Designation: E 1464 – 92 (Reapproved 2005)

An American National Standard

Standard Guide for Developing Energy Monitoring Protocols for Commercial and Institutional Buildings or Facilities[1]

1. Scope

1.1 This guide covers a methodological approach to developing protocols for collecting empirical building or facility energy performance data.

1.2 The methodological approach covered in this guide is appropriate for commercial and institutional buildings or facilities, and with some adaptations, the approach can also be used for larger multifamily buildings or small industrial buildings or facilities.

1.3 This guide does not specify a complete project or experimental design, the hardware or software needed for data collection and data management, or the data analysis techniques to be used.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions:* Terms related to buildings and facilities in this guide are defined in Terminology E 631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *building*—generally used in this guide to refer to either a building or a facility.

4. Significance and Use

4.1 The collection of empirical data to determine building energy performance is an important but complex and costly activity. Careful development of energy monitoring projects can make a crucial difference in the value of project results relative to the expense.

4.2 Increasing the widespread understanding of how energy is used and the types of services it provides in commercial, institutional, and related (light industrial, large multifamily, and mixed commercial/residential) buildings has proved to be difficult. This difficulty arises from the following variables: the complexity of buildings as energy systems; the diversity of sizes, uses, schedules, and types of buildings; the changes in uses of buildings; and the mixture of uses within individual buildings. These factors make building energy performance and energy (and dollar) savings from energy improvements difficult to categorize and compare.

4.3 The audience for this guide is diverse, including energy suppliers such as utilities, building owners and managers, building occupants, designers, public and private research organizations, equipment manufacturers, and public regulators.

4.4 The user of this guide must be familiar with the fundamental techniques of engineering project management and energy performance data collection, data management, and data analysis. See Refs **(1-4)**[3] for a discussion of techniques related to the collection and analysis of energy performance data.

5. Procedure

5.1 Because initial goals and objectives often lead to excessive costs for field data collection, an iterative approach to project development is usually necessary. Once the goals and objectives are defined, costs for completing the project can be estimated. If the costs are too high, the goals and objectives are redefined (next iteration) to attempt to achieve more realistic costs, and further iterations are conducted as necessary.

5.2 *Project Development Activities*:

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E6.25 on Overall Performance of Buildings.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The boldface numbers in parentheses refer to the list of references at the end of this guide.

5.2.1 Identify project goals, objectives, questions to be answered by the project, and constraints such as the available budget. This activity should always be conducted early in project development.

5.2.2 Specify the minimum data products and the desired project output. The data needed to answer the project questions or meet specific objectives must be identified. The data manipulations or calculations necessary to provide the desired results should be identified. If possible, desired formats for the presentation of data results should be developed. The nature of the minimum expected final output should be defined.

5.2.3 Choose an experimental design that is appropriate for the project to be conducted (**1-3**). The design is influenced by choices between the number of buildings to be monitored and the potential ability of the data collected to define the energy performance of interest. Increasing the number of buildings improves the potential usefulness of statistical measures of performance but also increases the cost. Increasing the measurement of physical quantities may improve the understanding of events in individual buildings, but it also increases the cost. Trade-offs between costs and measurements may begin as the experimental design is being developed.

5.2.4 Develop data management procedures that can handle the (typically) large amounts of data collected. Computer resources are required to handle the data reasonably; some evaluation of required computer resources should therefore be conducted. The required computer resources depend on the volume of data to be collected, the methods used to determine the data quality, and the methods used to analyze the data. All data should be stored on computer media, and good quality assurance practices include storing archive copies of the data in more than one location in case of fire. Procedures for determining data quality should be computer-based. Data quality should be examined as soon as possible after the data are collected to determine whether quality problems have arisen. Data archiving procedures should facilitate use of the chosen analysis methods or computer programs, which means that the formats required for analysis should be determined so that little data reprocessing is required. Data archiving procedures should also be well documented so that the data can be understood easily by analysts and good data transfer procedures (see Appendix X2) can be followed.

5.2.5 Specify minimum data analysis procedures (see Refs (**4-7**) for examples and guidance). The analysis procedures chosen will often affect the field data that must be collected. The specification should include the identification of analytical models, data reduction techniques, error analysis, and desired final output from the analysis to at least meet the requirements of 5.2.2. If the experimental design requires, sample sizes should be selected and the impacts of sample sizes on overall costs evaluated. Consideration should be given to the likelihood that advances in analytical methods will occur over the course of the project, which means that these minimum analysis procedures may require yearly review.

5.2.6 Specify the field data to be collected, based on an interactive consideration of required inputs for specific analysis methods and a definition of the building circumstances, conditions, or influences of interest. Data are of two major types: time-dependent and time-independent.

5.2.6.1 Time-dependent data include weather and energy consumption data. Users must be careful that times are recorded consistently throughout the project for all parts of a project. Problems can arise when switching between daylight and standard time and when projects span more than one time zone. All times should be recorded in standard time.

5.2.6.2 (*2*) Time-independent data include specific items of interest necessary to define the project, such as descriptive data of the building or data on the costs of installing an energy-saving device. Projects should not proceed unless project developers establish a reasonably concrete procedure for describing the buildings in the project. See Refs (**1-3**) for guidance in these areas. Users must be careful to avoid the problem caused by defining a building by the Standard Industrial Classification (SIC) code (**8**) of the company that occupies the building. The function of the company may be manufacturing steel, while the function of the building is to be an office. Good practice for protocol guiding the collection of building energy performance data would dictate that the building be treated as an office, but use of the SIC code could mistakenly identify the building as an industrial building.

5.2.7 Resolve inconsistencies between desires (goals, objectives, project questions, and desired data) and realistic expectations for accomplishments, including resource and time constraints and uncertainties concerning the correct methods to use. At this point, project developers must be able to state the ramifications of resource limitations; to compare options available for conducting the project within the available resources or with incremental resources; and to determine final goals, objectives, project questions, and project output for the different options. If uncertainties in methods (especially data processing or analysis methods) are great at this point, larger-scale projects should usually be preceded by pilot-scale projects to permit exploratory investigation or the tuning of potential methods to meet project needs. Uncertainties in data results, such as plus or minus percents at the 90 or 95 % confidence level, should be quantified to the extent possible and stated as part of the expected project output.

5.2.8 Design a detailed project. Once realistic project goals, objectives, questions to be answered, and data output and formats are defined, the detailed project design begins in earnest. The usual project planning and management methods can be used here. Tasks are identified and assigned to appropriate organizations or personnel. Final hardware selection or adjustments are made. It may be necessary to recruit participants for the project. Data collection methods and schedules are developed. Data verification and quality assurance procedures, as well as data recording methods and formats, are developed. Maintenance requirements are identified and a maintenance plan designed. If possible, methods for dealing with changes over time in the building must be identified and tested. An analysis plan is designed; analyses must include both initial analysis or verification of data for reasonableness and accuracy and ongoing analysis of data that are received (for error-checking, at a minimum, and final analysis of the overall results). An example of some of the detailed project design considerations for one type of energy monitoring project (measurement of end use energy for a sample of approximately 50 buildings in the service territory of a specific electric utility) is given in Appendix X1.

5.2.9 Conduct the project. As stated in 1.2, details are not provided here. So many details exist concerning projects for collecting building energy performance data that volumes can and have been written on the subject. Developers and managers of projects should understand that analysis of project data is necessary to develop results, which is the purpose for conducting the project. A primary failing of many projects is that data collection is permitted to take on a life of its own at the expense of the analysis. Analysis should proceed during the project as a quality assurance measure and should continue after the data collection is complete. Because projects may take years to complete, the potential evolution in data analysis methods during this time may cause adjustments in final methods or reporting requirements (see 5.2.5). A commitment to some continuing analysis of project data can often enhance overall project results significantly.

6. Report

6.1 For basic reporting of the project results, include the following information:

6.1.1 *Project or Program Description*—General information, including identification of the project or program, the reason it was conducted, and improvements made to the buildings or systems studied;

6.1.2 *Data Management Procedures*—General description of the methods used to archive the data, to determine data quality, to prepare the data for analysis, and to perform the data analyses;

6.1.3 *Analysis Methods and Results*—Summary of analysis (evaluation) methods, experimental design, and project results;

6.1.4 *Performance Data*—Summaries of monthly (billing) data, submetred or detailed energy consumption data, demand data (if included), and temperature and weather data; and

6.1.5 *Building Description Data*—Survey data that describe each building and associated building systems, functional use areas, tenants, schedules, base energy data, and energy improvements, as appropriate.

6.2 For project or program description reporting, include the following information:

6.2.1 Project or program identification, sponsoring organization(s), and contact persons for those interested in learning more about the work;

6.2.2 The number of buildings involved in the project and a brief description of the types of buildings;

6.2.3 Project goals, objectives, and the questions addressed; and

6.2.4 A brief, general description of the energy improvements made to the building(s) or system(s) during the project (for example, shell retrofit, systems retrofit, and operation and maintenance changes).

6.3 For reporting of the data management procedures, include the following information:

6.3.1 The software used for checking data quality, archiving data, processing data before analysis, and performing data analyses;

6.3.2 The computer resources required to conduct the project and the amount of data archived (bytes); and

6.3.3 The number of files archived, a general description of the data contained in these files, and a description of the data available for transfer to others.

6.4 For reporting of the analysis methods and results, include a description of the following:

6.4.1 The experimental design and analysis approach used.

6.4.1.1 Typical experimental designs include on-off, before-after, test-reference, simulated occupancy, nonexperimental reference, and engineering field test (see 5.2.3).

6.4.1.2 The analysis approach is described by recording the degree to which the data should be detailed, the modeling methods used for the energy data, and the form or type of the model (or equations) used to describe building or system performance. Any calculations or methods used to account for performance variations caused by changes in building characteristics (if any) are also recorded.

6.4.2 *Basic Analysis Results of the Energy Monitoring*—Energy use indexes should always be reported. The annual energy use intensity, EUI (MJ/m^2 of floor area (kBtu/ft^2)), is an example of a simple index. The EUI based on the total amount of all fuels used in a building should be the minimum value reported. If possible, the EUIs for heating, cooling, lighting, or other end uses that are expected to be measured by the energy monitoring project or affected by energy improvements made during the project should also be reported. If improvements are made affecting heating or cooling, the annual building performance index, BPI, should be calculated and reported. BPI is expressed in MJ/m^2-DD (kBtu/ft^2-DD), where the following must be specified: nature of the energy quantity (MJ), the floor area used (m^2), and the nature of the DD (degree days). If possible, any other performance index that is helpful in interpreting the results should also be reported. Typical electric demand values (for example, peak kW) can also be provided, when appropriate, for interpreting project results and when available for the summer, winter, or other periods of importance. The effects of complicated demand price structures may cause difficulties in presenting useful demand values, so the most appropriate presentation should be selected, and the important features of the demand presentation should be described.

6.5 Summaries of energy performance data for the monitored buildings should be developed to provide an overview of the results of the project. Data summations or aggregations are often performed as part of the analysis conducted for the project, and it is often useful to report important intermediate results that help provide insight into the project results.

6.6 For projects impacted by outdoor temperatures, such as those in which heating or cooling energy are measured or are of interest, outdoor temperature data should be reported daily as the minimum time interval (these data are needed to support proper analysis). Daily temperature data derived from shorter-interval temperatures are acceptable, that is, hourly, 15-min, and so forth, that are averaged over the day. Daily outdoor temperature data can also be calculated from the average of daily maximum and minimum temperatures (two values).

6.7 Building description data provide an understanding of the complexities of the buildings in the project. Suggested building description data include the following: general and building envelope data, tenant information to define energy systems used by each tenant, building zone information to define the functional uses of the building and the types of energy systems serving these functional uses, information on zone schedule and occupancy, energy systems data, and descriptions of energy improvements being evaluated, if any.

7. Data Storage

7.1 An archive copy of the data collected for a project should be made, preferably on a computer medium such as magnetic disk or magnetic tape, so that the results can be shared with interested individuals. Suggestions to consider when transferring data to others are provided in Appendix X2. Users of this guide are cautioned that careful planning of the data archiving procedure is necessary (see 5.2.4) to ensure that the requirements of Appendix X2 may be met.

8. Keywords

8.1 building; building energy performance; commercial; data analysis; data management; data verification; energy monitoring; experiment; facility; institutional; project development; project planning; protocol

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE OF INTRODUCTORY MATERIAL FOR DETAILED PROJECT DESIGN HANDBOOK

X1.1 This appendix provides a specific example of the type of material necessary to define and manage an energy monitoring project. This example treats the case of an electric utility that wishes to measure the end-use electrical loads for a sample of customers. This example thus does not apply to all types of energy monitoring projects, but it does indicate the issues that most commercial or institutional energy monitoring projects should address in developing a monitoring protocol.

X1.2 *Project Objectives and Configuration:*

X1.2.1 The primary objective of the project is to collect two years worth of data on end-use load, internal temperatures, and associated customer characteristics for a sample of approximately 50 commercial buildings.

X1.2.2 The data collected will be applied for research purposes within the utility. The data from this project will be made available to the entire utility for uses such as load forecasting.

X1.2.3 A project office that serves as the direct operational base is established in the major operational city for the project. This office coordinates all aspects of data collection and interaction with the utility. All recruitments of buildings and data collection activities are based in this office, with the required staff and equipment available for immediate application to project activities.

X1.2.4 The utility approves each site for installation. A value engineer aids in this process by reviewing the proposed installation documents and associated costs. Utility representatives help facilitate contact with the customers in the buildings to be monitored.

X1.2.5 The example is as follows. An actual project handbook would typically be expanded to cover more topics.

1. Introduction

1.1 *Overview of Handbook*—This handbook documents procedures used in the commercial energy end-use monitoring project. Step-by-step instructions are provided on how to implement, maintain, and ultimately terminate end-use metering at a selected customer site. An explanation of the overall measurement concepts guiding the project is provided, and status tracking methods necessary to assess the progress of the project may be discussed. Procedures for collecting characteristics data are also enumerated.

1.2 *Handbook Organization*—In general, the handbook is organized in chronological order. Procedures for activities occurring early in the project (such as site selection) are described first, and activities occurring at the end of the project (such as the removal of monitoring equipment from a site) are described last. Certain chapters, however, contain general information that is applicable to all phases of the project. An appendix of reference materials is also provided. This appendix contains a glossary, a list of codes used in the project and their meanings, and other reference materials that may be useful in project activities.

2. Overview of Process

2.1 This section provides a brief overview of the activities conducted at each site that participates in the project. Each of these activities is described in detail in the body of this handbook.

2.2 *Selection and Recruitment*—Procedures for site selection are described. After the sites are selected, each of the potential sites is visited briefly during a walk-by survey. During this walk-by, limited preliminary data on each site are collected so that the sites can be classified accurately by categories of interest for the project. The recruitment process is then initiated. The object of recruitment is to encourage site owners to agree to participate in the project. To help facilitate the recruitment process, utility account representatives will be involved extensively in this stage.

2.3 *Initial Site Survey*—An initial site survey (ISS) is completed by a survey team at each site that has been recruited successfully. The primary objectives of the ISS are to determine whether the site is suitable for monitoring and to develop an estimate of the cost of monitoring the site. If the site consists of multiple buildings, a primary building (the building to be monitored at the end-use level) is identified in the ISS. Detailed information on the electrical (and gas) distribution system(s) in the building is then collected, along with some basic information on the site and building in general. After the ISS is completed, the survey team estimates the full cost of monitoring the site and recommends whether the site should be accepted for the study. The utility must approve the site for participation before any further work occurs at the site. The data collection forms used are included in an appendix to this chapter.

2.4 *Site Characteristics Survey*—The site characteristics survey (SCS) consists primarily of a data collection effort conducted at the site. Detailed characteristics data on the building(s) and tenant(s) at each site are collected. The data collection forms used are included in an appendix to this chapter. For sites with multiple buildings, the survey focuses on the primary building. Information is collected on the building as a whole, each tenant in the building, the electrical and gas loads, and the distribution equipment in the building. If the site includes more than one building, limited data on each of the secondary buildings at the site is also collected.

2.5 *Measurement Plan Development*—The information collected in the SCS on electrical and gas loads and distribution equipment is used to develop a measurement plan (MP) for the site. Procedures for developing detailed specifications and costs for monitoring the site as part of the MP are also described. Measurement Plan Development includes assigning identified loads to data logger channels, determining the number of channels and loggers necessary to meet the measurement goals of the project, itemizing hardware requirements, specifying the location and type of monitoring equipment to be installed, and preparing an installation cost estimate. The data collection forms used are included in an appendix to this chapter. The completed measurement plan (with costs) is submitted to the utility for approval. The utility must approve the site for installation before further work can proceed at the site.

2.6 *Installation*—The MP developed for each site will be implemented by installing sensors and data logging equipment. Procedures for installing the equipment are described. Connecting the systems correctly, loading equipment and software settings, and initializing data collection are also part of the installation process. Each site is subjected to a verification process to ensure that the installation activities were accomplished correctly. The data collection forms used are included in an appendix to this chapter.

2.7 *Maintenance*—Procedures for maintaining loads and characteristics data at operational sites are described. Each site will be contacted at six-month intervals to determine from verbal communication whether gross changes have occurred with the building, the tenants, or the equipment. Updates to the SCC, the MP, or the site installations will be accomplished as necessary based on this information. The data from each site is analyzed routinely for a range of different quality issues. Should any of these tests fail, or should communication with the sites be disrupted, steps will be taken to identify the problems and achieve solutions. In cases in which extensive rework of the installation is required, an estimate of costs for the work will be developed. The utility must approve the site for restoration before extensive rework can proceed. The data collection forms used are included in an appendix to this chapter.

2.8 *Removal*—At the conclusion of the metering period for each building, the metering equipment and associated sensors will be removed and the site returned to a condition at least as good as that before the metering. Damaged surfaces in visible portions of the buildings will be repaired and holes patched. Specific instructions are also provided for return of the monitoring equipment to the project inventory. Both paper and electronic site files will be closed and stored in specified locations.

2.9 *Software Operations Guide*—Instructions for use of the PC software (PC-PROJECT) are provided. PC-PROJECT processes and stores both loads and characteristics data. The software controls the monitoring hardware to obtain raw loads data and then processes the data for storage. For characteristics data, PC-PROJECT is used to generate data collection forms, store and manipulate characteristics data, generate reports, and support project tracking.

3. Measurement Protocol

3.1 Data requirements for energy monitoring at selected commercial customer sites are described in this section. The conceptual approach for the measurement is also described. All staff involved in implementation of the project must understand these concepts. Data is collected for a site in the project. A site is defined as a collection of one or more buildings located within the same block that are occupied or operated by one business establishment. For purposes of the monitoring project, a building is generally considered to be a structure that has walls and a roof and always has a thermally independent system for providing end-use services. For example, a site might be an automobile dealership that has one building devoted to new car sales, one to repair, and one to used car sales.

3.2 One building at each site (generally the largest or most typical) becomes the focus for end-use metering and detailed data collection; this building is called the primary building. The space in this building is divided into tenant spaces. For the purposes of this study, the tenants are either business establishments or the common facilities of a building. Tenants are combined to form business types. Common and external facilities are always combined to form a common business type. All other tenants are combined, based on their industrial classification, to form either one of the five target business types (office, warehouse, restaurant, food-retail, or nonfood retail); the other commercial business type; or the noncommercial (residential and industrial) business type. In buildings having more than one floor, tenants are organized by tenant-floor spaces to facilitate the collection of site characteristics data.

3.3 Specific measurement concepts related to the collection of loads, characteristics, and temperature data are as follows. The section ends with a discussion of the intended use of data collected in this project.

3.4 *Loads Data:*

3.4.1 Energy consumption and power factor are measured in the project at 30-min intervals. The level of detail of these measurements, that is, whether they are end-use energy or total energy consumption measurements and whether they are made at the site, building, or business type level, depends on the configuration of the site.

3.4.2 *Levels of Measurement:*

3.4.2.1 The primary target level of measurement is the business type, defined as a group of tenants, located within a building, that all belong to the same business type market segment, for example, office. End uses are optimally measured by business type within a building. If a building is mixed use (that is, contains more than one business type), energy end-uses in the common and external areas of the building are monitored as a separate, common business type. If the building contains only one business type, or if the building is mixed use, but no services are shared by more than one business type, end-use measurement at the business type level can be achieved.

3.4.2.2 The secondary target level of measurement is the building. This level of metering is necessary because energy end-use services are shared in some buildings by more than one business type (for example, a building containing an office and retail establishment that has a central HVAC system). If an energy end-use service is shared among business types, it is assigned to the common business type. The individual business types may then be missing that end-use. For these sites, a complete picture of end-use consumption is possible only at the building level. For the example of an office/retail mixed-use building with a central HVAC system, the HVAC energy use is a service shared by different business types and is therefore assigned to the common business type. Thus the common business type includes all HVAC consumption in the building, while the office and nonfood retail business types have no HVAC end-use at all. In a case such as this, useful (complete) end-use breakdowns can be obtained only at the building level. Building level end-use measurements can be achieved for the primary building at every site, regardless of configuration; these measurements represent the minimum level of end-use detail required by the project.

3.4.2.3 If the primary building contains some noncommercial space, end-use energy consumption in that space is not monitored. Instead, only total energy consumption for that space will be measured. The total noncommercial consumption must be added to the sum of the building's end-use consumption to obtain total consumption in the primary building. If the commercial space in the building shares services with the noncommercial space, the building should be rejected from the study.

3.4.2.4 A third level of measurement is the site. If the site consists of only one building, this level is the same as the building level. However, if the site consists of more than one building, the project must account for consumption in the other buildings (the secondary buildings). If any secondary building at the site shares an electrical service with the primary building (that is, they both draw electricity from the same meter), the total consumption in the secondary building is monitored. This measurement will generally be taken at the point at which the service leaves the primary building to move to the secondary building. If the secondary building does not share any service with the primary building, no 30-min data are collected. Consumption for these buildings must be obtained from the utility's readings of the utility meter(s) serving those buildings.

3.4.3 *End Uses:*

3.4.3.1 Certain end-uses are required at each site (that is, they must be measured if they are present in the building), and certain end-uses are optional (that is, they should be monitored separately if it is not too costly to do so). Required end-uses include internal lighting, HVAC (heating, ventilation, and air conditioning), external loads, designated process load(s), and other loads. The required process loads vary by the business type of the site being monitored. Table X1.1 depicts the required end-use process loads for each business type.

3.4.3.2 The optional end-uses are the components of HVAC: heating, cooling, and ventilation/auxiliary. HVAC should be decomposed into these separate components when the incremental cost is low because of convenient arrangement of the building's electrical wiring, and the additional channels of data collection do not necessitate the use of additional loggers. If possible, the disaggregation of HVAC should be accomplished at the business type level of metering.

3.4.4 *Measurement Guidelines:*

3.4.4.1 Several measurement guidelines have been developed to help meet the project's goals of collecting high-quality data at a reasonable cost.

3.4.4.2 First, monitor as high in the distribution system as possible. For each building to be monitored, a detailed electrical distribution riser diagram is prepared. As part of the SCS, all significant pieces of equipment are identified and assigned to particular nodes of the electrical riser. Nodes are selected for monitoring based on the classification of equipment that is served by the node. The intention is to minimize the number of monitored nodes to keep the cost of the monitoring system and installation as low as possible. In practice, this means that the monitored nodes are as high in the electrical distribution system (or as near to the utility meter) as possible.

3.4.4.3 Second, do not insist on absolute end-use purity. Absolute purity of end-use measurement is expensive to achieve and often has marginal benefits. A criterion for end-use purity, called the "ten percent rule," has therefore been established. If an actual end-use assigned within a particular node is expected to represent less than 10 % of the consumption of the node, and the consumption of the actual end-use within that node represents less than 10 % of the total for that end-use within the business type (or building, if that is the appropriate

TABLE X1.1 Required End-Use Process Loads for Each Business Type

Business Type	Process Load		
	Food Preparation	Refrigeration	Data Processing
Office	...	...	required
Non-food retail	...	...	...
Restaurant	required	required	...
Food retail	required	required	...
Warehouse	...	required	...
Common	...	...	...
Other commercial	...	...	...

level of end-use detail), that end-use does not require separate monitoring in that node. Instead, the circuits in the node with that end-use should be reassigned to a more predominant end use. A secondary end-use will occasionally be encountered in individual electrical panels dominated by a single end-use. Where the secondary end-use is small, it will be considered part of the dominant end-use. For example, consider a panel with 20 interior lighting circuits and one circuit dedicated to a supplemental, window-mounted air conditioning unit. The entire panel would be monitored at a single point, identified as lighting, if the air conditioning unit represented less than 10 % of both the annual load of the panel and of the annual HVAC load of the building. The small packaged air conditioner would be identified in the connected load inventory as being connected to the monitored lighting node so that analysts could identify it as a source of error in the estimate of the building's lighting load.

3.4.4.4 Third, facilitate comparison between end-use data and data from the utility's meter. All of the channels of end-use metering must be designed so that they can be assigned to one, and only one, utility meter. An improved quality control standard is then made possible by comparing power as measured by the utility's meter with the sum of the power of end-use channels associated with each meter.

3.4.4.5 Fourth, use redundant metering to help identify installation problems. To ensure the correctness of all collected data and provide a mechanism to identify installation problems, every end-use measurement point must be traceable as a partial sum of a node higher in the electrical distribution system that is also (redundantly) measured. By comparing the differences (by phase) between the higher level and the sum of the lower level measurements, it is possible to isolate particular current transformers that have failed or were improperly installed (or not installed). These checks are particularly useful in isolating the reasons that a site which has been operating correctly for a period of time might begin to provide erroneous data. These check measurements will be kept to the absolute minimum but are invaluable in assuring data quality.

3.4.5 *Gas Consumption Metering*—Some fraction of the selected buildings use natural gas as their primary heating fuel, and most of the restaurants have some part of the cooking process load supplied by gas. Natural gas consumption must be monitored separately to gather complete consumption information on those buildings. Gas consumption will be monitored using industry standard meters as the measurement device and installing a pulse initiator in the meter. The pulse signals from the gas meters are recorded directly on the digital channels of the data logger and measured with the same time resolution as all other measurements. Only total gas consumption is monitored (that is, no end-uses are measured).

3.5 *Characteristics Data:*

3.5.1 To understand the end-use measurements of energy consumption better, information on the physical, operational, and economic characteristics of each metering site must be collected.

3.5.2 To support the interpretation of the metered loads, data must be collected on the characteristics of connected loads in each end-use metered building. For example, how many lights by type of light make up the lighting load in a particular office building? How many pieces of equipment and how much rated capacity is included in the lighting end-use that is not lighting?

3.5.3 To explain the differences in end-use load profiles and use intensity between various sites, data must be collected on the structural characteristics of each end-use metered building, the characteristics of connected loads, and the operational and economic characteristics of the business(es) that occupy the building. For example, do the differences in business hours explain the difference in lighting use intensity between two groceries in the sample?

3.5.4 To explain changes over time in end-use consumption for a particular site, data must be collected that track any changes in the physical, operational, or economic characteristics of the site at regular intervals throughout the end-use metering period. For example, did the introduction of a large computer system cause a change in the shape of the data processing end-use for a particular office building?

3.5.5 To support extrapolation of the end-use sample results to estimate commercial class load shapes and use intensities, data must be collected that are comparable to data that the utility collects on large, more statistically representative samples of the commercial sector.

3.5.6 There are five levels of characteristics data.

3.5.6.1 *Site*—For example, how many buildings are contained in the site and how many tenants there are in all of the buildings?

3.5.6.2 *Each Building at the Site*—For example, the share of floor area associated with each business type found in each building.

3.5.6.3 *Primary (End-Use Metered) Building Only*—For example, wall area, gross floor area, and percent of wall area that is glazed.

3.5.6.4 *Business Type Within the Primary Building*—For example, the enumeration of connected loads and the gross (floor) area of each business type. Common area is treated as a business type in mixed-use buildings.

3.5.6.5 *Tenant in the Primary Building*—For example, the hours of operation and the fraction of business expenses devoted to energy purchases. Vacant areas are treated as tenants.

3.6 *Temperature Data*—To identify and examine temperature-sensitive loads, a time series of internal and external temperature differences is necessary. Internal temperatures will be measured directly for the primary building at every site and collected on the same data collection system as the energy consumption information. External temperatures are available from other sources (utility weather data, NOAA). The internal temperature data collected will represent an average temperature over the time interval of data collection (normally 30 min). In general, one temperature measurement will be taken within each HVAC zone of the end-use metered buildings. An HVAC zone is a thermally isolated portion of a building that has a separate HVAC system or systems. For buildings containing more than one business type, and where these business types have separate HVAC zones, a temperature measurement will be taken in each HVAC zone within each business type.

3.7 *Intended Use of Data*—The data collected in this project include much information considered to be sensitive by the sites participating in the study. The anonymity of the participants must be respected to the maximum extent possible. The utility is therefore expected to use the data collected in this project for internal purposes only, unless the data is aggregated sufficiently to protect the individual participating sites from possible identification. In addition, the site and tenant contact information will be treated confidentially and will not be generally released even within the utility.

X2. CONSIDERATIONS FOR TRANSMITTAL OF DATA

X2.1 Data from monitoring projects should be stored in a form that can be transmitted to others for further analysis or comparison with other data. Data to be transmitted to others should be produced from an archive copy of the data stored on magnetic disk, magnetic tape, optical disk, or another computer storage medium. The archive copy should identify missing data points clearly. The data to be transmitted should be recorded in a useful format. Useful formats for data transmittal are standard Data Interchange Format (DIF), or alphanumeric characters recorded in American Standard Code for Information Interchange (ASCII), with each piece of data separated by a comma and each line of data terminated with a carriage return. Fixed format of the data in ASCII, with the format readily described in the data transmittal, can also be useful. Data stored in these formats can be read by a wide range of computer systems and computer programs.

X2.2 Nonstandard formats, such as compressed data formats, or binary or random access formats, are not recommended for data transmittal. Such formats, while they may be essential to reduce the volume of data for intermediate storage, are often difficult to read with the software typically available to most users.

X2.3 The transmitted data should include the results reported in Section 6 of this guide.

X2.4 The project should have the following documentation available for any data stored on computer media for the project: title or acronym used to refer to the data, data contact person(s), file identifiers or names for all data files developed, description of file(s) (for example, building identifiers, time periods covered, fuels and submetered data covered), size of file (number of bytes, number of records, and record length), and definition of data values (for example, data headings or variable names, units of variables, location in the file, special codes used, and missing value representation).

X2.5 When data are transmitted, the following should be provided: an appropriate reference citation for the data, a credit line for use in acknowledgments, the type of computer used to create the data file, the operating system used to create the data file, the software program used to create the data file, the output file type (for example, DIF, ASCII, and so forth), and the computer medium (for example, diskette or tape) characteristics.

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