THE END-USE LOADS AND CONSERVATION ASSESSMENT PROGRAM

ANCILLARY DATABASE PLANNING AND SPECIFICATION

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1.0 INTRODUCTION

The End-Use Loads and Conservation Assessment Program (ELCAP) is a large, end-use, hourly metering experiment composed of a number of individual metering projects. On the residential side, two projects are underway. The first is a sample of 500 residential units (attached and detached) drawn from a stratified sample from the 1983 Pacific Northwest Residential Energy Consumption Survey, or PNRES. An additional 200 residential dwellings will be metered in a controlled experiment to determine the effects of the Northwest Power Planning Council's model energy conservation standards.

The commercial work consists of three studies. In the first, 200 commercial buildings in the Seattle City Light service area are being metered. Thirty of the instrumented buildings will have been constructed according to the Seattle Energy Code (adopted in 1981), while the remaining 170 buildings will be randomly selected to represent pre-code construction. In the second study, in support of the Commercial Audit Program, approximately 40 commercial buildings are to be given energy audits and metered to determine the appropriateness of the audit recommendations and the accuracy of the estimated energy savings from retrofit. An additional 27 buildings will be metered to document the energy savings of the Purchase of Energy Savings Program, a pilot project to procure energy conservation through third party shared savings contracts.

The ELCAP database will provide the necessary field data to:

- validate the potential for conservation available to offset future generation needs,
- examine the timing of electricity use and, therefore, the load impacts of end-use electricity conservation measures, and
- estimate the electricity consumption by end-use of the regions' building stock to support BPA's end-use forecasting models.

The load data itself, however, will not provide the necessary information to conduct these analyses. Data on the characteristics of the buildings to be monitored, their occupancy patterns, demographic and economic characteristics of the occupants, and billing information must also be collected.

This document presents the plan for defining, acquiring, and storing the contents of the non-load data necessary for analysis of the ELCAP database. In order to determine what are the ancillary data requirements, the uses of the ELCAP data must be defined. Therefore, we first discuss, in broad terms, the various types of analysis that may be conducted on the ELCAP database in the following section. Section 3 discusses the design of the database, focussing on how data will be accessed, selection of the database manager, the structure of the database, data collection and entry, and data security.

The document concludes with a discussion of the contents and source of the ancillary database. Two alternatives are presented: 1) an ancillary database containing most of the data necessary to support the types of analysis described in Section 2, and 2) an ancillary database which will support cross-tabulation of the load data, but will not contain the information necessary to support some of the potential analysis efforts. The first database will require additional project funding to support, while the second database can be supported within existing project funds.

2.0 DATA ANALYSIS

The ELCAP program was initiated to support 1) the assessment of conservation potential in the Pacific Northwest, including the effectiveness of the Northwest Power Planning Council's Model Conservation Standards, 2) the end-use load forecasting models of the residential and commercial sectors, and 3) research on load shape.

In the following paragraphs, the types of analysis likely to be conducted using ELCAP data are discussed in fairly general terms. The topics singled out for discussion are not intended to be exhaustive inventory of the analyses that will be conducted, but representative of the types of analysis likely to be undertaken. Next, the types of ancillary data (again, in general terms) necessary to support analysis are described. Finally, this section concludes with a brief discussion of extrapolating the data from the ELCAP sample to the region as a whole.

2.1 CONSERVATION ASSESSMENT

The Pacific Northwest Regional Power and Planning Act placed the priority on meeting increased electrical loads with conservation and renewable resources over traditional thermal generation plants. The Northwest Power Planning Council, the body set up by the act to perform the power planning in the Northwest, intends to rely heavily upon conservation as a resource to defer generation needs.

The rationale for relying heavily on conservation as a resource lies in the uncertainties of cost, timing and environmental impacts associated with construction of large thermal generation plants, and in the uncertainty of the future level of demand. Since the future level of electricity demand is a subject of substantial disagreement, and because the lead time for a new coal steam generation plant is approximately 7-9 years, the Council felt that its resource plan must be flexible to adjust to changes in the need for power.

The resource plan, therefore, emphasizes what the Council calls the "options" approach to power planning, relying on resources which can rapidly be introduced or suspended. Central station plants are not very flexible--their lead times are simply too long. Conservation resources, however, appear to be quite flexible. They come in small units, a program can be implemented quite rapidly, and consumer participation tends to be high.

2.1.1 Conservation Analysis Topics

Since conservation is a demand side resource, information on its availability, reliability and cost is subject to a fair amount of uncertainty. This uncertainty results from unknown characteristics of energy requirements at the end-use level; the interaction of economic, demographic, and capital stock factors affecting energy use and, therefore, conservation decisions; and the lack of field experience in acquiring conservation resources.

Analyses are likely to be undertaken on many topics, including: conservation potential, effects of building energy performance standards, performance of specific conservation measures, assessment of appropriateness of building audit recommendations, and conservation marketing. These topics are described below.

Conservation Potential: This is one of the most important issues in conservation analysis. Since conservation measures are applied at the end-use level, it is quite important to know how electricity use is distributed among the various end-uses. This has historically been done through the application of studies from other regions, sub-metering on a limited sample size, conditional demand analysis (statistical allocation of total demand to end-use demand), and/or simulation of end-use energy consumption via engineering models. Unfortunately, these methods are always at least one step removed from actual empirical measurement of conservation potential and suffer from reliance upon professional judgment, small sample sizes, simulation of conditions, or out-of-region extrapolation of results.

ELCAP will provide field data on total building energy consumption as well as energy consumption by end-use. For regional conservation and power system planning purposes, this information must be available at the regional level, and would be desirable at some disaggregation of the region.

Impact of Model Conservation Standards: The Northwest Power Planning Council called for the implementation of energy efficiency standards on all new electrically heated residential and commercial buildings. Failure to implement equivalent standards by the appropriate governmental bodies will result in the imposition of a surcharge on the utility serving the area.

The model conservation standards have been criticized within the Pacific Northwest and elsewhere as ineffective, costly, and inappropriate. The ELCAP program contains an experiment to look at the effects of the model conservation standards on electricity use. The Residential Standards Demonstration Project (RSDP) will meter 200 newly constructed homes. Half (100) will be constructed to the specification of the model conservation standards, while the remaining 100 dwellings will be constructed according to current design practice and will serve as the control group.

In order to assess the effects of the model standards, differences in factors affecting energy use (such as occupant behavior, climate, equipment utilization) between the homes built to the prescriptions of the model standards and the control homes must be accounted for. Typically, regression analysis is used to explain the effects of these variables on energy use. By allowing only the energy efficiency to vary, the energy savings of the standards can then be estimated. The savings can then be compared with the incremental cost of constructing buildings according to the standards, providing BPA and the Council with field data on the cost and energy savings of the model standards.

For commercial buildings, 30 of the 200 sites in Seattle have been constructed since 1981 when the Seattle Energy Code went into effect. This code is similar, in most respects, to the prescriptions of the Council's Model Conservation Code for commercial buildings. An assessment of the effectiveness of the Seattle Energy Code, therefore, should also be performed using an approach similar to the residential evaluation.

Performance of Energy Conservation Measures: There are two issues here:

- by what amount will an energy conservation measure increase energy efficiency?
- will individuals alter their use of the energy consuming device, thus reducing the expected energy savings?

Typically, thermal simulation models have been used to estimate the efficiency improvements gained by retrofiting buildings with conservation options such as more efficient space conditioning equipment and/or improved thermal integrity of the building envelope. For other conservation measures, engineering calculations are typically performed based upon first principles.

Thermal simulation, however, relies on very detailed information about the building and its equipment, including: the thermal resistance of the walls, roof, floor, windows, and doors; occupancy/use patterns; type of equipment and their efficiencies; interior loads; etc. Unfortunately, inaccuracies in this information can easily lead to incorrect results. ELCAP will provide field data that will allow the ability of the thermal models to predict energy savings to be assessed.

The second issue is the critical one--what is the energy savings expected to accrue from implementing an energy conservation measure? Improving the efficiency of consumers electricity consuming stock may induce them to increase their demand for services of the stock, thus reducing the effectiveness of the conservation measure. Will the conservation measure offset sufficient capacity requirements at the time of system peak to avoid a brownout? Will consumers use conservation measures, such as setback thermostats and storm windows, after they are installed as part of a conservation program? These are just a subset of the issues that require field measurement of the performance of conservation measures, and ELCAP, fortunately, will provide the necessary information to assess the actual savings that accrue from weatherization activities.

Commercial Audits: An important issue is the accuracy and appropriateness of building energy audits for commercial buildings. If the commercial building audit is to be of any use in assessing conservation resource potential or in identifying energy management strategies, the accuracy of the predicted energy savings arising from audit recommendations, as well as the ranking of conservation measure attractiveness, must be known.

As part of the commercial audit program, approximately 40 commercial buildings will be metered using the same techniques and equipment as in ELCAP. These buildings will have a detailed audit performed upon them, and the auditor will recommend specific conservation retrofit measures which could be applied to reduce energy use in the building. The auditor's recommendations are often based upon a detailed thermal simulation of the building.

Using the metered end-use data, the audit estimates of conservation potential and estimated end-use energy use will be assessed. The evaluation will have to examine:

- the ability of the audit to estimate conservation potential, energy savings, and costs;
- the usefulness of the audit forms and procedures;
- the ability of the auditors to obtain, record, and analyze the necessary building information; and
- the accuracy of thermal simulation models in estimating thermal loads, equipment energy use, and utilization of equipment.

Conservation Marketing: If conservation programs are to be used to offset generation requirements, then Bonneville must have a good idea of the quality of the resource and where the highest payoff is (lowest expenditure per conserved kWh or kW). Conservation or demand side management programs, therefore, must be able to "target" specific consumers for program participation. In order to accomplish this, however, we must first be able to segment the potential resource by criteria likely to affect its attractiveness.

Perhaps an example will clarify this point. A potentially attractive demand side management program is direct load control of air conditioning in the region east of the Cascades. In order for the program to be of maximum efficiency (maximum ability to displace load for a minimum cost), only air conditioners likely to be on at the time control is desired should be controlled. In order to effectively acquire the resource, therefore, the program design would need to discriminate between households where all occupants are absent from the house during the day, and those where someone is home and is requesting air conditioning services during the likely control periods.

While direct load control is a specialized example, marketing research is crucial to the success of future demand side management efforts in the Pacific Northwest. Identifying the characteristics of a building which make it a better candidate for weatherization than the average building will enhance the ability to discriminate "cost-effective" building conservation opportunities from inefficient opportunities.

The ability to market conservation will depend upon the knowledge BPA has of the magnitude, accessibility, and cost of recovering the resource by market segment. ELCAP will provide the necessary support for performing a market segmentation analysis if, and only if, the necessary building structure, demographic and economic characteristics are collected.

2.1.2 Ancillary Data Requirements for Conservation Analysis

The following paragraphs describe, in rather broad terms, the types of data that are necessary to support the analysis activities described above.

Conservation Potential: A thorough accounting of each building's thermal characteristics is necessary to explain the thermal integrity of the building. On the commercial side, audits will provide the building's average U value (or the average thermal transmittance of the building), as well as the U for the roof and each wall orientation. Glazing area and U values will also be collected, as will the type of construction. On the residential side, estimates of the level of shell insulation, amount of glass, orientation, and infiltration will provide the ability to assess the thermal integrity of the shell.

Detailed information on the age, efficiency, and connected load of the capital stock and its occupancy or use profile will allow the estimation of the potential conservation resource.

Conservation Measure Performance and MCS Demonstration: As mentioned in Section 2.1.1, this analysis area consists of two topics: technical improvements in efficiency, and the effect of behavior upon improvements in efficiency. In order to conduct either type of analysis, the ELCAP sample must be segmented into those sites where the conservation measure in question has been installed, and those sites where the measure is absent.

Assessment of the technical improvements in energy efficiency arising from the conservation measure or the imposition of efficiency standards require knowledge of all of the characteristics of the end-use consuming capital stock identified above, as well as weather and technical characteristics that may not be obtained for the full sample of buildings. The technical assessment activity, due to its extreme data requirements, may be supported through case studies.

Assessment of the behavioral influence on the performance of conservation measures will require information on the demographic and economic characteristics of the occupant/owner, fuel prices, whether the occupant or owner pays the fuel bill, past conservation actions and the occupant/owners' attitudes towards conservation.

Commercial Audits: In addition to detailed characteristics of the building, its occupancy and schedule of operation, and equipment description, the recommendations of the auditor, his estimate of end-use energy use, and energy savings must be available for this analysis task.

Data on the costs of energy conservation measures proposed or actually installed will also be necessary to assess the economic performance of the energy conservation measures.

Conservation Marketing: This conservation analysis area will require information on the building occupants' and owners' attitudes towards conservation, and their perceptions of the importance of conservation as a regional and national issue. In order to conduct market segmentation studies, the demographic and economic characteristics of the occupants/owners must be obtained, as well as the characteristics of the building and its capital stock.

2.2 LOAD FORECASTING

The Division of Power Forecasting in BPA currently uses two long-term end-use energy demand forecasting models. These models are derivatives of the ORNL Residential and Commercial energy demand forecasting models. End-use models have achieved acceptance within the power-forecasting community because of their disaggregation of building or household energy use into consumption of electricity by water heaters, furnaces, air conditioners, etc. Strict econometric or trend forecasting methods, such as relating households or employees to energy use, usually fail to capture the effects of changing capital stocks. End-use models avoid this weakness by carefully tracking the composition and efficiency of the capital stock, thus allowing the forecaster to incorporate the effects of building energy use design standards, more efficient appliances, etc. into the forecast explicitly.

2.2.1 Load Forecasting Data Analysis

Unit Energy Consumption: One serious weakness of end-use models is that there is usually insufficient data to support the assumptions of energy use by end-use, let alone energy use by vintage of the end-use capital stock (these metrics are commonly referred to as the unit energy consumption, or UEC, in the load forecasting community). In the case of the BPA residential model, the end-use electricity use data was derived primarily from a conditional demand study using the 1979 PNRES survey. In this approach, the household energy use is disaggregated to end-use energy consumption using the composition of the households' energy-consuming capital stock.

The ELCAP database will provide information on electricity consumption by end-use. This data will allow the estimation of the unit energy consumption (or UEC's) directly from field measured data. Field measurement of the UEC's will allow, for the first time, a detailed validation of the models' end-use forecasts, and, perhaps, development of improved forecasting techniques.

Equipment Utilization Indices: ELCAP may also allow additional validation of parameters within the models. These models adjust the forecast of energy use to reflect the change in the utilization of the capital stock arising from changes in fuel prices and income. The parameters used to alter the forecast for utilization effects were derived by assumption--ELCAP could provide the data necessary to estimate the utilization effects directly from Northwest field data.

Homogeneity of Forecast Groups: One of the strengths of the end-use modelling approach is its disaggregate approach. Energy use is built up from geographic regions and specific segments of the capital stock (i.e. end-uses and building types). This type of model presumes that the segments and regions are homogenous in the factors that determine energy use for the segment. ELCAP data will allow a segmentation of ELCAP sites to determine whether the end-uses, building types, and geographic areas currently used in the end-use models are appropriate.

Forecasting Model Validation: Finally, and perhaps most important, ELCAP will provide the data necessary to evaluate the current power forecasting tools used in the Pacific Northwest. It may be quite possible that a new generation of load forecasting models will be developed based on the metered data to correct inadequacies of the current set of models.

2.2.2 Load Forecasting Ancillary Data Requirements

Unit Energy Consumption: This is essentially the same as the conservation assessment potential analysis topic. Additional data on the connected load for each device attached to a mixed use channel will allow the expansion of the number of end-uses for which UEC's can be derived using conditional demand analysis.

Homogeneity of Forecast Groups: The geographic area of the site, its building and occupant characteristics, the types of equipment connected to the electric system, as well as the fuel types of equipment competing with electricity are necessary to perform the segmentation of sites and end-uses.

Equipment Utilization Indices: The data specified above must be supplemented with fuel prices, economic characteristics of the occupant/owner, and income or a business activity index.

2.3 LOAD RESEARCH

A critical piece of information in the power system planning process is the expected load shape in future periods. Because electricity demand varies on hourly, weekly, and seasonal time periods, and because generation plants possess differing economic and operational characteristics, load shape will determine the optimal mix of generating resources. Historically, Bonneville has not provided forecasts of load shape--only forecasts of system peak demand and annual energy use were supported with available data.

Load shape is important in both power system operation and in power system planning. In power system planning, the problem is to forecast the future expected level of demand, and to select the resources best suited to meet the expected demand given both engineering and economic criteria. Because load shape is not constant through time, and because it is affected by the implementation of conservation programs, weather, changes in fuel prices, income (revealed in changes in the electricity consuming capital stock, as well as changes in the utilization of the existing electricity consuming capital stock), and other factors, the resources that will be best suited to meet expected loads will have differing capital and operating costs.

The size and number of the types of generation units will depend upon the size and timing of the load expected to be served. A typical power system will have:

- baseload generation units, with relatively high initial capital costs and relatively low operating costs, that are operated on a relatively continuous basis during all demand periods,

- intermediate generation units, with intermediate levels of both capital and operating costs, that generate power on an intermittent basis during periods of intermediate and peak demands, but may sit in hot reserve during low periods of demand, and

- o peak generation units, with relatively low initial capital costs and relatively high operating costs, that are operated only during periods of high demand.

In order to determine the economically optimal resource mix, (e.g. to trade off the capital cost against the operating cost given the length of time the resource will operate), the expected load shape must be known.

Load shape is also quite important in power system operation. All plants must occasionally be taken out of service for maintenance--maintenance should be scheduled so that the opportunity cost of having the plant out of service is minimized. As is the case in power system planning, some knowledge of the expected load shape is necessary in order to optimize plant maintenance scheduling.

2.3.1 Load Research Analysis

Load Shape: Bonneville is enhancing its load-shape forecasting methodology, relying on the Hourly Electric Loads Model (HELM). Currently, BPA is constructing the data necessary to drive the model from secondary sources, and deriving preliminary forecasts of load shape to evaluate the usefulness of HELM.

The ELCAP database will provide field data capable of supporting the load shape inputs for HELM. ELCAP could support the development of a load shape forecasting model which endogenously determines load shape as a function of weather, capital stock, economic, and demographic variables. ELCAP will be required to support the derivation of load shape profiles by end-use for both the residential and commercial sectors, and may be used to develop weather response functions for the weather dependent end-uses in HELM.

Contribution to Load Shape: A related topic is the contribution of the various end-uses to the system load shape. By understanding what the composition of system load at a particular time is likely to be, a number of strategies can be devised to either control or build load. In other words, before a direct load control program is instituted for water heaters, an understanding of the magnitude of load likely to be controlled at the system peak is desirable. Similarly, if the desired effect is to build load at off-peak hours or seasons, then the potential for additional use at off-peak hours (in part a function of the current use at off-peak hours) must be estimated.

2.3.2 Load Research Ancillary Data Requirements

It is desirable to collect the aggregate system load shape over the time span of metering, so that it will be possible to examine the contribution to peak demand of the aggregation of site end-use load profiles. Additionally, characteristics of the occupants, buildings, and their capital stocks are necessary to construct a load shape model.

2.4 EXTRAPOLATION TO THE REGION

An important aspect of the ELCAP data, as well as the analyses to be conducted, is the extent to which they can be generalized to the region. In the residential metering study, strata weights will be stored in the database for generalization from the metering study to the PNRES sample, and from PNRES to the region as a whole.

For the commercial study, however, no statistical basis for generalization to the region as a whole can be provided. Extrapolation will depend upon a thorough understanding of what drives energy consumption by end-use in commercial buildings. If the ELCAP case study buildings can provide the basis for this assertion, then using data from the regional characteristics survey (to be conducted in FY85), it may be possible to extend the commercial results to the region.

3.0 DATABASE DESIGN

This section outlines the design philosophy for construction of the ancillary database. First, we describe how the data will be accessed and used. Based on the needs for data access, we discuss the requirements of the database manager and select an appropriate tool. Next, the data structures are discussed, followed by a discussion of data entry. The section concludes with a description of the data security measures that will be enforced.

3.1 DATA USE

In the previous section, we discussed the types of analysis anticipated to be performed on the end-use load data and the required ancillary data necessary to support these analysis activities. This section describes how the ancillary data will be accessed and used.

3.1.1 Selection of Building Sites for Analysis

The first use of the ancillary database is selection of metering sites for analysis. Since the ancillary database contains descriptions of the building, its equipment and occupants, and the economic conditions affecting occupant behavior, it must allow the analyst to identify appropriate metering sites for subsequent analysis. It must allow him to define a subset of the 1000 metering sites which have attributes meeting his criteria for analysis. Based upon this list, he must then be able to extract the metered data from the engineering database.

It is not possible to anticipate all of the criteria that may be used to segment the metering sites. For example, the analyst may wish to examine all residential sites where total household income is between $16000 and $30000 annually. The database structure should allow any of the possible values for any of its fields to be used to select metering sites.

3.1.2 Statistical Analysis

The data will also be used in statistical analysis. The characteristics of the buildings, their equipment, occupancy, occupant demographics and economics will be used in hypothesis testing of the load data. For example, the hypothesis that households with higher incomes tend to have more efficient dwellings than households with lower incomes can be tested by combining data from the ancillary database with data from the engineering database.

Statistical analysis may also be conducted on the ancillary database itself, without integration of the load data. Detailed characteristics of the metering sites will be collected and stored as part of the ancillary database--such detailed data has not been collected as part of the regional surveys. Using the strata weights from the regional surveys, it may be possible to aggregate the detailed characteristics to the regional level, or to examine their relationship to the more aggregated characteristics existing in the regional survey databases.

3.1.3 Empirical Analysis

The ancillary data will be used to support development of conservation assessment, load forecasting, and load research tools. For example, ancillary data, in combination with the load data, will be used to calibrate and evaluate thermal simulation models used in auditing commercial buildings.

In summary, the primary uses of the ancillary database will be 1) to identify subsets of the metering sites, 2) to provide the necessary data to support statistical analysis of both the load and ancillary data, and 3) to support the development of load research, conservation assessment, and load forecasting tools. These data uses imply that the ancillary data must be stored in a format that allows sorting, selection based upon a set of criteria, extraction of data into separate datasets, and reporting of the database contents.

3.2 DATABASE MANAGEMENT SOFTWARE

This section discusses the selection of a database manager that fits the criteria listed above. Several additional criteria, however, must also be taken into account.

First of all, the database manager should be a commercially supported product. Development of a database manager from scratch implies that a great number of the problems already overcome by commercial products will be (hopefully) discovered and circumvented. In addition, commercially available products are usually supported by the vendor, which usually implies support of a staff intimately familiar with the design, capabilities, and limitations of the product.

Second, the database manager should allow for flexibility in the definition of the database structure. Perfect foresight as to how the database should be structured is desired--but rarely attained. The database manager should allow the addition of new fields to existing relations, whether the addition is a totally new field or the construction of a field from existing fields.

Third, it should be easy to use the database. We cannot expect the analysts using the database to be proficient in database design and computer programming. A command or query language should be provided so that routine inquiry tasks can be automated or eased. The data entry process should be easy, allowing the use of screen forms similar to the forms from which is stored in only one relation, with the exception of a common attribute used to relate relations to each other. For example, Section 4 presents a proposed tabulation of the ancillary database contents. A first approximation of the construction of relations is evident in the groupings of the data. For example, the site description data are grouped together in one relation, data on the logger forms a separate relation, while energy rate structure data forms a third relation. Data in the first two relations can be combined using the common field SITEID, a field uniquely identifying each metering site. Information on the utility rate structure can be combined with site information data by cross-referencing the SITEID from the site information relation to the SITEID in the utility data relation, and cross-referencing the EUTIL field (identification field for the electric utility) with the EUTIL field in the rate structure relation.

In order to reduce the size of the datasets analysts will be working with and to simplify database management, three separate databanks will be developed, supported, and maintained. One will contain all the information necessary to support the residential metering sites. Another will contain the commercial data, while a third will contain the system load curve. It is not necessary or desirable to maintain the load curve data within RDB--this data will be maintained in a separate file supported by an extraction procedure that allows the user to extract a specific time frame of system load data.

3.4 DATA ENTRY

To the maximum extent possible, all entry of data into the database will be from previously digitized data. Portable computers will be used for entry of the residential audit data onsite. For commercial buildings, the audit data will be remotely entered by the audit contractor using a forms management system.

The measurement plan data will also exist in digitized format from other tasks within ELCAP. The chief data entry tasks consist of entering the utility specific data (rate schedule, etc.) and providing updates to the database when items change. Some of the utility billing information could require data entry, but it appears that almost all of the data will already be available in some machine readable form.

3.5 DATA SECURITY

The ancillary database will be very valuable. The content and structure of the database must be protected from system failures, unauthorized tampering, and corruption. RDB provides facilities for protecting the structure and contents of the database by limiting actions that can be taken by a qualified user. These procedures will be implemented.

Additionally, the database will be backed up on a regular basis to ensure that a unintentional action by a qualified (or, more probably, unqualified) user does not destroy the data. RDB provides methods for ensuring the integrity of data from system failures, and these will also be fully implemented.

4.0 DATABASE CONTENTS

In this section, we present, in tabular form, the specific data items to be included in the ancillary database. In the tables that follow, each data item is given a name, description, and source. Section 4.1 provides a listing of data items that are needed to support the analysis activities identified in Section 2, while Section 4.2 provides a listing of data that can be provided within the current budget and statement of work.

4.1 PROPOSED ANCILLARY DATABASE CONTENTS

The following tabulation describes, in fairly detailed terms, the proposed contents of the ancillary database. The variables have been selected to support the general types of analysis described in Section 2, although there may still remain some omissions.

Please note that a database of this extent is not supported under the existing statement of work.

Variable Name	Description	Source
4.1.1 Site Description Data:		
SITEID	Six byte code assigned to identify site	PNL
BLDGSITE	Number of buildings at site	MP
BLDGMETE	Number of buildings metered at site	MP
CONTACT	Building owner/occupant contact	MP
PHONE	Phone number of building owner/occupant	MP
ADDRESS	Address of building	MP
BLDGTYPE	Type of building	MP
STRATA	Strata from which building was drawn	SAMPLE
WEIGHT	Strata weight	PNRES
STUDY	Member of which study (CAP, PNRES, etc.)	MP
MAJUSE	Type of activity (retail, wholesale, etc.) (applicable only in commercial buildings)	AUD
MAJSIC	Major SIC of building (applicable only in commercial buildings)	AUD
FIRMS#	Number of firms at site	MP
FIRML#	Number of firms in metered building	AUD
WEATHN	Id of closest NOAA weather station	PNL
WEATH#	Id of closest ELCAP meterological site	PNL
WEATHZ	BPA climate zone	PNL
CERTDATE	Date logger was certified as working	05
INSTID	Installer ID	MP
AUDID	Auditor ID	AUD

AUD = Audit
Utility = obtained from utilities
MP = Measurement Plan
CONST = Constructed value
PNL = PNL assigned value
05 = PNL task 05
PNRES = Pacific Northwest Residential Energy Consumption Survey

CAVEATS	Text description of problems in metering this site	MP

4.1.2 Logger Data:

SITEID	6 byte field used to identify each site	PNL,
PNRES		
LOGID	ID of logger	MP
SOFTV	Logger software version	05
HARDV	Hardware version	05
ETEST	Percent deviation of logger measurement and utility meter during certification test	05
GTEST	Percent deviation of logger measurement and utility meter during certification test	05
LOGLOC	Logger location	MP
CHN#	Number of active channels	MP
CHNTYPE	Analogue or digital	MP
SENTYPE	Type of sensor used for this channel	MP
CLBCOEF	Calibration coefficient for sensor	05
PHASE	Voltage Phase if applicable	MP
ENDUSE	End-use assignment of channel	MP
CHNDESC	Description of what channel measures	MP

4.1.3 End Use Data:

SITEID	Six byte code assigned to identify site	PNL
EUEQ	Channel aggregation equation used to define end-use energy use	MP
EUFUEL	End-use fuel type	AUD
EU%MISC	Estimate of % of connected load mixed for this end-use aggregation	AUD

For Commercial buildings:

EUMAJSIC	Major SIC associated with this end-use	AUD
EUMAJUSE	Major functional use associated with end-use	AUD
EUCL1	Estimate of connected load on end-use 1	AUD
EUSQF1	Floor area served by end-use 1	AUD
EUFUSE1	Functional use type served by end-use 1	AUD
EUFUSE%1	Percent of floor area served by end-use 1 which is that functional use	AUD
EUSIC1	SIC served by end-use 1	AUD
EUSIC%1	Percent of floor area served by end-use 1	AUD

AUD = Audit
Utility = obtained from utilities
MP = Measurement Plan
CONST = Constructed value
PNL = PNL assigned value
05 = PNL task 05
PNRES = Pacific Northwest Residential Energy Consumption Survey

Variable Name	Description	Source
	which is primary SIC	
EUCL2	Estimate of connected load on end-use 2	AUD
EUSQF2	Floor area served by end-use 2	AUD
EUFUSE2	Functional use type served by end-use 2	AUD
EUFUSE%2	Percent of floor area served by end-use 2 which is that functional use	AUD
EUSIC2	SIC served by end-use 2	AUD
EUSIC%2	Percent of floor area served by end-use 2 which is primary SIC	AUD
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EUCLN	Estimate of connected load on end-use N	AUD
EUSQFN	Floor area served by end-use N	AUD
EUFUSEN	Functional use type served by end-use N	AUD
EUFUSE%N	Percent of floor area served by end-use N which is that functional use	AUD
EUSICN	SIC served by end-use N	AUD
EUSIC%N	Percent of floor area served by end-use N which is primary SIC	AUD
HVAC1TYP	Type of primary HVAC system	AUD
HVAC1FUL	Primary HVAC system fuel	AUD
HVAC1SQF	Floor area served by HVAC system 1	AUD
HVAC2TYP	HVAC system type, HVAC system 2	AUD
HVAC2FUL	HVAC system 2 fuel	AUD
HVAC2SQF	Floor area served by HVAC system 2	AUD
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HVACNTYP	HVAC system type, HVAC system N	AUD
HVACNFUL	HVAC system N fuel	AUD
HVACNSQF	Floor area served by HVAC system N	AUD
	For Residential Buildings:	
EUCL#X	Connected load of appliance X to end-use #	AUD, MP
EUCL#	Total connected load on end-use #	CONSTRUCT

4.1.4 Utility Data:

SITEID		
EACCTN	Name of Electric account	AUD
EACCT#	Electric billing account number	MP

AUD = Audit
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Variable Name	Description	Source
EBILPD	Electric billing period (date)	Utility
EBILUS	Electric billing consumption (kWh)	Utility
EBILPK	Electric billing peak	
EBILBU	Flag for budget billing	Utility
EBILRA	Id for rate structure applied to account	PNL
EMTRS#	Number of electric meters serving site	MP
EMTRL#	Number of electric meters serving logger load	MP
EUTIL	Electric utility serving site	MP
EUTILF	Flag for type of utility IOU, PUD, REA, etc.	PNL
GACCTN	Name of Gas account	AUD
GACCT#	Gas billing account number	MP Utility
GBILPD	Gas billing period (date)	Utility
GBILUS	Gas billing use	Utility
GBILBU	Flag for budget billing	Utility
GBILRA	Id for rate structure applied to account	PNL
GMTRS#	Number of gas meters serving site	MP
GMTRL#	Number of gas meters serving logger loads	MP
GUTIL	Gas utility serving site	MP
SACCTN	Name of Steam account	AUD
SBILPD	Steam billing period (date)	Utility
SBILUS	Steam billing use	Utility
SBILBU	Flag for budget billing	Utility
SBILRA	Id for rate structure applied to account	PNL
SACCT#	Steam billing account number	MP
SMTRS#	Number of steam meters serving site	MP
SMTRL#	Number of steam meters serving logger loads	MP
SUTIL	Steam utility serving site	MP

4.1.5 Rate Structure Data:

EUTIL	Electric Utility id	MP
EBILRA	Id for electric rate structure	PNL
EEPBK1	Electric energy charge, block 1	Utility
EEPBK2	Electric energy charge, block 2	Utility
EEPBK3	Electric energy charge, block 3	Utility
EEQBK1	Electric quantity in first energy block	Utility
EEQBK2	Electric quantity in second energy block	Utility
EEQBK3	Electric quantity in third energy block	Utility
EDPBK1	Electric demand charge, block 1	Utility
EDPBK2	Electric demand charge, block 2	Utility
EDPBK3	Electric demand charge, block 3	Utility

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Variable Name	Description	Source
EDQBK1	Electric quantity in first demand block	Utility
EDQBK2	Electric quantity in second demand block	Utility
EDQBK3	Electric quantity in third demand block	Utility
GEBK1	Gas energy charge, block 1	Utility
GEBK2	Gas energy charge, block 2	Utility
GEBK3	Gas energy charge, block 3	Utility
GEQBK1	Gas quantity in first energy block	Utility
GEQBK2	Gas quantity in second energy block	Utility
GEQBK3	Gas quantity in third energy block	Utility

4.1.6 Economic/Demographic Data:

	Commercial buildings:	
SITEID		
MAJSIC	SIC used by firm to report employment	AUD
EMPLOY	Firm's employment at this location	AUD
GSALES	Gross sales for previous quarter	AUD
RPTQTR	Reporting quarter for EMPLOY & GSALES	AUD
TENURE	Date firm occupied these premises	AUD
OWNER	Owner occupied building?	AUD
UTIL	Utilities included in rent?	AUD
RENT	Monthly rent	AUD
AVGOCC	Average occupancy (employees + customers)	AUD
PEAKOCC	Peak occupancy	AUD
OWNTYPE	Ownership type (franchise, chain, local)	AUD
NGASA	Natural gas available in area?	AUD
	Residential Buildings:	
SITEID		
INCOME	Total household income	AUD
OWN	Ownership flag	AUD
RENT	Rent per month	AUD
ASSVAL	Assessed value, if owned	AUD
ASSVALY	Year of valuation	AUD
HHSIZE	Household size	AUD
AGE	Age of household head	AUD
UTIL	Utilities included in rent?	AUD
EDUC1	Education of household head	PNRES
EDUC2	Education of spouse	PNRES

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Variable Name	Description	Source
EMPLOY	Number of household members with full-time employment	AUD
PEEXP	Price expectations, electricity (%/yr)	AUD
PGEXP	Price expectations, gas (%/yr)	AUD
POEXP	Price expectations, fuel oil (%/yr)	AUD
TENURE	Year moved in	AUD
NEW	Dwelling new when purchased?	PNRES
NGASA	Natural gas available in neighborhood?	PNRES
	for renters only:	
REF6		
STO6		
OVE6	Response to PNRES question 6	
CW6		
CD6		
DW6		

4.1.7 Building Characteristics Data

Variable Name	Description	Source
	Commercial buildings:	
SQFT	Gross floor area of the metered building	AUD
VOL	Volume of the metered building	AUD
SA	Surface area of the metered building	AUD
SAEXP	Surface area exposed to ambient conditions	AUD
STORIES	Number of stories (including parking and basements)	AUD
STORPAR	Number of stories devoted to parking	AUD
STORBAS	Number of basement stories	AUD
CONTYPE	Construction type	AUD
MASS	Mass of the building	AUD
UA	Weighted U of the building	AUD
WALLSQF	Wall area net of windows	AUD
WALLTYPE	Wall type	AUD
WALLU	Wall weighted U	AUD
ROOFSQF	Roof area net of skylights	AUD
ROOFTYPE	Principal type of roof construction	AUD
ROOFU	Weighted U for roof	AUD
DOORSQF	Door area net of windows	AUD
DOORTYPE	Type of door construction	AUD
DOORU	Weighted U value for doors	AUD
WSQFEA	Window area east orientation	AUD

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Variable Name	Description	Source
WTYPEA	Primary window type, east orientation	AUD
WUEA	Weighted U for east windows	AUD
WSQFWE	Window area west orientation	AUD
WTYPWE	Primary window type, west orientation	AUD
WUWE	Weighted U for west windows	AUD
WSQFNO	Window area north orientation	AUD
WTYPNO	Primary window type, north orientation	AUD
WUNO	Weighted U for north windows	AUD
WSQFSO	Window area south orientation	AUD
WTYPSO	Primary window type, south orientation	AUD
WUSO	Weighted U for south windows	AUD
SKYSQF	Area of skylights	AUD
SKYTYPE	Type of skylight construction	AUD
SKYU	Weighted U for skylights	AUD
MVENRATE	Estimated ach due to mechanical ventilation	AUD
NVENRATE	Estimated ach due to natural ventilation	AUD
USEDFN1	Functional use of area 1	AUD
USESQF1	Area of functional use 1	AUD
USEHSQF1	Area heated, functional use 1	AUD
USECSQF1	Area cooled, functional use 1	AUD
USEDFN2	Functional use of area 2	AUD
USESQF2	Area of functional use 2	AUD
USEHSQF2	Area heated, functional use 2	AUD
USECSQF2	Area cooled, functional use 2	AUD
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USEDFNN	Functional use of area N	AUD
USESQFN	Area of functional use N	AUD
USEHSQFN	Area heated, functional use N	AUD
USECSQFN	Area cooled, functional use N	AUD
EMPSIC1	Employment in largest SIC	AUD
EMPSIC2	Employment in second largest SIC	AUD
EMPSIC3	Employment in third largest SIC	AUD
OCPUSE1	Peak occupancy in functional area 1	AUD
OCPUSE2	Peak occupancy in functional area 2	AUD
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OCPUSEN	Peak occupancy in functional area N	AUD
SCHEDULE	Occupancy schedule	AUD
	Residential:	

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Variable Name	Description	Source
SQF	Total living space	AUD
SQFC	Area of regularly conditioned space	AUD
VOL	Volume of living space	AUD
VOLC	Volume of regularly conditioned space	AUD
STYLE	Style of dwelling (ranch, split, etc.)	AUD
YRBLT	Year built	AUD
YRMOD	Year remodelled	AUD
GCVAP	Ground cover vapor barrier?	AUD
FOUNTY	Foundation type	AUD
UA	Average U	AUD CONS.
FLOUHSA	Area of floors over unheated spaces	AUD
FLOUHST	Type of floor over unheated spaces	AUD
FLOUHSU	Weighted U of floors over unheated spaces	AUD
WALLSQF	Wall area, net of windows	AUD
WALLU	Wall weighted U	AUD
WALLIM	Wall insulation material	AUD
WTN	Primary window type, north orientation	AUD
WSQFN	Window area, north orientation	AUD
WTS	Primary window type, south orientation	AUD
WSQFS	Window area, south orientation	AUD
WSS	Window shading, south orientation	AUD
WTE	Primary window type, east orientation	AUD
WSQFE	Window area, east orientation	AUD
WSE	Window shading, east orientation	AUD
WTW	Primary window type, west orientation	AUD
WSQFW	Window area, west orientation	AUD
WSW	Window shading, west orientation	AUD
ATCON	Attic construction	AUD
ATINS	Attic insulation	AUD
ATVEN	Attic ventilation	AUD
ATU	Attic weighted U	AUD
ATSQF	Attic area	AUD
DOORN	Number of doors, north exposure	AUD
SDOORN	Number of storm doors, north exposure	AUD
DOORUN	Weighted U value of doors, north exposure	AUD
DOORS	Number of doors, south exposure	AUD
SDOORS	Number of storm doors, south exposure	AUD
DOORUS	Weighted U value of doors, south exposure	AUD
DOORE	Number of doors, east exposure	AUD
SDOORE	Number of storm doors, east exposure	AUD
DOORUE	Weighted U value of doors, east exposure	AUD
DOORW	Number of doors, west exposure	AUD
SDOORW	Number of storm doors, west exposure	AUD

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Variable Name	Description	Source
DOORUW	Weighted U value of doors, west exposure	AUD
INTVEN	Interior ventilation	AUD38
PRIMHF	Primary heating fuel	AUD39
WOODTY	Type of wood heating system	AUD40
WOODOA	Outside air for wood heating?	AUD40
WOODLO	Location of wood heating system	AUD40
ELECHT	Type of electric heating system	AUD41a
ELECHL	Connected load of heating equipment	AUD41a
DIST%I	Percent of ductwork insulated	AUD42
CLOCK	Clock Thermostat?	AUD41b
AIRT	Type of air conditioning system	AUD44
AIRL	Connected load of air conditioning system	AUD44
SEPCON	Separate conditioning for attached units?	AUD45
WHS	Solar assist on water heater?	AUD46
WHI	Water heater blanket?	AUD46
WHT	Water heater timer?	AUD48
WHLOC	Water heater location	AUD46
WHD%I	Percent of hot water distribution insulated	AUD47
WHDLOC	Hot water distribution location	AUD47
WHTEMP	Hot water temperature	AUD49

4.1.8 Conservation Data:

ECMP	Energy conservation measures undertaken as part of a conservation program since 1980	AUD
ECMNP	Energy conservation measures undertaken without program since 1980	AUD
ECMCOS	Cost of purchasing and installing ECM's since 1980	AUD Utility
	For commercial buildings:	
EMP	Does firm have an energy management program?	AUD
AUDDAT	Date of most recent energy audit	AUD
AUDINS	Who performed energy audit	AUD
AUDREC	Audit recommendations	AUD
EMS	Is an energy management system installed in building?	AUD
EMSCON	What is controlled by the energy management system?	AUD
NIGHT	Schedule of night setback of HVAC system	AUD

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Variable Name	Description	Source
	For residential buildings:	
RNHDHS	Flag for rooms not heated during heating season	AUD
LR#	Number of living rooms	AUD
DR#	Number of dining rooms	AUD
KWE#	Kitchen with eating	AUD
KWOE#	Kitchen without eating	AUD
B#	Bedrooms	AUD
FR#	Family rooms	AUD
DSS#	Den, study, library, sewing room	AUD
OLR#	Other large room	AUD
OSR#	Other small room	AUD
LRNH	Number of living rooms not heated	AUD
DRNH	Number of dining rooms not heated	AUD
KWENH	Kitchen with eating not heated	AUD
KWOENH	Kitchen without eating not heated	AUD
BNH	Bedrooms not heated	AUD
FRNH	Family rooms not heated	AUD
DSSNH	Den, study, library, sewing room not heated	AUD
OLRNH	Other large room not heated	AUD
OSRNH	Other small room not heated	AUD
SHW#	Number of showers in residence	PNRES
SHWFR#	Number of showers with flow restrictors	PNRES
LIKAUD	Likelihood of audit	PNRES
AUDDAT	Date of most recent energy audit	AUD
AUDINS	Who performed audit	AUD
AUDREC	Audit recommendations	AUD

4.1.9 Load Research Data:

SYSLOAD	System load curve	BPA

4.2 DATABASE CONTENTS SUPPORTED UNDER EXISTING WORK STATEMENT

In the following tabulation, the contents of the ancillary database that can be supported given existing project resources is presented. The following conclusions can be drawn:

- o The contents are not sufficient to conduct many of the desired analyses,

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Variable Name	Description	Source

o The data will support cross-tabulation of the load data by major building, occupant, and economic characteristics.

In the following listing, the contents of the ancillary database that can be supported with existing project funds is presented.

Variable Name	Description	Source
4.2.1 Site Description Data:		
SITEID	Six byte code assigned to identify site	PNL
CONTACT	Building owner/occupant contact	MP
PHONE	Phone number of building owner/occupant	MP
ADDRESS	Address of building	MP
BLDGTYPE	Type of building	MP
STRATA	Strata from which building was drawn	SAMPLE
WEIGHT	Strata weight	PNRES
STUDY	Member of which study (CAP, PNRES, etc.)	MP
EUTIL	Electric utility serving site	MP
EUTILF	Flag for type of utility IOU, PUD, REA, etc.	PNL
MAJUSE	Type of activity (retail, wholesale, etc.) (applicable only in commercial buildings)	AUD
MAJSIC	Major SIC of building (applicable only in commercial buildings)	AUD
FIRML#	Number of firms in metered building	AUD
WEATHN	Id of closest NOAA weather station	PNL
WEATH#	Id of closest ELCAP meterological site	PNL
WEATHZ	BPA climate zone	PNL
CERTDATE	Date logger was certified as working	05
INSTID	Installer ID	MP
AUDID	Auditor ID	AUD
4.2.2 Logger Data:		
SITEID	6 byte field used to identify each site	PNL
LOGID	ID of logger	MP
SOFTV	Logger software version	05
HARDV	Hardware version	05

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Variable Name	Description	Source

4.2.3 End Use Data:

SITEID	Six byte code assigned to identify site	PNL
EUFUEL	End-use fuel type	AUD
	For Commercial buildings:	
HVAC1FUL	Primary HVAC system fuel	AUD
HVAC1SQF	Floor area served by HVAC system 1	AUD
HVAC2FUL	HVAC system 2 fuel	AUD
HVAC2SQF	Floor area served by HVAC system 2	AUD
.		
.		
.		
HVACNFUL	HVAC system N fuel	AUD
HVACNSQF	Floor area served by HVAC system N	AUD
	For Residential Buildings:	
HEATT	Type of heating equipment	AUD
HEATF	Primary heating fuel	AUD
HEATSQF	Floor area heated	AUD
COOLT	Type of cooling equipment	AUD
COOLSQF	Floor area cooled	AUD

4.2.4 Economic/demographic Data:

	Commercial buildings:	
SITEID		
MAJSIC	SIC used by firm to report employment	AUD
EMPLOY	Firm's employment at this location	AUD
OWNER	Owner occupied building?	AUD
UTIL	Utilities included in rent?	AUD
AVGOCC	Average occupancy (employees + customers)	AUD
PEAKOCC	Peak occupancy	AUD
	Residential Buildings:	
SITEID		
INCOME	Total household income	PNRES
OWN	Ownership flag	PNRES

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Variable Name	Description	Source
HHSIZE	Household size	PNRES
AGE	Age of household head	PNRES
UTIL	Utilities included in rent?	PNRES
EMPLOY	Number of household members with full-time employment	PNRES

4.2.5 Building Characteristics Data

	Commercial buildings:	
SQFT	Gross floor area of the metered building	AUD
SAEXP	Surface area exposed to ambient conditions	AUD
STORIES	Number of stories (including parking and basements)	AUD
STORPAR	Number of stories devoted to parking	AUD
STORBAS	Number of basement stories	AUD
CONTYPE	Construction type	AUD
UA	Weighted U of the building	AUD
USEDFNN	Functional use of area N	AUD
USESQFN	Area of functional use N	AUD

	Residential:	
SQF	Total living space	AUD
SQFC	Area of regularly conditioned space	AUD
STYLE	Style of dwelling (ranch, split, etc.)	AUD
YRBLT	Year built	AUD
FOUNTY	Foundation type	AUD
UA	Average U	AUD CONS.
WALLSQF	Net wall area	AUD
WINSQF	Area of Windows and doors	AUD
WALLU	Wall weighted U	AUD
WALLIM	Wall insulation material	AUD
ATU	Attic weighted U	AUD
ATSQF	Attic area	AUD
WOODTY	Type of wood heating system	AUD
CLOCK	Clock Thermostat?	AUD
AIRT	Type of air conditioning system	AUD
AIRL	Connected load of air conditioning system	AUD
SEPCON	Separate conditioning for attached units?	AUD
WHS	Solar assist on water heater?	AUD
WHI	Water heater blanket?	AUD
WHT	Water heater timer?	AUD

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Variable Name	Description	Source
WHTEMP	Hot water temperature	AUD

4.2.6 Conservation Data:

ECMP	Energy conservation measures undertaken as part of a conservation program since 1980	AUD
ECMNP	Energy conservation measures undertaken without program since 1980	AUD
	For commercial buildings:	
EMP	Does firm have an energy management program?	AUD
AUDDAT	Date of most recent energy audit	AUD
AUDINS	Who performed energy audit	AUD
AUDREC	Audit recommendations	AUD
EMS	Is an energy management system installed in building?	AUD
	For residential buildings:	
RNHDHS	Flag for rooms not heated during heating season	AUD
AUDDAT	Date of most recent energy audit	AUD
AUDINS	Who performed audit	AUD
AUDREC	Audit recommendations	AUD

4.2.7 Load Research Data:

SYSLOAD	System load curve	BPA

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