

RATIO ESTIMATION OF NATIONAL ENERGY TECHNICIAN NEEDS

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I. Introduction

The goal of this research was to determine current and future needs of employers for technicians "...involved in planning use and/or applying energy conservation methods" The following specific areas of energy conservation were investigated. They were space heating, water heating, cooling, lighting, and other (See Appendix). The populations sampled were major energy-using industries, businesses, housing institutions, utilities, government facilities, institutions, and architectural firms.

II. Methodology

Ratio estimators were used since national census data was available for total employment figures in each of the populations to be sampled. /8/ The ratio of energy technicians to total employees for the sample was multiplied times the total employees in the sampled population. The five steps in the method were as follows:

- Step 1. Determination of the number of members in the survey area population for each of the following groups:
- A. Major energy-using industries. References:
 1. Dun & Bradstreet Middle Market Directory, 1978 (S.I.C. Code 53). /3/
 2. Dun & Bradstreet \$1,000,000 Directory, 1978. /4/
 3. Thomas Register of American Manufacturers. /11/
 4. Annual Survey of Manufacturers, Government Printing Office.
 5. U.S. Dept. of Commerce listings. Retailers, wholesalers, trade companies, architectural firms and engineering firms.
 - B. Major energy-using businesses. Reference: Dun & Bradstreet Middle Market Directory, 1978 (S.I.C. Code 20 to 39) /3/
 - C. Major energy-using housing institutions. Reference: Dun & Bradstreet Middle Market Directory, 1978 (not individual listings, but owning companies) /3/
 - D. Municipal utilities (energy audit groups). Reference: Directory of Electric Utilities, Electrical World, 1977-1978 (86th ed.). /7/
 - E. Major government facilities. References:
 1. U.S. Government Manual, 1977-1978 (listing of departments and

- agencies, with addresses of federal). /12/
- 2. State agency directories.
- 3. Local agency directories.
- F. Institutions References:
 1. The New American Guide to Colleges (with addresses). /10/
 2. Local telephone directory listings for hospitals, and primary and secondary schools.
- G. Architectural firms. Reference: Local telephone directories.

Step 2. Determination of the total number of employees (groups A through G) all geographical areas to be surveyed. This information is obtainable from the Statistical Abstract of the United States, /9/ which lists employment for each category by states. Specific data for each group was shown on the indicated page in the 1977 edition.

Group	Identity
A	Manufacturers
B	Retail, etc.
C	Housing Institutions
D	Utilities
E	Government
F	Education
G	Architectural Firms

- Step 3. Determination of sample size for each employer category (groups A through G).
1. From Step 1, total members for each group equal N.
 2. If personalized survey letters are to be used, a response rate of 33% (+ or -) can be expected; if impersonal survey letters are to be used (addressed to "general manager" or other similar title only), a response rate of 10% (+ or -) should be expected. For purpose of calculating sample size, expected response rate is a percentage (10 or 33) equal to R.
 3. Sample size for each group equals n.

Therefore,

for N > 600	$n = \frac{30}{R}$ and
for N < 600	$n = \frac{.05N}{R}$

Example A. If N = 700; R = 10% (or .10):

$$n = \frac{30}{.10} = 300.$$

If N = 2000; R = 10%

$$n = \frac{30}{.10} = 300.$$

Example B. If N = 700; R = 33% (or .33):

$$n = \frac{30}{.33} = 90.$$

Example C. If N = 100; R = 10%:

$$n = \frac{.05 \times 100}{.10} = 50.$$

If N = 100; R = 33%:

$$n = \frac{.05 \times 100}{.33} = 15.$$

If time and cost restraints allow larger mailouts, more precision may be obtained; however, in no case should $n > 50\%$ of N.

- Step 4. Determination of questionnaire content. The survey ascertained numerical data for the following items:
1. Energy technicians currently employed by organization.
 2. Energy technicians (estimated) to be employed by organization two, five and ten years from now.
 3. Total number of employees currently employed by organization.
- (See Appendix)
- Step 5. Determination of final estimates of employment in various categories (groups A through G) from survey responses. After responses are received, a final estimate of needs can be made:

Total number of employees (ascertained in Step 2) equals E; total number of employees reported by responding organizations equal E_r ; total number of technicians of technicians reported by responding organizations equals T_r ; thus, to find T (total number of technicians needed), the following equation applies: /See 8/

$$T = E \left(\frac{T_r}{E_r} \right).$$

This equation may be used for each category (groups A through G), and it may be used to find current total technician employment and to project total technician needs for any year for which data was obtained.

III. Survey Results

The survey questionnaire was sent to 986 manufacturers, businesses, institutions etc. The initial mailing resulted in a 9.98% response rate. The second mailing increased the response rate to 16%. The first and second mailings were tested using the t-test for two independent populations and it was found there was not a significant difference in the percentage of energy technicians for the two samples. This was evidence that the data was not biased. The response totals are given in Table 1.

Table 1. Response Totals

Group	Category	Total employees surveyed
A	Mfg.	5504
B	Retail	4930
C	Housing	3850
D	Utilities	1974
E	Government	2679
F	Education	63,616
G	Architects	95

Table 2 gives the results of the ratio estimation of employees involved in energy planning in 1978 and estimates for 1983 and 1988.

IV. Bound on the Error of Estimation

The bound on the error of estimation for the estimated number of full time employees involved in energy planning and use can be found by the following equation./8/ Let B_g = bound on the error of estimation for group^g.

$$\hat{r}_g = \frac{T_r}{E_r}$$

where T_r is number of technicians in the sample

and E_r is number of employees all categories in the sample

Then,

$$B_g = 1.96 \sqrt{E^2 \left(\frac{N-n}{nN} \right) \frac{1}{E} \sum_{i=1}^n \frac{(E_{ri} - r_g T_{ri})^2}{n-1}}$$

where E = total number of employees in the population

\bar{E} = average number of employees in a responding organization

n = number of organizations sampled in group g .

N = total number of organizations in group g .

E_{ri} = number of employees in sample i

T_{ri} = number of technicians in sample i

\hat{r}_g = ratio of technicians to employees for group g .

Table 2. Numerical Employment Data Categories (Groups).

Group	Total Emp. for Group Nation-wide, based on 1977 Statistical Abstract of U.S.	Est. # of full-time emp. involved in energy planning and use in 1978	Proj. # of energy emp. in 1983	Proj. # of energy employees in 1988
A	19,118,000	66,129	77,338	81,305
B	17,810,000	36,138	37,583	38,302
C	711,000	21,734	26,084	27,947
D	1,889,000	46,985	60,410	72,875
E	15,048,000	84,824	95,300	99,503
F	6,378,500	28,449	33,578	35,151
G	200,000	8,111	8,787	10,207
Totals	61,054,500	291,394	339,106	365,318

Table 3 gives the 95% confidence bound on the estimates in Table 2 for each group.

The bound on the error is almost as large as the estimate for group G, and it is close to 50% of the estimate for group A, B, and E. However, the ratio estimates in Table 2 are useful for groups A-F.

V. Summary

The ratio estimator gives more precision than tradition methods of estimating employee needs./8/ The results of Table 2 are quite useful for forecasting needs for energy technicians. Some of the bounds on the

estimate are large as shown in Table 3 but are still useful as preliminary estimates for groups A-F. To improve the precision of the estimates would require a great amount of cost in additional mailings.

The survey shows there is a great need for the energy technician. The survey estimator predicted as a point estimate an average annual need for 7,352 new energy employees for the next decade. The point estimate for the total need for new energy employees in the ten-year period, 1979 through 1988, is 73,524.

Table 3

Group	95% confidence bound on the estimates (B_g) in employee units	1978 Relative precision B_g/T
A	29,927	.45
B	22,369	.62
C	3,768	.17
D	12,977	.28
E	42,435	.50
F	3,291	.115
G	7,720	.95

References

1. Annual Survey of Manufacturers. Washington, D.C.: Superintendent of Documents, Government Printing Office, latest ed.
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4. Dun and Bradstreet, \$1,000,000 Directory. New York: Marketing Services Division, 1978 (or latest ed.).
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6. Electric Power Research Institute Contract No. RP 1266-6, Educational Research in Solid Fuel Technology, performed by Technical Education Research Center - Southwest, July 1, 1978 - February 28, 1979.
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