Data Collection Protocols

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1. Background and Purpose

Across the country, energy and energy efficiency investments are made based- in-part- on estimates of consumption for end-uses such as lighting, appliances, or HVAC equipment. In the past, annual or seasonal energy end-use estimates were sufficient for making these investment decisions. However, these annual and seasonal load shapes are becoming less useful because they lack the granularity to make investment decisions in today's market. Today, hourly profiles are required to calculate:

1. Dollar savings of energy conservation based on time-variable avoided costs
   a. Typically the avoided costs are used in energy efficiency cost-effectiveness tests
   b. More and more the customer's electric rates are also time variable

2. Capacity savings
   a. In today's energy market, capacity savings are a very large component of cost-effectiveness of energy efficiency programs.
   b. To the extent that a utility builds / buys peaking resources by a defined hourly (or daily) peak value, hourly load profiles assist in more accurately assigning avoided capacity costs to utility programs and for Forward Capacity Market bids to ISO's

3. Peak coincidence of power draw and demand reductions through energy efficiency and demand response programs, and
4. Greenhouse gas emission reductions based on time-variable mix of electricity generation.

The energy and energy efficiency industries are currently using existing load shapes some of which are either old, not provided by the hour, or are simulated with no to little data supporting the simulations. Obtaining updated, empirically-based hourly load shapes is needed to better inform investment decisions.

Therefore the question is, how can the industry obtain empirically-based hourly load shapes?

There are two main avenues to develop hourly end-use load shapes, based on empirical data:

1. Conduct an independent metering study to gather end-use usage data for desired load-shapes.

2. Leverage data gathered though meter-based evaluations of energy efficiency programs, and data gathered though other metering studies, to develop end-use load shapes.

While developing load shapes though independent end-use metering studies has certain advantages over leveraging data gathered though evaluations of efficiency programs, they are costly and invasive to customers. Because of this, comprehensive load-shape studies are rarely done. A more economically feasible approach is to develop load-shapes by making use of data gathered though meter-based evaluations of energy efficiency programs is significantly lower in cost, However, the disadvantages of leveraging data from energy efficiency studies is the dependency upon what studies are being conducted and what data is being collected. To the extent that load shapes are needed for end-uses which are not being evaluated as part of current or near future study, load shape simulation models or independent metering studies may need to be conducted. In addition, if the data needed for developing end-use load shapes is not being collected during evaluation activities, leveraging that data will be of little use.

The recent experiences of the NEEP EM&V Forum suggests that the compilation of load shape studies[1] offer an option to partially address the need for updated end-use load shapes. This could be performed by using data from current and near future measurement and verification studies. However, this solution requires planning and guidance to ensure these studies will provide useful data, Developing and using Standard Data Collection Protocols, as part of measurement and verification studies, as well as other metering studies, will assist in ensuring that data can be leveraged from these studies to develop end-use load shapes.

This report describes the objectives and details of a Standard Data Collection Protocol for major Commercial and Residential end-uses.

1.1 *Objectives*

The ultimate objective of the effort is to develop a system that can be used to guide the production of readily usable dataset that can leverage project data from future meter-based measurement and evaluation studies, or metering studies to develop end-use load shapes. In addition, the guide will align data collection activates from meter-based measurement and verification studies with those of end-use load shape studies. To accomplish this goal, the key objective of the study is to establish a protocol that facilitates the usability – including potential aggregation – of primary and secondary data that might be gathered in future metering based studies. In addition to creating composite load shapes, the protocols can also be used to revisit completed studies by performing additional analyses supported by the data that were not completed in the original study.

These protocols are not intended to dictate or specify what data will be collected in future projects, but rather to shape the manner in which common data from different studies is gathered and stored such that it becomes more usable for load shape development studies, when the data being collected is applicable.

A primary use of the protocol would be as an attachment to RFPs to specify a format for final delivery of data in addition to a report deliverable. The protocols also do not prescribe a required level of disaggregation for data collected in M&V projects, nor does it require specifications for M&V project approaches or sample designs. The protocol is intended to aid in developing consistent data that is collected as part of meter-based M&V studies so it can easily be organized and used in appropriate end-use load shape development.

The protocols seek to accomplish the following:

- The specification of recommended primary and secondary data items that may be collected for a range of residential and commercial/industrial end-use categories. The focus is on defining and organizing data in a manner that will be familiar to energy efficiency EM&V practitioners in order to minimize inconsistencies and enhance accessibility.
- The specification of a user-friendly data structure that can be used in multiple file formats that will facilitate electronic data transfer.
- The development of comprehensive, detailed and user-friendly documentation of the protocols that can be appended to requests for proposals.

[1] Developing load shapes for one or more end-uses by leverage data gathered though impact evaluations of energy efficiency programs or data gathered though other metering studies.

The protocols were designed to facilitate the integration of data that are collected during different time periods or within different sampling frameworks, including instances where metered data is combined from different seasons. In developing the protocols it was also important to consider how to handle actual metered versus modeled or extrapolated/ normalized data as well as how to treat data that may be sampled or collected within multiple locations at the same site and extrapolated to the entire site.

The protocols recognize and allow for alternative on-site measurement approaches and a range of potential secondary data that may be available and used in a given project. Although the protocols are directed at guiding how a given projects data needs should be collected and maintained, they also may include guidance on data elements that are outside of the scope of a given project, but might be included in the project data collection process for minimal incremental cost or effort. The primary data types given primary consideration include the following:

1. On-site measurements of end-use equipment (and associated on-site collected survey data)
2. Energy Efficiency program tracking system data
3. Program Administrator data that may not be included in the program tracking system
4. Calculated or modeled data that were produced as intermediate or final results of a project (but not including all data inputs to the models)

2. Protocol Format

The draft protocols are presented in the form of two spreadsheets with this brief accompanying document that describe and discuss the spreadsheets and overall concepts. The spreadsheets are intended to provide the detailed data specifications, including data definitions, measurement units, data format, data organization and file structure. The spreadsheets are organized by residential and commercial & industrial (C&I) sectors because the level of data resolution or granularity can vary significantly between these two sector groups. Furthermore, these sector groups have different protocols for the different end-uses covered. Having separate spreadsheets for these sectors and end-uses relieve the protocol from having to conform to a single format and maximizes data collection resolution where it's needed. Depending on the type of project being bid on the relevant protocol spreadsheet would be included in future RFPs. This accompanying document presents the framework and details of two of the six protocols - commercial lighting and commercial refrigeration - followed by a brief description of the other four protocols included in the document. These protocol frameworks are described in the next sections.

The protocols are designed around a basis where there is a record in a database or a row in a spreadsheet for each metered sample point in a study. It is common to have specific equipment or system components metered or trended and have their trended use extrapolated to larger systems or the entire end-use. For example a time-of-use measurement of a lighting fixture is extrapolated to the rest of the lighting that are on the same switch or controls, which may be a small group, an entire floor, or even the whole building. The protocols gather information at each level of data collection aggregation from logged component, to circuit or system, to the building, and to the study or project. Conceptually, the higher level fields would contain repetitive data in a large table format or they would be linked using ID's in a relational database of multiple studies. For example, if four HVAC unitary units were trended in a building, there would be four data rows but those four rows would have identical building and site level data. Generically, the information at each level are described in the following list:

- Metered data level – meter unique identifier (ID), component information such as fixture wattage, motor horsepower, air conditioner efficiency, etc.
- System/Circuit level – system capacity, system controls, end-use load shape results
- Building/Site level – type of building, location for weather-dependent end-uses, end-use fuels
- Study/project level – The study may be an end-use metering study or evaluation of an energy efficiency program or efficiency measure, information includes the study sponsors, firms conducting the study, and type of study.

An example of using the full commercial lighting protocol is included in the commercial spreadsheet with three records of fictional data. This shows that the protocol can be easily transposed into column headings in Excel for immediate use or for smaller studies. Furthermore, the protocol can be used to define database tables such as Access,SAS, or other file formats. The key element of the data structure is that they contain the proper field headings, as specified in the spreadsheet. The delivered format of the data can be flexible and might include data formatted from Excel, SAS, Access, etc.

The two draft protocol workbooks included with this document contain the desired structure of the data files and accompanying field names. These workbooks also include notes on the information expected from each field and a field description. They are organized by sector and by end-use using separate spreadsheets:

- Commercial protocols: Lighting (includes example), Refrigeration (2 spreadsheets), HVAC, Process

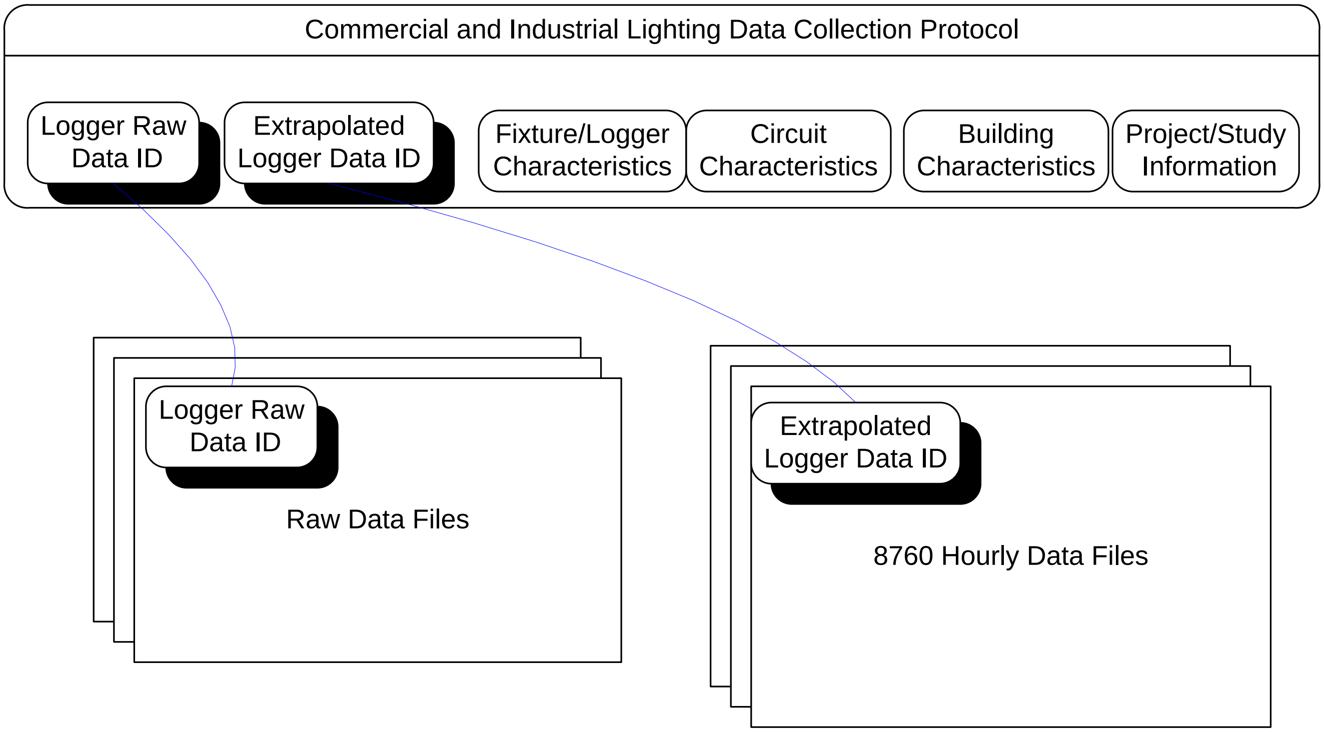
- Residential protocols: Lighting, HVAC

2.1 *Commercial Lighting Protocol - Detailed Description*

The commercial lighting protocol builds upon the NEEP C&I Lighting load shape study and focuses on the compilation of end-use metered data from energy efficiency program evaluations and other studies. The framework for the protocols was developed at the light logger level and further expanded out to the lighting circuit level, building level, and study/program level. This protocol is developed such that the table can be included in an RFP attachment as the specification of how final data should be archived in addition to the report and other deliverables asked for in the RFP. The protocol does not define the analysis processes but rather it is intended to aid evaluators and data collectors in developing common and consistent data. The top block in Figure 1 represents the lighting protocol spreadsheet which then links to raw and/or extrapolated data files and/or datasets (e.g., SAS datasets) using two unique identifiers[2].

[2] "Raw data" is typically meter/trend data that has not been modified or analyzed. Raw data is useful if re-analyzing existing data would be beneficial or necessary for the study. "Extrapolated data" is typically raw data that has been analyzed and/or fit to an end-use profile (and possibly annualized). The original metered/trended data may be completely subsumed and/or non-recoverable from the extrapolated data

Figure 1: Diagram of Data Collection Framework – C&I Lighting



The elements included in this data collection protocol are fully provided in the accompanying spreadsheet and are based on the common aspects of any light logger deployment using currently available technology yet remains flexible for use with more advanced (lighting + occupancy, wireless-networked loggers) or alternative (circuit/panel power measurement) measurement strategies. These C&I lighting elements are categorized in a micro-to-macro type progression, starting on the *logger level*, and progressing to higher levels of the *circuit level, building/site level,* and *project/study level.*

The logger level framework assigns one record (or spreadsheet row) to each unique deployment of a time-of-use or power measurement logger used for determining lighting usage. There is a unique ID assigned for each logger deployment event and associated raw data file (e.g., one spreadsheet row constitutes a complete deployment "event" - logger is deployed, logs usage for a given time, and is retrieved.This example is illustrated in the commercial lighting protocol spreadsheet). This unique ID uses a naming convention (serial number + first letter of make/manufacturer) to strike out the chance of duplicate IDs, even over different projects, sponsors, and years. The draft protocol spreadsheets have the complete descriptions, notes on the information expected, and the required data unit type for each data field, where necessary. The list below provides a sample of some of the specific logger-level details covered by the protocol about the logger installation. The full listing of desired fields and information on the units and data types desired in those fields are provided as part of the protocol spreadsheets.

- Logger type and location
- Time logger was installed and removed
- Logger level results e.g., kWh while logging, percent on while logging, number of on/off events
- Monitored fixture technology
- Fixture power (kW)
- Fixture control type

- Flags for possible fixture HVAC interaction that references to building level record data[3]

There is also a logger level data field that maps the raw data file to the refined or extrapolated file. This ensures clarity of what raw data was used to create the extrapolated (e.g., 8,760 annual) file and consistency in the formatting of the altered data, regardless of the logging method. The goal of the logger level framework is to gather comprehensive detail about what the logger monitored, how dependable the logger data is, the type of data the logger produced, and a consistent data trail to provide history and context to post-generated data.

Typically, loggers are installed on a specific fixture and their data are used to represent a larger circuit or group of commonly controlled fixtures. The information about the larger circuit or fixture group is included in the next section of the protocol, the circuit level. This level's framework has the purpose of expanding on the logger level detail to describe lighting circuit loads and usage trends that can be potentially described indirectly through the logger. Data fields concerning total circuit load and specific circuit control devices and operating hours are covered under this level. As mentioned previously, examples are provided in the spreadsheet with all fields populated with example data.

In general, multiple loggers are installed in a specific building or facility to capture the hours of use of different functional use areas or different energy efficient lighting measures. Basic information about the building can be used to determine interactive heating and cooling effects from the lighting retrofit and the compilation studies may also want to develop building type aggregations similar to what was completed for the NEEP C&I lighting load shape study. The building/site level's framework covers general building information such as building type, age, HVAC systems, and floor area, while also documenting contact information for building personnel that assisted with the site visit.

Finally, the logger level records will belong to a particular research, evaluation, or other measurement study or project. This information is documented under the project/study level's framework, with data fields for project type and year the study was conducted, project sponsors or clients, programs evaluated, consulting firms involved with the study, and contact information for the study . Information for all the loggers in a particular study can be captured once and associated with all of the logger-level records.

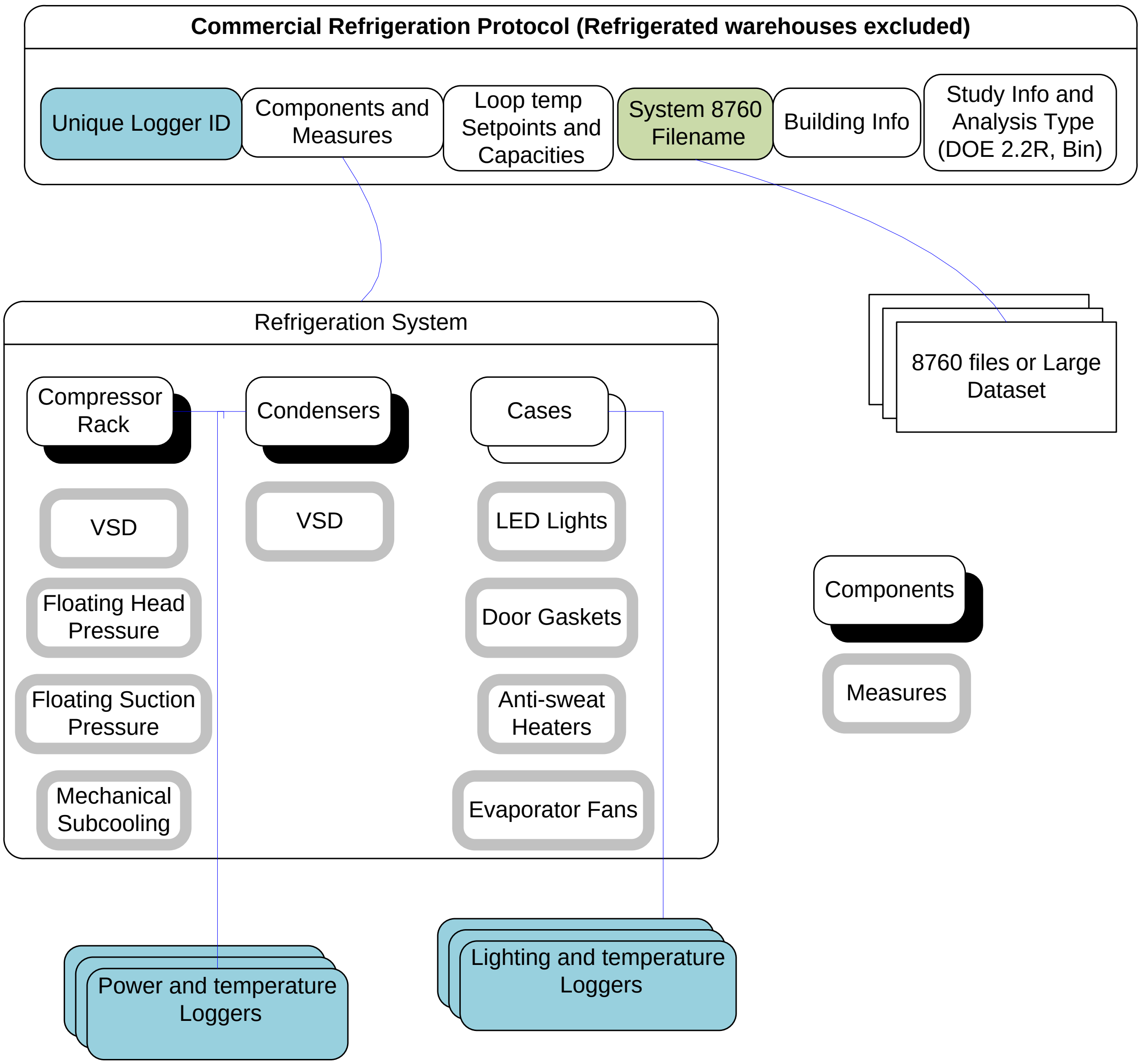
2.2 *Commercial Refrigeration Protocol - Detailed Description*

The commercial refrigeration protocol also focuses on the compilation of end-use metered data from energy efficiency program evaluations and other studies; however, projects involving refrigeration measures often use multiple sources of trend data besides logger data, like EMS and contractor supplied data points. Due to the complexity and variation that can be found in refrigeration systems, limitations were introduced to the protocol to exclude refrigerated warehouses and other complex or process refrigeration systems that would commonly fall under custom-type studies/projects. The framework for the refrigeration protocol was developed to begin at the refrigeration system level and similar to the lighting protocol, the building level, and study/program level. For refrigeration end-use, refrigeration components were broken down with greater detail to refrigeration component levels – the compressor rack, condenser, and case components. The protocol does not define the analysis processes but rather it is intended to aid evaluators and data collectors in developing common and consistent data. Figure 2 represents the

[3] The protocols do not suggest an approach for determining interactive effects; this data field is meant to flag that interactive effects may exist. The method used to quantify these effects is left to the study.

refrigeration protocol spreadsheet which then links to raw (metered, EMS, contractor-supplied, etc.) and/or extrapolated datasets (e.g., SAS datasets) using a unique identifier for the refrigeration system.

Figure 2: Diagram of Data Collection Framework – Commercial Refrigeration



The elements included in the refrigeration data collection protocol are based on common aspects of commercial refrigeration M&V data points typically collected for a large range of modular refrigeration technologies and measures utilized in the commercial retail sector (e.g., Small convenience stores to big-box grocers). Complex refrigeration systems that are typically found in specialized facilities (e.g., refrigerated warehouses, dairy plants, fish processing facilities, industrial refrigerated process loads) are excluded from the protocol – these systems are often handled on a case-by-case basis and cannot be conformed to this standardized protocol.

Because of the inherent complexity of refrigeration systems, these C&I refrigeration elements are categorized differently from the conceptually simpler C&I lighting protocol, Instead, these elements are organized by *General* details and *Specific* details. The general details progress in a micro-to-macro approach as follows: *logger/trend level, system level, building/site level, and project/study level*. The specific details cover refrigeration system component groups – *compressor (racks), condensers, and cases* - which are the levels where specific logger or trend measurements are made. These categories are described in further detail below.

On the general level detail, the system level framework assigns one record (or spreadsheet row) to each unique physical refrigeration system. A unique ID is assigned for each physical refrigeration system and every raw trend data file or extrapolated dataset associated with the system has this unique refrigeration system ID as a prefix to its own unique ID. Specifics about the general refrigeration system such as various circuit/loop and condenser temperature set points, capacities, and high-level compressor, case, and controls information are included under the refrigeration system level. The trend/component-logger level data documents the source of the trend data and specifics about what that data discloses about the refrigeration component. If the trend data is from a logger, information about logger type and location, time installed and removed, and logger level results (e.g., kWh while logging, percent on while logging, number of on/off events, temperature while logging) are included in data collection framework. The trend level data fields also include monitored component descriptions like device type, make, model, applicable capacity and efficiency, and how the device is typically controlled. The goal of the trend-data level framework is to gather comprehensive detail about what the trend data monitored, how dependable the trend data is, the type of trend data produced, and a consistent data trail to provide history and context to aggregated/extrapolated data.

Building and project/study level information is disclosed under general level detail to capture the analysis methodology (e.g., DOE2.2R simulation, regression analysis, temperature bin analysis, etc.) and parameters that describe the building shell and thermal performance characteristics, as well as operating hours of the building and refrigeration equipment. The building/site level's framework also covers general building information such as building type, age, HVAC systems, and floor (total, conditioned, and refrigerated) area, while also documenting contact information for building personnel that assisted with the site visit. The unique system level records will belong to a particular research, evaluation, or other measurement study or project. Data fields for project type and year the study was conducted, project sponsors or clients, programs evaluated, consulting firms involved with the study, and contact information for the study. Information for all the refrigeration systems in a particular study can be captured once and associated with all of the trend and logger records

Trend data can be for a specific component as described above, and can typically be used to represent the usage or load shape of other components in the refrigeration system. The general refrigeration system level expands in to the specific refrigeration component level where details on the three categorized components – the compressor (rack), condenser(s), and refrigerated cases, are recorded. Equipment and control specifications for individual refrigeration measures are listed with association with one of these three component levels (e.g., VSDs under condensers, LED case lighting and anti-sweat heater controls under cases, floating suction pressure and mechanical sub-cooling under compressor racks). Since the protocol's intent is not to define analysis processes or to have a rigid, limited allowance for refrigerated measure types, each component level attempts to capture common equipment design parameters that will only be applicable to certain types of refrigeration systems and measures. This comprehensive detail is necessary to allow sufficient coverage for the majority of commercial retail-level refrigeration measures and the data points necessary to conduct systematic performance/load-shape analyses for the refrigeration systems and associated measures.

3. Additional Protocols

The draft protocol spreadsheets have the complete descriptions, notes on the information expected, and the required data unit type for each category's data field described above, where necessary. The brief descriptions below are in reference to the other protocols available in the spreadsheets beyond commercial lighting and refrigeration which were described above. These descriptions are brief and reference commercial lighting and refrigeration to avoid repetition.

3.1 *Commercial HVAC Protocol – Brief Description*

The commercial HVAC protocol, similar to the commercial refrigeration protocol, can involve projects that can use multiple sources of trend data besides logger data. The framework of the commercial HVAC protocol begins on the *system level* where the cooling and heating equipment are identified, average set points and schedules for active and setback conditions, and potential balance point temperatures are collected. The *logger/trend data level* identifies the source of trend data, creates unique identifiers for the logger/trend data, and identifies the equipment that the trend data had measured. *Building/site level* fields gather building type, vintage, location, and size, as well as how the 8,760 or metered data is used in the energy analysis.

3.2 *Commercial Process Protocol – Brief Description*

The commercial process protocol is similar in framework as the commercial refrigeration protocol, but it is the most simplified protocol in order to provide flexibility for energy end-uses that involve a process such as those in industrial energy efficiency programs. This generic protocol is not specific to a particular process or type of equipment. The framework of the commercial process protocol begins on the *system level*. The *logger/trend data level* identifies the source of trend data, creates unique identifiers for the logger/trend data, and identifies the equipment that the trend data had measured. *Building/site level* fields are less likely to be captured for these projects but if they do gather building type, vintage, location, and size - that data can be captured. The most important level for these projects may be the *study level* which describes how the 8,760 or metered data is used in the energy analysis since this may be different for each process project.

3.3 *Residential HVAC Protocol – Brief Description*

The residential HVAC protocol framework starts at the *logger level* and the data collection fields specify what HVAC component was logged and ties that logger/component to a system number identified in the *HVAC system level*. The "HVAC System Logged" data field is meant to identify the particular complete HVAC system (i.e., for split-system ACs, the "System" would be the air-handler, furnace, condenser unit, evaporator coil, and other constituent parts that make the system) that the HVAC component being logged is associated with, and is not meant to differentiate between HVAC components. The HVAC system level elements identify what types of heating and cooling systems service the building, what fuel types are used, and how they are generally controlled. System specification information is also collected on this level. The *building/site level* collects building type, vintage, conditioned floor area, and regional location.

3.4 *Residential Lighting Protocol – Brief Description*

The residential lighting protocol draws some similarity to the commercial lighting protocol as it was also developed around the micro-to-macro progression, starting at the light *logger level* and expanding out to the *building* and *project/study level*. The logger level elements included in the residential lighting protocol are focused around identifying fixture control, lamp base type, and lamp shape. The building/site level information covers residential building type, vintage, general location to determine weather, and HVAC systems to identify potential space-conditioning interaction.