on air conditioners for demand-response program evaluation or for the purpose of energy efficiency evaluation using relatively short data collection periods. Further, the challenges associated with collecting data for this project have made it clear that any future endeavor would greatly benefit from a much more systematic approach.

As we consider the future of end-use metering we must examine various approaches to secure the information. We will review several alternatives including:

- **Traditional approaches** - Traditional end-use metering approaches involved the installation of a load recording device directly on the load of interest. This form of end-use data collection is very customer intrusive requiring access to the customer's facility/home to install the monitoring devices on the appliance or circuit. Cost of the traditional approach was high, which often limited the sample size; however, data quality and the "signal to noise ratio[4]" was also very high.

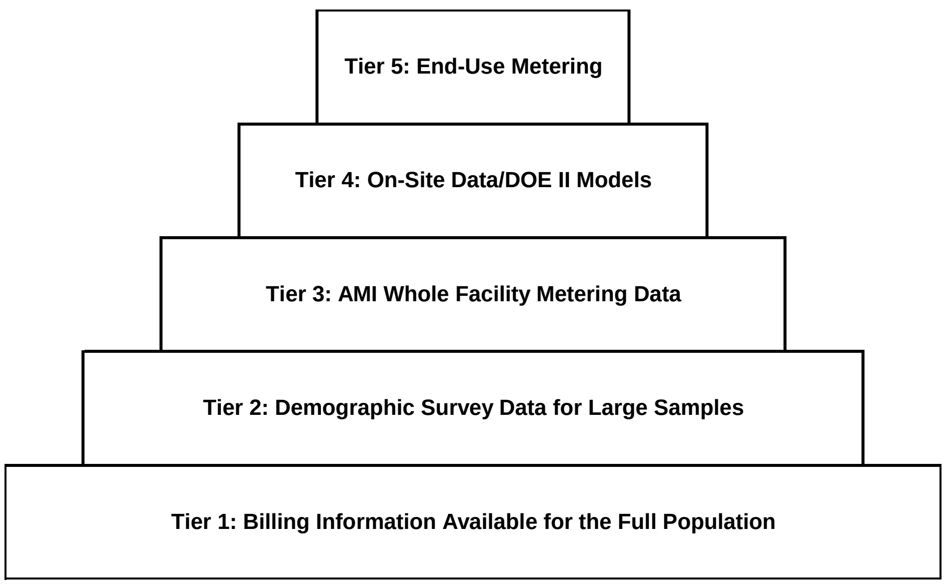
- **Advanced Metering approaches** - Residential end-use data collection may not need to rely on traditional approaches to collect end-use data due to advancements in metering technology. The Single Point End-use Energy Disaggregation (SPEED) and Non-Intrusive Appliance Load Monitoring (NIALMS) devices permit the collection of a multitude of appliance end-use loads without the wiring nightmares of past years. These hardware/software systems purport to allow for the collection of appliance-specific load data without entering customer premises and without installing metering devices on appliances. The analysis software seeks to recognize appliance signatures in the data for example an electric water heater with a 3,500 Watt heating element would look significantly different than a 100 Watt light bulb. However, when appliances have relatively similar electric signatures the ability of the software to distinguish between 3,500 watt water heater element and a 3,500 watt stove burner is somewhat suspect.
- **Statistical approaches** - Statistical approaches, in particular conditional demand analysis, have been used for years to identify the end-use loads within more aggregate data. Typically, responses from a large market saturation survey (i.e., several thousand respondents) are coupled with billing data. Statistical regression techniques are built to estimate the monthly, seasonal, or annual usage of customers with various appliances. Experience to date with the application of conditional demand analysis to short-time integration power-consumption data is limited but has the potential to provide additional end-use detail over traditional monthly billing data approaches.
- **Prototype/DOE2 Engineering Modeling approaches** - When reliable end-use load data are not available, an hourly building energy simulation approach may be used to create the loads. Popular computer tools capable of hourly building load simulations include DOE2 and its user-friendly derivative (eQuest), EnergyPlus, TRNSYS, and BLAST. Currently, the most popular of these, and used throughout the world, is DOE2. One clear advantage of the DOE2 modeling approach is the ability to quickly and easily change weather data by simply utilizing different weather files.
- **Short-term energy efficiency metering approach** - In this study, we found a number of projects that deployed direct metering of energy efficiency measures (e.g., chillers, ductless heat pumps, water heaters). These projects used direct measurements on reasonably sized samples. The one limitation to the energy efficiency evaluation

[4] In this context, the "signal to noise ratio" refers to how well the end-use load is isolated from other household loads.

approach is that the metering usually occurred for relatively short periods of time, i.e., one week to several months, and is focused on the energy efficiency measures in question (these may or may not be end-uses of interest).

- **Hybrid approaches** - Hybrid approaches that link several of the aforementioned strategies together warrant careful consideration in any future end-use metered data collection effort. We tend to think of these as a pyramid with improvements in the “signal-to-noise” ratio as we move up the pyramid coupled with increased cost and complexity. Figure 2 below presents one possible construct. This shows the foundation of the data collection pyramid as being embedded in the billing data that is available at the utility for the full population of customers of interest. All of these strategies can be linked statistically so the highest point of inference is the actual end-use metering data, which has the “best” signal to noise ratio.

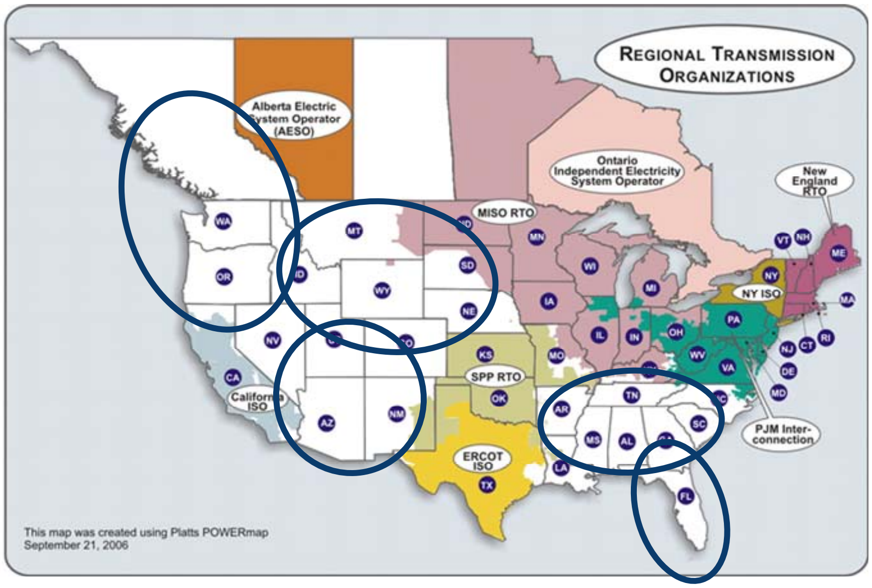
Figure 2: Hybrid Approach



1.6.1 Regional Transmission Areas

Figure 3 presents a U.S. map with the regional transmission organizations highlighted in color and “other” potential regions highlighted using ellipses. As we think about how best to organize future end-use metering data collection efforts, we naturally turn to how transferable the information is from one region to another. Transferability may indeed differ by customer class or customer segment. Clearly, different regions may have very different climates and could even have different usage patterns driven by variations in regional expectations and behavior.

Figure 3 – Regionalizing the effort



1.7 Conclusion and Recommendations

The results of this project have shown that there appear to be some usable end-use datasets available. Since data collection efforts are conducted on an ad-hoc basis within and between the Pacific Northwest and Eastern regions, it makes it difficult to assess how transferable the data is for populations not directly represented by the research efforts. There were significant limitations that were not possible to capture in this study, including limitations on transferability imposed not by inconsistency of methodology and data format, but by heterogeneity of critical determinants of load shape. There was also found to be significant differences in the data priorities among program administrators. Therefore, we recognize that specific program administrators may have different priorities for data collection than what was identified.

The following recommendations are provided to assist the regions with developing a coherent method of warehousing, distributing, and updating end-use and efficiency measure load data for the regions to eventually have a full array of data for all end-uses and efficiency measures.

1.7.1 Near-term Recommendations (Up to 12 Months)

Near-term recommendations are provided to focus on immediate tasks to meet the urgent needs of the capacity markets and the initial steps necessary to support a large coordinated effort by the regions to collect end-use data that would be broadly usable and transferable.

Coordinate with metering studies currently in progress

There is an opportunity to engage the entities conducting the studies to ensure adequate sample size and ancillary data collection and potentially provide additional funding to support data collection that will yield useful results for the Pacific Northwest and/or East regions. This is most important for the Pacific Northwest region, which stands to gather a significant amount of useful end use and measure load shape data from the BC Hydro study. The following studies have been identified as potentially useful, and are in the planning stages:

- The BC Hydro Power Smart Residential End Use Metering Study
- New York City has launched a pilot end-use metering project in governmental facilities.
- Northeast Utilities and United Illuminating in Connecticut are preparing to conduct a new commercial and industrial energy evaluation study over the 2009 summer season.
- Northeast Utilities and United Illuminating in Connecticut are also planning to conduct a residential low income evaluation.

Implement new metering studies targeted at specific end-use analysis groups

For the residential sector, the major data collection efforts recommended at this time are related to plug loads (consumer electronics) and HVAC analysis groups for both regions, due to lack of regional studies and low transferability related to the HVAC analysis groups.

For the non-residential sector, HVAC analysis groups, data center cooling and refrigeration end use analysis groups generally could use new metered data for both regions. The Eastern region has significantly better coverage on the non-residential sector, and some data from completed studies could be combined into a regional meta-study.

The Pacific Northwest should use its new metering studies to examine whether some ELCAP data may still be applicable to today's loads. It is important to note that planning these studies takes significant lead time. In order to have monitoring equipment in the field in time for summer peak monitoring, entities need to start planning no later than December of the previous year. Ideally, in order to pilot test all the protocols, procedures and specifications, the effort should be initiated a full year in advance of when full scale implementation is planned.

Pilot the transfer of end use data from one region to another

To assess the feasibility of transferring data from one region to another, KEMA recommends piloting one specific end use, preferably one with a high transferability rating (e.g. non-residential lighting). Analysis groups that have a high transferability rating should be the easiest to combine, however it is advisable to perform a statistical comparison of the datasets from each region to make sure that no significant bias is being introduced into the results. If there are no data from within the region than there really is no way to perform this bias analysis and justifying the transferability of the data becomes more problematic, particular with respect to capacity market M&V requirements.

Develop detailed protocols for end-use data collection

If entities between (and within) the regions envision coordinating future efforts to develop load shapes, then region-wide (or even national) protocols are needed to establish consistent methods and procedures for handling the data for end-use and measure savings shapes that are transferable between regions. These protocols would also enable data from smaller studies (e.g. conducted for individual program evaluations) to be combined into larger regional meta-studies.

The protocol effort should be coordinated with other concurrent initiatives and leverage the work of previously developed protocols. The components of a regional data collection protocol should include developing consistent definitions for end-use categorizations and efficiency measure types, precise instrumentation instructions, robust data verification procedures, and specific protocols for collecting the necessary ancillary data, including equipment information, building and occupant characteristics data.

As part of this process, stakeholders should concurrently discuss what a centralized data warehouse for the end-use datasets might look like and ensure that the data collection protocols include guidance for the standardization of data format and storage.

1.8 Mid-Term Recommendations (1-3 years)

Some recommendations are provided, looking ahead to several years from now. These needs are less urgent, but support future coordinated regional end-use data efforts.

Implement multi-region end-use data repository

The end goal of the project is to develop a central warehouse for storing the end-use load datasets and providing consistency in data format and definitions to allow the load shape data to be widely usable. Advances in computational abilities could allow this warehouse to be virtual if robust, yet flexible, data storage specifications are developed. Storage could be dispersed with access over the web. This approach would naturally have additional risk of losing data but could be a viable option to explore if resources to support a central repository are inadequate. A key aspect of whatever data warehouse or repository is eventually implemented is the need for an easy to use interface tool that would allow sorting, adding, and accessing data. This tool would also need key connections to the variables used in the regionalization process and the ability to generate profiles and conduct simple analyses.

Plan for other study types (non-metering studies)

As regions begin collecting data and looking to transfer usable datasets from one area to another, it may become clear that additional region-specific ancillary data is needed to improve the accuracy of the transfer. Examples of customer population-specific data needed may include typical building characteristics, inventory of system types and efficiencies, air and water system temperatures, and saturation of different equipment types, to name a few.

Assess feasibility of disaggregating end use information from AMI whole premise data

Consider launching regional initiatives (one in the Pacific Northwest and one in the Northeast or Mid-Atlantic) to test the ability to leverage end-use information from whole premise interval load data coupled with demographic data using statistical techniques. To support the vision for a hybrid approach to developing end-use load shape datasets in the future, this would be the first step to test the ability to leverage end-use information from whole premise interval load data coupled with demographic data using statistical techniques.

Concurrent to this, the Regions may consider surveying their utility stakeholders to identify opportunities to collect large amounts of whole facility load information through AMI. While utilities have been metering hourly load data for many years for other purposes, these new approaches to developing end-use load and savings data could be substantially less expensive than previous end use data efforts, such as ELCAP. The survey should be divided by customer class and should identify the frequency and potential cost of data capture. In addition, this initial feasibility assessment, should measure the willingness of the regional utilities to engage in such as an exploratory study to leverage their AMI data.

Consider seeking funding for use in launching a regional initiative in the Pacific Northwest and Northeast sponsored by the Council and NEEP. The projects would be proof of concept with the capacity to expand to a full national initiative.

1.9 Long-Term Recommendations (>3 years)

Continue to maintain and update the catalog of end use data

The catalog of end-use and measure load data studies has the potential to be extremely useful to continued efforts to develop regionally applicable load shapes for the range of uses encompassing energy efficiency planning, capacity markets, and air quality. As energy efficiency becomes an increasingly important part of utility portfolios to meet load growth, more and more entities are seeking the data to validate cost, demand and air emissions savings. Maintaining the central repository and catalog is an important long term goal for this project.

2. Introduction

KEMA, Inc. (KEMA) has contracted with the Northwest Power and Conservation Council (Council) and the Northeast Energy Efficiency Partnerships (NEEP) to develop a detailed catalog of available end-use data for typical loads in the Pacific Northwest and the East regions (defined as New England states, Mid–Atlantic states, and New York). This work will comprise Phase 1 of the Council's End-Use Load Data Update Project. The overall project purpose is to develop a coherent method of warehousing, distributing, and updating end-use and efficiency measure load data for the regions to eventually have a full array of data for all end-uses and efficiency measures. The results of Phase 1 will inform the next steps in the overall project.

2.1 Definition of End-Use and Measure Load Shapes

Total hourly energy consumption related to a specific end-use varies over the 8,760 hours of the year. This variation of hourly consumption over the year is represented by the end-use's load shape. The end-use's load shape represents what fraction of annual energy consumption occurs in each hour (or other time period) of the year.

Similarly, energy savings benefits associated with energy efficiency program measures vary over the 8,760 hours of the year, and the distribution of savings over the year is represented by the measure's load shape.

For some measures, the variation of annual energy savings over hours is similar to the variation of annual end-use energy consumption. For other measures, such as many types of controls, most of the energy savings tend to occur at hours of lower energy use so that the measure shape is nearly opposite to the end-use shape. In these cases, using the end-use shape as a proxy for the measure shape will tend to misrepresent the shape of the measure.

Savings cannot be directly metered. Only usage can be directly metered. However, metering data can provide the foundation for meaningful savings estimates. Depending on the nature of the measure, it may be sufficient to meter only a baseline condition or only the high-efficiency condition as the basis for estimating savings, or it may be necessary to meter both. In all cases, the estimated savings are a calculated value using the measured values as inputs.

For this project, both end use consumption and measure savings shapes were categorized into applicable end use categories for data collection purposes. Many of the more recent data studies were found to be energy efficiency impact evaluations. The project attempted to collect information on the exact measures included in the studies. Older studies, such as ELCAP, were mostly baseline studies. Due to the number and diversity of specific measures included in any one project, the measures were broadly grouped into end use categories.

2.2 Background on Project Needs

The impetus for this project varies by region, but revolves around the need to better define the impacts of energy efficiency measures on an interval basis and across specific performance periods. In the East, the emergence of capacity markets that allow energy efficiency programs to participate has also brought about the need to evaluate the demand reduction value of measures across specific performance hours and within a prescribed statistical relative precision. Additionally, the Regional Greenhouse Gas Initiative (RGGI) and recent efforts to recognize energy efficiency in meeting air-quality regulations has also added another layer of reporting requirements that is driving concern about the need for energy efficiency load shapes. The existing cost effectiveness test in the East is characterized as focusing on avoided fuel costs, which are driven by annual energy-savings estimates. There have been some coordinated regional efforts at developing energy efficiency demand impacts; however, there is a short-term need for many of the energy efficiency implementers in the region to develop reliable energy efficiency load shapes that can meet current and future reporting needs.

The Pacific Northwest region currently utilizes detailed measure-level spreadsheets that are used to perform time-of-use (TOU) cost effectiveness analyses, based on energy-consumption profile-data from the End-use Load and Consumer Assessment Program (ELCAP) (also known as the End-use Load and Conservation Assessment Program and the Regional End-use Monitoring Program or REMP) and other sources (other end-use data and modeling efforts). One of the primary concerns is that data collection for the ELCAP study dates is pre-1990 and energy utilization intensities of HVAC equipment and appliances have changed significantly over the last twenty years. The approach that is generally used in this region is the development of 8,760 hourly profiles based upon ELCAP-metered data, which are then binned into the appropriate time-of-use (TOU) bins for calculating cost effectiveness of energy efficiency measures. One of the primary issues is that there are new end-use metering studies being planned to update these analysis tools, and the project sponsors would like to make sure that the efforts capture the proper level of detail.

2.3 Project Objectives

The overall objective of this project is to assess the existing end-use and measure load shape data available for typical loads in the Pacific Northwest and Eastern regions. This phase of the load-data update will identify problems with the existing load-shape data and establish priorities and study scopes for load-shape improvements to support energy efficiency program planning, electricity markets, and environmental policy.

Elements of Phase 1 of the project include:

- Research and inventory the existing load shape data available.
- Determine what load shape data is necessary to meet utility energy efficiency program, ISO-New England, and Forward Capacity Market (FCM), and air quality regulatory needs.
- Identify weaknesses in the existing data for use in efficiency programs, ISO-NE FCM, and air quality regulations.
- Evaluate the transferability and applicability of existing load-shape data to the regions.
- Provide a road map for meeting future short-term and long-term end-use metering needs.

2.4 Report Organization

Chapter 3 provides an overview of the approach to identifying usable end-use load datasets and the results of data collection effort.

Chapter 4 summarizes the needs of users of end-use load shape data, including energy efficiency planners, capacity market operators and air-quality analysts.

Chapter 5 reviews the metrics for determining usability of the end-use load datasets identified, and issues related to transferring load shapes from one region to another.

Chapter 6 presents information related to the studies that were classified as "usable" and summarizes the gaps in available data.

Chapter 7 provides a prioritization scheme for load shape improvements for each region.

Chapter 8 offers a vision and roadmap for coordinating future end-use data efforts.

Chapter 9 summarizes the recommendations for near-, mid- and long-term load shape improvement efforts.

3. The Search for Usable Datasets

The primary objective of this phase of the project is to search for and assess the usability of available end-use and efficiency measure load data sets in order to facilitate consensus on identifying what new load research needs to be performed. One of the key challenges in the data collection effort was to cast the net wide enough to capture all potentially useful datasets, while collecting enough dataset characteristic information to ultimately assess its usability. In this chapter, we first outline our approach for locating potentially useful datasets and then provide a summary of the survey results and the types of studies that were found.

3.1 Methodology for Identifying Datasets

The primary data collection effort was the implementation of an Internet-based survey that was designed to identify end-use data collection studies. The survey was distributed to approximately 102 industry contacts located in various regions of the U.S. and Canada. The survey was also submitted internally to KEMA personnel who are knowledgeable about end-use metering projects completed by KEMA and the former RLW Analytics, which is now part of KEMA.

We supplemented the web-survey effort with the results of the recent 2007 California Load Shape Update Initiative, for which KEMA had conducted a similar catalogue for California-specific studies. Once a broad set of studies was identified, KEMA followed up with specific industry contacts to further identify potentially useful studies and collect more information related to specific dataset properties.

3.1.1 Web Survey Effort

The Internet-based survey was designed to identify end-use data collection efforts at the study level and was distributed to 102 industry contacts from various regions of the country, but primarily focused on the Northeast, Pacific Northwest and Mid-Atlantic Regions. The primary goal of the survey was to broadly search for potentially useful end-use datasets and to collect the basic information necessary to determine whether follow up efforts were warranted. See Appendix A for the full survey.

The web survey was initially implemented on March 2, 2009 and was available for responses for a period of more than seven weeks. KEMA staff distributed notification of the survey via e-mail, followed with e-mail reminders. After the first week of implementation KEMA started contacting respondents who preferred to complete the survey by phone. After the second wave of e-mail reminders, KEMA staff contacted (by phone) all respondents who had started the survey but left the web site before completing it, and provided assistance to complete the survey. Finally, after about the fifth week of implementation, KEMA staff attempted to call the entire list of e-mail recipients and offered to help them complete the survey.

Note that the implementation of the web survey sought to make it easy for industry contacts to input information related to the studies they were aware of. This approach still required significant follow-up with specific people, in order to identify as many potentially useful studies as possible. Most contacts likely focused on larger and more recent studies they were aware of. In contrast, KEMA was able to conduct a much more exhaustive review of studies completed by KEMA (and former RLW Analytics).[5]

The survey was broadly segmented into two end-use categories, residential and non-residential, and within these categories there were end-use analysis group categories that were developed with stakeholder input. The end use analysis groups are intended to capture both measure savings shapes and end use consumption shapes. The residential end-use consisted of 13 analysis groups and 69 different measures within the groups. Table 14 provides a list of the 13 residential analysis groups that are organized into five higher level end-use categories.

Table 14: Residential Analysis Groups[6]

End Use	Analysis Group
Appliances	Appliances - Kitchen
Appliances	Appliances - Laundry
Appliances	Appliances -Refrigerators
Water Heating	Domestic Hot Water
HVAC	HVAC – Cooling
HVAC	HVAC – Fan Energy
HVAC	HVAC - Heating
HVAC	HVAC - Ventilation
HVAC	HVAC - Other
Lighting	Lighting - Exterior
Lighting	Lighting - Interior
Other	Plug Load (Electronics)
Other	Pool Pump

There were 22 non-residential analysis groups used in the survey as shown in Table 15.

[5] RLW Analytics was acquired by KEMA Inc., effective January 1, 2009.

[6] "HVAC – Other" category is intended to broadly capture general HVAC measures such as controls, envelope (including insulation, window film, etc) and quality installation measures.

Table 15: Non-Residential Analysis Groups

End Use	Analysis Group
Agricultural	Agricultural - Process
Agricultural	Agricultural - Pumping
Appliances	Appliances - Laundry
Other	Clean Room
Other	Compressed Air
Other	Data Center Equipment
Other	Data Center Cooling
Other	Food Service Equipment
HVAC	HVAC - Cooling
HVAC	HVAC - Fan Energy
HVAC	HVAC - Heating
HVAC	HVAC - Other
HVAC	HVAC - Reheat
HVAC	HVAC - Ventilation Only
Process	Industrial - Process
Lighting	Lighting - Exterior
Lighting	Lighting - Interior
Process	Motors - Drives
Other	Plug Load (Electronics)
Process	Pump
Refrigeration	Refrigeration
Other	Water Heating

Table 16 provides a summary of the survey response rate by region, which shows that about 38% responded to the survey and about 23% actually provided data.

Table 16: Summary of Survey Response Rate by Region

	No response		Yes, but no studies		Yes, provided	
Region	**(n)**	**%**	**(n)**	**%**	**(n)**	**%**
Northeast	21	75%	7	25%	0	0%
Pacific NW	18	56%	4	13%	10	31%
Other	24	68%	5	12%	13	31%
Overall response rate	63	62%	16	16%	23	23%

3.1.2 California Load Shape Update Initiative (2006) Results

In the fall of 2006, KEMA was contracted to assist the California Public Utilities Commission (CPUC) and its investor-owned utilities to develop a Load Shape Update Initiative (LSUI) to identify near- and long-term load shape improvement objectives and criteria for prioritizing end-uses and measures for load shape improvements. The primary motivation for this particular project was to support efforts to update the Database of Energy Efficiency Resources (DEER) and develop load shapes that could be matched to the hourly 8,760 avoided costs that were developed in 2004.

The project provided the CPUC with a better understanding of what load shapes existed within California and an assessment of data quality. In addition, KEMA developed an inventory of load data collected within California. Meaningful information was collected from 16 load-shape/load-data owners from across 9 organizations. Information compiled for each dataset included time frame, end-uses covered, whether hourly data was included, and whether shapes were developed by direct metering.

Given the similarity of the 2006 California effort to this Council and NEEP project, the information collected and load data inventory for the CA LSUI was added to the list of end-use load studies identified through the web survey.

3.1.3 Other Follow-Up Efforts with Industry Contacts

KEMA conducted a number of follow-up interviews with industry contacts who appeared to have potentially useful end-use load data. These interviews were meant to further explore the studies that appeared to have potentially useful load shape data and focused on additional questions about the data itself, as well as efforts to obtain any written reports related to relevant studies. The follow-up questions covered such topics as:

- Is the data readily accessible from the study?
- What type of interval data was collected (i.e., true power, current only, on/off transition data)?
- What was the data structure and usability?
- Clarify the form of data, whether in 15-minute, hourly, or another form.
- What type of data was captured and with what types of measurement equipment?
- Was the data normalized?
- Was there weather data included or if not was a date and time stamp attached to the data?
- Is the data available at little or no cost?
- Is there an electronic copy of the report available?

The follow-up interviews revealed that while some of the data is available and indeed useful, many of the studies were not ultimately deemed very useful. Common problems include small sample sizes, not collecting necessary information to expand to a broader population, and very short-term monitoring of measures.

A handful of the potentially useful studies have provided electronic versions of the reports in addition to several more supplying web links to be able to download study reports. It is also important to note that although a potentially useful study contact may "say" that the data is available, none of the data has been collected as of this writing.

3.2 Identification of Dataset Properties

The following is a list of dataset properties that KEMA sought to collect as basic information necessary to assess "usability."

- Data source
  - Region
  - Utility or agency that sponsored the study
  - Contact person (email address, and company/organization)
- Sector (Residential, Non-residential)
  - End-use or efficiency measure
  - End-use(s)
  - Measure level detail
  - Whether further end-use description information is available
  - Whether equipment nameplate data was collected
  - Whether equipment vintage was collected
  - Whether equipment operating hours were collected
  - Whether units of production were collected
- Site characteristics
  - Whether facility description was collected
  - Whether facility square footage was collected
  - Whether hours of operation were collected
  - Whether SIC or NAICS code was collected
  - Whether number of employee information was collected
  - Whether climate characteristic data was collected
  - Whether location was recorded
- Customer characteristics

  - Any available customer segment detail
- Data characteristics
  - Metered or simulated data
  - Sample size
  - Duration of project
  - Usage or impact
  - Data collection equipment type
  - Data collection and validation protocols
  - Time granularity of metered data (5-minute, 15-minute, hourly, etc)
  - Data format (Excel, SAS, SQL, hardcopy, etc.)
  - Study date(s)
  - Data accessibility (self-reported rating)
  - Estimated cost to acquire the data (no cost or potential costs to be researched further)
  - Additional comments/shortcomings of data.

Furthermore, KEMA sought to differentiate between studies that focused on end use load shapes and those that developed measure savings shapes. The specific end uses and measures were grouped into the broad end use categories for the assessment of data availability.

While most of the web-survey respondents answered "don't know" to many of the specific data-set characteristics, the follow-up phone calls sought to systematically collect this information for data sets that appeared to be promising and potentially useful. Ultimately, the data collection process was an iterative exercise, with each step collecting enough information to determine whether further effort was warranted.

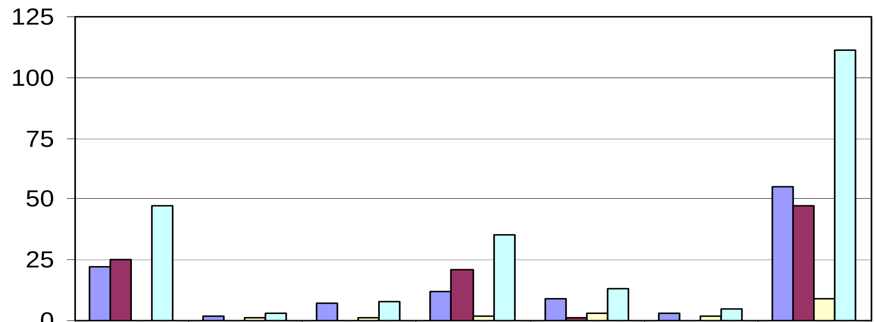
3.3 Survey Results

The following sections will summarize the results of the overall data collection efforts and provide an overview of all studies identified and catalogued. Figure 4 provides a listing of the number of studies that were catalogued by customer sector and region, which shows that about 74% of the 111 studies identified were conducted in the New England (NE) or California (CA) regions.[7] There were slightly more residential studies (55) than non-residential (47) and nine studies that covered both customer sectors. The final list of studies should contain most of the

[7] This may be due to the fact that KEMA and the former RLW Analytics have conducted a significant number of direct metering studies in these two regions, and our staff systematically pulled together information related to all these studies that were conducted in-house.

recent activity although there may be some studies that have not been captured in regions with particularly low survey response rates.

Figure 4: Studies Catalogued by Customer Sector and Region



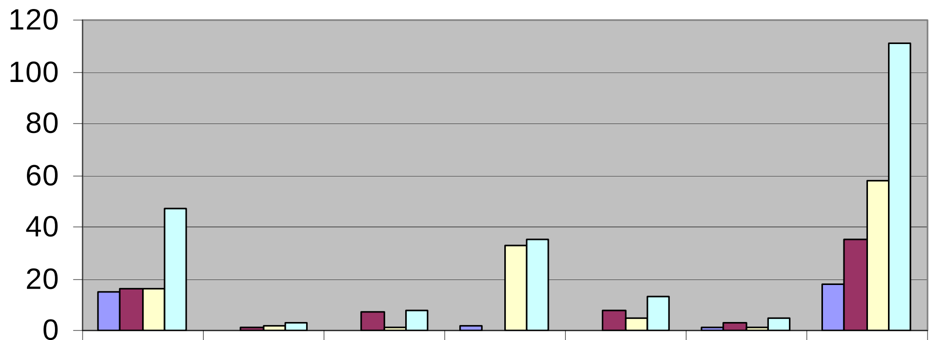
	CA	Mid-Atl	Mid West	NE	NW	Other	Total
Residential	22	2	7	12	9	3	55
Non-Residential	25	0	0	21	1	0	47
Both	0	1	1	2	3	2	9
Total	47	3	8	35	13	5	111

The studies were classified based upon the general purpose of the study and the type of data collected into one of three categories as follows:

- **Compilation Studies** – were studies that compiled primary interval data from other studies and used either DOE2 modeling or statistical modeling techniques to produce average end-use load shapes.
- **Load Research Studies** – were studies that utilized long-term end-use power metering to develop average end-use load shapes. The samples were typically selected to define end-uses at the rate class level with little or no customer-specific data collected other than the interval power data.
- **Evaluation Studies** – were studies that primarily focused on evaluating savings impacts for energy efficiency measures or demand-response programs. These studies were typically characterized by shorter-term monitoring of program participants that only collected data about the specific program measures being evaluated.

Figure 5 shows the distribution of the study types by region, which shows that there were 18 compilation studies, 35 load research studies, and 58 evaluation studies catalogued.

Figure 5: Distribution of Study Types by Region



	CA	Mid-Atl	Mid West	NE	NW	Other	Total
Compilation	15	0	0	2	0	1	18
Load Research	16	1	7	0	8	3	35
Evaluation	16	2	1	33	5	1	58
Total	47	3	8	35	13	5	111

The bulk of the compilation studies were conducted in California and can be reduced to six studies (the 15 listed are because of multiple customer sectors) as follows:

- **e-Shapes** – Proprietary software tool that utilizes DOE2 and 1990's vintage prototype models
- **CEC Forecast Load Shapes** – Load shapes that are built using 1990's vintage prototype DOE2 models
- **Commercial End-use Survey (CEUS)** – Load shapes built using survey data from 800 commercial buildings 1990's vintage prototype DOE2 models
- **Database for Energy Efficient Resources (DEER)** – Load shapes built from CEUS models, but with different calibration procedures that incorporate metered energy efficiency evaluation data to update operating schedules
- **End-use Disaggregation Algorithm (EDA)** – Lawrence Berkeley Lab algorithm that developed non-residential end-use load shapes from whole premise interval data, 1993 vintage
- **Load Shape Disaggregation (LSD)** – San Diego Gas & Electric 1995 vintage study that developed non-residential end-use load shapes from whole premise interval data.

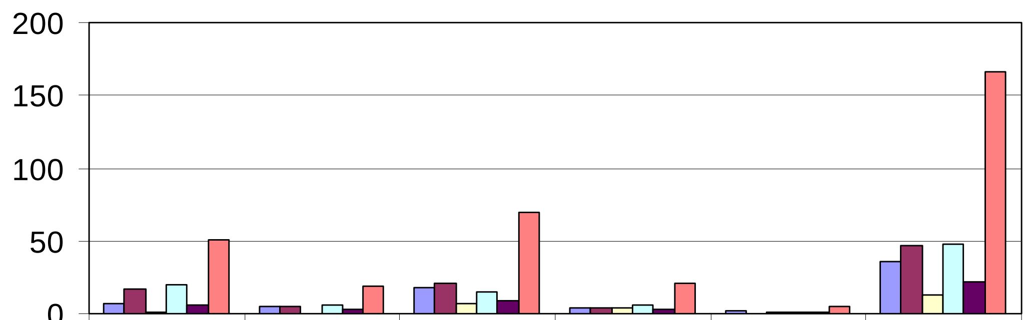
The two New England compilation studies were both Coincidence Factor (CF) studies that compiled measure-level short-term metering data from prior evaluation studies and developed measure level CFs across specific performance hours. The first study was the Connecticut CF study, which was completed before the Independent System Operator of New England (ISO-NE) finalized their Forward Capacity Market (FCM). The performance hours used to develop the CFs in this report are different from the performance hours defined for FCM. The State Program Working Group (SPWG) CF study was completed in response to the ISO-NE FCM and utilized metered data from the CT CF study along with other New England Evaluation metered data available at the time.

The remainder of the survey results section will look at the end-use level results of the cataloguing effort and will exclude data from the compilation studies, because many of the primary sources of data used in the compilation studies are included in the catalogue. Additionally, the whole premise end-use will also be excluded from the end-use level results. Whole premise data were not included because the focus of this effort was to identify end-use data that could be utilized directly to evaluate energy efficiency measure without applying analytical methods to identify individual end-uses within the data.

3.3.1 Residential End-Use Survey Results

One of the first variables examined was the sample size of the various residential end-uses that were collected in the catalogue. Figure 6 provides the results of the residential sample size data by end use. The sample size data was binned into categories based on size, with smallest category being 50 or less, 51 to 150, 151 to 250 and 251 to 700 sample points. The end-use categories are higher level versions of the analysis groups. For example, the appliances end-use contains appliances – kitchen, appliances – laundry, and appliances – refrigerator analysis groups as well as the plug-load analysis group. The other end-use contains the pool pump analysis groups and measures related to pools and spas. The results show that 36 out of 144 end-use data points (26%) had a sample size of 50 or fewer and that almost three quarters of the residential end-uses data points had samples of 51 or greater.

Figure 6: Residential Sample Size Data by End-use

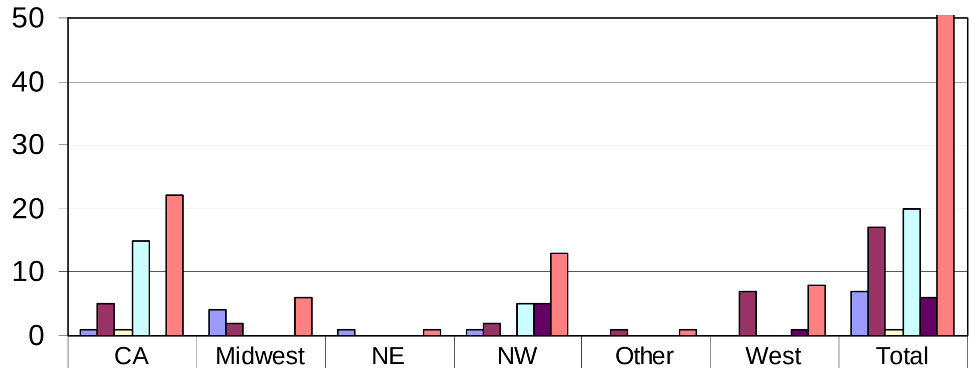


	Appliances	DHW	HVAC	Lighting	Other	Total
0-50	7	5	18	4	2	36
51-150	17	5	21	4	0	47
151-250	1	0	7	4	1	13
251-700	20	6	15	6	1	48
Blank	6	3	9	3	1	22
Total	51	19	70	21	5	166

The next series of figures will drill down to the end-use level and examine the sample size distribution by region for the appliances, HVAC, and lighting end-uses. It is important to note that the results in these figures are being reported at the end-use level, but that does not mean that each sample point represents a unique study. In fact, in most cases one study would produce multiple sample points for different measures within a single end-use category or even across end-use categories.

Figure 7 provides the distribution of the residential appliance end-use sample sizes by regions, which shows that close to half of the appliance end-use data was collected in California. The Northwest region had 13 appliance end-use sample points and was the next most active region. In general, the appliance sample sizes tended to be fairly large with 20 end-use sample points greater than 250. Although this may look like a fairly substantial amount of data, it is important to note that these end-use sample points come from 18 different studies, and six of the studies were old load research studies conducted in the Midwest region during the late 1980s and early 1990s that would be of little use today. Of the twelve remaining studies, the California data came from five studies, and the Northwest data is from four studies, but one of the four is still in the planning stages. There was one study each for the Northeast, other, and West regions.

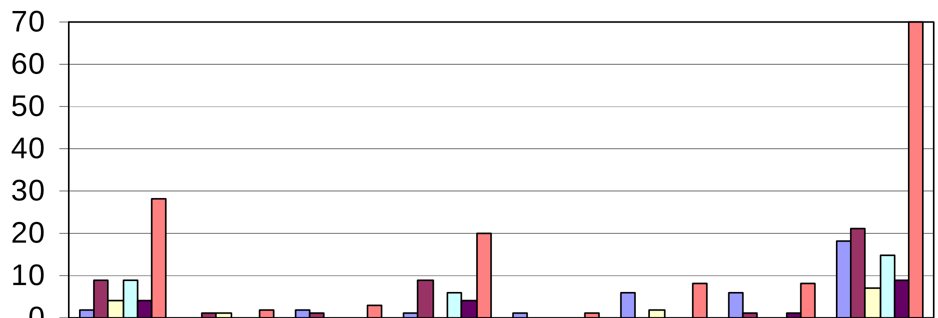
Figure 7: Residential Appliance End-use Sample Sizes by Region



	CA	Midwest	NE	NW	Other	West	Total
0-50	1	4	1	1	0	0	7
51-150	5	2	0	2	1	7	17
151-250	1	0	0	0	0	0	1
251-700	15	0	0	5	0	0	20
Blank	0	0	0	5	0	1	6
Total	22	6	1	13	1	8	51

Figure 8 shows the distribution of the residential HVAC end-use sample sizes by region, which shows that once again the California and Pacific Northwest regions were the most active with 28 and 20 of the end-use sample points respectively. The sample sizes for the HVAC end-use were fairly large with about 70% of the reported sample sizes greater than 50. HVAC measures are weather dependent, and it can be challenging to determine whether the data from one region of the country is transferable to another region particularly when moving from a warm, dry climate to a cooler, humid climate. This is a concern for the Northeast region, where only three residential HVAC end-use sample points were identified as well as the Mid-Atlantic region with only two end-use sample points. The 70 end-use data points came from 32 different studies, but almost half (15) of the studies were from the California region. The residential HVAC end-use data came from the Northwest region came from eight studies, the Northeast had three studies, and the Mid- Atlantic and South regions each had two studies. The other and West regions each had one study that provided HVAC end-use data.

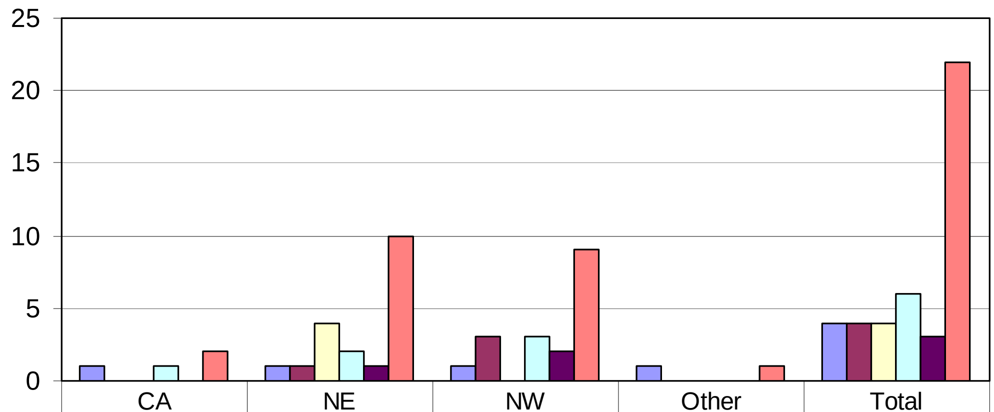
Figure 8: Residential HVAC End-use Sample Size by Region



	CA	Mid-Atlantic	NE	NW	Other	South	West	Total
0-50	2	0	2	1	1	6	6	18
51-150	9	1	1	9	0	0	1	21
151-250	4	1	0	0	0	2	0	7
251-700	9	0	0	6	0	0	0	15
Blank	4	0	0	4	0	0	1	9
Grand Total	28	2	3	20	1	8	8	70

Figure 9 provides the distribution of the residential lighting end-use sample size data by region, which shows that most of the activity has taken place in the Northeast (10) and Northwest (9), with 19 of the 22 sample points coming from these regions. This end-use was unique in the fact that there was virtually no activity outside of the Northeast and Northwest regions. The sample sizes of the studies were generally quite large, although the definition of sample is mixed between the number of loggers and the number of homes monitored, and we were unable to resolve this issue. The residential lighting end-use sample data shown came from sixteen different studies. The data for the Northeast region came from eight different studies and all of the studies were completed after 2000. The data for the Northwest region came from five studies, although one was quite old (ELCAP) and another is still in the planning stages. There were two residential lighting studies conducted in California, a small ceiling fan lighting study and a large room type study. The remaining residential lighting end-use data point comes from an Ontario Power Authority lighting evaluation.

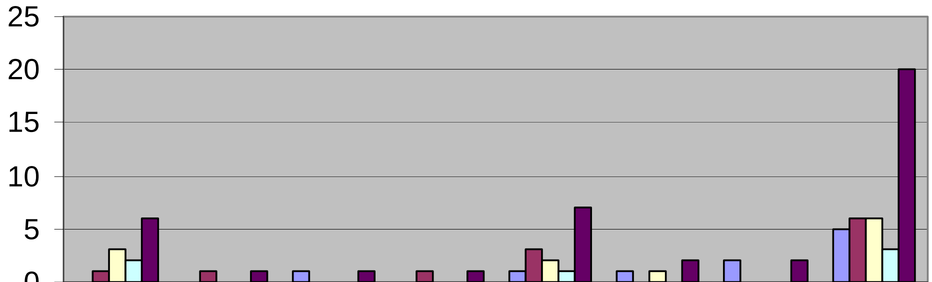
Figure 9: Residential Lighting End-use Sample Size by Region



	CA	NE	NW	Other	Total
0-50	1	1	1	1	4
51-150	0	1	3	0	4
151-250	0	4	0	0	4
251-700	1	2	3	0	6
Blank	0	1	2	0	3
Total	2	10	9	1	22

Figure 10 shows the distribution of the residential Domestic Hot Water (DHW) end-use by region, which indicates that most of the activity has occurred in the California (6) and Northwest (7) regions. In general, the sample sizes were fairly large with more than one-third of the end-use data in the largest sample bin. At the study level, there were a total of 18 residential DHW studies, with seven of those in the Northwest region. The California region had four residential DHW studies catalogued, and there were two each in the South and West regions. The Northeast, Mid-Atlantic, and Midwest regions each had one residential DHW study catalogued.

Figure 10: Residential Domestic Hot Water End-use Sample Sizes by Region



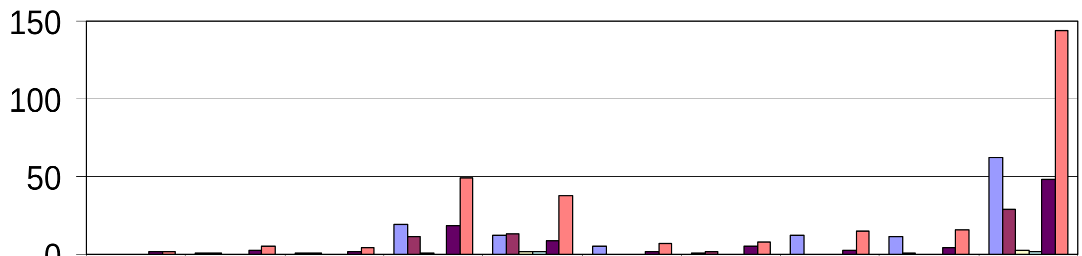
	CA	Mid-Atlantic	Midwest	NE	NW	South	West	Total
0-50	0	0	1	0	1	1	2	5
51-150	1	1	0	1	3	0	0	6
251-700	3	0	0	0	2	1	0	6
Blank	2	0	0	0	1	0	0	3
Total	6	1	1	1	7	2	2	20

3.3.2 Non-Residential End-Use Survey Results

The non-residential customer segment had twenty-two separate end-use analysis groups identified within the survey and over 136 different measures. In order to present the data in a single graph the end-use analysis groups were collapsed into nine higher level end-use categories that primarily involved combining six HVAC end-use analysis groups into one HVAC end-use category and interior and exterior lighting into one lighting category. The other end-use category consists of data center equipment and plug-load analysis group measures.

Figure 11 provides the distribution of the sample sizes for the non-residential end-use data, which shows that about two-thirds of the end-use sample points were in the smallest sample bin of 50 or fewer.

Figure 11: Non-Residential End-use Sample Size Data

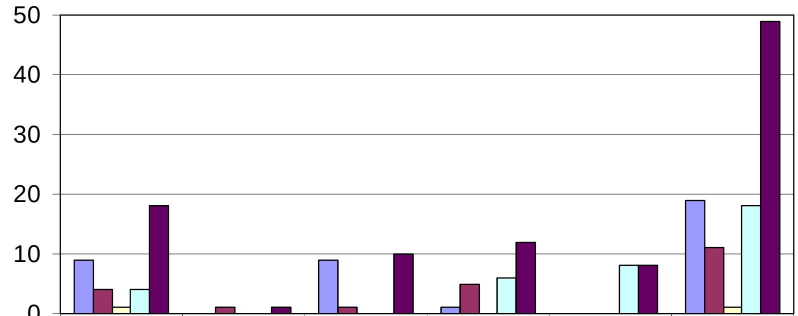


	Appl.	DHW	Food Service	HVAC	Lighting	Motors	Other	Process	Refrig.	Total
0-50	0	1	1	19	12	5	1	12	11	62
51-150	0	1	1	11	13	0	2	0	1	29
151-250	0	0	0	1	2	0	0	0	0	3
251-700	0	0	0	0	2	0	0	0	0	2
Blank	2	3	2	18	9	2	5	3	4	48
Total	2	5	4	49	38	7	8	15	16	144

As expected, most of the activity has been focused on the HVAC and lighting end-uses that account for just over 60% of the sample data points. Process and refrigeration end-uses are among the next tier of non-residential end-uses with 15 and 16 sample points respectively. The remaining five end-uses each have fewer than ten sample points and in aggregate account for the remaining 26 sample points.

Figure 12 shows the sample size distribution of the residential HVAC end-use analysis group by region, which shows that 18 of the 49 sample points are from studies conducted in the California region.

Figure 12: Non-Residential HVAC End-use Sample Size Data by Region

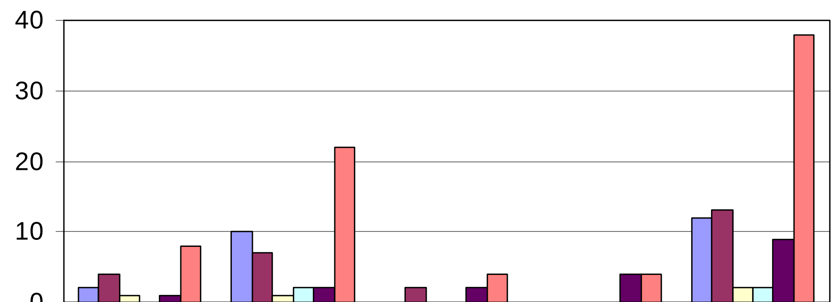


	CA	Mid-Atlantic	NE	NW	West	Total
0-50	9	0	9	1	0	19
51-150	4	1	1	5	0	11
151-250	1	0	0	0	0	1
Blank	4	0	0	6	8	18
Total	18	1	10	12	8	49

The Northwest region had the second most activity with 12 sample points, and the Northeast region had 10 sample points. With respect to sample sizes, the studies were generally small with 19 of the 49 sample points having a sample size of 50 or less. There were 11 sample points identified that had sample sizes of 51 to 150 and five of those were from the Northwest region. However, 18 of the 49 sample points had no sample size information, and half of the sample points from the Northwest region (6) have no sample size data. All of the Northeast region's sampling points have sample size data and 90% were sample sizes of 50 or less.

The non-residential lighting end-use analysis group had a total of 38 sample points, identified as shown in Figure 13. The New England region had the most activity with 22 of the 38 sample points coming from that region. There were eight sample points from the California region and only four from the Northwest region, with two of those having no sample size data. The sample sizes tended to be slightly larger than the non-residential HVAC end-use with 13 of the sample points coming from studies with sample sizes between 51 and 150. There were also two sample points each from studies with sample sizes between 151 and 250 and between 251 and 700.

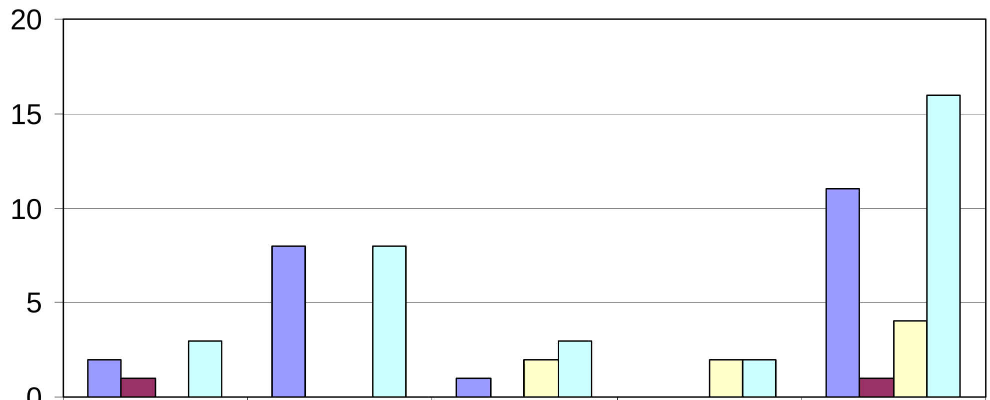
Figure 13: Non-Residential Lighting End-use Sample Size Data by Region



	CA	NE	NW	West	Total
0-50	2	10	0	0	12
51-150	4	7	2	0	13
151-250	1	1	0	0	2
251-700	0	2	0	0	2
Blank	1	2	2	4	9
Total	8	22	4	4	38

There was not a lot of end-use data collection activity directed at the non-residential refrigeration end-use as shown in Figure 14, with a total of only 16 sample points. Half of the total sample points came from the Northeast region (8 of 16) and all of these were from studies with sample sizes of 50 or less. California and the Northwest region each had three sample points, and one of the California studies had a sample size greater than 50 sites. This end use is characterized by smaller studies, with 11 of the 16 sample points coming from studies of 50 or fewer and only one study with a sample size larger than 50.

Figure 14: Non-Residential Refrigeration End-use Sample Size Data by Region

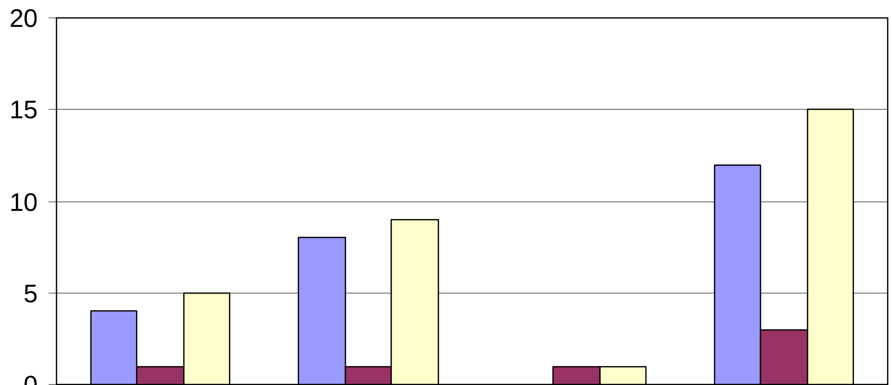


	CA	NE	NW	West	Total
0-50	2	8	1	0	11
51-150	1	0	0	0	1
Blank	0	0	2	2	4
Total	3	8	3	2	16

As expected, there was also not a lot of end-use data identified for the process end-use; there were a total of 15 process end-use sample points cataloged as shown in

Figure 15. The Northeast region had the most activity with 9 of the 15 sample points. There were five sample points from the California region and one sample point from the Northwest region. All of the studies that had sample size data (12 of 15) were in the smallest sample size bin of 50 or fewer. This end-use tends to be very site specific and industry specific in nature, and it is difficult to establish generic load data that can be widely utilized across different process applications.

Figure 15: Process End-use Sample Size Data by Region



	CA	NE	NW	Total
0-50	4	8	0	12
Blank	1	1	1	3
Total	5	9	1	15

4. Interviews with Users of Load Shape Data

To better understand the needs of the Pacific Northwest and East regions, KEMA conducted a number of interviews and two focus groups with three groups of users: energy efficiency program planners, capacity market representatives, and air-quality regulators. These groups of users all utilize end-use and measure load-shape data to better forecast the potential impacts related to energy efficiency programs, whether to estimate energy savings, demand reductions, or reduced air emissions.

The interviews focused on what data users were currently using, including the sources of data they have available to them now and whether the load shapes are 8,760 annual hourly profiles or some other time period. Users were also asked about their confidence in existing load shapes and where they see the need for new metering studies. See Appendix B for a list of industry contacts who were interviewed.

In general, for the Northwest the primary use of load shape data is to support the work of regional analysts working for the Council, BPA, regional electric utilities, the Energy Trust of Oregon, the Northwest Energy Efficiency Alliance, and other entities that implement energy efficiency and/or provide energy planning.

Similarly, for the EMV Forum members in the East the primary use of load shape data is to support the work of analysts and other entities that implement energy efficiency and/or provide energy planning. However, the EMV Forum members also may use this catalog to assist in developing and supporting demand reduction bids into the New England forward capacity market, other capacity markets as they develop, and to support air regulatory planning and analysis.

4.1 Energy Efficiency Program Planners

KEMA conducted a group interview with energy efficiency program planners from both the Pacific Northwest and East regions. One principal concern of energy efficiency program planners is related to estimating the cost-effectiveness of programs. Benefits associated with a program and measures are based on the quantity of energy saved and the avoided cost per unit of energy saved. For electricity, this avoided cost varies over the 8,760 hours (or other specified time periods) across the year. Part of the purpose of this interview was to determine what time granularity and specificity is required by program planners to more accurately estimate avoided costs related to program measures, and whether greater uncertainty exists around end-use load data or the avoided cost data.

A representative from the Bonneville Power Administration indicated that the Northwest Power and Conservation Council does not use 8,760 hourly data for avoided cost calculations, but does utilize time of use shapes consisting of four periods (high, medium, low, and off) by month. Some models in the region have utilized 8,760 shapes, but the Council uses the time of use approach in a Microsoft Excel® model to analyze costs. The majority of the work remains based on ELCAP data, although some, more recent, simulated shapes have also been created by consultants.

Similarly, for the Northeast one interviewee indicated that the State of Massachusetts was not using 8,760 shapes for cost-effectiveness calculations at the moment. Representatives from the East indicated that the principal driver for hourly load research is due to the inclusion of energy efficiency programs in the forward-capacity markets and the need for data related to how specific measures lead to demand savings, as specified by the ISO-New England.

It is not clear from where the Massachusetts data is sourced, but it is believed to have been stitched together on an ad-hoc basis. NSTAR, the largest Massachusetts-based, investor-owned electric and gas utility, has estimated 8,760 data from recent evaluations, primarily to develop peak demand savings for summer weekday periods. Both NSTAR and National Grid (with service territory encompassing Massachusetts, New York, New Hampshire, and Rhode Island) have done a significant number of load-research studies and monitoring of program participants for savings claims. These two utilities are believed to have conducted the majority of regional measure savings research, with large samples of projects based on monitoring. These monitoring periods tend to be relatively short (e.g., approximately six weeks) and extrapolated to a full year using engineering assumptions and modeling.

It is believed that in New England there is a big gap between the larger utilities (NSTAR, National Grid, and Northeast Utilities) and the other utilities' load-shape data because of the ability of large utilities to conduct their own load research. It was pointed out, however, that even for load shapes based on direct data logging, the short-term monitoring period may not have occurred during the peak 3 months relevant to the measure (e.g., summer peak period for HVAC). This means that the datasets may not have accurately captured typical performance during critical periods.

Maryland appears to be using a DOE2 building energy simulation model-based tool to produce simulated shapes. Pennsylvania is not believed to have any studies or state-specific data. In New York most of the energy efficiency activity has been implemented through the New York State Energy and Research Development Authority (NYSERDA), which typically has an M&V requirement for energy efficiency measures. The M&V is done on an ad-hoc basis typically by the energy services company and then reviewed by a Flex Tech contractor. There does not appear to be a centralized data collection and storage method for these data.

For the simulated load shapes, better information is needed related to building-level and population-level scheduling of equipment. Interviewees suggested a desire for more data related to the distribution of schedules and other operating control variables that affect timing of savings. This is especially applicable to the Pacific Northwest where old ELCAP data is available, and recent comparisons of the ELCAP data with simulated sectors show that the individual occupied buildings in the ELCAP sample have significantly diverse operating schedules, and users are not confident of the estimate of “people determined” effects (such as thermostat settings and hours of operations).

Snohomish County Public Utility District (SnoPUD) also indicated that they typically do short-term monitoring of custom measures. Although it is not specifically end-use research, there is data being collected, and they would like to include the necessary information to make it transferable and help contribute to the base of knowledge in the Pacific Northwest and other regions.

In terms of looking forward and evaluating the need for new studies for end-use and measure load shapes, interviewees indicated that there is a difference in energy efficiency programs that are being implemented now and what may be implemented in the future. There may be the potential for new technologies (related to consumer electronics and other plug loads) that are emerging as opportunities for program measures. This is applicable to both regions, and specifically for Massachusetts, where a ramp-up of programs is expected to expand beyond the typical HVAC and lighting measures.

In summary, it appears that the data collection related to end-use and measure load shapes is occurring on an ad-hoc basis. End-use load shapes serve to calibrate the time of use (TOU) avoided cost calculations. During other project calls, it has been noted that the precision to which TOU avoided cost can be estimated is far more uncertain than the load shape data (i.e. error band around error of avoided cost is greater than load shapes). Therefore, the principal driver for hourly 8,760 is not for avoided cost calculations for energy efficiency program planners, but rather to support the forward-capacity market bid programs in both the ISO-NE and PJM regions. Furthermore, New York is ramping up significant program activity, with a need to better understand the distribution of savings. There is an urgency related to the lack of consistency across programs and utilities in both regions and uneven information across the different states (including small versus large utilities).

4.2 ISO/RTO Capacity Markets

In June 2006, ISO New England (ISO-NE) received FERC approval for a new FCM to replace the Installed Capacity Market (ICAP). As a result of this new market, energy efficiency and demand-response providers joined generators in the opportunity to be compensated for meeting the region's capacity needs, and there is now an increased emphasis placed on the development of statistically reliable estimates for a widening array of demand savings classifications, for updated summer and winter peak coincidence factors that are consistent with ISO-NE definitions, and for savings load shape data to support energy efficiency program planning and evaluation.

Similarly, the PJM Interchange has developed a capacity market that allows energy efficiency resources to participate and has led to similar need for updated end-use load data. On Wednesday, May 20, 2009, KEMA facilitated a focused discussion around the needs of the FCM for both the ISO-NE and PJM Regional Transmission Organizations (RTOs). Representatives from PJM, Baltimore Gas & Electric, and the NY ISO attended the call along with KEMA senior consultants, who have assisted ISO-NE with the development of their protocols. The purpose of the interview was also to better understand the level of information that RTOs are expecting from energy services providers related to energy efficiency measure level savings and how utilities are filing their M&V plans.

Representatives from PJM indicated that they are only interested in demand reductions during capacity performance hours, and are not interested in annual savings. They also indicated that they expected to see interval data that supported the demand reductions claimed by the energy efficiency programs. Baltimore Gas & Electric indicated that they are working with both PJM and the Maryland Public Service Commission to develop the M&V plans for the evaluation of their energy efficiency portfolios. They have done some modeling to develop deemed impacts related to their programs for the PJM performance window of 2:00 PM – 6:00 PM non-holiday weekdays during the months June through August. The plan is to perform the M&V evaluations at the statistical significance required for each measure, although they only have to meet the statistical precision requirements at the portfolio level. Typically an energy efficiency provider will bid in a portfolio of energy efficiency programs and/or measures and the M&V requirements for statistical precision are applied at the portfolio level. This is a more easily obtainable standard than having to meet the requirements for each component of the portfolio.

It is not clear whether PJM sees a role for itself in developing demand-reduction values or establishing a clearinghouse for evaluating the performance of measures. Their first priority at the moment is to get energy efficiency into the capacity markets and not to make it onerous to participate in the market.

Interviewees were also asked if they would be comfortable borrowing load shapes from other regions. The NY ISO indicated a strong preference not to borrow load shapes; however, they may be open to doing so for some measures that are considered more transferable between regions, such as water heaters and appliances. For weather-sensitive measures, however, they would want some proof that the transferred data was accurate and suggested a small sample of end-use metering to validate the models.

Part of the concern stems from the limitations of a modeled approach that would be necessary for the transference of some load profiles where end-use hourly data may not accurately capture the day-to-day variations, due to temperature based on how prototypical days may be defined in a building energy simulation. Therefore, in terms of bidding into a capacity market, there is a risk a model may average out the peak savings and under-represent the demand savings for a peak day. The NY ISO is leaning more towards elements of direct metering, nested in larger-premise building samples.

When asked where the major gaps are in their portfolio, the NY ISO indicated that they believe there are significant gaps and that many of the load shapes are not 8,760 hourly, just typical weekend and weekday. Baltimore Gas & Electric mentioned that they have not yet had the opportunity to incorporate their end-use data into the DOE2 models, but that some data appears to be available that can be incorporated. They did indicate that they are looking at getting more metered data related to lighting, since it is such a large part of their EE portfolio. The only lighting data they have is from the mid-1990s for commercial facilities. No residential lighting information has been collected, and they may be interested in the nested-sample approach.

In terms of data needs for lighting measures for the capacity markets, it was noted that the demand reduction results may be largely transferable between regions, since the PJM window is from 2-6 p.m. in the summer, and daylight hours are similar between regions for this time period. If shoulder or winter months are important, then the load profiles may be less transferable due to differences in daylight hours.

NY ISO appears to be utilizing 2001 RECS data for appliance saturation data from the Energy Information Administration (EIA). They have also been using saturation and end-use consumption data for the different regions defined by EIA. New York has been using this characteristics data plus prototypes from hourly use data from the utilities to try to generate representative load shapes that represent the class and summer peaks. It is unclear whether a future capacity market in New York would include energy efficiency programs and require hourly end-use and measure load shapes to be created.

4.3 Air Quality Regulators

Interviews were also conducted with air quality regulators and consultants providing energy and emissions savings analysis related to both criteria pollutants and greenhouse gas emissions. In contrast to the group interviews conducted for energy efficiency planners and capacity market stakeholders, the air quality contacts were interviewed individually due to the diverse nature of this work.

The Clean Air Act requires that states develop State Implementation Plans (SIPs) to attain and maintain compliance with National Ambient Air Quality Standards (NAAQS). The Ozone

Transport Commission (OTC) Memorandum of Understanding (MOU) has also committed several eastern states to reducing NOx emissions on high-electric demand days. Hourly energy-consumption (load-shape) data are inputs into models that correlate energy consumption, power generation, and air emissions. Most of the work in this area is being conducted on the East Coast.

Since regulations under the Clean Air Act require criteria pollutants not to exceed certain levels, especially during specific periods, better time-of-use data related to whole buildings and end-uses can assist coordination with any program goals to reduce energy use during critical pollution periods. The purpose of these interviews was to better understand the end-use and measure load data currently being utilized by air quality regulators, the time granularity and quality desired, and their perceived gap in available data.

4.3.1 What They Want and How They Would Use the Data

In general, air regulators support increasing efforts to improve energy efficiency as a method to reduce growth in generation and emissions and to help with air quality issues on peak demand days as well as throughout the year. For an energy efficiency measure to be deemed valid enough to be included in a SIP for credit, significant M&V is required as well as sufficient documentation to support retirement of NOx allowances. To better understand how HEDD programs may improve air quality, analysis of 8,760 data will likely be required. Though it is not critical to have 8,760 data for general energy efficiency programs to be considered in SIP planning, it certainly is of academic interest to better understand the relationship between installed measures and impact on marginal emission rates.

Some stakeholders point out that it is useful for regulators to see the numbers and how energy efficiency benefits can be translated into air quality and greenhouse gas benefits, especially for high electric demand day initiatives. Towards this end, it is imperative to have load shapes that air regulators can have confidence in and that are based on sampling algorithms that are both robust and precise.

Looking at what load-shape data is available now, one consultant indicated that the Itron load shapes are not usable, because they can only be accessed on the web and cannot be exported. The Lawrence Berkeley National Lab (LBNL) data also appears to be quite outdated. The interviewee also would not recommend using anything prior to electricity market restructuring. New plug loads were also highlighted as an area of interest, since some of the old data from the early 1990s is not believed to be applicable any longer due to the dramatic change in applied technology found in appliances and user electronics.

For NESCAUM, they could not utilize 8,760 detail as this would increase the time to solve the model. A load curve based on day, night, and peak across each month would be sufficient detail for their model. Additionally, their efforts do not currently account for measure savings profiles that deviate from the end-use profile. They would seek improved load-curve data by end-use categories, such as space heating, lighting and cooling.

One regulator suggested that any data that is acceptable to the PJM capacity market should be good enough for the SIP M&V component.

4.3.2 Clean Air Act - State Implementation Plans (SIPs)

States must develop state implementation plans (SIPs) to document how they will meet the NAAQS compliance obligations under the Clean Air Act. Energy efficiency programs have only recently begun to be more formally included in SIPs, and mostly as voluntary initiatives. According to interviews with the Metropolitan Washington Council on Governments (MWCOG), one of the major reasons for the limited reliance on energy efficiency measures to meet air quality standards has been related to the complexity of validating energy efficiency program benefits, accurately relating energy savings to avoided emissions, the hurdles to translating energy efficiency program benefits to the NOx allowance retirement requirements, and the limited resources of state and local air agencies to accomplish these tasks.

One interviewee indicated that local governments have been willing to include energy efficiency actions in the Voluntary Bundle and Weight of Evidence portions of SIPs, but have expressed some concern that M&V is burdensome. It is also recognized that local government voluntary energy efficiency projects, while important, do not provide for very high levels of emission reductions. However, it is becoming clear that new large state-mandated energy efficiency programs have the potential to generate much more significant emission reduction benefits.

The next round of SIPs is due to the U.S. Environmental Protection Agency (EPA) in 2013, and discussions are now beginning to focus on how the emissions benefit of energy efficiency programs should be included. Options being considered are to maintain the programs in SIP Voluntary Bundles and Weight of Evidence, or to develop methods to account for large energy efficiency initiatives in the baseline emission projections. EPA has provided very little guidance on how to reflect energy efficiency in SIP baselines. Air quality planners are interested in how the EPA intends to provide guidance on SIP emission projections, including developing a better understanding of inputs such as the U.S. Department of Energy (DOE) Annual Energy Outlook (AEO), the National Energy Modeling System (NEMS), and ICF Consulting's Integrated Planning Model (IPM). To the extent the growth factors recommended by EPA for developing future attainment year emission inventories do not account for new state energy efficiency programs, it may be possible to develop techniques to adjust the emission baseline or growth factors.

The U.S. Department of Energy (DOE) has recently funded a grant to develop a protocol for how state air agencies may incorporate energy efficiency programs into SIPs. The MWCOG has worked with RSG Inc. to develop a calculator to allow air quality regulators to enter total energy savings into an Excel-based spreadsheet that then applies hourly load shapes and information on marginal emissions to develop an estimate of total avoided emissions. Hourly avoided emissions are available for CO2, NOx, and SO2 for 3 types of energy efficiency measures: air conditioning efficiency measures, lighting efficiency measures, and LED traffic signals. MWCOG is working to incorporate the RSG emission factors into an emission benefit dashboard and to integrate common assumptions and reporting into state and local energy and air quality planning. MWCOG is also working with the EPA Office of Air and Radiation (OAR) and Office of Air Quality Planning and Standards (OAQPS) to learn more about how energy efficiency is or is not reflected in growth factors used for SIP emission projections.

In terms of understanding energy efficiency impacts on an hourly basis, the main issues involve an understanding that there are significant differences in emission estimates if one uses system average emission rates, or rates that are based on a time-matched evaluation of both load impact and concomitant emissions profiles.

In Connecticut, Maryland, and New Jersey, one interviewee explained that gross MWh savings from a project consisting of commercial lighting and residential AC was applied to a default emissions factor and was then divided into ozone season day. This was based on an annual MWh savings value for the efficiency measures. It was recognized, however, that this approach underestimated the emissions benefits, because energy efficiency affects the marginal power generation units, which tend to have higher emissions factors.

One other possible approach being considered is to conduct a sensitivity attainment modeling run, using revised SIP modeling emission inventories that reflect an assessment of energy efficiency program impacts, and use the results of the sensitivity run in SIPs as weight of evidence.

4.3.2.1 High Electric Demand Days

The High Electric Demand Day (HEDD) Initiative is a multi-state effort to use increased energy efficiency and demand-response programs to reduce air emissions on the days of highest electric demand. The HEDD Initiative was initiated in 2006 based on findings of a strong correlation between the worst air quality days and the days of highest summer electrical demand in the Northeast and Mid-Atlantic states.

According to a representative from MWCOG, he believes that if there is strong interest in including HEDD initiatives in SIPs for credit, there will likely be a need to develop more information on 8,760 load shapes to help quantify the air quality benefits associated with energy efficiency measures.

4.3.2.2 Supporting Models for Estimating EE Savings

Part of the interviews with air-quality stakeholders sought to better understand how energy savings load-profile data is currently being used in models that analyze emissions benefits of energy efficiency. Most of the models that utilize 8,760 hourly efficiency measure data have been developed by consultants, rather than public agencies.

The Northeast States for Coordinated Air Use Management (NESCAUM) is working with state governments to assess SIPs and how energy efficiency can be a cost-effective energy solution. The model they use incorporate coarse time divisions encompassing 3 seasons – summer, winter and shoulder, as well as on-peak and off-peak periods. The time-of-use periods are not detailed enough to model when electricity generation peaking units operate. The data they use is a mix of DOE and EIA data and is based on three sectors: residential, commercial, and industrial. Currently, they do not have a specific need for 8,760 hourly load-shape data.

At Synapse, they recently completed a report related to HEDD days. They looked at the electricity generation from all generating units in Connecticut and modeled the load on each unit across the 8,760 hours of the year. This approach enabled them to develop 8,760 hourly emissions factor, over which energy efficiency hourly 8,760 data could be matched to determine hourly avoided emissions across the year.

4.4 Summary of Stakeholder Interviews

In summary, the capacity markets have the most stringent requirements and urgent need for hourly 8,760 energy savings data. Some energy efficiency programs across the country appear to be funding M&V of program impacts. Although there are some protocols, such as the International Performance Measurement and Verification Protocol (IPVMP), the metering related to the evaluation of efficiency programs is not coordinated or conducted in a consistent manner between regions. Most energy efficiency planners and air-quality analysts are utilizing whatever the best available data appears to be. A first and significant hurdle to overcome this problem is the need for an M&V protocol designed specifically to support the collection of end-use data that can be broadly usable and transferable.

The conclusion from interviews with users of the load-shape data is that capacity market requirements are the “gold standard” for end-use and measure-load profiles. It appears that any data that is good enough for ISO-NE and PJM should certainly be adequate for energy efficiency program planners and air-quality regulators.

5. Usability and Transferability of Data

Following the interviews with the users of the load shapes, KEMA assessed the usability of the identified datasets for load shapes. This chapter focuses on the approach and issues related to assessing data quality, reliability, and usability of identified datasets. We first explored metrics for determining the general usability of studies, and then secondly examined the issues and requirements inherent in making a promising study transferable to another region or customer population.

5.1 Issues Related to Usability

Although there are practical limits to how accurate end-use and measure-load shapes can realistically be, the usability of datasets varies depending on several criteria. Load shapes based on outputs of building energy simulations require detailed specification of building and occupancy characteristics that can only partially represent typical building conditions in a relevant area. It is important to remember that any sample providing load data and customer characteristics is designed to estimate a population on average, while it is widely recognized that usage patterns in individual buildings vary widely from any norm.

It is worth noting that some stakeholders indicated a distrust of load shapes developed through building energy simulation. The concern is rooted in the translation of short term metered data (typically 2-4 weeks) into annual equipment operating schedules without appropriate benchmarking to annual usage data. Simulation has long been recognized as weaker in predicting total annual and peak consumption values than the difference in consumption from implementing specific efficiency measures. Unfortunately, it is impossible to maintain current end-use profiles for each region based on metered data. Some fraction must ultimately be based on modeling, although it is clearly desirable to have longer metering periods. Additionally, since energy savings cannot be directly measured, calculation tools of some sort will always be necessary (with simulation models being simply a complex calculation).

5.1.1 Accessibility of Data

The first and foremost indicator of usability is simply whether the underlying data is accessible, meaning that the study contact person has the ability to retrieve the relevant data. For this project, the accessibility rating is a self-reported, with 1 being readily accessible and 5 being completely inaccessible.

Accessibility encompasses understanding who keeps the raw data and in what format. Not only does the metered data need to be accessible, but also the associated building and customer characteristic. We seek to understand whether the full identification information exists, in what format, and whether the data was well-defined initially. Additionally, is the documentation available to understand how the baseline conditions were approached and estimated?

The results of the research indicate that most entities are willing to provide the data at little or not cost, as much of it was completed with public funds.

5.1.2 Statistical Significance/Sample Size

In order to properly represent a specific customer population, the initial data must be collected with an appropriate sampling approach. The level of statistical significance is an important metric for assessing the usability of load shapes for the ISO-NE FCM. Over the years, program implementation and evaluation staffs have grown quite adept at estimating aggregate efficiency impacts from samples with 10% relative precision at the 90% confidence level. Load research was traditionally focused on 90/+/-10% as recommended in the Public Utilities Regulatory Policies Act (PURPA) of 1978.[8] This has been deemed the "PURPA Standard" or the "90/10 Rule" and has manifested itself through endless discussions among interval load data collectors primarily in the load research community and more recently among evaluators of energy efficiency and demand response. While annual kWh savings are relatively easy to quantify with reasonable accuracy, pursuit of accurate coincident peak demand impacts poses some challenges. In a statistical framework, a sample design based upon a modest error ratio usually can yield annual energy impacts with ±10% relative precision. In practice, the KEMA team has found that upwards of twice this 'normal' sample size often is required to attain comparable precision for coincident peak-demand impacts.

5.1.3 Vintage of Data

We consider more recently conducted studies to be more usable than older data collected. This is due to the fact that as data get older, users feel less and less comfortable with them, unsure that they represent today's loads. This is due to:

- Changing technologies – For instance, consumer electronics is one of the fastest changing and growing end-uses in households today (e.g., plasma televisions, TiVo's).

[8] The accuracy level for collected information is addressed in the Code of Federal Requirements CFR 290.403 (b) which stated that "for loads during peak hours, sampling procedures must be designed with a statistically expected accuracy of ±10% at the 90% confidence level. A utility is not required to show that the resulting load curves have this same accuracy but is required to point out any significant deviations from expected accuracy.

- Changing operating practices – Similarly, population and cultural changes may also affect how consumers use technologies. For instance, household dishwasher usage may have decreased, as people cook less or use more disposable dishware.

For the most part, these changes are not well understood, and some end-uses and measures have changed more significantly than others in recent years. For instance, we fundamentally rely on some of the same end-uses, such as heating and cooling our buildings, refrigerating our food and using lighting. In some cases, the load shape may still be the same, but the scale or magnitude of energy use may have changed.

The ISO-NE Forward Capacity Market requires data collected within the last 5 years; however some studies that are "done well" can be used if justified. For the purposes of this project, we consider studies conducted since the year 2000 to be potentially useful.

5.1.4 Time Resolution/Granularity of Data

The ISO-NE FCM requires at least a 15-minute sampling rate, and this concurs with the load research standard. It is worth noting that if users are interested in absolute peak values, then shorter-time resolution may more accurately capture short-term peak. Fifteen-minute peak values are almost always higher than hourly peak values due to load diversity factors. As data storage technology and communication speeds continue to improve, we will be able to easily handle data with one-minute or even shorter integration periods. For the time being, we consider data collected at 15-minute intervals or less to be most usable. We also acknowledge that 1 hour data may be usable for energy efficiency and air quality regulators in many instances.

5.1.5 Geographic Location of Data

Studies with data collection occurring within the Pacific Northwest and East regions are generally deemed to be more useful to those regions than studies based in other geographic locations. Some measures by their nature, however, might be expected to have relatively little variation by geographic region or customer type. Even within a specific region, however, studies that focus only on energy efficiency program participants may not represent the general population. This is related to the issue of applying load shapes from one region to another region and is explored further in the section below.

5.1.6 Defining and Cataloging the Data

End-use data sources will be found in seemingly infinite combinations of types, formats, times, locations, and ancillary data contents. Conceptual design of a single cataloging format and retrieval system that is flexible enough to accommodate all the variations yet simple enough to be practical will prove to be a difficult task. There will necessarily be compromises between flexibility and simplicity.

The easiest approach from a creation standpoint might be a relational database format, but this typically requires a sophisticated software platform and probably some training before most people will feel comfortable accessing, assembling, and retrieving the data they are looking for.

A more accessible platform might be a multi-dimensional spreadsheet system using high-level entry tables that allow users to drill downward into the database until they find the specific files for which they are looking. They will often still be faced with the need to identify other related information that will be required to augment and define the primary data.

Recognizing the potentially massive quantities of data that will eventually be collected, processed, cataloged, and stored, it is inherent that the repository be permanently staffed with people who are dedicated to maintaining and accessing this database. The need for this data will be ongoing, so longer term plans should be developed for periodic data updating and establishing some kind of funding mechanism to avoid repeating the current situation of shortcomings in end-use data in the future.

Multi-dimensionality will be a characteristic of the database repository because of the multi-dimensional nature of the data themselves. Some of the data dimensions that contain two or more variations are, for example, source, sector, end-use, and type.

- The data source must contain, at a minimum, location, beginning and ending dates and times, collecting agency, and method of collection.
- The sector must include residential, commercial, and industrial, and each sector may need to be broken out even more (i.e., single family detached, mobile home, multifamily).
- The end-uses are too numerous to list here.
- The type may be defined several different ways, such as electric, gas and oil, or normalized/raw, for example.

Inherent variations in the lowest level of data, such as granularity, will impose difficult technical problems regarding required storage space. If it is desirable to keep the source data at its finest granularity, which could be one-minute interval or even less, then the actual storage format will need to be flexible so that hourly data may also be stored efficiently without skipping blank cells.

Other end-use databases currently exist throughout the country. Two of the most well-known sources of end-use data are the Center for Energy End-use Data (CEED) and the End-use Load and Conservation Assessment Program (ELCAP) data. A third substantially large residential database is owned by Duke Power Company. This latter data was the focus of a marginally successful attempt to transfer the data to a small group of participating utility companies around 1995.

Another (proprietary) database containing robust residential 15-minute interval end-use and temperature data for over 200 residences throughout northern Florida (what was Florida Power Corp. service area until 2000) is housed at the Florida Solar Energy Center. Another (also proprietary) is a database of robust commercial end-use data containing 15-minute interval data from about 50 commercial buildings in northern Florida (Florida Power Corp. service area). Yet another (also proprietary) residential end-use database of 15-minute interval data, including whole premise, heating and air conditioning, hot water, and several major appliances, was created during the early 1990s in Austin, Texas.

Future efforts to transfer end-use datasets should involve contacting the people responsible for maintaining these databases to learn what works well and what does not. This will provide valuable information through lessons-learned toward the conceptualization of the database for this project. Although the three proprietary databases were created for southern climates, the lessons learned will still be appropriate for any region of the country.

5.2 Transferability of Load Shapes between Regions

In the context of this project, the usability of a dataset from one region to another hinges on the transferability of the data. In order to be transferred, the data must first be normalized properly so that it is portable. This requires that usage patterns are defined independent of efficiency and technology.

Unfortunately, it is impossible to maintain current end-use profiles for each region based on metered data alone. Some fraction must ultimately be based on modeling. Modeling techniques are required to extrapolate short-term metered data, but it is clearly desirable to have longer metering periods.

This being said, transferability of shapes from one region to another requires a foundation upon which differences between regions are clearly articulated and accounted. While some differences are clear (e.g., weather, daylight hours), others are not as apparent (e.g., regional behavior differences or effects of dissimilar energy pricing).

When meaningful differences between regions are evident or suspected, defining data for those differences must be available for both regions so that their impacts on the raw data may be calculated. Too often the raw data source may not be readily transferred at all due to missing ancillary data required to define important differences.

The ancillary data requirements to transfer datasets between regions vary by end-use and measure type. For example, data from lighting loggers would indicate the percent time that lights are on relative to operating schedule. HVAC systems are far more challenging due to the need to define loading as a function of internal schedules and ambient weather conditions. In addition to the detailed building and system characteristics sufficient to build the energy consumption simulation model, other data is typically required.

Typical additional data requirements include:

- SIC/NAICS code for sample site
- Weather data and facility location
- Square footage
- Facility operating hours
- Capacities and operating schedules for relevant equipment.

Simulation approaches to transferring data (such as using a DOE2 model) appears to be potentially useful but requires a high-quality amount of data to customize the data for other regions. DOE2 models may require the following additional information:

- Room level identification of data location
- Operating schedules for all equipment at the facility
- Facility shell characteristics
- Inventory of HVAC system types and efficiencies
- Air and water system temperatures
- Temperature and other control set-points.

Statistical modeling approaches to transfer end-use metered data have been attempted with limited success. The greatest difficulty has been due to the fact that hourly data from most end-uses vary by hour, day of week, and month, thus exhibiting unwieldy levels of variability across several dimensions simultaneously. It becomes difficult or impossible to define a limited number of relevant dependent relationships within such complex variations. The modeler at the outset is usually faced with limited sources of ancillary data from both regions to even test for meaningful correlations.

For appliance end-use groups, additional ancillary data may also include appliance saturation and fuel saturation data from one region to another to account for differences in regional characteristics. This type of data may already be available through U.S. DOE Energy

Information Administration (EIA) Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS) data.

In addition to differences between end-uses, some stakeholders interviewed indicated that residential load shapes are expected to be more difficult to transfer between regions than non-residential shapes. This is to due to more standardized commercial building stock and facility operating procedures.

Other regional differences, such as electricity pricing and thermal comfort expectations and norms, may also affect end-use load shapes from region to region, but these have not been well studied or understood. Ultimately, however, there are practical limits to how accurate end-use and measure load shapes can realistically be, and these types of refinements may need to be addressed over in the mid- to long-term timeframe.

The need for the additional ancillary data to understand differences between regions may be one of the major obstacles to transferability today. Fundamentally, transferability considerations mean that data collection efforts may include not metering only, but other types of surveys as well.

5.2.1 General Transferability of End-use Analysis Groups

In general terms, the transferability of interval load data from a particular end-use analysis group is dictated primarily by the degree to which the power consumption of the equipment is impacted by the ambient weather conditions. Obviously HVAC measures, such as space heating and cooling, have an extremely high degree of weather-dependent load variation in the operating profile. However even some measures that may seem to be relatively weather independent like residential refrigeration and water heating can exhibit seasonally variable usage patterns. For example, residential refrigerators are typically located in conditioned space; however there are secondary refrigerators that are located in garages and basements where the heat rejection component of the refrigeration cycle and the conductive heat transfer is directly linked to ambient conditions. Similarly, water heating energy usage is linked to the incoming ground water temperature and the conductive heat transfer is driven by the temperature differential between the heated water and the space where the water heater is located.

The transferability rating looks at the general schedule variability of the analysis group as well as the variability the end-use due to weather. In the following sections we rate the general transferability rating of each of the residential and non-residential end-use analysis groups utilized in the cataloguing effort. It is important to note that these tables assume that the C&I sector will be properly segmented and that data would be transferred across regions, but within segments. For example the transferability of lighting data for the large office segment from one region would be rated for its transferability to the large office segment of another region and not the small office or retail segments. The transferability rating is a high-level rating that attempts to quantify the theoretical probability that end-use data from one region of the country could be transferred to another region assuming that the data sets from both regions are complete and contain sufficient ancillary information.

5.2.1.1 Residential End-Use Analysis Groups

Table 17 provides the schedule variability ratings, weather variability ratings, and transferability ratings for each of the thirteen residential end-use analysis groups identified in the survey. There are three ratings (Low, Medium, and High) within each of the rating categories, and with respect to the schedule variability and weather variability a Low rating is better than a High rating, as these two components are inversely related to the transferability of the end-use data. The transferability rating is color coded using the traffic light color system. End-use analysis groups with a high transferability rating are highlighted in green and should be relatively easy to transfer from one region to another. The high transferability end-use groups were appliances (kitchen, laundry, and refrigerators), lighting (interior and exterior), and plug loads (consumer electronics). The end-use analysis groups with a medium transferability rating are highlighted in yellow and are not as easily transferable because of increased schedule and or weather variability. The medium transferability rating end-use groups consisted of domestic hot water and pool pumps. Finally, the low transferability rating end-use analysis groups are highlighted in red and would be the most difficult to transfer from one region to another. The low transferability end-use groups consisted all of the HVAC end-uses: cooling, fan energy, heating, ventilation, and other.

Table 17: Residential Analysis Groups Transferability Ratings

Analysis Group	Schedule Variability	Weather Variability	Transferability Rating
Appliances - Kitchen	Medium	Low	High
Appliances - Laundry	Medium	Low	High
Appliances -Refrigerators	Low	Medium	High
Domestic Hot Water	Low	Medium	Medium
HVAC – Cooling	Medium	High	Low
HVAC – Fan Energy	Medium	High	Low
HVAC - Heating	Medium	High	Low
HVAC - Ventilation	Medium	Medium	Low
HVAC - Other	Medium	High	Low
Lighting - Exterior	Medium	Low	High
Lighting - Interior	Low	Low	High
Plug Load	Low	Low	High
Pool Pump	Low	Medium	Medium

5.2.1.2 Non-Residential End-Use Analysis Groups

Table 18 provides the schedule variability ratings, weather variability ratings, and transferability ratings for each of the 22 non-residential end-use analysis groups identified in the survey. Once again, the three ratings (Low, Medium, and High) within each of the rating categories were used along with traffic light color system for the transferability rating. There were six end-use groups that received a high transferability rating (highlighted in green) that included appliances – laundry, compressed air, data center equipment, food service equipment, and lighting. There were another seven end-use analysis groups rated as having medium transferability that included agricultural (process and pumping), industrial process, motors – drives, plug load, pumps, and water heat. These end-use groups were rated as having medium transferability, because at least some of the measures within the analysis group are directly linked to ambient conditions. For example, industrial process could contain process cooling measures. Finally, there were nine end-use analysis groups that were rated as having low transferability, because their operation was directly linked to ambient weather conditions. These measures included all of the HVAC groups (cooling, fan energy, heating, other, reheat, and ventilation only) as well as clean room, data center cooling, and refrigeration.

Table 18: Non-Residential Analysis Groups Transferability Ratings

Analysis Group	Schedule Variability	Weather Variability	Transferability Rating
Agricultural - Process	Medium	Medium	Medium
Agricultural - Pumping	Medium	Medium	Medium
Appliances - Laundry	Low	Low	High
Clean Room	Low	High	Low
Compressed Air	Low	Low	High
Data Center Equipment	Low	Low	High
Data Center Cooling	Medium	High	Low
Food Service Equipment	Low	Low	High
HVAC - Cooling	Low	High	Low
HVAC - Fan Energy	Low	High	Low
HVAC - Heating	Low	High	Low
HVAC - Other	Low	High	Low
HVAC - Reheat	Medium	High	Low
HVAC - Ventilation Only	Low	High	Low
Industrial - Process	Medium	Medium	Medium
Lighting - Exterior	Low	Low	High
Lighting - Interior	Low	Low	High
Motors - Drives	Medium	Medium	Medium
Plug Load (Electronics)	Low	Medium	Medium
Pump	Low	Medium	Medium
Refrigeration	Low	High	Low
Water Heating	Low	Medium	Medium

5.3 Need for a Consistent Protocol for Load Shapes

Region wide or even national protocols are needed to establish consistent methods and procedures for developing end use and measure savings shapes, such that the information can be transferable and useful to other regions and populations. The protocol would ensure that data from performance monitoring studies can be used to satisfy diverse needs of energy suppliers and planners, energy end-users, designers, researchers, equipment manufacturers, and regulators. The broad priority for the data protocol is transferability and to enable data from smaller studies (e.g. conducted for individual program evaluations) to be combined into larger regional meta-studies.

A number of data collection protocols already exist to provide guidelines for instrumentation, data formats, and ancillary data requirements for estimating energy consumption and measure savings, among other things. A single broad protocol should leverage these existing guidelines and provide a framework specifically to support the development of end use load and savings shapes. This may include identifying which methods and procedures should be used for monitoring and developing the experimental plans, specifications and procedures. The guidelines will provide consistent and comparable procedures and definitions, resulting in transferable data sets.

The Council and NEEP have identified a significant need for a new protocol. Prior to developing the protocol to guide the development of end use and measure shapes, the larger team should define the high-level issues for this protocol. For specifics and details, small sub-committees will be engaged, supporting the diverse needs of the energy efficiency community for the protocol and the range of potential monitoring projects.

5.3.1 Description of Existing Data Collection Protocols

Data collection protocols have been established for energy efficiency monitoring and should be used as the starting point for the protocol for load shape development. This section addresses a range of current protocols that are in common use. For comparison, the ELCAP protocol is also discussed.

International Performance Measurement and Verification Protocol

The international performance measurement and verification protocol (IPMVP) was designed to establish methods to determine energy and water efficiency savings. First published in 1996, the IPMVP technical committees of hundreds of industry experts created this protocol for accurately measuring and verifying efficiency savings using a replicable methodology. The 2007 IPMVP is available free on the website of the Energy and Valuation Organization.[9]

The IPMVP provides the international standard for energy efficiency investments. It is incorporated by reference into other key protocols, including federal and state energy efficiency evaluation protocols discussed below, a greenhouse gas project protocol[10], and U.S. green building standards for Leadership in Energy and Environmental Design[11]. IPMVP can be used to determine savings for residential, commercial and industrial, and new and retrofit projects. It is also designed to provide a resource for utility demand-side management program staff and emissions reduction trading program designers.

IPMVP protocols define four options for M&V design. These are:

Option A. Retrofit isolation: Key parameter measurement.

- May be appropriate for simple replacement lighting and motors where key parameters like power draw can be measured and other factors like operating hours may be estimated.

Option B. Retrofit Isolation: All parameter measurement.

- Allows for routine (like weather) and non-routine adjustments (like increases in production or facility size), focusing only on the isolated retrofit. Appropriate for projects like variable speed motor drives for pumps.

Option C: Whole facility.

- Savings determined using measured energy (typically utility bills) and continuous measurements of the entire facility's energy use; applicable for multifaceted energy management programs where metered data is available in the baseline period.

Option D: Calibrated simulation.

- Energy use is simulated, then calibrated with billing data; applicable for multifaceted energy management programs where metered data is not available in the baseline period.

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[9] International Performance Measurement and Verification Protocol (IPMVP), Concepts and Options for Determining Energy and Water Savings, prepared by the Efficiency Valuation Organization, April 2007. Available from http://www.evo-world.org/

[10] World Resources Institute and World Business Council for Sustainable Development, Greenhouse Gas Protocol for Project Accounting. 2005. Found at www.ghgprotocol.org

[11] U.S. Green Building Council, www.usgbc.org

ASHRAE Guideline 14

The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) has developed guidelines for energy efficiency monitoring beginning in the 1980s. For example, the ASHRAE handbook for HVAC Applications includes a chapter on building and energy monitoring[12]. ASHRAE continues to develop and update guidelines for measuring energy and demand savings in buildings.

The 2002 ASHRAE Guideline 14, Measurement of Energy and Demand Savings[13], was developed for building energy-management projects, as a tool for reliably measuring energy, demand and water savings for commercial transactions. The ASHRAE guideline provides minimum acceptable levels of performance in determining savings achieved in conservation projects. ASHRAE is currently engaged in updating this guideline. One of the objectives of the update is to ensure consistency with IPMVP terminology.

Guideline 14 is intended to assess energy savings for individual buildings or a few buildings on a single utility meter. Focusing on a very technical level, it provides procedures for calculation of energy, demand, and water savings using measured billing data. All forms of energy (electricity, gas, oil, district heating and cooling, and renewables) as well as water and wastewater are included in the procedures. All types of facilities are included. It does not address large scale programs, metering standards, or industrial process loads.

Four approaches are possible within ASHRAE Guideline14. These are retrofit isolation, whole building prescriptive approach, whole building performance approach, and whole building calibrated simulation.

One of the strengths of ASHRAE Guideline 14 is the detailed protocol for taking into account independent variables, such as weather, occupancy, and production. The guideline provides protocols to project the measured baseline energy to the post-measure conditions, accounting for all energy-governing variables that affect the energy conservation measure. The IPMVP defers to the ASHRAE Guideline 14 for details on calibrating simulations.

[12] 2007 ASHRAE Handbook, Heating Ventilating and Air-Conditioning Applications, Atlanta, GA
[13] ASHRAE Guideline 14-2002 Measurement of Energy & Demand Savings, available through www.ashrae.org

California Evaluation Protocols

The California Public Utilities Commission (CPUC) developed detailed requirements[14] to guide professionals conducting evaluations of California's energy efficiency programs and program portfolios. The CPUC incorporates by reference the evaluation protocols in the lengthy California Evaluation Framework[15]. The framework provides a comprehensive set of guidelines for conducting evaluations of energy efficiency programs in California. Recommendations are included for conducting measurement evaluation, process evaluations, market effects, training and education, and evaluating non-energy benefits. The evaluation protocols provide the official requirements that all evaluation professionals must rely upon for planning and executing evaluation, measurement and verification, process evaluation, market effects evaluation, codes and standards program evaluation, emerging technology program evaluation, sampling and uncertainty protocols, reporting protocols, and effective useful life protocols.

Federal Energy Management Program Guidelines

The Federal Energy Management Program developed measurement and verification guidelines for federal energy projects[16]. The FEMP guidelines are considered an application of the IPMVP, applying to measurement and verification for energy savings projects developed under federal energy-savings performance contracts. Under these contracts, an energy service company (ESCO) contractor provides and arranges financing and implementation of energy improvements. The contractor is paid from the cost savings generated by the improvements. The FEMP M&V Guide specifies M&V methods and procedures for quantifying energy savings for projects contracted by federal agencies. The current version has been updated to have consistent definitions with the IPMVP.

Under FEMP, the ESCO develops the M&V plan during contract negotiations. The M&V plan includes monitoring to establish baseline conditions and post-installation conditions. The same four options are defined for FEMP and IPMVP.

The FEMP Guidelines provide a model for a specific application of the IPMVP.

ELCAP

[14] TecMarket Works, The. California Energy Efficiency Evaluation Protocols: Technical methodological and Reporting Requirements for Evaluation Professionals. April 2006 Prepared for the CPUC
[15] TechMarket Works, The California Evaluation Framework, Southern California Edison, 2004. Available at www.calmac.org.
[16] M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 3.0, Federal Energy Management Program of the U.S. Department of Energy, 2008, available at http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf

The End-Use Load Conservation Assessment Program was a large scale monitoring effort conducted for the Bonneville Power Administration. Detailed hourly end-use metering of over 100 commercial sites and over 400 residential sites provided data on energy use. The data supported energy-use planning for future electrical demand. It was also used to assess the conservation potential for electric power in the Northwest. The ELCAP protocol provided standard terminology and definitions, very precise instrumentation instructions, and robust data verification procedures minimizing data-definition errors and increasing data collection consistency. ELCAP also included extensive protocols for collecting building, equipment, and occupant characteristics.

5.3.2 Components of a Regional Data Collection Protocol for Load Shapes

The major elements of a regional data collection and load shape protocol would include:

- A classification system for monitoring projects, such as the IPMVP options A through D, that groups types of projects and protocols based on similarities of goals, objectives, experimental approach, and data collection requirements
- A guide specification, such as the California evaluation protocols, that provide a consistent format for communicating the methodological requirements for particular monitoring projects
- Standard definitions and terminology, including consistent definitions for end-use categorizations and efficiency measure types
- Standardization of data format and storage protocol
- Different protocols for residential and non-residential, including protocols for collecting building and occupant characteristics data
- Standardization of measures, and consensus on how measures are categorized
- Standardization of data quality verification procedures

6. Identification of Potentially Useful Studies

Of the 110 studies identified, KEMA focused on a subset of "potentially useful studies" for further analysis and data collection follow up. The selection criteria used for the initial screening of the potentially useful studies list was based on a high-level review of each dataset, because we understand that the Northeast region has a strong short-term need to determine coincident impacts of energy efficiency measures to satisfy the needs of ISO/RTO based capacity markets.

Given the virtual lack of end-use load research activity since the early 1990s and the movement of Evaluation Metering and Verification (EM&V) activities toward annualized energy-savings impacts and away from collecting metered data, there is a huge void of end-use data that needs to be filled. When such a need exists and there is a dearth of data, virtually any study that provides operating schedules for measures appears to be promising. Some stakeholders indicate a reluctance to use modeled data, The concern is rooted in the translation of short term metered data (typically 2-4 weeks) into annual equipment operating schedules without appropriate benchmarking to annual usage data. Almost all recent studies have been short-term monitoring efforts that used modeling to extrapolate to annual 8,760 hourly data. Furthermore, the vast majority of recent end-use data collected has been for energy efficiency program evaluation.

Cobbling a group of smaller studies into a meaningful and useful end-use profile that meets the prescriptive requirements of the capacity markets can be challenging when using data from one region due to differences in weather, construction practices, etc. More challenging still is to take a study from one region of the country and utilize the load profiles in another region.

6.1 Classification of Studies

The studies were classified by customer class (i.e., residential, non-residential, and both) and the type of study as follows;

- **Compilation Studies** are studies that compile primary interval data from other studies and used either DOE2 modeling or statistical modeling techniques to produce aggregate load shapes. These studies typically consist of compilations of short-term end-use metered data from energy efficiency evaluation studies that have been collected for a period of two to six weeks. One of the major strengths of these types of studies is that typically large datasets can be constructed and the overall relative precision of the load shapes and coincidence factors developed is improved. The weakness of these types of studies is capturing sufficient common detail in all of the datasets to weight individual components correctly and develop aggregate profiles that are representative of the population.

- **Load Research Studies** are studies that utilize long-term end-use power metering to develop load profile data. One of the major strengths of these types of studies is that the data is typically collected over months or years and long-term operating data over a wide range of weather conditions are available. The weakness of these studies is that they tend to be designed to identify usage within a rate class, and there is very little supporting demographic data about the sample or the population.

- **Evaluation Studies** are studies that primarily focus on evaluating savings impacts for energy efficiency measures or demand-response programs. These studies are typically characterized by shorter-term (2 to 6 weeks) metering studies that are narrowly focused on evaluating the energy efficiency impacts of a particular EE program over a single or multi year period. Generally, a lot of useful customer- and measure-specific collateral data are collected, although these data are not always incorporated in the interval data set. One of the weaknesses of these types of evaluations is that they tend to be narrowly focused on a current program year's participants, which may change over time or not be meaningful for other populations. Also these studies use a fairly short metering period to develop annual operating profiles, and this may be particularly problematic for weather sensitive measures when the metering period occurs during shoulder months.

The studies were reviewed using a variety of different evaluation criteria to determine which could be the most useful. Since there were not a lot of details about the work that was done, the studies were screened based upon the data that were provided consistently such as sample size and the date when the study was completed. The following criteria were used to establish usability criteria:

- Sample size
- Vintage of studies 2000 or more recent
- Studies that developed load profiles

After the initial screening effort, a phone survey was implemented to identify more details about the studies as follows:

- Types of ancillary data available in electronic format
- Type of interval data collected (i.e., true power, current only, on/off transition data) [17]

[17] True power refers to the measure of current, voltage and power factor to determine the integrated power usage and is the most accurate measurement. Current only measurement refers to a method that only measures the current in amps and then the voltage and power factor are assumed in order to calculate the demand. Finally on/off transition data typically measures a change of state either using a photocell in the case of lighting loggers or sensing electrical current in the case of CT loggers. These

- Whether the data was normalized and identification of normalization variables
- Inclusion of interval weather data or identification of interval weather data source
- Cost and/or level of effort to acquire the data

Although these additional screening questions were asked of the contacts, most respondents were not able to provide much detail about the data sets. There were a large number of potentially useful studies identified that were conducted by RLW Analytics/KEMA[18] that were available for internal staff review, and detailed summaries of these studies were completed.

Another issue that further complicated the analysis is the existence of studies that were either currently being fielded or still in the planning stages. It is difficult to assess the usefulness of these studies, because they have not been completed, and so there is little specific information to judge their value. However these studies are in the pipeline and are identified and catalogued.

6.2 Summary of Potentially useful Studies

As previously mentioned, the initial standard for determining potentially useful studies was set fairly low because of the perceived need to utilize end-use load shape data for the ISO/RTO capacity markets. As a result, a fairly large group (50) studies were identified as "potentially useful" and subject to initial screening. Many evaluation efforts of the same energy efficiency program were conducted across multiple years and utility territories and were initially catalogued as separate studies in the database. However, these multi year evaluation studies have been combined here in this section to streamline the discussion. This compression technique reduced the number of studies to 37, and these potentially useful studies were evaluated for usability using a subjective ranking system as follows:[19]

A – Meets capacity market standards (for defined region, measure(s)), and is usable as a stand alone study within a region

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data typically carry a time stamp with each transition and can be converted to time series data, which provides a percent on value per fixed time interval (for example 15 – minutes). The time series data is then converted into interval load data by multiplying the electrical load of the device being monitored by the percent on. This type of metering is particularly efficient for devices that have fixed electrical load and variable operating schedules like lighting.

[18] RLW Analytics was acquired by KEMA Inc. effective January 1, 2009.

[19] Originally, it was envisioned that the project would develop separate usability ratings for the capacity markets and energy efficiency, but following the interviews with stakeholders, it became clear that one rating would be sufficient, with energy efficiency planners being able to use both "A" and "B" grade studies.

B – Meets efficiency planning standards (for defined region, measure(s)), and is usable as part of a compilation study

C – Has some issues (e.g. low sample size or data is a little old), but could be used as a last resort or to guide modeling efforts

D – Study should not be used (or data not available to be used)

IP – Study is currently in progress

The following series of tables will present a summary of the useful studies organized by region along with the sponsoring entity, study name, study end data, analysis groups evaluated, and usability rating.

Table 19 provides a listing the useful studies in the Pacific Northwest region, which shows a total of six studies that were rated a "B" or in progress. There were no studies that were rated an "A" primarily because most of the studies catalogued in this region have either not been completed yet or we do not have sufficient information to rate their usability. There were four studies that received a usability rating of "B." The Puget Sound Energy study is an evaluation study that examined non-residential lighting measures installed in 2005. The BC Hydro LMP study is an aging residential end-use load research study of diminishing relevance and sample size, and the Seattle City Lights Space Heat Thermostat Metering Study had a small sample size of 18 premises. ELCAP is also rated a "B"; although the data is aging, the scope and magnitude of the study means that some of the data remains potentially useful.

Table 19: Potentially Useful Studies in the Pacific Northwest Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
Puget Sound Energy	Commercial & Industrial Lighting Savings Verification Study	2007	Lighting	B
BC Hydro	Load Monitoring Project (LMP)	1994 -2009	Appliance-Kitchen, Appliance Laundry Appliance Refrigerator, Water Heating	B
Seattle Cty Light	Space Heat Thermostat Metering Study	2006	HVAC - Heating	B
BPA	End-Use Load and Consumer Assessment Program (ELCAP)	mid 1980s - early 1990s	Water heating, HVAC - Cooling, HVAC - Heating, Lighting interior, Lighting exterior, Plug Load, HVAC - Fan Energy,	B
BC Hydro	Power Smart Residential End Use Study	Planning Stages	Appliance-Kitchen, Appliance Laundry Appliance Refrigerator, Water Heating	IP
NEEA	Ductless Heat Pump Pilot Evaluation	Not Completed	HVAC-Cooling, HVAC- Fan, HVAC-Heat HVAC-Other, Water Heating	IP
NEEA	Northwest Energy Star Homes Impact Evaluation	Not Completed	Lighting	IP

Table 20 provides a list of the potentially useful studies identified in the Northeast region, which shows a total of 18 studies that were rated. There was only one study that was rated an "A" study and that was the State Program Working Group (SPWG) Lighting Coincidence Factor (CF) Study. This study was a compilation study of lighting logger data that was collected as part of residential and non-residential energy efficiency program evaluation activities. The Connecticut Coincidence Factor Study was also a compilation study, which looked at HVAC-cooling and motors–drives measures, but it was rated a "B," because the relative precision of the coincidence factors (CFs) did not meet capacity requirements.[20] Of the remaining 16 studies, all of them received a usability rating of "B," which means that they are usable as part of a compilation study. None of the analysis group data listed has been included in either the SPWG Lighting Coincidence Factor Study or the CT Coincidence Factor Study.

[20] The CT Coincidence Factor Study also evaluated Lighting, but all of the Lighting Logger data was included in the SPWG Lighting Coincidence Factor Study and therefore the Lighting analysis group is not listed in the table.

Table 20: Potentially useful Studies in the Northeast Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
SPWG	SPWG Lighting Coincidence Factor Study	2007	Non-Residential Lighting Residential Lighting	A
NSTAR, N-Grid UI, CL&P	Residential Central AC Regional Evaluation	2009	HVAC - Cooling	B
UI	UI Water Heater Controller Study	2008	Water Heating	B
NSTAR, N-Grid NU,UI, VEIC	CFL Lighting Markdown Evaluation	2008	Lighting	B
NSTAR, N-Grid NU, UI	MA & CT Ductless Heat Pump Study	2008	HVAC- Cooling HVAC-Heating	B
NSTAR	BSCS lighting and Non-lighting Studies	2007 & 2008	HVAC-Cooling,HVAC-Other, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
MA Utilities	Mass SAVE Impact Study	2007	Lighting	B
Efficiency Maine	Maine Low Income Light and Appliance Study	2007	Lighting Appliances-Refrigeration	B
SPWG	Residential Room AC Impact Study	2007	HVAC- Cooling	B
UI, CL&P & WMECo	School Lighting Baseline Study	2006	Lighting	B
UI & CL&P for ECMB	CT Coincidence Factor Study	2005	HVAC-Cooling,Motors-Drives	B
NU	Custom Services	2005	HVAC-Cooling, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
NH Electric Coop	New Hampshire Small Business Lighting	2005	Lighting	B
NU	NU Municipal Program	2004	Lighting	B
NSTAR N-Grid	Small Business Solutions (SBS)	2003,2005, 2006	HVAC-Other, Lighting Motor - Drives, Refrigeration	B
N-Grid	Small C&I Unitary HVAC Pilot Impact Study	2003	HVAC-Cooling	B
NU & UI	NU & UI Energy Star Homes Evaluation	2002	Lighting	B
NSTAR	C&I New Construction and Retrofit	2001	HVAC-Other, Compressed Air, Lighting Motor - Drives, Refrigeration, Indsutrial-Process	B
NSTAR	C&I Retrofit	2003	HVAC-Cooling,HVAC-Other, Compressed Air, Motor - Drives, Refrigeration, Lighting	B

Table 21 provides a listing of the five potentially useful studies identified in the Mid-Atlantic region, which all received a usability rating of "B." The studies had relatively large sample sizes and would have been rated higher if there were facility-specific equipment information collected and some indication that the cooling equipment would not be curtailed during all of the high temperature hours.

Table 21: Potentially useful Studies in the Mid-Atlantic Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
BGE	Demand Response Infrastructure Pilot Program	2007	HVAC - Cooling	B
BGE	Res. Water Heater, Residential and Commercial AC Control Evaluation	on going	Res. Water - Heating and HVAC-Cooling Non-Res HVAC-Cooling	B
BGE	Residential Water Heater Control (2001 - 2005)	2005	Res. Water - Heating	B
BGE	Residential AC Control (2001 - 2005)	2005	Res. HVAC - Cooling	B
BGE	Commercial AC Control Evaluation (2001 - 2006)	2006	C&I HVAC - Cooling	B

Table 22 provides a listing of the ten potentially useful studies from the California region that were rated for usability within that region. The Database of Energy Efficiency Resources (DEER) is a compilation study that uses both residential and commercial DOE2 prototypical models and synthetic schedules developed from energy efficiency evaluation short-term metered data to develop hourly load shapes. The DEER Residential models provide load shapes for all but two of the residential analysis groups (HVAC – ventilation only and HVAC – other). The non-residential models also provide coverage across eleven of the most important non-residential analysis groups.

There were three large residential studies that also received an “A” rating: the Refrigerator Recycling Program, the Residential CFL Load Shapes by Room Type Study and the Residential End-use Load Research Study. These studies received an “A” rating, because they all had large sample sizes and the evaluated analysis groups that should be transferable to other regions. There were a few good residential HVAC – cooling studies that were removed from the potentially useful study list prior to rating because that particular analysis group would be difficult to transfer to other regions. There were four studies that received a usability rating of “B” primarily because the sample sizes seemed a little small. The Industrial End-use Study (IEUS) is still in progress.[21] Reports related to most California studies can be found at www.calmac.org.

[21] The IEUS project may have a revised scope that only includes surveys with no end-use metering, which would further reduce the rating for this study.

Table 22: Potentially useful Studies in the California Region

Sponsoring Entity	Study Name	Study End Date	Analysis Groups Evaluated	Usability Rating
PG&E and Others	Compressed Air Management Program	2006 - ongoing	Compressed Air	B
CPUC	Database of Energy Efficiency Resources (DEER) (Residential)	2001 - ongoing	All Residential Analysis Groups except HVAC - Ventilation Only & Other	A
CPUC	Database of Energy Efficiency Resources (DEER) (Non Res)	2001 - ongoing	All Non-Res Analysis Groups covered by catalogued studies except Water Heating	A
SDG&E	Express Efficiency Hours of Operation	2006	Lighting	B
CPUC	Industrial End Use Survey (IEUS)	In Progress	Industrial - Process	IP
SCE	Refrigerator Recycling Study	2005	Appliances-Refrigeration	A
SDG&E	Residential CFL Load Shapes by Room Type	2004	Lighting	A
SCE PG&E	Residential End Use Load Research Study	1996, 2001	Appliance-Kitchen,Laundry & Refrigerator, Water Heating HVAC - Cooling & Heating, Plug Load, Pool Pump	A
LBNL Ecos	Residential Plug Load Study	2006	Plug Load	B
SCE, PG&E CPUC	Savings By Design	2006, 2007 Ongoing	Industrial - Process, Refrigeration, Compressed Air, HVAC - Cooling, Heating&Ventilation Only, Lighting	B

6.3 Description of Potentially useful Studies

There were 31 of the potentially useful studies identified and rated in the previous section that received a usability rating of “B” or better, and in this section a brief description of these studies will be provided by region.

6.3.1 Pacific Northwest Region

The Pacific Northwest region had a total of seven studies that were evaluated, but only four received a usability rating of “B” or better. This was due to the fact that three of the studies were not yet complete and another study (PacifiCorp System Wide Potential for Demand Side & Other Resources) utilized DOE modeling based on the ELCAP data.

(Puget Sound Energy) Commercial Lighting Verification Study – This study was completed in 2007 and examined lighting measures installed in 2005. It covered the C&I Retrofit, C&I New Construction and Small Business Lighting programs. The study utilized a nested sample design with on-site monitoring within a larger phone verification sample. For on-site monitoring, the study used time-of-use (TOU) loggers and RMS power loggers for day-lighting systems. Broad room types were also tracked. C&I retrofit had sample size of 30 on-site monitoring (within 125 phone verifications), and Small Business Lighting had 35 on-site monitoring locations (within 125 phone verifications).

(Seattle City Light) Space Heat Thermostat Metering Study – This study was performed by SBW and was completed in 2006. The study measured HVAC-heating in 18 apartments. The data has average amp readings for 15-minute periods, indoor temperature, outdoor temperature, and some have total spot watt measurements. This study was performed on 100% electric heat apartments. The data has date and time stamps and was measured during the winter and spring heating season period.

(BC Hydro) Load Monitoring Project (LMP) – This study has been monitoring residential kitchen appliances since 2006, and initially included a sample of 140 homes with about 400 end-uses, but is now about 20 homes and 60 end-uses. The data is in a 15-minute format with true RMS Power data in an MV90 format[22]. The data has been normalized and has time and day stamps.

(Bonneville Power Administration) End-Use Load and Consumer Assessment Program (ELCAP) – This study gathered end use data from the mid-1980s through the early 1990s to better understand commercial and residential electricity use characteristics. Residential end-uses included whole building, lighting water heating, HVAC, appliances, to name a few. Commercial sector metering also encompassed a range of end uses, including lighting, water heating, HVAC, ventilation, and refrigeration.

6.3.2 Northeast Region

The Northeast region had a total of eighteen studies that received a usability rating of "B" or better, which was the most of any region. Within this region, there were two compilation studies that have already been created to combine the data from previous evaluations, and the other potentially useful studies selected in this region were chosen because their data is not included in the existing compilation studies and is suitable for use to augment those studies. There are nine non-residential studies and seven residential studies, excluding the compilation studies that have been selected.

[22] MV90 is a multi-vendor data management system for collecting and managing data from the complex metering devices typically used for large commercial and industrial customers.

Compilation Studies

(SPWG) Lighting Coincidence Factor Study – was conducted by RLW/KEMA for the State Program Working Group and completed in 2007[23]. The study utilized existing residential and non residential lighting logger data and created summer and winter lighting load profiles that were used to develop coincidence factors for the ISO-NE FCM on-peak and seasonal peak performance hours.

(**UI and CL&P) 2005 Coincidence Factor Study** – This consists of various past studies, including air-cooled chillers, unitary HVAC, VFD, and other cooling end-use measures. There is not believed to be a high degree of precision associated with this data.

Non-Residential Studies

(NSTAR) 2004-2005 and 2006 BSCS Impact Study – These are relatively recent projects for which approximately 4-7 weeks of monitoring was completed during the shoulder months, September and October of 2007. Many of the sites had custom measures, including control measures. This may make it difficult to apply the impact load shapes elsewhere, since the load shapes are very customer specific. Otherwise, the data collected was high quality and meets all technical criteria for the ISO-NE FCM. TOU lighting loggers and power monitoring were used to analyze the following:

- 22 compressed air systems
- 71 HVAC – cooling measures
- 32 HVAC – other measures
- 12 industrial – process measures
- 53 lighting measures
- 10 motors – drives measures
- 14 refrigeration measures

(NSTAR, NGrid, UI, CL&P) Residential Central Air Conditioning Regional Evaluation – This study was performed by ADM Associates and completed in August 2009. Assessment of savings and load reductions was based on data collected for a sample of 96 central air conditioning units. Site-specific information was collected for each residence. One-time power measures of the new CAC unit's compressors and air handler was taken to determine kW load.

[23] The New England State Program Working Group (SPWG) supports regional EM&V activities for state energy efficiency programs participating in the ISO-New England Forward Capacity Market.

Loggers were installed to monitor indoor temperature and run times of the CAC motor. Monitoring periods ranged from 4-6 weeks.

(NSTAR Electric) C&I New Construction Retrofit Impact Study – This study was performed by RLW Analytics and was completed in 2001. TOU loggers and power monitoring were used to analyze the following:

- 5 compressed air systems
- 21 HVAC – other measures
- 4 Industrial – process measures
- 39 Lighting measures
- 17 Motors – drives measures
- 6 refrigeration measures

(**NSTAR Electric) C&I Retrofit Impact Study** – This study was performed by RLW Analytics and was completed in 2003. TOU lighting loggers and power monitoring were used to analyze the following:

- 2 compressed air systems
- 3 HVAC – cooling measures
- 12 HVAC – other measures
- 5 lighting measures
- 13 motors – drives measures
- 4 refrigeration measures.

(NU, CL&P and WMECO) 2005 Custom Services Impact Studies – This study was performed by RLW Analytics in the summer of 2005 and evaluated the 2004 program year measure installations for the Commercial and Industrial Custom Services program. Many of the measures were related to the installation of variable speed air compressors and other industrial processes. TOU lighting loggers and power monitoring were used to analyze the following:

- 23 compressed air systems
- 11 HVAC – cooling measures
- 4 Industrial – process measures
- 13 lighting measures
- 12 motors – drives measures

- 4 refrigeration measures.

(Various NH Utilities) Small Business Lighting Study – This study was performed by RLW Analytics and was completed in 2004. TOU lighting loggers were used to gather 15-minute data at 100 commercial buildings.

(NU, CL&P and WMECO) 2004 Municipal Impact Studies – This study was performed by RLW Analytics. This study utilized TOU lighting loggers to evaluate the lighting Measures at 45 Municipal Facilities

(NGRID & NSTAR) SBS Custom Impact – These studies were performed by RLW Analytics in 2003, 2005 and 2006 and evaluated Small Business Services energy efficiency program. On-site engineering savings estimates were performed using short term monitoring equipment to quantify gross savings impacts. TOU lighting loggers and power monitoring were used to analyze the following:

- 5 HVAC – other measures
- 114 lighting measures
- 6 motors – drives measures
- 30 refrigeration measures.

(UI, CL&P, Western MA) CT School Lighting Baseline Study – This study was done by RLW Analytics and was completed September 2006. The study used TOU lighting loggers to gather 15-minute lighting data at 79 schools. Approximately 646 lighting loggers were installed in the schools. The data is available in Excel tables and is readily accessible.

(National Grid) Small C&I Unitary HVAC Pilot Impact Study – This evaluation of a unitary HVAC tune-up pilot program involved pre- and post-tune-up metering of a sample of the AC units at 20 sites and the subsequent calculation of annual kWh and peak kW savings for each unit. The tune-ups for the sample units were conducted between July 25 and August 4, during the hottest part of the cooling season. Metering periods included from 48 to 66 days pre-tune-up and from 52 to 61 days post-tune-up times. All metering equipment was installed by June 11, 2003 and removed by September 25, 2003. The average metering time for all sites was 16 weeks, ranging from 15 to 17 weeks per site. Impacts of the tune-ups performed were calculated from the M&V performed.

<u>Residential Studies</u>

(Various Utilities) CFL Markdown Impact Study – RLW/KEMA and NMR performed this residential CFL lighting study that was completed in 2008. Random digit dialing was utilized to recruit customers that may have purchased the markdown bulbs and auditors were required to verify that the bulbs were in the program. Lighting loggers were used to gather 15-minute CFL time of use for this study during both summer and winter months, approximately 664 loggers were installed.

(Various Sponsors) CT and MA Ductless Heat Pump Impact Study – KEMA is conducting this ongoing study. Approximately 40 homes are having their ductless heat pumps monitored at this time. No report is yet available.

(NU and UI) Energy Star Homes Impact Study – RLW Analytics, in conjunction with NU and UI, performed an energy star homes impact study that was completed in 2002. This study used lighting loggers to measure interior lighting at 112 sites.

(Various MA Utilities) Mass SAVE Impact Study – RLW Analytics performed an impact study of the Mass SAVE program that was completed in 2007. This study used lighting loggers to measure interior lighting at 171 sites.

(Various NE Sponsors) Residential Room AC Impact Study – RLW Analytics performed an impact study of Energy Star rebated room AC units throughout the New England region that was completed in 2007. This study used plug meters to measure the power of the AC units and regression models to develop normalized operating profiles for room AC units at 93 sites.

(Efficiency Maine) Low Income Light and Appliances Impact Study – This study was performed by RLW Analytics and gathered data from 2006 until 2007. The study gathered 15-minute refrigerator and lighting use data for 40 low-income homes.

(UI) Water Heater Controller Impact Study – This impact evaluation was completed in 2008 and was performed by RLW Analytics. The study used spot power measurements and TOU CT logger along with interval power meters to measure the operation of the water heater elements during the summer 2008 season. There was both a pre- and post-control meter period that each lasted about 4 to 6 weeks, and data was collected for about 57 homes.

6.3.3 Other Regions

There were nine studies evaluated from California and eight of these received a usability rating of "B" or better. Most the studies identified have been incorporate into the Database for Energy Efficiency Resources (DEER), which is a compilation study that utilizes prototypical DOE2 models and synthetic schedules created from evaluation data to produce 8,760 hourly end-use load shapes. Although the DEER models were developed with public funding and could be utilized by the sponsors, there would need to be some major data collection efforts and modifications to the models to produce reliable results that could be transferred to the East or Pacific Northwest regions. California is a large state with many different climate zones, but it does not include climates with extremely high heating degree requirements nor does it include climates with high levels of relative humidity accompanying high dry bulb temperatures. The evaluation studies that are being utilized by DEER for schedule information may be transferable to other regions on a case-by-case basis and are listed below.

(PG&E and Others) Compressed Air Management Program (CAMP) – Short-term measurements of true power are made for every CAMP site. CAMP has been implemented for several utilities and is ongoing. Total accumulated sample size has not been compiled. Quoted sample size is conservative currently 40 sites.

(SDG&E, Sempra Utilities) Hours of Operation (Express Efficiency) – This lighting study was completed in 2006. Lighting loggers were installed in 120 C&I buildings and measured lighting use for a 3-week period.

(SCE) Refrigerator Recycling Program – This residential refrigerator program was conducted by ADM Associates and was completed in 2005. The study monitored the interval power of the refrigerators at 240 homes for a one- to two-week period, and the data was extrapolated to calculate annual usage.

(SDG&E, Sempra Utilities) Residential CFL Load Shapes by Room Type – This study was performed by KEMA along with Jeff Hirsch from the DEER and completed in 2004. The study data and information is in the DEER database. TOU lighting loggers were installed at 400 homes.

(SCE & PG&E) Residential End-use Load Research Study – There were two residential load research efforts. The SCE study was completed in 1996, and only paper copies of the data are accessible. The PG&E study was completed in 2001, and electronic data in SAS format are available for the following:

- 1600 appliances – kitchen
- 400 appliances – laundry
- 800 appliances – refrigerators
- 800 HVAC – cooling
- 16 pool pump
- 800 water heating.

(LBNL & Ecos) Residential Plug Load Study – This study was completed in 2006 and involved 300 surveys, 75 site visits, and over 1300 products that were metered. The products consisted mainly of televisions, set top boxes (like TIVo or DVRs), computers, and other electronic equipment. The metering period was less than two months, and true power data was collected. The data is accessible and is available in SAS and Excel format.

(SCE, PG&E & CPUC) Savings By Design – This involves multi-year program evaluation conducted by RLW/KEMA. Two studies were completed in 2006 and 2007, and a third study is ongoing. These evaluations involve the use of short-term metering for 2-3 weeks using TOU lighting loggers and power meters to collect data for the following:

- 6 compressed air systems
- 87 HVAC – cooling measures
- 6 HVAC – heating measures
- 32 HVAC – ventilation measures
- 90 Industrial – process measures
- 76 lighting measures
- 10 refrigeration measures

6.4 Assessment of Data Availability (Gap Analysis)

The severity of the end-use data gap issue is driven by the extent to which smaller studies of similar measures can be combined within one region and data from other regions can be transferred and or combined to provide reasonably good load shapes. This discussion will look at the potentially useful studies that have been found in total and then discuss how the studies were distributed regionally.

Table 23 provides the number of studies and the number of sample points that have metered data from the potentially useful studies for each of the twenty-two non-residential analysis groups. Note that ten of the twenty-two analysis groups had no coverage at all. A few of the analysis groups (HVAC- fan energy, lighting exterior, and water heating) had no sample sizes specified. The HVAC – fan energy analysis group and the HVAC – ventilation only analysis group each had only six sample points identified in the studies.

Table 23: Assessment of Data Availability – Non-residential Analysis Groups

Analysis Group	# of Studies	# of Sample Points
Agricultural - Process	0	0
Agricultural - Pumping	0	0
Appliances - Laundry	0	0
Clean Room	0	0
Compressed Air	7	98
Data center equipment	0	0
Data center cooling	0	0
Food Service Equipment	0	0
HVAC - Cooling	10	317
HVAC - Fan Energy	1	NA
HVAC - Heating	4	6
HVAC - Other	5	73
HVAC - Ventilation Only	2	6
HVAC - Reheat	0	0
Industrial - Process	10	110
Lighting - Exterior	4	NA
Lighting - Interior	16	973
Motors - Drives	6	84
Plug load	0	0
Pump	0	0
Refrigeration	11	68
Water Heating	1	NA
Totals	**77**	**1735**

Considering that each of the analysis groups could have multiple measures within them, none of the categories with the exception of lighting – interior have an abundance of data available.

The situation is significantly better for the residential analysis groups as indicated in Table 24, which shows that only the HVAC – ventilation only analysis group does not have any coverage. The sample sizes are also significantly larger for the residential analysis groups; virtually all groups appear to have adequate coverage. However, it should be noted that national energy efficiency standards are updated periodically and it is desirable to have end-use data representing all ages of technology, including the newest.

Table 24: Assessment of Data Availability – Residential Analysis Groups

Analysis Group	# of Studies	# of Sample Points
Appliances - Kitchen	7	1,925
Appliances - Laundry	4	760
Appliances - Refrigerators	7	1,435
HVAC - Cooling	9	1,441
HVAC - Fan Energy	3	220
HVAC - Heating	5	478
HVAC - Ventilation Only	0	0
HVAC - Other	1	120
Lighting - Exterior	5	200
Lighting - Interior	9	2,700
Plug Load	7	600
Pool Pump	2	66
Domestic Hot Water	8	1,372
Totals	**67**	**11,317**

6.4.1 Pacific Northwest Region

As discussed in the previous sections, the potentially useful studies identified in the Pacific Northwest region are generally still in progress and or there are few details available to judge the viability of the studies. This gap assessment is based on the pending studies, delivering the results as indicated in the catalogue.

6.4.1.1 Residential end-uses

The residential customer sector has good coverage in this region as long as the BC Hydro Power Smart Residential End-use metering study is implemented with the large sample sizes that were indicated in the customer survey. If this study is not implemented, the sample sizes will be significantly reduced; then the coverage for these analysis groups gets thin rather quickly. Table 25 provides the sample sizes and the initial assessment of available data given the current information about the studies. Another wild card in this region is the PacifiCorp Long term System Wide Assessment of Demand Side and Other Resources, which shows significant coverage across many of the residential analysis groups, but no sample sizes are provided.

Table 25: Residential Data Availability for the Pacific Northwest

	PNW Region		
Analysis Group	**# of Studies**	**# of Sample Points**	**Data Availability**
Appliances - Kitchen	3	325	High
Appliances - Laundry	3	360	High
Appliances - Refrigerators	3	355	High
Domestic Hot Water	4	455	High
HVAC - Cooling	3	220	Medium
HVAC - Fan Energy	3	220	Medium
HVAC - Heating	4	438	High
HVAC - Ventilation Only	0	0	Low
HVAC - Other	1	120	Medium
Lighting - Exterior	3	120	Medium
Lighting - Interior	3	370	High
Plug Load	3	300	High
Pool Pump	1	50	High

6.4.1.2 Non-residential end-uses

There was only one non-residential study identified in this region, and it was the Puget Sound Energy lighting study with a total of 65 sample points. Therefore, based on the available information, ***all non-residential analysis groups have a high need for end-use data, due to low data availability.***

6.4.2 The East Region

The East region is significantly different from the Pacific Northwest, because there has been more non-residential evaluation activity than residential.

6.4.2.1 Residential end-uses

The residential end-use analysis groups have significantly less coverage in the East as evidenced by Table 26, which shows that more than half (7 of the 13) analysis groups have no coverage, based on studies conducted in this region. Additionally, only one (lighting interior) of the remaining six analysis groups has a low need for additional data.

Table 26: Residential Data Availability for the Eastern Region

	Northeast		
Analysis Group	# of Studies	# of Sample Points	Data Availability
Appliances - Kitchen	0	0	Low
Appliances - Laundry	0	0	Low
Appliances - Refrigerators	1	40	Medium
Domestic Hot Water	1	93	Medium
HVAC - Cooling	3	133	Medium
HVAC - Fan Energy	0	0	Low
HVAC - Heating	1	40	Medium
HVAC - Ventilation Only	0	0	Low
HVAC - Other	0	0	Low
Lighting - Exterior	2	80	Medium
Lighting - Interior	5	1,930	High
Plug Load	0	0	Low
Pool Pump	0	0	Low

6.4.2.2 Non-residential end-uses

Table 27 provides a non-residential end-use gap analysis for the East, which indicates that ten of the twenty-two analysis groups have no sample data at all. This was the same result as the overall non-residential gap analysis, and the same analysis groups are involved and are rated as having a high need for additional data. Once again, the lighting - interior is the only analysis group that appears to have adequate coverage and a low need for additional data. Although, even this group may need additional data if load shapes are developed at the two-digit SIC code level and data needs to be allocated across 13 different C&I sectors. The remaining analysis groups were all rated as having a medium need for additional data, primarily because there are some data available for the calculation of load shapes, but the sample sizes do not appear to be robust.

Table 27: Non-residential Gap Assessment for the Eastern Region

	Northeast		
Analysis Group	**# of Studies**	**# of Sample Points**	**Data Availability**
Agricultural - Process	0	0	Low
Agricultural - Pumping	0	0	Low
Appliances - Laundry	0	0	Low
Clean Room	0	0	Low
Compressed Air	5	52	Medium
Data center equipment	0	0	Low
Data center cooling	0	0	Low
Food Service Equipment	0	0	Low
HVAC - Cooling	4	145	Medium
HVAC - Fan Energy	0	0	Low
HVAC - Heating	1	NA	Low
HVAC - Other	4	73	Medium
HVAC - Reheat	0	0	Low
HVAC - Ventilation Only	0	0	Low
Industrial - Process	5	20	Medium
Lighting - Exterior	3	NA	Medium
Lighting - Interior	11	777	High
Motors - Drives	6	84	Medium
Plug load	0	0	Low
Pump	0	0	Low
Refrigeration	8	58	Medium
Water Heating	0	0	Low

6.5 Summary of Gap Analysis

In general, it appears that the residential sector has more end-use and measure load-shape data available than the non-residential sector. Furthermore, more usable studies appear to be available in the East compared to the Pacific Northwest. In the next chapter, we explore how the identified usable data can be leveraged and where new metering studies may be warranted.

7. Prioritization of Near-term Activities

In this chapter, we outline some options related to near-term activities to update or develop end-use load shapes. These activities are comprised primarily of either utilizing data from existing studies or collecting new data. The underlying assumption is that there are virtually no publicly available end-use data sets; and therefore, the gap analysis from the previous section was conducted to identify the potentially useful studies for the various end-use analysis groups where data may be available. This step was necessary to identify where the option of compiling end-use data from groups of other studies may be a viable option. Of course this begs the question as to whether the data can be easily obtained in a usable format for both compilation within a region and transfer to other regions. For the sake of this discussion, we will assume that the underlying data from the identified potentially useful studies would be available for additional analysis.

In order to allocate limited near-term resources, a ranking of the relative importance of different end-use analysis groups was developed. The relative importance level of different end-use analysis groups is based on a high-level assessment of the perceived and actual contribution of measures within the end-use analysis groups to overall savings within the two regions. (See Appendix C for additional information on how the importance levels were developed.) The relative importance of end-use analysis groups is categorized as follows:

- **Tier 1** – Most Important. Highest contribution to savings and high need, per web survey
- **Tier 2** – Moderately Important. Moderate contribution to savings and/or need, per web survey
- **Tier 3** – Lower Importance. Lower contribution to savings

The rankings utilized the web survey results for importance along with market-potential study data from California and Connecticut to rank the end-use analysis groups. See Appendix A for further details on how these ratings were determined for each end-use analysis group.

Generally, there are five options that could be pursued to develop the end-use data sets as follows:

- **Option 1** – Combine existing end-use studies of common measure types into meta studies using data collected within a region (Regional Meta Study). This option is theoretically the most attractive and easiest to implement because there is no primary data collection effort (end-use metering) and there are no transferability issues due to using data from other regions. Of course there still are challenges when attempting to combine datasets that involve the format and content of the data. Typically the data were collected to support one evaluation effort and a combined datasets is reduced in detail to the lowest common denominator. One particularly challenging aspect is assigning weights to the observations within the combined dataset. These challenges could be mitigated by developing common data collection and storage procedures that are designed to support the combination of multiple datasets as they are developed.

- **Option 2** – Look to utilize all data from within the region as well as data from other regions to fill gaps in the regional data (Trans-Regional Meta Study). This option is also theoretically attractive because there is no primary data collection effort (end-use metering) involved. However, because data from multiple regions will be combined the issue of data transferability must be addressed. Analysis groups that have a high transferability rating should be the easiest to combine, however it is advisable to perform a statistical comparison of the datasets from each region to make sure that no significant bias is being introduced into the results. If there are no data from within the region than there really is no way to perform this bias analysis and justifying the transferability of the data becomes more problematic particular with respect to capacity market M&V requirements. This strategy includes utilizing DEER load shapes, with no customization. We recognize that this option also still has all of the data combination challenges discussed above for Option 1 along with the transferability issue.

- **Option 3** – Work to develop a database for regionally customized DOE2 Models using California Database for Energy Efficient Resources (DEER) as a starting point. Once again this option is theoretically attractive because there is no primary data collection effort. However, customizing the DOE2 models used by DEER to reflect the conditions within a particular region will require a significant data collection effort to identify saturation data of energy efficiency equipment within both Residential and Non-residential customer sectors. DEER models consist of 29 C&I prototypes and 4 Residential prototypes and each provide about 10 different end-uses, excluding whole premise load. Additionally, calibration of these models to system load is another process that should be undertaken and can be tremendously onerous depending on the level of rigor attempted. At the other end of the spectrum, if a load shape is needed for a relatively unimportant measure that is not weather dependent, then the DEER database could be used directly to extract a load shape.

- **Option 4** – Field new end-use data collection effort to evaluate the measure(s) within a particular region or across multiple regions. This option is attractive because it provides the flexibility to design and conduct the study to meet specific data needs for energy efficiency, air standards or capacity markets. Depending on the level of complexity involved in combining datasets (either from within a region or from multiple regions) or attempting to customize DEER DOE2 prototype models, this may be the easiest and cleanest option.

- **Option 5** – Do nothing because the end-use or measure is not important at this time.

The first option should be the most cost-effective method for developing an end-use data set, because it would utilize all the usable interval data from within a region to develop load shapes that could be utilized for energy efficiency cost-benefit testing, green house gas reporting, or for capacity markets. Unfortunately, this method requires large quantities of high-quality data from within a region, and there were very few analysis groups identified that met this criteria.

The second option would look to utilize all the data from within one region as well as data from other regions to compile the dataset. This would be a more challenging undertaking, because it would be necessary to adjust the data for regional differences so that the data would provide accurate results. Some of the challenges include regional differences in weather, construction practices, baseline equipment, and saturations of other energy efficiency devices that impact the measure of interest. For example, water heating measures can be impacted by saturations low flow showerheads and front-load washing machines that use less water. Similarly, saturations of programmable thermostats can impact the operation of air conditioning primarily during hours when the cooling set point has been raised. This Option 2 is only considered if the transferability rating for an end use analysis group is "high."

The third option would be to utilize regionally customized DOE2 models using the California DEER models as a starting point. Although this is listed as a near term option, it has taken California many years to get the models to their current status. There are multiple residential and commercial prototypical models that are built from the room level up and each of these are accurately calibrated to annual energy consumption for the portion of aggregate load that they represent. As of 2008 the models were being adjusted so that they would also accurately predict peak demands. The DEER process has utilized short term metering data from energy efficiency evaluation efforts conducted throughout the state to continuously update and perfect the operating schedules of the electrical end-use equipment in the models. In order for this method to be utilized effectively, the aggregate load data for residential and commercial sectors would have to be defined for monthly energy and demand so that the models could be calibrated. Additionally load data for the commercial sector should be segmented by North American Industry Classification System (NAICS) codes so that the models for each segment can be calibrated. This initial level of effort to develop model calibration data may be considered to onerous for some, but it is really the bare minimum. Additionally, building survey data and the development of equipment operating schedules using metered data should also be utilized to develop accurate prototypical models for the region of interest. This approach is a "hybrid" approach of both imported and local data. Entities developing load shapes may consider augmenting existing data sources to build up relative precision and run statistical analysis on data to support imported data is transferable.

Conversely to the rigorous implementation of regionally customized DOE 2 models utilizing regional survey data and system load calibration procedures, the DEER database could be used directly as a source of load shapes. This method should be limited to relatively unimportant savings measures and would require that the measure is not weather dependent or that the weather within the region of interest matches one of the California climate zones maintained in the DEER database[24]. One step up in terms of rigor would be to obtain the DOE 2 input models from DEER and run them using regionally specific weather files, but without altering saturation assumptions or operating schedules. Obviously these shortcut approaches are of questionable validity in terms of meeting the criteria of M&V for Capacity Markets, which require the use of calibrated models. However, when there is no end use data available for a specific measure and its degree of implementation does not warrant more rigorous M&V activity than one of these shortcut methods could be employed.

The fourth option, to field a new end-use metering study should be divided into two categories based on the purposes of the study. The first category would be to field a traditional Load Research end-use metering study that utilizes long term metering and collects data for a period of years. The second category would be the energy efficiency impact evaluation that utilizes short term interval metering to evaluate the energy savings and demand impacts of a specific measure or energy efficiency program. For the purposes of this discussion we will assume that option four refers to the energy efficiency impact evaluation. This option has been primarily employed on a regional basis to evaluate prescriptive type measures like residential compact fluorescent lighting or residential room air conditioners. This type of effort can be relatively cost effective method for obtaining end-use data because the study sponsors can share both the data and the costs. It is important that these types of studies are designed up front to account for any geographical differences within the region so that all of the sponsors can utilize the data equally.

The fifth option would be to do nothing in the near term because the end-use analysis group just isn't important enough to allocate limited resources to in the short term. These end-use groups may become more important in the future and new data collection efforts would need to be fielded.

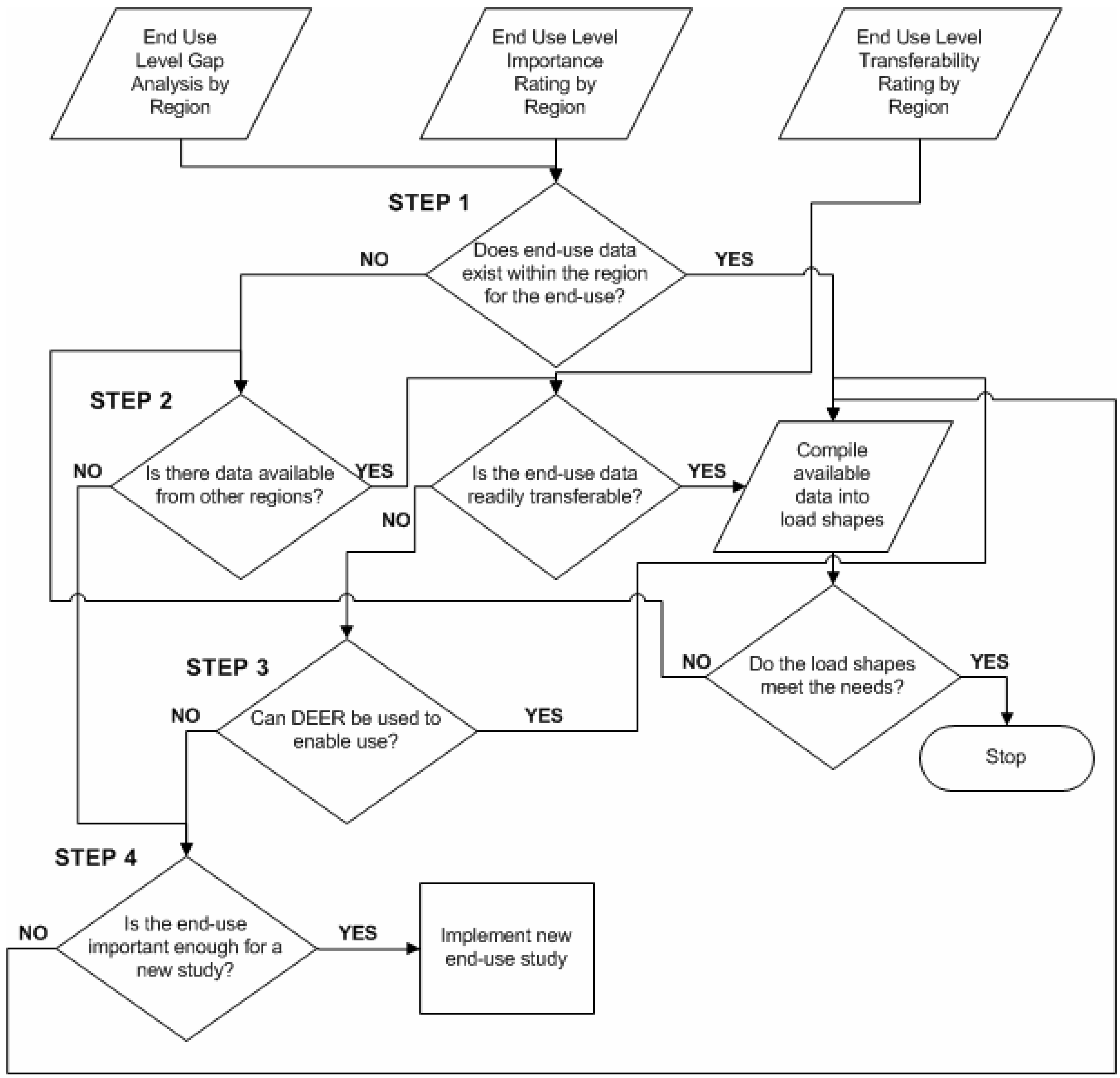
Figure 16 provides a flowchart for the near term action plan that details the general decision making process for determining, what the best course of action would be for the end-use analysis groups. The decision making process utilizes the end-use analysis group-level Gap Analysis, Importance Rating and Transferability Rating to inform the decision making process.

[24] This methodology is employed widely for market potential studies to estimate the energy savings and demand impact potential for energy efficiency measures.

- The first step in the process is to determine whether there is sufficient interval end-use or measure load data from within the region to develop usable load shapes.
    - If yes then compile the data into aggregate end-use and measure load shapes and review the results for adequacy for their intended purpose.
        - ➢ If yes then the process is complete
        - ➢ If no then look for end-use load data from other regions
- The second step is to determine whether there is sufficient interval end-use and measure load data available from other regions that can be used.
    - If yes than determine if the end-use analysis group is readily transferable ("high")
        - ➢ If yes then compile the new data into aggregate end-use load shapes, or simply utilize the load shapes available from other regions (e.g. DEER)
        - ➢ If no then determine if "DEER" DOE2 model type approach can be utilized
- The third step is to determine if utilizing the DEER method of developing prototype DOE2 models to produce end-use and measure load shapes is a viable option.
    - If yes then collect necessary data to develop and calibrate the models and compile the end-use load shapes
    - If no then proceed to step four
- The fourth step is to determine whether the end-use analysis group is important enough to field a new end-use data collection effort.
    - ➢ If yes then design and implement new study
    - ➢ If no then either compile existing data or do nothing

It is important to note that the underlying assumption of this analysis was that leveraging existing data sources (including the DEER database) would be a more cost effective approach than fielding a new metering study and on a theoretical basis this is true. However, this greatly simplifies the challenges associated with combining multiple datasets or attempting to customize DEER models and being able to develop a usable dataset for energy efficiency program evaluation, air quality reporting or capacity markets. It could well be that fielding a new metering study to evaluate specific measures is the most efficient and cost effective option. This is certainly true when there are no existing data sources to utilize and is also probably true where a rigorous customization of DEER would need to be employed. Utilization of DEER load shapes without customization (or with minimal customization) may be a viable approach for end use analysis groups with high transferability.

Figure 16: End-use Analysis Group Near-term Action Plan Flowchart



7.1 Pacific Northwest Region

In general the Pacific Northwest Region has the highest need for utilizing data from other regions or fielding new studies to address the large gap in end-use data for the non-residential sector. There has been no new non-residential end use data collection efforts identified in the region since ELCAP, which was completed in the early 1990s. Based upon the availability (or lack of availability) of end-use data from other regions it seems inevitable that there will have to be primary end-use metering studies conducted in the Pacific Northwest region particularly for the non-residential sector. In order to minimize the costs implications the region should look to develop trans-regional meta studies as an initial step and then look to fill in the gaps as needed.

7.1.1 Residential

Table 28 provides a summary of the near term action plan for the residential sector analysis group end-uses in the Pacific Northwest region. The analysis groups have been ranked in order of importance with the most important (Tier 1) end-uses listed at the top of the table. There are four Tier 1 analysis groups and all but one of the end-uses appears to have enough data available within the region (Option 1) to compile some regionally specific end-use load shapes. The HVAC- Cooling end-use could benefit from some additional data from outside of the region, the use of DEER type models, or the implementation of a new metering study to develop the load shapes.

Table 28: Assessment of Short Term Update Priority, for PNW Residential

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Residential Analysis Groups	Importance Level	Data Availability	Transferability Rating	Near Term Action
Lighting - Interior	Tier 1	High	High	Option 1/2
HVAC - Cooling	Tier 1	Medium	Low	Option 1/4
HVAC - Heating	Tier 1	High	Low	Option 1
Plug Load (Electronics)	Tier 1	High	High	Option 1/2
Domestic Hot Water	Tier 2	High	Medium	Option 1
Lighting - Exterior	Tier 2	Medium	High	Option 1/2
Appliances - Laundry	Tier 2	High	High	Option 1/2
Appliances - Refrigerators	Tier 2	High	High	Option 1/2
HVAC - Fan Energy	Tier 3	Medium	Low	Option 1/4
Pool Pump	Tier 3	High	Medium	Option 1
HVAC - Other	Tier 3	Medium	Medium	Option 1/4
HVAC-Ventilation Only	Tier 3	Low	Low	Option 5
Appliances - Kitchen	Tier 3	High	High	Option 1/2

There are also four Tier 2 end-uses listed and once again three of them appear to have sufficient data available from within the region to develop load shapes. The Lighting - Exterior end-use is the one Tier 2 analysis group that would probably need to use additional data from outside the region in order to develop usable load shapes. The five remaining end-use analysis groups are all rated Tier 3 for importance and two of the five appear to have adequate coverage of data from within the region to develop load shapes.

Note that the HVAC – Ventilation Only analysis group has a near term action plan of Option 5, which is to do nothing. This analysis group had no end-use data collection activity identified and was ranked 12th out of 13 in terms of importance. Therefore no near term activity should be directed at developing load shapes for the HVAC – Ventilation Only analysis group.

Although the PNW region appears to have a large amount of viable data sources identified within the region for developing residential end-use load shapes the numbers are heavily dependent on the successful implementation of one study that is still in the planning stages. Virtually all of the residential sector end use analysis groups that have Option 1 as their near term action plan rely almost exclusively on the BC Hydro Power Smart Residential End-Use metering study for data. This study is still in the planning stages and currently looks to be targeting sample sizes of around 300 for most of the Residential sector end-use analysis groups. If this study is not implemented or if sample sizes are significantly reduced, then the available data from within the region becomes very sparse, and would probably require that data from other regions be utilized. We recommend that the PNW region engage BC Hydro Power immediately to assess whether a partnering opportunity exists to minimize metering costs for both parties.

7.1.2 Non-residential

The prognosis for the PNW non-residential sector is not good, because there has been no end use interval data collection activity in the region that was identified through this cataloguing effort. The region will have to rely on newer studies that have been conducted in California and the Eastern Region for borrowed data or launch a significant new metering effort within the region. Some level of new metering effort within the region is unavoidable, and the scope of the effort could be managed effectively by looking at specific outside sources of data and considering the ability to leverage these data where practical. It could be that customization of the DEER DOE 2 prototype models is the most cost effective method for developing end-use and impact load shapes, however, even this method would benefit from primary data collection from within the region to identify building stock characteristics and develop operating schedules.

Since there is no existing newer data from within the region that can be used to check the validity of the transferred data, ELCAP data from the early 1990's will have to be used, or consider simply using load shapes from other regions for end use analysis groups with "high transferability. ELCAP data will have little value for checking the magnitude of the energy usage directly unless load based adjustment factors can be developed to calibrate aggregate loads predicted by ELCAP profiles to actual aggregate electrical loads within a distribution company system or on a statewide basis. The ELCAP data should still provide valid load shape data as long as the load shapes can be normalized to remove the impacts of the older technologies. This is relatively straightforward for a technology like lighting where the energy efficient equipment achieves savings through a pure increase in efficiency. It becomes more difficult for measures where the savings profiles do not follow the load (e.g. control measures or variable frequency drives).

Another issue that affects all regions is the gaps identified for several of the non-residential sector analysis groups. There are two Tier 1 groups (HVAC – Fan Energy, Plug Loads) that had no data sources identified. Similarly there are five Tier 2 groups (Data Center Cooling, HVAC - Ventilation, HVAC – Reheat, Pump and Data Center Equipment) that had no interval data identified and these measures may also require that new metering efforts be implemented.

Table 29 summarizes recommended actions for each Analysis Group. Where transferability is "high," these end uses are recommended to utilize data available from other regions. Where transferability is medium or low, new metering is recommended. Within each option category, the end use analysis groups are listed in order of importance.

Table 29: Assessment of Short Term Update Priority, for PNW Non-Residential

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Non-Residential Analysis Groups	Importance Level	Data Availability	Transferability Rating	Near Term Action
Lighting - Interior	Tier 1	Low	High	Option 2
Lighting - Exterior	Tier 1	Low	High	Option 2
Compressed Air	Tier 2	Low	High	Option 2
Appliances - Laundry	Tier 3	Low	High	Option 2
Food Service Equipment	Tier 3	Low	High	Option 2
Motors - Drives	Tier 1	Low	Medium	Option 4
Plug Load (Electronics)	Tier 1	Low	Medium	Option 4
HVAC - Cooling	Tier 1	Low	Low	Option 4
HVAC - Fan Energy	Tier 1	Low	Low	Option 4
HVAC - Heating	Tier 1	Low	Low	Option 4
Refrigeration	Tier 1	Low	Low	Option 4
Industrial - Process	Tier 2	Low	Medium	Option 4
Water Heating	Tier 2	Low	Medium	Option 4
Pump	Tier 2	Low	Medium	Option 4
Data Center Equipment	Tier 2	Low	Medium	Option 4
Agricultural - Pumping*	Tier 2	Low	Medium	Option 4
Data Center Cooling	Tier 2	Low	Low	Option 4
HVAC - Other	Tier 2	Low	Low	Option 4
HVAC-Ventilation (Only)	Tier 2	Low	Low	Option 4
HVAC-Reheat	Tier 2	Low	Low	Option 4
Agricultural - Process	Tier 3	Low	Medium	Option 4
Clean Room	Tier 3	Low	Low	Option 4

* Agricultural – Pumping is a Tier 2 priority for PNW (and Tier 3 for East)

7.2 Eastern Region

The Gap Analysis for the Eastern region indicated that there were potentially useful studies for both Residential and Non-residential customer sectors. There were some residential analysis groups that did not have any usable studies available.

7.2.1 Residential

Table 30 provides a listing of the recommended near term activities for the Eastern region Residential sector end use groups, which are ranked in order of importance. Of the four Tier 1 end use groups only the Lighting – Interior has sufficient data from within the region to compile load shapes. The others will require either the use of additional data from other regions, the customization of DEER DOE 2 models and/or the fielding of a new regional metering study. The Plug Load (Office Electronics) end use will probably require a new metered data collection effort within the region as there is little available data from other regions. The Tier 2 end use groups will also require the use of additional data from outside of the region, but most of the groups have high transferability ratings so this should not be a major issue.

Table 30: Assessment of Short Term Activity for Eastern Region Residential

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5:* Do Nothing)

Residential Analysis Groups	Importance Level	Data Availability	Transferability Rating	Near Term Action
Lighting - Interior	Tier 1	High	High	Option 1
HVAC - Cooling	Tier 1	Medium	Low	Option 1/4
HVAC - Heating	Tier 1	Medium	Low	Option 1/4
Plug Load (Electronics)	Tier 1	Low	High	Option 2/4
Domestic Hot Water	Tier 2	Medium	Medium	Option 1/2
Lighting - Exterior	Tier 2	Medium	High	Option 1/2
Appliances - Laundry	Tier 2	Low	High	Option 2/4
Appliances - Refrigerators	Tier 2	Medium	High	Option 1/2
HVAC - Fan Energy	Tier 3	Low	Low	Option 4
Pool Pump	Tier 3	Low	Medium	Option 5
HVAC - Other	Tier 3	Low	Medium	Option 3/4
HVAC-Ventilation Only	Tier 3	Low	Low	Option 5
Appliances - Kitchen	Tier 3	Low	High	Option 2/4

The Tier 3 end use groups all had little or no available data identified from within the region and all would require using data form other regions to develop load shapes or new metering. The Pool Pump and HVAC – Ventilation Only analysis groups should probably have no short term actions taken to develop load shapes (some data may be available from California DEER database for pool pumps, if needed).

The East has a much higher need to leverage residential sector end use group interval data from other regions than the PNW region. This region has to meet the data requirements of the Regional Capacity Markets for both PJM Interconnection and ISO-NE, which consist of prescriptive statistical relative precision requirements and technical specification requirements for the metering equipment used to collect the data. These requirements were considered when selecting the potentially useful studies from within the region, but may be an issue when determining the usability of studies from other regions. Of the four Tier 1 analysis groups, only Lighting – Interior appears to have enough data from within the region to compile load shapes that would be usable for the capacity markets. The HVAC – Heating and HVAC – Cooling end use groups would need to be supplemented with data from outside the region. These groups have low transferability and may require the use of DOE 2 models to make sure that regional differences in efficiency, weather, construction practices and occupant usage patterns are properly addressed. The final Tier 1 groups (Plug Loads) may require a new regional data collection effort, depending on the quality of the data that was collected in other regions.

Three of the four Tier 2 analysis groups (Domestic Hot Water, Lighting Exterior and Appliances – Refrigerators) have relatively large amounts of interval data from within the region that should be supplemented with data from other regions in order to meet the relative precision requirements for the capacity markets. The other Tier 2 group (Appliances – Laundry) would require the use of interval data from outside the region, or new metering, in order to develop load shapes as none was identified from within the region.

There were no interval data identified from within the region for any of the five Tier 3 end use groups and two of these (Pool Pump and HVAC – Ventilation Only) should have no short term action to develop load shapes. The two groups (HVAC – Fan Energy, HVAC – Other) may need new metering as they have low transferability. The Appliances – Kitchen analysis group had data available from other regions and these data should be used in the short term to develop load shapes for the measures within this group.

7.2.2 Non-residential

Table 31 provides a listing of the short term activities recommended for the Eastern region non-residential end use analysis groups ranked in order of importance. Most of the Tier 1 end use groups can develop load shapes by utilizing data collected within the region in conjunction with data collected from other regions. Once again the Plug Load (Electronics) end use group would require data provided from a new metering study and the HVAC Heating end use has some data from the region, but could also benefit from additional new metering to develop profiles in the short term.

Table 31: Assessment of Short Term Activity for Eastern Region Non-Residential

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5*: Do Nothing)

Non-Residential Analysis Groups	Importance Level	Data Availability	Transferability Rating	Near Term Action
Lighting - Interior	Tier 1	High	High	Option 1/2
HVAC - Cooling	Tier 1	Medium	Low	Option 1/4
Lighting - Exterior	Tier 1	Medium	High	Option 1/2/4
HVAC - Fan Energy	Tier 1	Low	Low	Option 1/4
Plug Load (Electronics)	Tier 1	Low	Medium	Option 4
HVAC - Heating	Tier 1	Low	Low	Option 1/4
Motors - Drives	Tier 1	Medium	Medium	Option 1/2/4
Refrigeration	Tier 1	Medium	Low	Option 1/4
Industrial - Process	Tier 2	Medium	Medium	Option 1/2/4
Data Center Cooling	Tier 2	Low	Low	Option 4
HVAC - Other	Tier 2	Medium	Low	Option 1/4
HVAC-Ventilation (Only)	Tier 2	Low	Low	Option 4
HVAC-Reheat	Tier 2	Low	Low	Option 4
Water Heating	Tier 2	Low	Medium	Option 3/4
Pump	Tier 2	Low	Medium	Option 3/4
Compressed Air	Tier 2	Medium	High	Option 1/2/4
Data Center Equipment	Tier 2	Low	Medium	Option 4
Agricultural - Pumping*	Tier 3	Low	Medium	Option 5
Appliances - Laundry	Tier 3	Low	High	Option 5
Food Service Equipment	Tier 3	Low	High	Option 5
Agricultural - Process	Tier 3	Low	Medium	Option 5
Clean Room	Tier 3	Low	Low	Option 5

* Agricultural – Pumping is a Tier 3 priority for East (and Tier 2 for PNW)

Five of the nine Tier 2 end use groups (Data Center Cooling, HVAC – Ventilation, HVAC - Reheat, Water Heating, Pump and Data Center Equipment) had no primary data identified in the potentially useful studies and would need to have some new data collection activities implemented to produce load profiles. The remaining Tier 2 groups had some data collected within the region that could be combined with data collected from other regions (e.g. California) to develop load profiles. The five Tier 3 groups all had no data identified in any of the potentially useful studies and all of them were deemed to be unimportant for the short term (i.e. minimal contributions to regional energy efficiency efforts) with no recommended activities at this time.

Within the East there were many sources of non-residential interval data identified, however none of the eight Tier 1 analysis groups had enough data from within the region to meet the requirements of the capacity market, with the possible exception of the Lighting – Interior analysis group[25]. The Plug Load (Office Electronics) analysis group did not have any interval data sources identified from any region and would require the fielding of a new data collection effort to develop load profiles for this group. The remaining Tier 1 analysis groups all had some sources of data identified from within the region that could be supplemented with data from other regions (e.g. California) or new metering to produce load shapes with better relative precision.

There are nine Tier 2 analysis groups and six of these (Data Center Cooling, HVAC - Ventilation Only, HVAC – Reheat, Water Heating, Pump and Data Center Equipment) all appear to need a new data collection effort to develop interval data . The other three Tier 2 groups (Industrial Process, HVAC – Other and Compressed Air) all have interval data from within the region that can be leveraged with some additional new metering to develop load shapes suitable for the capacity markets. To some extent the Industrial Process measures tend to be site specific custom measures that are not widely applicable to other sites so the value of developing these load shapes for use at other facilities is debatable.

There are five Tier 3 end use analysis groups Tier 3 groups (Agricultural – Pumping, Appliances – Laundry, Food Service Equipment, Agricultural – Process and Clean Room) and none of these had interval metered data sources identified through the catalogue effort. These groups have been designated as not being important enough (i.e. contribute minimally to regional efficiency portfolios) to warrant any short term activity at this time.

[25] This is really dependent on how the data is segmented, and we would recommend by two digit NAICS at a minimum with additional large and small sub categories within each segment. Using this method the aggregate precision may be met, but precision within each of the buckets would be difficult to achieve.

8. Future Regional End-use Data Efforts

This study has shown that there is relatively little current end-use data being collected today with the exception of data collected for demand response pilot programs or for the purpose of energy efficiency evaluation using relatively limited time periods. Further, the challenges associated with collecting data for this project have made it clear that any future endeavor would greatly benefit from a much more systematic approach. This chapter provides an overview for long-term approaches to future end use data collection efforts.

8.1 Customer Class Considerations

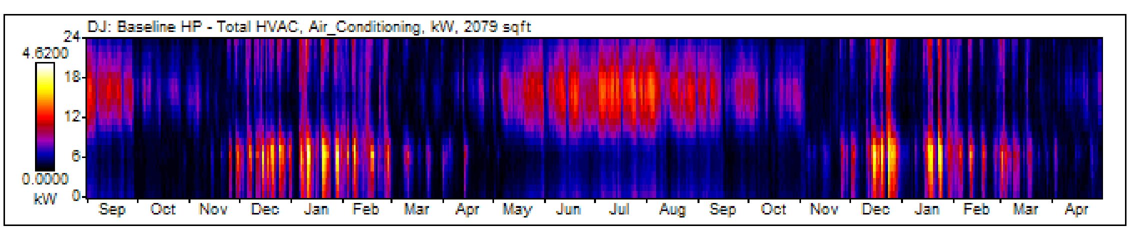
In developing a full catalogue of end use and measure load shapes, one of the first things is to consider how to segment the population(s) of interest. In this section we explore end-use stratification strategies for the residential and non-residential sectors across the three major customer classes, namely, residential, commercial and industrial.

8.1.1 Residential

When crafting an end-use residential study, several distinctions need to be considered, in order to account for end-use load shape variations in the residential customer class. The first distinction should be based on the fuel type of major energy using equipment found in the home. Electric space heating and electric cooling contribute significantly to the distinct load patterns of the residential class. Since most electric utilities peak loads occur on the hottest and coldest days of the year, electric heating and cooling end-uses contribute significantly to the peak load conditions.

Figure 17 shows an "EnergyPrint" of the average heat pump end-use load profile from a study conducted by PowerSouth. In the horizontal format of the EnergyPrint, time is on y-axis and runs from 1 am at the bottom to 12 midnight at the top, and the day of the year is on the x-axis and runs from September 2003 through April 2005. The magnitude of demand is done in a color gradient with low levels of load in the black to blue spectrum and high levels of load in the yellow to white spectrum. The scale on the left hand side of the figure shows that the heat pump load ranged from 0 kW (black) to a high of 4.6 kW (white) across each hour.

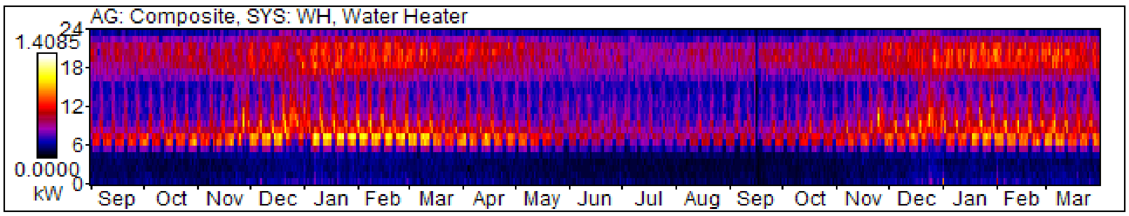
Figure 17 – Heat Pump End-Use Load Showing Cooling and Heating Requirements



The figure displays two complete winter seasons and shows the highest demand in the early to mid-morning hours. The one full cooling season displays a wide band of intense demand from April through August but the summer load is actually lower than the winter demand.

Water heating also contributes to the peak loads due to the significant size of the connected load and should therefore also be considered when structuring an end-use study. Figure 18 displays the average diversified water heating profile from the Alabama study and shows a clear bi-modal load pattern with significant use in the early morning hours and again in the evening with sporadic use during the day. On an average diversified basis, the water heating load contributed up to 1.4 kW of load to the residential profile.

Figure 18 – Water Heating Load Showing Bi-Modal Load Profile



Customers with electric heating/cooling and/or water heating end-uses are relatively identifiable due to utility tariff structures[26] and due to the unique usage patterns[27] and usage history of the customers. Residential customers selected for end-use monitoring, based on the above sampling criteria and any preliminary screening, may then be confirmed through a customer contact either personally or by other means such as mail or telephone surveying methods.

Residential end-use data collection might also focus on building type. This end-use segmentation could be based on dwelling type and grouped into single family dwellings, apartment dwellings, and manufactured/mobile homes. In addition, considerations could be given to additional categories, e.g., construction type, and might include single family dwellings on slab or over basement, single story versus multistory, or perhaps even vintage. In addition, end-use data gathering for apartments must also consider common uses such as hall and security lighting. Likewise, end-use data gathering for mobile home parks and apartment complexes must also consider common uses, such as security lighting and also common buildings (community centers) and recreational uses such as swimming pools and gym areas.

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[26] Some utilities develop rate structures or rate riders that differentiate customers with electric space heating or water heating.
[27] On several occasions we have used PRISM like models to identify customers with extreme sensitivity to heating and cooling degree days as a predictor of central air conditioning, heat pump, or electric heating load.

The final "residential" class that may need stratification is farming. Under the farming umbrella several sub classifications should be considered including livestock, dairy, vegetable and grain farming. Many rural households actually include significant "shop" loads that could be classified as industrial in character.

8.1.2 Non-Residential

8.1.2.1 Commercial Customers

Commercial establishments may best be categorized by building use. As an example, the Commercial Building Energy Consumption Survey[28] (CBECS) classifies buildings based on the principal activity occurring in each facility. Table 32 presents the CBECS building classifications.

Table 32 – Building Type Classification

Building Type Description
Vacant
Office / Professional
Laboratory
Warehouse non-refrigerated
Food sales
Public order/safety
Health care (outpatient)
Warehouse (refrigerated.)
Religious worship
Public assembly
Education
Food service
Health care (inpatient)
Skilled nursing
Hotel/ Motel/Dorm
Strip shopping
Enclosed shopping center/mall
Retail (excluding mall)
Service (excl. food)
Other

Similarly, the California Commercial End-Use Survey[29] classifies commercial operations into ten building types and a variety of miscellaneous subcategories (see Table 33 below). Each of the

[28] The Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey conducted by the Energy Information Administration ("EIA") and collects information on the stock of commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures.

[29] Please see Verification of End-use Estimates for Commercial Buildings; Sub-Task 4.0; Energy Information Administration; Prepared by KEMA, Inc. under subcontract to Z, Inc.; Contract Number DE-AM01-EI41006; August 28, 2008; Screen 16 of 94.

ten building types is then further subdivided into building operations (e.g. lodging is divided into Hotel, Motel, Resort, and Other Lodging). Commercial end-use studies may therefore collect whole-premise data for each of the ten categories in total (or any other stratification deemed appropriate) or for each individual categories stratified by the building types identified for the category.

Table 33 – CEUS Building Type Classifications

CEUS BUILDING TYPES		
Office	**Retail Store**	**Lodging**
Administration and management 011	Department / Variety Store 041	Hotel 081
Financial / Legal 012	Retail Warehouse/Clubs 042	Motel 082
Insurance/Real Estate 013	Shop in Enclosed Mall 043	Resort 083
Data Processing/Computer Center 014	Shop in Strip Mall 044	Other Lodging 084
Mixed-Use/Multi-tenant 015	Auto Sales 045	**Public Assembly**
Lab/R&D Facility 016	Other Retail Store 046	*Religious Assembly (worship only) 091*
Software Development 017	**Warehouse**	*Religious Assembly (mixed use) 092*
Government Services 018	*Refrigerated Warehouse 051*	Health/Fitness Center 093
Other Office 019	Unconditioned Warehouse, High Bay 052	Movie Theaters 094
Restaurant/Food Service	Unconditioned Warehouse, Low Bay 053	Theater / Performing Arts 095
Fast Food or Self Service 021	Conditioned Warehouse, High Bay 054	Library / Museum 096
Specialty/Novelty Food Service 022	Conditioned Warehouse, Low Bay 055	Conference/Convention Center 097
Table Service 023	**Health Care**	Community Center 098
Bar/Tavern/Nightclub/Other 024	*Hospital 061*	Other Recreational/Public Assembly 099
Other Food Service 025	*Nursing Home 062*	**Services**
Food Stores	Medical/Dental Office 063	Gas Station / Auto Repair 101
Supermarkets 031	Clinic/Outpatient Care 064	*Gas Station w/Convenience Store 102*
Small General Grocery 032	*Medical/Dental Lab 065*	Repair (Non-Auto) 103
Specialty/Ethnic Grocery 033	**Education**	Other Service Shop 104
Convenience Store** 034	Daycare or Preschool 071	**Miscellaneous**
Liquor Store 035	Elementary School 072	*Assembly / Light Mfg. 111*
Other Food Store 036	Middle / Secondary School 073	*Police / Fire Stations 112*
	College or University 074	*Post Office 113*
	Vocational or Trade School 075	Other 130

Commercial end-use studies may also focus on the major energy using devices associated with commercial establishments. Such devices could include air conditioning, refrigeration, space heating, motors, data processing, and plug loads. Air conditioning is almost universally used in the commercial establishments, particularly where the public is served. Some commercial loads, such as data processing and cooling are closely related and interdependent. Refrigeration is used primarily in the food business (all types of food stores and restaurants) and may impact air conditioning loads, particularly in large supermarkets. Motors, while found on the air handling systems, can also be found with the moving or transporting of people (e.g, escalators and elevators) as well as other process applications, especially pumping of liquids. Electric cooking and electric water heating are not universal applications in the commercial class. Commercial establishments tend to rely on natural gas for these end-uses unless historically low electricity tariffs prevail in the region.

8.1.3 Industrial Customers

Industrial electric loads for many utilities make up a significant and vitally important segment of system load. At a minimum, the industrial customer load needs to be understood and profiled as an end-use. In order to segment industrial customers into homogeneous subgroups, a classification system needs to be utilized. Industrial end-use studies have traditionally utilized the Standard Industrial Classifications (SIC) to develop stratification scenarios. However, the North American Industry Classification System (NAICS) is the new standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was developed under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the SIC. The NAICS search engine may be accessed at: http://www.census.gov/eos/www/naics/.

Industrial load profiles developed based on NAICS or SIC classifications may be of interest to utility load forecasters. However, further understanding of the end-uses within the industrial complex may be of less value. In the energy efficiency evaluation work in the Northeast, the industrial process loads are a unique category along with lighting, HVAC, motors, refrigeration, and compressed air. In practice, reliable application of SIC and/or NAICS coding is problematic, for example warehouses used for particular industrial classifications may be almost randomly coded to either warehouse or to the specific industrial classification. For understanding the consumption of the warehouse it is often not clear which classification would really be correct.

8.1.4 Commercial and Industrial Classification Alternatives

The Electric Reliability Council of Texas (ERCOT) has developed an alternative C&I classification for use in their load profiling and settlement process. ERCOT first segments the C&I class by demand and non-demand customers. Next, for the demand customers, three classifications based on load factor are constructed. Low load factor customers are those that have an annual load factor less than 30%. Medium load factor customers are those between 30% and 60%. And, high load factor customers are any customer above 60%. Commercial and Industrial end-use profiles, segmented by load factor, will produce more homogeneous groupings of customers. Obviously extremely high load factor loads have an end-use profile that is essentially flat. However, as load factor decreases, customer groups can strain the system, from a coincident demand perspective, but have insufficient usage to set rates that will recover costs. These groups of customers will be much more volatile and need to be understood so that, at a minimum, equitable pricing scenarios can be developed.

8.1.5 Other

Other end-use segments may include irrigation, municipal pumping, street lighting, and traffic lighting to name a few. Only the first two of these categories bear discussion as the profiles for the latter two can be estimated using total kWh for the application, hours of daylight, and/or hours in the day. The end-use profile for street lighting is a function of total annual kWh (or MWh) spread uniformly over the hours of nighttime. Traffic lighting load profiles, on the other hand, can be spread uniformly over all hours. That leaves municipal pumping. The number of municipal pumping end-uses is relatively minor, consisting primarily of water pumping and sewage lifts. These end-uses tend to be highly variable and subject to such diverse things as rainfall and the time of the beginning of the Super Bowl half time.

8.2 Evaluating Options

As we consider the future of end-use metering we must examine various approaches to secure the information. We will review several alternatives including:

- Traditional approaches;
- Advanced Metering approaches;
- Prototype/DOE2 Engineering Modeling approaches;
- Short-term energy efficiency metering approach;
- Statistical approaches; or
- Hybrid approaches.

8.2.1 Traditional Approach

Traditional end-use metering approaches involved the installation of a load recording device directly on the load of interest. This form of end-use data collection is very customer intrusive requiring access to the customer's facility/home to install the monitoring devices on the appliance or circuit. Even though the metering installation is temporary, the traditional approach often required a licensed electrician if access to the customer's electrical distribution panel was required. In a number of early studies, multiple channel recorders were used to numerous end-use loads along with the customer's total load. The extreme case being ELCAP which often used multiple 56 electrical power end-use channel data loggers in individual commercial buildings. In many instances the end-use loads were either hard wired to the data collection devices or may have used some other transfer medium, e.g., sending data over the internal house wiring to a data collection device located outside the residence or facility. In turn, data was sent to the utility by visiting the meter on a monthly basis or using some form of remote interrogation, e.g., telephone/modem. Recruitment in these types of projects is a major challenge. Many customers are unwilling to be inconvenienced by the installation process (e.g., allowing someone access to their home or electrical distribution system) or unwilling to allow the monitoring equipment to be located at the premise. Data management systems were used to collect, store, report, and extrapolate sample load data from various end-use applications to system representations of those end-use applications. End-use data provided a direct means of estimating the end-load and the variability of end-use load. Traditional projects would span several years collecting end-use information across a wide array of temperature conditions. Cost of the traditional approach was high which often limited the sample size, however; data quality and the "signal to noise ratio[30]" was also very high.

8.2.2 Advanced Metering Approaches

Residential end-use data collection may not need to rely on traditional approaches to collect end-use data due to advancements in metering technology. The Single Point End-use Energy Disaggregation (SPEED) and Non-Intrusive Appliance Load Monitoring (NIALMS) devices permit the collection of a multitude of appliance end-use loads without the wiring nightmares of years gone by. The SPEED/NIALMS monitoring are a unique approach to the identification and collection of end-use loads. These hardware/software systems allow for the collection of appliance-specific load data without entering customer premises, or without installing metering devices on appliances. The analysis software seeks to recognize appliance signatures in the data for example an electric water heater with a 3,500 Watt heating element would look significantly different than a 100 Watt light bulb. However, when appliances have relatively similar electric signatures the ability of the software to distinguish between 3,500 watt water heater element and a 3,500 watt stove burner is somewhat suspect

SPEED/NIALMS hardware can be installed behind existing utility meters. Once installed, data are collected and sent remotely over telephone lines. Data are translated/interpreted by software at a central location and appliance end-use profile estimates are the end product. The SPEED/NIALMS devices are designed to identify the major appliance profiles and the total house load. With these data in hand, an estimate of total house residual loads (lights and plugs) may be developed. These non-intrusive methods hold tremendous promise but, to date, have not been widely used by the industry.

8.2.3 Energy Efficiency Evaluation Approach

In this study, we found a number of projects that deployed direct metering of energy efficiency measures (e.g., phantom loads, chillers, ductless heat pumps). These projects used direct

[30] In this context, the "signal to noise ratio" refers to how well the end-use load is isolated from other household loads.

measurements on reasonably sized samples. The one limitation to the energy efficiency evaluation approach is that the metering usually occurred for relatively short periods of time, i.e., one week to several months, and is focused on the energy efficiency measures in question (these may or may not be end-uses of interest). In addition, end-use metering is often used in conjunction with certain engineering algorithms, where information can be collected to inform the engineering estimates of savings. An example of this would be metering hours of use by space type for compact florescent bulbs. We found a mixture of true power measurement as well as projects that only measure amps and assumed stable voltage and power factors for conversion to watts.

8.2.4 Statistical Approaches

Statistical approaches, in particular conditional demand analysis have been used for years to identify the end-use loads within more aggregate data. Typically, responses from a large market saturation survey (i.e., several thousand respondents) are coupled with billing data. Statistical regression techniques are built to estimate the monthly, seasonal or annual usage of customers with various appliances. A necessary requirement is that the mix of appliance types needs to be diverse among the survey respondents to allow for valid sampling. These regression techniques have been extended and used with hourly data to develop hourly conditional demand estimates.

For most utilities, however, this meant analyzing a few hundred residential customers or a couple of hundred general service customers. In its simplest form, one could develop an average load profile for customers with and without central air conditioning. Next, you could use a simple subtraction algorithm to estimate the air conditioning load of the average customer. Of course, much more sophisticated constructs can be used to simultaneously estimate the hourly load of several appliances or appliance bundles. With these techniques the costs are more reasonable but the signal-to-noise ratio is weaker. Experience to date with the application of conditional demand analysis to short time integration power consumption data is limited but has the potential to provide additional end-use detail over tradition monthly billing data approaches.

8.2.5 Prototype DOE2 Modeling Approach

When reliable end-use load data are not available, an hourly building energy simulation approach may be used to create the loads. Popular computer tools capable of hourly building load simulations include DOE2 and its user-friendly derivative (eQuest), EnergyPlus, TRNSYS, and BLAST. Currently, the most popular of these, and used throughout the world, is DOE2. However the basic DOE2 software is quite old, being based on Fortran 77 and uses a relatively obscure input format of BDL (building design language). Fortunately there are several commercial front-ends to DOE2 that assist in creating the basic models and creating the BDL input files. The US Department of Energy has been working for roughly the last decade on EnergyPlus, the replacement for DOE2. EnergyPlus, in spite of being a much more modern computational engine, lacks the user community of DOE2 and has yet to achieve widespread user acceptance, even though all federally supported development is directed to it instead of any alternative simulation tools.

In the computer modeling approach, the desired hourly end-use loads may be calculated using building-specific information along with available utility energy consumption data such as customer billing data, Cost of Service (COS) data and other available whole premise or end-use load data.

In the absence of specific hourly data, the modeler may utilize hourly end-use data from other sources that are known to be suitably representative of the building or customer segment of interest. The more specific and precise data that are available, the more precise will be the result.

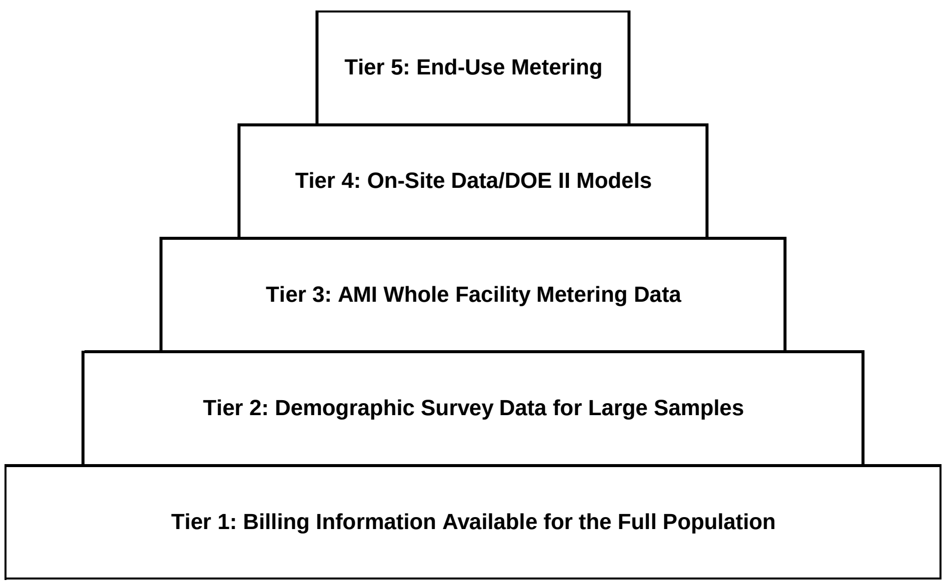
One clear advantage of the DOE2 modeling approach is the ability to quickly and easily change weather data by simply utilizing different weather files. This makes it possible to create the weather-sensitive models and load shapes for specific years (or shorter periods of time) and switch to typical or average weather years. Another advantage, of course, is the freedom to change actual conditions or assumptions at will and observe the effect on the resulting load profiles. Specific hourly end-use “savings” may be calculated this way. Similarly, it is relatively easy to reflect difference in usage profiles through simple changes in input assumptions.

Although this method is capable of generating reliable and precise hourly loads for any single building or complex of buildings, or even homogeneous classes of buildings, it is very detailed and complex, and should be performed only by skilled modelers. Additionally, every model should be tightly calibrated to the available measured energy consumption data (accounting for all fuel types, such as electricity, natural gas, oil, propane, etc), including monthly energy and demand and hourly whole premise and end-use data. It is widely accepted in the energy simulation community that building simulations produce relatively robust estimates of changes in consumption resulting from retrofit measures, while estimates of total building consumption has a relatively high level of uncertainty when compared to actual billing data. Billing data or total whole facility data can be used to help to better calibrate the models, and provide estimates of consumption that are reconciled to total facility load.

8.2.6 Hybrid Approaches

Hybrid approaches that link several of the aforementioned strategies together warrant careful consideration in any future end-use metered data collection effort. We tend to think of these as a pyramid with improvements in the “signal-to-noise” ratio as we move up the pyramid coupled with increased cost and complexity. Figure 19 presents one possible construct. This shows the foundation of the data collection pyramid as being embedded in the billing data that is available at the utility for the full population of customers of interest. In the second tier, the effort collects a large market research/baseline survey is conducted to provide a wide array of demographics that can be tied to the monthly billing determinants. Monthly, seasonal and annual end-use energy is generated by combining Tier 1 and Tier 2 data. Next, in Tier 3 we “turn on” whole facility AMI metering for a large sample of the customers responding to the demographic survey data. Following this tier we have sufficient data to extend the statistical analysis to the hourly level. In the fourth tier, a smaller sample is drawn and on-site audits are performed with the specific goal of constructing a building simulation model for each sample site. End-use estimates can be developed at this stage using engineering techniques. Finally, end-use metering is deployed selectively on a sub sample of the on-site/building simulation modeled homes. All of these strategies can be linked statistically so the highest point of inference is the actual end-use metering data which has the “best” signal to noise ratio.

Figure 19 – Hybrid Approach



Some clients are discussing the possibility of deploying “super samples” across customer classes based on both demographic and billing determinants for broad samples of customers. KEMA has an existing Mid-Atlantic client that is collecting interval data for more than 5000 residential and small power customers and needs only the demographic link to make this a very powerful data source. We have other clients that have near full deployment of AMI throughout their service territories (one located in the Pacific Northwest) that can "turn on" meters and begin collecting data on a moment's notice. At a minimum the Tier 1 through Tier 3 will allow the researcher to segment the residential and commercial classes in much more detail. These profiles can provide the foundation for a much broader end-use data collection focus. See Appendix D for more detailed discussion on leveraging AMI.

8.3 Regionalization

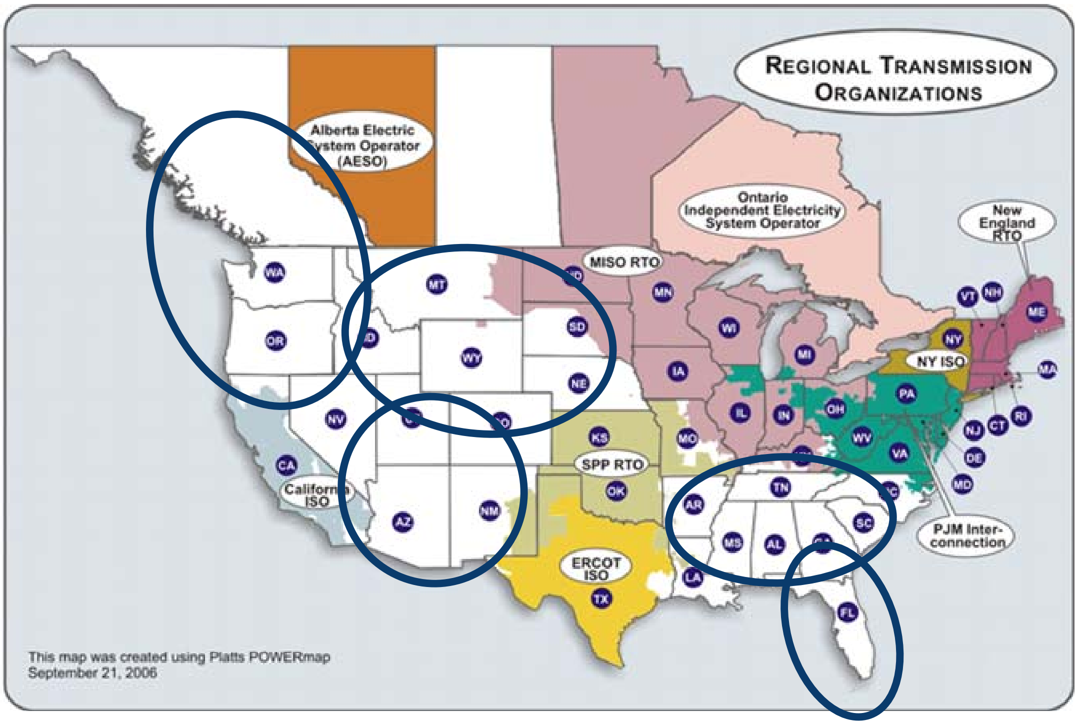
This section explores how a study might be regionalized and whether there are specific segments where information can be collected on a more national stage.

8.3.1 Regional Transmission Areas

As we think about how best to "organize" future end-use metering data collection efforts, we naturally turn to how transferable the information is from one region to another. Transferability may indeed differ by customer class or customer segment. Clearly, different regions may have very different climates and could even have different usage patterns driven by variations in regional expectations and behavior. Climate variation needs to include not simply difference in average dry bulb temperature but must also consider differences in day length and timing and differences in relative humidity (wet bulb temperatures). Differences in regional consumption, behavior and expectations have not been adequately explored to produce reliable transferable mechanisms other than relatively simple calibration or, possibly, re-weighting based on billing information. While building energy estimation computer simulation models have climate differences at their core.

Figure 20 presents a US map with the regional transmission organizations highlighted in color and "other" potential regions highlighted using ellipses. This relatively simple view creates twelve distinct regions and many will argue that a state as large as California could easily be broken into two or more regions or follow the fourteen geographic regions currently used for other purposes.

Figure 20 – Regionalizing the effort



8.3.2 The Role of "Other" Organizations

We fundamentally believe that no single utility will have the fortitude to undertake an extensive end-use metering project. Furthermore, the entities collecting/creating the information need to be willing to make the information readily available. This is likely to require a large coordinated effort including engagement with the National Labs. Furthermore, some of the regional entities are probably well suited to support and foster this effort including the sponsors of this research. At the very least, the Council and NEEP provide important coverage in two very significant regions of the United States.

9. Conclusion and Recommendations

The results of this project have shown that there appear to be some usable end-use datasets available, but that data collection efforts are conducted on an ad hoc basis within and between the Pacific Northwest and Eastern regions. This makes it difficult to assess how transferable the data is for populations not directly represented by the research efforts.

There were significant limitations that were not possible to capture in this study, including limitations on transferability imposed not by inconsistency of methodology and data format, but by heterogeneity of critical determinants of load shape. There was also found to be significant differences in the data priorities among program administrators. Findings and recommendations are provided at a high level from a region-wide perspective. We recognize that specific program administrators may have different priorities for data collection than what was identified.

9.1 Summary of Load Shape Strategies for Pacific Northwest

Table 34 and Table 35 present recommended strategies for load shape improvements for the residential and non-residential sectors of the Pacific Northwest region. The strategies describe the existing data sources that were considered "useful" and where new metering is needed.

Table 34: End-Use and Measure Shape Improvement Strategies (PNW Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5:* Do Nothing)

Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
HVAC - Cooling	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC - Heating	Option 1	Compile results from BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump (IP) and Seattle City Light Space Heat Thermostat Study.
Plug Load (Electronics)	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and consider leveraging LBNL/Ecos CA Residential Plug Load Study and SCE/PG&E Residential End Use Load Research study.
Tier 2 Importance		
Domestic Hot Water	Option 1	Compile results: BC Hydro LMP, BC Hydro Power Smart Residential End-Use Study (IP), and NEEA Ductless Heat Pump Pilot (IP).

Lighting - Exterior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
Appliances - Laundry	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
Appliances - Refrigerators	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
Tier 3 Importance		
HVAC - Fan Energy	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
Pool Pump	Option 1	Leverage BC Hydro Power Smart Res End-Use Study (IP)
HVAC - Other	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC - Ventilation Only	Option 5	The only data identified here is from ELCAP. We recommend that this data continue to be utilized.
Appliances - Kitchen	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.

Table 35: End-Use and Measure Shape Improvement Strategies (PNW Non-Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5:* Do Nothing)

Non-Residential Analysis Groups	Importance Level	Near Term Action	Description
Lighting - Interior	Tier 1	Option 2	Since no studies were found within the region, except for the Puget Sound Energy lighting study, data from outside the region may be utilized, as these end use analysis groups are generally considered transferable ("high"). The Northeast region has good coverage for lighting data and CA DEER provides publicly available data for the other end use groups.
Lighting - Exterior	Tier 1	Option 1/2	
Compressed Air	Tier 2	Option 2	
Appliances - Laundry	Tier 3	Option 2	
Food Service Equipment	Tier 3	Option 2	
Motors - Drives	Tier 1	Option 4	The remainder of the end use analysis groups are recommended for new metering, due to low or medium transferability. The new metering studies may also be used to assess the extent which the ELCAP load shape data may still be usable.
Plug Load (Electronics)	Tier 1	Option 4	
HVAC - Cooling	Tier 1	Option 4	
HVAC - Fan Energy	Tier 1	Option 4	
HVAC - Heating	Tier 1	Option 4	
Refrigeration	Tier 1	Option 4	
Industrial - Process	Tier 2	Option 4	
Water Heating	Tier 2	Option 4	
Pump	Tier 2	Option 4	
Data Center Equipment	Tier 2	Option 4	
Agricultural - Pumping*	Tier 2	Option 4	
Date Center Cooling	Tier 2	Option 4	

HVAC - Other	Tier 2	Option 4	The remainder of the end use analysis groups are recommended for new metering, due to low or medium transferability. The new metering studies may also be used to assess the extent which the ELCAP load shape data may still be usable.
HVAC - Ventilation (Only)	Tier 2	Option 4	
HVAC - Reheat	Tier 2	Option 4	
Agricultural - Process	Tier 3	Option 4	
Clean Room	Tier 3	Option 4	

Table 36a: Summary of Load Shape Strategies for the East

Residential Analysis Groups	Near Term Action	Description
	Tier 1 Importance	
Lighting - Interior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
HVAC - Cooling	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC - Heating	Option 1	Compile results from BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump (IP) and Seattle City Light Space Heat Thermostat Study.
Plug Load (Electronics)	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and consider leveraging LBNL/Ecos CA Residential Plug Load Study and SCE/PG&E Residential End Use Load Research study.
	Tier 2 Importance	
Domestic Hot Water	Option 1	Compile results: BC Hydro LMP, BC Hydro Power Smart Residential End-Use Study (IP), and NEEA Ductless Heat Pump Pilot (IP).
Lighting - Exterior	Option 1/2	Compile results from BC Hydro Power Smart Residential End-Use Study (IP) and NEEA Energy Star Homes Evaluation (IP). Potentially utilize these studies to assess the transferability of lighting use profile data from other regions (e.g. DEER). Also utilize these studies to assess whether ELCAP data can still be used.
Appliances - Laundry	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
Appliances - Refrigerators	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.
	Tier 3 Importance	
HVAC - Fan Energy	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
Pool Pump	Option 1	Leverage BC Hydro Power Smart Res End-Use Study (IP)
HVAC - Other	Option 1/4	Although some limited regional data appears to be in progress, BC Hydro Power Smart (IP) and NEEA Ductless Heat Pump Study (IP), new metering is probably recommended here due to low transferability. These studies can also be utilized to assess whether ELCAP load shapes are still valid.
HVAC - Ventilation Only	Option 5	The only data identified here is from ELCAP. We recommend that this data continue to be utilized.
Appliances - Kitchen	Option 1/2	Utilize BC Hydro Power Smart Res End-Use Study (IP) to verify whether data from other regions (e.g. DEER) can be utilized.

Table 35, Table 36b and Table 37 present recommended strategies for load shape improvements for the residential and non-residential sectors of the Eastern region. Again, the strategies describe the existing data sources that were considered "useful" and where new metering is needed.

Table 36b: End-Use and Measure Shape Improvement Strategies (East Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5:* Do Nothing)

Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1	There have been a number of high quality lighting studies completed in the Eastern Region. In particular, the region is recommended to utilize the SPWG Lighting Coincidence Factor Study.
HVAC - Cooling	Option 1/4	Compile results from the UI and CL&P 2005 Coincidence Factor Study (B) and the NGrid Residential Room AC Impact Study (B), and NSTAR/NGrid/UI/CL&P CAC Regional Evaluation (B) and conduct new metering.
HVAC - Heating	Option 1/4	Compile results from MACT Ductless heat pump study and conduct new metering.
Plug Load (Electronics)	Option 2/4	Utilize LBNL/Ecos CA Residential Plug Load Study and SCE/PG&E Residential End Use Load Research study. Otherwise, conduct new metering.
Tier 2 Importance		
Domestic Hot Water	Option 1/2	Utilize data from the UI Water Heater Controller Study, NYLE Heat Pump Water Heater Evaluation Study and leverage data from other regions such as the Mid-Atlantic (e.g. BGE Residential Water Heater Evaluation studies).
Lighting - Exterior	Option 1/2	Compile data from the SPWG Lighting Coincidence Factor and NU/CL&P CFL Markdown Impact study, and consider bringing in data from other regions (e.g. DEER) since the end use analysis group has a "high" transferability rating.
Appliances - Laundry	Option 2/4	Consider leveraging publicly data from other regions, such as DEER, or conduct new metering studies.
Appliances - Refrigerators	Option 1/2	Compile data from the Efficiency Maine Low Income Appliance Impact Study and consider leveraging data from other regions, such as DEER, or BC Hydro Power Smart Res End Use Study (IP).
Tier 3 Importance		
HVAC - Fan Energy	Option 4	Since no data was found, and end use group transferability is low, new metering is recommended.
Pool Pump	Option 5	Leverage BC Hydro Power Smart Res End-Use Study (IP) should it become available.
HVAC - Other	Option 3/4	Since no data was found, DOE modeling or new metering is recommended.
HVAC-Ventilation Only	Option 4/5	Since no studies were found, new metering is recommended, or no action, as the measure is considered low importance.
Appliances - Kitchen	Option 2/4	Due to high transferability, first consider leveraging data from other regions, such as simply utilizing DEER load shapes, or conduct new metering studies.

Table 37: End-Use and Measure Shape Improvement Strategies (East Non-Residential)

(*Option 1*: Regional Meta-study, *Option 2*: Trans-Regional Meta-study, *Option 3*: DOE2/Modeling, *Option 4*: New Metering, *Option 5:* Do Nothing)

Non-Residential Analysis Groups	Near Term Action	Description
Tier 1 Importance		
Lighting - Interior	Option 1/2	There have been a number of high quality lighting studies completed in the

		Eastern Region. In particular, the region is recommended to utilize the SPWG Lighting Coincidence Factor Study.
HVAC - Cooling	Option 1/4	Compile results of UI/CL&P 2005 Coincidence Factor Study, NGrid Small C&I Unitary HVAC Pilot Impact Study, NSTAR BSCS Non-Lighting M&V Impact Study and NSTAR CS Impact Study and conduct new metering.
Lighting - Exterior	Option 1/2/4	Compile results of UI/CL&P 2005 Lighting Coincidence Factor Study, NSTAR BSCS Impact Study and NSTAR CS Custom Impact Study and perhaps conduct some new metering.
HVAC - Fan Energy	Option 1/4	Compile UI/CL&P 2005 Coincidence Factor Study and conduct new metering
Plug Load (Electronics)	Option 4	No studies were found related to non-residential plug load. New metering is recommended.
HVAC - Heating	Option 1/4	Compile UI/CL&P 2005 Coincidence Factor Study and conduct new metering
Motors - Drives	Option 1/2/4	Compile data from UI/CL&P 2005 Coincidence Factor Study, CL&P Municipal Impact Study, NSTAR BSCS Non-Lighting M&V Impact Study, NSTAR C&I Retrofit Impact Study and conduct new metering.
Refrigeration	Option 1/4	Compile results from a number of studies that are available, including NSTAR BSCS Impact Studies, NSTAR SBS Impact Study, NSTAR CS Impact Study, NSTAR C&I Impact Study and NGrid SBS Customer Impact.
Tier 2 Importance		
Industrial - Process	Option 1/2/4	Compile data from NSTAR BSCS Non-Lighting Impact Study, NSTAR BSCS Impact Study, NSTAR C&I Retrofit Study and NSTAR C&I New Construction Retrofit Study.
Data Center Cooling	Option 4	No studies were found related to data center cooling. New metering is recommended.
HVAC - Other	Option 1/4	Compile results of NSTAR BSCS Non-Lighting M&V Impact Study, NSTAR C&I Retrofit Impact Study, and NGrid Custom HVAC Impact Study, and conduct new metering.
HVAC-Ventilation (Only)	Option 4	Since no studies were found, DOE modeling or new metering is recommended.
HVAC-Reheat	Option 4	Since no studies were found, DOE modeling or new metering is recommended.
Water Heating	Option 3/4	Since no non-residential water heating studies were found, DOE modeling or new metering is recommended.
Pump	Option 3/4	No studies found. DOE modeling or new metering recommended.
Compressed Air	Option 1/2/4	Compile results of NSTAR studies: BSCS Non-Lighting M&V Impact Study, CS Impact Study, C&I Retrofit Study, C&I New Construction Retrofit Impact Study, and conduct new metering.
Data Center Equipment	Option 4	No studies found. New metering recommended.
Tier 3 Importance		
Agricultural - Pumping	Option 5	Due to minimal contributions to efficiency program savings, no action is recommended at this time.
Appliances - Laundry	Option 5	
Food Service Equipment	Option 5	
Agricultural - Process	Option 5	
Clean Room	Option 5	

9.2 Recommendations

The following recommendations are provided to assist the Regions with developing a coherent method of warehousing, distributing and updating end-use and efficiency measure load data for the Regions, to eventually have a full array of data for all end-uses and efficiency measures.

9.2.1 Near-term (Up to 12 Months)

Near-term recommendations are provided to focus on immediate tasks to meet the urgent needs of the capacity markets and the initial steps necessary to support a large coordinated effort by the Regions to collect end-use data that would be broadly usable and transferable.

9.2.1.1 Coordinate with metering studies currently in progress

This project identified several studies that are currently underway that could be leveraged to collect useful information for the Regions. The Pacific Northwest is strongly encouraged to contact BC Hydro, since the availability of end use and measure data points for this region is quite sparse without this study. There is an opportunity to engage the entities conducting the studies to ensure adequate sample size and ancillary data collection, and potentially provide additional funding to minimize the costs of new metering efforts for the Pacific Northwest and/or Eastern Regions.

The following studies are in the planning stages:

- The BC Hydro Power Smart Residential End Use Metering Study is currently planned with large sample sizes of around 300 for most of the residential end-use analysis groups.
- New York City has launched a pilot end-use metering project in governmental facilities. The pilot will encompass secondary schools and New York City facilities. The project will use EnergyICT equipment to isolate selected end-use loads to better inform facility managers on on-going facility performance.
- Northeast Utilities and United Illuminating in Connecticut are preparing to conduct a new energy evaluation study to monitor 55 commercial and industrial sites, with 35 lighting sites and 20 non-lighting sites over the 2009 summer season.
- Northeast Utilities and United Illuminating in Connecticut are also planning to conduct a residential evaluation to meter lighting, as well as construct DOE2 models for weatherization and insulation measures.

9.2.1.2 Recommendations for new metering studies

As outlined in Chapter 7 of this report, fielding new metering studies and data collection efforts are recommended for some end-use analysis groups (designated as Option 4). Residential and non-residential plug loads appear to be the only significant opportunity for the Regions to coordinate new metering studies, as the other end use analysis groups appear to have low or medium transferability.

For the residential sector, the major data collection efforts recommended at this time is related to plug loads (consumer electronics) and HVAC analysis groups for both regions, due to lack of regional studies and low transferability related to the HVAC analysis groups.

For the non-residential sector, HVAC analysis groups, data center cooling and refrigeration end use analysis groups generally could use new metered data for both regions. The Eastern region has significantly better coverage on the non-residential sector, and some data from completed studies could be combined into a regional meta-study.

It is important to note that planning these studies takes significant lead time. In order to have monitoring equipment in the field in time for summer peak monitoring, entities need to start planning no later than December of the previous year. Ideally, in order to pilot test all the protocols, procedures and specifications, the effort should be initiated a full year in advance of when full scale implementation is planned.

9.2.1.3 Pilot the transfer of end use data from one region to another

To assess the feasibility of transferring data from one region to another, KEMA recommends piloting one specific end use, preferably one with a high transferability rating (e.g. non-residential lighting). Analysis groups that have a high transferability rating should be the easiest to combine, however it is advisable to perform a statistical comparison of the datasets from each region to make sure that no significant bias is being introduced into the results. If there are no data from within the region than there really is no way to perform this bias analysis and justifying the transferability of the data becomes more problematic, particular with respect to capacity market M&V requirements.

9.2.1.4 Develop detailed protocols for end-use data collection

If entities between (and within) the regions envision coordinating future efforts to develop load shapes, then region-wide (or even national) protocols are needed to establish consistent methods and procedures for handling the data for end-use and measure savings shapes that are transferable between regions. These protocols would also enable data from smaller studies (e.g. conducted for individual program evaluations) to be combined into larger regional meta-studies.

These efforts should be coordinated with other initiatives, such as the NEEP EM&V Forum efforts to develop and/or identify common protocols for calculating efficiency savings across the region. The previous ELCAP protocols may also be a good starting point to develop the detail needed.

While several data collection protocols have been established for energy efficiency monitoring, these are typically general in nature, and do not provide the necessary specificity to ensure that data collected would be transferable between geographic areas or different customer populations. Therefore, the components of a regional data collection protocol should include developing consistent definitions for end-use categorizations and efficiency measure types, precise instrumentation instructions, robust data verification procedures, and specific protocols for collecting the necessary ancillary data including building and occupant characteristics data.

This protocol for developing load shapes should specify which end-use metering protocols are generally appropriate to ensure that consistent information is captured from the various tiers of the end-use information pyramid. This effort should build on existing protocols and should seek to establish minimum standards for use in future projects.

As part of this process, stakeholders should concurrently discuss what a centralized data warehouse for the end-use datasets might look like, and ensure that the data collection protocols include guidance for the standardization of data format and storage. The Regions should work on completing an end-use metering project architecture that specifically addresses and develops consensus on the customer groups to be studied, the end-uses to target, and the methodological strategy (or strategies) to employ. This would include more in-depth discussion and consideration on how best to regionalize and test the transferability of the resulting information, as well as defining the characteristics of the data repository and interface tool.

9.2.2 Mid-Term (1-3 years)

Some recommendations are provided, looking ahead to several years from now. These needs are less urgent, but support future coordinated regional end-use data efforts.

9.2.2.1 Implement multi-region end-use data repository

The end goal of the project is to develop a central warehouse for storing the end-use load datasets and providing consistency in data format and definitions to allow the load shape data to be widely usable. Advances in computational abilities could allow this warehouse to be virtual if robust yet flexible data storage specifications are developed. Storage could be dispersed with access over the web. This approach would naturally have additional risk of losing data but could be a viable option to explore if resources to support a central repository are inadequate. A key aspect of whatever data warehouse or repository is eventually implemented is the need for an easy to use interface tool that would allow sorting, adding, and accessing data. This tool would also need key connections to the variables used in the regionalization process and the ability to generate profiles and conduct simple analyses.

9.2.2.2 Plan for other study types (non-metering studies)

As regions begin collecting data and looking to transfer usable datasets from one area to another, it may become clear that additional region-specific ancillary data is needed to improve the accuracy of the transfer. Examples of customer population specific data needed may include typical building characteristics, inventory of system types and efficiencies, air and water system temperatures and saturation of different equipment types, to name a few. A preliminary study should be conducted to assess where the data gaps are for transferring data between utility territories, geographic regions and the two Regions.

9.2.2.3 Assess feasibility of disaggregating end use information from AMI whole premise data

Electronic metering with the ability to collect high resolution whole building data is currently being rolled out by several utilities across the country. This new dataset has the potential to supplement historic end use metering data. Experience to date with the application of conditional demand analysis to short time integration power consumption data is limited, but has the potential to provide additional end-use detail over traditional monthly billing data approaches.

Consider launching regional initiatives (one in the Pacific Northwest and one in the Northeast or Mid-Atlantic) to test the ability to leverage end-use information from whole premise interval load data coupled with demographic data using statistical techniques. To support the vision for a hybrid approach to developing end-use load shape datasets in the future, this would be the first step to test the ability to leverage end-use information from whole premise interval load data coupled with demographic data using statistical techniques.

Concurrent to this, the Regions may consider surveying their utility stakeholders to identify opportunities to collect large amounts of whole facility load information through AMI. While utilities have been metering hourly load data for many years for other purposes, these new approaches to developing end-use load and savings data could be substantially less expensive than previous end use data efforts, such as ELCAP. The survey should be divided by customer class and should identify the frequency and potential cost of data capture. In addition, this initial feasibility assessment should measure the willingness of the regional utilities to engage in such as an exploratory study to leverage their AMI data.

Consider seeking funding for use in launching a regional initiative in the Pacific Northwest and Northeast sponsored by the Council and NEEP. The projects would be proof of concept with the capacity to expand to a full national initiative.

9.3 Long-Term (>3 years)

9.3.1.1 Continue to maintain and update the catalog of end use data

The catalog of end-use and measure load data studies has the potential to be extremely useful to continued efforts to develop regionally applicable load shapes for the range of uses encompassing energy efficiency planning, capacity markets, and air quality. As energy efficiency become an increasingly important part of utility portfolios to meet load growth, more and more entities are seeking the data to validate cost, demand and air emissions savings. Maintaining the central repository and catalog is an important long term goal for this project.

10. Appendix A: Web Survey Instrument

NWPCC/NEEP End-Use Load Dataset Catalog Project

Introduction to the End-Use Load Dataset Catalog Project

This is a joint project by the Northwest Power and Conservation Council (NPCC) and the Northeast Energy Efficiency Partnerships (NEEP) Evaluation Measurement and Verification Forum (NEEP EMV Forum) to develop a detailed catalog that identifies and characterizes measured interval load data for efficiency measures and/or end-uses.

In this survey, we ask you to identify available efficiency measure and/or end-use load studies that you have worked on. We are looking for metered or measured interval load data. We also seek to understand the basic characteristics of the measure and end-use load data that may be available from your organization. At the conclusion of the survey, we also ask you to help us prioritize items for future research.

The primary use of this catalog will be to support the work of regional analysts working for the Council and other entities that implement energy efficiency and/or provide energy planning. The results may also be used to assist in developing and supporting demand reduction bids into the New England Forward Capacity Market.

The results of this project, the End-Use Load Dataset Catalog, will be made publicly available. Please complete your response by Friday, March 13th, 2009.

Thank you in advance for your participation.

A. STUDY OVERVIEW PAGE

The following questions pertain to a single study. Please enter the name of a recent study sponsored or conducted by your organization.

Although the following questions will focus on one study, you will have the opportunity to input as many studies as you want. (At the conclusion of this survey, you will be re-directed to this page. If you have a lot of studies, and would prefer to complete the survey over the phone, please click here.)

1. Please enter the name of relevant study: ______________________________

2. Utility or Agency sponsoring the study: _______________________

3. Approximate beginning date of the study: ______________________

4. Approximate end date of the study: _______________

5. What customer sector(s) did the study focus on? [Select one]
   a. Residential [Go to 6]
   b. Non-residential [Go to 7.]
   c. Both [Go to 6.]

6. Please further identify which residential segment(s). [Allow multiples]
   a. Single-family
   b. Multi-family
   c. Mobile home/Manufactured Housing
   d. Low income
   e. Other (Specify: _______________)

[IF 5=a. Residential, GO TO B1.]

[IF 5=c. Both, GO TO 7.]

7. Please further identify which non-residential sector(s). [Allow multiples]
   a. Agriculture
   b. Commercial
   c. Industrial
   d. Government
   e. Military
   f. Other (Specify: _______________)

[IF 5=b. Non-residential, GO TO C1.]

[IF 5=c. Both, GO TO B1.]

B. END USES – MEASURES (RES)

B1. Which of the following residential end-uses were included in this study?

	Sample Size
Appliances - Kitchen	

Appliances - Laundry	
Appliances - Refrigerators	
HVAC - Cooling	
HVAC - Fan Energy	
HVAC - Heating	
HVAC-Ventilation Only	
HVAC - Other	
Lighting - Interior	
Lighting - Exterior	
Plug Load	
Pool Pump	
Domestic Hot Water	
Whole Building	

Other (Specify: _______________)

[IF 5=a. Residential. GO TO D1.]
[IF 5=c. Both, GO TO C1.]

C. END USES – MEASURES (NON-RES)

C1. Which of the following non-residential end-uses were included in this study?

	Sample Size
Agricultural - Process	
Agricultural - Pumping	
Appliances - Laundry	
Clean room	
Compressed air	
Data center equipment	
Date center cooling	
Food Service Equipment	
HVAC - Cooling	
HVAC - Fan Energy	
HVAC - Heating	
HVAC - Other	
HVAC - Ventilation Only	

HVAC - Reheat	
Industrial - Process	
Lighting - Exterior	
Lighting - Interior	
Motors - Drives	
Plug load	
Pump	
Refrigeration	
Water heating	
Whole Building	

Other (Specify: _______________)

D1. STUDY DETAILS

In this section, please provide some additional information about the study or dataset collected. If you do not know the answer, then please be sure to identify someone who can and enter their contact information at the bottom of this page.

11. How was the measure or end-use load data collected? [Select one]
    a. Metered
    b. Modeled/simulated
    c. Both
    d. Don't know

12. What was the duration of measurement or simulation?
    a. Multi-year study
    b. 1 year of study
    c. Less than 1 year of study
    d. Less than 6 months of study
    e. Less than 2 months of study
    f. Don't know

13. Were any of the following end-use or measure information collected as part of this project? (Check all that apply)

	YES	NO	Don't Know
a. End-use or measure description			
b. Equipment vintage			
c. Equipment nameplate information			
d. Equipment hours of usage or operation			
e. Units of production			

14. Were any of the following end-use or measure information collected as part of this project? (Check all that apply)

	YES	NO	Don't Know
a. Facility description			
b. Facility square footage			
c. Facility hours of operation			
d. SIC or NAICS code			
e. Number of employees			
f. Climate characteristics			
g. Location			
h. Other customer characteristics (Specify: ________________)			

[NEXT PAGE]

15. What was the data collection equipment?
    a. Commercial true power data logger
    b. Other commercial data logger
    c. Custom data logger
    d. Other (Specify: ______________)
    e. Don't know

16. What is the time granularity of the data?
    a. Less than 5 minutes
    b. 5 minutes
    c. 15 minutes
    d. 30 minutes
    e. 60 minutes
    f. On/off
    g. Other (Specify: ____________)
    h. Don't know

17. Were data collection and validation protocols utilized?
    a. Yes
    b. No
    c. Don't know

18. What is the data storage medium or format?
    a. SAS dataset
    b. Excel data files
    c. SQL server files
    d. MS Access data files
    e. Flat text file
    f. Hard-copy
    g. Other (Specify: ___________________)
    h. Don't know

19. On a scale of 1 to 5, how accessible is the data collected in this study for you to obtain?
   a. 1. Readily accessible
   b. 2
   c. 3
   d. 4
   e. 5. Completely inaccessible [GO TO 81]

20. Is there anyone else who can better provide the above information and details about this study? (We hope to follow up with this contact, and would greatly appreciate it if you would notify this person on our behalf.)

   Name:
   Title:
   Organization:
   Email:
   Phone:

[NEXT PAGE]

79. Would your organization be willing to share this data?
   a. Yes, could likely provide at no cost [GO TO 81]
   b. Yes, could provide for a fee
   c. No [GO TO 81]
   d. No, because the data belongs to someone else
      a. Name
      b. Organization
      c. Phone number
      d. Email

80. What is the estimated cost to provide this dataset? ______________________

80a. How long might it take to assemble and transfer the data?
   a. More than 1 year
   b. Approximately 1 year
   c. Maybe 6 months
   d. Less than 3 months

[NEXT PAGE]

81. Did the results of this study develop load shapes?

a. Yes
b. No [GO TO 83]

82. If yes, then do the load shapes describe the usage (end-use consumption) or the measure impact (change in consumption)? Check one for each measure listed
[Only show list of measures that were selected by respondent in B1 and C1]

LIST OF END-USES	End-Use Consumption	Change in Consumption	Both
Xx			
Yy			

[NEXT PAGE]

83. Please provide any comments that may help understand the nature and applicability of this dataset.

D17. Are you aware of any other efficiency measure or end-use load studies at your organization?

a. Yes, return to beginning of survey [GO TO G]
b. Yes, but please call me for further details [GO TO Section E]
c. No [GO TO Section E]

E. IMPORTANCE OF OBTAINING LOAD SHAPES

As part of this catalog project, we would like to identify gaps in existing load research studies. Please indicate below which end-use categories you think new load research studies should focus on.

85. On a scale of 1 to 5, please rank the need for interval load profile information on the following residential end-uses:

	Not at All Important		Critically Important

End-Use Analysis Groups	1	2	3	4	5
Appliances - Kitchen	O	O	O	O	O
Appliances - Laundry	O	O	O	O	O
Appliances - Refrigerators	O	O	O	O	O
HVAC - Cooling	O	O	O	O	O
HVAC - Fan Energy	O	O	O	O	O
HVAC - Heating	O	O	O	O	O
HVAC-Ventilation Only	O	O	O	O	O
HVAC - Other	O	O	O	O	O
Lighting - Interior	O	O	O	O	O
Lighting - Exterior	O	O	O	O	O
Plug Load	O	O	O	O	O
Pool Pump	O	O	O	O	O
Domestic Hot Water	O	O	O	O	O
Whole Building	O	O	O	O	O
Whole Building by Space Conditioning Types	O	O	O	O	O
Whole Building by Dwelling Types	O	O	O	O	O
Whole Building by Primary Heating Types	O	O	O	O	O
Other (Specify: _______________)	O	O	O	O	O

86. On a scale of 1 to 5, please rank the need for hourly load profile information on the following non-residential end-uses:

	Not at All Important				Critically Important
End-Use Analysis Groups	1	2	3	4	5
Agricultural - Process	O	O	O	O	O
Agricultural - Pumping	O	O	O	O	O
Appliances - Laundry	O	O	O	O	O
Clean room	O	O	O	O	O
Compressed air	O	O	O	O	O
Data center equipment	O	O	O	O	O
Date center cooling	O	O	O	O	O

Food Service Equipment	O	O	O	O	O
HVAC - Cooling	O	O	O	O	O
HVAC - Fan Energy	O	O	O	O	O
HVAC - Heating	O	O	O	O	O
HVAC - Other	O	O	O	O	O
HVAC-Ventilation Only)	O	O	O	O	O
HVAC-Reheat	O	O	O	O	O
Industrial - Process	O	O	O	O	O
Lighting - Exterior	O	O	O	O	O
Lighting - Interior	O	O	O	O	O
Motors - Drives	O	O	O	O	O
Plug load	O	O	O	O	O
Pump	O	O	O	O	O
Refrigeration	O	O	O	O	O
Water heating	O	O	O	O	O
Whole Building	O	O	O	O	O
Whole Building by Business Types (or NAICS/SIC Codes)	O	O	O	O	O
Other (Specify: _______________)	O	O	O	O	O

F. OTHER INDUSTRY CONTACTS

We are also looking for studies conducted by other organizations.

Please enter the name of others who could contribute to our research efforts.

ADDITIONAL DATASET HOLDER 1

Name:

Title:

Organization:

Email:

Phone:

Name(s) of studie(s):

ADDITIONAL DATASET HOLDER 2

Name:

Title:

Organization:
Email:
Phone:
Name(s) of studie(s):

[Leave “Back” “Next” “Cancel” options]

G. SUBMIT SURVEY ANSWERS

Click here to submit the details related to the previous dataset/study you have entered. [CHANGE “DONE” button to “SUBMIT ANSWERS”]

On the next page, you will be able to follow a link to enter more datasets/studies.

F. SURVEY SUCCESSFULLY SUBMITTED

Thank you for participating in this survey.

Please click HERE to enter information related to another end-use load or measure based study at your organization.

11. Appendix B: List of Stakeholders Interviewed

11.1 Energy Efficiency and Program Planners

First	Last	Company
Colleen	Orsburn	VEIC
Gail	Azulay	NSTAR
Grace Ann	Mallett	National Grid
Jeff	Harris	NEEA
Jeremy	Newberger	National Grid
Jill	Steiner	Snohomish County PUD
Jon	Powell	Avista corp
Kim	Oswald	Consultant on Evaluation (CT)
Kimberly	Crossman	National Grid
Lauren	Gage	Bonneville Power Administration
Paul	Gray	United Illuminating
Ralph	Prahl	Consultant on Evaluation (MA)

11.2 Capacity Market Stakeholders

First	Last	Organization
Amanda	Whitehead	PJM
Murty	Bhavaraju	PJM
Serhan	Ogur	PJM
Arthur	Maniaci	NY ISO
Cheryl	Hindes	Baltimore Gas & Electric
Jim	Kirby	PJM
Mary	Straub	Baltimore Gas & Electric
Steve	Carlson	KEMA Inc

11.3 Air Quality Regulators and Consultants

First	Last	Organization
Chris	Salmi	New Jersey Air Quality
Jeff	King	Washington Dc, Air Quality
Chris	James	Synapse
Colin	High	RSG Inc.
Jason	Rudokas	NESCAUM
Rick	Rodrigue	CT Air Quality

12. Appendix C. Developing Importance Levels for End-use Analysis Groups

In developing the relative importance levels for the end-use analysis groups, we utilized energy efficiency savings numbers from the aggregated California 2006-2008 program portfolio of measures, Connecticut Potential Study and web survey responses. The results are shown below, with the furthest column on the right summarizing the importance level.

12.1 Residential End-use Analysis Groups

		CA numbers		CT Numbers		Web survey			
Residential Analysis Groups	High peak?	Estimated kWh savings, as portion of total portfolio savings	Importance Level	Estimated kWh savings, as portion of DSM potential	Importance Level	Average Rating	Frequency of 5	Importance Level	Importance Level
Appliances - Kitchen		0%	Small	0.7%	Small	2.2	1	Small	Tier 3
Appliances - Laundry		0%	Small	4.5%	Medium	2.6	2	Medium	Tier 2
Appliances - Refrigerators		12%	Large	7.5%	Large	2.3	2	Medium	Tier 2
Domestic Hot Water		0%	Small	18.5%	Very large	3.1	2	Medium	Tier 2
HVAC - Cooling	Y	2%	Medium	8.8%	Large	3.8	4	Large	Tier 1
HVAC - Fan Energy	Y	1%	Small	3.8%	Medium	2.9	1	Small	Tier 3
HVAC - Heating		0%	Small	2.4%	Medium	3.7	5	Large	Tier 1
HVAC - Other	Y	3%	Medium	29.6%	Large	2.4	1	Small	Tier 3
HVAC-Ventilation Only	Y	1%	Small	0.4%	Small	2.5	1	Small	Tier 3
Lighting - Exterior		10%	Large	0.0%	Small	3.0	2	Medium	Tier 2
Lighting - Interior		64%	Very large	8.1%	Large	3.6	6	Very Large	Tier 1
Plug Load		0%	Small	15.3%	Very large	3.5	5	Large	Tier 1
Pool Pump		3%	Medium	0.4%	Small	2.6	1	Small	Tier 3

KEY for CA and CT	
>10%	very large
5-10%	large
2-5%	medium
<2%	small

KEY for WEB SURVEY	
0-1	Small
2-3	Medium
4	Large
5-6	Very large

Based on Frequency of 5 = Critically Important
(1 = Not at all important)

12.2 Non-residential End-use Analysis Groups

Non-Residential Analysis Groups	High peak?	CA numbers: Estimated kWh savings, as portion of total portfolio savings	CA numbers: Importance Level	CT numbers: Estimated kWh savings, as portion of DSM potential	CT numbers: Importance Level	Web survey: Average Rating	Web survey: Frequency of 5	Web survey: Importance Level	Importance Level
Agricultural - Process						2.2	0	Small	Tier 3
Agricultural - Pumping*						2.6	2	Medium	Tier 2
Appliances - Laundry		0%	Small			2.3	0	Small	Tier 3
Clean room				0.2%	Small	1.9	0	Small	Tier 3
Compressed air				3.8%	Medium	2.7	1	Small	Tier 2
Data center equipment				0.4%	Small	3.0	1	Small	Tier 2
Date center cooling				0.4%	Small	3.3	2	Medium	Tier 2
Food Service Equipment		0%	Small	0.0%	Small	2.9	1	Small	Tier 3
HVAC - Cooling	Y	7%	Large	15.7%	Very large	3.9	5	Very large	Tier 1
HVAC - Fan Energy	Y	1%	Small	6.7%	Large	3.4	4	Large	Tier 1
HVAC - Heating		0%	Small	0.6%	Small	3.7	3	Large	Tier 1
HVAC - Other	Y	1%	Small	11.0%	Very large	3.1	2	Medium	Tier 2
HVAC-Reheat	Y	0%	Small	2.0%		3.1	2	Medium	Tier 2
HVAC-Ventilation (Only	Y	1%	Small		Medium	3.1	2	Medium	Tier 2
Industrial - Process		7%	Large	3.7%	Medium	3.2	3	Medium	Tier 2
Lighting - Exterior		1%	Small	2.4%	Medium	3.5	5	Very large	Tier 1
Lighting - Interior		41%	Very large	27.1%	Very large	3.8	5	Very large	Tier 1
Motors - Drives		3%	Medium	5.3%	Large	3.3	3	Medium	Tier 1
Plug load				2.8%	Medium	3.4	4	Large	Tier 1
Pump				6.1%	Large	3.0	2	Medium	Tier 2
Refrigeration		7%	Large	10.7%	Very large	3.2	3	Medium	Tier 1
Water heating		0%	Small	0.7%	Small	3.1	2	Medium	Tier 2

KEY for CA and CT	
>10%	very large
5-10%	large
2-5%	medium
<2%	small

KEY for WEB SURVEY	
0-1	Small
2-3	Medium
4	Large
5-6	Very large

Based on Frequency of 5 = Critically Important (1 = Not at all important)

HVAC - Heating rating tweaked based on average rating f

* Denotes that Agricultural – Pumping is a Tier 2 importance level for the Pacific Northwest (and a Tier 3 importance level for the East)

13. Appendix D. The Advent of AMI

This section discusses the opportunities presented by improvements in advanced metering infrastructures (AMI).

13.1 How AMI Can Change the Landscape

Historically, end-use load research data collection projects have been costly and time consuming. Customers with the desired end-use applications were recruited. The circuits in their home associated with the desired end-use applications were identified and isolated so that monitoring devices could be installed.

This approach has been fraught with potential complications and error. Customers had to the refrain from connecting additional devices to the metered circuit(s) for the duration of the study. The possible presence of external loads brought into question the validity of data collected from these end-use projects. In addition to projects that monitored end-use applications on isolated circuits, kWh sub meters have also been installed, in series with the plug of the desired end-use application(s), for the purpose of obtaining daily/weekly/monthly usage information. Unfortunately, these meters only provided kWh usage information and did not aid in the in identification of the load profile of the end-use application.

The introduction of Advanced Metering Infrastructure (AMI) dramatically changes how end-use load research can be conducted. AMI refers to systems that measure, collect, and analyze energy usage from devices, such as electricity meters, through various communication media, on request or on a pre-defined schedule. The AMI includes: hardware, software, communication equipment, customer associated systems, and meter data management (MDM) software capable of gathering metering data from multiple sources (e.g. usage of the end-use application(s), total dwelling usage, gas consumption, water consumption, etc.) in time-differentiated registers.

AMI allows the load research cycle to be vastly improved to reduce the lead time and cost associated with installing and collecting data at the whole facility level. Coupling 15-minute or hourly AMI data with demographic information holds the promise of vastly increased and targeted samples. It is possible that application of data streams at even shorter time integration, such as one minute data could reveal additional end-use dependency. Some claim that we will someday have interval information on virtually all of our customers. While that day may be coming, we believe that statistical sampling strategies can be deployed in the near-term to substantially improve the available information content.

Some clients are discussing the possibility of deploying “super samples” across customer classes based on both demographic and billing determinants for broad samples of customers. KEMA has an existing Mid-Atlantic client that is collecting interval data for more than 5000 residential and small power customers and needs only the demographic link to make this a very powerful data source. We have other clients that have near full deployment of AMI throughout their service territories (one located in the Pacific Northwest) that can “turn on” meters and begin collecting data on a moment’s notice. At a minimum the Tier 1 through Tier 3 will allow the researcher to segment the residential and commercial classes in much more detail. These profiles can provide the foundation for a much broader end-use data collection focus.

In addition, the two-way communication capability of AMI raises the bar with regard to traditional, automatic meter reading (AMR) in that AMI holds the promise of two-way communication with end-use applications. Two-way communication is expected to lead to the introduction of utility programs that allow the utility operational control of the end-use application, as well as the data gathering capability discussed above. Direct end-use operational load control has become part of the least cost dispatching decisions made by the Independent System Operator (ISO) charged with providing system power to the utility. Although the primary benefits and motivation for AMI are to provide utilities the functionality to improve power quality, identification of power disruptions, and other electric service issues, the existence of AMI’s two-way communication will also enable utilities to monitor and collect end-use load data with virtually no impact on the customer.

13.2 AMI Deployment

We believe an important next step is to identify utilities that have or plan to have an AMI capability that includes the collection of large quantities of whole facility data currently and during the next three to five years. This information would be invaluable in helping to scope a more robust end-use data collection effort.