ELCAP

End-use Load and Conservation Assessment Program

Overview

Objectives and Methods

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Bonneville Power Administration
Portland, Oregon

INTRODUCTION

The End-use Load and Conservation Assessment Program (ELCAP) is designed to support BPA's load forecasting and conservation program planning functions. Jointly sponsored by BPA's Offices of Conservation and Power Management, ELCAP employs state-of-the-art monitoring equipment developed by Battelle Pacific Northwest Laboratories. Data concerning end-use electricity demand will be collected on an hourly basis from samples of residential and commercial structures in the Pacific Northwest. In addition, structures will be inspected, occupants will be interviewed, indoor temperature monitored, and, in selected sites, outside weather data collected.

Objectives

The following interests have influenced the design of ELCAP:

1. Hourly and peak load forecasting

2. Short and long-term annual forecasting

3. Assessment of the impacts of conservation measures and load management techniques

4. Evaluation of BPA conservation programs

5. Assessment of the effects of the Northwest Power Planning Council's (NPPC) proposed energy efficiency building standards

6. Evaluation of BPA standard heat loss analysis procedures

7. Evaluation of the performance of various computerized mathematical heat loss models

The above order is not intended to imply relative influence. To the extent possible, design objectives have been arrived at by concensus.

Although similar types of data will be collected from both residential and commercial structures, ELCAP is best viewed as three related, but separate projects:

ELCAP/R - Residential

ELCAP/C - Commercial

ELCAP/MF - Multifamily

RESIDENTIAL

The sample for ELCAP/R has been drawn from two sources: the 1983 Pacific Northwest Residential Energy Survey (PNWRES-83); and the units constructed under the Residential Standards Demonstration Program (RSDP) (see figure 1). Approximately 500 units representing existing construction will be drawn from the PNWRES-83; approximately 200 from the RSDP. This section provides a brief description of the samples and the procedures used for selection.

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* For a complete description of the sampling procedures employed, see "End-Use Load and Conservation Assessment Program: Residential Sample Design" BPA, forthcoming.

Existing Construction

The sample of existing structures has been drawn from those which participated in the PNWRES-83 using a multistage stratified random design*. Due to the expense of the data collection equipment (about $3,000 per site, installed), the sample is limited to 500 units. To insure adequate representation of the critical population, the sample frame has in turn been limited. To further insure adequate distribution over critical characteristics, the final sample frame has been highly stratified.

The sampling procedures have been designed and executed through an interactive method involving discussion with BPA analysts and analyses of initial PNWRES-83 data.

As a result of this process, the PNWRES-83 sample has been stratified on the basis of the following nine characteristics.

1. Space heating fuels

   - electricity using permanently installed equipment
   - wood
   - forced air natural gas or oil
   - combinations of the above
   - other

2. Number of units in the structure

   - 1
   - 2-4
   - 5 or more

3. Occupancy

   - owner
   - renter

4. Attachment

   - detached
   - attached

5. Type of construction

   - site
   - factory (includes mobile)

6. Year built

   - Before 1960
   - 1960-1978
   - 1979-1982

7. Income

   - Under $16K
   - $16-$35K
   - Over $35K

8. Geographic location

   - Western Oregon and western Washington
   - Eastern Oregon and eastern Washington
   - Idaho and Montana

9. Type of ownership of serving electric utility

   - Public
   - Investor

As depicted in Figure 1 and Table 1, five separate samples have been selected from the PNWRES-83 using varying combinations of these characteristics.

Base Sample: Because they comprise the largest portion of the residences of primary concern to BPA and its customers, the largest portion of the sample (400 units) has been selected from those with the following characteristics:

   o permanently installed electric space heating equipment is reportedly installed

   o single family

   o owner occupied

   o detached

   o site constructed

"Reportedly" is stressed because the information on which this selection is made derives from occupants' responses to the personal interview conducted as part of the 1983 Pacific Northwest Residential Energy Survey (PNWRES-83). Prospective residences have been selected from the 4,703 which participated in the PNWRES. Of the 1,446 units which satisfied these criteria, an additional 33 were eliminated if they both:

> o failed to sign a waiver permitting access to their fuel billing histories; and

> o reported that they had not had an energy audit and expressed little interest in receiving an audit.

Of the 400 units selected, 12 had failed to sign a waiver. As part of the ELCAP contact procedures, all occupants will be asked to sign open-ended waivers. Those which again refuse to sign will be rejected.

In selecting the 400 owner-occupied, electrically heated residences for ELCAP, the final frame of 1,413 PNWRES units was further stratified based on the following criteria:

o   Geographic Area

   - West of the Cascades
   - Oregon and Washington East of the Cascades
   - Idaho and Western Montana

o   Serving Utility Type

   - Public
   - Investor

o   Income

   - Less than $16,000
   - Between $16,000 and $34,999
   - $35,000 and Over
   - unknown

o   Year unit was constructed

    - Before 1960
    - Between 1960 and 1978
    - 1979 and after
    - unknown

o   Presence of wood stove or fireplace insert

    - No
    - Yes

This yields a matrix comprised of 128 cells or "strata" with an average of between 13 and 14 units per cell. Overall, each eligible PNWRES unit had about a 1:4 chance of being selected for the ELCAP (p = .293). For each of the residences selected, a potential replacement was selected from the same stratum according to the following priorities:

1. Same electric utility meter reading route

2. Same electric utility

3. The geographically closest electric utility of the same ownership status (public vs. investor owned) and similar service territory (urban - rural).

In most cases, the replacement is located in at least an immediately adjacent utility.

In each unit selected, each circuit on the electric service panel will be separately monitored. As a minimum, data will be available for each of the following end-uses:

1. Space heat
2. Water heat
3. Lights and convenience outlets

In a large percentage of the residences, data will also be available for:

4. Cooking (range, oven)
5. Clothes washing
6. Clothes drying

To the extent they are available, data may be available for:

7. Refrigerators
8. Freezers
9. Dishwashers
10. Dehumidifiers
11. Hot tubs, jaccuzi's, sauna's
12. Air-to-air heat exchangers

In some cases, it may also be possible to isolate lights and outlets in specified zones of the house--for example kitchen, bathroom, recreation room. If a wood stove is in the residence, a simple temperature sensitive switch will be installed to monitor usage.

Pilot testing of the contact, recruitment, and installation procedures was begun in April 1984, with full field operations scheduled to begin in July 1984. The target for completion of the installation is the end of October 1984.

Following installation, each residence will be inspected by energy professionals. A brief survey will be conducted in November 1984 to update information concerning the current occupants. Similar surveys will be repeated on at least an annual basis; no more than three surveys will be conducted in any one year.

Case Studies: Each of the following case studies is systematically targeted on important subsectors of the remainder of the population.   In an effort to maximize comparability, each case study sample represents a variation in one of the Base Sample selection characteristics.   The only exception is the number of units in the structure: multifamily buildings (5 or more units) are covered under a separate ELCAP study.

In each case, samples of 25 units are to be drawn from the PNWRES-83.   The samples are as follows:

o   Case Study #1 – Units are attached to other single family units on at least one side (excluding roof or floor).

o   Case Study #2 – Mobile or manufactured units as opposed to site constructed.

o   Case Study #3 – Units occupied on a rental basis.

o   Case Study #4 – Units heated with forced air natural gas or oil furnaces.

A fifth Case Study will involve units selected into the Base Sample, but which use both electricity and gas or oil for purposes of space heating.   They may, in addition, use wood.   These "mixed fuel" units will be drawn on an "as encountered" basis.   That is, if upon contact, the occupants express interest and are willing to participate, but the unit uses both a forced-air, fossil
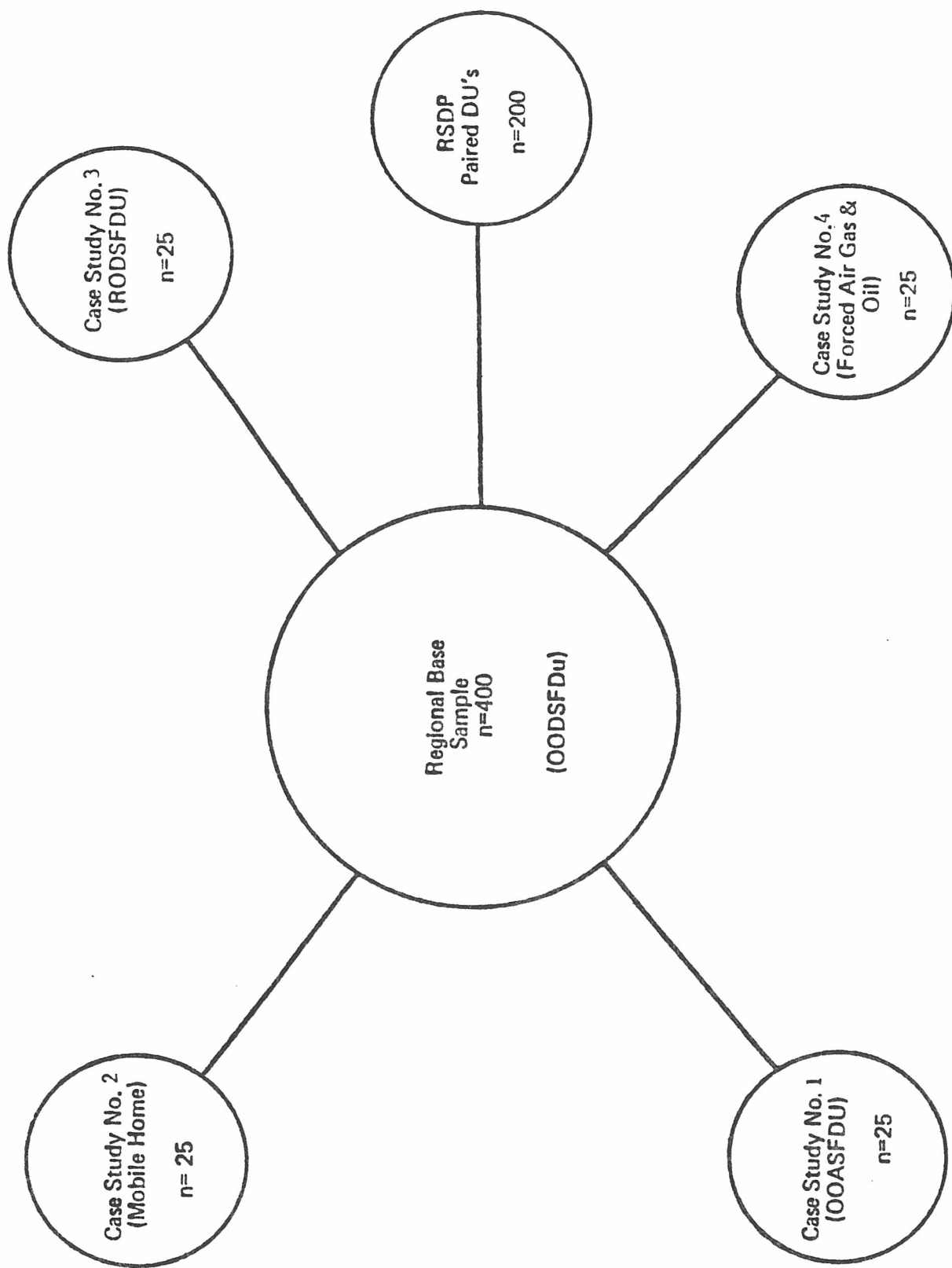
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Figure 1

END-USE LOAD AND CONSERVATION ASSESSMENT PROGRAM

Residential Sample Design

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                          Full PNWRES 1/
                            N = 4703
                           2,967,093
                    /                        \
           PESHE 2/                              Non-PESHE
        N = 2685 (57%)                          N = 2018 (43%)
        1,608,828 (54%)                         1,360,266 (46%)
        /         \                            /              \
                              +----------------------+
                              | Case Study 4         |
                              | Single Family        |
                              | Owner Occupied       |
                              | Detached Unit        |
                              | Forced Air Gas-Oil   |
   Multifamily    Single Family | as Primary Fuel    |    Other
   N = 215 (5%)   N = 2470 (53%) | N = 516 (11%)     |    N=1502 (32%)
   252,085 (9%)   1,356,743 (46%)| 506,603 (17%)     |    853,663 (29%)
                     /       \  +----------------------+
            Other         Renter Occupied        Owner Occupied
            N = 33 (7%)   N = 477 (10%)          N = 1960 (42%)
            12,975 (.4%)  354,885 (12%)          988,883 (33%)
                          /       \              /            \
                                +-----------------+       +-----------------+
              Other           | Case Study 3    |       | Case Study 2    |
              N = 248 (7%)    | Detached Unit   | Standard Home  | Mobile Home |
              197,080 (7)     | N = 229  (5%)   | N = 1566 (33%) | N = 394 (8%)|
                              | 157,805  (5%)   | 785,283  (26%) | 203,600 (7%)|
                                +-----------------+  /    |    \  +-----------+
                                            +-----------------+  +-----------------+
                              Missing       | Base Study      |  | Case Study 1    |
                              N = 26 (.6%)  | Detached Unit   |  | Attached Unit   |
                              13,240 (.4%)  | N = 1446 (31%)  |  | N = 94 (2%)     |
                                            | 723,300  (24%)  |  | 48,743 (2%)     |
                                            +-----------------+  +-----------------+
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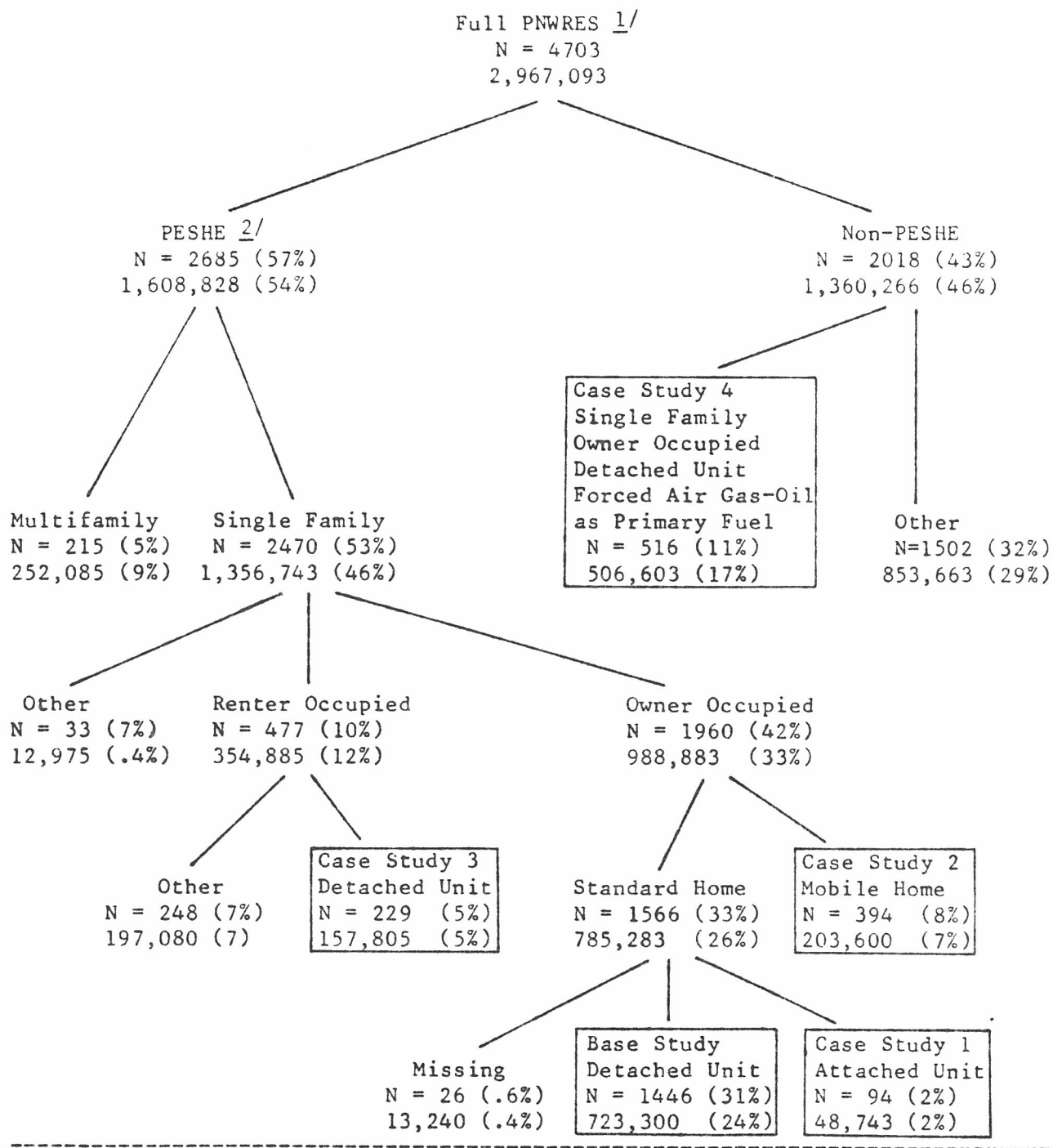
Table 1. Interrelationships of ELCAP 3/ base and case studies within the
PNWRES framework. The N equals the actual number of households in PNWRES and
the number below is an estimate of the total number of households in the BPA
Service Area (percentage of total in parenthesis).

1/ PNWRES-Pacific Northwest Residential Energy Survey
2/ PESHE-Permanent electric space heating equipment
3/ ELCAP-End-use load and conservation assessment program

fuel furnace and permanent electric space heating equipment, it will not be rejected; it will be included in this fifth Case Study and the replacement house will also be selected into the Base Sample.

In an effort to reduce costs, units for each of the four designed case studies have been selected which are "geographically proximate" to units included in the Base Study. In most instances, units are either on the same electric utility meter reading route or in the same mail zip code area as Base Study units.

New Structures

The sample of new residential structures will be drawn from those constructed under the Residential Standards Demonstration Program (RSDP). The program is sponsored by BPA and administered through the four state energy offices in an effort to demonstrate the Northwest Power Planning Council's model residential energy standards. Up to 200 units constructed under the RSDP will be asked to participate in the ELCAP. The units are to be constructed in pairs such that approximately 100 units will have been constructed to meet the Model Conservation Standards (MCS). The remaining 100 units are to represent current construction practices and each is to be "comparable" to a specified MCS dwelling. The units are to be distributed over the States as illustrated in Table 2.

	Model Council Standards	Control	Total
Washington	45	45	90
Oregon	30	30	60
Idaho	15	15	30
Montana	10	10	20
Total	100	100	200

TABLE 2

Residential Standards Demonstration Program

Sample of Paired Dwelling Units

The ELCAP monitoring will be anticipated at the time of construction. An empty panel box will be installed adjacent to the service panel; a telephone line will be pulled to the empty box; temperature sensor leads will be pulled to boxes in at least three separate locations in the dwelling; to the extent possible, all major appliances will be served from separate circuits; and to the extent possible, lights and convenience outlets will be grouped so as to isolate at least the kitchen and the bathroom(s).

Information pertaining to the thermal characteristics of the RSDP units and major installed equipment and appliances will be obtained from blueprints and periodic inspections to be carried out in conjunction with the program. Any necessary additional information will be obtained by inspection at the time the recording equipment is installed. Information concerning the residents and their household appliances will be obtained through a brief survey form.

COMMERCIAL SECTOR

Our current state of knowledge concerning energy consumption patterns in the commercial sector is less well developed than is that concerning the residential sector. Furthermore, data collection procedures are more complex and hence more costly than those appropriate to the residential sector.

With partial BPA support, Seattle City Light (SCL) initiated an extremely productive end-use recording effort in 1983 with a phased sample of first two and ultimately 8 commercial structures served by SCL. The project proposed here is designed to build on the experience developed through SCL's efforts and to extend the results in two directions simultaneously. First, the sample will be extended to include a larger variety of buildings in Seattle. The second extension will be to include buildings which actually undertake energy conservation efforts.

This project brings together several BPA interests, including load forecasting, conservation assessment, and conservation marketing. The actual hourly end-use load data will serve as input to hourly load forecasting models; the results of the building simulations will support conservation assessment efforts; and comparisons between the simulation results and actual usage patterns for buildings which adopt conservaton measures will assist in assessing the impacts of conservation measures and in calibrating the simulation models employed.

The full study will encompass up to 250 buildings. Approximately 200 will be selected from the SCL service territory and up to 50 will be selected from successful applicants under the Commercial Financial Incentives Program (CFIP) and the Commercial Audit Program (CAP) (see figure 2). Each building will be fitted with multichannel hourly end-use recording equipment and will be subjected to a thorough energy audit. In addition, the building owners and managers may be interviewed. For a minimum of 30 buildings, characteristics data from the energy audit will be input to standard heat loss simulation models (i.e., DOE 2.1), and the results benchmarked to the actual usage patterns. It will then be possible to simulate the installation of various conservation measures and to derive estimates of the energy savings.

At least in the case of those buildings participating in the CFIP, various conservation measures will be installed and/or changes made in the management of certain energy-using equipment, especially the HVAC system.

Seattle Study

The sample of buildings to be selected from the SCL territory has been designed to represent two major classes of buildings found in the Seattle commercial buildings stock. The two classes to be represented are as follows:

o Buildings which were constructed prior to adoption of the Seattle Energy Code (January 1981); and

o buildings which have been constructed since adoption of the new Seattle Energy Code.

Pre-Code Sample

The sample of pre-code buildings is a two phase, stratified random selection of 170 buildings. The sample is to be selected from a listing of all commercial tax parcels located within the Seattle City Light service area. The sample of 30 post-code buildings is to be selected from a listing of all permits which have been issued by the Seattle Department of Construction and Land Use since the new code went into effect--approximately January 1981.

In order to control unit costs and increase the chance of achieving the targeted sample sizes, "very large buildings" and "sprawling" facilities have been deferred. A "very large building" is more than six stories high and/or has more than 100,000 square feet of floor area. A "sprawling" building is defined as one with multiple power centers, any one of which is more than 100 feet from a centrally located data logger. These large and sprawling buildings will be included in the sample frame and placed in a separate category within each building use type. Later in the study a decision will be made on whether to include any of these structures as part of the sample which is instrumented. At that point it will be possible to assess, based on actual data collection costs, the impact on the final sample size of including these "very large" and "sprawling" buildings.

Pre-Code Sample*: The first phase of the sampling process involves stratification of the tax parcels by type of use based on Standard Industrial

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* A complete description of the procedures used to select the sample of pre-code buildings is contained in "End-Use Load and Conservation Assessment Program: Commercial Sample Design, BPA, forthcoming.

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Classification (SIC) codes. Using four-digit SIC codes, tax parcels have been grouped into ten major types, as follows:

- Warehousing
- Dry goods retail
- Grocery
- Restaurant
- Office
- Lodging
- School
- Health care
- Other
- Not elsewhere classified

In the case of certain major groups which are highly heterogenous, minor building types have been identified.

The sample of 170 pre-code buildings has been allocated to each of the use type categories in proportion to best estimates of the categories' portion of annual regional electricity consumption. Annual electricity sales by SIC group were obtained from the four largest utilities in the BPA service area:

- Portland General Electric (PGE),
- Pacific Power and Light (PP&L),
- Puget Sound Power and Light (PSP&L), and
- Seattle City Light (SCL).

Sales data were for the years 1981 and 1982. After converting the data to a comparable format, they were grouped into the nine use types listed above. At this point, the sales category "Other" includes both the use types "Other" and "Not Elsewhere Classifed."

The other source of data on the distribution of regional sales by building type was provided by Synergic Resources Corporation (SRC). These estimated data are the result of studies SRC has carried out for BPA in support of the Division of Power Forecasting's effort to revise its Commercial Sector Forecasting Model. A comparison of the estimated sales shares between the average of the four utilities and the SRC data is presented in Table 3. Both data sources are subject to a wide variety of errors including basic classification errors in raw sales data and building permit data. A quantitative assessment of the relative error seemed impossible. The best available assumption was that both sets of estimates were of equal precision and that the true values might be best represented by a simple average. This average estimate was adopted as the basis for assigning sample proportions to these nine major building types. The average values are also shown in Table 3.

Table 3

IMPACT OF AVERAGING ESTIMATES OF

ELECTRICAL USE BY BUILDING

USE TYPE

PERCENT OF COMMERCIAL SALES

BUILDING USE TYPES	FOUR UTILITIES	SRC EUI MODEL	AVERAGE OF BOTH SOURCES
WAREHOUSE	7.25%	10.60%	8.93%
DRY GOOD RET	14.85%	18.99%	16.92%
GROCERY	10.21%	8.08%	9.14%
RESTAURANT	6.67%	11.50%	9.08%
OFFICE	20.68%	20.06%	20.37%
LODGING	3.90%	3.02%	3.46%
SCHOOLS	10.50%	11.86%	11.18%
HEALTH	5.54%	5.47%	5.50%
OTHER	20.41%	10.42%	15.42%
ALL TYPES	100.00%	100.00%	100.00%

The effort to classify SIC codes and Land Use codes into major and minor building use types resulted in the conclusion that the nine categories shown in Table 3 are not sufficiently detailed for the purposes of this study. In particular the categories of schools, health, and other needed to be broken down further in order to arrive at groups which could be expected to be homogeneous with respect to their pattern of energy use. The data from PGE, SCL, PP&L, and PSP&L and, in some categories, the SRC data provided

information on which to base more detailed estimates in these categories. The total share in the major category was held constant. The minor categories were calculated as a percentage of the major category. Table 4 shows the final results of this estimation procedure. The percentages shown are the final set of proportions used in selecting the first phase sample.

The final procedure for disaggregating sales shares also produces an estimate for the "not elsewhere classified" category. This category is estimated to approximately two thirds of the consumption for the "other" category as shown in Table 2. This share of consumption is primarily attributable to customers in the Major SIC group 40, Transportation, Communications, Electric, Gas, and Sanitary Services. Commercial customers like water district pumping stations, municipal waste treatment, and electric power plants would be found in this group.

TABLE 4

ELECTRICAL USE BY MAJOR AND MINOR BUILDING USE TYPES

PERCENT OF COMMERCIAL SALES

BUILDING USE TYPES	AVERAGE OF SRC AND FOUR UTILITIES
WAREHOUSE	8.93%
DRY GOOD RET	16.92%
GROCERY	9.14%
RESTAURANT	9.08%
OFFICE	20.37%
LODGING	3.46%
SCHOOLS	11.18%
ELEM/SEC	7.41%
COLLEGES	3.77%
HEALTH	5.50%
HOSPITALS	3.07%
NURSING HOMES	2.08%
LABS	0.23%
OTHER	0.13%
OTHER	4.64%
ASSEMBLY	2.02%
MOVIES	0.15%
PUBLIC ASSEMBLY	0.26%
MUSEUMS/ART GAL	0.18%
CHURCHES	1.43%
AUTO REPAIR	0.44%
SERVICE STATIONS	0.73%
POST OFFICE	0.32%
LIBRARIES	0.14%
LAUNDRIES	0.40%
SPORTS CLUBS	0.26%
BAKERIES	0.14%
FUNERAL HOMES	0.08%
FIRE STATION	0.07%
POLICE STATION	0.02%
NOT CLASSIFIED	10.77%
ALL TYPES	100.00%

From the original list of 13,961 tax parcels, 2,978 had improved values of less than $10,000. These parcels were eliminated from the frame as it seemed unlikely that any structure classified as a commercial building would have a tax value less than $10,000. From the remaining 10,982 parcels, a sample of 1,052 was selected with probabilities corresponding to the proportions presented in Table 4.

Following selection, information concerning the gross floor area, number of stories and year of construction were obtained for each parcel. Based on this information, buildings in each use type category have been divided into five combined age-size strata, as follows:

- Large old group
- Large young group
- Small old group
- Small young group
- Very large buildings

The criteria used to define "Very large buildings" included, (1) buildings over six stories; and (2) buildings with more than 100,000 square feet. This definition differs slightly from that provided previously because no direct measure of "sprawling facilities" is available.

The breakpoints for distinguishing old and young, small and large buildings vary over the use type categories and are based on observed frequency distributions prepared for each of the major use types. Quotas were then established for each stratum within each use type category. The number of cases assigned to each stratum is proportional to that stratum's share of the respective major use type floor area, as determined in the first phase sample.

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The second phase of the sampling process involves a drive-by survey of at least 400 of the 1,052 parcels selected in the first phase. These 400 will be distributed according to the sample proportions derived previously. The surveys will be conducted using the first 400 parcels selected from a random ordering within each size-age stratum.

Parcels which are vacant, contain a building of a different use type, or contain a building with confused circuit layout or mixed end-uses on individual circuits will be eliminated from the sample. Replacement parcels will be added from the random order listing.

The end-use disaggregation will vary over sampled structures depending on the use-types contained in the structure and the availability of separate end-use loads at the electric service panel. As a minimum, data will be available for the following end-use categories:

1.   Heating, ventilating, and air conditioning system (HVAC)

2.   Lights

3.   Other

To the extent possible, the three components of the HVAC system will be monitored as separate end-uses. In some cases, it may also be possible to divide the structure into two or more zones and monitor the HVAC or its components separately for each zone. Similarly, the lighting load may be divided into at least two groups:

2a.   Indoor lighting

2b.   Outdoor lighting

The latter group may be further divided into,

    2b.i. Display lighting

    2b.ii. Area lighting

The structure may also be divided into zones with indoor lighting separately monitored in each zone. Whenever a building is divided into zones for purposes of monitoring both the HVAC and lighting loads, comparable zone boundaries will be used.

The "Other" category may be divided into two broad categories as follows:

    3.a. Major uses

    3.b. Minor and miscellaneous uses

The "major uses" will vary most dramatically over the "building use type" categories, as indicated in Figure 2. In some cases, the availability of the end-use as a separate load is a criterion for acceptance of the structure. For example, if it is not possible to isolate the "cooking load" in a sampled restaurant, the structure will be rejected. These "criterion situations" are indicated by an "X" in Figure 3.

In other cases, the availability of the end-use load may be critical, depending on the estimated proportion of the total load presented by its end-use. For example, in a refrigerated warehouse, it must be possible to isolate the "refrigeration" load; otherwise, the building will be rejected from the sample.

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Following the selection of each building into the final sample, the signing of an access agreement, and the installation of the monitoring hardware, each building will be thoroughly inspected by trained professionals. For at least 20 buildings, the results of "energy audits" will be input to a heat-loss simulation model (i.e., DOE 2.1). The subsequent analyses will serve a variety of purposes, including:

o   evaluation of the model

o   assessment of the interaction between various end-use categories

o   assessment of the estimated impacts on the hourly load shape and aggregate electricity consumption of various energy conservation measures.

	1	2	3	4	5	6	7	8	9	10
Cooking				X			/	/		
Refrigeration/ Freezing	X*		X	X			/	/		
Water Heating			/	X	/	X	/	X		
Data Processing			/		/		/	/		
Elevators/Escalators		/				/		/		
Special Equipment							/	X		

Figure 3

Other Major End-Uses by Building Use Type

INDEX

Building Use Types
1. Warehousing
2. Dry goods retail
3. Grocery
4. Restaurant
5. Office
6. Lodging
7. Schools
8. Health
9. Other
10. NEC

Building End-Uses

X – Required
/ – As available

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* – Required for refrigerated or freezer warehousing

Post-Code Sample: The selection of recently constructed buildings is highly constrained. The sample has been confined to only six major use types and comprises nearly all of the available stock of these types. The 30 post-code buildings will be distributed equally over the six most important major use type categories--five per category.

Although it is neither large nor intended to be representative, the sample of post-code buildings is of considerable analytic significance. The Energy Code adopted by the Seattle City Council in 1980 is a close approximation to the model energy standard proposed for the commercial sector by the Northwest Power Planning Council.

The end-use disaggregation requirements for post-code buildings are the same as those previously described for pre-code buildings. Thus, the HVAC and lighting loads will be separately monitored in all structures and, in most cases, will be futher subdivided. The availability of the major end-uses will also vary over the building use-types as indicated in figure 3. Each of the post-code buildings will also receive a thorough inspection and, for at least 10 buildings, the results will serve as input for a series of DOE 2.1 simulation analyses.

BPA Programs

Up to 50 buildings from two of BPA's commercial conservation programs will be invited to participate in the ELCAP. The invitations will be divided about equally between the two programs.

Commercial Financial Incentives Program: The CFIP is a second phase field test of a mechanism by which BPA might purchase the energy savings from buildings which take energy conservation measures (ECM). The detailed end-use monitoring conducted as part of the ELCAP will assist in the measurement of the impacts of the ECM's on the hourly load profiles of the buildings. The data will also support testing of the procedures used by the proposers to estimate savings and to evaluate the performance of the DOE 2.1.

Final contracts with the CFIP participants will be negotiated by June 1984. Access agreements are to be negotiated, immediately followed by installation of the hardware. To the extent possible, installation will precede implementation of at least all ECM's requiring capital investment. Data concerning the building characteristics including an audit sufficient to support DOE 2.1 analyses are to be provided as part of the CFIP.

In general, preference will be given to buildings located in climates similar to Seattle's, and to buildings in the "dominant" use-type categories, as described earlier. "Very large," or "sprawling" structures will be reviewed on a case-by-case basis, and buildings with confused circuitry may be rejected. The monitoring plans will follow the pattern described previously, (Figure 3) with special regard for these end-uses likely to be affected by the proposed ECM's.

Commercial Audit Program: The CAP involves a subsidized audit program in which electric utilities and energy consulting firms solicit requests and conduct audits of buildings used for commercial purposes. The audits will result in a series of recommendations, including appropriate ECM's with varying costs and expected savings. The program does not include financial assistance for the implementation of any of the ECM's.

It is anticipated that in most cases the "low cost/no cost measures" will be taken, and that, in some cases, building owners may independently take measures which involve capital investments. The ELCAP monitoring will assist in measuring the impacts of these measures on the hourly load profile as well as at greater levels of aggregation of electricity usage. The monitoring and subsequent analyses will also contribute to improving and refining the audit methodology, including assessments of the accuracy of measure savings estimates.

The CAP sample will be selected after the CFIP sample. Thus, in order to conserve installation costs, preference will be given to buildings which are geographically proximate to those participating in the CFIP. Again, "very large," and sprawling" structures will be reviewed on a case-by-case basis. Buildings with confused circuitry are likely to be rejected. As in the CFIP, the monitoring plans will parallel those used in the SCL study.

MULTIFAMILY

For purposes of the ELCAP, structures containing five or more residential units are defined as "multifamily buildings." Clearly, the energy end-uses and load shapes in such buildings are predominantly residential in nature. However, the necessary recruitment and installation procedures are likely to be more akin to those used in the commercial sector. As a result it seemed appropriate to treat multifamily buildings as a separtate study within the ELCAP.

Due to a variety of factors, including high potential costs, high potential risk, and expected evolution in the data acquisition hardware, selection, recruitment, and installation of multifamily buildings is to be lagged behind the comparable single family residential and commercial sectors. Selection and recruitment are expected to begin in September 1984 at the earliest.

Based on the results of the 1983 PNWRES, residential units located in multifamily buildings account for approximately 10 percent of the regional stock and approximately 15 percent of those which use electricity for space heating purposes. Multifamily buildings which are classified as commercial accounts by electric utilities generally account for approximately 15 percent of the annual commercial electricity load in the region. If the sector were to be treated proportionately to the single family sector, between 40 and 60 units would be selected, perhaps in separate buildings. Based on their contribution to commercial energy use, approximately 30 buildings would be selected. Due to the sophistication of the equipment being used, the marginal

costs associated with monitoring additional units in a given building are relatively low. Assuming an averge of 8 units per building, a sample of 30 buildings would produce data for up to 240 units. In an effort to minimize costs, we have reduced the sample to 25 buildings, distributed as described in Table 5.

Seattle	10
Portland/Eugene	5
Klamath Falls	3
Tri-Cities	3
Spokane/Bend	4
TOTAL	25

Sample of Multifamily Buildings

Proposed Distribution By Site

TABLE 5

In buildings containing 10 or fewer units, up to five end-uses will be separately monitored in each unit. Additional channels will be used for whole-building uses and for micro-climate data. In larger buildings, samples of units will be selected for end-use monitoring. Only the total hourly load will be monitored in the remaining units, in addition to whole buildings uses.

Detailed energy audits are to be completed for each of the selected buildings and the occupants will be queried early in the project and periodically as needs arise, but no more than three times a year.

Seattle Study

The Seattle portion of the study is to be conducted in conjunction with a study being conducted by SCL. Using Water Department records, SCL is selecting succesive concentric samples of 100 and then 45 buildings which will receive detailed energy audits. BPA will select a stratified sample of 10 buildings which use electricity for space heating purposes. The procedures developed during this portion of the project will serve as a model for selecting samples in the five other locations.

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