SAMPLING AND ESTIMATION PROCEDURES FOR ELECTRIC UTILITY EXPERIMENTS

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1. Background

Historically, the fields of experimental design and of sample surveys have been largely treated as separate methodological areas in the field of statistics. Sample surveys are typically concerned with characterizing a given finite population or assessing an existing situation, whereas the experimental setting involves making an assessment of behavior under, or characterization of the response to, purposefully-imposed changes. Because of these diverse objectives, the two methodological areas usually do not occur in a single application.

Although the two fields have been frequently combined in pilot survey contexts (e.g., for evaluating different data collection techniques), the direct use of experimental techniques in a survey context is rather limited. A notable exception occurs in the field of indirect load management studies conducted by electric utility companies (or sponsored by utility regulators). Other research applications might also be formulated in such a fashion. In such studies, inferences to a specific finite human population are obviously desired; implementing experimental conditions on a sample from this population allows one to draw (limited) inferences about how the entire population would respond or behave if a "treatment" had been implemented on a population basis. The actual population to which statistical inferences may be extended is the effective population--that portion of the total population that would (and could) have participated in the actual implementation of a "treatment". Clearly, the effective population appropriate for a given study depends upon the experimental and screening procedures used. Hence, these procedures as well as other experimental conditions, need to be as close as possible to implementation conditions so that a meaningful effective population is achieved.

The purpose of this paper is to develop and illustrate techniques for estimating certain types of effective population parameters, and their variance approximations, for a limited class of such screening/experimental designs. While these procedures are described and illustrated in terms of electric utility experiments, they are nevertheless applicable to a broad range of experiments utilizing probability samples from finite human populations.

2. Basic Sampling Structure for Electric Utility Experiments

Inferences in electric utility experiments are generally intended to be made for all customers in a given class of the utility's service area or some specific subgroup of this class. Moreover, experiments conducted on this class of customers are more often than not randomized block designs in which blocks are defined by experimental strata formed by grouping customers having at least similar historical electric usage characteristics. A third important feature of these experiments is their voluntary nature. A general sampling strategy for such experiments is depicted in Figure 1 as consisting of six steps:

Step 1: Defining the eligibility criteria, strata, and the size of the experiment(s) to be conducted.

Step 2: Selection of an initial sample of customers.

Step 3: Screening of customers in the initial sample to determine what stratum they are a member of and if they are in the effective population for same.

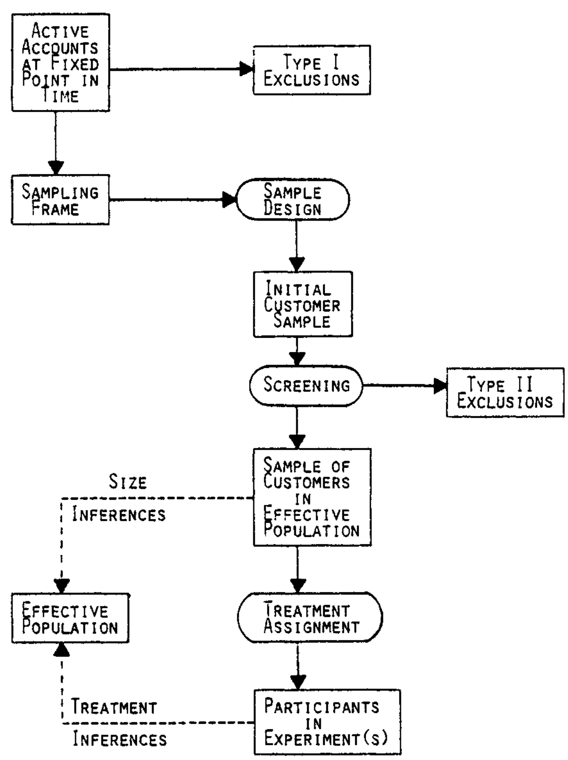
Step 4: Randomly assigning treatments to identified members of the effective population.

Step 5: Conduct of experiment involving installation of equipment and collection/processing of electricity consumption at (generally) 15 minute intervals for a prespecified period of time (often a year or more).

Step 6: Analysis of data for purposes of drawing statistical inferences to the effective population as well as model-based inferences to other analytic populations of interest.

Several points concerning this general sampling strategy need to be emphasized. First, making valid statistical inferences to the intended

FIGURE 1. GENERAL SAMPLING STRATEGY FOR ELECTRIC UTILITY EXPERIMENTS



effective population necessitates that the precepts of probability-based sampling be applied to the maximum extent possible. Secondly, the conditions under which the experiments are conducted should emulate as closely as possible those which will be present during the actual implementation of the indirect load management technique under study (since the experiments are intended to predict the impact of same). In particular, the rationale for exclusions of persons from the experiment needs to be carefully planned and evaluated. (Figure 1 identifies two typical types of exclusions--those identifiable during the frame construction and those identifiable only at the screening phase.) Thirdly, the effective population must be the same for all treatments being compared (otherwise treatment differences would be confounded with differences in effective populations, a distinct possibility in experiments conducted under voluntary participation).

The sample design of the general strategy must therefore have the following objective: to realize a valid probability sample of customers from each stratum of sufficient size to support the intended experiment(s) and do so in an overall cost-effective fashion. The actual form of design utilized in a particular application will of course depend on a host of factors, including: ability to identify strata on the billing file; nature of the eligibility criteria (including knowledge needed to apply same); prevalence of eligibles on the sampling frame (overall and by stratum); nature of auxiliary information available on the billing file and from earlier research; timeframe available for the study; nature of the field force available to support the study; total costs (including cost of formulating/implementing the design and development of any specialized software needed to properly analyze the resulting data); and, last but not least, precision requirements of the study.

Clearly, the extreme cost per experimental unit demands that efficiencies in design and estimation be exacted wherever possible. Moreover, the precision requirements for parameter estimates for the effective population must be kept in perspective with errors associated with other subjective, or at best, model-based parameter estimates to be made for alternative populations of interest. For example, the recognized length of the experiment (often a year or more) coupled with the voluntary nature and cost of the experiments understandably entice some researchers to impose eligibility requirements which result in an effective population which differs markedly from the target population for the proposed load management technique. As a second example, the utility might wish to model the impact of different penetration rates for a particular program to reflect potential changes in economic conditions and/or form of remuneration to the customer.

3. Estimation of Treatment Specific Parameters and Size of Effective Population

In electric utility experiments concerning customers' usage characteristics under alternative treatments, two general types of parameters are of interest: means, and ratios. Means (e.g., average kWh during some specific time period) are defined as

$$\bar{Y}_k = \sum_{i=1}^{M} Y_{ik}/M,$$

where M = number of customers in the effective population, and Y_{ik} = value of the usage variable for the i^{th} customer in the effective population, if he/she were exposed to treatment k. For screening designs producing self-weighting treatment samples within strata, this mean is estimated as

$$\hat{\bar{Y}}_k = \sum_{h=1}^{H} \hat{\bar{Y}}_k(h)M(h) \Big/ \hat{M} \qquad (1)$$

where H = number of strata; $\hat{M} = \sum_{h=1}^{H} \hat{M}(h)$; $\hat{M}(h)$ = the estimated number of customers in the h^{th} stratum who are in the effective population; and $\hat{\bar{Y}}_k(h)$ = mean of the usage variable, over sample participants in the h^{th} stratum who received treatment k. Note that M is assumed to be independent of the treatments; hence a common estimate of the population size is utilized for all treatments. For each stratum h, the form of the size estimate, $\hat{M}(h)$, depends upon the sample design and screening procedures used in the particular experiment.

Ratios are defined as $R_k = \bar{Y}_k/\bar{Z}_k$, where $\bar{Y}_k$ and $\bar{Z}_k$ are means for two different usage variables. Such ratios (for example, the proportion of consumption occurring in a given time period) are estimated for the k^{th} treatment as

$$\hat{R}_k = \hat{\bar{Y}}_k/\hat{\bar{Z}}_k, \qquad (2)$$

where $\hat{\bar{Y}}_k$ and $\hat{\bar{Z}}_k$ are estimated according to (1).

It is also of interest to compare the means (or ratios) of two different treatments by computing the difference in treatment estimates. For example, let

$$\hat{D} = \hat{\bar{Y}}_2 - \hat{\bar{Y}}_1 \text{ or} \qquad (3)$$

$$\hat{D} = \hat{R}_2 - \hat{R}_1 \qquad (4)$$

depending on the type of parameter (i.e., mean or ratio). Approximate confidence limits on the true population difference can then be determined (under suitable distributional assumptions) by utilizing the estimated variance of $\hat{D}$. Clearly, the variance of $\hat{D}$ will depend on the sample design, screening procedures and form of estimator employed by the analyst.

The remainder of the paper describes two distinctly different designs that have been used to date by the Research Triangle Institute in conducting electric utility experiments. To the extent possible, emphasis is placed on contrasting the impact these designs have on the form of $\hat{D}$ and the estimated variance of the first order Taylor linearization of same.

4. Variance Approximations for a Single-Phase Screening Design

The simplest form of sample design occurs when the experimental strata can be identified on the billing file (and hence frame). It is then possible to select and screen self-weighting samples of customers independently in each stratum. For such a design, the approximate standard error of the first-order Taylor linearization of an estimated mean (of the variable Y) for the k^{th} treatment is computed as the square root of

$$\hat{V}_{Yk} = \sum_{h=1}^{H} \hat{V}_{Yk}(h) \tag{5}$$

where

$$\hat{V}_{Yk}(h) = \left(\frac{1}{\hat{M}}\right)^2 \left\{[[\hat{M}(h)]^2 + \hat{Q}(h)] \quad [s_{Yk}(h)]^2 + [\hat{\Delta}_{Yk}(h)]^2 \hat{Q}(h)\right\}$$

and $\hat{\Delta}_{Yk}(h) = [\hat{\bar{Y}}_k(h) - \hat{\bar{Y}}_k]$; $\hat{Q}(h)$ = estimated variance of $\hat{M}(h)$; $s_{Yk}(h)$ = estimated standard error of $\hat{\bar{Y}}_k(h)$.

Standard errors of the ratio estimates for the k^{th} treatment (see eq. (2)) are approximated by taking the square root of

$$\hat{V}_{Rk} = \sum_{h=1}^{H} \hat{V}_{Rk}(h) \tag{6}$$

where

$$\hat{V}_{Rk}(h) = \left(\frac{1}{\hat{M}\hat{\bar{Z}}_k}\right)^2 \left\{[[\hat{M}(h)]^2 + \hat{Q}(h)] \right.$$

$$[[s_{Yk}(h)]^2 + \hat{R}_k^2 [s_{Zk}(h)]^2 - 2\hat{R}_k s_{YZk}(h)]$$

$$\left. + [\hat{\Delta}_{Rk}(h)]^2 \hat{Q}(h)\right\}$$

and $\hat{\Delta}_{Rk}(h) = [\hat{\bar{Y}}_k(h) - \hat{R}_k\hat{\bar{Z}}_k(h)]$, and $s_{YZk}(h)$ = estimated covariance of $\hat{\bar{Y}}_k(h)$ and $\hat{\bar{Z}}_k(h)$.

Similarly, the estimated variance of treatment differences is given by

$$\hat{V}_D = \sum_{h=1}^{H} \hat{V}_D(h)$$

where

$$\hat{V}_D(h) = \hat{V}_{Y1}(h) + \hat{V}_{Y2}(h) - 2\hat{Q}(h)\ \hat{\Delta}_{Y1}(h)\ \hat{\Delta}_{Y2}(h)/\hat{M}^2$$

for $\hat{D}$ given by eq. (3), or

$$\hat{V}_D(h) = \hat{V}_{R1}(h) + \hat{V}_{R2}(h) - 2\hat{Q}(h)\ \hat{\Delta}_{R1}(h)\ \hat{\Delta}_{R2}(h)/\hat{M}^2\ \hat{\bar{Z}}_1\hat{\bar{Z}}_2$$

for $\hat{D}$ given by eq. (4). It is important to note that the last term in each of the above formulae is brought about by the fact that the estimated treatment means are not independent since the total sample, rather than treatment-specific subsamples, is used to estimate the size of the effective population.

As previously indicated, the appropriate estimate of the size of the effective population in each stratum depends upon the particular sampling/screening design. As an example, suppose that the desired sample size for each stratum, m(h), is predetermined, and that a randomly-ordered list of customers is used, within each stratum, to select the experimental participants. (After selection, the m(h) customers are assigned at random to the treatments.) With this design, an estimate of the participation rate for the h^{th} stratum is given by

$$\hat{p}(h) = \frac{m(h) - 1}{n(h) - 1} \tag{7}$$

where n(h) is the number of customers in the h^{th} stratum who had to be screened in order to achieve the m(h) participants. The size of the effective population, for the h^{th} stratum, is then estimated as $\hat{M}(h) = N(h)\hat{p}(h)$, where N(h) is the (known) number of customers in the stratum-h frame. An estimate of the variance of $\hat{M}(h)$--denoted by $\hat{Q}(h)$ in the above variance-approximation formulae--is given, for this design, as

$$\hat{Q}(h) = [N(h)]^2\ \hat{p}(h)[1 - \hat{p}(h)]/[n(h) - 2]. \tag{8}$$

If the number of sample exclusions occurring in the h^{th} stratum, n(h)-m(h), is assumed to be distributed according to a negative binomial distribution with parameters p(h) and m(h), where p(h) is the probability that a member of the h^{th} stratum is in the effective population, then both (7) and (8) can be shown to unbiased (see Sukhatme and Sukhatme, 1970, p.31-33).

The single-stage screening approach described above has been employed in a number of studies involving electric utility experiments--especially those dealing with time-of-day electricity pricing for residential customers. Typically, these studies involve some specific subset of residential customers within the utility's service area. A list of customers is available from the company's billing records; this list may include a number of customers outside the effective population who cannot be identified from the billing records (e.g., renters or seasonal customers may be regarded as ineligibles). If the relative number of such customers is small, then the single stage screening approach is quite adequate. On the other hand, if a large number of potential ineligibles are included in the sample frame, a more complex screening mechanism would generally be more efficient. An example of such an experiment is described in Section 5.

5. An Example of a More Complex Design

This section briefly describes a study that is being conducted by Florida Power and Light Company (FPL), with assistance from statisticians and economists from Research Triangle Institute. The principal goals of the study are to assess, in terms of reduced electricity consumption (especially at times of high system load), the following:

(1) the potential effectiveness of increased attic insulation for certain residential customers, and

(2) the potential effectiveness of such customers' installing high efficiency air conditioning systems.

These two components of the experiment are referred to, respectively, as the Insulation Study, and the Heating, Ventilation, and Air Conditioning (HVAC) Study. The HVAC Study is applicable only to a subset of the customers meeting the eligibility criteria of the Insulation Study. The results of the FPL study, along with other marketing information, will be used to establish the degree to which the company should offer incentives to its customers for taking such conservation measures.

The overall experimental design and prescribed sample sizes for the study are depicted in Table 1, which also shows the definitions of the various treatments. Relative to most surveys of large human populations, the sample sizes are clearly small; the expense in conducting such experiments is one reason (e.g., special meters allowing short-term [usually 15 minutes] monitoring of kWh usage must be installed on the sample customers' dwellings). Fortunately, the usage variables of interest are highly correlated with variables for which accurate measurements are available for virtually all members of the population (i.e., prior kWh values), so that stratification by such a variable(s) not only is feasible but also is highly beneficial in attaining reasonable precision on the estimates of interest.

Figure 2 defines the region and usage strata used in the FPL experiments, as well as the four insulation categories used for the Insulation Study. The Insulation Study treatments 2A and 2B are defined in relation to the prior insulation levels of customers' dwellings so that all sample dwellings selected to receive these treatments would achieve an attic insulation level of at least R-19.

The choice of the primary stratification variable--i.e., average 30-day electricity consumption during the 12-month period immediately preceding the sample selection--was made for three principal reasons:

(1) This variable is, in general, highly correlated with the usage variables of interest and can be determined accurately for most customers from the company's billing records. (It should be noted that the billing data file contained monthly kWh values, by billing cycles, for over 1,000,000 SFD residential customers. For "new" customers, estimates based upon their partial data were utilized to obtain a 30-day consumption value. For the vast majority of customers, complete 12-month histories were available.)

TABLE 1. DESIGN CELLS AND REQUIRED SAMPLE SIZES FOR FPL EXPERIMENTS*

		Insulation Study							HVAC Study		Totals	
Insulation Category:		1		2		3		4	All		Insulation Study	Overall
Treatment:		1	2A	1	2B	1	2B	1	3	4		
Region	Usage Stratum											
North	1	4	4	4	4	4	4	6	6	6	30	42
	2	4	4	4	4	4	4	6	6	6	30	42
	3	4	4	4	4	4	4	6	6	6	30	42
	4	4	4	4	4	4	4	6	6	6	30	42
	5	4	4	4	4	4	4	6	6	6	30	42
	6	4	4	4	4	4	4	6	6	6	30	42
South	1	4	4	4	4	4	4	6	6	6	30	42
	2	4	4	4	4	4	4	6	6	6	30	42
	3	4	4	4	4	4	4	6	6	6	30	42
	4	4	4	4	4	4	4	6	6	6	30	42
	5	4	4	4	4	4	4	6	6	6	30	42
	6	4	4	4	4	4	4	6	6	6	30	42
Total		48	48	48	48	48	48	72	72	72	360	504

Treatment Definitions:

1 = No treatment (customers are offered $50 incentive payment).

2A = Attic insulation is upgraded to R-19+ by adding R-19.

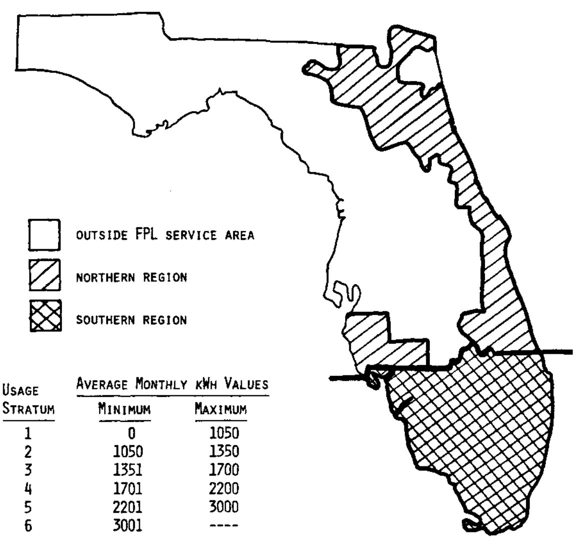
2B = Attic insulation is upgraded to R-19+ by adding R-11.

3 = Existing AC system(s) is replaced with a high-efficiency AC system (EER ≥ 10) of appropriate capacity, plus attic insulation is upgraded, if necessary, as in Insulation Study.

4 = Existing AC system(s) is replaced with a high efficiency heat pump(s) (EER ≥ 8), plus attic insulation is upgraded, if necessary, as in Insulation Study.

* See Figure 2 for definitions of strata and insulation categories.

FIGURE 2. STRATA FOR FPL EXPERIMENTS



Usage Stratum	Average Monthly kWh Values: Minimum	Maximum
1	0	1050
2	1050	1350
3	1351	1700
4	1701	2200
5	2201	3000
6	3001	----

Insulation Category	Average R-value Over Living Area: Minimum	Maximum
1	0	10
2	10	13
3	13	19
4	19	--

(2) The effects of customers' transient activities (e.g., vacations) are less pronounced for such a variable, relative to electricity usage over a shorter time period (e.g., a given month).

(3) The experiment must furnish estimates of usage variables throughout the year, since the overall benefit of implementing such "treatments" must be evaluated on such a basis.

The particular stratum breakpoints chosen for use in the experiment and the rationale for equal sample sizes per stratum were based upon the following considerations:

(1) The experiment should be capable of providing reasonably precise estimates of treatment effects for both geographic regions and for both "low-use" and "high-use" customers, since the conservation measures could be offered on such a selective basis if they were judged to be differentially beneficial for such customer groups (hence, e.g., the need for adequate sample sizes for both low- and high-use customers).

(2) Subject to (1) and the overall sample size constraints, the experiment should attempt to maximize the precision of estimates of overall population parameters of interest.

To meet this second experimental design objective, a modified Dalenius-Hodges (DH) procedure was utilized (see Cochran, 1977). As in the usual DH procedure, the residential population (actually, those identified as living in single family dwellings [SFDs]) was partitioned into a large number of categories according to their prior electricity consumption. Data from a prior FPL survey were utilized to estimate the prevalence of customers in each such usage interval who would be eligible for participation in the experiment. These prevalence estimates allowed the estimated sizes of the eligible population, by usage interval, to be used as inputs to the DH cumulative square root criterion. The resultant stratum breakpoints are those shown in Figure 2.

The nature of the study and its extensive eligibility requirements, especially those relating to dwelling and appliance characteristics, were such that the prevalence of customers eligible, available, and willing to participate was expected to be low and was anticipated to vary considerably by stratum. In contrast to the simple, single-phase screening design described in Section 4, a much more complex screening design was therefore clearly necessary to support the experiment. A three-phase screening design was developed and implemented. Table 2 provides an outline of the participation requirements at the various phases of screening. It should be noted that the modified DH procedure described above was utilized only to determine stratum breakpoints. Initial sample sizes for Phase I were determined by use of the expected prevalence information and were primarily geared to achieving a prespecified minimum sample size of eligible customers.

Phase I involved a mail survey of 15,002 customers, each selected randomly within one of

TABLE 2. PARTICIPATION REQUIREMENTS FOR FPL EXPERIMENTS

1. General Requirements
   * SFD on September 1981 FPL Residential billing file
   * not currently a participant in a load research test
2. Customer Availability/Accessibility Requirements
   * owner-occupied at least part of the year
   * owner/occupant can be contacted for administering screening questionnaires and to consider signing of participation agreement. This requires:
     - owner be available at billing address (not necessarily address of meter) during fall 1981,
     - occupant be available for on-site interview in winter 1982,
     - owner-occupant be available at residence address in spring-summer 1982 to sign participation agreement,
     - owner-occupant be present in summer 1982 to allow installation of meters/insulation/air conditioning equipment.
3. Dwelling Structure/Appliance Requirements
   * central air conditioning/electric heat
   * detached SFD (i.e., no apartments, condominiums, or townhomes)
   * at least 75% of living area capable of having insulation installed and/or added between the ceiling and the roof
   * no more than 2 separate central heating or air conditioning systems
   * wiring/air conditioning systems amenable to installation of required meters
   * for HVAC study only: not heat pump or package HVAC system
4. Customer Willingness Requirements
   * owner/occupant submits to administration of screening questionnaires
   * owner indicates willingness to participate (Phase II)
   * owner signs participation agreement permitting random assignment of treatment, insulation/meter/equipment installation, and usage monitoring.

the 12 region/usage strata; the purpose was to identify customers who would be potentially eligible for participation in the experiment. This survey involved an initial mailing, two followup mailings, and a telephone followup survey of a subsample of the nonrespondents. An overall response rate of over 80% was achieved for Phase I.

The sample design for Phase II involved identifying the Phase I respondents eligible for the study, and post-stratifying these eligibles according to their reported insulation level (some insulation, no insulation, or unknown). A subsample of 2,000 of the potentially-eligible customers who had responded to the Phase I survey was then selected for Phase II. The Phase II screening involved an on-site inspection of these customers' dwellings plus personal interviews. Eighty-six percent of these customers provided sufficient information for determining their eligibility status. Seventy-seven percent of the Phase II respondents were determined to be eligible (and willing) to continue in the study. In addition to confirming eligibility for the experiment, Phase II also furnished measurements of attic insulation R-values. These were used at Phase III for further stratification of the customers into the four insulation categories defined in Figure 2. Information on the type of air conditioning system (i.e., heat pump, non-heat-pump) was also obtained.

Phase III involved the following (see Table 1):

(1) selecting the required number of customers for each cell of the Insulation Study design (i.e., 6 per stratum for category

4, and 8 per stratum for the remaining categories);
(2) selecting 12 non-heat-pump customers per stratum for the HVAC study;
(3) assigning treatments;
(4) enrolling customers into the study;
(5) installing the necessary metering, air conditioning equipment, and insulation; and
(6) making substitutions for those customers found to be ineligible, unavailable, or unwilling to be in the experiment.

For carrying out items (1) and (2) above, a sequential sample selection procedure was utilized (Chromy, 1981). Use of this procedure allowed a self-weighting sample of customers to be selected for each of the experimental design cells. Specifically, the sample was allocated to post-strata in proportion to the weighted number of customers and the resulting non-integer allocations were randomly rounded so as to produce the intended overall sample size. Simple random samples of the (conditional) fixed size were then selected in each design cell. Item (4) above involved securing a customer's signature on a participation agreement. Although the agreement stated the study objectives and indicated the types of treatments involved in the study, it did not indicate which treatment the particular customer would receive. Hence treatment and population confounding was avoided (see Section 2).

Table 3 summarizes the results of the screening activities in terms of the estimated size of the respondent population at each phase. In stratum N1, for example, a random sample of 3,532 of the single-family dwelling customers was selected at Phase I. About 24% of these responded to the survey and were found to be eligible. After the second phase (involving a subsample of 163 of these customers), the percentage of eligibles dropped to 19%. After the third phase, only 16% of the original N1 stratum population was judged to be in the effective population. Only 10% were judged to

TABLE 3. SUMMARY OF SCREENING RESULTS

Region Usage Stratum	Initial # SFDs	Est. Proportion of Customers Eligible After: Phase I*	Phase II*	Phase III Insul. Study	Phase III HVAC Study
N1	165,119	.24 (3,532)	.19 (163)	.16	.10
N2	52,165	.45 (540)	.34 (156)	.31	.19
N3	41,152	.52 (437)	.45 (155)	.41	.24
N4	28,175	.59 (437)	.49 (155)	.48	.24
N5	12,351	.61 (416)	.43 (164)	.39	.23
N6	3,748	.62 (302)	.36 (162)	.32	.19
S1	360,332	.17 (3,901)	.15 (173)	.12	.10
S2	124,016	.33 (1,306)	.28 (175)	.25	.20
S3	102,469	.38 (1,147)	.32 (173)	.29	.22
S4	82,954	.49 (1,114)	.43 (174)	.39	.32
S5	49,245	.56 (846)	.48 (173)	.45	.31
S6	24,586	.56 (1,024)	.34 (177)	.31	.15
North	302,710	.36 (5,664)	.29 (955)	.26	.15
South	743,602	.30 (9,338)	.25 (1,045)	.22	.18
Total	1,046,312	.32 (15,002)	.26 (2,000)	.24	.17

* Sample sizes are shown in parentheses.

be both eligible and non-heat-pump customers (i.e., eligible for the HVAC study).

Collection of detailed electricity usage data (for overall house loads and on air conditioning systems) is currently underway and will continue through September 1983. Software for analysis of the data is currently being developed that will:
(a) incorporate variance approximations that appropriately reflect the screening process described above,
(b) allow alternative weighting schemes to be easily considered,
(c) allow treatment comparisons for a variety of usage characteristics to be made,
(d) provide outputs in a format convenient for inclusion in reports and for interpretation of results.

With regard to (a), it should be noted that there are two basic modifications to the general methodological approach described in Section 4 (for the single-phase screening) that are needed. First, unlike the single-phase case, population sizes at the final screening phase are unknown and must be estimated. Second, the variance estimation must take into account the actual Phase III screening approach, which deviates from the inverse sampling approach.

With regard to (b), it should be noted that alternative weighting schemes arise from two types of considerations. First, alternative definitions of the effective population can be considered. Second, alternative schemes for estimating the proportion of eligibles within the design cells need to be considered (e.g., to achieve more robustness in the estimated proportions) so that the sensitivity of final results can be analyzed with regard to such variations.

6. Summary Remarks

Many researchers conduct experiments where inferences to finite human populations are desired. This paper has attempted to provide a theoretical basis and practical illustration of how the precepts of finite population sampling and classical experimental design can be combined for validly estimating population parameters of interest and the approximate precision of same.

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