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BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

VOLUME 4

D R A F T

APPENDIX B2

APPENDIX B3

HARZA-EBASCO
SUSITNA JOINT VENTURE

Alaska Power Authority

BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT
DRAFT LICENSE APPLICATION

VOLUME 4

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(1983 VERSION)

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RAILBELT ELECTRICITY DEMAND (RED) MODEL
CHANGES MADE JULY 1983 TO AUGUST 1985

November 1985

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APPENDIX B2

SUMMARY

This report describes the 1983 version of the Railbelt Electricity Demand (RED) model, a partial end-use/econometric model for forecasting electricity consumption in Alaska's Railbelt region through the year 2010. It contains complete documentation of the modeling approach, structure of the equations, and selection of parameter values. In addition, information is presented on the data bases used, supporting research, model output, and the Battelle-Northwest residential energy-use survey conducted in the Railbelt during March and April, 1981. This survey was used to help calibrate the model.

RED has several unique capabilities: a Monte Carlo simulator for analysis of uncertainty in key parameter values, a fuel price adjustment mechanism that incorporates the impacts of fuel prices on demand, and the capability to explicitly consider government subsidized investments in conservation measures. The 1983 version contains the following features:

- an aggregate business electricity consumption forecasting methodology that is based on the model's own forecast of commercial, light industrial, and government building stock
- calibration of the Residential sector end uses, appliances saturation, and fuel mode splits on actual data
- a variable price elasticity adjustment mechanism to faithfully reflect consumer response to electricity, gas, and fuel oil prices in both the Residential and Business Sectors
- a Housing Module that transforms a forecast of the total number of regional households into forecasts of the occupied and unoccupied housing stock by four types of housing units
- parameters updated to reflect 1980 Census information and construction and energy market activity between 1980 and 1982, as well as additional energy research performed in several other parts of the country
- two load centers, Anchorage-Cook Inlet and Fairbanks-Tanana Valley

- a report-writing module that reports price elasticities and price effects on consumption (price-induced conservation and fuel switching), as well as households served, saturation of appliances, electricity consumption by sector, peak demand, and the sensitivity of forecast results to variation of key model parameters.

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1.0 INTRODUCTION

This document describes the 1983 version of the Railbelt Electricity Demand (RED) model, a computer model for forecasting electricity consumption in Alaska's Railbelt region through the year 2010 (see Figure 1.1). The original version of this model was developed by Battelle, Pacific Northwest Laboratories (Battelle-Northwest) as part of the Alaska Railbelt Electric Power Alternatives Study (Railbelt Study). The Railbelt Study was an electric power planning study performed by Battelle-Northwest for the State of Alaska, Office of the Governor and the Governor's Policy Review Committee between October 1980 and December 1982.

In March 1983, Battelle-Northwest was asked by the Harza-Ebasco Susitna Joint Venture of Anchorage, Alaska to review the RED model structure, to make appropriate changes, to document the changes, and to validate the model. During the update, Harza-Ebasco assisted and guided in the work performed. The 1983 version of the RED model is used as one of a series of linked models to produce updated forecasts of electrical power needs in the Railbelt over the next 30 years. The other models used in the 1983 update foecasting methodology are the State of Alaska's PETREV petroleum revenue forecasting model, the University of Alaska Institute of Social and Economic Research's MAP economic and population forecasting model, and the Optimized Generation Planning (OGP) model for planning the Railbelt electricity generation system and for estimating electricity costs. Separate documentation is available for those models. The outcome of the RED update process is contained in this documentation report. The report contains complete documentation on the model, information on data bases used in model development, and a section on model validation.

The RED forecasting model documented in this report is a partial end-use/econometric model. Initial estimates of total residential demand are derived by forecasting the number of energy-using devices and aggregating their potential electricity demand into preliminary end-use forecasts. The model then modifies these preliminary forecasts, using econometric fuel price elasticities, to develop final forecasts of total residential energy consumption. The model thus uses both technical knowledge of end uses and econometrics to

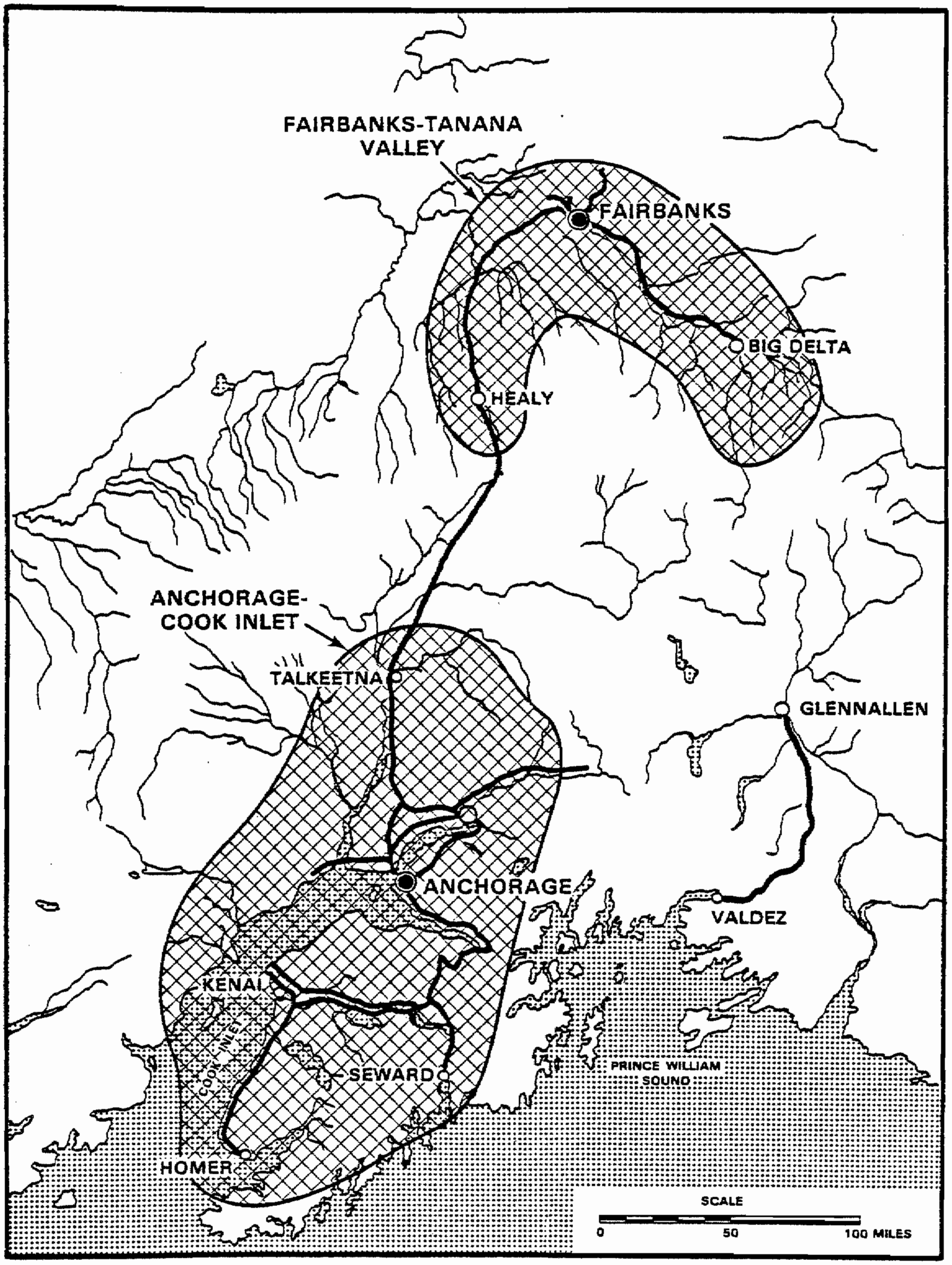

FIGURE 1.1. The Railbelt Region of Alaska

produce the residential forecast. The business sector (commercial, small industrial, and government load) is treated similarly. However, because little information is available on end uses in the business sectors in Alaska, preliminary demand is estimated on an aggregated basis rather than by detailed end use. Miscellaneous demand is based on the demand of the other three sectors, while large industrial load and military load is forecasted exogenously by the model user.

Other important features of the model are a mechanism for handling uncertainty in some of the model parameters, a method for explicitly including government programs designed to subsidize conservation and consumer-installed dispersed energy options (i.e. microhydro and small wind energy systems), and the ability to forecast peak electric demand by load center. The 1983 version of the model recognizes two load centers: Anchorage-Cook Inlet (including the Matanuska-Susitna Borough and the Kenai Penninsula) and Fairbanks-Tanana Valley. The model produces annual energy and peak demand forecasts for every fifth year from 1980 to 2010, and then linearly interpolates to derive annual energy and demand forecasts for years between the five-year forecasts.

To produce a forecast, the model user must supply the model with region-specific estimates of total employment and total households for each forecast period. A few statewide variables are also required, such as forecasts of the age/sex distribution of the state's population. All of these variables are produced by the University of Alaska Institute of Social and Economic Research MAP econometric model; however, they can be derived from other sources. The user must also supply price estimates for natural gas, oil, and electricity. The estimates used in the 1983 update are consistent with input and output data of the other models used in the forecasting methodology. Finally, the model user may select either ranges or default values for the model's parameters and may run the model in either a certainty-equivalent or uncertain (Monte Carlo) mode. The model then produces the forecasts.

This report consists of 13 sections. In Section 2.0 an overview of the RED model is presented. In Section 3.0 the Uncertainty Module, which provides the model with Monte Carlo simulation capability, is described. Section 4.0 describes the Housing Module, which forecasts the stock of residential housing units by type. These forecasts are used in the electricity demand forecasts of the Residential Consumption Module, discussed in Section 5.0. Forecasts of demand in the business sector are produced by the Business Consumption Module, which is described in Section 6.0. The price adjustment mechanism is the subject of Chapter 7.0. The effects of government market intervention to develop conservation and dispersed generation options are covered by the Program-Induced Conservation Module, Section 8.0. Section 9.0 discusses miscellaneous electricity demand (street lighting, second homes, etc.). Large industrial demand is covered in Section 10.0. The Peak Demand Module, Section 11.0, concerns the relationship between annual electricity consumption and annual peak demand. Section 12.0 covers model validation, and Section 13.0 provides miscellaneous statistics on Railbelt electrical demand. The report also includes appendices on the Battelle-Northwest residential electric energy survey used to calibrate RED, conservation research conducted by Battelle-Northwest in support of the study, and model output for the 1983 update.

2.0 OVERVIEW

The Railbelt Electricity Demand (RED) model is a simulation model designed to forecast annual electricity consumption for the residential, commercial-light industrial-government, heavy industrial, and miscellaneous end-use sectors of Alaska's Railbelt region. The model also takes into account government intervention in the energy markets in Alaska and produces forecasts of system annual peak demand. In the 1983 version of RED, forecasts of consumption by sector and system peak demand are produced in five-year steps for two Railbelt load centers:

- Anchorage-Cook Inlet (including Anchorage, Matanuska-Susitna Borough and Kenai Peninsula)
- Fairbanks-Tanana Valley (including the Fairbanks-North Star Borough and Southeast Fairbanks Census Area).

Between these five-year steps, the model linearly interpolates to estimate annual energy and peak demand. When run in Monte Carlo mode, the model produces a sample probability distribution of forecasts of electricity consumption by end-use sector and peak demand for each load center for each forecast year: 1985, 1990, 1995, 2000, 2005, 2010. This distribution of forecasts can be used for planning electric power generating capacity.

Figure 2.1 shows the basic relationship among the seven modules that comprise the RED model. The model begins a simulation with the Uncertainty Module, selecting a trial set of model parameters, which are sent to the other modules. These parameters include parameters to compute price elasticities, appliance saturation parameters, and regional load factors. Exogenous forecasts of population, economic activity, and retail prices for fuel oil, gas, and electricity are used with the trial parameters to produce forecasts of electricity consumption in the Residential Consumption and Business Consumption Modules. These forecasts, along with additional trial parameters, are used in the Policy-Induced Conservation Module to model the effects on electricity sales of subsidized conservation and dispersed generating options. The revised consumption forecasts of residential and business (commercial, small industrial, and government) consumption are used to estimate future miscellaneous consumption and total electricity sales. Finally, the unrevised and revised consumption forecasts are used along with a user-supplied estimate of large industrial load and trial system load factor forecast to estimate peak demand. The model then returns to start the next Monte Carlo trial. When the model is run in certainty-equivalent mode, a specific "default" set of parameters is used, and only one trial is run.

The RED model produces an output file of trial values for electricity consumption by sector and system peak demand by year and load center. This information can be used by the Optimized Generation Planning (OGP) model or other generation planning model to plan and dispatch electric generating capacity for each load center and year.

The remainder of this section briefly describes each module. Detailed documentation of each of the modules is contained in Sections 3.0 through 11.0 of this report.

UNCERTAINTY MODULE

The purpose of the Uncertainty Module is to randomly select values for individual model parameters that are considered to be key factors underlying forecast uncertainty. These parameters include the market saturations for major appliances in the residential sector; the parameters used to compute price elasticity and cross-price elasticities of demand for electricity in the residential and business sector; the market penetration of program-induced conservation and dispersed generating technologies; the intensity of electricity use per square foot of floor space in the business sector; and the electric system load factors for each load center.

These parameters are generated by a Monte Carlo routine, which uses information on the distribution of each parameter (such as its expected value and range) and the computer's random number generator to produce sets of parameter values. Each set of generated parameters represents a "trial." By running each successive trial set of generated parameters through the rest of the modules, the model builds distributions of annual electricity consumption and peak demand. The end points of the distributions reflect the probable range of annual electric consumption and peak demand, given the level of uncertainty.

The Uncertainty Module need not be run every time RED is run. The parameter file contains "default" values of the parameters that may be used to conserve computation time.

HOUSING MODULE

The Housing Module calculates the number of households and the stock of housing by dwelling type in each load center of each forecast year in which the model is run. Using regional forecasts of households and total population, the housing stock module first derives a forecast of the number of households served by electricity in each load center. Next, using exogenous statewide forecasts of household headship rates and the age distribution of Alaska's population, it estimates the distribution of households by age of head and size of household for each load center. Finally, it forecasts the demand for four types of housing stock: single family, mobile homes, duplexes, and multifamily units.

The supply of housing is calculated in two steps. First, the supply of each type of housing from the previous period is adjusted for demolition and compared to the demand. If demand exceeds supply, construction of additional housing begins immediately. If excess supply of a given type of housing exists, the model examines the vacancy rate in all types of houses. Each type is assumed to have a maximum vacancy rate. If this rate is exceeded, demand is first reallocated from the closest substitute housing type, then from other types. The end result is a forecast of occupied housing stock for each load center for each housing type in each forecast year. This forecast is passed to the Residential Consumption Module.

RESIDENTIAL CONSUMPTION MODULE

The Residential Consumption Module forecasts the annual consumption of electricity in the residential sector for each load center in each forecast year. It does not, in general, take into account explicit government intervention to promote residential electric energy conservation or self-sufficiency. Such intervention is covered in the Program-Induced Conservation Module. The Residential Consumption Module employs an end-use approach that recognizes nine major end uses of electricity, extra hot water for two of these appliances, and a "small appliances" category that encompasses a large group of other end uses. For a given forecast of occupied housing, the Residential Consumption Module first forecasts the residential appliance stock and the portion using electricity, stratified by the type of dwelling and vintage of the appliance. Appliance efficiency standards and average electric consumption rates are applied to that portion of the stock of each appliance using electricity. The stock of each electric appliance is then multiplied by its corresponding consumption rate to derive a preliminary consumption forecast for the residential sector. Finally, the Residential Consumption Module receives exogenous forecasts of residential fuel oil, natural gas, and electricity prices, along with "trial" values of parameters used to compute price elasticities and cross-price elasticities of demand from the Uncertainty Module. It adjusts the preliminary consumption forecast for both short- and long-run price effects on appliance use and fuel switching. The adjusted forecast is passed to the Program-Induced Conservation and Peak Demand Modules.

BUSINESS CONSUMPTION MODULE

The Business Consumption Module forecasts the consumption of electricity by load center in commercial, small industrial, and government uses for each forecast year (1980, 1985, 1990, 1995, 2000, 2005, 2010). Direct promotion of conservation in this sector is covered in the Program-Induced Conservation Module. Because the end uses of electricity in the commercial, small industrial and government sectors are more diverse and less known than in the residential sector, the Business Consumption Module forecasts electrical use on an aggregate basis rather than by end use.

RED uses a proxy (the stock of commercial, small industrial floor, and government space) for the stock of electricity-using capital equipment to forecast the derived demand for electricity. Using an exogenous forecast of regional employment, the module forecasts the regional stock of floor space.

Next, econometric equations are used to predict the intensity of electricity use for a given level of floor space in the absence of any relative price changes. Finally, a price adjustment similar to that in the Residential Consumption Module is applied to derive a forecast of business electricity consumption (excluding large industrial demand, which must be exogenously determined). The Business Consumption Module forecasts are passed to the Program-Induced Conservation and Peak Demand Modules.

PROGRAM-INDUCED CONSERVATION MODULE

Because of the potential importance of government intervention in the marketplace to encourage conservation of energy and substitution of other forms of energy for electricity, the RED model includes a module that permits explicit treatment of user-installed conservation technologies and government programs that are designed to reduce the demand for utility-generated electricity. This module was designed for analyzing potential future conservation programs for the State of Alaska and was not used in the 1983 updated forecasts. The module structure is designed to incorporate assumptions on the technical performance, costs, and market penetration of electricity-saving innovations in each end use, load center, and forecast year. The module forecasts the aggregate electricity savings by end use, the costs associated with these savings, and adjusted consumption in the residential and business sectors.

The Program-Induced Conservation Module performs estimates of payback period and penetration rate of commercial sector and residential sector conservation options. In the residential sector, the model user supplies information to the module on the technical efficiency (electricity savings), electricity price, and costs of installation. The module then calculates the internal rate of return on the option to the consumer, as well as the option's payback period for technologies considered "acceptable" by the user. The module's payback decision rule links the payback period to a range of market saturations for the technologies. The savings per installation and market saturation of each option are used to calculate residential sector electricity savings and costs. In the business sector, the model user must specify the technical potential for new and retrofit energy-saving technologies. The user must also specify the range of conservation saturation as a percent of total potential conservation. The Program-Induced Conservation Module then calculates total electricity savings due to market intervention in new and retrofit applications and adjusts residential and business consumption for each load center and forecast year.

MISCELLANEOUS CONSUMPTION MODULE

The Miscellaneous Consumption Module forecasts total miscellaneous consumption for second (recreation) homes, vacant houses, and street lighting. The module uses the forecast of residential consumption (adjusted for conservation impacts) to predict electricity demand in second homes and vacant housing units. The sum of residential and business consumption is used to forecast street lighting requirements. Finally, all three are summed together to estimate miscellaneous demand.

PEAK DEMAND MODULE

The Peak Demand Module forecasts the annual peak load demand for electricity. A two-stage approach using load factors is used. The unadjusted residential and business consumption, miscellaneous consumption, industrial demand and load center load factors generated by the Uncertainty Module are first used to forecast preliminary peak demand. Next, displaced consumption (electricity savings) calculated by the Program-Induced Conservation Module is multiplied by a peak correction factor supplied by the Uncertainty Module to allocate a portion of electricity savings from conservation to peak demand periods. The allocated consumption savings are then multiplied by the load factor to forecast peak demand savings, and the savings are subtracted from peak demand to forecast revised peak demand.

The following sections describe each module of the model in greater detail.

3.0 THE UNCERTAINTY MODULE

RED's Uncertainty Module allows the forecaster to incorporate uncertainty in key parameters of the RED Model forecast. In other words, the impact of uncertain parameter values can be reflected in the forecast values.

RED allows generation of key subsets of the full set of parameters. It is not practical to allow all parameters to vary on all runs of the model, because the total number of such parameter values required for a single pass through the model is greater than 1000. For example, if the user wanted to generate 50 values for every uncertain parameter, over 50,000 values would have to be produced. While this exercise is within RED's capabilities, the cost is very high.

MECHANISM

A Monte Carlo routine uses the host computer's pseudo random number generator to translate user-supplied information on a parameter, such as its expected value, its range, and its subjective probability distribution, into random trial parameter values. By producing simulations using several such randomly generated values of the parameter, the model will yield electricity consumption forecasts that incorporate each parameter's uncertainty.

INPUTS AND OUTPUTS

The Uncertainty Module requires three basic inputs:

- the number of values to be generated
- a selection of parameters to vary
- the parameter file.

The parameter file contains the default values, ranges, and (if required) the expected value and variance of each parameter. Table 3.1 provides a summary of the inputs and outputs of the module.

TABLE 3.1. Inputs and Outputs of the RED Uncertainty Module

(a) Inputs

Symbol	Variable	Input From
N	Number of Values to be Generated	User Interface
(see Table 3.2)	Parameter's Range, Variance, and Expected Values	Parameter File

(b) Outputs

Symbol	Variable	Output To
(See Table 3.2)	Random Parameter Values	Other Modules
N	Number of Times Model is to be Run	Model Control Program

MODULE STRUCTURE

An overview of information flows within the Uncertainty Module is given in Figure 3.1. First, the program asks whether the user would like to generate a parameter. If the answer is no, then the default value (from the parameter file) for each parameter is assigned. If a random parameter value is to be generated, then the user is queried as to which parameters will be allowed to vary.

The next step is to choose the number of values to be generated for each parameter. This is the number of times the remainder of the model will be run, each time with a different generated value for each parameter. Next, an arbitrary seed for the random number generator is entered.

Next, the computer generates a random number for each value to be produced. This is accomplished by calling the computer's "pseudo" random number generator, which generates a random number between 0 and 1. From the parameter file, the information on the range of the parameter, or (for parameters with a normal distribution) the range, expected value, and variance is used to

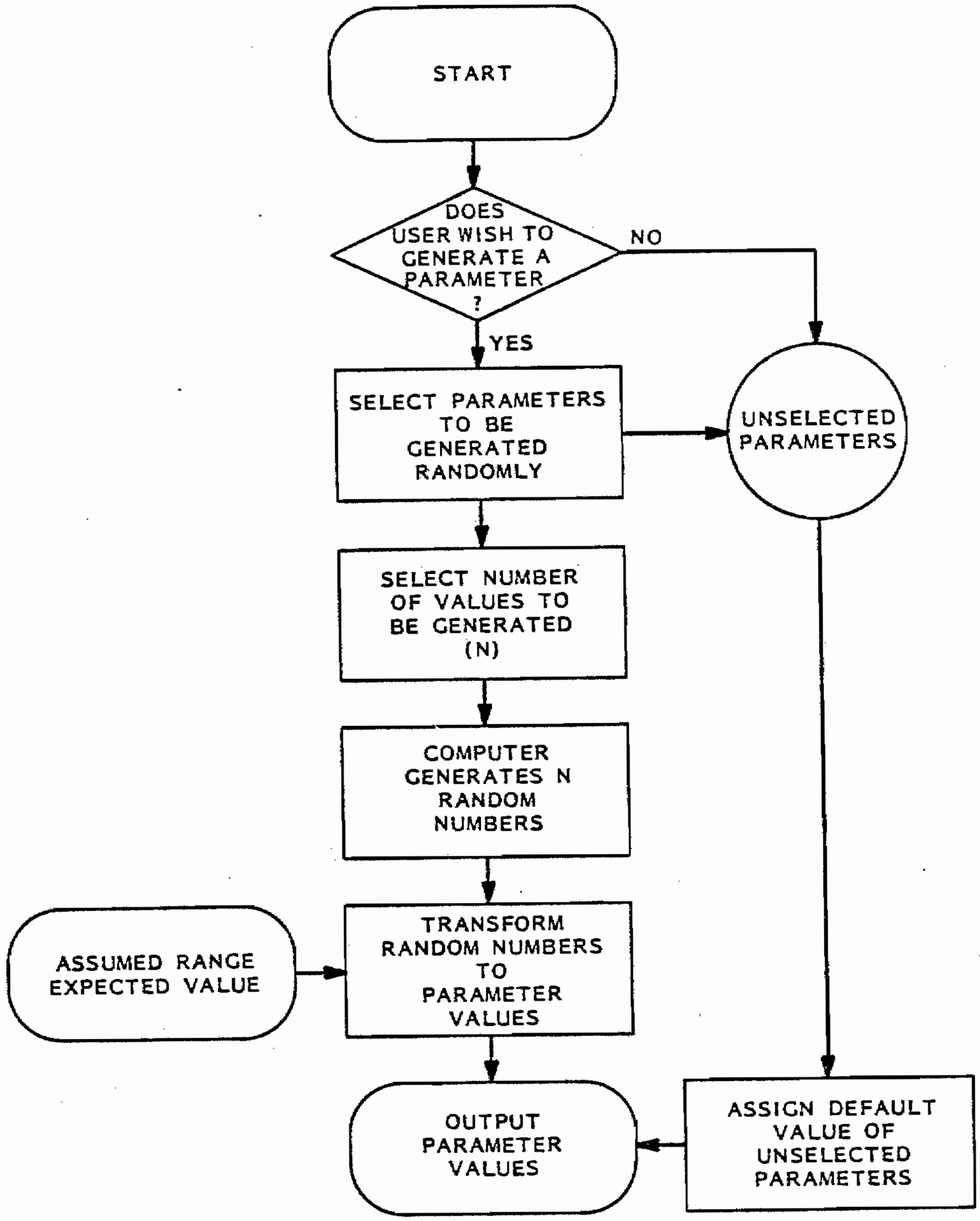

FIGURE 3.1. RED Uncertainty Module

construct cumulative probability functions for each parameter. The random values for each parameter are then generated by applying the random numbers to these functions.

PARAMETERS

Table 3.2 provides a list of the parameters that can be generated by the Uncertainty Module. Where information exists on parameter distributions from

TABLE 3.2. Parameters Generated by the Uncertainty Module[a]

Symbol	Name	Statistical Distribution
b_{as}; c_{as}; d_{as}	Housing Demand Coefficients	Normal
SAT	Saturation of Residential Appliances	Uniform
A; B; λ; OSR_ℓ; GSR_ℓ	Residential, Business Parameters for Own-, Oil-Cross and Gas-Cross Price adjustment	Normal
BBETA	Floor Space Consumption Parameter	Normal
CONSAT	Saturation of Conservation Technologies	Uniform
LF	Load Factor	Uniform

(a) Values of these parameters (except CONSAT, which varies by case) are found in Tables 4.9, 5.4 through 5.11, 6.8, 7.5, and 11.2.

econometric results, the distribution of values is assumed to be normally distributed. Where no information exists on the shape of the parameter distribution, all values within the range are considered equally likely and the distribution is assumed uniform.

4.0 THE HOUSING MODULE

The consuming unit in the residential sector is the household, each of which is assumed to occupy one housing unit. The Housing Module provides a forecast of civilian households and the stock of housing by dwelling type in each of the Railbelt's load centers. The type of dwelling is a major determinant of energy use in residential space heating. Furthermore, the type of dwelling is correlated with the stock of residential appliances. This module, therefore, provides essential inputs for the Residential Consumption Module.

MECHANISM

The Housing Module accepts as input an exogenous forecast of the regional population and number of households to forecast household size. The total households forecast is adjusted for military households and is then stratified by the age of the head of household and the number of household members. The housing demand equations then use this distribution of households by size and age of head to predict the initial demand for housing by type of dwelling. The initial demand for each housing type is compared with the remaining stock, and adjustments in housing demand and construction occur until housing market clearance is achieved.

INPUTS AND OUTPUTS

Table 4.1 presents the data used and generated within this module. Exogenous forecasts of regional households, population, and the state-wide distribution of households by age of head are needed as input, while the module passes information on the occupied and vacant housing stock to the remainder of RED.

MODULE STRUCTURE

The Housing Module's structure is shown in Figure 4.1. The module begins each simulation with a user-supplied forecast of households and population for the load center. The assumed number of households for each load center is first adjusted for military housing demand and multiplied by a decimal fraction

TABLE 4.1. Inputs and Outputs of the RED Housing Module

(a) Inputs

Symbol	Variable	Variable Input From
THH	Regional Household Forecast	Forecast File
HH_{Ata}	State Households by Age Group	Forecast File
b, c, d	Housing Demand Coefficients	Uncertainty Module

(b) Outputs

Symbol	Variable	Variable Output From
HD_{TY}	Occupied Housing Stock by Type	Residential Module

to obtain a forecast of households served by utilities. Total households are then stratified by age and size of household, and then used to generate an estimate of demand for each type of housing (TY). Demand is compared to the initial stock, resulting in new construction or reallocation of demand as appropriate. The end result is a set of estimates of occupied and unoccupied housing units by type. Finally, the housing stock is reinitialized for the next forecast period.

The first step in the Housing Module is to find the number of civilian households in a given Railbelt load center.

$$CHH_{it} = THH_{it} - BHH_{it} \tag{4.1}$$

where

CHH = total number of civilian households

BHH = military households residing on base (exogenous)

THH = total households (exogenous)

i = region subscript

t = forecast period subscript.

On-base military households are subtracted out because they do not significantly affect off-base housing. In addition, since the military supplies

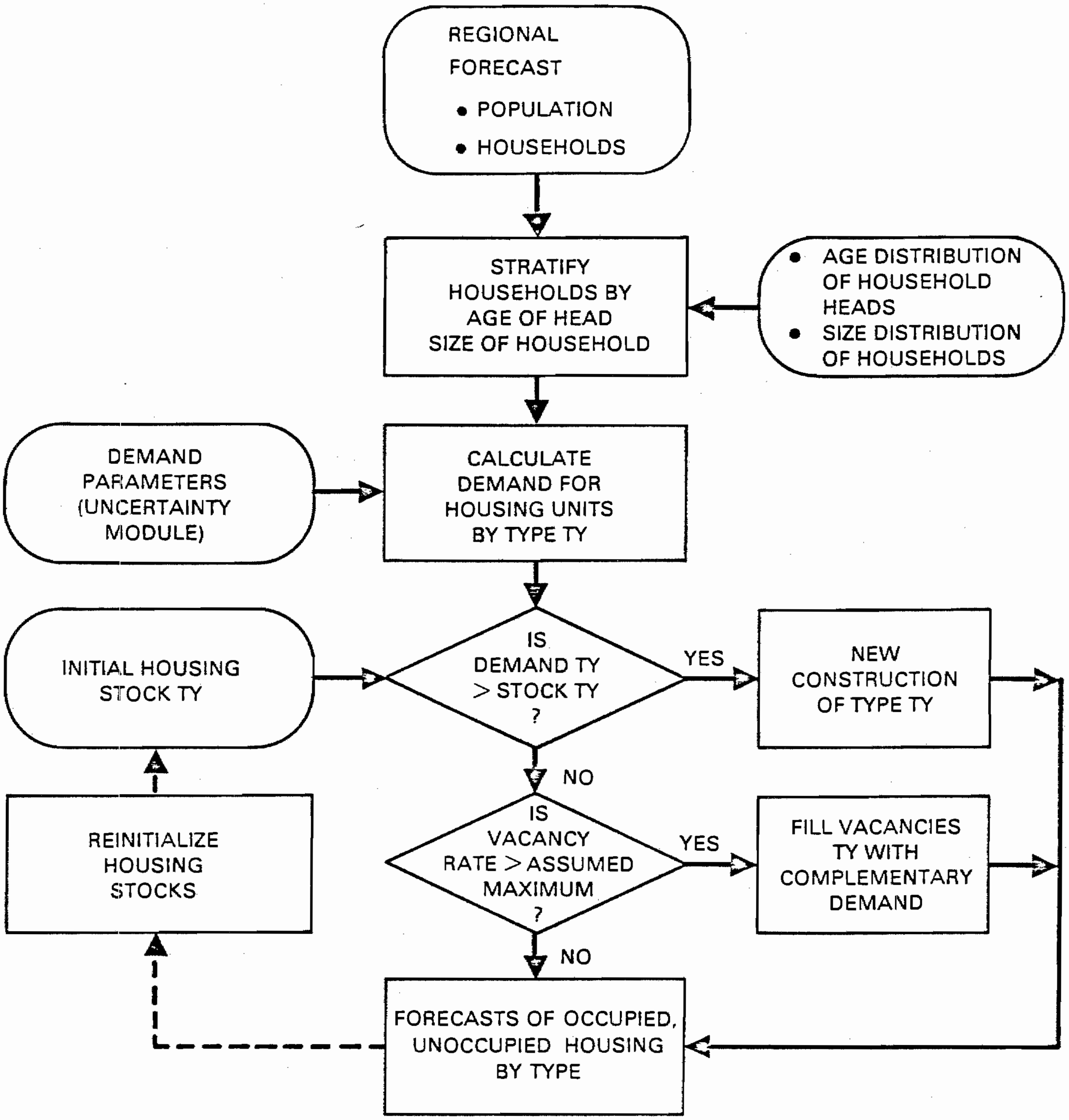

FIGURE 4.1. RED Housing Module

electricity to them, on-base households have no impact on the residential demand for utility-supplied electricity.[a]

Once the total number of civilian households in the load center has been obtained, they are stratified by the size of the household and the age of the household head. To obtain the distribution of households by size of household, the total number of households is multiplied by the probabilities of four size categories derived from information provided in the 1980 Census of Population. To estimate the distribution of households by the age of head, the 1980 Census ratio between the regional and state relative frequencies of age of head is assumed to remain constant. The user supplies forecasts of the statewide age distribution of heads of households from a forecasting model or by some other method. Using the state relative frequency distribution, therefore, and applying the constant ratios of regional to statewide frequencies, the model obtains forecasts of the regional distribution of households by age of head.

The joint distribution by size of household and age of head is obtained by multiplying the two distributions:

$$HH_{itas} = CHH_{it} \times \frac{HH_{Ata}}{THH_{Ata}} \times P_{its} \times R_{ia} \qquad (4.2)$$

where

HH = number of households in an age/size class

THH = total number of households

CHH = total civilian households

A = subscript denoting aggregate state variable

P = regional household size probability (parameter)

R = ratio of the regional to state relative frequency of age of household head (parameter)

a = age of head subscript

s = household size subscript.

(a) Military purchases of electricity from the utility system are handled as industrial loads.

The demand for a particular type of housing - single family, multifamily, mobile home, or duplex - is hypothesized to be a function of the size of the household and the age of the head (which serves as a proxy for household wealth). Equations projecting demand for three of the types of housing (single family, multifamily, mobile homes) were estimated by the Institute of Social and Economic Research (ISER) from Anchorage data collected by the University of Alaska's Urban Observatory (Goldsmith and Huskey 1980b). The remaining category (duplex) is filled with the remaining households.

The demand for a particular type of housing is given by the following equations:

$$HD_{SFit} = CHH_{it} \times b_0 + b_{a1} \times S_{1it} + b_{a2} \times S_{2it} + b_{a4} \times S_{4it} + b_{2s} \times A_{2it} + b_{3s} \times A_{3it} + b_{4s} \times A_{4it} \quad (4.3)$$

$$HD_{MFit} = CHH_{it} \times c_o + c_{a1} \times S_{1it} + c_{a2} \times S_{2it} + c_{a4} \times S_{4it} + c_{2s} \times A_{2it} + c_{3s} \times A_{3it} + c_{4s} \times A_{4it} \quad (4.4)$$

$$HD_{MHit} = CHH_{it} \times d_o + d_{a1} \times S_{1it} + d_{a2} \times S_{2it} + d_{a4} \times S_{4it} + d_{2s} \times A_{2it} + d_{3s} \times A_{3it} + d_{4s} \times A_{4it} \quad (4.5)$$

$$HD_{DPit} = CHH_{it} - HD_{SFit} - HD_{MFit} - HD_{MHit} \quad (4.6)$$

where

HD = housing demand

SF = index for single family

$S_{sit} = \sum_{a=1}^{4} HH_{itas}$; s = 1,2,4

$A_{ait} = \sum_{s=1}^{4} HH_{itas}$; a = 2,3,4

MF = index for multifamily

MH = index for mobile home

DP = index for duplex

a = index denoting the age of houehold head

a = 1	<25
a = 2	25-29
a = 3	30-54
a = 4	55+

s = index denoting the size of household

s = 1	≤ 2
s = 2	3
s = 3	4-5
s = 4	6+

b, c, and d are parameters from the Uncertainty Module. Expected values and ranges of these parameters are presented in Table 4.9.

The model then adjusts the housing stock and housing demand so that the housing market is cleared. Initially, the housing stock is calculated as the previous period's stock net of demolition:

$$HS_{TYit} = HS_{TYi(t-1)} \times (1 - r_t) \qquad (4.7)$$

where

HS = housing stock

TY = index denoting the type of housing (SF, MF, MH, and DP)

r = period-specific removal rate (parameter).

Net demand for each type of dwelling is defined as the demand minus the housing stock:

$$ND_{TYit} = HD_{TYit} - HS_{TYit} \qquad (4.8)$$

where

ND = net demand.

If net demand for all types of housing is positive, then enough new construction immediately occurs to meet the net demand plus an equilibrium amount of vacancies required to ensure normal functioning of the housing market:

$$NC_{TYit} = ND_{TYit} + V_{TY} \times (HS_{TYit} + ND_{TYit}) \qquad (4.9)$$

where

NC = new construction

V = normal vacancy rate (parameter).

The equilibrium vacant housing stock is the "normal" vacancy rate times the stock of housing.

If the net demand for a particular type of housing is negative, however, then the vacancy rate for that type of housing has to be calculated:

$$AV_{TYit} = 1 - \frac{HD_{TYit}}{HS_{TYit}} \qquad (4.10)$$

where

AV = actual vacancy rate.

If the actual vacancy rate is greater than its assumed maximum, then the excess supply of that particular type of housing is assumed to drive down the price of that type of dwelling. Individuals residing in other dwellings could be induced to move to reduce mortgage or rent payments. An adjustment to the distribution of housing demands, therefore, is appropriate.

Substitution first occurs, if possible, within groups of housing that are close substitutes (single-family and mobile homes; duplexes and multifamily). If not enough excess demand exists from the close substitutes to fill the depressed market, then substitution occurs from all types. The procedure is as follows:

1. The number of excess vacancies within a type is calculated by subtracting the housing demand from one minus the maximum vacancy rate, times the stock.

2. The number of substitute units available to fill the excess supply is given by subtracting one minus the normal vacancy rate, times the close substitute stock from the close substitute demand.

3. The minimum of 1 or 2 is subtracted from the complementary housing demand and added to the depressed demand.

4. If excess supply persists (the actual vacancy rate is above its assumed maximum), then the above procedure is repeated; only the number of housing units available is now calculated using maximum vacancy rates and all types of housing where the actual vacancy rate is less than their assumed maximum. The available units are then allocated based on normalization weights of the number available by type.

The final outputs of this module are occupied housing by type (HD_{TYit}) and unoccupied housing:

$$VH_{it} = \sum_{TY} HS_{TYit} - HD_{TYit} \qquad (4.11)$$

where

VH = total vacant dwelling units.

PARAMETERS

Military Households

The number of on-base military households, presented in Table 4.2, is assumed to remain constant over the forecast periods. The level of military activity in Alaska has stabilized, and little indicates that a major shift will occur in the future.

TABLE 4.2. Number of Military Households Assumed to Reside on Base in Railbelt Load Centers

Anchorage	Fairbanks
3,212	3,062

Source: Supplied by ISER.

Household Size and Demographic Trends

A key factor in the residential demand for electricity is the number and type of residential customers. The number of customers approximately equals the number of households served by electricity, with the difference being caused by such factors as vacant housing with electrical service. Thus, it is important in forecasting the demand for electricity to forecast the number of households. The number of households in a load center is, in turn, a function of the size of the population and the rate of household formation. Household formation depends on the number of persons of household formation age; certain economic factors that may influence household formation, such as potential household income, price of housing, interest rates; changing tastes for marriage and housing; and government housing programs.

Table 4.3 shows how the size of households has changed in the United States and in the Railbelt since 1950. The table indicates that the average number of persons per housing unit has declined dramatically in both the U.S. and the Railbelt during the period. Since 1970, the size decline has been more

TABLE 4.3. Household Size Western U.S. and Railbelt 1950-1980 (Persons per Occupied Unit)

	United States	Anchorage-Cook Inlet	Fairbanks-Tanana Valley
1950	3.5[(a)]	3.4[(a)]	3.3[(a)]
1960	3.3	3.4	3.6
1970	3.1	3.4	3.4
1980	2.7	2.9	2.9

(a) Obtained by dividing total resident population by total households. Includes only urban places of 10,000 persons for Alaska locations.

Sources: U.S. Department of Commerce 1982; Goldsmith and Huskey 1980b; Harrison 1979; and U.S. Bureau of the Census 1960.

rapid in the Railbelt than in the nation as a whole, resulting from increasing numbers and proportions of young, single adult householders and childless couples. This trend toward smaller households headed by young adults probably has a practical limit somewhere near the Western Census Region 1980 average household size of 2.6. However, recent revisions have been made to the University of Alaska's MAP economic and population model to forecast the number of households based on the household formation rates implicit in the 1980 census figures. These imply that the lower limit may not be reached. Table 4.4 shows the MAP forecast size of households in the Railbelt for the years 1980-2010 for a typical economic scenario. The average size of households is relatively insensitive to the scenario used, depending almost entirely on the age distribution of population.

Household formation rates are thought to depend on the income of potential householders, the price of housing, and borrowing costs implied by interest rates. Unfortunately, Alaska economic data do not include time series on Railbelt household income or housing prices; therefore, it has not proved possible to estimate household formation rates based on these variables.

The RED model formerly estimated the number of households in each Railbelt load center from a MAP model estimate of statewide households and the

TABLE 4.4. Forecast Size of Households, Railbelt Load Centers

Year	Anchorage-Cook Inlet	Fairbanks-Tanana Valley
1980	2.91	3.00
1985	2.73	2.89
1990	2.69	2.85
1995	2.67	2.81
2000	2.64	2.79
2005	2.63	2.76
2010	2.62	2.71

Source: University of Alaska Institute of Social and Economic Research, case HE.6, FERC 0% Real Growth in Oil Prices relationship between the age distribution of the population in each load center and the age distribution of Alaska's population. The 1983 version now simply accepts a MAP model forecast of the number of households in each load center. The number of households served by electric utilities is estimated by multiplying the numbers of households times a constant to reflect the proportion of households served by electricity.[a] The number of households served by utility-generated electricity is virtually 100% in Anchorage. Rural areas of the Matanuska-Susitna Borough and Kenai Peninsula Borough have a few residences not served (mostly seasonal homes), but the Fairbanks North Star Borough and Delta Junction areas have many year-round dwellings not served by utilities.

Historic and Projected Trends in Demand for Housing

The demand for a particular type of housing--single family, multifamily, mobile home, or duplex--is hypothesized to be a function of the size of household and the age of the household head. The economics literature generally also includes price of housing and household income in the demand for housing. However, Alaska economic information does not include time series on family income and housing prices that could be used to forecast housing demand by type. Cross-sectional data on household income do exist for Anchorage in 1977 by type of housing (Ender 1978); however, the lack of historical time series on household income prevent the estimation of household income as a function of economic growth over time in the Railbelt. However, the age of the head of household serves to some extent as a proxy for household income, with older household heads generally more wealthy and able to afford larger homes. Larger households also require more space and larger homes. These factors are included in the demand equations for individual types of houses contained in the RED model.

Government Program Effects

ISER performed an analysis of State of Alaska housing programs in 1982 (ISER 1982) with the following findings. Alaska Housing Finance Corporation

(a) Although this calculation is actually performed in the Housing Module, its description is included in this doucment with the discussion of residential electricity demand in Section 5.0.

(AHFC) operates several different housing programs on behalf of the state in which it acts as a secondary lender to provide mortgage loan money at the lowest possible interest rates. Between July 1980 and December of 1982, AHFC had a substantial negative impact on mortgage interest rates in Alaska, ranging from 2.5 percentage points in July, 1980 to slightly more than 4 percentage points in December 1981. Average loan volume repurchased by AHFC increased 5 times between 1979 and 1981, and accounted for 85% of all Alaska home loans from July 1980 to October 1981. Much of the activity was due to the special Mortgage Loan Purchase program enacted in June 1980. ISER found that the State of Alaska's low interest housing loan programs caused construction of new homes statewide to be about one thousand units higher (or one third higher) than it would have been without the program and caused conversion of about 300 units from rental to sales units. The other substantial effect was on the quality of housing purchased. New homes built during 1980-1981 were an average $25,000 more expensive than existing homes. The proportion of multifamily construction was not clearly affected one way or the other by the loan programs. In 1980 and 1981 new multifamily construction in Anchorage was only 30% of total units built, whereas it had been 50% or more every year from 1974 through 1979. However, opposite effects were found in Fairbanks. Loan program impacts were confounded with the levels of rents. These were depressed between 1979 and 1981 and failed to support the construction of new multifamily rental units.

Compared to a situation without large-scale interest subsidies, ISER's findings suggest that continuation of these large-scale subsidies would result in the following: 1) more first-time home buyers and more expensive units being built (though it is not clear that these would necessarily be single-family detached houses rather than condominiums); and 2) downward pressure on rents, reducing the incentive for building multifamily rental units. Depending on people's tastes for single-family detached units versus condominiums and the builder's cost of providing units of each type, government programs could cause single-family construction to increase or decrease as a proportion of the total. In the RED model, government programs are assumed to have no long-term net effect on housing mix by type.

Housing Demand by Type of Housing

Table 4.5 compares the demand for types of housing in the Anchorage-Cook Inlet load center with and without the influence of household age and household size as reflected in the RED model structure. With the influence of household size and age, relatively more households occupy single-family homes, which have a lower electric fuel mode split than multifamily housing. By the year 2010, residential electricity demand is about 3% lower with the effects of size and age of households on housing mix than without these effects. As revealed by the table, even fairly large differences in the proportions of households in the various types of dwellings have little impact on electricity consumption forecasts.

TABLE 4.5. Impact of Householder Age and Household Size on Housing Mix and Total Utility Sales, Anchorage-Cook Inlet

	1980	1990	2000	2010
Single Family Proportion of Served Households:				
With Age and Size Effects	0.496	0.549	0.549	0.545
Without Age and Size Effects	0.496	0.461	0.461	0.461
Multifamily Proportion of Served Households:				
With Age and Size Effects	0.284	0.245	0.261	0.264
Without Age and Size Effects	0.284	0.383	0.383	0.383
Mobile Home Proportion of Served Households:				
With Age and Size Effects	0.115	0.126	0.127	0.129
Without Age and Size Effects	0.115	0.097	0.097	0.097
Duplex Proportion of Served Households:				
With Age and Size Effects	0.105	0.080	0.063	0.063
Without Age and Size Effects	0.105	0.059	0.059	0.059
Residential GWH Sold by Utilities:				
With Age and Size Effects	979.5	1336.1	1599.6	1883.9
Without Age and Size Effects	979.5	1382.2	1656.4	1955.0

Source: RED Model Runs, Case HE. 6, FERC 0% Real Price Increase.

After an initial adjustment, Table 4.5 also shows a slight downward trend in the proportion of single-family households as the size of households declines between 1990 and 2010. This is consistent with the falling historical trend in the proportion of single-family houses in Railbelt communities from 1950-1980, as shown in Table 4.6. Although a short-term reversal of the historical trend may have been occurring since 1980, especially in Fairbanks, high vacancy rates and depressed rents probably explain the high proportion of single-family homes constructed since 1980. In particular, the very high proportion of single-family construction in Fairbanks since 1980 can be attributed to high vacancy rates in multifamily units between 1977 and 1980. Vacancy rates for multifamily dwellings in Fairbanks ranged upward from 0.5% in May 1976 to 13.5% in June 1980. The vacancy rates have fallen dramatically since (to 1.7% by June 1982), and building permits for new multifamily units have recovered, increasing by over 50% in the North Star Borough from 1981 to 1982 (Community Research Quarterly, Winter 1982).

Tables 4.7 and 4.8 present the parameters used to derive the joint distribution of households by size and age of head. The baseline figures for the

TABLE 4.6. Single-Family Housing as Proportion Year-Round Housing Stock by Type, Railbelt Load Centers, 1950-1982

	Anchorage - Cook Inlet	Fairbanks - Tanana Valley
1950[a]	0.592	0.713
1960	0.628	0.518
1970	0.471	0.389
1980	0.462	0.450
1982[a]	0.472	0.472
Proportion Single-Family Housing Built 1980-82	0.539	0.781[b]

(a) Urban Anchorage and Fairbanks only.
(b) Fairbanks-North Star Borough only.

Source: Table 13.1.

TABLE 4.7. Probability of Size of Households in Railbelt Load Centers

Year	Size	Anchorage	Fairbanks
1980[(a)]	<2	0.476	0.455
	3	0.190	0.210
	4-5	0.291	0.287
	6+	0.042	0.048
1985[(b)]	<2	.489	.468
	3	.188	.208
	4-5	.282	.278
	6+	.042	.048
1990[(b)]	<2	.502	.481
	3	.185	.205
	4-5	.272	.268
	6+	.041	.047
1995[(b)]	<2	.515	.494
	3	.182	.202
	4-5	.262	.258
	6+	.041	.047
2000[(b)]	<2	.528	.507
	3	.180	.200
	4-5	.253	.249
	6+	.041	.047
2005[(b)]	<2	.541	.520
	3	.178	.198
	4-5	.244	.240
	6+	.041	.047
2010[(b)]	<2	.554	.533
	3	.175	.195
	4-5	.234	.230
	6+	.041	.047

(a) Source: Battelle-Northwest End-Use Survey.

(b) The Anchorage initial distribution reaches the Western U.S. regional average by 2010 (Bureau of the Census 1977). The Fairbanks distribution is assumed to have the same rate of change as Anchorage.

TABLE 4.8. Regional Frequency of Age of Household Head Divided by the State-Wide Frequency

Age of Head	Anchorage	Fairbanks
<25	1.064	1.108
25-30	1.013	1.103
31-54	1.018	0.988
55+	0.867	0.842

Source: 1980 Census of Population General Population Characteristics: Alaska PC80-1-B3.

distribution of size parameters were derived from the Battelle Northwest end-use survey. Those parameters were adjusted to approximately approach the 1977 Western Regional average household size of 2.6 (Bureau of Census 1977) by the year 2010 in Anchorage in constant linear increments. Fairbanks uses the same increments and converges to a household size of about 2.7. The ratio of regional to statewide frequency of age of head was derived from the 1980 Census of Population for Railbelt locations. These ratios are assumed to remain constant over the forecast period.

The housing demand parameters were originally estimated by ISER using a linear probability model. The expected values in Table 4.9 are the estimated coefficients reported by ISER. The ranges were calculated as the width of the 95% confidence intervals; the variance was backed out of the reported F statistics.

Vacancies

Table 4.10 presents the assumed normal and maximum vacancy rates by type of house. ISER derived the normal vacancy rates by taking the ten-year U.S. averages of vacancy rates for owner and renter units (Goldsmith and Huskey 1980b). Single-family and mobile homes have the owner rate; multifamily homes have the renter rate; and duplexes are the average of owner and renter rates. For the maximum vacancy rates, Anchorage multifamily rates were available. The relationship between the normal rates for multifamily and all other types was used to derive the maximum rates.

TABLE 4.9. Housing Demand Equations: Parameters' Expected Value, Range, and Variance

Parameter	Expected Value	Range	Variance
b_o	0.461	--	--
b_{a1}	-0.303	0.142	0.001
b_{a2}	-0.175	0.152	0.001
b_{a4}	0.080	0.230	0.003
b_{2s}	0.182	0.205	0.003
b_{3s}	0.317	0.182	0.002
b_{4s}	0.380	0.226	0.003
c_o	0.383	--	--
c_{a1}	0.225	0.124	0.001
c_{a2}	0.086	0.133	0.001
c_{a4}	-0.090	0.202	0.003
c_{2s}	-0.203	0.180	0.002
c_{3s}	-0.280	0.159	0.002
c_{4s}	-0.352	0.198	0.003
d_o	0.097	--	--
d_{a1}	0.068	0.101	0.001
d_{a2}	0.039	0.109	0.001
d_{a4}	0.014	0.159	0.002
d_{2s}	0.008	0.152	0.001
d_{3s}	-0.020	0.130	0.001
d_{4s}	-0.016	0.162	0.002

Source: Goldsmith and Huskey 1980b, Table B.6.

Depreciation and Removal

Housing demolition rates (Table 4.11) are a function of the age of the housing stock and the demand for housing. ISER found that approximately 1% of the housing stock was removed between 1975 and 1980 in Anchorage and Fairbanks (Goldsmith and Huskey 1980b). As the existing stock ages, the removal rate is assumed to grow toward the U.S. average, which has been estimated to be between 2 and 4% per forecast period (5 years).

TABLE 4.10. Assumed Normal and Maximum Vacancy Rates by Type of House (Percent)

Type	Normal Rate[(a)]	Maximum Rate[(b)]
Single Family	1.1	3.3
Mobile Home	1.1	3.3
Duplex	3.3	10.0
Multifamily	5.4	16.0

(a) Imputed by ISER from Bureau of the Census (1980a).
(b) Imputed by ISER from Anchorage Real Estimate Research Committee (1979).

TABLE 4.11. Assumed Five-Year Housing Removal Rates in Railbelt Region, 1980-2010 (Percent of Housing Stock at Beginning of Period Removed During Period)

Years	Removal Rate (percent)
1980-1985	1.25
1985-1990	1.50
1990-1995	1.75
1995-2000	2.00
2000-2005	2.25
2005-2010	2.50

Source: Author Assumption.

The professional economics literature has devoted some attention to depreciation rates in housing. In an article in the Review of Economics and Statistics, Leigh (1980) used a perpetual inventory method of calculating the national stock of efficiency-adjusted residential housing units and checked these estimates against the Census of Housing for 1950, 1960, and 1970 as well as other authors' estimates. The various sources sited in Leigh's article show values for economic depreciation/replacement ranging from 0.4 to 2.35%, with most estimates grouped around 1.0 to 1.5%. Leigh herself calculates about 1%

for the period 1950 through 1970. ISER calculated an approximate five-year 1% rate of removal for Anchorage and Fairbanks housing units by comparing the estimated number of units in 1970 and 1979 with cumulative building permits data. Because the housing stock ages and new houses provide more "services" than old houses, the rate of economic depreciation for a given area is assumed to be larger than the rate of physical depreciation. Consequently, housing units are physically replaced less frequently than 1% per year. The U.S. average physical depreciation rate was calculated by de Leeuw (1974) at between 2 and 4% per five-year period or 0.4 to 0.8% per year. It is assumed that as the Alaska housing stock ages, the very low current removal rate of 1.0% per five years will approach the national lower bound rate, 2.0% by 2000 and 2.5% by the year 2010.

Base Year Housing Stock

The base-year housing stock figures displayed in Table 4.12 are the counts of year-round housing stock from the 1980 Census of Housing for Alaska.

TABLE 4.12. Railbelt Housing Stock by Load Center and Housing Type, 1980 (number of units)[a]

Housing Type	Anchorage	Fairbanks
Single Family	40,562	10,873
Mobile Homes	10,211	2,175
duplexes	8,949	2,512
Multifamily	27,980	8,607
Total	87,702	24,167

(a) A unit is occupied by one household. Thus, a 4-plex is considered four housing units.

Source: 1980 Census of Housing, STF3 Data Tape.

5.0 THE RESIDENTIAL CONSUMPTION MODULE

The Residential Consumption Module provides forecasts of electricity consumption for the Residential Sector. The forecasts of the residential sector's needs do not include the impacts of conservation produced by market intervention by government. The potential for and impacts of such conservation activities are handled in the Program-Induced Conservation Module (see Chapter 8.0). Furthermore, the module's forecast of residential requirements is the amount of electricity that needs to be delivered to the residential sector - it does not include allowances for line losses.

The Residential Consumption Module estimates the amount of electricity residential consumers use, with explicit consideration of the impacts of electricity price changes and fuel switching among electricity, gas, and oil. Impacts of fuel switching to and from other fuels (such as wood) are handled in the Program-Induced Conservation Module.

MECHANISM

The Residential Consumption Module employs an end-use approach. In an end-use analysis, the first step is to identify the major uses of electricity. Future market saturations of the uses are forecasted so that the future stock of electricity-consuming devices is defined. The next step is to estimate the amount of electricity demanded to meet a future demand for the services of the devices. The forecast of average consumption of the appliance stock, therefore, reflects both the trend in the size of the device and its utilization rate, as well as projected increases in the efficiency of the device. Once the stock of major electricity-consuming devices and their corresponding average annual per-unit consumption of electricity are forecast, the future consumption of electricity by device type is obtained by multiplying the number of devices by their predicted annual average consumption of electricity. Using the same procedure for miscellaneous residential uses and summing over all end-uses yields an aggregate forecast of electricity requirements.

One major problem of the end-use approach is that the impacts of changes in fuel prices (both electricity and alternatives) and income on electricity usage are usually treated directly through the forecaster's judgment. The RED Residential Consumption Module addresses this problem differently. By adjusting the aggregate residential consumption figure with variable price and cross-price adjustment factors computed in the model from actual consumption data and prices, RED accounts for price change and fuel-switching impacts in the residential sector. These adjustments can be interpreted as electricity conservation induced by changes in fuel prices.

INPUTS AND OUTPUTS

Table 5.1 presents the inputs and outputs of the module. The number of households by dwelling type is the number of occupied civilian dwelling units served by electricity predicted in the Housing Module. The price adjustment parameters, as well as the appliance saturations, are generated in the Uncertainty Module. The output of the module is preliminary residential sales of electricity.

MODULE STRUCTURE

The Residential Consumption Module identifies the following major uses of electricity in the residential sector:

1. Water Heating
2. Cooking
3. Refrigeration
4. Freezing
5. Clothes Washing (and additional water heating)
6. Clothes Drying
7. Dishwashing (and additional water heating)
8. Saunas-Jacuzzis
9. Space Heating

In addition, several other uses of electricity by households are captured by a small appliance category. Small appliances include televisions, radios, lighting, head-bolt heaters, kitchen appliances, heating pads, etc. The basic

TABLE 5.1. Inputs and Outputs of the RED Residential Module

(a) Inputs

Symbol	Variable	From
HD_{TY}	Electrically Served Households by Type of Dwelling	Housing Stock Module
A,B,λ, OSR,GSR	Price Adjustment Coefficients	Uncertainty Module
SAT	Appliance Saturations	Uncertainty Module

(b) Outputs

Symbol	Variable	To
RESCON	Residential Electricity Requirements	Miscellaneous, Peak Demand and Conservation Modules

premise of this module is that the household is the primary consumer of electricity, not the individual. However, the number of individuals in the household significantly affects the consumption of energy for clothes washing, clothes drying, and water heating. Therefore, an adjustment is included in the model for changes in the average household size to recognize the impact of such changes on the usage of these appliances.

For the nine major uses of electricity, the end-use approach is used (see Figure 5.1). Figure 5.1 shows the calculations that take place in the Residential Consumption Module. Beginning with a regional estimate of occupied housing stock by type, the module uses appliance market saturation parameters to estimate the stock of each of the major appliances recognized by the model. The module then calculates the initial fuel mode split for multifuel appliances, calculates preliminary electric consumption for each appliance type (including small appliances), and then sums these estimates together into a preliminary consumption estimate for the residential sector. Price forecasts for gas, oil, and electricity and "trial"-specific own-price and cross-price adjustments are used to adjust the preliminary forecast. The adjustments are described in Section 7.0.

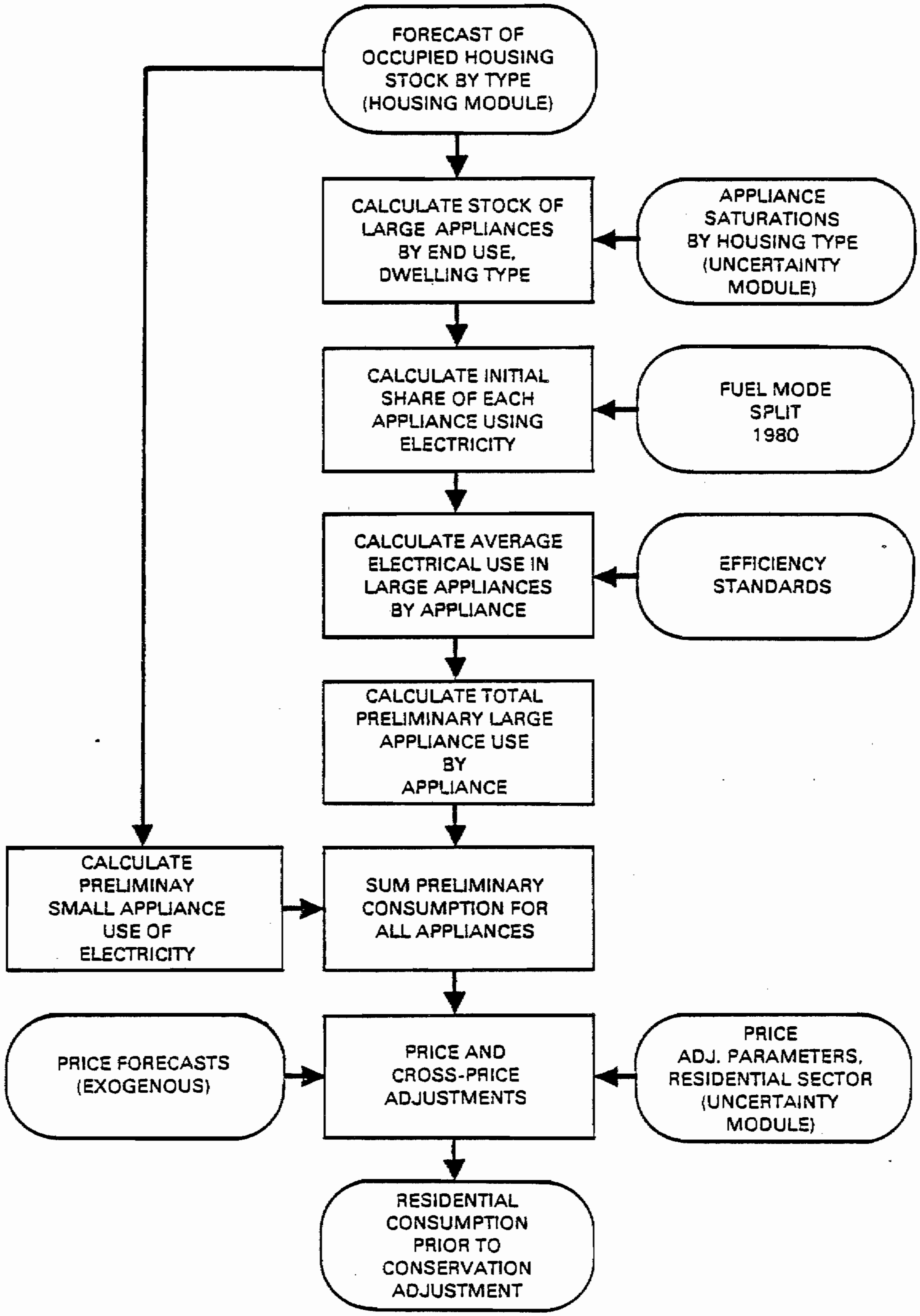

FIGURE 5.1. RED Residential Consumption Module

Results from the Battelle-Northwest (BNW) end-use survey (see Appendix A) show significant differences in the saturations of these nine end uses by the type of dwelling in which the household resides. The module, therefore, uses the number of occupied housing units of each type of dwelling (single family, multifamily, mobile home, and duplex) as predicted by the Housing Module as one of the inputs to estimate the stock of appliances.

The Housing Module predicts the number of occupied primary[a] residences by type in a given region served by electric utilities. By multiplying the number of occupied housing units by type by an assumed percentage served, the Housing Module forecasts the number of primary occupied housing units served:

$$HHS_{TYit} = SE_{it} \times HD_{TYit} \qquad (5.1)$$

where

HHS = households served

TY = denotes the type of dwelling

SE = proportion of households served by an electric utility

HD = stock of occupied dwellings from the Housing Module

i = region subscript

t = forecast period (t = 1, 2, 3, ..., 7).

Once the number of electrically served households by type of dwelling is known, the applicance stock can be estimated. The saturation rate for an appliance is the percentage of households residing in a certain type of dwelling and having the appliance in question. By multiplying the housing-type-specific saturation rate by the number of households residing in that type of housing and then summing across housing types, the model forecasts appliance demand in each future forecast period t:

$$AD_{itk} = \sum_{TY=1}^{4} SAT_{TYitk} \times HHS_{TYit} \qquad (5.2)$$

(a) Excluding second or recreation homes.

$$AD_{itk} = \sum_{TY=1}^{4} \left(SAT_{TYitk} \times HHS_{TYit} \right) \qquad (5.2)$$

where

AD = appliance demand

SAT = saturation rate (parameter)

k = end-use appliance.

Next, the model calculates the number of future additions to the stock. Assuming demand is fully met, the number of new appliances in period t is found by calculating the stock of appliances surviving from all previous periods and subtracting this surviving stock from appliance demand:

$$NA_{itk} = AD_{itk} - \sum_{m=1}^{t-1} NA_{imk} \times \left(1 - d_{tk}^{m}\right) - AS_{iok} \times \left(1 - d_{tk}^{o}\right) \qquad (5.3)$$

where

NA = number of new appliances

AS_{iok} = initial stock of appliances (1980)

d_{tk}^{m}= vintage specific scrap rate in period t; for vintage m (parameter) (m = 1, 2, 3, ..., 7).

Equation 5.3 can be rearranged so that the stock equals the demand:

$$AD_{itk} = AS_{iok} \times \left(1 - d_{tk}^{o}\right) + \sum_{m=1}^{t} NA_{imk} \times \left(1 - d_{tk}^{m}\right) \qquad (5.3')$$

The future appliance stock, therefore, can be stratified by vintage. Next, the model calculates the initial stock of electricity-consuming appliances by multiplying the number of appliances in each vintage by the percentage using electricity:

$$EAS_{iok} = FMS_{ik} \times AS_{iok} \qquad (5.4)$$

$$ENA_{imk} = FMS_{ik} \times NA_{imk} \qquad (5.5)$$

$$EAD_{itk} = FMS_{ik} \times AD_{itk} \qquad (5.6)$$

where

EAS = initial stock of electric appliances

FMS = fuel mode split

ENA = additions to the electric appliance stock

EAD = total electric appliance stock.

The Residential Consumption Module next calculates the average annual electricity consumption of each major appliance. Different vintages of appliances use different amounts of electricity, so the average consumption must reflect the vintage composition of the stock. Furthermore, industry energy efficiency standards for appliances could change in future years. The future vintage specific consumption rate can be derived by multiplying the current (1980) consumption rate by a growth factor and adjusting for any changes in efficiency standards. By weighting these figures by the proportion of the stock they represent, the average consumption of each appliance type in a forecast year is derived:

$$AC_{itk} = AC_{iok} \times \frac{EAS_{iok} \times (1-d^{o}_{tk})}{EAD_{itk}} + \sum_{m=1}^{t} \left(AC_{iok} \times (1+g_k)^{(m-1)} \times Z \times (1-cs_{mk}) \times \frac{ENA_{imk}\,(1-d^{m}{}_{tk})}{EAD_{itk}} \right) \qquad (5.7)$$

where

AC_{itk} = average consumption of appliance k in period t (parameter)

AC_{iok} = average consumption of appliance k in the beginning period (parameter)

Z = length of forecast periods t and m in years (parameter) set equal to 5 for this study.

g = growth rate of appliance k consumption (parameter)

cs = conservation standards target consumption reduction (parameter).

Finally, the preliminary consumption for each major appliance can be calculated by multiplying the stock of each appliance by its calculated average consumption:

$$CONS_{itk} = EAD_{itk} \times AC_{itk} \times AHS_{itk} \tag{5.8}$$

where

CONS = preliminary consumption of electricity prior to price adjustments

AHS = household size adjustment parameter for clothes washing, clothes drying, water heaters only.

The Residential Module makes no distinction among the various types of appliances in the small appliance category. The requirements for these units are simply the product of the number of households in the region, the initial consumption level, and a growth factor in consumption over time:

$$CONS_{itsa} = \sum_{TY} HHS_{TYit} \times [AC_{iosa} + (ACG_{itsa} \times t \times Z)] \tag{5.9}$$

where

ACG = growth factor in small appliance consumption

sa = index denoting small appliances.

Total preliminary residential consumption is found by summing across end uses:

$$RESPRE_{it} = \sum_{k=1}^{9} CONS_{itk} + CONS_{itsa} \tag{5.10}$$

where

RESPRE = total preliminary residential consumption.

$RESPRE_{it}$ reflects mainly the physical characteristics of the stock of electrical appliances and household income. Consumers, however, can respond dramatically to changes in the prices of electricity and alternative fuels. The own- and cross-price adjustment factors measure the responsiveness of consumers to price changes. Specifically, the own-price adjustment factor is the ratio of the percentage of change in the quantity taken of electricity during a five-year period to the weighted percentage change in price of electricity relative to the prices of other goods during the period.

Similarly, the demand for electricity is also a function of the prices of alternative fuels. For example, the <u>cross</u>-price adjustment factor for gas measures the responsiveness of the quantity of electricity taken with respect to change in the price of natural gas. In other words, the cross-price adjustment factor predicts the percentage change in the quantity of electricity taken for a one-percentage change in the relative price of an alternative fuel.

If the cross-price effect is positive, then the fuels are said to be substitutes. As the price of another fuel rises, the quantity taken of electricity rises. For example, natural gas and electricity are substitutes. If the price of gas rises enough relative to the price of electricity, then some natural gas customers will switch to electricity. If the cross-price effect is negative, the fuels are complements, implying that increases in the price of the alternate fuel will cause reductions in the amount of the electricity that is taken.

The RED model distinguishes between short-run and long-run responses to price. In the short run, or the immediate future, consumers cannot alter their usage as much as over longer periods of time, since their stock of appliances is fixed. Over a longer period of time, they can replace elements of their stock with devices that use less electricity, or perhaps use another fuel source. Therefore, the speed with which consumers adjust from the short-run to the long-run is important.

The price effects generated in RED are aged over the forecast period from their short-run values to their long-run values, thus explicitly modeling consumers' changing the pattern of use in the short run and fuel switching in the long run. The Uncertainty Module generates both the short-run values of the price effect for specific trials and the coefficient of the speed of consumer response. Chapter 7.0 discusses both the economic theory and literature underlying the estimation of the own-price effect and cross-price effects of gas and oil on electricity consumption, as well as the manner in which the effects are calculated.

The actual calculation of the price adjustment of residential consumption is as follows:

$$RESCON_{it} = RESPRE_{it} \times (1 + OPA_{it}) \times (1 + PPA_{it}) \times (1 + GPA_{it}) \qquad (5.11)$$

where

RESCON = consumption of electricity in the residential sector
OPA = own-price adjustment for electricity
PPA = cross-price adjustment for fuel oil
GPA = cross-price adjustment for natural gas.

RESCON is the predicted electricity consumption in the residential sector before adjustments for program-induced conservation. This figure is passed to the Peak Demand and Program-Induced Conservation Modules. Note that RESCON is a single number. The Residential Consumption Module does not report price-adjusted consumption of electricity by end use.

PARAMETERS

The percentage of households served by an electric utility (Table 5.2) is an important parameter. ISER has estimated that only 91% of the occupied housing in Fairbanks was connected to an electric utility (Goldsmith and Huskey 1980b). Due to the high emphasis the Alaska state legislature and governor have placed on energy, the extension of electrical service to all who would like service is highly probable. Therefore, electrical services are assumed to be extended to the entire stock of housing in the Fairbanks load center by 1995. The Anchorage-Cook Inlet load center is assumed to be 100% served.

TABLE 5.2. Percent of Households Served by Electric Utilities in Railbelt Load Centers, 1980-2010

Year	Anchorage	Fairbanks
1980[(a)]	100	91
1985[(b)]	100	93
1990[(b)]	100	96
1995[(b)]	100	100
2000[(b)]	100	100
2005[(b)]	100	100
2010[(b)]	100	100

(a) Source: Goldsmith and Huskey 1980b, Table C.13, C.14, D.4, D.5.
(b) The state is assumed to extend electrical service to all residents by 1995.

Appliance Saturations

Because historical growth and comparison with the lower forty-eight states provide only limited guidance on both current and future market saturations of major appliances, somewhat arbitrary maximum penetration rates have been estimated. The estimates were made by comparing recent utility saturation rate studies by San Diego Gas & Electric (SDG&E) in 1982 and Southern California Edison (SCE) in 1981 (realizing their limited relevance in estimating Alaska saturation rates), information from 1980 Census of Housing for Alaska, information from the Battelle-Northwest end-use survey, and other related literature. Wide bands of uncertainty should be presumed for all appliances examined since saturation rate data in the literature were not consistent. Table 5.3 summarizes saturation rates examined.

Market penetration rates for many appliances in Alaska are already outside the bounds of lower forty-eight state experience and have been increasing over time. However, many of the major appliances will likely never reach 100% market saturation for a variety of reasons, such as transient population, the convenience of substitutes such as laundromats, small housing units with

TABLE 5.3. Appliance Saturation Rate Survey (table values in percent of households)

Appliance	SDG&E(1982)[a] (total market area)	SCE (1981) (range of values observed in market area)[b]	Railbelt: Housing Census (1980 (range of values: lowest, highest area)	Railbelt BNW End-Use Survey (1981) (range of values: lowest to highest area and building type)
Clothes Drier	--	71.1-81.2	--	61.0-90.2
Refrigerator	97.5	96.2-96.6	--	99
Freezer	26.2	9.1-33.5	--	57.2-94.8
Hot Tub/Jacuzzi/ Saunas	11-39	1.3-19.4	--	2.5-16.9
Water Heater	--	92.3-97.7	92.0-97.7	86.9-100.0
Cooking Range	96.2	98.3-99.5	99.5-99.9	95.7-100.0
Dishwasher	55.4	41.2-58.0	--	23.3-78.2
Clothes Washer	68.9	75.6-89.3	--	63.8-92.5
Microwave Ovens	34.5	17.9-38.9	--	--
Space Heating	94.6	--	99.9	--

(a) Average values for all customers.
(b) By building type. Types were single family, apartments/condominiums/town houses, and mobile homes.
(c) Areas were Anchorage (Anchorage, Matanuska-Susitna, and Kenai Peninsula Boroughs) and Fairbanks (North Star Borough plus Southeast Fairbanks Census Area). Fairbanks was the lower value.
(d) Building types were single family, mobile home, multifamily, and duplex. See Tables 5.4-5.11.

Sources: See reference list.

inadequate space for some appliances, changing consumer perferences, etc. The saturation rate estimates assumed in the RED model reflect a compromise between 1) rapid historical growth in appliance stocks in Alaska, 2) approaching boundaries on market saturation and 3) comparable saturation data from other sources.

Tables 5.4 through 5.7 show the default value and range for future market saturations of major appliances that can use one of several fuels in normal home installation. The table values are the expected percentages of housing units of a given type that will own the appliance in a given year (having access to and owning an appliance may result in different saturation rates) and market area, and the subjective uncertain range that can be used instead of the default value if the Monte Carlo option is chosen. The table title indicates the type of housing. The assumptions for each type of appliance are given below.

Hot Water

Hot water was available in nearly 99% of single-family homes in the Anchorage market area, according to the Battelle-Northwest end-use survey. It is assumed that 99% is a maximum for two reasons: the market saturation of hot water in the Western U.S. was 99% in the 1970 Census (Bureau of Census 1970); and Alaska can be expected to have rural cabin-like structures with limited electric service for some time to come. In the Fairbanks market area, single-family saturations are projected to increase to the Anchorage level by 1990. The end-use survey and 1970 Census both show saturations in the vicinity of 90% in this area. Increasing urbanization in Fairbanks and better electric service should increase this percentage.

The other types of structures in the Battelle-Northwest survey showed market saturations of nearly 100% in all market areas. The exception was multifamily housing. However, the wording of the question in the survey upon which this calculation is based may have been interpreted as asking whether the respondent had a hot water tank in his unit rather than (as was intended) whether he had hot water available. A 100% market penetration for hot water in duplexes and multifamily buildings was assumed. Mobile homes were considered the same as single-family units.

TABLE 5.4. Market Saturations (percent) of Large Appliances with Fuel Substitution Possibilities in Single-Family Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Water Heater		Clothes Dryers		Range (cooking)		Saunas-Jacuzzis	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	98.6[a]	--	90.2	--	99.9[a]	--	14.1	--
	1985	98.8	95-100	91.2	88-94	100.0	100-100	16.3	13-19
	1990	99.0	98-100	92.5	89-95	100.0	100-100	18.7	14-22
	1995	99.0	98-100	93.7	90-96	100.0	100-100	21.0	16-26
	2000	99.0	98-100	95.0	92-98	100.0	100-100	23.4	18-28
	2005	99.0	98-100	95.0	92-98	100.0	100-100	25.7	20-30
	2010	99.0	98-100	95.0	92-98	100.0	100-100	28.1	23-33
b. Fairbanks	1980	86.9[a]	--	81.4	--	99.5[a]	--	7.9	--
	1985	93.0	91-95	84.0	80-88	100.0	100-100	8.9	6-12
	1990	99.0	98-100	87.5	82-92	100.0	100-100	10.0	6-14
	1995	99.0	98-100	92.5	87-97	100.0	100-100	11.2	6-16
	2000	99.0	98-100	95.0	92-98	100.0	100-100	12.4	7-17
	2005	99.0	98-100	95.0	92-98	100.0	100-100	13.6	8-18
	2010	99.0	98-100	95.0	92-98	100.0	100-100	14.8	9-19

(a) For hot water and cooking, missing values in the Battelle-Northwest survey were not counted.

TABLE 5.5. Market Saturations (percent) of Large Appliances with Fuel Substitution Possibilities in Mobile Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Water Heater Default	Water Heater Range	Clothes Dryers Default	Clothes Dryers Range	Range (cooking) Default	Range (cooking) Range	Saunas Jacuzzis Default	Saunas Jacuzzis Range
a. Anchorage	1980	98.2[a]	--	79.0	--	95.7[a]	--	6.1	--
	1985	99.0	98-100	80.0	79-81	100.0	100-100	6.9	3-11
	1990	99.0	98-100	82.0	80-84	100.0	100-100	7.8	4-12
	1995	99.0	98-100	84.0	82-86	100.0	100-100	8.7	5-13
	2000	99.0	98-100	85.0	83-87	100.0	100-100	9.6	6-14
	2005	99.0	98-100	90.0	85-95	100.0	100-100	10.5	6-14
	2010	99.0	98-100	95.0	91-99	100.0	100-100	11.4	7-15
b. Fairbanks	1980	99.0[a]	--	92.3	--	98.6[a]	--	2.5	--
	1985	99.0	98-100	94.0	91-97	100.0	100-100	2.8	1-5
	1990	99.0	98-100	95.0	92-98	100.0	100-100	3.1	1-7
	1995	99.0	98-100	95.0	92-98	100.0	100-100	3.5	1-8
	2000	99.0	98-100	95.0	92-98	100.0	100-100	3.8	1-8
	2005	99.0	98-100	95.0	92-98	100.0	100-100	4.2	1-8
	2010	99.0	98-100	95.0	92-98	100.0	100-100	4.5	1-9

(a) For water heat and cooking, missing values in the Battelle-Northwest end-use survey were not counted.

TABLE 5.6. Market Saturations (percent) of Large Appliances with Fuel Substitution Possibilities in Duplexes, Railbelt Load Centers, 1980-2010

Load Center	Year	Water Heater		Clothes Dryers		Range (cooking)		Saunas Jacuzzis	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	100.0[a]	--	90.0	--	96.4	--	16.9	--
	1985	100.0	100-100	91.0	90-92	100.0	100-100	19.0	16-22
	1990	100.0	100-100	92.5	90-95	100.0	100-100	21.2	17-25
	1995	100.0	100-100	93.0	91-96	100.0	100-100	23.4	18-28
	2000	100.0	100-100	95.0	92-98	100.0	100-100	25.6	21-31
	2005	100.0	100-100	95.0	92-98	100.0	100-100	27.6	23-33
	2010	100.0	100-100	95.0	92-98	100.0	100-100	29.8	25-35
b. Fairbanks	1980	100.0[a]	--	85.5[b]	--	100.0	--	8.2	--
	1985	100.0	100-100	91.0	90-92	100.0	100-100	9.2	6-12
	1990	100.0	100-100	92.5	90-95	100.0	100-100	10.3	6-14
	1995	100.0	100-100	93.0	91-96	100.0	100-100	11.4	6-16
	2000	100.0	100-100	95.0	92-98	100.0	100-100	12.5	8-18
	2005	100.0	100-100	95.0	92-98	100.0	100-100	13.5	9-19
	2010	100.0	100-100	95.0	92-98	100.0	100-100	14.6	10-20

(a) Values for Battelle-Northwest end-use survey were adjusted to 100 percent for water heaters in 1980. For explanation, see text.
(b) 1980 clothes dryer penetration in Fairbanks for 1980 adjusted downward by one to match the number of washers in duplexes.

TABLE 5.7. Market Saturations (percent) of Large Appliances with Fuel Substitution Possibilities in Multifamily Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Water Heater		Clothes Dryers		Range (cooking)		Saunas Jacuzzis	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	100.0[a]	--	75.7	--	98.2	--	13.6	--
	1985	100.0	100-100	83.0	82-84	100.0	100-100	15.0	12-18
	1990	100.0	100-100	83.5	82-85	100.0	100-100	16.4	12-20
	1995	100.0	100-100	84.0	82-86	100.0	100-100	17.7	13-23
	2000	100.0	100-100	85.0	83-87	100.0	100-100	18.9	14-24
	2005	100.0	100-100	90.0	85-95	100.0	100-100	19.9	15-25
	2010	100.0	100-100	95.0	92-97	100.0	100-100	20.9	16-26
b. Fairbanks	1980	100.0[a]	--	61.0	--	100.0	--	5.7	--
	1985	100.0	100-100	65.0	61-69	100.0	100-100	6.3	3-9
	1990	100.0	100-100	70.0	65-75	100.0	100-100	6.9	3-11
	1995	100.0	100-100	80.0	75-85	100.0	100-100	7.5	3-13
	2000	100.0	100-100	85.0	80-90	100.0	100-100	8.0	3-13
	2005	100.0	100-100	90.0	85-95	100.0	100-100	8.5	4-14
	2010	100.0	100-100	95.0	92-97	100.0	100-100	8.9	4-14

(a) Water heat survey numbers adjusted to 100 percent for 1980. For explanation, see text.

Clothes Dryer

The Battelle-Northwest survey and 1970 Census both show Railbelt market saturations for clothes dryers far above the U.S. average (Bureau of Census 1970). Information available from the 1980 U.S. Statistical Abstract for 1979 shows that about 61.5% of electrically served housing units have an electric or gas dryer (up from 44.6% in 1970) (Bureau of Census 1980b). In contrast, the Battelle survey showed market saturations ranging from 61% in Fairbanks multi-family structures to over 90% in other types of housing. Single-family dryer saturations ranged from 81% in Fairbanks to 90% in Anchorage. Because Alaska already has such high saturations, the forecast is outside the bounds of historical experience. A reasonable estimate is that no more than 95% of single-family homes, mobile homes, and duplexes will ever have dryers because of the availability of laundromats and because of the room taken up by washer-dryer combinations in small housing units. For multifamily units, penetration is assumed to be much slower because of the space problem. Since washers and dryers are now installed in pairs in most new housing, market saturations for dryers (which are now about 2% below those for washers in most areas) will approach that for washers as old housing stock is replaced. In general, the lower the existing saturation, the greater is the uncertainty concerning its future growth rate.

Cooking Ranges

Several data sources were examined to arrive at market saturation rate estimates. The Battelle-Northwest end-use survey indicated that between 96 and 100% of all households surveyed had a range available. SDG&E (1982) reported a 96.2% saturation rate while SCE (1981) ranged from 98.3% for multi-family units to 99.5% for single-family units. The substitution of hot plates, broiler ovens (1979 estimated national saturation rate of 26%) and microwave ovens (1979 estimated national saturation rate of 7.6%) may account for the difference between 90 and 100%. Therefore, 100% of all housing units currently are assumed to have cooking facilities available by 1985. This percentage holds throughout the period.

Saunas, Jacuzzis, Etc.

These units are a relatively new phenomenon in private homes, almost all having been installed since 1970. The Battelle-Northwest end-use survey found market saturations ranging from 2.5 to 17%, SDG&E (1982) 11 to 39%, and SCE (1981) 1.3 to 19.4%, all depending upon market area and housing type. According to the survey, 14% of Anchorage single family households reported having one of these units, compared to 10.4 and 11.0%, respectively, for SCE and SDG&E. Among single-family homes built since 1975 in Anchorage, the saturation was 21%, while among single-family homes built since 1980 in the SDG&E survey area, the saturation was 23.8%. To arrive at saturation rate estimates, a target rate slightly larger than both was assumed for newly constructed single-family homes in Anchorage to allow for the increasing popularity of saunas-jacuzzis. Additional allowances were made for the existing stock of housing to acquire saunas-jacuzzis. The additional allowances changed over time based on the belief that saturation growth rates would fall as the newness of the item wore off. This phenomenon may happen with any relatively new technology. Once it has reached that segment of the population initially desiring to own a sauna or jacuzzi, additional growth will be slower since a lower maximum penetration rate, when compared to other appliances, is assumed. Additional supportive evidence for a lower maximum penetration rate is found from California. There, saturation rates are lower than in Alaska and growth rates are slowing down. One additional impact on the willingness of those individuals initially not strongly desiring to own a sauna or jacuzzi may be the relatively high price, at least when compared to other major appliances. Also, installation costs may be higher in Alaska since poorer weather would necessitate that the unit be enclosed. However, the inflation-adjusted cost of saunas and jacuzzis, whirlpools, etc. is expected to drop somewhat as it does with any new appliance type. This could raise future market saturations above current levels. By weighing these factors, and considering economic growth prospects for the subregions, the estimated default values were chosen. They are presented in Tables 5.4 through 5.7.

One potential problem exists in Table 5.7. The Battelle-Northwest end-use survey created a slight ambiguity in terms of appliance ownership for multifamily homes by not asking residents of this type of housing whether they actually owned or had access to a sauna or jacuzzi. In some apartment complexes, a central recreation building houses a sauna or jacuzzi that all residents may use. If every individual in the apartment complex claims they each have a sauna or jacuzzi when in fact only one exists, the saturation rate is overstated. This phenomenon is brought out in the SCE (1981) data, where 19.4% of all apartment/condominium/townhouse occupants claimed a hot tub/-jacuzzi. However, only 6.7% of that total had their own private hot tub/-jacuzzi. A level of 19.4% gives an incorrect representation of the penetration rate for saunas and jacuzzis and an overestimate of electricity consumption. To correct for this problem, default values and ranges in Table 5.7 have been adjusted downward for slower future growth.

Tables 5.8 through 5.11 indicate default market saturations and ranges of values for large household appliances that are almost always electric. These include refrigerators, freezers, dishwashers, and clothes washers. The table title indicates the housing type, and the table values show an expected market saturation for each appliance by market area and year. The ranges shown in the tables reflect the degree of uncertainty attached to the default value. The wider the range, the greater is this subjective uncertainty. The assumptions supporting the table values are given below by appliance.

Refrigerators

The Battelle-Northwest end-use survey found that virtually 100% of all households had a refrigerator. This is in agreement with several other studies such as SDG&E (1982) at 97.5%, SCE at 96.2 to 96.6%, and the national Residential Energy Consumption Survey (RECS) at 99.8%. The California Energy Commission (CEC) found in 1976 that enough housing units had second refrigerators to raise total California market saturation to 113-116%. ISER, in their report to the Alaska State Legislature, assumed that this high percentage would likely not prevail in Alaska because of the cooler climate (Goldsmith & Huskey 1980b). Therefore, a default value of 99% was chosen throughout. In the RED model, the ISER assumption is modified to permit a range of values from 98 to 100%.

TABLE 5.8. Market Saturations (percent) of Large Electric Appliances in Single-Family Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Refrigerators		Freezers		Dishwashers		Clothes Washers	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	99.0	--	88.3	--	78.2	--	91.7	--
	1985	99.0	98-100	90.0	85-95	85.0	80-90	92.0	90-94
	1990	99.0	98-100	90.0	85-95	90.0	85-95	92.5	90-95
	1995	99.0	98-100	90.0	85-95	90.0	85-95	93.7	91-96
	2000	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2005	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2010	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
b. Fairbanks	1980	99.0	--	84.9	--	53.8	--	84.9	--
	1985	99.0	98-100	88.0	86-90	79.0	75-85	86.0	84-88
	1990	99.0	98-100	90.0	85-95	90.0	85-95	87.5	85-90
	1995	99.0	98-100	90.0	85-95	90.0	85-95	92.5	90-95
	2000	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2005	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2010	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98

TABLE 5.9. Market Saturations (percent) of Large Electric Appliances in Mobile Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Refrigerators		Freezers		Dishwashers		Clothes Washers	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	99.0	--	94.8	--	43.9	--	80.6	--
	1985	99.0	98-100	92.0	90-95	67.6	62-72	85.0	80-90
	1990	99.0	98-100	90.0	85-95	90.0	85-95	90.0	85-95
	1995	99.0	98-100	90.0	85-95	90.0	85-95	90.0	85-95
	2000	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2005	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2010	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
b. Fairbanks	1980	99.0	--	73.0	--	48.6	--	92.3	--
	1985	99.0	98-100	82.0	75-89	71.4	66-76	93.0	91-95
	1990	99.0	98-100	90.0	85-95	90.0	85-95	92.5	91-96
	1995	99.0	98-100	90.0	85-95	90.0	85-95	94.0	92-96
	2000	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2005	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98
	2010	99.0	98-100	90.0	85-95	90.0	85-95	95.0	92-98

TABLE 5.10. Market Saturations (percent) of Large Electric Appliances in Duplexes Railbelt Load Centers, 1980-2010

Load Center	Year	Refrigerators		Freezers		Dishwashers		Clothes Washers	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	99.0	--	66.5	--	76.5	--	92.5	--
	1985	99.0	98-100	75.0	70-80	85.0	80-90	93.0	91-95
	1990	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	1995	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	2000	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	2005	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	2010	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
b. Fairbanks	1980	99.0	--	75.2	--	57.4	--	85.5	--
	1985	99.0	98-100	80.0	75-85	85.0	80-90	91.0	90-92
	1990	99.0	98-100	85.0	80-90	90.0	85-95	92.5	90-95
	1995	99.0	98-100	85.0	80-90	90.0	85-95	93.0	91-96
	2000	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	2005	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98
	2010	99.0	98-100	85.0	80-90	90.0	85-95	95.0	92-98

TABLE 5.11. Market Saturations (percent) of Large Electric Appliances in Multifamily Homes, Railbelt Load Centers, 1980-2010

Load Center	Year	Refrigerators		Freezers		Dishwashers		Clothes Washers	
		Default	Range	Default	Range	Default	Range	Default	Range
a. Anchorage	1980	99.0	--	62.5	--	73.3	--	76.5	--
	1985	99.0	98-100	65.0	60-70	85.0	80-90	85.0	80-90
	1990	99.0	98-100	70.0	65-75	90.0	85-95	90.0	85-95
	1995	99.0	98-100	70.0	65-75	90.0	85-95	92.0	90-94
	2000	99.0	98-100	70.0	65-75	90.0	85-95	95.0	92-98
	2005	99.0	98-100	70.0	65-75	90.0	85-95	95.0	92-98
	2010	99.0	98-100	70.0	65-75	90.0	85-95	95.0	92-98
b. Fairbanks	1980	99.0	--	57.2	--	23.3	--	63.8	--
	1985	99.0	98-100	65.0	60-70	34.0	30-39	68.0	63-72
	1990	99.0	98-100	70.0	65-75	50.0	45-55	70.0	65-75
	1995	99.0	98-100	70.0	65-75	74.0	70-79	80.0	75-85
	2000	99.0	98-100	70.0	65-75	90.0	85-95	85.0	80-90
	2005	99.0	98-100	70.0	65-75	90.0	85-95	90.0	85-95
	2010	99.0	98-100	70.0	65-75	90.0	85-95	95.0	92-98

Freezers

The end-use survey found market area-wide saturations of freezers ranging from about 80% in Fairbanks to over 90% in Anchorage. These figures are 10 to 20% higher than assumed by ISER for 1980 for these areas, about 40% above 1970 Census values for the Railbelt, and 30 to 40% above the U.S. average. In other words, area-to-area comparisons and historical experience are not very helpful for predicting future saturations. For single-family homes and mobile homes, the maximum saturation has been assumed to have been just about reached because with better shopping facilities and increased urbanization, fewer freezers will be necessary for long-term food storage from bulk buying.

For duplexes and multifamily units, the percent of saturation should remain significantly lower. The tenants in such units tend to be more transient and are probably less involved in Alaskan hunting, fishing, and gardening pursuits than most Alaskans. Consequently, they would have less demand for freezers. Second, rental units tend to be smaller. Consequently, renters might tend to substitute rented commercial cold-storage locker space for a freezer to conserve scarce living space in duplexes and multifamily units. The range of uncertainty is shown to be quite broad, since market penetration has been rapid in the last 10 years, but the maximum appears to have been reached in some cases.

Dishwashers

The Battelle-Northwest end-use survey found market saturations for dishwashers well above the existing U.S. average. In the U.S. as a whole, the 1979 saturation was about 41% of homes served by electricity (Bureau of Census 1980b), but this percentage ranged from 50% in Fairbanks to 75% in Anchorage survey homes. Saturations have increased by about 50 percentage points in both Railbelt load centers since 1970, again outside the range of historical experience. (Using this experience, ISER (Goldsmith and Huskey 1980b) projected 1978 market saturations of 50% in Anchorage and 36% in Fairbanks.) The rate of increase in market saturation was very rapid in the 1970s, but further increases in saturation in Anchorage in particular may be limited since a high proportion of some types of housing units already have dishwashers. A maximum saturation of 90% was assumed for all homes. The annual rates of saturation growth for the 1970s were then projected for each region: 9% per year for Anchorage, and 8% per year for Fairbanks. Except for Fairbanks multifamily, where historical growth rates are assumed, 90% maximum saturation is assumed to occur in 1990. The growth rate was then assumed to fall to zero. A wide range of uncertainty is assumed for dishwasher saturations because of the tenuous nature of the required assumptions.

Clothes Washers

The Battelle-Northwest end-use survey found that area-wide clothes washer saturations ranged from about 84% in Fairbanks to 89% in Anchorage. These figures are well above the 73% reported for the U.S. in 1979 in the 1980 Statistical Abstract (Bureau of Census 1980b). It also represents about 10 to 15 percentage points growth since the 1970 Census. The rate of saturation increase did not slow down appreciably in the 1970s compared to the 1960s; consequently, market saturation may not have yet approached its maximum. For forecasting, the maximum penetration is assumed to be 95%. Different types of housing reach this maximum at different rates. In particular, since single-family homes are already 85 to 90% saturated, they reach 95% slowly, achieving this level by the year 2000. Some markets are closer to being completely saturated. Even at low rates of growth they reach 95% somewhat earlier. In no case is clothes-washer saturation allowed to be below that for clothes driers. The Battelle-Northwest survey generally found that washer saturation was one to two percentage points higher than that for dryers. Where this was not the case (e.g., duplexes in Fairbanks) the difference appears to have occurred because of the small number of households in the category. The market saturations for washers and driers gradually converge, since they are now usually installed in pairs. Multifamily saturation of washers and driers grows the slowest, reaching 95% by 2010 in Fairbanks.

Fuel Mode Splits

The fuel-mode splits presented in Table 5.12 were also derived from the Battelle-Northwest end-use survey and 1980 Census of Housing with the exception noted below. These parameters are assumed to remain fixed over the forecast period, as the cross-price elasticity adjustment handles fuel switching.

TABLE 5.12. Percentage of Appliances Using Electricity and Average Annual Electricity Consumption, Railbelt Load Centers

Appliance	Anchorage: Percentage Using Electricity[a] SF	MH	DP	MF	Anchorage: Annual kWh Consumption	Fairbanks: Percentage Using Electricity SF	MH	DP	MF	Fairbanks: Annual kWh Consumption
Space Heat (Existing Stock)										
Single Family	16.0	NA	NA	NA	32,850	9.7	NA	NA	NA	43,380
Mobile Home	NA	0.7	NA	NA	24,570	NA	0.0	NA	NA	33,210
Duplex	NA	NA	22.8	NA	21,780	NA	NA	11.7	NA	28,710
Multi Family	NA	NA	NA	44.4	15,390	NA	NA	NA	14.8	19,080
Space Heat (New Stock: 1985)										
Single Family	10.0	NA	NA	NA	40,100	9.7	NA	NA	NA	53,000
Mobile Home	NA	0.7	NA	NA	30,000	NA	0.0	NA	NA	40,600
Duplex	NA	NA	15.0	NA	26,600	NA	NA	11.7	NA	35,100
Multi Family	NA	NA	NA	25.0	18,800	NA	NA	NA	14.8	23,300
Water Heaters (Existing)	36.5	50.4	44.0	60.9	2,800	33.1	42.8	43.1	26.2	3,300
Water Heaters (New: 1985)	10.0	50.4	15.0	25.0	3,000	33.1	42.8	43.1	26.2	3,475
Clothes Dryers	84.3	88.1	81.3	86.6	1,032	96.2	94.6	94.4	100.0	1,032
Cooking Ranges	75.8	23.2	85.2	88.2	850	79.0	48.2	95.0	97.1	850
Sauna-Jacuzzis	93.5	100.0	93.7	81.8	1,600	61.8	100.0	60.8	100.0	1,600
Refrigerators	100.0	100.0	100.0	100.0	1,636	100.0	100.0	100.0	100.0	1,636
Freezers	100.0	100.0	100.0	100.0	1,342	100.0	100.0	100.0	100.0	1,342
Dishwashers	100.0	100.0	100.0	100.0	250	100.0	100.0	100.0	100.0	250
Additional										
Water Heating (Existing)	36.5	50.4	44.0	60.9	799	33.1	42.8	43.1	26.2	799
Water Heating (New: 1985)	10.0	50.4	15.0	25.0	799	33.1	42.8	43.1	26.2	799
Clothes Washers	100.0	100.0	100.0	100.0	90	100.0	100.0	100.0	100.0	90
Additional										
Water Heating (Existing)	36.5	50.4	44.0	60.9	1,202	33.1	42.8	43.1	26.2	1,202
Water Heating (New: 1985)	10.0	50.4	15.0	25.0	1,202	33.1	42.8	43.1	26.2	1,202
Miscellaneous	100.0	100.0	100.0	100.0	2,110	100.0	100.0	100.0	100.0	2,466

(a) SF = single family; MH = mobile homes; DP = duplexes; MF = multifamily.

Discussions were held with several Anchorage area home builders, the staff of Anchorage Municipal Power and Light, ISER, and two real estate management firms in Anchorage concerning incremental fuel mode splits for new housing stock. The consensus was that very few units are being constructed in the Anchorage area in 1983 with either electric heat or electric hot water where gas is available because electric thermal units are considered to have unattractively high operating costs. This is believed to be a phenomenon caused by past electricity price increases and is therefore not accommodated by the RED price adjustment coefficients after 1980. Accordingly, the 1983 version of the model judgmentally imposes reduced incremental electric fuel mode splits in space heating and water heating for new housing units built in the Anchorage-Cook Inlet load center since 1980. The fuel mode splits are kept above zero to reflect construction in portions of the Anchorage-Cook Inlet load center not served by gas. Where incremental fuel mode splits are shown, electricity use rates for both the new and old stock are shown in Table 5.12. Post-1985 use rates for all appliances appear in Table 5.13.

Comparison of Census and Battelle Northwest end-use survey results for the percentage of water heaters using electricity in Fairbanks in 1980 revealed lower values in the Census. The assumption was made that the Census results were more accurate and additional time went into a further analysis of the Battelle Northwest end-use survey. As a result of this and a study of the methodology employed in the Census, original end-use survey fuel mode split values have been scaled downward by a correction factor of 0.6 for hot water. After the correction factor, the figures now reported in Table 5.12 are believed to be accurate.

Consumption of Electricity per Unit

The average kilowatt hour consumption figures are primarily based on values summarized from other studies presented in Henson (1982) and also SDG&E (1982). Below is a brief discussion of each parameter. Studies reviewed are shown in Table 5.14.

TABLE 5.13. Growth Rates in Electric Appliance Capacity and Initial Annual Average Consumption for New Appliances

Appliance	Average Annual kWh Consumption for New Appliances (1985) Anchorage	Fairbanks	Growth Rate in Electric Capacity Post-1985 (annual)
Space Heat			
Single Family	40,100	53,000	0.005
Mobile Homes	30,000	40,600	0.005
Duplexes	26,600	35,100	0.005
Multifamily	18,800	23,300	0.005
Water Heaters	3,000	3,475	0.005
Clothes Dryers	1,032	1,032	0.0
Cooking Ranges	1,200	1,200	0.0
Saunas-Jacuzzis	1,750	1,750	0.0
Refrigerators	1,560	1,560	0.00
Freezers	1,550	1,550	0.00
Dishwashers	230	230	--
Additional Water Heating	740	740	0.005
Clothes Washers	70	70	0.0
Additional Water Heating	1,050	1,050	0.005
Small Appliances and Lighting	2,110	2,466	(a)

(a) Incremental growth of 50 kWh per customer in Anchorage per 5-year period; 70 kWh in Fairbanks.

TABLE 5.14. Comparison of Appliance Usage Estimates from Selected Studies (measured in kWh)

Appliance	Scanlon Hoffard[a]	Parti & Parti	ESC	George	SRI[b]	MRI[b]	CEC[b]	AHAM	SDG&E
Refrigerators	--	--	--	--	1,270	1,665	--	--	--
Frost Free	2,177	1,624	--	1,455	1,523	--	1,858	2,250	1,880
Standard	869	684	--	681	933	--	893	1,500	906
Freezer	--	1,084	1,622	1,294	1,478	1,342	1,316	--	--
Frost Free	2,252	--	--	--	--	--	--	1,820	1,210
Standard	1,881	--	--	--	--	--	--	1,190	811
Electric Range	1,024	804	1,083	753	1,180	782	674	700	671
Clothes Washer	--	--	--	--	98	88	70	103	259
Clothes Dryer	--	1,051	1,363	1,170	990	1,032	950	993	808
Washer/Dryer Combination	2,680	--	--	--	--	--	--	--	--
Water Heater	3,021	4,535	2,628	--	4,490	4,046	3,826	4,219	2,581
Dishwasher	1,539	538	--	--	360	149	250	363	259
Color Television	639	613	--	726	490	--	420	--	--
Space Heating	11,966	3,441	7,301	5,876	14,153	2,258	9,834	--	2,486 SF[c] 785 MF 1,152 MH
Central Air Conditioning	1,505	1,809	1,596	2,183	5,494	3,573	2,924	--	--
Miscellaneous	2,127	1,865	1,882	1,950	--	--	1,259	--	--

(a) Results of final (7th) iteration.
(b) Engineering estimates.
(c) SF denotes single family units, MF multifamily units, and MH mobile homes units.

Sources for Table 5.13:
1) The Christian Science Monitor, 1981, pp. 15.
2) San Diego Gas and Electric 1982.
3) Scanlon and Hoffard 1981.

Space Heat

For space heating in the existing housing stock, the average annual consumption figures derived by ISER are used (Goldsmith and Huskey 1980b). These figures were derived based on heating degree days, floor space, and average consumption of all electric homes within the Railbelt region and were adjusted downward by 10% to allow for additional conservation in the building stock since ISER's study.

Water Heaters

The average consumption for water heaters is based on the California Energy Commission's (CEC's) estimates and several engineering studies summarized in Henson (1982). The figure separates out consumption for clothes washers and dishwashers and has been adjusted upward by 15% to account for the colder-water inlet temperature in Alaska. Anchorage values were also adjusted downward for some heating of municipal water supplies (see Tillman 1983).

Clothes Dryers

For clothes dryers, average consumption is the figure reported by the Midwest Research Institute (MRI). ISER (MRI 1979) picked a lower estimate based on household size, but the colder climate in Alaska should also raise the estimated use of dryers. This is reflected in high saturation values for this appliance.

Cooking-Ranges

This category is broadly interpreted as production of heat for cooking purposes. The figure reported was derived by averaging the values from several reports.

Saunas-Jacuzzis

The authors informally contacted several suppliers of saunas, jacuzzis and hot tubs and were told that the consumption of these devices ranged from 100-3000 kWh annually. Hunt and Jurewitz found 1300 kWh annual consumption for new additions to the stock. However, SDG&E (1982) reported annual average consumption at approximately 2700 kWh. A conservative consumption figure of

1600 kWh annually was chosen to reflect the presence of bathtub whirlpools and other small units as well as larger units.

Refrigerators

An average value from SDG&E (1982) was used, allowing for a 75% saturation of frost-free units in the Railbelt, as revealed by the Battelle-Northwest residential survey.

Freezers

This figure showed little variation among Merchandising Week, MRI, and ISER. The MRI figure was chosen.

Dishwashers

The value assumed for dishwashers is the mean of several engineering studies cited in Henson (1982) and SDG&E (1982). Additional water heating associated with dishwashing has been separated out.

Dishwasher and Clothes Washer Water

These values are from the CEC, adjusted upward to account for colder water inlet temperatures in Alaska.

Miscellaneous Appliances

For miscellaneous appliances, estimates of consumption were originally prepared by ISER by subtracting estimated large appliance electricity consumption for 1978 from total 1978 consumption/residential customer (Goldsmith and Huskey 1980b). Lighting was inferred from national statistics and increased to 1000 kWh/year/customer. The remainder was charged to small appliances. Research for the RED Model checked ISER's work by assuming: 1) televisions (rated at 400 kWh/year) are included in small appliances; and 2) the ISER estimate of 480 kWh/year/customer for headbolt heaters is replaced with load center-specific estimates derived from load-center specific utilization data produced by the Battelle-Northwest end-use survey and National Oceanic and Atmospheric Administration (NOAA) data on normal minimum temperatures (NOAA 1979); and 3) 1000 kWh/year lighting. The revised estimates for block heaters are as follows: Anchorage, 459 kWh/year/customer; Fairbanks, 1127 kWh/year/-customer. Because the results were broadly consistent with ISER's figures, ISER's totals were used (Goldsmith and Huskey 1980b).

Electrical Capacity Growth

Table 5.15 presents average annual kWh consumption for new appliances in 1985. Revised numbers are presented reflecting the authors' belief that improved efficiency ratings for appliances coming onto the market will largely offset future increases in energy use brought about by increases in appliance size. This is not merely a phenomenon of Alaska fuel prices; rather, it reflects national energy market trends. Alaskans have little choice concerning the purchase of more efficient appliance technologies since the available appliance mix is dictated by national markets.

Little information is available on changes in appliance efficiencies in the absence of price effects in the Alaska market. However, the appliance manufacturers associations and the U.S. Department of Energy (DOE) have developed estimates of appliance efficiency for several types of new appliances (see King et al. 1982). The major source for the efficiency ratings on new appliances was a DOE survey of appliance manufacturers (Form CS-179) that asked actual energy efficiency information on current models of appliances for 1972 and 1978. In addition, manufacturers were asked to make projections of new appliance efficiency for 1980. The Association of Home Appliance Manufacturers has since revised some of the estimated efficiencies of the 1980 (sometimes 1981) models and has found that estimated efficiencies have improved more than was anticipated at the time of the CS-179 survey. In fact, refrigerators freezers, dishwashers, and clothes washers have improved enough in average efficiency to offset the effects of product size increases and new energy-using features (such as the frost-free option on refrigerators), leading to a significant net reduction in average kilowatt-hours used in the new models.[a] Table 5.15 summarizes the findings of the CS-179 survey and appliance manufacturers.

(a) Personal Communication, Jim McMahon, Energy Analysis Program, Lawrence Berkeley Laboratory, May 24, 1983.

TABLE 5.15. Electric New Appliance Efficiency Improvements 1972-1980 (percent impact on energy use, 1972 base)

Appliance	CS-179 Findings[a] 1972-1978	CS-179 Findings[a] 1972-1980	Appliance Manufacturers[b] 1972-1980
1. Water Heat			
Efficiency	-1.1	-1.9	NA
Size Increase	NA	NA	NA
Other Features	NA	NA	NA
Net Energy Use	NA	NA	NA
2. Ranges			
Efficiency	-15.7	-20.1	NA
Size Increase	NA	NA	NA
Other Features	NA	NA	NA
Net Energy Use	NA	NA	NA
3. Clothes Dryers			
Efficiency	-0.0	-4.2	-3.1
Size Increase	NA	NA	0.4
Other Features	NA	NA	0.4
Net Energy Use	NA	NA	-2.7
4. Refrigerators			
Efficiency	-20.5	-34.3	-45.6
Size Increase	NA	NA	8.0
Other Features	NA	NA	11.6
Net Energy Use	NA	NA	-26.0
5. Freezers			
Efficiency	-24.7	-32.8	-48.0
Size Increase	NA	NA	-10.0[c]
Other Features	NA	NA	18.5
Net Energy Use	NA	NA	-39.5
6. Dishwashers			
Efficiency	NA	NA	-45.0[d]
Size Increase	NA	NA	} 14.0[d]
Other Features	NA	NA	
Net Energy Use	NA	NA	-31.0[d]
7. Clothes Washers			
Efficiency	NA	NA	-51.6[d]
Size Increase	NA	NA	"slight"[d]
Other Features	NA	NA	12.1[d]
Net Energy Use	NA	NA	-39.5[d]

NA = Not Available
(a) Source: King et al. 1982.
(b) Source: McMahon 1983.
(c) Net decrease in average size. More compact models sold.
(d) 1972-1981.

Even in the absence of further changes in Railbelt energy prices, residential consumers in the region are expected to have access to increasingly efficient models of major appliances. In the recent past, efficiency improvements have more than offset increases in the size of these appliances. For the future, consumers are assumed to adopt more efficient available models to just offset increases in size of new models for the years after 1985. Two exceptions are allowed. Table 5.15 shows that water heaters have not improved significantly in efficiency. Once properly installed (and then only if in an unheated space), the limits of efficiency improvements will have been reached on existing designs. From there on, further improvements are possible from redesign of water-using appliances, tankless point-of-use water heating, and significant behavioral changes of household residents, but these are unlikely without further price increases in the Railbelt. Thus, as household incomes rise, it is assumed that hot water usage increases and efficiency improvements do not offset these increases in the absence of price changes. A similar factor is assumed to be at work in space heating. Rising household incomes are assumed to increase the average size of the housing stock and comfort demands at a faster rate than efficiency improvements can reduce demand in the absence of energy price changes.

Prior to 1985, a mix of influences is expected to be operating on energy use. Water heaters and space heating systems are assumed to increase in size with little or no offsetting conservation effects in the absence of fuel price increases. Clothes dryers are assumed to have about the same energy use as in 1980, with small increases in size offset by small improvements in efficiency. New ranges are assumed to increase in size and in energy-using features over the existing stock to surpass the existing upper bound usage in Scanlon and Hoffard (1981) single-family homes. Refrigerators have gained radically in energy efficiency historically and are assumed to continue to do so between 1980 and 1985, offsetting size and energy-use increases. 1980 refrigerator energy usage rates already reflect a large proportion of frost-free units. (Battelle-Northwest survey results show about 75 to 80% frost-free units in the Anchorage load center, 65 to 70% frost-free in Fairbanks.) Thus, little increase in energy use can be expected from penetration of frost-free units. Although nationally freezers have become more efficient, additional penetration of frost-free models in the Railbelt is assumed before 1985, leading to a small increase in average energy use. Clothes washers and dishwashers are assumed to continue their recent historic trend toward greater efficiency and conservation of hot water before 1985. After that, water use increases while efficiency improvements just offset increased capacity and use. Sauna and jacuzzi 1985 energy use reflects additional market penetration of slightly larger units than comprise the 1980 stock.

Appliance Survival

Table 5.16 presents the percentage of appliances remaining in each five-year period after their purchase. These figures were derived by ISER based on Hausman's work (1979) with implicit discount rates for room air conditioners. Hausman found that the stock of a particular vintage of air conditioners was fairly well approximated by a Weibull distribution. By substituting differing lifetimes (EPRI 1979) for alternative appliances, ISER used his results to derive the figures in Table 5.16. For saunas and jacuzzis, RED assumes the appliance lifetime was comparable to refrigerators.

Household Size Adjustments

Clothes washers, clothes dryers, and water heaters are used more intensively by large families. Relying on a 1979 Midwest Research Institute study of metered appliances and family size (Midwest Research Institute 1979), ISER researchers calculated an adjustment factor for usage of electricity in clothes washers, clothes washer water, clothes dryers, and water heaters (Goldsmith and Huskey 1980b). As household size declines, so does energy use in these appliances, other things equal. Table 5.17 shows the equations used. ISER annualized the equations (which were based on daily use), normalized them to an average household size of three persons, and calculated a ratio to adjust calculated electricity consumption for average household size.

Price Elasticities

The final parameters used in the Residential Module are the parameters used to compute the price effects described briefly in the module structure section of this chapter. Because of the complexity of the algebra involved,

TABLE 5.16. Percent of Appliances Remaining in Service Years After Purchase, Railbelt Region

a. Old Appliances	5	10	15	20	25	30
Space Heat (All)	0.90	0.80	0.6	0.3	0.1	0.0
Water Heaters	0.6	0.3	0.1	0.0	0.0	0.0
Clothes Dryers	0.8	0.6	0.3	0.1	0.0	0.0
Ranges-Cooking	0.6	0.3	0.1	0.0	0.0	0.0
Saunas-Jacuzzis	0.8	0.6	0.3	0.1	0.0	0.0
Refrigerators	0.8	0.6	0.3	0.1	0.0	0.0
Freezers	0.9	0.8	0.6	0.3	0.1	0.0
Dishwashers	0.6	0.3	0.1	0.0	0.0	0.0
Clothes Washers	0.6	0.3	0.1	0.0	0.0	0.0
b. New Appliances						
Space Heat (All)	0.89	0.73	0.56	0.42	0.3	0.1
Water Heaters	0.75	0.35	0.1	0.0	0.0	0.0
Clothes Dryers	1.00	0.75	0.35	0.1	0.0	0.0
Ranges-Cooking	0.75	0.35	0.1	0.0	0.0	0.0
Saunas-Jacuzzis	1.00	0.75	0.35	0.1	0.0	0.0
Refrigerators	1.00	0.75	0.35	0.1	0.0	0.0
Freezers	1.00	1.00	0.75	0.35	0.1	0.0
Dishwashers	0.75	0.35	0.1	0.0	0.0	0.0
Clothes Washers	0.75	0.35	0.1	0.0	0.0	0.0

Source: ISER (Goldsmith and Huskey 1980b) except for saunas-jacuzzis, which is author assumption.

TABLE 5.17. Equations to Determine Adjustments to Electricity Consumption Resulting from Changes in Average Household Size

Appliance	Equation
Clothes Washer	AHS[(a)] = 1 x AHH[(b)]
Clothes Washer Water	AHS = 0.25 + 0.75 AHH
Clothes Dryer	AHS = 0.25 + 0.75 AHH
Water Heater	AHS = 0.51 + 0.49 AHH

(a) AHS = Adjustment factor.
(b) AHH = Average household size (Based on 3.0).

the discussion of this topic has been given its own chapter (Chapter 7.0), where the parameters are reported. The values for the parameters came from Mount, Chapman, and Tyrell (1973).

6.0 THE BUSINESS CONSUMPTION MODULE

The Business Module forecasts the requirements for electricity in the commercial, light industrial, and government sector of the Railbelt economy. The figures predicted here do not consider the impacts of explicit program-induced conservation. Program-induced conservation is handled in the Program-Induced Conservation Module. Heavy industrial use is forecasted exogenously, as described in Section 10.0.

MECHANISM

The structure of the forecasting mechanism in the Business Consumption Module is dictated by the availability of data that can be used to produce forecasts. Unlike many Lower 48 utility service areas, the Railbelt has a very weak data base for estimating and forecasting commercial, light industrial, and government electricity consumption. No information exists for consumption of electricity by end use in this sector, so RED produces an aggregate forecast of business electricity consumption. The Business Consumption Module uses a forecast of total employment for each load center to forecast business (commercial, light industrial, and government) floor space. The module then uses this forecast of the stock of floor space (a proxy for the stock of capital equipment) to predict an initial level of business electricity consumption. This initial prediction is then adjusted for price impacts to yield a price-adjusted forecast of business electricity consumption.

INPUTS AND OUTPUTS

Table 6.1 presents the inputs and outputs of the Business Consumption Module. Load-center-specific forecasts of total employment are exogenous to RED. Currently these come from forecasts of the ISER Man in the Arctic Program (MAP) model. The elasticity of use per square foot of building space and price adjustment parameters are assigned in the Uncertainty Module. The output of the Business Consumption Module is the price-adjusted forecast of electricity requirements of the business sector before the impacts of program-induced conservation are considered.

TABLE 6.1. Inputs and Outputs of the Business Consumption Module

a) Inputs

Symbol	Name	From
TEMP	Total Regional Employment	Forecast File (exogenous)
BBETA	Electricity Consumption Floor Space Elasticity	Uncertainty Module (parameter)
A,B,λ,OSR,GSR	Price Adjustment Coefficients	Uncertainty module (parameter)

b) Outputs

Symbol	Name	To
BUSCON	Price-Adjusted Business Consumption	Miscellaneous, Peak Demand and Conservation Modules

MODULE STRUCTURE

Figure 6.1 presents a flow chart of the module. The first step is to use employment forecasts to construct estimates for the regional stock of floor space by five-year forecast period. The predicted floor space stock is then fed into an electricity consumption equation that is econometrically derived to yield a preliminary forecast of business requirements, which is then adjusted for price impacts.

After investigating several alternative methods for forecasting business floor space, Battelle-Northwest researchers decided to use a very simple formulation of the floor space forecasting equation in the 1983 version of RED. The floor space per employee in Anchorage and Fairbanks is assumed to increase at a constant rate to levels about 10% and 15%, respectively, above today's levels by the year 2010. This takes into account both the evidence of historic increase in floor space per employee in Railbelt load centers and the historic lower levels of floor space per employee in Alaska compared with the nation as a whole. The assumption is still quite conservative, since Alaska's commercial floor space per employee is far below the national average. The forecasting equation is shown as equation 6.1.

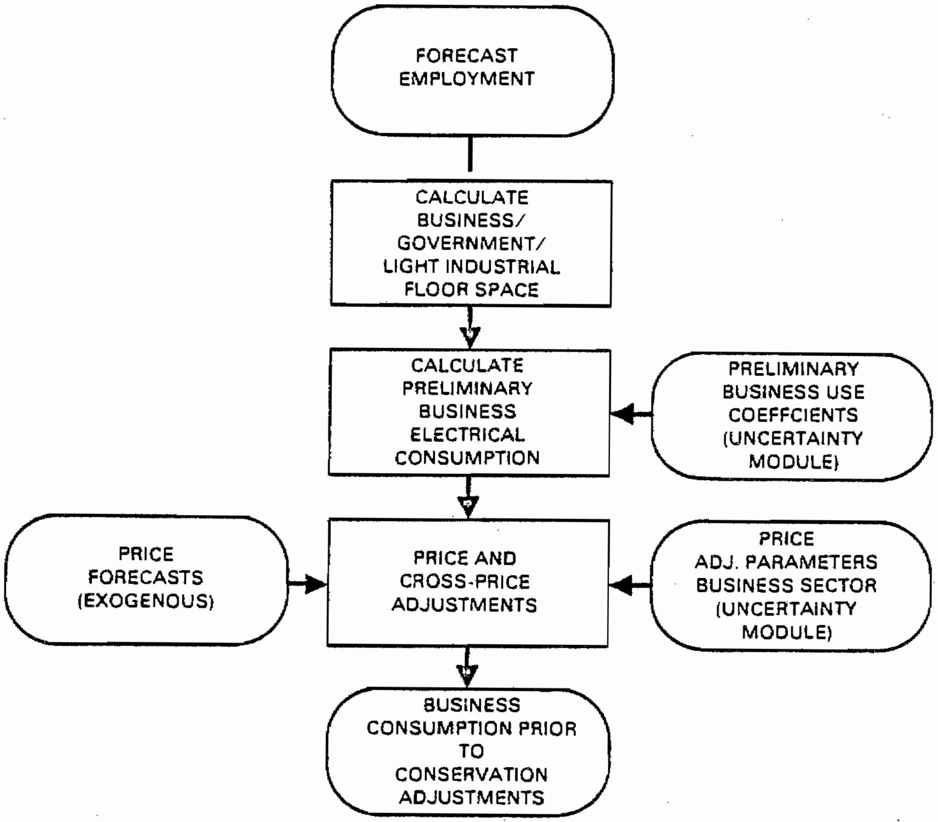

FIGURE 6.1. RED Business Consumption Module

$$STOCK_{it} = a_i \cdot (b_i)^{k-2} \cdot TEMP_{ik} \tag{6.1}$$

where

STOCK = floor space in business sector

a = initial (1980) floor space per employee

b = annual growth factor (1 plus growth rate) in floor space per employee

TEMP = total employment

i = index for the region

t = time index, t=1,2,3,...,7

k = time index, k=1,2,3,...,31.

The controlling data series for the commercial forecast is an annual estimate of commercial floor space, which is derived for the period 1974 to 1981. The beginning point is an estimate of commercial floor space in the two locations developed by ISER (Table 6.2 and Table 6.3) that shows the 1978 stock of energy-using commercial floor space in Anchorage to be about 42.3 million square feet (from which 860 thousand square feet of manufacturing floor space were subtracted to yield 41.4 million) and in Fairbanks about 10.8 million square feet. This estimate was adjusted backwards and forwards for the period 1974 to 1981 using a predicted construction series (Equation 6.4) to produce a stock series for the two locations.

Once the forecast of the stock of floor space is found, the module then predicts the annual business electricity requirements before price adjustments, based on a regression equation:

$$PRECON_{it} = \exp[BETA_i + BBETA_i \times \ln(STOCK_{it})] \qquad (6.2)$$

where

PRECON = nonprice adjusted business consumption

BETA = parameter equal to regression equation intercept

BBETA = percentage change in business consumption for a one percent change in stock (floor space elasticity).

exp,ln = exponentiation, logarithmic operators

t = index for the forecast year (1980, 1985, ..., 2010).

Finally, price adjustments are made with the price adjustment mechanism identical to that in the Residential Consumption Module.

$$BUSCON_{it} = PRECON_{it} \times (1 + OPA_{it}) \times (1 + PPA_{it}) \times (1 + GPA_{it}) \qquad (6.3)$$

where

BUSCON = price-adjusted business requirements (MWh)

OPA = own-price adjustment factor

PPA = cross-price adjustment factor for fuel oil

GPA = cross-price adjustment factor for natural gas.

TABLE 6.2. Calculation of 1978 Anchorage Commercial-Industrial Floor Space

		$10^3 ft^2$
AMATS Survey (Anchorage Bowl, 1975)		42,067
Minus Non-energy Using (parking lots, cemeteries, etc.)		18,918
Energy Using Floor Space		23,149
20 Percent Adjustment for Underreporting		4,630
		27,779
Sectors not Included in Survey:		
1. Girdwood/Indian[a]		53
2. Eagle River/Chugiak[b]		300
3. Hotels/Motels[c]		1,000
4. Assorted Cultural Buildings[d]		500
		29,632
Item:[e]		
Retail Trade	6,148	
Warehousing	3,722	
Education	3,528	
Wholesale Trade	3,131	
Transport-Communication-Public Utilitites	2,663	
Government	1,405	
Manufacturing	706	
Other	7,331	
Growth Between 1975-1978[f] (about 25 %)		7,400
1978 Estimated Commercial-Industrial Floor Space[g]		37,000
General	25,120	
Education	5,000	
Warehousing	4,520	
Hotels	1,500	
Manufacturing	860	
1978 Non-Manufacturing Floor Space, Anchorage		36,140

Source: Adapted from Goldsmith and Huskey (1980b).

TABLE 6.2. (contd)

(a) Twenty-five businesses in 1975 acording to telephone book. Assume 2,500 square feet/business.
(b) Based on the ratio of the housing stock in 1978 between Eagle River/Chugiak and Anchorage.
(c) Assumes 2,000 rooms at 500 square feet/room. Based on Jackson and Johnson 1978, p. 40.
(d) Forty-six establishments identified in 1975 telephone book. Average size assumed to be 10,000 square feet.
(e) Detail does not add to total in original. Total was assumed correct.
(f) This is based upon two indicators. The first is the growth in employment between 1974-75 and 1978. Civilian employment was as follows: 1974 - 58,700, 1975 - 69,650, and 1978 - 76,900. Employment growth was 31% in the period 1974 to 1978 and 10% in the period 1975 to 1978. (State of Alaska, Department of Labor, Alaska Labor Force Estimates by Industry and Area, various issues.) The second is the growth in the appraised value of buildings over the period 1975 to 1978. After adjusting for inflation, the increase was 48%. Based on the assumption that the rapid employment increase in 1975 resulted in undersupply of floor space in that year, we assume a 25% growth in floor space between the summer of 1975 and 1978.
(g) Independent estimates of floor space in 1978 in the educational category and the hotel/motel category were available from the Anchorage School District and Anchorage Chamber of Commerce, respectively. The remaining growth was allocated proportionately among the other categories.

TABLE 6.3. 1978 Commercial-Industrial Floor Space Estimates

	Million Square Feet
Greater Anchorage Area	41.4
Anchorage	36.1
Kenai-Cook Inlet	3.2
Matanuska-Susitna	1.5
Seward	0.6
Greater Fairbanks Area	10.8
Fairbanks	10.4
Southeast Fairbanks	0.4

Source: Adapted from Goldsmith and Huskey (1980b).

The price-adjusted business requirements are then passed to the Program-Induced Conservation and Peak Demand Modules.

PARAMETERS

As described in the subsection on MECHANISM, the data base available in the Railbelt for forecasting business electricity consumption is very weak. Among the principal problems in forecasting for this sector are the following:

- No information on electricity consumption by end use exists for this sector in the Railbelt.
- Many of the Railbelt's large commercial users of electricity (considered industrial users in many electricity demand forecasting models) are primarily commercial users. In addition, many government offices are in rented commercial space. This makes it impossible to use employment by industry to forecast electricity consumption separately for commercial, industrial, and government end-use sectors since the Standard Industrial Classification (SIC) codes in which employment is typically reported do not at all correspond to the traditional end-use sectors of electricity-demand models.
- While an estimate exists for the stock of business floor space in the Railbelt in 1978 and can be used to estimate the intensity of commercial electricity use, the only comprehensive data base on commercial (including industrial and government) building construction available to estimate changes in stock is subject to tight copyright controls. It was necessary, therefore, to estimate historic construction to derive historic series of the stock of business floor space.

These problems made it reasonably clear that forecasts by end use or even end-use sector were impossible. However, it was unclear whether stock or employment was a better predictor of business electricity consumption.

The approach used to resolve the issue consisted of three steps. First, the historical relationships of electricity consumption per employee and per square foot of commercial floor space were examined to determine the most appropriate relationship on which to base the forecasts. Second, equations developed for related work were applied to the two locations and examined as to the plausibility of their forecasts. Finally, a less sophisticated forecasting methodology was devised due to data limitations. This methodology took maximum advantage of the existing Railbelt data base.

The historical relationships of electricity consumption per square foot and per employee in the commercial sector were examined to determine whether one or the other of the two relationships was more appropriate as a basis for consumption forecasting electrical energy consumption. This examination, reported in the subsection on consumption below, concluded that floor space was theoretically superior and a slightly more stable predictor of electricity consumption.

Floor Space Stock Equations

Several different methods were used in an attempt to forecast commercial building stock in the Railbelt. These methods included adapting forecast equations from related work performed by Battelle-Northwest in the Pacific Northwest and the nation as a whole. It was not possible to directly estimate building stock equations for the Railbelt due to copyright restrictions on the use of the data used to estimate the Pacific Northwest and national equations.

The forecast method used a relatively unsophisticated approach to develop floor space forecasts. Commercial sector energy consumption and building stock figures for Anchorage and Fairbanks were compared to similar estimates in the Lower 48. These comparisons then formed the basis for the method used for forecasting floor space.

Data on "actual" floor space in the commercial sector are scarce; this limited the comparison to one year (1979 for U.S. figures; 1978 for

Alaska).[a] Some Lower 48 multistate regional estimates, but no independent state-wide estimates, were available. Table 6.4 summarizes the results of these comparisons to Railbelt estimates for a variety of sources.

An average 531 square feet per employee existed in commercial buildings in the U.S. in 1979 (using Energy Information Administration data on square footage and total U.S. employment, less mining and manufacturing employment). Broken out by region, the figures ranged from 364 to 751. The highest space-per-employee ratio occurs in the North Central region, and the smallest is in the West. Comparable figures for 1978 in the Railbelt fall at the lower end of that range. For comparison, the table shows estimates from a survey performed by the Bonneville Power Administration (BPA) by commercial building type: trade employees use 891 ft^2; services employees use 1194 ft^2; and office employees use 305 ft^2. Figures for the distribution of commercial square footage by building type in the U.S. do not exist, but if the square footage estimates in Table 6.4 are accurate, they may indicate a relatively higher proportion of offices in the Railbelt on average than in the U.S.

Estimates for the Railbelt from historical data (1978) and the RED model (1980) fall below the U.S. national average for square footage per employee. The estimates are reasonable, however, and the differences largely reflect differences in the precise definition of employees (U.S. Department of Commerce or State of Alaska definition) in the available data used in the denominator.

The reasonableness of the square-footage-per-employee figure in the Railbelt can also be evaluated by examining comparable figures for kWh/employee and kWh/ft^2 in Table 6.4. The 1979 national average energy use shown is 7303 kWh per employee. Regional averages range from 4468 kWh in the West to 9997 in the North Central region. With California's moderate temperatures (low heating

(a) F. W. Dodge, a division of McGraw-Hill, Inc., markets local historical estimates of residential and nonresidential construction by building type, from which estimates of historical building stock may be generated. However, copyright restrictions on these data prevented their direct use in RED model development unless they were purchased for use in the project. Tests of the data base in other projects persuaded us that the expense of purchasing the F. W. Dodge data set for use in RED Model development was not justified.

TABLE 6.4. Comparisons of Square Feet, Employment, and Energy Use in Commercial Buildings: Alaska and U.S. Averages

		ft^2/Employee		kWh/Employee	kWh/ft^2
EIA[a,b]					
U.S. (1979)		531		7,303	13.75
NE		562		7,310	13.02
NC		751		9,997	13.31
S		476		7,358	15.45
W		364		4,468	12.27
Alaska(1978)[c]					
Anchorage		375		7,851	20.9
Fairbanks		336		7,550	22.5
Climate Zone[a,b]					
<2000 CDD[d]	7000+ HDD[e]				10.21
<2000 CDD	5.5-7000 HDD				13.02
<2000 CDD	4-5,500 HDD				11.16
<2000 CDD	<4000 HDD				15.15
>2000 CDD	<4000 HDD				16.80
PG&E (1981)[f]					22 (range 5-65)
Power Council (1983)[g]					
	Warehouse				16
	Office				36
	Hospital				45
BPA (1980)[h]					
	Trade	891	Retail/Wholesale		18.16
	Services	1,194	Office		7.75
	Office	305	Warehouse		5.34
			Health		24.31
RED Alaska (1980)[i]					
Anchorage		429		8,407	19.57
Fairbanks		360		7,496	20.80

(a) EIA 1983.
(b) U.S. Bureau of the Census 1980b.
(c) Goldsmith and Huskey 1980b.
(d) CDD = cooling degree days
(e) HDD = heating degree days
(f) Pacific Gas and Electric Co. 1981.
(g) Northwest Power Planning Council 1983.
(h) Bonneville Power Assocation 1982.
(i) RED Model Run Case HE.6--FERC 0% Real Increase in Oil Prices (Employment Alaska Department of Labor basis from MAP model).

and low cooling load) in the West, and the large heating load in the North Central, these figures are reasonable. Alaska's figures of 7851 and 7550 kWh per employee are slightly higher than the national average, which follows, given Alaska's hours of winter daylight and temperatures. No independent utility survey-based estimate could be found.

The RED model (1980) predicts 8,407 and 7,496 kWh per business sector employee in Anchorage and Fairbanks, respectively. The definition of employees differs between the two estimates for the Railbelt, but a figure 10 to 15% higher than the NC region for an area such as the Railbelt that has large heating, lighting (due to shortened days), and a reasonable cooling load is not unacceptable.

The national average kilowatt-hour use per square foot in commercial buildings shown in the table is 13.75 kWh/ft^2. The regional averages vary from 12.27 kWh/ft^2 in the West up to 15.45 kWh/ft^2 in the South. Alaska's figures are almost double the Western regional average. This reflects the relatively high consumption per employee and low square footage per employee. First assumptions might attribute this to the relatively high heating load, but a comparison of regions by climate zone [that is, by heating-degree (HDD) and cooling-degree-days (CDD)] does not support this hypothesis. Moving from the coldest to the warmest climate, kWh/ft^2 figures basically increase. Assuming Alaska belongs to the coldest climate classification, Railbelt averages might be expected to fall at the bottom end of the range. Also, the Railbelt commercial building stock is predominantly heated with gas or oil, which ought to put the Railbelt at the bottom of the range, not the top.

An alternate explanation would examine the mix of commercial building types within the regions. In all cases, warehouses are the least energy intensive, while restaurants, grocery stores, and health facilities are relatively energy intensive. Estimates by Pacific Gas and Electric (PG&E) (1981) ranged from 5 to 65 kWh/ft^2, with an average of 22. A report prepared for the Pacific Northwest Power Planning Council (1983) showed existing commercial stock consumption at 16 kWh/ft^2 in warehouses, 36 kWh/ft^2 in offices, and 45 kWh/ft^2 in hospitals. BPA estimates (1982) show consumption in warehouses around 5.5 kWh/ft^2, offices at around 8, retail facilities around

18.25, and health facilities at 24.5 kWh/ft^2. As shown in Table 6.3, non-energy using commercial space has been eliminated to the extent possible in the Railbelt figures. These figures suggest (as in the ft^2/employee case) that the Alaska mix of commercial buildings may lean relatively more heavily toward more energy-intensive space like offices, restaurants, and hospitals. In addition, the Alaska consumption data include some industrial sector consumption and therefore inflate the estimates of kWh/ft^2.

Lack of data in the area of square feet of stock of commercial buildings severely limited the depth of these comparisons. The comparisons that were performed are only as good as the data from which they were derived, which varied considerably in quality. However, figures for square foot, energy, and employee ratios estimated from available data suggest that estimates from the RED model are fairly reasonable, especially considering the level of sophistication of the model and the quality of available data.

Given the problems reported below with a satisfactory statistical relationship for predicting floor space, a rather simplified approach to forecasting commercial floor space was used. This approach is that square footage per employee will grow from its current low level to reach current Lower 48 values by the end of the forecast period, 2010. Although this is not a very satisfying alternative, professional judgment suggests this to be more appropriate than the other options. It recognizes a direct relationship between floor space and employment and permits fairly easy use of sensitivity analysis.

This simplified formulation is derived by assuming that floor space per employee grows by 10% in Anchorage by the year 2010 and by 15% in Fairbanks. This is a conservative assumption since best estimates put Anchorage growth in stock per employee at about 11% for the 1970s, and Fairbanks' growth at 46%. The year 2010 stock-per-employee estimates (U.S. Department of Commerce definition of employment) would then be 412 square feet and 386 square feet per employee in Anchorage and Fairbanks, respectively. This brackets the 1979 U.S. western regional average. These growth rates are then applied to the 1980 estimates of Railbelt load center floor space per employee (Alaska Department of Labor employment definition). This provides commercial floorspace forecast equations for the two cities as follows:

Anchorage	$429.5(1.0033)^k$ x Employment	
Fairbanks	$360.4(1.0046)^k$ x Employment	

where k is the forecast period in years. The only change necessary for forecasting was to convert the annual growth rates into five-year forecasts. The coefficients are shown in Table 6.5.

TABLE 6.5. Business Floor Space Forecasting Equation Parameters

Load Center	Parameter Values	
	a_i	b_i
Anchorage	429.5	1.0033
Fairbanks	360.4	1.0046

Other Methods Tried

In previous versions of the RED model, the parameters used to forecast the annual change in floor space stock were extracted from work at Battelle-Northwest for BPA. Staloff and Adams developed a theoretical and empirical formulation of a stock-flow model for the demand and supply of floor space.[a] Using three-stage least squares multiple regression, they estimated their system of equations using pooled cross-section/time-series data for the years 1971-1977 for the 48 contiguous states and tested the equation on Alaska data, among other regions.

In their formulation, the percentage change in the stock of floor space is a function of the changes in the following: the annual change of the nominal interest rate, the annual percentage changes of the Gross National Product (GNP) deflator, the annual percentage change in regional income, and the annual percentage change in regional population, as well as some cross-product terms:

$$\Delta/Stock_{i\ell}/ = \beta_1 \Delta\Delta r + \beta_2 \Delta/GNPDEF_{\ell}/ + \beta_3 \Delta/POP_{i\ell}/$$

$$+ \beta_4 \Delta/INC_{i\ell}/ + 2\beta_5 \Delta r_{\ell}/GNPDEF_{\ell}/ + \quad (6.4)$$

(a) Staloff, S. J. and R. C. Adams. 1981 (Draft).

$$2\beta_6\ \Delta r_\ell/POP_{i\ell}/ + 2\beta_7\ \Delta r/INC_{i\ell}/ + \qquad (6.4)\ \text{contd}$$

$$2\beta_8/GNPDEF_\ell//INC_{i\ell}/ + 2\beta_9/POP_{i\ell}//INC_{i\ell}/$$

where

Stock = floor space stock

β_1-β_9 = parameters

Δ = symbol for the first difference (annual change)

GNPDEF = gross national product price deflator

POP = population

INC = income

i = index for the region

ℓ = index for the year

// = symbol for the annual percentage change

r = nominal interest.

The Anchorage Consumer Price Index (CPI) was used as a proxy for the GNP price deflators. It is assumed (as historically revealed) that the nominal interest rate was approximately three percentage points above the measure of inflation. A proxy for regional income was derived by multiplying regional employment by the statewide average wage rate. Parameter values are shown for equation 6.4 in Table 6.6.

TABLE 6.6. Original RED Floor Space Equation Parameters

Parameter	Coefficient	Standard Error	T-Statistic
β_1	-0.1291	0.00345	-3.75
β_2	1.2753	0.2566	-4.97
β_3	0.3553	0.0302	11.76
β_4	-0.113	0.0037	-3.04
β_5	0.1929	0.0355	5.43
β_6	-0.0947	0.0078	-12.09
β_7	-0.0078	0.0008	-9.92
β_8	-0.0116	0.0253	-0.46
β_9	-0.0412	0.0061	-6.68

Table 6.7 shows how well the stock-flow floor space relationship performed in Anchorage and Fairbanks historically. Although the stock-flow equation performs fairly well on backcast and could be used to predict stock of commercial space for the historical period, in forecasts of future years it predicted virtually no growth in square footage per employee in Fairbanks and vigorous growth in building stock per employee in Anchorage. Since Fairbanks' actual commercial stock per employee grew faster between 1974 and 1981 than Anchorage's stock per employee, this forecast result appeared incorrect. For forecasting purposes, the equation was replaced with a simpler formulation that trended square footage per employee from existing levels in the Railbelt to near the current western average.

TABLE 6.7. Predicted Versus Actual Stock of Commercial-Light Industrial-Government Floor Space, 1975-1981,[a] (million square feet)

Year	Anchorage Predicted	Forecast Error as Percent of Actual (%)	Fairbanks Predicted	Forecast Error as Percent of Actual (%)
1975	31.2	-7.2	6.6	-3.8
1976	33.8	-9.3	7.2	-18.1
1977	37.0	-6.9	7.8	-23.0
1978	40.5	-2.4	8.2	-24.1
1979	42.3	-1.1	9.4	-16.0
1980	43.8	-0.7	9.9	-13.3
1981	44.7	-0.4	10.4	-9.2

(a) Because of the double lag structure of equation 6.1, only 1975-1981 can be compared.

Source: Unpublished test results of Staloff and Adams (1981 Draft).

Several other equations estimated for related national commercial buildings work at Battelle-Northwest were also applied to the Railbelt to determine their ability to forecast floor space. The equations used were estimated using pooled Lower 48 Standard Metropolitan Statistical Area (SMSA) and non-SMSA level data. The magnitude of the units of the independent variables (primarily the population, employment, and construction activity variables) was within an order of magnitude of those in Alaska. However, the magnitude of population, employment, and construction activity in the Railbelt is still small compared to those in the U.S. data used to estimate the equations. This may partly explain why building stock equations estimated with Lower 48 data do not perform well when applied to Alaska.

Annual additions to commercial floor space were estimated with several linear, logrithmic, and difference forms as a function of the following:

- lagged commercial building stock additions
- AAA bond rate in two forms--current and first differences
- population, both lagged and first difference
- employment, both lagged and first difference
- income, both lagged and first difference.

The equations "fit" the data on which they were estimated reasonably well, with R-square values generally above 0.9 and significant t-values on all coefficients. However, the equations did not perform well when applied to the two Alaska locations. All of the equations, in fact, produced negative levels of construction in forecasts. As mentioned above, this may be partly due to the magnitude of the units of the independent variables in relation to those used to estimate the equations. More importantly, the special behavior of the Alaskan economy may not be adequately described by equations estimated using data from the Lower 48 states.

Business Electricity Usage Parameters

These parameters were estimated with regression analysis. Using predicted historical floor space shown in Table 6.7[a] and using historical commercial-light industrial-government electricity consumption, the following regression equations were estimated:

$$\ln(CON_{it}) = BETA_i + BBETA_i \times \ln(STOCK_{it}) + \varepsilon_{it} \qquad (6.5)$$

(a)Copyright restrictions precluded the combining of "actual" data--that is, estimated construction based on FW Dodge construction data and 1978 building stock estimate produced by ISER. Predictions of historical floor space were done with equation 6.4.

where

CON = historical business sector consumption (MWh)

BETA = intercept

BBETA = regression coefficient

STOCK = predicted stock of floor space, hundreds of square feet

ε = stochastic error term.

Table 6.8 presents the results of the regression analysis.[a] The parameters BBETA are allowed to vary within a normal distribution, truncated at the 95% confidence intervals in Anchorage and 90% in Fairbanks..

TABLE 6.8. Business Consumption Equation Results

	Anchorage	Fairbanks
BETA	-4.7963	-0.9611
standard error	0.6280	3.6314
t-statistic	-7.6368	-0.2647
BBETA	1.4288	1.1703
standard error	0.0491	0.3293
t-statistic	29.1159	3.5538
GAMMA		0.1629
standard error	--	0.0535
t-statistic	--	3.0444
THETA		-0.0028
standard error	--	0.0024
t-statistic	--	-1.1547
$\bar{R}^2$	0.9906	0.9121

The estimating equation (equation 6.5) was modified with dummy variables for Fairbanks to capture and remove the effects of a rising trend in Fairbanks electricity prices after 1974 and the effects of the pipeline boom on consumption from 1975 to 1977. The regression equation estimated for Fairbanks is as follows:

(a) Regression intercept was adjusted to calibrate consumption in the business sector to its actual 1980 value for forecasting purposes.

$$\ln(CON_t) = BETA + BBETA \times \ln(STOCK_t) + GAMMA \times V + THETA \times DT + \varepsilon_t \quad (6.6)$$

with CON_t, BETA, BBETA, and ε defined as above and where

D = Dummy variable (1974 through 1981 = 1)

V = Dummy variable (1975 through 1977 = 1)

T = Time index for T = 1, ..., 9. (1973 through 1981)

GAMMA, THETA = regression coefficients.

The dummy variables were held at zero in forecasting.

The historical electricity consumption data were obtained from FERC Form 12s for the Railbelt utilities (supplied by ISER) and from Alaska Power Administration. These data lump together commercial and industrial sales by size of demand and there is no reliable way to disaggregate these two types of consumers. This is felt to be a significant shortcoming of the data series. Commercial and industrial loads should be separated because the typical characteristics of industrial demand for electricity are different from the demands of commercial and government users. Part of past Railbelt industrial load identified by subtracting commercial consumption for users over 50 KVa from the Homer Electric Association (HEA) service area load and assuming this load was mainly industrial.[a] Historical loads are shown in Section 13.0.

Historical electrical consumption per square foot of estimated commercial floor space and per employee, and estimated floor space per employee are displayed in Table 6.9. The consumption per estimated square foot in Anchorage shows a 2.0% annual increase for the period, while Fairbanks shows an annual decrease of 3.1%. The actual cause of this decrease in Fairbanks is unknown, but may be due to declines in space heating, or to priced-induced conservation, or to growth in warehouses as a proportion of commercial stock. The floor space is low at the beginning of the period on a per-employee basis relative to Anchorage (as well as other known estimates) but then increases at a faster

(a) The major industrial users in HEA's service area include Union Oil, Phillips Petroleum, Chevron U.S.A., Tesoro-Alaskan Petroleum Corp., and Collier Chemical. Other large commercial (non-industrial) users are included in HEA's over-50 KVa figures, but could not be separated.

TABLE 6.9. Electricity Consumption Per Employee and Square Foot and Square Footage Per Employee for Greater Anchorage and Fairbanks, 1974-1981

Year	kWh/ft² Anchorage	kWh/ft² Fairbanks	kWh/Employee Anchorage	kWh/Employee Fairbanks	ft²/Employee Anchorage	ft²/Employee Fairbanks
1973	19.9	27.7	6612	6631	332.6	217.8
1974	19.5	26.8	6414	5399	329.8	201.1
1975	21.1	31.7	6341	5368	300.0	169.1
1976	22.8	30.5	7044	5641	309.1	185.2
1977	22.9	30.8	7445	6922	325.5	224.1
1978	21.9	29.6	7847	7550	359.1	255.1
1979	20.8	23.5	7663	6858	369.2	292.4
1980	22.9	21.7	8644	6913	377.6	318.3
1981	23.3	21.5	NA[a]	NA	NA	NA

(a) Not applicable.

rate. Once the floor space per employee estimates for Fairbanks reach similar levels to those in Anchorage, the kWh/ft^2 figures for Fairbanks appear to stabilize.

The energy consumption per employee figures show increases over time of 3.4% and 0.5% annually for Anchorage and Fairbanks, respectively.[a] These two series show some instability with slight decreases in 1975 and 1979. The growth rates are too high, too unstable, and too disparate for long-term application, reflecting a period of extreme growth within the state. With more disaggregated data, employment may prove to be a suitable argument for industrial electricity consumption. However, with a rather limited Railbelt industrial sector, forecasts of industrial demand are better handled on a scenario building basis; i.e., identify industry expansion plans case by case.

Several regression equations were estimated in an attempt to develop a theoretically satisfying relationship to predict electricity consumption

(a) No data are available on consumption of electricity by SIC industry code. Multiple regression techniques proved unsuccessful in determining the separate effects of each subsector's employment on commercial demand, due to high colinearity among explanatory variables.

separately in the commercial, light industrial, and government sectors. All failed most normal statistical tests. The aggregate nature of the electricity consumption data and employment data, the rather high trend exhibited for per-employee consumption, and the limited data series prevented statistical estimates of consumption on a per-employee basis. No further attempt was made to estimate a statistical relationship between electricity consumption and employment.

Business Price Adjustment Parameters

The parameters used in the price adjustment mechanism are an important part of the business electricity forecasting mechanism. As in the Residential Consumption Module, the parameter default values and ranges were picked from Mount, Chapman, and Tyrell (1973). Chapter 7.0 discusses these parameters and their use in the price adjustment mechanism.

7.0 PRICE ELASTICITY

This section describes the price adjustment mechanism employed in the RED model. In both the Residential and Business Modules, this mechanism modifies preliminary estimates of electricity consumption generated elsewhere in the model. Changes in consumption are made to account for changes over time in electricity, natural gas, and oil prices. The changes in electrical consumption computed by the price adjustment mechanism can be considered price-induced conservation of electricity.[a] Outputs from the price adjustment mechanism are the final RED electricity consumption estimates for each sector, region, and time period.

The remainder of this section is divided into four parts. A brief general introduction to the RED price adjustment mechanism is given in the next subsection. This is followed by a survey of economic literature on electricity demand. In the third part, the structure and parameters selected for the RED price adjustment mechanism are discussed. Implementation of the selected structure and parameters is described in the final subsection.

THE RED PRICE ADJUSTMENT MECHANISM

The RED price adjustment mechanism is motivated by economic theory, which hypothesizes the following: consumption of any commodity is determined both by "scale" variables such as population, income, and employment, as well by the prices of the particular commodity, its substitutes, and its complements. Elsewhere in the RED model, preliminary estimates of electricity consumption are generated, with consideration only of "scale" variables. The price adjustment mechanism described in this section completes the analysis of consumption determinants suggested by economic theory.

The mechanism works in the following manner. Preliminary, non-price adjusted estimates of electricity consumption by region, sector, and time

(a) Of course, with falling electricity prices or increases in gas and oil prices, the price adjustments could result in increased electricity consumption or "negative conservation" of electricity. The price adjustments include fuel switching.

period are introduced into the model. These preliminary estimates were generated under the assumption that 1980 price levels are maintained through the year 2010.

The price adjustment mechanism accounts for the fact that prices in any forecast period K are not necessarily the same as prices in 1980, even in real (inflation-adjusted) terms. If real electricity prices increase (decrease) in any region and sector between 1980 and period K, economic theory suggests that electricity consumption in that region and sector would decrease (increase) relative to its non-price-adjusted preliminary estimate. Conversely, if real natural gas or oil prices increase (decrease) in any region and sector between 1980 and period K, electricity consumption in that region and sector would increase (decrease) relative to its non-price-adjusted preliminary estimate because natural gas and oil are substitutes for electricity. Thus, the RED price adjustment mechanism scales preliminary estimates of electricity consumption upward or downward based on changes in real electricity, natural gas, and oil prices.

The amount by which preliminary period K consumption is scaled upward or downward depends on three general factors: 1) the percentage change in real electricity, natural gas, and oil between forecast period K-1 and forecast period K, as well as price changes occurring prior to period K-1; 2) the short-run elasticities of electricity demand with respect to the three prices; and 3) the speed with which final consumers of electricity move toward their long-run equilibrium consumption levels when these prices change, which is represented by a "lagged adjustment coefficient", or alternatively, the long-run demand elasticity. Short-run elasticities of demand are defined as the percentage change in consumption in year t caused by a one percent increase in price in year t. Own-price elasticities refer to changes in electricity consumption caused by changes in electricity prices; cross-price elasticities refer to changes in electricity consumption associated with changes in either natural gas or oil prices. Short-run elasticities represent the instantaneous adjustment that consumers make when prices change. Of course, in the case of electricity, a significant period of time may pass before consumers have fully responded to a price change in year t: time is required to change old habits, to replace old appliances with more energy-efficient ones, to weatherize residences or commercial/industrial buildings, and to switch to other energy sources. The lagged adjustment coefficient represents the rate at which consumers move toward their final equilibrium consumption level; the higher this coefficient, the more current consumption depends on past consumption, and thus the slower consumers respond to current price changes. In fact, simple algebra can show that the long-run demand elasticity (either own- or cross-price), which is defined as the percentage change in electricity consumption in year $t + \infty$ caused by a one percent change in price in year t, can be defined in terms of the lagged adjustment coefficient and the short run elasticity. The formula for the long-run elasticity ELR is given by

$$ELR = \frac{ESR}{1-\lambda} \tag{7.1}$$

where ESR is the short-run elasticity and λ is the lagged adjustment coefficient.

Alternatively, a set of long-run price elasticities can be entered into the mechanism. These elasticities describe the change in consumption caused by a price change once the consumer has reached a point of equilibrium with that price change.

LITERATURE SURVEY

Since the "energy crises" of the early 1970s, an extensive economic/econometric literature on the demand for energy, and electricity in particular, has been generated. A survey of this literature was performed with two primary objectives: first, to identify possible structures of the RED price adjustment mechanism; second, given the structure, to identify potential parameter values for the mechanism. These objectives center around the concepts of elasticity and adjustment coefficients. In performing the survey, the objectives led to the following questions.

- Should the RED Residential and Business Sectors be combined or modeled separately?

- Should the own-price elasticity be a constant or a function that depends on the price level?
- Should both natural gas and oil cross-price elasticities be included in the mechanism and should these elasticities be constant or vary by the price levels of the two fuels?
- Should the relationship between short-run and long-run price elasticities (both own- and cross-) be modeled explicitly by including lagged adjustment coefficient in the mechanism, or should the two types of elasticities be included in the mechanism separately?
- Once the structure is selected, what are the most appropriate values for the parameters of the mechanism?

All of the studies surveyed were econometric in nature, in which electricity demand functions were estimated using statistical techniques. A variety of data bases was used in these studies, and the fuctional forms, independent variables, and estimation techniques employed varied substantially as well. All but a few of the studies modeled residential, commercial, and industrial electricity demand separately; in many studies, only one of these sectors was considered. Many of the studies estimate price elasticities that do not vary according to price levels; this is accomplished by regressing the natural logarithm of consumption on the natural logarithms of the prices and other independent variables. The coefficients of the price terms can then be interpreted as elasticities. Non-constant elasticities were estimated in a few studies, using a variety of functional forms. One method of estimating variable price elasticities is to regress the natural logarithm of quantity on the natural logarithms of the prices, the natural logarithms of the other independent variables, and the reciprocals of the prices:

$$\log Q = a + b \log P +++ c\ 1/P +++ \qquad (7.2)$$

where "log" denotes natural logarithm, Q is consumption of electricity and P its price, a,b,c are parameters to be estimated, and "+++" denotes the other price and independent variables in the equation. In this specification, the own-price elasticity is equal to b - c/p, which depends on P.

Several studies include only natural gas as a substitute for electricity, a smaller number include only oil, and some studies include both. The substitute commodities included in an equation depend on the intentions of the researcher and the type of data used: neither oil nor natural gas prices typically vary much in cross-sectional samples, so their effects on electricity consumption are difficult to discern when using this type of data.

Finally, the type of elasticity estimated (short-run, long-run, both) varies across the studies survey. In studies using time-series data, the coefficients on prices and the other independent variables are typically interpreted as short-run elasticities. An exception to this occurs when lagged consumption is included as an independent variable in the estimation equation; then, the coefficients in the prices represent short-run elasticities, and the long-run elasticity is given by equation 7.1 with λ the coefficient on lagged consumption. In equations estimated using cross-sectional samples, the coefficients are typically interpreted as long-run elasticities. Pooled time-series -- cross-section samples pose a bit more of a problem; the estimated coefficients contain both long-run and short-run effects. However, when lagged consumption is included as an explanatory variable, the price coefficients again represent short-run elasticities and long-run elasticities are again given by equation 7.1.

Table 7.1 summarizes the econometric studies of residential electricity demand surveyed. For each study, the type of elasticity estimated (constant, variable), the time period for which it is relevant (short-run, long-run, both), and the type of data used (cross-section, time-series, pooled cross-section -- time-series) are presented. Also shown are the substitutes' prices and non-price factors considered in each study. The own- and cross-price elasticities estimated in each study are presented in Table 7.2. For those studies in which lagged consumption was included in the equation, its coefficient, the lagged adjustment coefficient, is also presented.

Estimates of the short-run own-price elasticity vary considerably. In absolute values, the minimum estimate is 0.101, while the maximum is 0.3. Many of these differences can be attributed to the data used in the estimation; estimates based on national data would be expected to differ from estimates for

TABLE 7.1. Residential Electricity Demand Survey

Author	Type of Elasticity	Time Frame	Type of Data	Substitute Prices	Other Demand Determinants[a]
Anderson, K.P. (1972) Residential Demand for Electricity: Econometric Estimates For California and the United States. The Rand Corporation, Santa Monica, CA	Constant	Long run	Cross-section 1969, states	Average price of Natural Gas	
Anderson, K.P. (1973) Residential Energy Use: An Econometric Analysis R-1297-NSF. The Rand Corp., Santa Monica, CA	Constant	Short run long run	Cross-section 1969, states	Fuel oil, bottled gas, coal	Y, HS, SHU, NU, W, S
Baughman, M.L., Joskow, P.L., Dilip, K.P. 1979 Electric Power in the United States: Models and Policy Analysis. MIT Press, Cambridge, MA	Constant	Short run long run	Time series 1968-1972 48 states	Energy price index	Yi, N, MT, LT, P_i
Blattenberger, G.R., Taylor, L.D., Rennhack, R.K. 1983, "Natural Gas Availability and the Residential Demand for Energy". The Energy Journal. 4(1):23-45	Constant	Short run long run	Time series 1960-1975 states	Marginal price natural gas, fixed charge natural gas, price of fuel oil	mpe, fce, x, ddh, ddc
Halvorsen, Robert. 1976 "Demand For Electric Energy in the United States". Southern Econ Journal. 42(4):610-625.	Constant	Long run	Cross-section 1969 states	Average price per therm for all types of gas purchased by sector	c_r, P_{nm}, Y*, J, D, Z, R, H, E

TABLE 7.1. (contd)

Author	Type of Elasticity	Time Frame	Type of Data	Substitute Prices	Other Demand Determinants[(a)]
Halvorsen, Robert. 1978 Econometric Models of U.S. Energy Demand. D.C. Heath and Co., Lexington, MA	Constant	Long run	Pooled 1961-1969 48 states	Average real gas price for all types of gas in cents	P_R, Y_H, A, D, J, U, M, H_A, T per therm
Hirst, Eric, and Carney, Janet. 1979. "The ORNL Residential Energy-Use Model: Structure and Results". Land Economics. 55(3):319-333	Constant	Short run long run	Cross-section 1970		HT, HS_A, C, TI, EU, U
Houthakker, H.S. and Taylor, L.D. 1970. Consumer Demand in the United States. Harvard Univ. Press, Cambridge, MA	Constant	Short run	Time series		g_{t-1}, X_t, P
Mount, T. D., Chapman, L. D., and Tyrrell, T. J. 1973. Electricity Demand in the United States: An Econometric Analysis.	Variable	Short run long run	Cross-section 1947-1970 States	Price of gas-includes natural, liquid petroleum, manufactured and mixed gas.	Population, per capita income, avg. electricity price, price index for appliances, mean January temperature

(a) For symbols, see glossary at end of section.

TABLE 7.2. Residential Survey Parameter Estimates

Author	Short-Run Own Price Elasticity	Long-Run Own Price Elasticity	Lagged Adjustment Coefficient (λ)	Gas Cross-price Elasticity	Oil Cross-price Elasticity
Anderson (1972)	--	-0.91	--	0.13L	--
Anderson (1973)	-0.3	-1.12	0.732	0.30L	0.27L
Baughman, et al (1979)	-0.19	-1.00	0.842	0.055, 0.17L	0.015, 0.005L
Blattenberger, et al (1983)	-0.101	-1.052	0.904	0.0025, 0.018L	--
Halvorsen (1976)	--	-0.97	--	0.16L	--
Halvorsen (1978)	--	-1.14	--	0.05L	--
Hirst, Carney (1979)	-0.16	-0.83	--	0.025, 0.20L	0.005, 0.04L
Houthakker, Taylor (1970)	-0.13	-1.89	0.873	--	--
Mount, Chapman, Tyrrell (1973)	-0.14	-1.21	0.884	0.025, 0.21L	--

individual states, and estimates for more recent periods would be expected to differ from older estimates. The functional forms used and the set of independent variables considered also appear to play a role. However, in neither case does a clear relationship appear.

The long-run own-price elasticities display even greater variation, largely because two methods of estimating these elasticities exist: 1) using a cross-sectional sample, or 2) using a time-series or a pooled sample and including a lagged endogenous variable. For the studies surveyed, the second approach generally leads to larger (in absolute values) estimates of the long-run own-price elasticity.

As expected, in studies in which both long- and short-run elasticities are estimated, the long-run elasticity is larger in magnitude than the short-run elasticity. The relationship reflects the fact that consumers can manage only a limited response to price changes in the short run, when their housing and appliance stocks are fixed, but respond more fully over time when these stocks can be varied.

Estimates of the lagged adjustment coefficient do not vary as much as the other parameters; most estimates are about .85. Oil and natural gas price elasticities vary much less than the other parameters of interest, but quite a lot relative to their magnitudes and are considerably smaller than the own-price elasticities.

Most of the literature surveyed considered commercial and industrial electricity demand separately. Industrial demand elasticities are typically larger than those in the commercial sector because of the large amounts of electricity used for purposes in which oil, natural gas, and coal serve as very good substitutes. In the commercial sector, most electricity consumption is for lighting and cooling, uses in which fuel-switching is not as easy.

The RED Business sector is a combination of industrial and commercial sectors. Most business concerns in the Railbelt, however, are commercial or light industrial. Therefore, the industrial electricity demand elasticities were deemed inappropriate to the Railbelt, and only the commercial electricity demand literature was surveyed.

Only two studies that deal explicitly with the commercial sector were found. These two studies are summarized in Tables 7.3 and 7.4, which parallel Tables 7.1 and 7.2. Even among these two studies the estimated price elasticities vary considerably; the two short-run own-price elasticities are -.03 and -.29. The cross-price elasticities again vary considerably less, and are much smaller in magnitude than the own-price elasticities.

For both the residential and commercial sectors, the hypothesis that own-price elasticities are constant was statistically tested and rejected by Mount, Chapman, and Tyrrell (1973) (MCT). In that study, own-price elasticities were found to increase in magnitude as the level of electricity prices increased. Thus, the absolute value of the own-price elasticity of electricity demand is higher in regions with high electricity prices than in areas with lower electricity prices and increases (decreases) over time as the real electricity price increases (decreases) over time. In both sectors, oil and natural gas were each found to significantly affect electricity consumption, and long-run elasticities were found to be larger than short-run elasticities. However, the parameter estimates do vary according to sector; Mount, Chapman, and Tyrrell, who estimated models for both sectors, found significantly greater price responsiveness in the short run and long run in the commercial (Business) sector, with approximately equal lagged adjustment coefficients.

SELECTION OF RED PRICE ADJUSTMENT MECHANISM STRUCTURE AND PARAMETERS

On the basis of the literature surveyed in the previous section and consideration of the non-price modules of the RED model, the RED price adjustment mechanism was specified in the following manner.

Sector Division

Separate price adjustment mechanisms are used for the two end-use sectors. In the only study surveyed in which both sectors were considered, MCT found that the electricity demand elasticities for the two sectors were considerably different. Thus, specifying a single mechanism to be applied to both sectors would lead to biased estimates of the price adjustments in each sector. However, each of the two mechanisms has the same structure; only the parameters and the price changes considered differ.

TABLE 7.3. Commercial Electricity Demand Survey

Author	Type of Elasticity	Time Frame	Type of Data	Substitute Prices	Other Demand Determinants[a]
Beierlein, James G., Dunn, James W., McConnon, James C. 1981. "The Demand for Electricity and Natural Gas in the Northeastern United States". The Review of Economics and Statistics. August 1981, pp. 403-408.	Constant	Short-run long-run	Cross-section time series 1967-1977 regional NE	Natural gas, fuel oil	Y_j, PE_j, Q_{it-1j}
Mount, T. D., Chapman, L. D., and Tyrell, T. J. 1973. Electricity Demand in the United States; An Econometric Analysis. Contract No. W-7405-eng-26. ORNL, Oak Ridge, Tennessee	Variable	Short-run long-run	Cross-section 1947-1970 States	Gas	Y, P, PE, Q_{t-1}

(a) For symbols, see glossary at end of section.

TABLE 7.4. Commercial Survey Parameter Estimates

Author	Short-Run Own Price Elasticity	Long-Run Own Price Elasticity	Lagged Adjustment Coefficient (λ)	Gas Cross-price Elasticity	Oil Cross-price Elasticity
Bierlein, et. al. (1981)	-0.03	-0.37	0.9167	0.045, 0.48L	-0.095, -1.09L
Mount, et. al. (1973)	-0.29	-1.36	0.8724	0.015, 0.06L	--

Variable Elasticity

The own-price elasticity in each sector is not constant, but varies with the level of the real electricity price. In the only study surveyed in which variable elasticities were estimated, MCT rejected the hypothesis that own-price elasticities were constant. Furthermore, a considerable amount of variation was found in the estimated own-price elasticities during the literature survey. This variation could be caused in part by variations in the estimating samples' price levels.

These factors would be unimportant if the level of electricity prices in the Railbelt region were fairly similar to the mean level of prices used in estimating the constant elasticity equations, if the levels of electricity prices within the Railbelt were uniform, and if real electricity prices in the Railbelt were not expected to change during the forecast period. In such a case, the estimate from a constant-elasticity model might provide a reasonable approximation to the true elasticity in the Railbelt. Even if the true elasticity were variable, when evaluated at the mean level of prices, it would be similar to a constant elasticity estimated with the same data. Unfortunately, none of these conditions hold; the average level of Railbelt electricity prices in 1980 was significantly below U.S. average electricity price; within the Railbelt, the level of Anchorage electricity prices was less than half the level of Fairbanks prices in 1980; and in several of the RED price scenarios, electricity prices increase rapidly enough that by the year 2000 they are 50 to 100% higher in real terms than they were in 1980.

Adjustment Over Time

Long-term price elasticities are not entered explicitly into the mechanism; instead, short-run elasticities and a lagged adjustment coefficient are employed. Thus, long-term elasticities appear explicitly in the mechanism via the relationship given above. This choice was made for three reasons. First, the explicit short-run elasticities are consistent with the implicit long-run elasticities; that is, the elasticity estimates can be taken from the same study, estimated with a lagged adjustment coefficient. If the long-run elasticity were entered explicitly, it could not be taken from the same study as the short-run elasticity because it is impossible to obtain both elasticities from one equation except via the lagged adjustment coefficient. Second, since the lagged adjustment coefficient did not vary much across the studies, whereas the long-run elasticities did, choosing a value for λ was more straightforward. Third, and most importantly, by including the lagged adjustment coefficient the impact of price changes in year t on consumption in year t + 1, t + 2, ..., t + 10 can be assessed directly; because t + 1, ... t + 10 is neither the short-run nor the long-run, with only the two sets of elasticities and no lagged adjustment coefficient these impacts cannot be directly measured, but only crudely guessed. This is particularly important in RED because it forecasts electricity consumption at five-year intervals; price changes in the first-year of the five-year period obviously have neither a long-run nor short-run impact on consumption in the fifth year of the period, but an intermediate impact.

Cross Price Elasticities

Short- and long-run natural gas and oil cross-price elasticities are included in the mechanism. In several of the studies surveyed, one or the other fuel was found to be a substitute for electricity, although due to data limitations they were only considered simultaneously in a handful of studies. Thus, the effect of oil and gas price changes on electricity consumption, although small in relation to the effect of electricity prices, cannot be ignored. It is important to include these prices in the RED price adjustement mechanism for the following reasons. Much of the own-price elasticity of electricity demand can be attributed to "fuel switching." As real electricity prices increase, some households and businesses will, the mechanism predicts, "switch" from electricity to natural gas or oil for heating and other energy uses. However, if real oil and gas prices are also increasing, the extent of this fuel switching will be diminished. The cross-price elasticities are employed in RED to account for this. One would think that the amount by which this fuel switching is diminished because of rising gas and oil prices would be a function of the level of oil and gas prices; in other words, that these cross-price elasticities are not constant with respect to their corresponding prices. Unfortunately, none of the studies surveyed employed variable cross-price elasticity models; thus, the cross-price elasticities in each of the two price mechanisms are constant.

Parameter Estimates

The parameter estimates for each of the two price adjustment mechanisms were taken from the study by Mount, Chapman, Tyrrell (1973). Oil cross-price elasticities, which were not estimated in the MCT study, were based on professional judgment and values taken from the literature survey. The parameter values used in RED are presented in Table 7.5. The MCT parameter values were used in RED for two reasons. First, their models were most consistent with the structure selected for the RED price adjustment mechanisms; there are separate equations for the residential and business sectors, variable own-price elasticities are employed, lagged adjustment coefficients are estimated, and a cross-price elasticity (gas) is included. Second, the elasticities estimated by MCT, when evaluated at 1980 Anchorage and Fairbanks prices (in real 1970 dollars, as in MCT), appear reasonable. In the residential sector, calculated short-run elasticities were -.1462 in Anchorage and -.1507 in Fairbanks; calculated

TABLE 7.5. Parameter Values in RED Price Adjustment Mechanism

Short-Run Elasticities	Residential Sector	Business Sector
Own-Price	$-.1552 + .3304/P^{(a)}$	$-.2925 + 2.4014/P^{(a)}$
Natural Gas	.0225	.0082
Oil	.01	.01
Lagged Adjustment	.8837	.8724

(a) Measured in mills per KWH, 1970 dollars.

long-run elasticities were -1.2571 and -1.296, respectively. The short-run elasticities are slightly below the average of the estimates presented in Table 7.2; since average prices are rather low in the Railbelt, this result is satisfactory. The long-run elasticities are slightly above the average of the studies surveyed, since the MCT lagged adjustment coefficient is at the high end of the range of those surveyed. This is satisfactory for the Railbelt because electricity comprises a large share of consumers' budgets due to the climate and winter hours of darkness and because in the past residents of the area have been conservation-minded. The business sector short-run own-price elasticities evaluated at 1980 prices are -.2270 in Anchorage and -.2600 in Fairbanks, and the respective long-run elasticities are -1.7788 and -2.0378. The short-run estimates are a little below the average MCT calculated, due to below-average Railbelt prices, and the long-run elasticities are at the high end of the range found in the survey.

DERIVATION OF RED PRICE-ADJUSTMENT MECHANISM EQUATIONS

The final outputs from the RED price adjustment mechanism are price-adjusted consumption of electricity for each sector, region, and time period, denoted $RESCON_{iK}$ and $BUSCON_{iK}$. Each of these is equal to preliminary estimates of consumption, denoted $RESPRE_{iK}$ and $PRECON_{iK}$, multiplied by a series of price adjustment factors:

$$RESCON_{iK} = RESPRE_{iK} \cdot (1 + OPA_{iK\ell}) \cdot (1 + PPA_{iK\ell}) \cdot (1 + GPA_{iK\ell}) \qquad (7.3)$$

$$BUSCON_{iK} = PRECON_{iK} \cdot (1 + OPA_{ik\ell}) \cdot (1 + PPA_{iK\ell}) \cdot (1 + GPA_{iK\ell}) \qquad (7.4)$$

where

i = region index
K = time period index
ℓ = sector index (=1 residential, = 2 business)
OPA = own-price adjustment factor
PPA = oil (petroleum)-price adjustment factor
GPA = gas-price adjustment factor and denotes multiplication.

Thus, final consumption in a sector is equal to preliminary, non-price adjusted consumption scaled upward or downward depending on the signs and magnitudes of the three corresponding adjustment factors. These factors combine information on price changes in periods K, K-1,., own- and cross-price elasticities in periods K, K-1, ..., and lagged adjustment coefficients in the following manner. First, denoting electricity, oil, and natural gas prices by $PE_{iK\ell}$, $PO_{iK\ell}$, and $PG_{iK\ell}$, (define the five-year percentage change in prices):

$$PCPE_{iK\ell} = (PE_{iK\ell} - PE_{i,K-1,\ell})/PE_{i,K-1,\ell} \tag{7.5}$$

$$PCPO_{iK\ell} = (PO_{iK\ell} - PO_{i,K-1,\ell})/PO_{i,K-1,\ell} \tag{7.6}$$

$$PCPG_{iK\ell} = (PG_{iK\ell} - PG_{i,K-1,\ell})/PG_{i,K-1,\ell}. \tag{7.7}$$

Then calculate the average annual percentage change in price during the five-year period:

$$PCPEA_{iK\ell} = (1 + PCPE_{iK\ell})**.2 - 1 \tag{7.8}$$

$$PCPOA_{iK\ell} = (1 + PCPO_{iK\ell})**.2 - 1 \tag{7.9}$$

$$PCPGA_{iK\ell} = (1 + PCPG_{iK\ell})**.2 - 1 \tag{7.10}$$

where "**" denotes exponentiation. Thus, during each of the years between K-1 and K, prices increase an average of $100 \cdot PCPEA_{iK\ell}$, and $100 \cdot PCPOA_{iK\ell}$, and $100 \cdot PCPGA_{iK\ell}$ percent.

The impact of a change in the price of electricity in the first year of the five-year period on consumption in the fifth year of the period can be analyzed in steps. First, the impact of the price change on consumption in the first year (denoted t) is given by

$$\%\Delta Q_{it\ell} = ESR_{it\ell} \cdot \%\Delta P_{it\ell} \tag{7.11}$$

where $\%\Delta$ denotes percentage change, Q_t is consumption in year t, sector ℓ, region i, $P_{it\ell}$ is the price, and $ESR_{it\ell}$ is the short-run own-price of electricity. Equation 7.9 states that consumption in year t falls (increases) in percentage terms by an amount equal to the price increase (decrease) scaled by the own-price elasticity (which is negative). The effect of the price change in year t on consumption in year t + 1 is the sum of two components. First, lagged consumption has fallen by $\%\Delta Q_{it\ell}$, so this period's consumption falls by $\lambda\%\Delta Q_{it\ell}$. Second, the price change which occurred in year t persists (the price did not go back to its year t-1 level) so consumption in year t + 1 falls by $ESR_{i,t+1,\ell} \cdot \%\Delta P_{it\ell}$. Thus, the change in year t + 1 consumption of electricity caused by a price change in year t is given by

$$\%\Delta Q_{i,t+1,\ell} = \lambda\%\Delta Q_{it\ell} + ESR_{i,t+1,\ell} \cdot \%\Delta P_{it\ell} \qquad (7.12)$$

$$= (\lambda\ ESR_{it\ell} + ESR_{i,t+1,\ell}) \cdot \%\Delta P_{it\ell} \qquad (7.13)$$

Similarly, the change in year t + 2 consumption is equal to the sum of two components:

$$\%\Delta Q_{i,t+2,\ell} = \lambda\%Q_{i,t+1,\ell} + ESR_{i,t+2,\ell} \cdot \%\Delta P_{it\ell} \qquad (7.14)$$

$$= (\lambda^2 ESR_{it\ell} + \lambda ESR_{i,t+1,\ell} + ESR_{i,t+2,\ell}) \cdot \%\Delta Pit\ell \qquad (7.15)$$

This process can be carried out to year t + 4, the final year of the five-year period:

$$\%\Delta Q_{i,t+4,\ell} = \%\Delta P_{it\ell} \cdot (\lambda^4 ESR_{it\ell} + \lambda^3 ESR_{i,t+1,\ell} \qquad (7.16)$$

$$+ \lambda^2\ ESR_{i,t+2,\ell} + \lambda\ ESR_{i,t+3,\ell}$$

$$+ ESR_{i,t+4,\ell})$$

which gives the percentage change in year t + 4 consumption resulting from the price change $\%\Delta P_{it\ell}$ in year t. Similar price changes occur in year t + 1 ($\%\Delta P_{i,t+1,\ell}$), t + 2 ($\%\Delta P_{i,t+2,\ell}$), t + 3 ($\%\Delta P_{i,t+3,\ell}$), and t + 4 ($\%\Delta P_{i,t+4,\ell}$), with equal percentage price changes assumed during each of the five years. That is:

$$\%\Delta P_{it\ell} = \%\Delta P_{i,t+1,\ell} = \%\Delta P_{i,t+2,\ell} = \%\Delta P_{i,t+3,\ell} = \%\Delta P_{i,t+4,\ell} = PCPEA_{ik\ell} \quad (7.17)$$

The impact of these individual price changes on consumption in year t + 4 can be derived in a manner similar to that used to obtain equation 7.16. The sum of the impacts of the five annual price changes is given by equation 7.18:

$$\%\Delta Q_{i,t+4,\ell} = PCPEA_{ik\ell} \cdot \Big(\lambda^4 \; ESR_{it\ell} + 2\lambda^3 \; ESR_{i,t+1,\ell} + 3\lambda^2 \; ESR_{i,t+2,\ell} + 4\lambda \; ESR_{i,t+3,\ell} + 5 \; ESR_{i,t+4,\ell}\Big) \quad (7.18)$$

Equation 7.18 accounts for price changes which occur between period K-1 and K; price changes which occurred before K-1 also influence consumption in period K, just as price changes in period t affect consumption in, for example, period t + 9:

$$\%\Delta Q_{i,t+9,\ell} = \%\Delta P_{i,t,\ell} \; (\lambda^9 \; ESR_{it\ell} + \lambda^8 \; ESR_{i,t+1,\ell} + \ldots + \lambda^5 \; ESR_{i,t+4,\ell} + \lambda^4 \; ESR_{i,t+5,\ell} + \ldots + \lambda \; ESR_{i,t+8,\ell} + ESR_{i,t+9,\ell}) \quad (7.19)$$

The combined total impact of the five annual price changes in t, t+1, t+2, t+3, t+4, on consumption in period t+9 (period K+1) is given by

$$\%\Delta Q_{i,t+9,\ell} = \lambda^5 \%\Delta Q_{i,t+4,\ell} + PCPEA_{ik\ell}\left(\lambda^4\ ESR_{i,t+5,\ell} + 2\lambda^3\ ESR_{i,t+6,\ell} + 3\lambda^2\ ESR_{i,t+7,\ell} + 4\lambda\ ESR_{i,t+8,\ell} + 5ESR_{i,t+9,\ell}\right) \tag{7.20}$$

Extending this analysis forward, combining terms, and rearranging, one obtains the percentage change in any five-year period K as a function of average annual price changes between K-1 and K, K-2 and K-1, etc:

$$\%\Delta Q_{ik\ell} = \lambda^5 \%\ \Delta Q_{i,K-1,\ell} + \left(\sum_{m=1}^{K} PCPEA_{im\ell}\right) \cdot \left(\lambda^4\ ESR_{i,K1,\ell} + 2\lambda^3\ ESR_{i,K2,\ell} + 3\lambda^2\ ESR_{i,K3,\ell} + 4\lambda\ ESR_{i,K4,\ell} + 5\ ESR_{i,K5,\ell}\right) \tag{7.21}$$

Where the subscripts K1,,,K5 denote, respectively, the first year in the period between K-1 and K, the second year in the period between K-1 and K, etc. The summation over past price changes takes into account that these price changes persist: that once prices have increased, the increase and its effects are permanent, until and unless future price decreases offset them.

Equation 7.17 defines $OPA_{i,k,\ell}$ as the percentage adjustment to electricity consumption which must be made because of real electricity price changes. Restated,

$$OPA_{iK\ell} = \lambda^5 \, OPA_{i,K-1,\ell} + \left(\sum_{m=1}^{K} PCPEA_{im\ell} \right) \cdot \left(\lambda^4 \, ESR_{i,k1,\ell} + \lambda^3 \, ESR_{i,K2,\ell} + \lambda^2 \, ESR_{i,K3,\ell} + \lambda \, ESR_{i,K4,\ell} + ESR_{i,K5,\ell} \right) \tag{7.22}$$

Similarly, price adjustment factors for oil and natural gas price changes can be derived, with one simplification - the oil and gas cross-price elasticities are constant. Thus,

$$PPA_{iK\ell} = \lambda^5 \, PPA_{i,K-1,\ell} + \left(\sum_{m=1}^{K} PCPOA_{im\ell} \right) \cdot OSR_\ell \cdot (\lambda^4 + 2\lambda^3 + 3\lambda^2 + 4\lambda + 5) \tag{7.23}$$

$$GPA_{ik\ell} = \lambda^5 \, GPA_{i,K-1,\ell} + \left(\sum_{m=1}^{K} PCPGA_{im\ell} \right) \cdot GSR_\ell \cdot (\lambda^4 + 2\lambda^3 + 3\lambda^2 + 4\lambda + 5) \tag{7.24}$$

where OSR_ℓ is the short-run oil cross-price elasticity in sector ℓ and GSR_ℓ is the short-run gas cross-price elasticity in sector ℓ.

All that remains is to attach values to $ESR_{i,Kj,\ell}$. In the MCT study, short-run elasticities are defined by

$$E_{SR} = a - b/P. \qquad (7.25)$$

Implementation of this requires calculating the average elasticity for a given year Kj, so that

$$ESR_{i,Kj,\ell} = A_{\ell} - .5\ B_{\ell}/P_{i,Kj-1,\ell} - .5\ B_{\ell}/P_{i,Kj,\ell} \qquad (7.26)$$

where $P_{i,Kj-1,\ell}$ is the price at the end of the year before Kj, and $P_{i,Kj,\ell}$ is the price at the end of year Kj.

GLOSSARY OF SYMBOLS

Y = income per household
HS = average family size
SHU = single detached housing units (fraction of total)
NU = nonurban housing units (fraction of total)
W = mean December temperature
S = mean July temperature
Yi = income per capita (67 dollars)
N = population density
Pi = energy price index relative to CPI (dollars per Btu)
MT = average temperature of warmest three months of year (°F)
LT = average temperature of coldest three months of year (°F)
mpe = marginal price of electricity
fce = fixed charge for electricity
x = total personal income
ddh = heating degree days
ddc = cooling degree days
C_r = number of residential customers
P_{rm} = marginal price of electricity
Y* = per capita personal income
J = average July temperature
D = heating degree days
Z = population per square mile
R = percent rural population
H = percent of housing units in single-unit structures
E = number of housing units per capita
P_R = average real price of residential electricity, in cents per kwh
Y_H = average real income per capita, in thousands of dollars
A = index of real wholesale prices of selected electric appliances
U = percentage of population living in rural areas
M = percentage of housing units in multiunit structures
H_A = average size of households
T = time
HT = stock of occupied housing units

HS_A = average size of housing units

C = the fraction of households with a particular type of equipment

T1 = thermal performance of housing units

EU = average annual energy use for the type of equipment

U = usage factor

g_{t-1} = lagged personal consumption expenditure for electricity per capita in 1958 dollars.

X_t = total personal consumption expenditure per capita in 1958 dollars

p = implicit deflator for electricity/implicit deflator for PCE (1958=100)

Yj = value of retail sales

PE_j = average deflated price per KWH of electricity

Q_{it-1j} = lagged per capita fuel consumption

Y = income per capita

P = population

PE = price of electricity (mills per KWH)

Q_{t-1} = lagged demand in millions of KWH.

L = long run

8.0 THE PROGRAM-INDUCED CONSERVATION MODULE

The purpose of the Program-Induced Conservation Module is to account for the electricity savings that can be obtained with a given set of consumer-installed conservation technologies and government policies, together with the associated costs of these savings. The peak demand or capacity savings of the technologies set are calculated in the Peak Demand Module.

The module forecasts only those portions of conservation that are not market- or price-induced. The module was developed as part of Battelle-Northwest's Alaska Railbelt Electric Power Alternatives Study in 1981 and was designed as a tool to enable the State of Alaska to analyze the impact of potential large-scale conservation programs. The future of such programs in Alaska is in doubt (Tillman 1983) and the data on the savings and costs of existing programs are uncertain. The Program-Induced Conservation Module was not used in the 1983 updated forecasts, but a description of the module is given below.

MECHANISM

The fuel price adjustments in the Residential Consumption and Business Consumption Modules account for market-induced technology-related conservation impacts, as well as reductions in appliances use and changes in the way in which they are used. The Program-Induced Conservation Module analyzes government attempts to intervene in the marketplace to induce conservation via loan programs, grants, or other policy actions. The module accounts for the effects of this program-induced conservation on demands for electric energy and generating capacity.

RED separates conserved energy into two parts: energy saved from the actions of residential consumers and energy saved from reduced energy use in the business and government sectors. Figure 8.1 provides a flow chart of the process employed.

A separate, interactive program developed with RED (CONSER) is called by RED to prepare a conservation data file. This file contains information on the

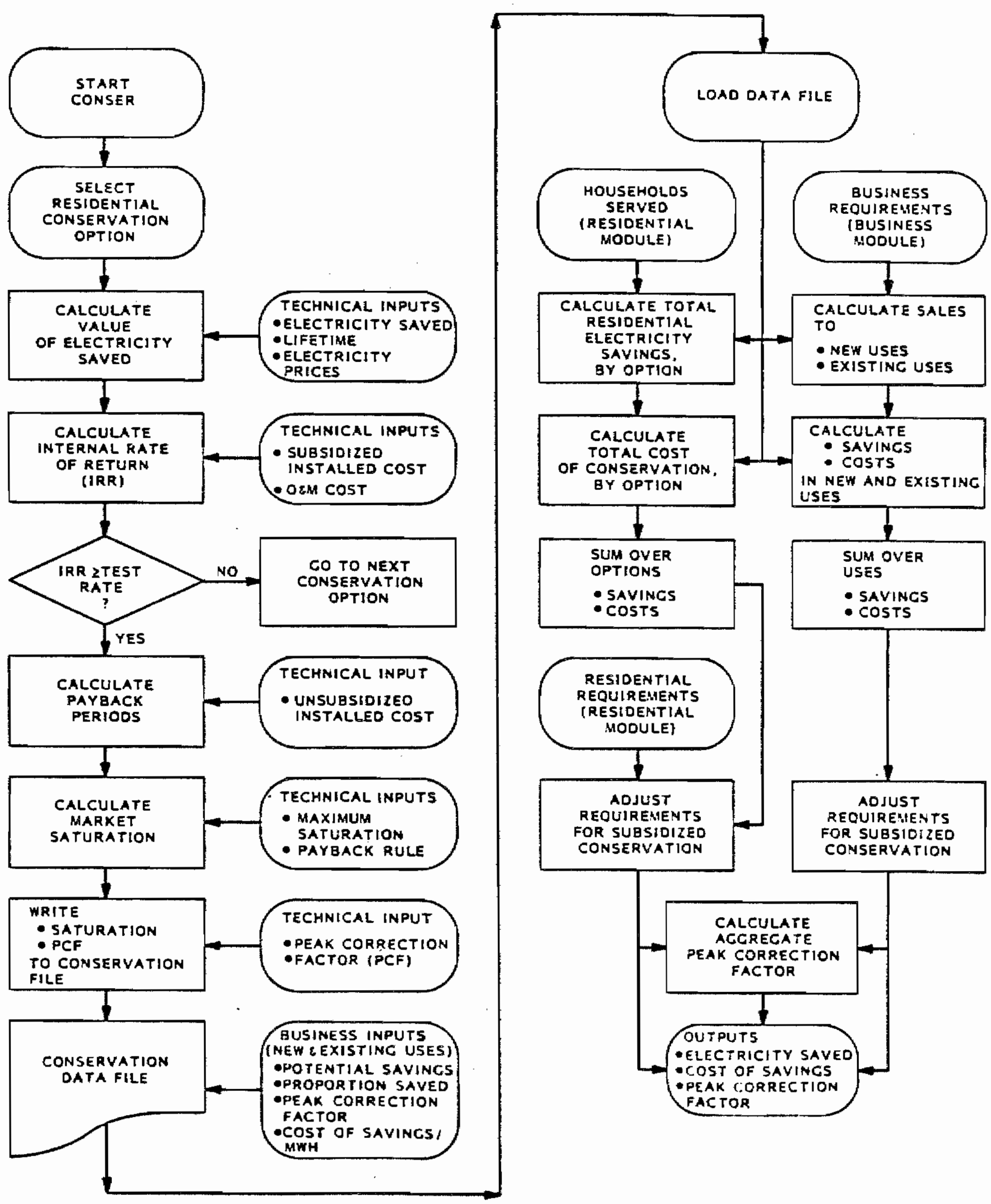

FIGURE 8.1. RED Program-Induced Conservation Module

costs, energy savings, and the level of market acceptance of various consumer-installed conservation options. For the residential sector, CONSER queries the user for the technical parameters of each option (up to ten options may be included). Based on a user-supplied forecast of electricity prices and the costs associated with each option, CONSER calculates the internal rate of return on each technology. The user compares this rate to a bank passbook savings rate as a very loose minimum test of acceptability. If the user decides, based on this comparison, that the option should be included in the analysis, CONSER calculates the payback period for each option. CONSER then writes the default values and range of values for the option's market saturation rate to an output data file. The user is then queried for the market saturation of electricity in the use that the conservation option offsets (e.g., electric water heating). This market saturation is also written to the output data file.

Government residential conservation programs primarily reduce the effective purchase price of conservation options to the consumer. Therefore, CONSER next requests the user's estimate of consumer purchase and installation costs for each option with and without government subsidization. The saturation of each technology with and without subsidization is calculated and is written to the output data file.

For the business sector, CONSER requests the potential proportion of predicted electricity use that might be saved through conservation, the estimated proportion of these potential conservation savings that are realized, and the costs per kWh for conservation savings in existing and new buildings. These values are also written to the output data file, which now becomes an input data file for the Conservation Module.

RED uses the residential conservation information in the CONSER data file to account for the impacts of the conservation technologies under consideration. First, the amounts of conservation occurring in the residential sector with and without government subsidization are calculated by multiplying together the electric use saturation rate, the conservation saturation rate, and the number of households. Next, the level of program-induced conservation is calculated by subtracting the nonsubsidized conservation savings from the subsidized figure. Finally, this figure is subtracted from the price-adjusted residential requirements to derive the utilities' total residential sales.

The business conservation calculation separately addresses the sales to new and existing uses, and two potential pools of electricity savings are calculated. For simplicity, existing uses are defined as the previous forecast periods' electricity requirements, whereas new uses are defined as the difference between the previous period's requirements and the current period's requirements. The two potential pools of savings are the sales to new uses and retrofits times user-supplied potential savings rates (for new uses and retrofits). The predicted level of savings in each case is found by multiplying the potential pools of savings times user-supplied conservation saturations with and without government intervention. Finally, the total program-induced savings are derived by subtracting the savings without government intervention from sales with government intervention for both new and existing uses. Total price adjusted requirements, minus program-induced business conservation, equals utilities' total sales to business.

The economic costs of the residential conservation technology package are found by multiplying together the government subsidized conservation saturation rate, the electric saturation rate, the number of households, and the cost to consumers per installation without government intervention for each conservation option, and summing over options. For the economic costs of business conservation, the total megawatt hours saved by government-subsidized conservation is multiplied by the cost per megawatt hour saved.

Finally, the Conservation Module helps calculate the effect of conservation on peak demand. Unfortunately, not all conservation technologies can be given credit for displacing the demand for peak generating capacity. Therefore, CONSER queries the user for a peak correction factor, a variable that takes on a value between zero and one if the option receives credit for producing some portion of its energy savings during the peak demand period; otherwise the value is zero. These peak correction factors for each option are aggregated in RED. First, they are weighted by the proportion of total program-induced electricity savings each option represents during a given forecast period. Next, the weighted correction factors are summed together. The resulting aggregated peak correction factor is sent to the peak demand model to calculate the peak savings of the set of conservation technologies.

INPUTS AND OUTPUTS

The inputs and outputs of the Program-Induced Conservation Module are summarized in Table 8.1. The potential market for the conservation option is defined by the total number of households served (HHS) and the saturation of the electrical devices (ESAT) whose use of electricity can be displaced by investment in a particular conservation option. ESAT equals the total market saturation of the appliance times the fuel mode split. The total number of households served is calculated in the housing module, while ESAT is interactively entered by the user. RCSAT, the penetration of the potential market by the conservation technology, is determined within the CONSER parameter routine. The technical energy savings and the costs of residential conservation devices (both installation and maintenance) are interactively specified within CONSER by the user.

The business segments of CONSER also query the user for the potential and actual saturations of electricity conservation in the business sector and the costs per megawatt hour saved for business investments in conservation.

Finally, the correction factors are decimal fractions that are interactively supplied by the user to CONSER and that reflect the extent to which conservation options receive credit for peak savings.

The outputs of the Program-Induced Conservation Module are the final electricity sales to the business and residential sectors, and the electricity savings of the conservation technology set considered in a given run of the RED model.

MODULE STRUCTURE

The price adjustment mechanisms used in the Business and Residential Consumption Modules employ price elasticities derived from studies that did not distinguish among the impacts of conservation technologies and other effects of energy price changes. Since conservation of electricity is argued to be induced either by energy price changes or by market intervention designed to encourage conservation, the treatment of conservation in RED was cautiously developed to eliminate the possibility of double counting energy savings and costs.

TABLE 8.1. Inputs and Outputs of the Conservation Module

a) Inputs

Symbol	Name	From
HHS	Total households served	Residential Module
TECH	Technical energy savings	CONSER, Interactive Input
COSTI	Installation and purchase cost of the residential conservation device	CONSER, Interactive Input
COSTO	Operation and maintenance costs of the residential conservation device	CONSER, Interactive Input
RCSAT	Residential saturation of the device (with and without government intervention)	CONSER, Interactive Input
ESAT	Residential electric use saturation	CONSER, Interactive Input
PRES	Expected residential electricity price	CONSER, Interactive Input
RESCON	Price-adjusted residential consumption	Residential Module
CF	Peak correction factor	CONSER, Interactive Input
PPES	Potential proportion of electricity saved in business in new and retrofit uses	CONSER, Interactive Input
BCSAT	Business conservation saturation rate (with and without government intervention)	CONSER, Interactive Input Uncertainty Module
COST	Cost per megawatt hour saved in business	CONSER, Interactive Input
BUSCON	Business price-adjusted consumption	Business Module

b) Outputs

Symbol	Name	To
TCONSAV	Total electricity saved (business plus residential)	Report
TCONCOST	Total cost of conservation (business plus residential)	Report
ADRESCON	Adjusted residential consumption	Miscellaneous and Peak Demand Modules
ADBUSCON	Adjusted business consumption	Miscellaneous and Peak Demand Modules
ACF	Aggregate peak correction factor	Peak Demand Model

In RED's formulation, the Program-Induced Conservation Module serves primarily as an accounting mechanism that tracks the impacts of a given set of technology options in the residential sector and the aggregate level of conservation in the business sector. However, since government policies and programs could have a significant, direct impact upon the level of conservation adopted, and since the incremental impacts of these actions are not incorporated in the price adjustment process of the Residential and Business Consumption Modules, the Program-Induced Conservation Module explicitly calculates these impacts and accordingly adjusts the forecasted sales to consumers.

Scenario Preparation (CONSER Program)

The calculations of the Conservation Module require scenarios of the saturation of conservation options, the expected electricity savings, and their associated costs. To reduce the amount of data entry in scenario preparation and to facilitate the use of a broad set of conservation technologies and government policy options, a separate program (CONSER) queries the user for information necessary to calculate the saturations, savings, and costs. These parameters are then written to a data file where they can be accessed by the remainder of the Conservation Module. Two steps are required: 1) determining if an option will achieve market acceptance; and 2) calculating market saturations for options gaining acceptance.

The first step is to determine whether a specific conservation option will achieve market acceptance. For the residential sector, the way RED identifies acceptable options is to compare them with other investments available to the consumer. Conservation is an investment with a financial yield that can be calculated and compared with other investment options. By comparing the internal rate-of-return (IRR) of a conservation option with the market rate of interest, one can determine whether conservation options' return is sufficient to encourage market acceptance.

The market rate of interest to which RED compares the internal rate-of-return is the standard commercial bank passbook interest rate. Passbook accounts have several characteristics:

1. They are virtually risk free.
2. They are extremely liquid.

3. They have trivial requirements as to the size of the initial deposit.
4. They are readily available to everyone.

Investments in conservation technologies, however, are characterized by the following:

1. risky
2. difficult to liquidate
3. (sometimes) require a large initial payment.

These factors would cause most homeowner-investors to require a higher rate of return on conservation than those on passbook accounts to invest in conservation. Therefore, a conservation option can pass the internal rate market interest test even though it might not be adopted. Such a comparison insures that every option that could achieve market acceptance is included in the portfolio of conservation technologies to be considered.

The IRR is calculated with the following formula:

$$\sum_{\ell=0}^{T} \frac{ES_{i\ell k} - C_{i\ell k}}{(1 + \rho_{ik})^{\ell}} = 0 \tag{8.1}$$

where

- T = lifetime of the device (maximum of 30 years)
- ρ = internal rate-of-return
- ℓ = subscript for the year. Takes on values 1 to 30
- ES = value of electricity saved
- C = total cost of the option in the year
- i = subscript for the load center
- k = subscript for the option

The value of electricity savings is based on the energy prices the consumer expects. It is calculated by querying the user for price forecasts and the electricity savings (in kWh) for each option and multiplying:

$$ES_{i\ell k} = PRES_{i\ell} \times TECH_{ik} \tag{8.2}$$

where

- $PRES_i$ = dollars per kWh in load center i
- $TECH_{ik}$ = annual kWh savings in region i per installation of device k.

The cost ($C_{i\ell k}$) is the 1980 dollar installation and purchase cost in the year the device is purchased and the annual maintenance and operating 1980 dollar costs in all remaining periods.

Recognizing that initial cost is a major barrier to conservation, the Congress has provided incentives for individuals to install energy-conserving equipment. Furthermore, the State of Alaska has also instituted several programs aimed to promote installation of conservation equipment. Because the main impact of these programs is to reduce the initial cost of conservation, CONSER uses the subsidized installation and purchase costs of the device to forecast whether a device will achieve additional market acceptance over an unsubsidized case.

As previously stated, CONSER requests the expected electricity price forecast for each year, the operating and maintenance costs, the kWh savings and the government subsidized purchase and installation costs of the device for each region. CONSER calculates the internal rate of return of the option, prints this information, and asks the user if the option is to be used. If it is, then the unsubsidized costs of purchasing and installing the option are also requested.

If the scenario to be considered does not include government intervention, the installation and purchase costs entered for the subsidized and unsubsidized cases should be the same (and equal to the unsubsidized costs).

The next step of scenario preparation is to determine the market saturation rate of each conservation option. RED employs a payback decision rule to determine the default value and the range of the conservation saturation rate. Since the expected value of electricity savings probably is not constant across time, the payback period is calculated by dividing the installation and purchase costs by the cumulative net value of electricity savings (value of energy savings minus operating and maintenance costs), starting with the first year and continuing until the ratio is less than one. The number of years required to drive the ratio to less than one is the payback period.

The payback period is calculated for both the subsidized and nonsubsidized cases. Since the subsidized case usually will have lower installation and purchase costs, the payback periods for the subsidized case will usually be lower and the conservation saturation rates will usually be higher.

CONSER also requests the name of the conservation option, a forecast of the market saturation rates for electric devices from which the option displaces consumption, and the peak correction factor for each conservation option. The saturation of electric devices is used within the Conservation Module to define the potential market of the conservation option, whereas the peak correction factor indicates the extent to which the option displaces electricity consumption at the peak. This information, as well as the costs and saturation of the conservation option (for the unsubsidized and subsidized cases), is written to a data file for later access by the remainder of the Program-Induced Conservation Module.

Funding constraints in the Railbelt Alternatives Study prohibited the development of detailed cost and performance data for business conservation applications. CONSER, therefore, requires the user to provide the following for both new and retrofit uses: the potential proportion of electricity that conservation technology can displace and an estimate of the proportion of those potential savings actually realized for subsidized and unsubsidized cases. CONSER also requests the cost per megawatt hour saved for both cases and the peak correction factor for new and retrofit uses.

This business sector information is also written to CONSER's output data file. By running CONSER with several different technology packages and government policy packages, conservation scenario files can be easily constructed for later analysis within RED.

Residential Conservation

Using the information from the data file that CONSER creates, the calculation of electricity saved by the set of technologies is straightforward. By multiplying the electric device saturation and the incremental number of households served, the total number of potential applications of the conservation device is found. The incremental number of households served in the first forecast period (1980) is zero, since the current consumption rates already include the current level of conservation.

By next multiplying the potential number of uses by the savings per installation and the saturation of the conservation option, the amount of electricity saved is derived:

$$CONSAV_{itkj} = RCSAT_{ikj} \times TECH_{ik} \times (ESAT_{itk} \times HHS_{it} - ESAT_{i(t-1)k} \times HHS_{i(t-1)}) \quad (8.3)$$

where

CONSAV = electricity saved (kWh)
RCSAT = conservation saturation rate
TECH = electricity savings per installation (kWh)
ESAT = electric device saturation rates
HHS = total households served
t = denotes the forecast period (1,2,3,...,7)
j = denotes subsidized (j=1) or nonsubsidized (j=o).

The total electricity displaced through the residential conservation set considered is found by summing across the options (subscript k):

$$RCONSAV_{it1} = \sum_{k=1}^{K} CONSAV_{itk1} \quad (8.4)$$

where

RCONSAV = residential electricity conserved (kWh)
K = total number of residential options considered.

Since the price adjustment mechanism does not account for government-induced conservation, the model next adjusts residential sales by the incremental conservation attributable to government programs:

$$ADRESCON_{it} = RESCON_{it} - (RCONSAV_{it1} - RCONSAV_{ito}) \quad (8.5)$$

where

ADRESCON = final electricity requirements of residential consumers
RESCON = price-adjusted residential consumption.

The electrical device saturation and the incremental number of households define the number of potential applications. The cost of purchasing and installing the option is calculated by multiplying the potential number of new uses by COSTI (the installation and purchase costs per option). Next, by multiplying COSTO (annual operations and maintenance costs per option) by the cumulation of previous forecast periods' potential uses, the operating and maintenance costs are found. Finally, by summing all these components, the total annual costs associated with conservation savings in a given forecast period can be found. During any forecast year, the annual costs are equal to one year's total installation costs, plus operating costs associated with all previous additions to stock:

$$CONCOST_{itkj} = \Big[COSTI_{ikj} \times RCSAT_{itkj} \times (ESAT_{itk} \times HHS_{it} - ESAT_{i(t-1)k} \times HHS_{1(t-1)})/5 + COSTO_{ik} \times \sum_{h=1}^{t} RCSAT_{ikj} \times (ESAT_{ihkj} \times HHS_{ih} - ESAT_{ihkj} \times THHS_{i(h-1)}) \Big] \quad (8.6)$$

where

CONCOST = the option's total annual cost

COSTI = unit cost in 1980 dollars for purchasing and installing the conservation option

COSTO = unit cost in 1980 dollars of operating and maintaining the conservation option

h = forecast period subscript. Can take on values 1 to t.

By summing over the options, the total costs of the residential conservation set is found.

$$RCONCOST_{itj} = \sum_{k=1}^{K} CONCOST_{itkj} \quad (8.7)$$

where

RCONCOST = present value of the total costs of the set of residential conservation options.

The total costs of conservation are the unsubsidized total costs ($RCONCOST_{ito}$), consumers pay the subsidized costs ($RCONSAV_{it1}$), and government pays the difference ($RCONCOST_{ito}$ - $RCONCOST_{it1}$).

Business Conservation

For business conservation impacts, funding constraints prohibited collection of detailed cost and performance data. Fortunately, a limited number of studies have estimated the potential energy savings and associated costs for aggregate conservation investments in new and existing buildings.

RED separates the conservation impacts for the business sector into two parts: those arising from retrofitting existing buildings, and those arising from incorporating conservation technologies in new construction. As in the residential segment of the Program-Induced Conservation Module, the potential pool of electricity that can be displaced must be identified for both new construction and retrofits. This "pool" is determined by the state of conservation technology and is supplied to the conservation module from the CONSER output file. The actual amount of conservation that occurs depends upon the price of electricity and competing fuels and upon the cost and performance characteristics of the options available. This is also supplied by CONSER.

In RED, the potential pool of displaced electricity for businesses is derived by first separating business sales into sales to existing structures and sales to new structures. For simplicity, the change from the previous periods' business requirements as calculated by the Business Consumption Module is assumed to be the sales to new buildings:

$$SALNB_{it} = BUSCON_{it} - BUSCON_{i(t-1)} \quad (8.8)$$

where

SALNB = sales to new buildings

BUSCON = business consumption prior to conservation adjustments.

Therefore, the sales to existing buildings are the sales in the previous period:

$$SALEX_{it} = BUSCON_{i(t-1)} \tag{8.9}$$

where

SALEX = sales to existing buildings.

To find the potential pool of electricity use displaced through retrofits and incorporation of conservation options in new buildings, the Program-Induced Conservation Module multiplies the disaggregated sales figures times the potential percentage of electricity saved in new and retrofit buildings:

$$POTNB_{it} = SALNB_{it} \times PPES_{itN} \tag{8.10a}$$

$$POTEX_{it} = SALEX_{it} \times PRES_{itE} \tag{8.10b}$$

where

POTNB = potential amount of displaced electricity in new buildings

PPES = proportion of electricity that technically can be displaced via retrofit or incorporation of conservation options in new buildings.

POTEX = potential amount of displaced electricity in existing buildings

E = subscript for existing buildings

N = subscript for new buildings.

These figures, however, only provide the technically feasible amount of electricity that could be displaced. Market forces determine what level of the potential electricity savings will be achieved.

In the residential segment of the Program-Induced Conservation Module, RED used an internal rate-of-return test and a payback period decision rule to determine first, whether an option would achieve market acceptance, and second, what level of acceptance it would achieve. As mentioned above, the information available for business conservation does not permit such an analysis. Therefore, the model user is required to assume a level of potential market saturation. The saturation rates (one for retrofits, one for new buildings) must reflect the prices of fuels (including electricity), the costs of the package of options employed, and the electricity savings expected for subsidized and nonsubsidized cases.

The saturation rates are obtained from the data file CONSER creates. The displaced electricity can be found by multiplying the total saturation rates by the total potential pool of electricity savings:

$$BCONSAV_{itNj} = BCSAT_{itN} \times POTNB_{itj} \qquad (8.11a)$$

$$BCONSAV_{itEj} = BCSAT_{itE} \times POTEX_{itj} \qquad (8.11b)$$

where

BCONSAV = electricity savings

BCSAT = saturation rate for conservation options in business.

As in the residential sector, the business requirements must be adjusted for the incremental impact of government programs:

$$ADBUSCON_{it} = BUSCON_{it} - (BCONSAV_{itN1} - BCONSAV_{itNo}) \qquad (8.12)$$

$$- (BCONSAV_{itE1} - BCONSAV_{itEo})$$

where

ADBUSCON = adjusted business consumption.

The total cost of the conservation set in a given future forecast year is given by multiplying the 1980 dollar cost per megawatt-hour saved by the conservation savings in each use:

$$BCONCOST_{itj} - (BCONSAV_{itEj} \times COST_{iEj} + BCONSAV_{itN1}) \qquad (8.13)$$

where

BCONCOST = business conservation costs, future forecast year

COST = 1980 dollar costs per megawatt hour saved.

The total costs of the conservation in a future forecast year to "society" is the nonsubsidized costs ($BCONCOST_{ito}$), whereas the value of the subsidy in that year is ($BCONCOST_{ito}$ - $BCONCOST_{it1}$), and businesses bear only the subsidized costs ($BCONCOST_{it1}$).

Peak Correction Factors

The last item to be calculated is the aggregate peak correction factor for the incremental impact of government conservation programs on peak demand. This factor is calculated by weighting each option's peak correction factor by the option's proportion of incremental conservation:

$$ACF_{it} = \sum_{k=1}^{K} \frac{(CONSAV_{itk1} - CONSAV_{itko}) \times CF_k}{(RCONSAV_{it1} - RCONSAV_{ito}) + (BCONSAV_{it1} - BCONSAV_{ito})} \tag{8.14}$$

$$+ \frac{(BCONSAV_{itE1} - BCONSAV_{itEo}) \times CF_E + (BCONSAV_{itN1} - BCONSAV_{itNo}) \times CF_N}{(RCONSAV_{it1} - RCONSAV_{ito}) + (BCONSAV_{it1} - BCONSAV_{ito})}$$

where

ACF = aggregate peak correction factor

CF = option-specific peak correction factor, equal to the proportion of the electrical demand of displaced appliances that can be displaced at the peak demand period of the year (e.g., January).

PARAMETERS

One of the requirements of the Alaska state program whereby homeowners request state money to install conservation measures is that the payback period for the measure be less than seven years. Therefore, if a conservation option's payback period is assumed to be greater than seven years, the options market penetration will be very limited, effectively zero. However, if the option pays for itself within the first year, then the option would penetrate the entire potential market immediately. The relationship between payback period and penetration rate for payback periods between zero and seven years is assumed to be linear. A range of 15% on these values is arbitrarily assumed. Table 8.2 presents these market penetration parameters.

TABLE 8.2. Payback Periods and Assumed Market Saturation Rates for Residential Conservation Options

Payback Period (years)	Assumed Saturation (%)	Assumed Range (%)
0	100.0	--
1	87.5	80-95
2	75.0	67.5-82.5
3	62.5	55-70
4	50.0	42.5-57.5
5	37.5	30-45
6	25.0	17.5-32.5
7	12.5	5-20
8	0	0-5

Source: Author Assumption

9.0 THE MISCELLANEOUS MODULE

MECHANISM

The Miscellaneous Module uses outputs from several other modules to forecast electricity used but not accounted for in the other modules, namely, street lighting, second homes, and vacant housing.

INPUTS AND OUTPUTS

This module uses the forecasts of electrical requirements of the residential and business sectors and the vacant housing stock. The only output is miscellaneous requirements. Table 9.1 provides a summary of the inputs and outputs of this module.

TABLE 9.1. Inputs and Outputs of the Miscellaneous Module

a) Inputs

Symbol	Name	From
ADBUSCON	Adjusted Business Requirements	Program-Induced Conservation Module
ADRESCON	Adjusted Residential Requirements	Program-Induced Conservation Module
VACHG	Vacant Housing	Housing Module

b) Outputs

Symbol	Name	To
MISCON	Miscellaneous Requirements	Peak Demand Module

MODULE STRUCTURE

Figure 9.1 provides a flowchart of this module. For street lighting, the requirements are assumed to be a constant proportion of conservation-adjusted business and residential requirements:

$$SR_{it} = s1 \times (ADBUSCON_{it} + ADRESCON_{it}) \qquad (9.1)$$

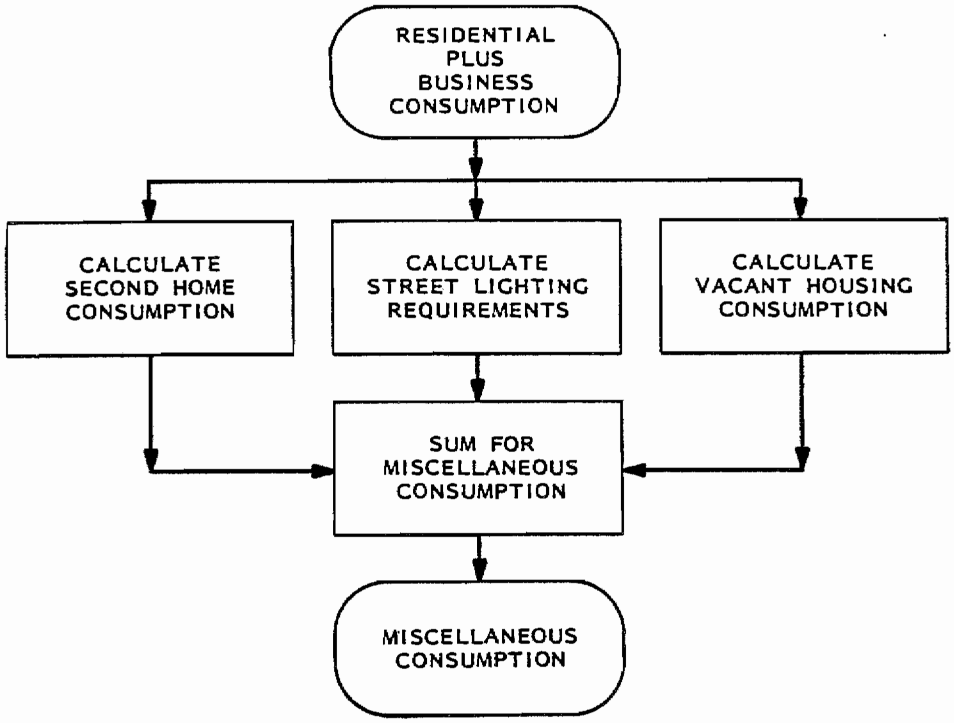

FIGURE 9.1. RED Miscellaneous Module

where

SR = street lighting requirements

ADBUSCON = business requirements after adjustment for the incremental conservation investments

ADRESCON = final electricity requirements of residential consumers

i = subscript for load center

t = forecast period (1,2,3...,7)

sl = street lighting parameter.

For second-home consumption, RED calculates the number of second homes as a fixed proportion of the total number of households. A fixed consumption factor is then applied:

$$SHR_{it} = sh \times CHH_{it} \times shkWh \tag{9.2}$$

where

SHR = second home requirements

CHH = total number of civilian households

sh = proportion of total households having a second home

$shkWh$ = consumption factor.

Finally, the use of electricity by vacant housing is a fixed consumption factor times the number of vacant houses:

$$VHR_{it} = vh \times VACHG_{it} \tag{9.3}$$

where

VHR = vacant housing requirements

$VACHG$ = number of vacant houses

vh = assumed consumption per vacant dwelling unit.

Total miscellaneous requirements are found by summing the three components above:

$$MISCON_{it} = SR_{it} + SHR_{it} + VHR_{it} \tag{9.4}$$

where

$MISCON$ = miscellaneous electricity consumption.

PARAMETERS

Table 9.2 gives the parameter values used for the Miscellaneous Module. These parameters are all based on the authors' assumption because no other source of information is available. Tillman (1983) found that Anchorage Municipal Power and Light has a conservation program in place to convert city street lights from mercury vapor lamps to high-pressure sodium lamps, resulting in some savings of electric energy. This is considered to be a one-shot success whose total impact grows proportionately to street lighting demand. Even since this program was instituted, miscellaneous demand has continued to grow. It is assumed that the effects of additional requirements for street lighting will partially offset the effect of conservation, and that

TABLE 9.2. Parameters for the Miscellaneous Module

Symbol	Name	Value
Sl	Street lighting[a]	0.01
sh	Proportion of households having a second home[b]	0.025
shkWh	Per unit second-home consumption[b]	500 kWh
Vh	Consumption in vacant housing[c]	300 kWh

(a) 1980 ratio of street lighting to business plus residential sales.
(b) O. Scott Goldsmith, ISER, personal communication.
(c) Author assumption. Reflects reduced level of use of all appliances.

this component of miscellaneous demand will continue to be about proportional to residential and business use in the future.

10.0 LARGE INDUSTRIAL DEMAND

Large industrial demand for electricity in the RED model is not provided by the model itself; rather, the model provides for a data file called EXTRA DAT, which is read by the program each time a forecast is made. The model user supplies a "most likely" default value forecast of electricity energy and demand at system peak to the EXTRA DAT file for each load center he wishes to include in the model run. If he wishes to develop a Monte Carlo forecast, he must also supply forecasts for higher and lower probability conditions. These exogenous estimates can be assembled from any source; however, they should be consistent with the economic scenario used in any given model forecast. This was done for the 1983 update.

The EXTRA DAT data set has other uses. Although military demand for electricity in the Railbelt historically has been self-supplied, the model user could test the effect of military demand on utility sales or total Railbelt demand by adding military annual energy and peak to the exogenous forecast for each load center. Self-supplied industrial energy can be handled in a similar fashion. Finally, EXTRA DAT can be used to account for cogeneration of electricity and for utility load management. The model user only needs to estimate the effect of such projects for 1980, 1985, 1990, etc. on annual energy sales and load at the time of year when the electrical system peak load occurs. He then subtracts these estimates from his estimates of large industrial (plus military) annual energy and demand at system peak and enters the difference in EXTRA DAT for each forecast period and load center. This data file will accept negative numbers showing net conservation. Other types of conservation or demand that cannot be analyzed in detail in other sectors of the model can also be handled here. Examples might include agricultural and transportation demand for electricity or the impacts of district heating systems on electrical consumption.

MECHANISM, STRUCTURE, INPUTS AND OUTPUTS

The user supplies data for the file EXTRA DAT for each load center and forecast period on net total industrial, military, agricultural, transportation annual energy demand at system peak (net of cogeneration effects) for each load center for cumulative probabilities of 0.75, 0.5 (default value), and 0.25 that demand will be greater than or equal to the value specified. The model then adds these estimates to the appropriate reports in the forecast results. Inputs and outputs are identical. Outputs are supplied to the Peak Module (to calculate system peak demand) and to the report writing routines.

PARAMETERS

There are no parameters in the RED model large industrial demand calculations.

11.0 THE PEAK DEMAND MODULE

Up to this point, only the method to forecast the total amount of electricity demanded in a year has been considered. However, for capacity planning, the maximum amount of electricity demanded (or peak demand) is probably more important. Peak demand defines the highest rate of consumption of electric energy during the year. As identified in RED, it does not include losses of energy in transmission.

MECHANISM

Unlike the Lower 48, where utilities frequently have done extensive customer time-of-day metering and other analyses to estimate peak demand by customer type and end use, the Railbelt utilities have virtually no information on peak demand by type of customer and end use. Consequently, the RED model does not forecast peak demand by end use; instead the Peak Demand Module uses regional load factors to forecast peak demand. The load factor is the average demand for capacity throughout the year divided by the peak demand for capacity in the year. RED first calculates the peak demand without the peak savings of program-induced conservation. Next, the peak savings of the incremental program-induced conservation are calculated, taking into account the mix of conservation technologies being considered. Finally, by netting out the peak savings, RED calculates the peak demand the system must meet.

INPUTS AND OUTPUTS

Table 11.1 provides a summary of the inputs and outputs of the Peak Demand Module. The load factors (LF) are generated by the Uncertainty Module, whereas the aggregate peak correction factor (ACF) comes from the Conservation Module. The business, residential, and miscellaneous requirements (BUSCON, RESCON, and MISCON) come from the Business, Residential, and Miscellaneous Modules, whereas the conservation-adjusted requirements (ADRESCON and ADBUSCON) come from the Conservation Module. The outputs of this module are 1) the peak demand in each regional load center at the point of sale to final users, and 2) the incremental peak savings of subsidized conservation.

TABLE 11.1. Inputs and Outputs of the Peak Demand Module

a) Inputs

Symbol	Name	From
LF	Regional load factor	Uncertainty Module
RESCON	Residential requirements prior to adjustment for subsidized conservation	Residential Consumption Module
BUSCON	Business requirements prior to adjustment for subsidized conservation	Business Consumption Module
ADRESCON	Residential requirements adjusted for subsidized conservation	Conservation Module
ADBUSCON	Business requirements adjusted for subsidized conservation	Conservation Module
ACF	Aggregate peak correction factor	Conservation Module

b) Outputs

Symbol	Name	To
FPD	Peak demand	Report
PS	Incremental peak savings	Report

MODULE STRUCTURE

Figure 11.1 provides a flow chart of this module. First, the peak demand without subsidized conservation is calculated. This is done by dividing the total electricity requirements in each region by the product of the load factor times the number of hours in the year. Next, the same operation is performed using energy requirements adjusted for the energy savings resulting from subsidized conservation investments. This yields the preliminary peak savings. RED then adjusts the peak savings by multiplying the aggregate peak correction factor times the peak savings. The corrected peak savings are then subtracted from the peak demand calculated in the first step to derive the regional peak demand at the point of sale.

The first step is to calculate the total electricity requirements without subsidized conservation by adding the residential, business, and miscellaneous requirements:

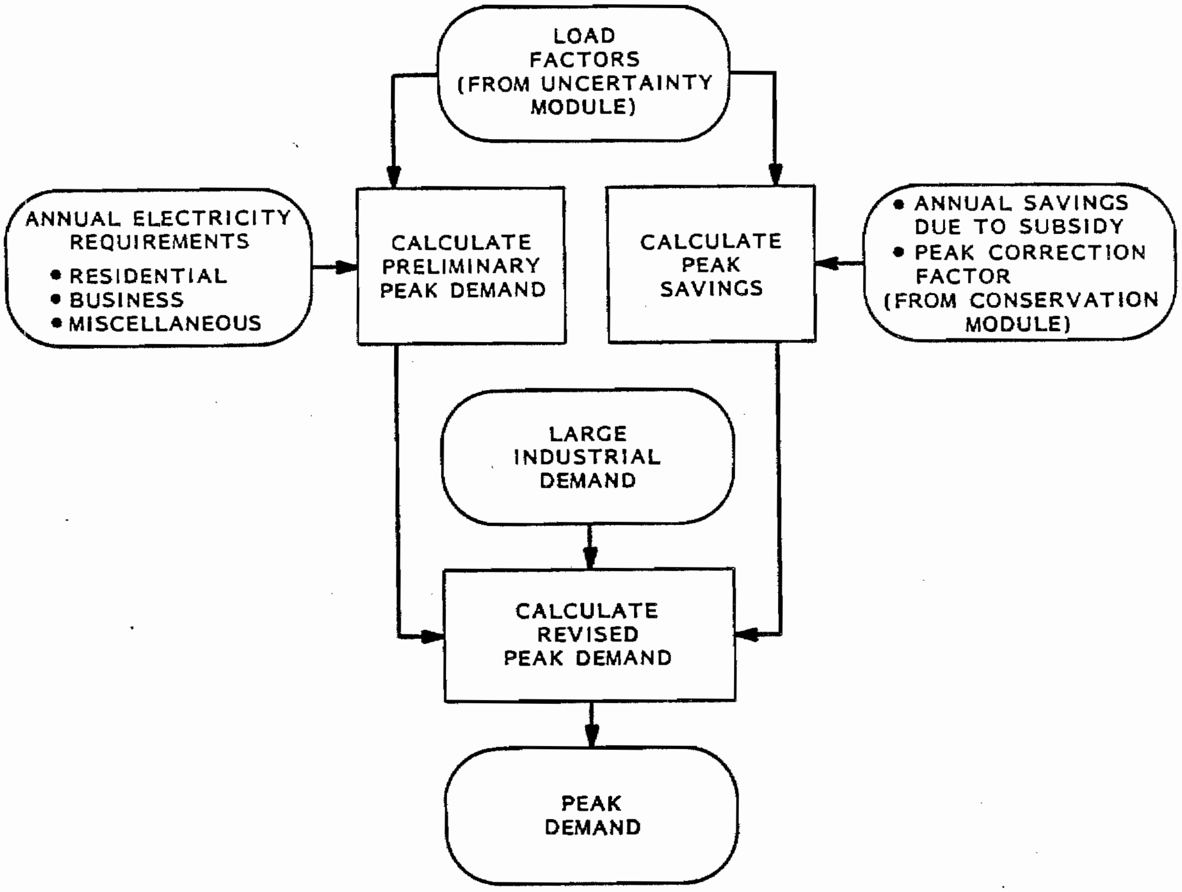

FIGURE 11.1. RED Peak Demand Module

$$TOTREQB_{it} = BUSCON_{it} + RESCON_{it} + MISCON_{it} \quad (11.1)$$

where

TOTREQB = total electricity requirements before conservation adjustment (MWh)

BUSCON = business requirements before conservation adjustment (MWh)

RESCON = residential requirements before conservation adjustment (MWh)

MISCON = miscellaneous requirements (MWh)

i = index for the load center

t = index for forecast period (t = 1,2,...,7).

Next, the Peak Demand Module calculates the peak demand without accounting for the incremental conservation due to subsidized investments in conservation by applying the load factor:

$$PD_{pit} = \frac{TOTREQB_{it}}{LF_{it} \times 8760} \tag{11.2}$$

where

PD = peak demand (MW)

LF = load factor

8760 = number of hours in a year

p = index denoting preliminary.

To calculate the peak savings due to subsidized conservation investments, RED first must find the incremental number of megawatt hours saved:

$$TOTREQS_{it} = BUSCON_{it} - ADBUSCON_{it} + RESCON_{it} - ADRESCON_{it} \tag{11.3}$$

where

TOTREQS = incremental megawatt hours saved by subsidized conservation investments

ADBUSCON = business requirements after adjustment for the incremental impact of subsidized conservation

ADRESCON = residential requirements after adjustment for the incremental impact of subsidized conservation.

Next, peak savings are found by multiplying the incremental electricity saved by the aggregate peak correction factor and applying the load factor:

$$PS_{it} = ACF_{it} \times \frac{TOTREQS_{it}}{LF_{it} \times 8760} \tag{11.4}$$

where

PS = peak savings (MW)

ACF = aggregate peak correction factor.

Finally, by subtracting the peak savings from the preliminary peak demand, the final peak demand for each region is derived:

$$FPD_{it} = PD_{pit} - PS_{it} \tag{11.5}$$

where

FPD = index denoting final peak demand.

PARAMETERS

The only parameters in the Peak Demand Module are the system load factors assumed for the Anchorage and Fairbanks load centers. These load factors are shown in Table 11.2.

TABLE 11.2. Assumed Load Factors for Railbelt Load Centers

Load Center	Load Factor (%) Default	Load Factor (%) Range
Anchorage	55.73	49.2-63.4
Fairbanks	50.00	41.6-59.1

In the RED model, peak electricity demands are estimated as a function of the seasonal load factors (average energy demands/peak energy demands) for the major load centers in the Railbelt. Thus, identification of appropriate load factors is crucial in determining the need for peak generating capacity for a given amount of forecasted electrical energy demand.

Forecasting future load factors and thus, peak electrical energy demands, is a difficult process because of the interaction among many factors that determine the relationship between peak and average electrical demands. The analysis conducted in support of the parameter estimates in Table 11.2 quantitatively and qualitatively evaluated annual load factors for the Anchorage and Fairbanks load centers. The impacts of the diversity between the two load centers in the timing of the occurrence of peak loads is also briefly discussed below.

Simple trend-line fitting and more complex ARIMA time series modeling were used in an attempt to develop quantitative forecasts for future load factors for the Anchorage and Fairbanks load centers. A qualitative analysis was also conducted of the impacts of conservation programs, changes in customer mix, and other variables as they may affect future load factors for the two load centers.

The central conclusion arising from the analysis is that no scientifically defensible basis for projecting that future load factors for the Anchorage and Fairbanks areas will either increase or decrease could be developed within the resources of the study.[a] Thus, average load factors for the period 1970-1981 of 0.56 for Anchorage and 0.50 for Fairbanks were used as default values in developing peak demand estimates. Historic minimum and maximum values of the load factors of individual utilities in each load center were examined. The lowest and highest of these in each load center were used as the minimum and maximum load factor values for the load center.

Quantitative Analysis of Trends in Load Factors in the Railbelt

Trend analysis is not a preferred approach to forecasting future electrical load factors and peak loads in the Railbelt. Ideally, the methodology for forecasting future load factors over a long-range planning horizon (in RED, 30 years is the planning horizon) should incorporate information on structural variables that determine the load factor. Examples of such structural variables are the forecasted demands of different customer classes (i.e., residential, commercial, and industrial) and the forecasted patterns and saturation rates of appliances.

Developing a structural econometric model of load factors and/or peak loads is a complex task. In addition, while Anchorage Municipal Light and Power has conducted very limited metering of residential sector customers, in general there is no data base in Alaska that associates patterns of residential electrical use with appliance stock and socioeconomic characteristics. Even less data are available on the commercial sector. Thus, the data necessary for building a structural time-of-use model are not available for the Railbelt

(a) This is consistent with Anchorage Municipal Light and Power findings of no trend in load factor (personal communication, Max Foster, AMLP economist, to Mike King, June 11, 1981).

area. Thus, in this study, quantitative analysis of Anchorage and Fairbanks load factors was limited to trend analysis.

Simple Trend Analysis

Table 11.3 presents estimates of the annual load factors for areas approximating the Anchorage and Fairbanks service areas and the month in which the peak load occurred in the period 1970-1981. The load factors presented in Table 11.3 were estimated by the following equation:

$$\frac{REG}{PMW*8.76}$$

where

REG = regional energy generation for Anchorage or Fairbanks areas in gigawatt hours

PMW = largest monthly peak regional energy demand for Anchorage or Fairbanks areas in megawatts.

TABLE 11.3. Computed Load Factors and Month of Peak Load Occurrence for Anchorage and Fairbanks 1970-1981[a]

	Anchorage		Fairbanks	
Year	Load Factor	Peak Load Month	Load Factor	Peak Load Month
1970	0.524	December	0.445	December
1971	0.575	January	0.443	December
1972	0.562	December	0.486	January
1973	0.585	January	0.505	January
1974	0.589	December	0.446	December
1975	0.495	December	0.474	December
1976	0.583	December	0.555	January
1977	0.548	December	0.466	December
1978	0.576	December	0.553	January
1979	0.593	December	0.574	January
1980	0.541	December	0.488	December
1981	0.559	December	0.511	December

(a) Computed from data presented in DOE/APAdmin (1982).

All data for estimating the load factors were obtained from tables developed by the Alaska Power Administration (APAdmin) (DOE-APAdmin 1982). The area designated as the "Southcentral" region in the APAdmin statistics is assumed to be representative of the Anchorage service area in the Railbelt and the area designated as the "Yukon" is assumed to be representative of the Fairbanks area.

The information presented in Table 11.3 clearly shows that the period when Railbelt peak loads occur (and thus, when annual load factors are determined) is in the winter, coinciding with the timing of coldest winter weather and maximum hours of darkness. It is desirable for forecasting purposes to standardize for weather-related impacts on the load factor. Including weather-related impacts in the trend analysis could lead to erroneous conclusions if a nonrepresentative mix of weather patterns occurred over the period of the time series data. In addition, weather is such a random variable that it is almost impossible to forecast.

Assuming that a strong correlation between non-weather-related load factors and time could be identified, future non-weather-related load factors might be reasonably forecast using the coefficient in the time trend equation. To correct the load factors for weather-related influences, the annual load factors for each year presented in Table 11.3 were multiplied by the number of heating degree days in each corresponding year. The resulting adjusted load factors for Anchorage and Fairbanks were then regressed against a time variable using the following simple equation:

$$Y = a + bx$$

where

Y = load factor multiplied by heating degree days

x = time.

The explanatory power of time in explaining changes in the adjusted load factor was low for both Anchorage and Fairbanks. The R^2 values for the regressions were 0.39 for Anchorage and 0.02 for Fairbanks, respectively. Both the t and F values for time in the Anchorage equation were significant at 95% levels of confidence. The time coefficient was negative, indicating that Anchorage's weather-adjusted load factor was declining over time. For reasons that will be discussed later, it does not appear that forecasting a declining load factor in either Anchorage or Fairbanks is realistic. In any case, the level of explanatory power provided by the time trend equations was too low to base any forecasts of future load factors upon the results.

Trend Analysis Using an ARIMA Model

A more complex method of using time series data to forecast future load factors in an ARIMA model (Autoregressive Integrated Moving Average) was also attempted. The first step in this process was to calculate load factors by month for the period 1970-1981. These monthly load factors were calculated in a manner similar to that used in calculating the peak load factors presented in Table 11.3. Calculating load factors for each month in the 12-year period provided a data base of 144 observations, which was more than sufficient for developing an ARIMA model.

The next step was to attempt to identify the correct specification of the ARIMA model in terms of the lag operators to be used and the degree of differencing to be employed. The objective in identifying the model is to obtain a stationary historical time series that will consistently represent the parameters underlying the trends in the time series.

The appropriate lag operators for the model were specified to be 1 and 12. That is, the load factor in a particular month should be correlated with the load factor in the previous month and the load factor in the previous year. Computation of autocorrelation coefficients for the data using lag operators of one and 12 and various levels of differencing revealed that using first differences on both lag operators produced a stationary time series with small random residuals in a relatively short time for both Anchorage and Fairbanks.

Thus, the ARIMA model for load factors was identified as the following:

$$(1-\phi_1 B)(1-B^{12})\ Y_t = (1-\theta_1 B)(1-\theta_{12} B)\ a_t$$

where

a_t = random error term ("white noise")

B = lag operator

ϕ_1 = sequential autoregressive parameter for the first difference on the load factor of the previous month

θ_1 = sequential moving average parameter for the first difference on the load factor of the previous month

θ_{12} = seasonal moving average parameter for the first difference on the load factor of the previous year

Y_t = load factor in a particular month.

This model specification is similar to the one developed by Uri (Uri 1976) for forecasting peak loads using an ARIMA time series model.

The model was applied to the monthly load factor data and relatively low residual sum of squares (i.e., unexplained variation in the data) were obtained. The coefficients of the ARIMA model were then input into an ARIMA forecasting routine that uses the most recent historical data and the coefficients to generate forecasts for specified forecasting periods.

The forecasts generated by the ARIMA forecasting model predicted that the load factor for Anchorage over the next 30 years would increase from 0.56 to 0.66, whereas the load factor for Fairbanks would decrease from 0.51 to 0.42. However, project resources were insufficient to permit validation and refinement of the ARIMA coefficients and the resulting forecasts. In addition, qualitative analysis of the factors influencing load factors does not support the conclusion that Fairbanks load factors are likely to decline over time.[a]

Qualitative Analysis Of Load Factors

Although peak load forecasting has received a substantial amount of research attention, the relationship between peak loads and average energy

(a) Whether the load factor is computed on a monthly basis, as in Table 11.3, or on an annual basis, as in Table 13.2 it appears that Fairbanks' load factor is increasing slightly. In any event, 0.42 appears unrealistically low. Note also that simple trend analysis showed opposite results.

demands has not received the same degree of attention. Locating research literature on the relationship between peak loads and average loads and on the factors that influence this relationship proved to be a difficult task. In addition, it is questionable how applicable the results of studies from other areas are to the Railbelt because of the unique characteristics of the area and the fact that load factors tend to be unique to each utility system.

The following discussion represents an attempt to synthesize available information into a useful form for evaluating potential changes in Anchorage and Fairbanks load factors. Much of the discussion is somewhat subjective, and empirical results on these topics are unavailable. Consequently, there was not a strong enough basis for concluding that load factors will change substantially from present levels in the major load centers of the Railbelt.

Impacts of Changes in the Customer Load Mix on the Load Factor

The customer mix, which can be measured by the proportion of total power demands comprised by the residential, commercial and industrial sectors, is a crucial factor in determining the load factor of an electrical service area.

The analysis of power demands by customer is important. If it could be demonstrated that the demands of particular customer classes are the primary cause of Railbelt system peak demands and that changes in the current mix of customer demands are likely to occur in the future, future changes in the Railbelt system load factor could be evaluated.

In general, residential power demands have the greatest degree of variation both by time of day and by season of the year. Commercial power demands demonstrate slightly less variation over time. Industrial power demands are the most constant type of power demand over time.

A typical Lower 48 load pattern for residential, commercial, and industrial customers on a peak day is shown by a daily load profile in the Pacific Northwest in Figure 11.2. Note the substantial amount of variation in residential power demands by time of day relative to other sectors. The pattern of demand illustrated in Figure 11.2 is typical for most utilities,

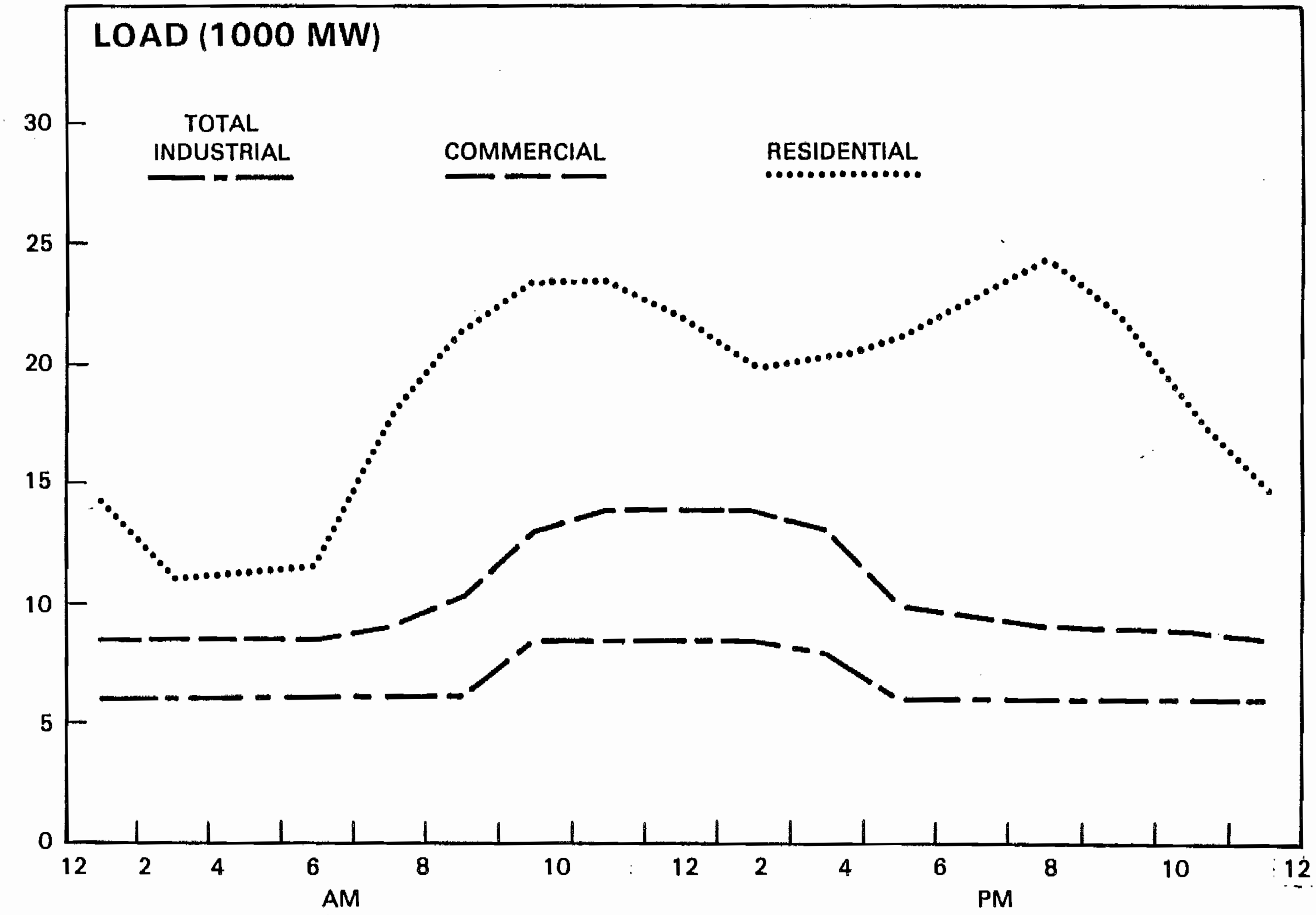

FIGURE 11.2. Daily Load Profile in the Pacific Northwest

since sectoral load patterns in most utility service areas will reveal substantially greater variation in residential loads over time than for other sectors.

Data on load patterns by type of customer in Alaska were not available. However, a limited amount of data on total utility system loads was available. An analysis of these data shows that highest power demands in Alaska occur in the late afternoon and early evening. This is illustrated by the data presented in Table 11.4 for two peak days during the winter of 1981-1982.

TABLE 11.4. Time Period of Peak Demands in Anchorage and Fairbanks[a]

	Time Period of Peak Demand	
Service Area	December 29, 1981	January 2, 1982
Anchorage[b]	4 p.m.	5 p.m.
Fairbanks[c]	4 p.m.	5 p.m.

(a) Source: Memorandum from Myles C. Yerkes of the Alaska Power Authority to the Committee on Load Forecasts and Generation, Alaska Systems Coordinating Council.
(b) Includes Anchorage Municipal Power and Light and Chugach Electric Association.
(c) Includes Fairbanks Municipal and Golden Valley Electric Association.

The late afternoon timing of the occurrence of peak demand in the Railbelt generally indicates that both residential and commercial demands are likely to be important in determining the occurrence of peak demand. Thus, it does not appear that the load factor of the Alaska power system would be particularly sensitive to changes in the relative mix of residential and commercial power.

The percentages of total Railbelt forecasted power consumption comprised by individual sectors for various future time periods are presented in Table 11.5. The information presented in this table demonstrates that in the case examined there is no clear trend in the share relationship between commercial and residential demand. Thus, even if Railbelt residential and commercial use had different load patterns, it is not clear that this would result in any

TABLE 11.5. Percentages of Total Forecasted Railbelt Electrical Consumption Comprised by Individual Customer Sector[a]

Year	Anchorage Residential	Anchorage Commercial	Fairbanks Residential	Fairbanks Commercial
1980	52.8	47.2	44.8	55.0
1990	49.1	51.9	49.2	50.8
2000	47.9	52.1	51.8	48.2
2010	46.1	53.9	51.4	48.6

(a) Sectors add to 100% (excludes miscellaneous and industrial demand).
Source: RED Model Run, Case HE6--FERC 0% Real Growth in Price of Oil.

clear trend in system load factor. Industrial demand could change the load factor, but industrial demand is handled separately in RED (see Section 10.0).

Impacts of Conservation on the Load Factor

Future conservation efforts in the Railbelt have the potential to improve the annual system load factor by reducing winter electrical demands by a greater amount than average electrical demands. The residential energy conservation measures that are most likely to be included in Alaska's long-term energy conservation program are presented in Table 11.6.

TABLE 11.6. Conservation Measures Most Likely to be Implemented in the Residential Sector of Alaska[a]

Measure	Level
Ceiling Insulation	R-38
Wall Insulation	R-11
Glass	Storm Window Installation
Weatherstripping	Doors and windows
Water Heater Improvement	Blankets and Wraps

(a) Source: 1983 Alaska Long-Term Energy Plan

The measures listed in Table 11.6 are generally related to the overall goal of improving thermal energy efficiency in the residential sector. Thus, one would expect that the implementation of most of these conservation measures would result in greater energy demand reductions in the winter than the average demand reduction for the entire year.

However, it should be noted that electricity is used for space heating in only a small percentage of the Railbelt's residences and businesses. Thus, the impact of improvements in thermal efficiency on the total electrical power system load factor may not be large.[a]

Electrical demands for lighting are probably the major causal factor in creating the large disparity between peak and average electrical demands in Alaska. Currently, according to the 1983 Alaska's Long-Term Energy Plan, lighting is not targeted as an area for future conservation efforts in Alaska. Without a sustained conservation effort in lighting, it appears unlikely that conservation will result in a significant change in the annual load factor in the Railbelt.

In summary, it appears that future conservation efforts in the Railbelt will result in positive, but very small, improvements in the power system load factors. A successful program to increase lighting energy efficiency could significantly increase the positive impacts of conservation upon the system load factor.

Load Center Diversity

The diversity in the timing of peak electrical demands is important in determining how changes in demand will affect the system load factor. The impacts of demand diversity between Fairbanks and Anchorage will be particularly important after the two load centers are intertied in 1984.

(a) Note also (from Section 5.0) that the incremental electric fuel mode split in space and water heat for the Anchorage service area is very low. This means that over time the measures shown in Table 11.6 will grow less and less effective in saving electricity, other things being equal.

Data on demand diversity among customer classes in Alaska were not available. A limited amount of data on demand diversity among untilities was available. These data, collected by the Alaska Systems Coordinating Council (Yerkes 1982), reveals that the diversity among utilities in the timing of peak demands is not great. The ratio of the highest peak demand for the Alaska power system as a whole (the coincident peak) to sum of the peaks for the individual utilities (the noncoincident peak) was 0.98 for selected peak days in December, 1981 and January, 1982.

This high coincidence factor, which equates to a low level of diversity among the various utilities in the timing of peak demands, implies that future shifts in the mix of demand among the various load centers will have little impact on overall peak demand. A primary cause of peak power demands that occurs in Alaska is high-pressure Arctic weather systems that generally tend to increase the demand for electric power in almost all areas of Alaska. Thus, diversity in demand among utilities has little impact on total system peak demand, although more research would be necessary to reach the same conclusion for the various customer classes.

12.0 MODEL VALIDATION

The purpose of a model validation is to assess the accuracy and plausibility of the model's forecasts. In engineering or physical systems, this can be accomplished via controlled experiments, where a system can be characterized, simulated, and compared to experimental results.

Unfortunately, demand forecasting models attempt to describe the interactions of physical systems, individuals, and the environment. It is impossible, therefore, to conduct the type of validation that typically accompanies physical science models.

Validation of integrated economic/engineering models typically consists of two tests: the ability of the model "come close" to historical figures when the actual inputs are used, and the "reasonableness" of the forecasts. This section applies both of these tests to the RED model.

ASSESSMENT OF RED'S ACCURACY

In order to assess the accuracy of a simulation model, the usual procedure is to substitute historical values for the inputs or "drivers" of the model, produce a backcast, and compare the predicted and actual values. Unfortunately, the period for which this type of exercise can be produced is relatively brief.

End-use forcasting models are very data intensive, and RED is no exception. Much of the data necessary to run the model (including fuel mode split and appliance saturations) required a primary survey of the population. Historical data for these critical parameters is incomplete; therefore, the accuracy tests which can be performed on the model are limited.

A partial validation of RED's accuracy, therefore, was performed by taking the linearly interpolated forecast values from the case.

The linearly interpolated forecasts were then compared with the actual consumption levels in 1982. Table 12.1 presents a cross tabulation of these values.

TABLE 12.1. Comparison of Actual Base Case, and Backcast Electricity Consumption (GWh) 1982

	Anchorage-Cook Inlet			Fairbanks-Tanana Valley		
	Actual	Base[(b)] Case	Backcast	Actual	Base[(b)] Case	Backcast
Residential	1,146	1,060	1,097	178	205	208
Business[(a)]	1,072	1,118	1,170	269	243	254
Other	23	25	23	5	7	6
Total	2,241	2,203	2,290	452	455	468
% Difference from Actual	--	-1.7%	2.2%		0.6%	3.5%

(a) Including Industrial Demand.
(b) Sherman Clark No Supply Disruption. This value is a linear interpolation between the 1980 and 1985 forecast values.

Even though RED is designed to be a long-run model, it produces an interpolated forecast with an error of only 0.6% in Fairbanks, and an error of only -1.7% in Anchorage when compared to actual data in the most recent year available.

The model was also run using best estimates of 1982 economic drivers and fuel prices shown in Table 12.2. These results are shown in Table 12.1 as the Backcast case. The results are also very close to the actual values in most cases for the individual sectors; the forecast of total consumption was within 3.5% of the actual value in both load centers. Given that the model is a long run model, that forecasts of actual households and employment and to be used in place of unknown actual data, and that the 1980 fuel mode splits, appliance saturations, and use rates had to be used in place of 1982 values (which are not available) the backcast performance for 1982 is very good.

The remaining discrepencies in the forecasts for the individual sectors appear to be related to the quality of the input data. In general, however, there are insufficient data available to determine whether the "actual" economic data are correct until about two to three years after the fact. Alaska "actual" data periodically undergo substantial revision. Therefore, the performance of individual sectors for a short-term forecast of this type should

TABLE 12.2. 1982 Values of Input Variables

	Anchorage Cook-Inlet	Fairbanks-Tanana Valley
Households[a]	83,677	22,922
Employment[a]	120,533	33,500
Electricity Prices	($/kWh)[b]	
Residential	0.45	.100
Business	0.42	.095
Natural Gas Prices'	($/mcf)[b]	
Residential	1.84	12.53[c]
Business	1.61	11.08
Fuel Oil Prices	($/gallon)[b]	
Residential	1.19	1.21
Business	1.12	1.17

(a) Forecasts by MAP model for Sherman Clark NSD case. Consistent estimates of households and total employment are not available for 1982 from official sources.
(b) All prices are in nominal dollars.
(c) Propane price.

considered less important than the forecasts' long-term plausibility.The next subsection covers the subject of long-term plausibility of the forecasts.

REASONABLENESS OF THE FORECASTS

In order to test the reasonableness of RED's long-term forecasts, we compared the base case used in the 1983 update with three comparable long-term forecasts. The three forecasts were: forecasts by Pacific Northwest Power Planning Council (PNPPC) and Bonneville Power Administration for the Pacific Northwest, an area with large electric space heat loads and rising prices; and a forecast by Wisconsin Electric Power Company (WEPCO) for Wisconsin and Upper Michigan, an area with relatively stable electric prices and low electric space heat penetration. The intent was to compare forecasts from areas similar to the Railbelt Region. The Pacific Northwest forecasts were selected because of the low electricity prices the region shares with the Anchorage load center, while the Wisconsin area closely corresponds to the climate and fuel mode split exhibited in the Railbelt.

The Pacific Northwest Power Planning Council created by an act of Congress to coordinate and direct acquisition of generation resources in the Pacific Northwest, prepared a twenty-year forecast of electricity demand in the Northwest. PNPPC modelled four alternate load growth scenarios (low, medium low, medium high, and high) for the purposes of generation planning. We chose the medium high scenario for comparison because it corresponds more closely to the economic conditions expected to occur in the Railbelt.

The Bonneville Power Administration (BPA) is the marketer of all federal power in the Pacific Northwest. BPA, due to its adversarial relationship with the PNPPC, recently completed construction of their own forecasting tools. We chose to examine BPA's medium scenario as it represents their assessment of the most probable situation.

The Wisconsin Electric Power Company markets power to Milwaukee-Kenosha-Racine Standard Metropolitan Statistical Area, plus selected counties in central and northern Wisconsin and upper Michigan. Unlike the two Pacific Northwest organizations, WEPCO markets to a service area with relatively little electric space heating. As in the southern Railbelt, the primary fuel source is natural gas, with electricity supplying only 4 to 5 percent of total energy used. Consequently, there are fewer the opportunities for savings of electric energy in conservation of building heat than exist in the Pacific Northwest. In contrast to the Pacific Northwest, where annual residential electric consumption in 1980 averaged 17,260 kWh per household, and 11,000 to 13,000 in the Railbelt WEPCO customers averaged 7,240. The fact that the electric load in the WEPCO area is mostly not related to the thermal shell of the building is reflected in the much higher growth rates of electricity consumption than in the Pacific Northwest or the Railbelt. This increasing power forecast is also caused by the assumption by WEPCO that electricity rates would rise at only 0.3 percent per year in real terms through the end of the century, much less than in the Pacific Northwest or the Railbelt. In WEPCO's service area, it was assumed electricity would capture a high (40-65 percent) share of new residential units due to its projected cost advantage over oil and gas.

Table 12.3 presents a decomposition of two commonly used metrics for the BPA, PNPPC, WEPCO and RED forecasts: the annual growth rate in use per employee and use per household. The RED forecasts both exhibit higher growth rates than either of the Pacific Northwest forecasts, but lower than the rates in the WEPCO forecast.

TABLE 12.3. Comparison of Recent Forecasts, 1980-2000

	Average Percent Growth Rate, Use Per Household	Average Percent Growth Rate Use Per Employee
Pacific Northwest Power Council	-.64	.14
Bonneville Power Administration	-.64	-.31
Wisconsin Electric Power Company[a]	1.41	3.97
RED		
Anchorage	-.36	1.04
Fairbanks	0.98	0.93

(a) For Wisconsin Electric Power Company, the residential forecast is use per customer.

This is the expected relationship of the forecasts. The BPA and PNPPC forecasts assume vigorous conservation programs and rising electricity prices in a region characterized by high market penetration of electric space heat and water heat in both the residential and commercial sector. Furthermore, because Pacific Northwest electricity prices have been low historically, there are many opportunities available for cheaply saving large amounts of electricity. In contrast, the Railbelt and WEPCO regions do not have as many inexpensive opportunities to save large amounts of power, since most thermal requirements are being met with natural gas. Furthermore, the rate of increase in electricity prices is expected to remain low in the WEPCO region, reducing incentives to conserve. The RED forecasts occupy a middle ground, both in terms of base year consumption and in terms of the rate of increase in consumption. With moderate rates of electricity price increases and fewer inexpensive conservation opportunities, RED shows lower rates of conservation than the Pacific Northwest. In comparison with the WEPCO area, the Railbelt is expected to have a declining electric share in space heat and water heat, so the rate of increase in use per customer would be less. In addition, since Railbelt customers on the average use more electricity than WEPCO customers and are facing higher projected rates of electricity price increases, the forecasted rate of increase in the rate of electricity consumption should be lower. Based on this comparison, the results of the RED forecast, therefore, seem to be in line with what other forecasters are predicting.

13.0 MISCELLANEOUS TABLES

Abbreviations Used

APA	= Alaska Power Authority
AP&T	= Alaska Power and Telephone (TOK)
AP Admin	= Alaska Power Administration
CEA	= Chugach Electric Association
GVEA	= Golden Valley Electric Association
GWH	= Gigawatt Hour
HEA	= Homer Electric Association
kWh	= Kilowatt Hour
KVa	= Kilovolt
MEA	= Matanuska Electric Association
MW	= Megawatt
MWH	= Megawatt Hour
FMUS	= Fairbanks Municipal Utility System
SES	= Seward Electric System
SQ FT	= Square Foot

TABLE 13.1. Number of Year-Round Housing Units by Type, Railbelt Load Centers, Selected Years

	Single Family	Duplex	Multifamily	Mobile Home	Total
Anchorage-Cook Inlet Load Center:					
(Urban) 1950[Aa]	3,325	964	1,128	202	5,619
1960[b]	19,195	1,552	8,033	1,783	30,563
1970[c]	21,935	3,981	14,259	6,403	46,578
1980[d]	40,562	8,949	27,980	10,211	87,702
1982[e]	47,610	9,899	31,893	11,379	100,781
Fairbanks-Tanana Valley Load Center:					
(Urban) 1950[a]	1,295	166	352	2	1,815
1960[b]	6,527	671	4,547	853	12,598
1970[c]	5,335	1,068	6,072	1,254	13,729
1980[d]	10,873	2,512	8,607	2,175	24,167
1982[e]	12,218	2,551	8,927	2,193	25,889
Railbelt:					
1950[a]	4,620	1,130	1,480	204	7,434
1960[b]	25,722	2,223	12,580	2,636	43,161
1970[c]	27,270	5,049	20,331	7,657	60,307
1980[d]	51,435	11,461	36,587	12,386	111,869
1982[e]	59,828	12,450	40,820	13,572	126,670

(A) Excludes Kenai-Cook Inlet Census Division, Seward Census Division, Matanuska-Susitna Census Division.
(a) U.S. Department of Commerce Census of Housing 1950; Alaska, General Characteristics, Table 14. These are all dwelling units.
(b) U.S. Department of Commerce Census of Housing 1960: Alaska, Table 28. These are all housing units.
(c) U.S. Department of Commerce Census of Housing 1970: Alaska, Table 62. These are all year-round housing units.
(d) U.S. Department of Commerce Census of Housing, 1980: STF3 data tapes. All year-round housing-units.
(e) 1980 Census, plus estimated 1980-1982 construction from Mr. Al Robinson, economist, U.S. Department of Housing and Urban Development, Anchorage.

TABLE 13.2. Railbelt Area Utility Total Energy and System Peak Demand

	Anchorage-Cook Inlet			Fairbanks-Tanana Valley		
	Annual Energy (GWh)	Peak Demand (MW)	Load Factor	Annual Energy (GWh)	Peak Demand (MW)	Load Factor
1965	369	82.1	0.51	98	24.6	0.45
1966	415	93.2	0.51	108*	26.7	0.46
1967	461	100.8	0.52	NA	NA	NA
1968	519	118.0	0.50	141*	42.7	0.38
1969	587	124.4	0.54	170*	45.6	0.43
1970	684	152.5	0.51	213	57.1	0.43
1971	797	166.5	0.55	251*	70.6	0.41
1972	906	195.4	0.53	262	71.2	0.42
1973	1,010	211.5	0.55	290	71.5	0.46
1974	1,086	225.9	0.55	322	89.0	0.41
1975	1,270	311.7	0.47	413	108.8	0.43
1976	1,463	311.0	0.56	423	101.0	0.48
1977	1,603	375.4	0.49	447	117.5	0.43
1978	1,747	382.8	0.52	432	95.8	0.51
1979	1,821	409.6	0.51	418	100.7	0.47
1980	1,940	444.4	0.50	402	95.4	0.48
1981	2,005	444.7	0.51	422	93.1	0.52
1982	2,254	471.7	0.55	452	94.4	0.55

TABLE 13.3. Anchorage-Cook Inlet Load Center Utility Sales and Sales Per Customer, 1965-1981

	Residential			Commercial-Industrial-Government		
	Sales (GWH)	Customers	Sales Per Customer (kWh)	Sales (GWH)	Customers	Sales Per Customer (kWh)
1965	174	27,016	6,425	189	3,994	47,235
1966	194	28,028	6,937	215	4,147	51,909
1967	208	30,028	6,941	241	4,363	55,206
1968	233	34,443	6,766	277	4,804	57,715
1969	262	37,653	6,971	316	5,125	61,656
1970	309	41,151	7,517	363	5,784	62,713
1971	369	43,486	8,487	415	6,006	69,057
1972	419	47,707	8,788	473	6,420	73,704
1973	457	49,433	9,239	539	6,693	80,557
1974	494	54,606	9,044	577	7,232	79,791
1975	592	58,326	10,147	659	7,750	85,073
1976	675	62,413	10,817	769	8,789	87,598
1977	739	71,275	10,375	846	9,860	85,753
1978	841	76,999	10,928	884	10,219	86,542
1979	845	76,494	11,047	878	10,368	84,684
1980	936[a]	77,743	12,040	1,002[a]	10,629	94,270
1981	916[b]	80,089	11,437	1,030[b]	11,021	93,458
Annual Growth Rate 1965-81	10.9%	7.0%	3.7%	11.2%	6.5%	4.4%

(a) 1979 data used for SES.
(b) Based on 1980 MEA, 1979 SES data.

TABLE 13.4. Fairbanks-Tanana Valley Load Center Utility Sales and Sales per Customer, 1965-1981

	Residential			Commercial-Industrial-Government		
	Sales (GWH)	Customers	Sales Per Customer (kWh)	Sales (GWh)	Customers	Sales Per Customer (kWh)
1965	39	8183	4,804	55.198	1,318	41,880
1966	47	8170	5,712	59.376	1,467	40,474
1967	NA	NA	NA	NA	NA	NA
1968	61	9,344	6,569	77.906	1,469	53,033
1969	77	10,023	7,672	91.212	1,579	57,766
1970	91	10,756	8,418	118.560	1,888	62,797
1971	106	11,184	9,515	133.056	1,929	68,977
1972	121	11,487	10,529	135.873	2,002	67,869
1973	133	11,825	11,233	150.823	2,054	73,429
1974	154	13,261	11,600	161.615	2,242	72,085
1975	190	13,877	13,719	210.759	2,342	89,991
1976	194	15,419	12,561	219.175	2,530	86,630
1977	198	17,197	11,500	240.463	2,834	84,849
1978	178	17,524	10,153	242.668	2,854	85,027
1979	169	18,070	9,344	219.335	2,795[a]	78,474
1980	160	18,054	8,890	214.263	2,737	78,283
1981	159	19,379	8,219	224.354	2,942	76,259
Annual Growth Rate 1965-81						
9.2%	5.5	3.4	9.2%	5.1	3.8	

(a) Includes 1979 estimated 70 customers for AP&T.

TABLE 13.5. Adjustment for Industrial Load Anchorage-Cook Inlet, 1973-1981

	Total Achorage Comm-Ind-Govt MWH Demand	Homer Electric MWH Industrial Load[(a)]	Anchorage "Commercial"	Anchorage Sq Ft.(b)
1973	540,476	56,130	484,346	
1974	579,068	58,298	520,770	29,660,900
1975	661,192	62,806	598,386	33,471,800
1976	771,054	72,063	698,991	37,049,800
1977	846,939	83,989	762,950	39,618,900
1978	896,072	82,984	813,088	41,440,000
1979	904,851	87,955	816,896	42,733,800
1980	988,957	99,103	889,854	44,042,700
1981	1,030,753	130,318	900,435	44,817,400

	MWH Use/Sq Ft.	kWh/SQ FT	% From Previous Yr
1973	0.0179	17.9	-
1974	0.0176	17.6	-1.7
1975	0.0179	17.9	1.7
1976	0.0189	18.9	5.6
1977	0.0193	19.3	2.1
1978	0.0196	19.6	1.6
1979	0.0191	19.1	-2.6
1980	0.0202	20.2	5.8
1981	0.0201	20.1	-0.5

(a) Commercial-Industrial Load over 50 KVA (commercial users included)
(b) Predicted value. See Chapter 6.0.

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APPENDIX A

RESIDENTIAL SURVEY

APPENDIX A

BATTELLE-NORTHWEST RESIDENTIAL SURVEY

To calibrate an end-use model of electricity demand, the initial number of appliances that use electricity must be known. At the time the RED model was undergoing initial development (1981), there was no adequate information available in the Railbelt concerning either residential appliance stock and fuel mode split or uses of electricity in the commercial sector. While it did not appear possible to collect significant useful information on the commercial sector within project resource constraints, BNW researchers concluded that a residential survey was both possible and desirable. This initial evaluation was reinforced when it became clear that data would not be available from the 1980 Census of Housing on detailed housing characteristics until 1982 at the earliest, and that reporting on appliances would be less complete than in 1970. Accordingly, plans were made to survey the residential sector.

Although a lot of new information of good quality was developed in the survey, there were several constraints on the survey process. First, the resources available to design, test, run, and analyze the survey were extremely limited. This precluded in-person interviews, large samples, or follow-up of non-respondents. Second, it was not possible to stratify the survey sample, both because there was no accurate information on types of dwellings in any Railbelt community except Anchorage and because utility customers could not be matched to dwelling types or demographic characteristics. To conserve project resources for analysis, we chose to do a blind mailing of the survey instrument with no follow-up to random samples of each utility's residential customers. Where possible, the random mailings were done by the utilities themselves. Where Battelle-Northwest did the mailings, random subsets of customers or complete customers lists were supplied by the utilities to Battelle-Northwest.

SURVEY DESIGN

Because budget limitations precluded follow-up interviewing as a means to improve survey response rate and to check errors, it was very important to have a survey instrument that required minimal respondent effort and time, gathered only the least controversial and highest priority information, and was easy to understand. Questions considered controversial items (income), questions difficult to understand (insulation values or energy efficiency of appliances), and questions requiring substantial respondent effort (estimates of annual electrical bills) were dropped. The highest priority questions concerning appliance stock and fuel mode split were retained. A draft of the questionnaire was sent to the Railbelt utilities and other interested parties in Alaska, and was reviewed by several senior Battelle-Northwest researchers. Based on their comments and the results of a pretest with uncoached clerical staff, the questionnaire was simplified to the point that it required the average test respondent only two to five minutes to answer all questions. A copy of the survey form is shown in Figure A.1.

SAMPLE SIZE AND COMPOSITION

Because of the high labor costs of selecting respondents, addressing the mailings, and key punching and verifying the survey results, it was decided that an acceptable level of accuracy for survey results would be plus or minus 6 percent with 95 percent confidence on the entire sample for a load center. In order to obtain utility cooperation in mailing the questionnaire, we considered it necessary to achieve this level of accuracy for each utility's service area to provide them with usable data. Thus, accuracy of survey results for load centers that contain more than one utility is somewhat greater than the sampling error for each utility would suggest. Because of the care taken in survey design to maximize response rate, we believed that an average response rate of 50 percent was possible with no follow up. The desired number of respondents was therefore doubled to obtain the number of mailings in each utility service area. A total of 4,000 questionnaires were sent to the respondents, of which 1764 usable responses were received, for an average response

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

Alaska Railbelt Electric Power Alternatives Study

Dear Alaskan:

Battelle, Pacific Northwest Laboratories is working under contract to the State of Alaska to help determine the future needs for electricity in the Railbelt Region, and the best way to meet those needs.

Many individuals believe that the Susitna hydroelectric power project is the best way. Others think that these needs can be better met by employing coal, conservation, or some other means. First, however, we need to estimate future electric energy needs in the Railbelt. We can only do this properly if we know how people in the region use electricity.

That's where you can help us.

Please take a few minutes to complete the questionnaire on the other side--it is only one page long and will take only 5 minutes or so to answer.

Why should you help? First, the information you provide will be vital in decisions your state government will make over the next year and a half to build or not build the Susitna project. Either way, your electricity bill will be affected. Second, whether or not the Susitna project is built, the confidential information you provide will help your local utility plan ways in which to meet your future electricity needs.

Since this is an issue of such importance to you and Alaska, every response is vital. All responses will be strictly confidential. There will be no way anyone can tell who you are from your response. The results of this survey will be published in your local newspaper.

Please respond as accurately as you can. Thank you for your cooperation.

Sincerely,

Michael J. King
Research Economist

P.S. In order for us to consider your response, you will need to return the questionnaire within three weeks. For your convenience, you will find a postage paid envelope enclosed.

FIGURE A.1. Battelle-Northwest Survey Form

Please complete the following questionnaire and return it in the enclosed envelope. If you have already completed and returned a questionnaire, please disregard this request.

1. What type of building do you reside in?
() single family home () duplex
() mobile home () multifamily (3 or more units)

2. Number of persons in your household (please respond in each category):

Adults 18+					Children 5-18				Children Under 5				
0	1	2	3	4 or more	0	1	2	3 or more	0	1	2	3	4 or more
()	()	()	()	()	()	()	()	()	()	()	()	()	()

3. How many rooms are in your residence?______ How many bedrooms?______

4. Approximate square feet of living space (just your estimate):

() less than 700
() 701-1000
() 1001-1300
() 1301-1600
() 1601-2000
() 2001-2400
() greater than 2400

5. In what year was your house (building) built? (just your estimate)

() before 1950
() 1950-1959
() 1960-1969
() 1970-1974
() 1975-1980

6. What is the main fuel used for heating your home?

() natural gas
() propane-butane
() fuel oil, kerosene, or coal oil
() solar collectors
() passive solar (check one: () south facing windows () custom solar design)
() electricity
() coal or coke
() wood
() district heating system

7. In addition to your main fuel, what additional fuels do you use to heat your home?
() none
() natural gas
() propane-butane
() fuel oil, kerosene, or coal oil
() solar collectors
() passive solar (check one: () south facing windows () custom solar design)
() electricity
() coal or coke
() wood
() district heating

8. What proportion of your heating needs are met by:

	0-1/4	1/4-1/2	1/2-3/4	3/4-all
main fuel	()	()	()	()
second fuel	()	()	()	()
other fuels	()	()	()	()

9. What type of heating distribution system do you use?

() forced air () radiant or convection () hot water or steam.

10. Please indicate the fuel your appliances use:

	don't have	electricity	natural gas	butane-propane	wood	coal	solar	fuel oil or kerosene
water heater	()	()	()	()	()	()	()	()
range/stove	()	()	()	()	()			
sauna/jacuzzi/etc.	()	()	()					
clothes dryer	()	()	()	()				
clothes washer	()	()						
freezer	()	()						
dishwasher	()	()						

11. Do you have an electric refrigerator? () yes () no
If yes, is it frost free? () yes () no

12. If you use plug-ins for vehicles:

How many vehicles do you usually plug-in? () 1 () 2 () 3 or more
Do you plug the vehicle(s) in: () overnight () just in the morning?
At approximately what temperature do you start plugging them in?__________

13. The uses described above are for my:

() primary residence () second or vacation home.

FIGURE A.1. (contd)

rate of 44.1 percent. Table A.1 shows the total number of residential customers in each utility, the number and percent surveyed, the number and percent responding.

RESIDENTIAL

TABLE A.1. Customers, Number Surveyed, and Respondents for the Residential Survey Battelle-Northwest

Utility[a]	1980 Year End Customers[b]	Customers Surveyed Number	Customers Surveyed Percent	Customers Responding Number	Customers Responding Percent
Chugach Electric (CEA)	42,567	530	1.2	222	41.9
Anchorage Municipal (AMPL)	13,744	522	3.8	214	41.0
Seward Electric (SES)	1,090	424	38.9	185	43.6
Homer Electric (HEA)	8,620	518	6.0	249	48.1
Matanuska Electric (MEA)	11,722	520	4.4	268	51.5
Goblen Valley (GVEA)	13,591	524	3.9	252	55.0
Fairbanks Municipal (FMUS)	4,463	504	11.3	156	31.0
Copper Valley (CVEA)	1,588	458	28.8	252	55.0
Total	97,385	4,000	4.1	1,798	44.9
Total Used	97,385	4,000	4.1	1,764	44.1

(a) CVEA is not part of the interconnected Railbelt, since it serves Glennallen and Valdez. This utility and load center were eventually dropped from the analysis.
(b) Source: Alaska Power Administration. 1979 customer totals were used for CVEA, HEA, and GVEA. Residential customers only.

MAILING PROCESS AND COLLECTION OF RESULTS

The survey questionnaire was administered in one of three ways. In some cases the utilities randomly selected a list of residential customers and performed the mailing. In these cases, Battelle-Northwest provided the utility an appropriate number of mailings, consisting of the questionnaire and pre-stamped, self-addressed return envelope. To ensure confidentiality, the questionnaire was stamped only with the initials of the utility, providing identification of the service area. No other identification of the respondent was possible from the survey form or the return envelope. When Battelle-Northwest performed the mailings, the utilities provided either a random sample of customer addresses or their complete mailing list of residential customers, from which a random sample was drawn. No known geographic bias was introduced by the sampling technique. Finally, Fairbanks Municipal Utility System (FMUS) provided neither a mailing list nor mailing services to the project. In this case, the Fairbanks telephone directory was used as a source of customer addresses. Although an attempt was made to exclude addresses outside the City of Fairbanks served by Golden Valley Electrical Association, unknown biases were probably introduced into the Fairbanks sample by the sampling procedure. The response rate was also signficantly lower for the FMUS sample.

As the survey forms were received, they were coded, keypunched and verified. The raw card image data file was recorded on magnetic tape and loaded into an SPSS data file, organized by subfiles corresponding to each utility. The results for each utility were weighted according to the total number of residential customers in each load center in 1980, the last year's count available at the time the file was assembled. The weights are shown in Table A.2.

TABLE A.2. Weights Used in Battelle-Northwest Residential Survey

Utility	Weight
Chugach	2.81
Anchorage Municipal	1.17
Seward Electric	.06
Homer Electric	.45
Matanuska Electric	.54
Golden Valley	1.21
Fairbanks Municipal	.67
Copper Valley	1.00

OUTPUT

The output of the survey was organized in SPSS files and printed in frequency distributions and standard SPSS CROSSTABS tables. An example of typical output is shown in Figure A.2 for freezer saturation. In the figure, 712 out of 807 Anchorage area single family households are shown to have

STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES 07/28/81

FILE ENDUSE.D (CREATION DATE = 06/17/81)
SUBFILE CEA AMLP SEA HEA MEA

* * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * *
FF FREEZER FUEL BY TYPE
* *

FF / TYPE (COUNT / ROW PCT / COL PCT / TOT PCT)	-1.	SINGLE FAMILY 1.	MOBILE HOME 2.	DUPLEX 3.	MULTIFAMILY 4.	ROW TOTAL
-1. MISSING	0	36	0	11	20	67
	0.7	52.8	0.7	16.0	29.9	5.9
	6.7	4.4	0.7	9.8	13.1	
	0.0	3.1	0.0	0.9	1.8	
0. DO NOT HAVE	1	59	3	26	37	126
	0.4	46.8	2.4	20.7	29.7	11.0
	8.1	7.3	4.5	23.7	24.4	
	0.0	5.2	0.3	2.3	3.3	
1. HAVE	6	712	62	73	96	949
	0.6	75.1	6.5	7.7	10.1	83.1
	85.2	88.3	94.8	66.5	62.5	
	0.5	62.4	5.4	6.4	8.4	
COLUMN TOTAL	7	807	65	110	153	1142
	0.6	70.6	5.7	9.6	13.4	100.0

CHI SQUARE = 91.30715 WITH 8 DEGREES OF FREEDOM SIGNIFICANCE = 0.0000

FIGURE A.2. Saturation of Freezers in Anchorage-Cook Inlet Load Center

Figure Note: Subfiles for each surveyed utility were combined and weighted by weights in Table A.2. Seven households were unidentified by type of house and were ignored.

freezers (missing values were counted as "do not have"). The computer shows this as 88.3 percent saturation of single family households. This percentage was used in Table 5.8. In practice, these computer estimates were usually modified with professional judgment; however the Battelle-Northwest survey supplied the raw data on which the judgment was made.

APPENDIX B

CONSERVATION RESEARCH

APPENDIX B

CONSERVATION RESEARCH

The Railbelt area has limited ability to adopt conservation measures that would result in large-scale electricity savings. According to Tillman (1983), past conservation in load centers like Fairbanks has been largely the result of price increases for electricity. In addition, Railbelt utility managers believe that future electrical conservation will be largely the result of price, not conservation programs. The impact of conservation programs in the Railbelt has been taken into account in the fuel mode splits, use rates, and price effects incorporated in the 1983 update. In addition, selected conservation programs in the Lower 48 states were analyzed to determine if anything could be learned about program impacts in the Railbelt.

An attempt was made to compare conservation of electricity in the Railbelt with conservation effects as forecasted by four policy-making bodies elsewhere in the United States. The goal was to obtain a range of potential energy savings due to price- and program-induced conservation and determine if such estimates would be applicable (and to what degree) in Alaska. The four policy-making bodies chosen were the Pacific Northwest Power Planning Council, the Bonneville Power Administration, the California Energy Commission and the Wisconsin Electric Power Company. The first three entities were chosen because they represented regions in the Western U.S. and because conservation programs played a signficant role in their regional planning. Wisconsin Electric Power Company was chosen as an example of a utility in a colder climate where natural gas was the predominant fuel source. However, Wisconsin has its peak demand for electricity in the summer when natural gas cannot fuel air conditioning.

It became clear upon examination of the various programs that direct comparison of the forecasts was not possible at the end-use level nor was it possible to compare the assumptions supporting the forecasts (e.g., heating/ cooling degree days, appliance standards, etc.). The following list touches on some of the differences among forecasts which made either direct or indirect comparison difficult.

- Definitions of conservation differed.
- Variables were not consistent across regions.
- Programs were not consistent across regions.
- Some documentation showed a lack of internal consistency in reporting values.
- One entity reported savings in peak capacity while the others reported both capacity and energy forecasts.
- Direct comparison of baseline, high, and low load growth scenarios was not possible because of the level of conservation implied in the forecasts; i.e., in a low demand case more conservation is assumed than in the high demand case, or conservation instead may be assumed in a sensitivity case.
- Savings could be projected either by program, or appliance, or end-use sector.

In addition, each of the four Lower 48 entities quantifies the components of conservation effects differently. The Northwest Power Council's approach is to assume no change in technological efficiency; therefore, there is no price-induced conservation. Conservation is treated as an energy resource. A separate supply function (with price and program components) determines the value of potential conservation. The difference between the forecast demand and the supply function is the value of conservation potential. The program and price components of the conservation increment cannot be readily separated. Potential savings are reported at the appliance level.

The California Energy Commission also forecasts a conservation increment in which price and program shares are not easily discernible. Part of the program-induced savings has been quantified and double counting of price-induced conservation is subtracted by a 20% implicit reduction in savings estimates. The Bonneville Power Administration forecast has both technological change and price response imbedded in their model, but only part of their program-induced conservation is quantifiable.

The Wisconsin Electric Power Company lacks the more sophisticated end-use models used by the other three and focuses more on the peak demand savings potential. Trend analysis driven by population projections is used to estimate capacity requirements. There is some conservation implicit in the demand growth estimated by the model. For example, air conditioning efficiency improvements are assumed, and three "adjustments" are made to total demand for rate structure reform, solar water heat, and solar space heat; but in general, only fragments of the conservation response are quantified.

The literature provides some idea of the energy use attributable to budgeted and proposed programs, however. The following subsection discusses the separate definitions of conservation adopted by the four policy-making bodies, the forecasts of program-induced energy savings, and the methods adopted to avoid double counting of competing programs and double counting of price and program effects. The last subsection looks at current estimates for Alaska and determines whether the conservation program savings have relevance to Alaskan forecasts.

PACIFIC NORTHWEST POWER PLANNING COUNCIL

The Pacific Northwest Power Planning Council (PNPPC) was created in 1981 in accordance with the Pacific Northwest Electric Power Planning and Conservation Act (the Act) to encourage conservation and the development of renewable resources in the Northwest and to assure an adequate and economical power supply. Conservation is defined by the PNPPC as the more efficient use of electricity by the consumer through replacing existing structures with electricity-saving technologies or the use of new, more energy-efficient devices and processes in the residential, commerical, industrial, and agricultural sectors. The PNPPC assessments do not distinquish between price-induced conservation and program-induced conservation. The forecast power supply estimates are based on the high market penetration rates the PNPPC assumes for each conservation program available under the Act. A conservation measure is assumed cost-effective at costs below 4.0 cents per kilowatt-hour (roughly the cost of power from regional coal plants). Not all of the economically achievable savings can be realized, however, due to constraints such as consumer resistance, quality control, and unforeseen technical problems. The PNPPC believes that given the wide range of measures permitted by the Act, over 75% of the economically achievable levels are possible (ranging from 56% for residential appliances to 100% in the industrial sector). Table B.1 lists the likely conservation savings at a cost equal to or less than 4.0 cents per kilowatt hours by the year 2000. Most of the savings in the residential sector come from building shell or hot water tank improvements. Electricity has a larger share of space and water heating loads in the PNPPC region than it does in the Railbelt. Thus, many of the conservation savings of electricity in the PNPPC could not be achieved in the Railbelt.

The PNPPC decided that all technically achievable conservation estimated for the industrial sector could be realized since the savings represented less then 10% of the region's current industrial electricity demand. This level was considered a reasonable goal for the industrial sector.

Including all conservation along with other available resource choices can avoid double counting of conservation induced by prices in the demand model and conservation counted as potential resources on the supply side. This implies that price-induced efficiency improvements within the end-use sectors and electricity uses where conservation programs are proposed are included in resource potential, not demand reductions. In the residential and commercial sectors technology efficiencies were frozen at 1983 levels so that the PNPPC models forecast future energy use as if no efficiency improvements were made. Unfortunately, once a conservation program or measure is available, savings in response to price changes cannot be separated from those derived from the program. Running the PNPPC demand model for individual programs will quantify the impact for each measure under a given fuel price and supply scenario.

BONNEVILLE POWER ADMINISTRATION

The Bonneville Power Administration (BPA) supplies about half of the electric power production in the Pacific Northwest. Its service area is

TABLE B.1. PNPPC Likely Conservation Potential at 4.0 Cents/kWh by the Year 2000

Residential (kWh/household)	
Existing Space Heat	854
New Space Heat	1404
Water Heating	1364
Air Conditioning	0
Refrigerators	259
Freezers	108
Cooking	15
Lighting	150
Other	229
	4383
Commercial (kWh/employee)[a]	
Existing Structure	1199
New Structures	825
	2024
Industrial (kWh/employee)[a]	
$1000-3000 subsidy/kW	655-3282

(a) Includes federal, state and local government, transportation, communication, public utilities, wholesale and retail trade, finance insurance, real estate, services.
(b) Includes mining, manufacturing, and construction.
Source: Pacific Northwest Power Planning Council, 1983.

roughly equivalent to the area covered by the PNPPC power planning efforts (Oregon, Washington, Idaho, Western Montana). Long-range electricity demand forecasts are made by BPA to assist in utility power planning. Projections are expressed as a baseline case to which alternative cases are added for a high-low range of electricity consumption. Forecasts made by BPA covering the region defined by the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) were done primarily to assist regional decision making until the publication of the PNPPC official 20-year energy forecast and plan in the spring of 1983.

BPA estimates of conservation potential savings include price-induced savings and savings from existing governmental, utility, and BPA conservation programs. Conservation programs that have yet to be initiated or budgeted are not included. Some improvements in technology efficiencies are implicitly included as part of the consumer price response.

The types of programs represented by the base, low, and high forecasts include the following:

- home energy efficiency improvement
- commercial energy efficiency improvement
- street and area lighting efficiency improvement
- institutional building efficiency improvement
- utility customer service system efficiency improvement
- support of direct application renewable resources projects.

The BPA currently sponsors weatherizing of electrically heated dwellings (primarily retrofit of existing housing), wrapping electric water heaters, encouraging the distribution and use of shower water flow restraints, and installing faucet flow control devices, low-flow shower heads, and solar hot water/heat pump water heater conversions. Table B.2 summarizes the savings estimates by program for residential and commercial sectors. Currently, there are no budgeted programs in the Industrial sector.

BPA's Office of Conservation estimated the savings from conservation measures that could not be explicitly modeled and subtracted that amount from computed demand. To avoid double counting of price-induced conservaton, the measure-specific savings were reduced by 20%. Again, most savings were found in space conditioning and water heating.

CALIFORNIA ENERGY COMMISSION

The California Energy Commission (CEC) is required by the Warren-Alquist Act of 1974 (Public Resources Code, Section 25309) to "identify emerging trends related to energy supply demand and conservation and public health and safety factors, to specify the level of statewide and service area electrical energy demand for each year in the forthcoming 5-, 12-, and 20-year periods, and to provide the basis for state policy and actions in relation thereto...". In

TABLE B.2. BPA Budgeted Conservation Program Savings (annual kWh savings by the year 2000)

Residential (kWh/household)	
Region Wide Weatherization	4,933
Low Income Weatherization	4,933
Water Heater Wrap	435
Shower Flow Restrictor	400
Residential Flow Control	
Shower Heads	600
Faucet Heads	270
Solar/Heat Pump Water	2,200
	13,771
Commercial (kWh/employee)[a]	
Public	
Heating	537
Cooling	0
Water Heating	0
Lighting	36
Other	0
Private	
Heating	916
Cooling	0
Water Heating	0
Lighting	43
Other	0
	1,532

(a) Includes local and state government, transportation and utilities, trade, finances, insurance, real estate, services and construction. High growth figures were used for total number of employees.

Source: Bonneville Power Administration. 1982a. Table 5.6 and Appendix II, Table 23.

compliance with the code, the CEC prepares a biennial report containing updated energy supply/demand projections and a supplemental electricity report. Information in this section reflects the fourth and most recent report (1983) in the series.

The CEC has adopted the following definition of conservation.

> "Conservation savings from local, utility, state, and Federal programs in place or approved, and savings resulting from private utilization of conservation measures in response to prices, and savings from programs on which analytical work is well advanced and for which there is a substantial likelihood they will be in effect by January 1985."

The code requires the CEC to include all conservation that is reasonably expected to occur based on credible evidence within the framework provided by their definition. Conservation programs and savings are categorized into three classes: 1) conservation reasonably expected to occur, 2) additional achievable conservation, and 3) conservation potential. Savings in Category 1 are used to reduce the demand estimate. Those in Category 2 are considered to have a moderate probability of occurring because of a higher uncertainty factor. Category 3 includes both 1 and 2 and any other conservation thought to be cost effective when compared to new generation sources. All conservation savings reasonably expected to occur must be included in the CEC's adopted forecast. Quantifying additional achievable conservation can help to establish new conservation programs. Table B.3 summarizes the savings reasonably expected to occur for each program or measure. Table B.4 lists the savings by end-use sector.

The CEC feels that because programs are the causative agent for many measures adopted, forecasts should report savings by program. Double counting of programs is eliminated by analyzing how specific conservation measures affect end uses of energy and reconciling competing programs' influence on each measure. A "sharing" structure is set up which includes effects of programs and price fluctuations. Price- and program-induced conservation becomes "disjointed." For example, in general the residential sector model does not have price-induced savings from consumer choice of more efficient appliances,

TABLE B.3. CEC Conservation Program Electricity Savings in the Year 2002[a]

Sector	Demand(GWH)	
Residential		kWh/household
Existing Retrofit and Programs	391	34
1975 HCD Building Standards	2,292	201
1978 CEC Building Standards	644	57
1982 CEC Building Standards	5,108	449
1978 CEC Appliance	6,069	533
OII-42 Programs	0	0
Other Retrofit Programs	301	26
Load Management Cycling	1,160	102
	15,965	1,403
Commercial		kWh/employee
1978 CEC Building Standards	6,011	549
1983 CEC Building Standards	1,083	99
1983 CEC Equipment Standards	1,057	97
Schools and Hospitals	234	21
Load Management Audits	1,683	154
Other Commercial	1,846	169
	11,914	1,088
Industrial		
1978 CEC Building Standards	323	97

(a) Reasonably expected to occur. Street lighting and agriculture sectors excluded.

Source: California Energy Commission 1983, Table 3-IV-1,2,3. Household and employment projections used were taken from U.S. Department of Commerce, Bureau of Economic Analysis, 1980 Regional Projections. Households at 11,377,270: commercial employment at 10,950,677; industrial employment at 3,321,917.

TABLE B.4. CEC Potential Energy Savings by End-Use Sector by the Year 2002

Sector	GWh	kWh/HH or employee
Residential	23,313	2,049
Commercial Bldg	12,849	1,173
Other Commercial	1,593	145
Street Lighting	983	86
Process Industry	0	0
Assembly Industry	4,985	1,501
Extraction Industry	0	0
Total	43,723	NA

Source: California Energy Commission, Volume I Technical Report, 1982, Table 3-7. Agriculture not included.

but estimates savings based on mandatory standards. In the commercial sector, CEC loan management audits compete with price to motivate customers to make efficiency improvements. However, as more programs are introduced this separation becomes more difficult. Once again, heavy reliance is placed on building shell improvements to achieve conservation of electricity.

WISCONSIN ELECTRIC POWER COMPANY

The Wisconsin Electric Power Company (WEPC) is an investor-owned utility serving the Milwaukee, Kenosha, and Racine Standard Metropolitan Areas, Central and Northern Wisconsin, and the Upper Peninsula of Michigan. Wisconsin's primary fuel source (70%) has been natural gas since 1977. Electricity accounts for only 4 to 5% of total energy used. WEPC has adopted a very broad definition of conservation, covering not only more efficient end use of electricity but also energy saved at the supply and conversion levels, e.g., fuel switching, time-of-use rates, load management, etc., although load management was not modeled. It should be noted that there is currently an on-going debate between WEPC and the Wisconsin Public Services Commission regarding this definition. Basically the problem centers around WEPC's desire to raise rates to pay for programs they define as conservation measures. The Commission uses the definition of improvement in efficiency of energy end use by the customer. The Commission feels that WEPC emphasizes load management over incentives to the customer and thereby serves the company objectives first.[a] WEPC counters with the following argument:

> "Staff has been critical of Wisconsin's Electric's perspective on conservation. It is true that Wisconsin Electric has viewed conservation in context of the over-all planning process. That process seeks to anticipate and influence load patterns in order to maximize efficiency and maintain financial strength with the ultimate purpose of insuring that reliable service can be delivered at the lowest reasonable cost. The encouragement of efficient end-use of electricity contributes to the achievement of planning goals to the extent that peak use is constrained. It may be detrimental to the extent that it results in inefficient plant utilization."[b]

Two points about this controversy are important to this study. First, total state or regional energy planning will be less efficient until a unified policy position is adopted. Such a situation occurred in the past between BPA and PNPPC and was resolved through guidelines provided by the Regional Power Act. Second, the WEPC conservation forecasts will include end-use efficiency improvements, price-induced and program-induced conservation, and energy savings from fuel switching.

WEPC uses trend analysis to estimate peak demand. The WEPC system is primarily concerned with providing adequate capacity and their modeling effort reflects that concern; there is very little disaggregation at the end-use level. The energy forecast is derived directly from demand and contains some conservation from an implicit reduction for improved air conditioning efficiencies. Then, adjustments in hourly energy use for rate structure reform and solar water and space heat are made. These adjustments are summed for monthly and annual energy forecasts. The adjustments were allocated to each sector in the following manner:

(a) Post Hearing Brief on Docket 6630-ER-14.
(b) Hearings before the Public Service Commission of Wisconsin Docket 6630-ER-14. "Application of Wisconsin Electric Power Company for Authority to Increase Rates for Electric Service Based on Projected 1983 Operations," 1982.

- rate structure reform to general secondary (commercial)
- solar to residential
- air conditioning efficiency improvements to residential and general secondary according to the percent of the efficiency reduction at summer peak demand attributable to each sector (62% residential, 38% commercial).

Table B.5 presents the energy savings by customer for the year 2000. Energy savings per household or employee were not available.

TABLE B.5. WEPC Conservation Potential by the Year 2000 (Base Case)

Sector	Savings
Residential	13 kWh/customer
General Secondary (commercial)	447 kWh/customer

Source: Number of customers from Response to Item 7 of the Public Service Commission of Wisconsin Docket 6630-ER-14 Regarding Conservation. Estimated savings from Wisconsin Electric Power Company 20-year Demand and Energy Forecast 1981-2000, Table 2-1.2. Air Conditioning load reduction developed from Table 1-3.1 and Table 2-1.4.

These conservation estimates represent only part of the total potential. Although the air conditioning component includes price response, the solar and rate structure components do not. The forecast does not include reductions for improved efficiency in other appliances. Double counting occurs in adjusting for improved appliance efficiency resulting from federally mandated standards and the associated response to the econometric pricing assumptions. WEPC avoided double counting (or rather discounted for it) by not quantifying separate adjustments for baseload and water heating efficiencies.

ALASKAN RAILBELT

The State of Alaska, various utilities in the Railbelt region, and the Municipality of Anchorage have implemented energy conservation programs that include measures for conserving electricity that have already reduced electricity consumption.

Major conservation programs currently available in the Railbelt include the State Division of Energy and Power Development energy audit and loan (DEPD) program; the Golden Valley Electric Association program (primarily education in support of the market place); similar education programs by the Chugach Electric Association and the Fairbanks Municipal Utility System; and the City of Anchorage Program involving audits, weatherization, and educational efforts. The Golden Valley program was partly responsible for a reduction of electricity use in this Fairbanks service area from 17,332 kWh/household in 1975 to 9303 kWh/household in 1982 (see Table B.6). In the past, however, the DEPD program has been the most extensive with an estimated 24% of all Railbelt houses having had an energy audit performed. The program has saved an estimated average of 1,582 kwh/year of electricity per Alaska household, with electricity equaling about 18% of total energy savings from the program. No reliable data on DEPD program electricity savings are available in the Railbelt load centers.

According to Tillman (1983), almost all of the Railbelt programs have been aimed at the residential sector, with conservation in the commercial and industrial sectors being accomplished primarily through market conditions. Price-induced conservation is then more easily distinguishable in those two sectors. In the AML&P program, total conservation potential through 1987 has been disaggregated into program- and price-induced components (see Table B.7) with approximately a 40 and 60% share, respectively. For a breakdown by program, see Table B.8.

Tillman indicates that price-induced electricity conservation will be more important in the future than programmatic conservation for the following reasons:

TABLE B.6. Average Annual Electricity Consumption per Household on the GVEA System, 1972-1982

Year	Annual Consumption (kWh)	Monthly Consumption (kWh)	Percent Change
1972	13,919	1,160	+5.6
1973	14,479	1,207	+4.0
1974	15,822	1,319	+9.3
1975	17,332	1,444	+9.5
1976	15,203	1,267	-12.3
1977	14,255	1,188	-6.2
1978	11,574	965	-18.8
1979	10,519	877	-9.1
1980	9,767	814	-7.1
1981	9,080	757	-7.0
1982	9,303	775	+2.5

Source: GVEA, as reported by Tillman (1983).

- It has the dominant share of impacts.
- Subsidized audits and investments programs for residences are being phased out.
- Practical impact limits are being achieved in institutional buildings and systems programs.
- Current plans for future programs are predominantly educational programs designed to support price or market-induced conservation.

Tillman (1983) notes that two miscellaneous AML&P programs are expected to save considerable electric energy by the year 1987. These are street lighting improvements, whose impact is taken into account in Section 9.0, and heating of the Anchorage municipal water supply to reduce the electricity use of water heaters. The water heater impact is factored into the use rates for Anchorage water heaters in Section 5.0

In attempting to determine the level of conservation potential, the question arises as to whether further investment in energy-savings programs

TABLE B.7. Programmatic Versus Market-Driven Energy Conservation Projections in the AML&P Service Area

Year	Programmatic Conservation[a] (MWh)	(% of Total)	Market Driven Conservation[b] (MWh)	(%)	Total[a] (MWh)	(%)
1981	12,735	39.5	19,558	60.5	32,294	100
1982	19,609	34.9	27,243	65.1	46,853	100
1983	20,896	37.1	35,374	62.9	56,289	100
1984	27,619	41.1	39,560	58.9	67,133	100
1985	30,195	40.4	44,536	59.6	74,730	100
1986	32,614	40.6	48,133	59.4	81,015	100
1987	35,421	41.0	50,940	59.0	86,363	100
Cumulative	179,089	40.3	265,344	59.7	444,677	

(a) Detail does not add to total in the orginal. 1981 programs included:

Residential	MWh/yr	kWh/Customer
Weatherization	586	42
State Programs	879	63
Water Flow Restrictor	200	14
Water Heat Injection	3,921	281
	5,586	400
Industrial		
Boiler Feed Pumps	7,148	2298

Planned conservation programs include hot water wraps in the residential sector and street light conversion and utility transmission conversion in the commercial sector. The number of customers was provided by the 1982 Alaska Electric Power Statistics of the Alaska Power Administration.

(b) 1981 Price elasticity effects equaled 19,558 MWh/yr.

Source: AML&P 1982.

TABLE B.8. Programmatic Energy Conservation Projections for AML&P (MWh/yr)

Program	1981	1982	1983	1984	1985	1986	1987
Weatherization	586	762	938	1,114	1,290	1,466	1,641
State Programs	879	1,759	2,199	2,683	3,078	3,518	3,737
Water Flow Restrictions	200	464	464	464	464	464	464
Water Heat Injection	3,922	3,922	3,922	3,922	3,922	3,922	3,922
Hot Water Heater Wrap	NA	NA	249	249	249	249	249
Street Light Conversion	0	555	1,859	3,307	4,788	6,306	7,861
Transmission Conversion	0	0	4,119	8,732	9,256	9,811	10,399
Boiler Pump Conversion	7,148	7,148	7,148	7,148	7,148	7,148	7,148
TOTAL	12,735	14,609	20,896	27,619	30,195	32,614	35,421
% Change From Previous Year	NA	14.7	43.0	32.2	9.3	9.8	8.6

Source: AML&P, as reported by Tillman (1983).

would be cost effective. An investigation of program-induced versus price-induced conservation forecasted by other regions could indicate if current market penetration levels in the Railbelt are realistic. Unfortunately, as we have seen, total separation of price and program effects forecasted by PNPPC, BPA, CEC, and WEPC has not yet been achieved. We have some indication that these forecasts do show programmatic contributions by the year 2000 in residential commercial, and industrial sectors. However, the extent to which technically achievable conservation limits can be approached in Alaska through programs and what proportion would be due to market actions is not clear. In general, because of differences in housing stock, fuel mode splits, fuel prices, climate, and other factors, forecasted program savings for other regions may have only limited relevance for the Railbelt.

APPENDIX C

RED MODEL OUTPUT

APPENDIX C

RED MODEL OUTPUT

This appendix displays selected RED model output produced for the 1983 update. Included in the following tables are information on the number of households served by electricity in each load center, housing vacancies, fuel price forecasts, electricity used per household and per employee, as well as summaries of price effects and programmatic conservation, annual electricity requirements by sector and load center, and total peak demand. The figures presented in these tables are at the point of sale and include estimates supplied by Harza-Ebasco of military and industrial demand. They do not include an adjustment for transmission losses. However, for the 1983 update of the alternative generation plans these reported figures were adjusted for transmission losses.

LIST OF TABLES

H12--SHERMAN CLARK NO SUPPLY DISRUPTION

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	46224.	26204.	10958.	8567.	91953.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	58740.	26349.	13505.	8460.	107054.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	64779.	29931.	14941.	8333.	117984.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	69822.	33259.	16200.	8022.	127302.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	75777.	36378.	17749.	8738.	138641.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	83343.	40411.	19721.	9649.	153124.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220.	5287.	1189.	1617.	15313.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	10646.	5867.	2130.	1765.	20407.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	11728.	7960.	2270.	2375.	24332.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	14736.	7841.	3328.	2339.	28244.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	16528.	7703.	3845.	2298.	30374.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	17951.	8681.	4220.	2121.	32973.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	19675.	9612.	4673.	2334.	36294.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089.	7666.	1991.	1463.	16209.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	509.	1496.	121.	292.	2417.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	646.	1005.	149.	289.	2089.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	713.	1616.	164.	284.	2777.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	768.	1796.	178.	445.	3187.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	834.	1964.	195.	288.	3281.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	917.	2182.	217.	319.	3634.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2654.	24.	722.	3518.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	129.	454.	25.	81.	689.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	162.	448.	37.	80.	726.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	182.	440.	42.	78.	742.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	197.	469.	46.	209.	921.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	216.	519.	51.	77.	864.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.052	0.049	0.092	0.087
1995	0.058	0.055	0.094	0.089
2000	0.062	0.059	0.096	0.091
2005	0.065	0.062	0.098	0.093
2010	0.067	0.064	0.100	0.095

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.740	11.290
1985	1.950	1.720	10.600	9.150
1990	2.880	2.650	11.240	9.790
1995	4.050	3.820	13.030	11.580
2000	4.290	4.060	15.110	13.660
2005	4.960	4.730	17.520	16.070
2010	5.380	5.150	20.310	18.860

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7.750	7.200	7.830	7.500
1985	6.450	5.900	6.510	6.180
1990	6.840	6.290	6.910	6.580
1995	7.930	7.380	8.010	7.680
2000	9.190	8.640	9.290	8.960
2005	10.650	10.100	10.770	10.440
2010	12.350	11.800	12.480	12.150

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6151.49	4821.83	13133.33
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	6019.76	4584.35	12814.12
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5959.31	4515.56	12734.87
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5989.38	4453.84	12753.21
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6059.12	4420.04	12839.17
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6123.98	4443.55	12977.52
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6178.94	3606.31	12321.24
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6453.56	3872.52	12932.07
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.00	6666.87	4050.14	13393.00
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.00	6795.45	4310.30	13851.75
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6838.86	4535.80	14190.66
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.00	6887.85	4655.96	14429.81
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04	7495.70
	(0.000)	(0.000)
1985	9580.38	7972.11
	(0.000)	(0.000)
1990	10355.06	8327.35
	(0.000)	(0.000)
1995	10918.45	8662.27
	(0.000)	(0.000)
2000	11416.40	8957.92
	(0.000)	(0.000)
2005	12089.67	9308.03
	(0.000)	(0.000)
2010	12932.63	9711.65
	(0.000)	(0.000)

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.169	0.000	-0.567	9.327	0.000	0.532
1982	12.337	0.000	-1.135	18.653	0.000	1.063
1983	18.506	0.000	-1.702	27.980	0.000	1.595
1984	24.674	0.000	-2.270	37.307	0.000	2.126
1985	30.843	0.000	-2.837	46.633	0.000	2.658
1986	38.476	0.000	-10.645	58.180	0.000	-0.356
1987	46.109	0.000	-18.454	69.726	0.000	-3.370
1988	53.742	0.000	-26.262	81.273	0.000	-6.385
1989	61.375	0.000	-34.071	92.819	0.000	-9.399
1990	69.008	0.000	-41.879	104.366	0.000	-12.413
1991	115.046	0.000	-91.197	119.940	0.000	-19.060
1992	161.084	0.000	-140.515	135.514	0.000	-25.707
1993	207.121	0.000	-189.833	151.088	0.000	-32.353
1994	253.159	0.000	-239.150	166.663	0.000	-39.000
1995	299.197	0.000	-288.468	182.237	0.000	-45.647
1996	234.019	0.000	-225.008	198.278	0.000	-52.588
1997	168.842	0.000	-161.547	214.320	0.000	-59.530
1998	103.665	0.000	-98.086	230.361	0.000	-66.471
1999	38.488	0.000	-34.626	246.403	0.000	-73.412
2000	-26.689	0.000	28.835	262.444	0.000	-80.354
2001	-7.502	0.000	6.470	282.489	0.000	-90.245
2002	11.685	0.000	-15.895	302.535	0.000	-100.137
2003	30.872	0.000	-38.260	322.580	0.000	-110.028
2004	50.059	0.000	-60.625	342.625	0.000	-119.920
2005	69.246	0.000	-82.990	362.670	0.000	-129.811
2006	78.151	0.000	-95.904	388.132	0.000	-143.338
2007	87.055	0.000	-108.819	413.595	0.000	-156.864
2008	95.960	0.000	-121.733	439.057	0.000	-170.391
2009	104.864	0.000	-134.647	464.520	0.000	-183.917
2010	113.769	0.000	-147.562	489.982	0.000	-197.444

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	0.758	0.000	0.000	0.514
1982	0.000	0.000	1.516	0.000	0.000	1.028
1983	0.000	0.000	2.274	0.000	0.000	1.542
1984	0.000	0.000	3.032	0.000	0.000	2.056
1985	0.000	0.000	3.789	0.000	0.000	2.570
1986	-0.200	0.000	4.184	-0.342	0.000	2.758
1987	-0.400	0.000	4.578	-0.685	0.000	2.946
1988	-0.600	0.000	4.972	-1.027	0.000	3.134
1989	-0.800	0.000	5.367	-1.369	0.000	3.323
1990	-1.000	0.000	5.761	-1.712	0.000	3.511
1991	-1.008	0.000	5.176	-1.673	0.000	3.084
1992	-1.016	0.000	4.592	-1.634	0.000	2.657
1993	-1.024	0.000	4.008	-1.595	0.000	2.231
1994	-1.033	0.000	3.424	-1.556	0.000	1.804
1995	-1.041	0.000	2.839	-1.517	0.000	1.378
1996	-0.868	0.000	1.350	-1.247	0.000	0.556
1997	-0.695	0.000	-0.140	-0.978	0.000	-0.265
1998	-0.522	0.000	-1.630	-0.708	0.000	-1.086
1999	-0.349	0.000	-3.119	-0.439	0.000	-1.907
2000	-0.176	0.000	-4.609	-0.169	0.000	-2.729
2001	0.129	0.000	-6.825	0.297	0.000	-3.910
2002	0.433	0.000	-9.042	0.763	0.000	-5.091
2003	0.738	0.000	-11.258	1.228	0.000	-6.271
2004	1.042	0.000	-13.475	1.694	0.000	-7.452
2005	1.347	0.000	-15.691	2.160	0.000	-8.633
2006	1.772	0.000	-18.662	2.819	0.000	-10.235
2007	2.198	0.000	-21.633	3.477	0.000	-11.836
2008	2.624	0.000	-24.604	4.136	0.000	-13.438
2009	3.049	0.000	-27.575	4.795	0.000	-15.039
2010	3.475	0.000	-30.546	5.454	0.000	-16.641

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1019.55	946.55	24.64	92.08	2082.82
1982	1059.57	1017.73	24.98	100.16	2202.45
1983	1099.60	1088.92	25.31	108.24	2322.07
1984	1139.62	1160.11	25.65	116.32	2441.70
1985	1179.64	1231.30	25.98	124.40	2561.32
1986	1212.65	1280.79	26.83	137.89	2658.16
1987	1245.65	1330.28	27.67	151.38	2754.99
1988	1278.66	1379.77	28.51	164.88	2851.82
1989	1311.67	1429.26	29.36	178.37	2948.66
1990	1344.67	1478.75	30.20	191.86	3045.49
1991	1374.10	1510.46	30.88	195.13	3110.56
1992	1403.52	1542.17	31.56	198.40	3175.64
1993	1432.94	1573.87	32.24	201.66	3240.72
1994	1462.36	1605.58	32.92	204.93	3305.79
1995	1491.78	1637.29	33.60	208.20	3370.87
1996	1517.70	1663.04	34.16	214.14	3429.04
1997	1543.62	1688.80	34.73	220.08	3487.22
1998	1569.53	1714.55	35.29	226.02	3545.40
1999	1595.45	1740.31	35.86	231.96	3603.57
2000	1621.36	1766.06	36.42	237.90	3661.75
2001	1655.85	1812.69	37.27	244.96	3750.76
2002	1690.33	1859.31	38.11	252.02	3839.78
2003	1724.81	1905.94	38.96	259.08	3928.79
2004	1759.30	1952.57	39.80	266.14	4017.81
2005	1793.78	1999.20	40.65	273.20	4106.82
2006	1839.22	2069.82	41.87	281.58	4232.48
2007	1884.65	2140.45	43.08	289.96	4358.15
2008	1930.09	2211.08	44.30	298.34	4483.81
2009	1975.53	2281.71	45.52	306.72	4609.48
2010	2020.96	2352.34	46.74	315.10	4735.14

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	190.64	229.84	6.75	0.00	427.23
1982	204.90	242.55	6.71	0.00	454.15
1983	219.15	255.25	6.67	0.00	481.07
1984	233.40	267.96	6.63	0.00	507.99
1985	247.65	280.66	6.59	0.00	534.91
1986	260.10	289.45	6.65	10.00	566.20
1987	272.55	298.24	6.70	20.00	597.50
1988	285.00	307.04	6.75	30.00	628.79
1989	297.45	315.83	6.80	40.00	660.08
1990	309.90	324.62	6.86	50.00	691.38
1991	323.22	332.83	7.08	50.00	713.14
1992	336.53	341.05	7.31	50.00	734.89
1993	349.85	349.27	7.54	50.00	756.65
1994	363.16	357.49	7.77	50.00	778.41
1995	376.47	365.70	7.99	50.00	800.17
1996	386.28	371.79	8.16	50.00	816.23
1997	396.09	377.87	8.32	50.00	832.29
1998	405.90	383.96	8.49	50.00	848.34
1999	415.71	390.04	8.65	50.00	864.40
2000	425.52	396.12	8.82	50.00	880.46
2001	436.86	405.61	9.04	50.00	901.52
2002	448.21	415.10	9.27	50.00	922.58
2003	459.56	424.59	9.50	50.00	943.65
2004	470.91	434.08	9.72	50.00	964.71
2005	482.25	443.57	9.95	50.00	985.77
2006	495.96	457.05	10.22	50.00	1013.23
2007	509.67	470.53	10.50	50.00	1040.70
2008	523.37	484.01	10.78	50.00	1068.16
2009	537.08	497.49	11.05	50.00	1095.62
2010	550.79	510.97	11.33	50.00	1123.09

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2082.82	427.23	2510.05
1982	2202.45	454.15	2656.60
1983	2322.07	481.07	2803.14
1984	2441.70	507.99	2949.69
1985	2561.32	534.91	3096.23
1986	2658.16	566.20	3224.36
1987	2754.99	597.50	3352.49
1988	2851.82	628.79	3480.61
1989	2948.66	660.08	3608.74
1990	3045.49	691.38	3736.87
1991	3110.56	713.14	3823.70
1992	3175.64	734.89	3910.53
1993	3240.72	756.65	3997.37
1994	3305.79	778.41	4084.20
1995	3370.87	800.17	4171.04
1996	3429.04	816.23	4245.27
1997	3487.22	832.29	4319.51
1998	3545.40	848.34	4393.74
1999	3603.57	864.40	4467.97
2000	3661.75	880.46	4542.21
2001	3750.76	901.52	4652.28
2002	3839.78	922.58	4762.36
2003	3928.79	943.65	4872.44
2004	4017.81	964.71	4982.51
2005	4106.82	985.77	5092.59
2006	4232.49	1013.23	5245.72
2007	4358.15	1040.70	5398.84
2008	4483.81	1068.16	5551.97
2009	4609.48	1095.62	5705.10
2010	4735.14	1123.09	5858.23

SCENARIO: MED : H12--SHERMAN CLARK NO SUPPLY DISRUPTION--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	420.68	97.54	518.23
1982	444.86	103.69	548.55
1983	469.04	109.83	578.87
1984	493.21	115.98	609.19
1985	517.39	122.13	639.52
1986	537.82	129.27	667.08
1987	558.24	136.41	694.65
1988	578.67	143.55	722.22
1989	599.10	150.69	749.79
1990	619.53	157.83	777.36
1991	632.75	162.80	795.55
1992	645.97	167.77	813.74
1993	659.19	172.74	831.92
1994	672.41	177.70	850.11
1995	685.63	182.67	868.30
1996	697.31	186.34	883.65
1997	708.99	190.00	898.99
1998	720.67	193.67	914.34
1999	732.35	197.34	929.68
2000	744.03	201.00	945.03
2001	762.00	205.81	967.81
2002	779.96	210.62	990.58
2003	797.93	215.43	1013.36
2004	815.90	220.24	1036.13
2005	833.86	225.05	1058.91
2006	859.29	231.32	1090.60
2007	884.71	237.59	1122.30
2008	910.14	243.86	1153.99
2009	935.56	250.13	1185.69
2010	960.98	256.40	1217.38

HE3--DOR AVG SCENARIO

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	45675.	26204.	10857.	8567.	91303.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	55299.	25877.	12721.	8460.	102357.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	61089.	27629.	14066.	8333.	111117.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	66029.	30825.	15318.	8187.	120360.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	71796.	34467.	16822.	8283.	131368.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	79066.	38351.	18715.	9159.	145291.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220.	5287.	1189.	1617.	15313.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	10646.	5684.	2130.	1720.	20180.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	10852.	7960.	2103.	2375.	23290.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	13498.	7841.	2697.	2339.	26375.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	15038.	7703.	3404.	2298.	28443.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	16862.	7895.	3966.	2252.	30975.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	18520.	9051.	4401.	2198.	34169.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089. (0.000)	7666. (0.000)	1991. (0.000)	1463. (0.000)	16209. (0.000)
1985	502. (0.000)	1496. (0.000)	119. (0.000)	292. (0.000)	2410. (0.000)
1990	608. (0.000)	1477. (0.000)	140. (0.000)	289. (0.000)	2514. (0.000)
1995	672. (0.000)	1492. (0.000)	155. (0.000)	284. (0.000)	2603. (0.000)
2000	726. (0.000)	1665. (0.000)	169. (0.000)	279. (0.000)	2839. (0.000)
2005	790. (0.000)	1861. (0.000)	185. (0.000)	14. (0.000)	2850. (0.000)
2010	870. (0.000)	2071. (0.000)	206. (0.000)	302. (0.000)	3449. (0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2837.	24.	767.	3745.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	119.	454.	23.	81.	678.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	149.	448.	30.	80.	706.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	165.	440.	38.	78.	721.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	185.	85.	44.	77.	391.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	204.	489.	48.	79.	819.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.090	0.085
1990	0.051	0.048	0.090	0.085
1995	0.054	0.051	0.090	0.085
2000	0.057	0.056	0.090	0.085
2005	0.061	0.058	0.092	0.087
2010	0.063	0.060	0.095	0.090

SCENARIO: MED : HE3--OUR AVG SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.740	11.290
1985	1.960	1.730	9.810	8.360
1990	2.710	2.480	9.760	8.310
1995	3.250	3.020	10.370	8.920
2000	3.410	3.180	11.220	9.770
2005	3.560	3.330	11.970	10.520
2010	3.710	3.480	12.770	11.320

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7.750	7.200	7.830	7.500
1985	5.970	5.420	6.030	5.700
1990	5.940	5.390	6.000	5.670
1995	6.310	5.760	6.370	6.040
2000	6.830	6.280	6.890	6.560
2005	7.290	6.740	7.360	7.030
2010	7.780	7.230	7.850	7.520

SCENARIO: MED ; HE3--DOR AVG SCENARIO--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6154.71	4831.81	13146.51
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	6026.18	4623.92	12860.10
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5958.98	4511.98	12730.96
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5988.97	4441.29	12740.26
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6060.87	4421.11	12841.98
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6126.81	4440.62	12977.44
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00 (0.000)	5739.52 (0.000)	3313.66 (0.000)	11519.18 (0.000)
1985	2536.00 (0.000)	6181.34 (0.000)	3593.90 (0.000)	12311.23 (0.000)
1990	2606.00 (0.000)	6440.63 (0.000)	3848.67 (0.000)	12895.29 (0.000)
1995	2676.01 (0.000)	6656.15 (0.000)	4088.11 (0.000)	13420.27 (0.000)
2000	2746.00 (0.000)	6793.05 (0.000)	4320.70 (0.000)	13859.75 (0.000)
2005	2816.00 (0.000)	6853.56 (0.000)	4507.50 (0.000)	14177.06 (0.000)
2010	2886.00 (0.000)	6893.36 (0.000)	4656.97 (0.000)	14436.32 (0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9518.78 (0.000)	7947.43 (0.000)
1990	10089.60 (0.000)	8249.74 (0.000)
1995	10604.92 (0.000)	8558.84 (0.000)
2000	11172.44 (0.000)	8874.75 (0.000)
2005	11850.11 (0.000)	9227.92 (0.000)
2010	12675.23 (0.000)	9628.13 (0.000)

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.120	0.000	-0.175	9.113	0.000	1.002
1982	12.240	0.000	-0.350	18.227	0.000	2.005
1983	18.360	0.000	-0.524	27.340	0.000	3.007
1984	24.480	0.000	-0.699	36.453	0.000	4.009
1985	30.599	0.000	-0.874	45.566	0.000	5.011
1986	36.745	0.000	-6.193	54.489	0.000	3.581
1987	42.890	0.000	-11.512	63.411	0.000	2.150
1988	49.035	0.000	-16.831	72.334	0.000	0.720
1989	55.180	0.000	-22.150	81.257	0.000	-0.711
1990	61.325	0.000	-27.469	90.179	0.000	-2.142
1991	68.809	0.000	-35.794	99.784	0.000	-5.000
1992	76.292	0.000	-44.119	109.389	0.000	-7.858
1993	83.776	0.000	-52.444	118.994	0.000	-10.717
1994	91.260	0.000	-60.769	128.599	0.000	-13.575
1995	98.743	0.000	-69.094	138.204	0.000	-16.434
1996	108.847	0.000	-79.056	151.908	0.000	-19.730
1997	118.951	0.000	-89.017	165.611	0.000	-23.026
1998	129.055	0.000	-98.978	179.314	0.000	-26.322
1999	139.159	0.000	-108.939	193.017	0.000	-29.618
2000	149.263	0.000	-118.901	206.720	0.000	-32.914
2001	161.975	0.000	-130.006	221.422	0.000	-36.866
2002	174.687	0.000	-141.111	236.125	0.000	-40.819
2003	187.398	0.000	-152.217	250.827	0.000	-44.772
2004	200.110	0.000	-163.322	265.529	0.000	-48.724
2005	212.822	0.000	-174.427	280.231	0.000	-52.677
2006	229.024	0.000	-189.201	298.900	0.000	-57.896
2007	245.226	0.000	-203.975	317.569	0.000	-63.116
2008	261.428	0.000	-218.749	336.238	0.000	-68.335
2009	277.631	0.000	-233.523	354.908	0.000	-73.554
2010	293.833	0.000	-248.296	373.577	0.000	-78.774

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	-0.266	0.000	1.061	-0.493	0.000	0.729
1982	-0.532	0.000	2.121	-0.986	0.000	1.457
1983	-0.797	0.000	3.182	-1.479	0.000	2.186
1984	-1.063	0.000	4.243	-1.972	0.000	2.914
1985	-1.329	0.000	5.304	-2.465	0.000	3.643
1986	-1.560	0.000	6.244	-2.805	0.000	4.154
1987	-1.791	0.000	7.185	-3.145	0.000	4.666
1988	-2.022	0.000	8.125	-3.485	0.000	5.178
1989	-2.253	0.000	9.066	-3.826	0.000	5.690
1990	-2.484	0.000	10.006	-4.166	0.000	6.202
1991	-2.685	0.000	10.464	-4.435	0.000	6.385
1992	-2.886	0.000	10.922	-4.704	0.000	6.567
1993	-3.087	0.000	11.380	-4.972	0.000	6.750
1994	-3.289	0.000	11.838	-5.241	0.000	6.933
1995	-3.490	0.000	12.296	-5.510	0.000	7.115
1996	-3.638	0.000	12.116	-4.978	0.000	6.245
1997	-3.787	0.000	11.937	-4.446	0.000	5.375
1998	-3.936	0.000	11.757	-3.915	0.000	4.505
1999	-4.084	0.000	11.578	-3.383	0.000	3.635
2000	-4.233	0.000	11.398	-2.851	0.000	2.765
2001	-4.175	0.000	10.890	-3.335	0.000	3.050
2002	-4.117	0.000	10.382	-3.819	0.000	3.335
2003	-4.059	0.000	9.875	-4.303	0.000	3.619
2004	-4.000	0.000	9.367	-4.786	0.000	3.904
2005	-3.942	0.000	8.859	-5.270	0.000	4.189
2006	-3.623	0.000	8.064	-4.841	0.000	3.799
2007	-3.305	0.000	7.269	-4.411	0.000	3.408
2008	-2.986	0.000	6.473	-3.982	0.000	3.018
2009	-2.667	0.000	5.678	-3.552	0.000	2.628
2010	-2.348	0.000	4.883	-3.123	0.000	2.238

SCENARIO: MED ; HE3--DOR AVG SCENARIO--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1017.74	940.84	24.56	92.08	2075.23
1982	1055.95	1006.33	24.82	100.16	2187.26
1983	1094.17	1071.81	25.08	108.24	2299.30
1984	1132.38	1137.29	25.34	116.32	2411.33
1985	1170.59	1202.78	25.60	124.40	2523.37
1986	1192.97	1232.72	26.15	137.89	2589.73
1987	1215.34	1262.65	26.71	151.38	2656.09
1988	1237.72	1292.59	27.27	164.88	2722.45
1989	1260.09	1322.53	27.83	178.37	2788.81
1990	1282.47	1352.46	28.38	191.86	2855.17
1991	1302.97	1379.57	28.89	195.13	2906.55
1992	1323.47	1406.68	29.39	198.40	2957.93
1993	1343.97	1433.78	29.89	201.66	3009.31
1994	1364.47	1460.89	30.40	204.93	3060.69
1995	1384.98	1487.99	30.90	208.20	3112.07
1996	1408.59	1518.20	31.48	214.14	3172.41
1997	1432.21	1548.42	32.05	220.08	3232.76
1998	1455.82	1578.63	32.63	226.02	3293.10
1999	1479.44	1608.84	33.20	231.96	3353.45
2000	1503.06	1639.06	33.78	237.90	3413.79
2001	1532.17	1683.35	34.54	244.96	3495.02
2002	1561.29	1727.64	35.30	252.02	3576.24
2003	1590.40	1771.93	36.06	259.08	3657.47
2004	1619.52	1816.22	36.83	266.14	3738.70
2005	1648.63	1860.51	37.59	273.20	3819.93
2006	1686.90	1924.15	38.68	281.58	3931.30
2007	1725.17	1987.79	39.77	289.96	4042.68
2008	1763.43	2051.43	40.86	298.34	4154.06
2009	1801.70	2115.06	41.95	306.72	4265.43
2010	1839.97	2178.70	43.04	315.10	4376.81

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

BREAKDOWN OF ELECTRICTTY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	190.01	228.93	6.74	0.00	425.68
1982	203.62	240.71	6.70	0.00	451.04
1983	217.24	252.50	6.66	0.00	476.40
1984	230.85	264.29	6.62	0.00	501.77
1985	244.47	276.08	6.58	0.00	527.13
1986	254.13	281.67	6.56	10.00	552.37
1987	263.80	287.27	6.53	20.00	577.60
1988	273.47	292.86	6.51	30.00	602.84
1989	283.14	298.45	6.49	40.00	628.07
1990	292.80	304.04	6.46	50.00	653.30
1991	303.27	310.23	6.64	50.00	670.14
1992	313.74	316.42	6.81	50.00	686.98
1993	324.21	322.61	6.99	50.00	703.82
1994	334.68	328.80	7.17	50.00	720.65
1995	345.15	335.00	7.34	50.00	737.49
1996	353.53	341.78	7.50	50.00	752.81
1997	361.91	348.56	7.66	50.00	768.12
1998	370.29	355.33	7.82	50.00	783.44
1999	378.67	362.11	7.97	50.00	798.76
2000	387.05	368.89	8.13	50.00	814.07
2001	396.48	377.71	8.30	50.00	832.49
2002	405.92	386.52	8.47	50.00	850.91
2003	415.35	395.34	8.64	50.00	869.33
2004	424.78	404.15	8.81	50.00	887.75
2005	434.22	412.97	8.98	50.00	906.16
2006	445.52	424.75	9.24	50.00	929.51
2007	456.83	436.53	9.51	50.00	952.86
2008	468.13	448.31	9.77	50.00	976.21
2009	479.44	460.08	10.03	50.00	999.56
2010	490.74	471.86	10.30	50.00	1022.90

SCENARIO: MED : HE3--DOR AVG SCENARIO--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2075.23	425.68	2500.90
1982	2187.26	451.04	2638.30
1983	2299.30	476.40	2775.70
1984	2411.33	501.77	2913.10
1985	2523.37	527.13	3050.50
1986	2589.73	552.37	3142.10
1987	2656.09	577.60	3233.69
1988	2722.45	602.84	3325.29
1989	2788.81	628.07	3416.88
1990	2855.17	653.30	3508.48
1991	2906.55	670.14	3576.69
1992	2957.93	686.98	3644.91
1993	3009.31	703.82	3713.13
1994	3060.69	720.65	3781.34
1995	3112.07	737.49	3849.56
1996	3172.41	752.81	3925.22
1997	3232.76	768.12	4000.88
1998	3293.10	783.44	4076.54
1999	3353.44	798.76	4152.20
2000	3413.79	814.07	4227.86
2001	3495.02	832.49	4327.51
2002	3576.24	850.91	4427.15
2003	3657.47	869.33	4526.80
2004	3738.70	887.75	4626.44
2005	3819.93	906.16	4726.09
2006	3931.30	929.51	4860.81
2007	4042.68	952.86	4995.54
2008	4154.06	976.21	5130.26
2009	4265.43	999.56	5264.99
2010	4376.81	1022.90	5399.71

SCENARIO: MED ; HE3--DOR AVG SCENARIO--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	419.13	97.19	516.32
1982	441.75	102.98	544.73
1983	464.37	108.77	573.14
1984	486.99	114.56	601.55
1985	509.62	120.35	629.97
1986	523.80	126.11	649.91
1987	537.99	131.87	669.85
1988	552.17	137.62	689.80
1989	566.36	143.38	709.74
1990	580.54	149.14	729.68
1991	590.96	152.98	743.94
1992	601.37	156.83	758.20
1993	611.79	160.67	772.46
1994	622.20	164.52	786.72
1995	632.62	168.36	800.98
1996	644.74	171.86	816.60
1997	656.87	175.36	832.22
1998	668.99	178.85	847.84
1999	681.11	182.35	863.46
2000	693.24	185.85	879.08
2001	709.61	190.05	899.66
2002	725.98	194.26	920.24
2003	742.35	198.46	940.81
2004	758.73	202.67	961.39
2005	775.10	206.87	981.97
2006	797.60	212.20	1009.80
2007	820.09	217.53	1037.63
2008	842.59	222.86	1065.45
2009	865.09	228.19	1093.28
2010	887.59	233.52	1121.11

HE9--DOR 50%

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	45685.	26204.	10859.	8567.	91315.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	55038.	25877.	12661.	8460.	102036.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	59947.	26890.	13789.	8333.	108959.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	64311.	29755.	14910.	8187.	117163.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	69574.	33363.	16295.	8024.	127255.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	76360.	37012.	18072.	8845.	140288.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220.	5287.	1189.	1617.	15313.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	10646.	5688.	2130.	1721.	20185.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	10725.	7960.	2103.	2375.	23163.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	12980.	7841.	2573.	2339.	25733.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	14324.	7703.	3194.	2298.	27520.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	16206.	7549.	3808.	2252.	29815.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	17773.	8681.	4223.	2109.	32786.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089. (0.000)	7666. (0.000)	1991. (0.000)	1463. (0.000)	16209. (0.000)
1985	503. (0.000)	1496. (0.000)	120. (0.000)	292. (0.000)	2410. (0.000)
1990	605. (0.000)	1477. (0.000)	139. (0.000)	289. (0.000)	2510. (0.000)
1995	659. (0.000)	54. (0.000)	152. (0.000)	284. (0.000)	1149. (0.000)
2000	707. (0.000)	1607. (0.000)	164. (0.000)	279. (0.000)	2758. (0.000)
2005	765. (0.000)	1802. (0.000)	179. (0.000)	274. (0.000)	3020. (0.000)
2010	840. (0.000)	1999. (0.000)	199. (0.000)	292. (0.000)	3329. (0.000)

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653. (0.000)	3320. (0.000)	986. (0.000)	895. (0.000)	8854. (0.000)
1985	118. (0.000)	2833. (0.000)	24. (0.000)	766. (0.000)	3741. (0.000)
1990	118. (0.000)	454. (0.000)	23. (0.000)	81. (0.000)	677. (0.000)
1995	143. (0.000)	448. (0.000)	28. (0.000)	80. (0.000)	699. (0.000)
2000	158. (0.000)	440. (0.000)	35. (0.000)	78. (0.000)	711. (0.000)
2005	178. (0.000)	431. (0.000)	42. (0.000)	77. (0.000)	728. (0.000)
2010	196. (0.000)	469. (0.000)	46. (0.000)	167. (0.000)	878. (0.000)

SCENARIO: HED : HE9--DOOR 50%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.049	0.046	0.090	0.085
1995	0.050	0.047	0.090	0.085
2000	0.051	0.048	0.090	0.085
2005	0.051	0.048	0.090	0.085
2010	0.051	0.048	0.090	0.085

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	1.730	1.500	12.740	11.290
1985	2.000	1.770	10.660	9.210
1990	2.630	2.400	9.090	7.640
1995	2.810	2.580	8.120	6.670
2000	2.710	2.480	7.660	6.210
2005	2.630	2.400	7.270	5.820
2010	2.560	2.330	6.890	5.440

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7.750	7.200	7.830	7.500
1985	6.490	5.940	6.550	6.220
1990	5.530	4.980	5.590	5.260
1995	4.950	4.400	4.990	4.660
2000	4.660	4.110	4.710	4.380
2005	4.430	3.880	4.460	4.130
2010	4.200	3.650	4.240	3.910

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SCENARIO: MED : HE9--DOOR 50%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6154.64	4831.62	13146.27
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	6026.77	4627.82	12864.60
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5958.47	4509.39	12727.87
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5988.15	4436.47	12734.61
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6060.94	4421.47	12842.40
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6127.57	4439.13	12976.70
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6181.26	3594.14	12311.40
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.01	6439.31	3840.88	12886.20
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.01	6651.89	4081.97	13409.87
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.01	6790.89	4325.95	13862.85
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6858.32	4497.49	14171.81
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2885.99	6895.94	4656.78	14438.72
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE9--DOOR 50X--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9519.96 (0.000)	7947.93 (0.000)
1990	10059.64 (0.000)	8237.21 (0.000)
1995	10482.60 (0.000)	8515.05 (0.000)
2000	11024.92 (0.000)	8822.88 (0.000)
2005	11680.86 (0.000)	9169.82 (0.000)
2010	12483.97 (0.000)	9564.47 (0.000)

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION IN GWH

ANCHORAGE - COOK INLET

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.145	0.000	-0.964	9.139	0.000	0.326
1982	12.290	0.000	-1.928	18.277	0.000	0.653
1983	18.435	0.000	-2.892	27.416	0.000	0.979
1984	24.580	0.000	-3.856	36.554	0.000	1.306
1985	30.725	0.000	-4.820	45.693	0.000	1.632
1986	35.683	0.000	-8.771	52.480	0.000	1.288
1987	40.641	0.000	-12.721	59.266	0.000	0.943
1988	45.599	0.000	-16.672	66.053	0.000	0.599
1989	50.557	0.000	-20.623	72.840	0.000	0.255
1990	55.515	0.000	-24.573	79.627	0.000	-0.090
1991	59.415	0.000	-27.410	84.960	0.000	0.223
1992	63.314	0.000	-30.246	90.294	0.000	0.536
1993	67.213	0.000	-33.083	95.627	0.000	0.849
1994	71.113	0.000	-35.919	100.961	0.000	1.162
1995	75.012	0.000	-38.755	106.294	0.000	1.475
1996	78.442	0.000	-39.549	112.088	0.000	2.579
1997	81.871	0.000	-40.343	117.883	0.000	3.683
1998	85.300	0.000	-41.137	123.677	0.000	4.786
1999	88.729	0.000	-41.931	129.471	0.000	5.890
2000	92.158	0.000	-42.725	135.265	0.000	6.993
2001	95.081	0.000	-42.540	140.985	0.000	8.663
2002	98.004	0.000	-42.355	146.705	0.000	10.332
2003	100.927	0.000	-42.170	152.426	0.000	12.002
2004	103.850	0.000	-41.985	158.146	0.000	13.671
2005	106.774	0.000	-41.800	163.866	0.000	15.341
2006	109.764	0.000	-41.008	170.770	0.000	17.767
2007	112.755	0.000	-40.215	177.674	0.000	20.194
2008	115.746	0.000	-39.423	184.578	0.000	22.621
2009	118.737	0.000	-38.631	191.482	0.000	25.048
2010	121.728	0.000	-37.838	198.386	0.000	27.474

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION IN GWH

GREATER FAIRBANKS

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	0.726	0.000	0.000	0.488
1982	0.000	0.000	1.452	0.000	0.000	0.975
1983	0.000	0.000	2.178	0.000	0.000	1.463
1984	0.000	0.000	2.904	0.000	0.000	1.950
1985	0.000	0.000	3.630	0.000	0.000	2.438
1986	-0.319	0.000	5.029	-0.532	0.000	3.250
1987	-0.638	0.000	6.427	-1.064	0.000	4.062
1988	-0.957	0.000	7.826	-1.596	0.000	4.873
1989	-1.276	0.000	9.225	-2.129	0.000	5.685
1990	-1.595	0.000	10.624	-2.661	0.000	6.497
1991	-1.846	0.000	12.375	-2.998	0.000	7.395
1992	-2.097	0.000	14.127	-3.335	0.000	8.292
1993	-2.348	0.000	15.878	-3.671	0.000	9.189
1994	-2.599	0.000	17.630	-4.008	0.000	10.087
1995	-2.850	0.000	19.381	-4.345	0.000	10.984
1996	-3.031	0.000	20.996	-4.588	0.000	11.839
1997	-3.211	0.000	22.611	-4.832	0.000	12.695
1998	-3.392	0.000	24.226	-5.075	0.000	13.551
1999	-3.572	0.000	25.840	-5.318	0.000	14.407
2000	-3.753	0.000	27.455	-5.561	0.000	15.262
2001	-3.905	0.000	29.126	-5.779	0.000	16.198
2002	-4.058	0.000	30.797	-5.997	0.000	17.134
2003	-4.211	0.000	32.468	-6.216	0.000	18.070
2004	-4.363	0.000	34.139	-6.434	0.000	19.006
2005	-4.516	0.000	35.810	-6.652	0.000	19.942
2006	-4.668	0.000	37.725	-6.892	0.000	21.091
2007	-4.820	0.000	39.641	-7.132	0.000	22.239
2008	-4.973	0.000	41.556	-7.372	0.000	23.388
2009	-5.125	0.000	43.472	-7.612	0.000	24.536
2010	-5.277	0.000	45.388	-7.852	0.000	25.685

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1018.53	941.60	24.58	92.08	2076.79
1982	1057.54	1007.83	24.85	100.16	2190.38
1983	1096.54	1074.07	25.13	108.24	2303.98
1984	1135.54	1140.31	25.40	116.32	2417.57
1985	1174.55	1206.55	25.68	124.40	2531.17
1986	1195.98	1234.59	26.20	137.89	2594.67
1987	1217.41	1262.64	26.73	151.38	2658.16
1988	1238.84	1290.68	27.26	164.88	2721.66
1989	1260.28	1318.73	27.79	178.37	2785.16
1990	1281.71	1346.77	28.31	191.86	2848.65
1991	1295.48	1365.61	28.58	195.13	2884.79
1992	1309.25	1384.44	28.84	198.40	2920.93
1993	1323.02	1403.28	29.10	201.66	2957.06
1994	1336.79	1422.11	29.36	204.93	2993.20
1995	1350.56	1440.95	29.62	208.20	3029.33
1996	1368.97	1471.17	30.23	214.14	3084.50
1997	1387.37	1501.39	30.83	220.08	3139.68
1998	1405.78	1531.62	31.43	226.02	3194.85
1999	1424.19	1561.84	32.04	231.96	3250.02
2000	1442.59	1592.06	32.64	237.90	3305.19
2001	1467.93	1635.87	33.37	244.96	3382.14
2002	1493.27	1679.69	34.10	252.02	3459.08
2003	1518.61	1723.50	34.84	259.08	3536.03
2004	1543.95	1767.32	35.57	266.14	3612.97
2005	1569.29	1811.13	36.30	273.20	3689.92
2006	1602.75	1874.00	37.32	281.58	3795.64
2007	1636.21	1936.86	38.33	289.96	3901.36
2008	1669.67	1999.73	39.34	298.34	4007.08
2009	1703.13	2062.59	40.36	306.72	4112.80
2010	1736.59	2125.46	41.37	315.10	4218.52

SCENARIO: MED ; HE9--DOOR 50%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	190.09	228.70	6.74	0.00	425.53
1982	203.79	240.26	6.70	0.00	450.74
1983	217.48	251.82	6.66	0.00	475.96
1984	231.18	263.38	6.61	0.00	501.18
1985	244.87	274.95	6.57	0.00	526.39
1986	253.79	279.77	6.53	10.00	550.09
1987	262.70	284.59	6.49	20.00	573.79
1988	271.62	289.41	6.46	30.00	597.49
1989	280.54	294.23	6.42	40.00	621.18
1990	289.45	299.05	6.38	50.00	644.88
1991	297.27	302.90	6.50	50.00	656.68
1992	305.09	306.75	6.63	50.00	668.47
1993	312.91	310.60	6.75	50.00	680.26
1994	320.73	314.45	6.88	50.00	692.06
1995	328.54	318.30	7.00	50.00	703.85
1996	334.40	323.55	7.12	50.00	715.06
1997	340.25	328.80	7.23	50.00	726.28
1998	346.10	334.05	7.35	50.00	737.50
1999	351.95	339.30	7.46	50.00	748.71
2000	357.80	344.55	7.58	50.00	759.93
2001	364.49	351.86	7.73	50.00	774.07
2002	371.18	359.17	7.87	50.00	788.22
2003	377.86	366.48	8.02	50.00	802.37
2004	384.55	373.79	8.17	50.00	816.51
2005	391.24	381.10	8.31	50.00	830.66
2006	399.65	391.31	8.52	50.00	849.48
2007	408.05	401.52	8.72	50.00	868.30
2008	416.46	411.74	8.92	50.00	887.12
2009	424.87	421.95	9.12	50.00	905.94
2010	433.28	432.16	9.33	50.00	924.76

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2076.79	425.53	2502.32
1982	2190.38	450.74	2641.13
1983	2303.98	475.96	2779.94
1984	2417.57	501.18	2918.75
1985	2531.17	526.39	3057.56
1986	2594.67	550.09	3144.76
1987	2658.16	573.79	3231.95
1988	2721.66	597.49	3319.15
1989	2785.16	621.18	3406.34
1990	2848.65	644.88	3493.54
1991	2884.79	656.68	3541.47
1992	2920.93	668.47	3589.39
1993	2957.06	680.26	3637.32
1994	2993.20	692.06	3685.25
1995	3029.33	703.85	3733.18
1996	3084.50	715.06	3799.57
1997	3139.68	726.28	3865.96
1998	3194.85	737.50	3932.34
1999	3250.02	748.71	3998.73
2000	3305.19	759.93	4065.12
2001	3382.14	774.07	4156.21
2002	3459.08	788.22	4247.30
2003	3536.03	802.37	4338.39
2004	3612.97	816.51	4429.48
2005	3689.92	830.66	4520.58
2006	3795.64	849.48	4645.12
2007	3901.36	868.30	4769.66
2008	4007.08	887.12	4894.20
2009	4112.80	905.94	5018.74
2010	4218.52	924.76	5143.28

SCENARIO: MED : HE9--DOOR 50%--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	419.45	97.15	516.60
1982	442.39	102.91	545.30
1983	465.33	108.67	574.00
1984	488.27	114.42	602.70
1985	511.21	120.18	631.39
1986	524.81	125.59	650.40
1987	538.41	131.00	669.41
1988	552.01	136.40	688.41
1989	565.61	141.81	707.42
1990	579.21	147.22	726.43
1991	586.50	149.91	736.41
1992	593.79	152.60	746.40
1993	601.09	155.30	756.38
1994	608.38	157.99	766.37
1995	615.67	160.68	776.35
1996	626.73	163.24	789.98
1997	637.80	165.80	803.60
1998	648.86	168.36	817.23
1999	659.93	170.92	830.85
2000	670.99	173.48	844.48
2001	686.49	176.71	863.20
2002	701.98	179.94	881.93
2003	717.48	183.17	900.65
2004	732.97	186.40	919.38
2005	748.47	189.63	938.10
2006	769.81	193.93	963.74
2007	791.15	198.23	989.37
2008	812.48	202.52	1015.01
2009	833.82	206.82	1040.64
2010	855.16	211.12	1066.28

H10--DOR 30%

SCENARIO: MED : H10--DOR 30%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473. (0.000)	20314. (0.000)	8230. (0.000)	7486. (0.000)	71503. (0.000)
1985	45378. (0.000)	26204. (0.000)	10803. (0.000)	8567. (0.000)	90953. (0.000)
1990	53335. (0.000)	25877. (0.000)	12287. (0.000)	8460. (0.000)	99958. (0.000)
1995	58322. (0.000)	25893. (0.000)	13407. (0.000)	8333. (0.000)	105956. (0.000)
2000	62565. (0.000)	28717. (0.000)	14505. (0.000)	8187. (0.000)	113975. (0.000)
2005	67890. (0.000)	32568. (0.000)	15906. (0.000)	7833. (0.000)	124197. (0.000)
2010	74779. (0.000)	36272. (0.000)	17705. (0.000)	8667. (0.000)	137422. (0.000)

SCENARIO: MED : H10--DOR 30%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220. (0.000)	5287. (0.000)	1189. (0.000)	1617. (0.000)	15313. (0.000)
1985	10646. (0.000)	5573. (0.000)	2130. (0.000)	1693. (0.000)	20042. (0.000)
1990	10513. (0.000)	7743. (0.000)	2103. (0.000)	2197. (0.000)	22556. (0.000)
1995	12292. (0.000)	7841. (0.000)	2410. (0.000)	2339. (0.000)	24881. (0.000)
2000	13633. (0.000)	7703. (0.000)	3006. (0.000)	2298. (0.000)	26641. (0.000)
2005	15550. (0.000)	7549. (0.000)	3638. (0.000)	2252. (0.000)	28990. (0.000)
2010	17358. (0.000)	8483. (0.000)	4126. (0.000)	2061. (0.000)	32028. (0.000)

SCENARIO: MED : H10--DOR 30%--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089. (0.000)	7666. (0.000)	1991. (0.000)	1463. (0.000)	16209. (0.000)
1985	499. (0.000)	1496. (0.000)	119. (0.000)	292. (0.000)	2406. (0.000)
1990	587. (0.000)	1477. (0.000)	135. (0.000)	289. (0.000)	2488. (0.000)
1995	642. (0.000)	1050. (0.000)	147. (0.000)	284. (0.000)	2124. (0.000)
2000	688. (0.000)	1551. (0.000)	160. (0.000)	279. (0.000)	2678. (0.000)
2005	747. (0.000)	1759. (0.000)	175. (0.000)	464. (0.000)	3144. (0.000)
2010	823. (0.000)	1959. (0.000)	195. (0.000)	286. (0.000)	3262. (0.000)

SCENARIO: MED : H10--DOR 30%--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2948.	24.	794.	3884.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	117.	671.	23.	259.	1070.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	135.	448.	27.	80.	689.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	150.	440.	33.	78.	701.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	171.	431.	40.	77.	719.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	191.	458.	45.	216.	910.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H10--DOR 30%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.049	0.046	0.090	0.085
1995	0.050	0.047	0.090	0.085
2000	0.050	0.047	0.090	0.085
2005	0.050	0.047	0.090	0.085
2010	0.050	0.047	0.090	0.085

SCENARIO: MED ; H10--DOR 30%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.740	11.290
1985	1.930	1.700	9.090	7.640
1990	2.480	2.250	7.760	6.310
1995	2.530	2.300	6.740	5.290
2000	2.450	2.220	6.290	4.840
2005	2.360	2.130	5.820	4.370
2010	2.260	2.030	5.390	3.940

SCENARIO: MED : H10--DOR 30%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	7.750	7.200	7.830	7.500
1985	5.530	4.980	5.590	5.260
1990	4.730	4.180	4.770	4.440
1995	4.110	3.560	4.140	3.810
2000	3.830	3.280	3.860	3.530
2005	3.550	3.000	3.580	3.250
2010	3.280	2.730	3.310	2.980

SCENARIO: MED : H10--DOR 30%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6156.53	4837.21	13153.75
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	6030.91	4653.44	12894.34
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5958.55	4507.71	12726.25
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5988.13	4432.69	12730.82
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6062.15	4422.68	12844.84
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6129.36	4438.60	12977.96
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H10--DOR 30%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6182.93	3586.15	12305.07
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6434.60	3822.03	12862.63
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.00	6647.01	4075.11	13398.12
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.00	6789.50	4329.67	13865.18
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6859.08	4502.21	14177.30
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.01	6899.46	4655.98	14441.45
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; H10--DOR 30%--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9482.69 (0.000)	7932.11 (0.000)
1990	9938.71 (0.000)	8192.36 (0.000)
1995	10347.97 (0.000)	8467.59 (0.000)
2000	10908.81 (0.000)	8782.72 (0.000)
2005	11583.80 (0.000)	9137.18 (0.000)
2010	12397.12 (0.000)	9536.33 (0.000)

SCENARIO: MED ; H10--DOR 30%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION IN GWH

ANCHORAGE - COOK INLET

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.084	0.000	0.489	8.982	0.000	1.576
1982	12.167	0.000	0.978	17.964	0.000	3.151
1983	18.251	0.000	1.468	26.946	0.000	4.727
1984	24.335	0.000	1.957	35.928	0.000	6.303
1985	30.418	0.000	2.446	44.911	0.000	7.879
1986	34.989	0.000	0.021	51.115	0.000	8.519
1987	39.560	0.000	-2.404	57.319	0.000	9.160
1988	44.131	0.000	-4.829	63.524	0.000	9.800
1989	48.702	0.000	-7.255	69.728	0.000	10.441
1990	53.273	0.000	-9.680	75.933	0.000	11.082
1991	56.616	0.000	-10.438	80.910	0.000	12.591
1992	59.960	0.000	-11.195	85.887	0.000	14.101
1993	63.303	0.000	-11.953	90.863	0.000	15.611
1994	66.647	0.000	-12.711	95.840	0.000	17.120
1995	69.990	0.000	-13.469	100.817	0.000	18.630
1996	72.621	0.000	-12.949	105.400	0.000	20.786
1997	75.251	0.000	-12.428	109.983	0.000	22.942
1998	77.882	0.000	-11.908	114.565	0.000	25.098
1999	80.512	0.000	-11.387	119.148	0.000	27.254
2000	83.142	0.000	-10.867	123.731	0.000	29.410
2001	85.632	0.000	-9.329	128.697	0.000	32.471
2002	88.122	0.000	-7.791	133.664	0.000	35.532
2003	90.612	0.000	-6.254	138.630	0.000	38.593
2004	93.102	0.000	-4.716	143.597	0.000	41.654
2005	95.592	0.000	-3.178	148.563	0.000	44.715
2006	98.267	0.000	-0.613	154.705	0.000	49.150
2007	100.943	0.000	1.952	160.846	0.000	53.585
2008	103.618	0.000	4.517	166.987	0.000	58.021
2009	106.293	0.000	7.082	173.128	0.000	62.456
2010	108.969	0.000	9.647	179.270	0.000	66.891

SCENARIO: MED ; H10--DOR 30%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION IN GWH

GREATER FAIRBANKS

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	1.338	0.000	0.000	0.899
1982	0.000	0.000	2.676	0.000	0.000	1.798
1983	0.000	0.000	4.014	0.000	0.000	2.697
1984	0.000	0.000	5.352	0.000	0.000	3.596
1985	0.000	0.000	6.691	0.000	0.000	4.495
1986	-0.310	0.000	8.527	-0.511	0.000	5.526
1987	-0.620	0.000	10.363	-1.022	0.000	6.557
1988	-0.930	0.000	12.199	-1.533	0.000	7.588
1989	-1.240	0.000	14.035	-2.044	0.000	8.619
1990	-1.550	0.000	15.872	-2.555	0.000	9.650
1991	-1.791	0.000	18.093	-2.878	0.000	10.783
1992	-2.031	0.000	20.315	-3.200	0.000	11.916
1993	-2.271	0.000	22.536	-3.522	0.000	13.049
1994	-2.512	0.000	24.758	-3.844	0.000	14.183
1995	-2.752	0.000	26.979	-4.166	0.000	15.316
1996	-2.928	0.000	29.014	-4.407	0.000	16.423
1997	-3.104	0.000	31.049	-4.648	0.000	17.530
1998	-3.280	0.000	33.083	-4.889	0.000	18.637
1999	-3.456	0.000	35.118	-5.130	0.000	19.744
2000	-3.632	0.000	37.153	-5.371	0.000	20.851
2001	-3.784	0.000	39.361	-5.591	0.000	22.128
2002	-3.935	0.000	41.570	-5.811	0.000	23.405
2003	-4.087	0.000	43.778	-6.031	0.000	24.682
2004	-4.239	0.000	45.986	-6.251	0.000	25.959
2005	-4.391	0.000	48.195	-6.471	0.000	27.236
2006	-4.543	0.000	50.797	-6.712	0.000	28.848
2007	-4.696	0.000	53.399	-6.952	0.000	30.460
2008	-4.848	0.000	56.001	-7.193	0.000	32.072
2009	-5.001	0.000	58.604	-7.433	0.000	33.684
2010	-5.154	0.000	61.206	-7.674	0.000	35.296

SCENARIO: MED ; H10--DOR 30%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1016.33	937.25	24.51	92.08	2070.17
1982	1053.12	999.14	24.72	100.16	2177.14
1983	1089.92	1061.03	24.93	108.24	2284.11
1984	1126.71	1122.92	25.13	116.32	2391.08
1985	1163.51	1184.81	25.34	124.40	2498.06
1986	1179.87	1204.43	25.73	137.89	2547.92
1987	1196.22	1224.06	26.12	151.38	2597.79
1988	1212.58	1243.69	26.50	164.88	2647.65
1989	1228.94	1263.32	26.89	178.37	2697.52
1990	1245.30	1282.95	27.28	191.86	2747.38
1991	1254.62	1299.15	27.53	195.13	2776.43
1992	1263.94	1315.36	27.78	198.40	2805.47
1993	1273.26	1331.57	28.02	201.66	2834.52
1994	1282.58	1347.78	28.27	204.93	2863.56
1995	1291.90	1363.99	28.52	208.20	2892.61
1996	1309.27	1395.40	29.06	214.14	2947.87
1997	1326.63	1426.82	29.60	220.08	3003.13
1998	1343.99	1458.23	30.14	226.02	3058.39
1999	1361.36	1489.65	30.68	231.96	3113.65
2000	1378.72	1521.07	31.23	237.90	3168.91
2001	1403.55	1565.35	31.97	244.96	3245.83
2002	1428.38	1609.63	32.72	252.02	3322.75
2003	1453.21	1653.91	33.46	259.08	3399.67
2004	1478.04	1698.20	34.20	266.14	3476.59
2005	1502.88	1742.48	34.95	273.20	3553.50
2006	1535.27	1804.20	35.93	281.58	3656.98
2007	1567.66	1865.93	36.91	289.96	3760.46
2008	1600.06	1927.65	37.89	298.34	3863.94
2009	1632.45	1989.38	38.87	306.72	3967.42
2010	1664.84	2051.10	39.86	315.10	4070.90

SCENARIO: MED : H10--DOR 30%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	189.10	227.53	6.73	0.00	423.36
1982	201.80	237.93	6.67	0.00	446.40
1983	214.51	248.32	6.62	0.00	469.45
1984	227.22	258.72	6.56	0.00	492.50
1985	239.92	269.11	6.51	0.00	515.54
1986	247.10	272.22	6.45	10.00	535.77
1987	254.28	275.33	6.39	20.00	555.99
1988	261.46	278.43	6.33	30.00	576.21
1989	268.63	281.54	6.27	40.00	596.44
1990	275.81	284.64	6.21	50.00	616.66
1991	282.47	288.03	6.29	50.00	626.79
1992	289.14	291.41	6.37	50.00	636.92
1993	295.80	294.79	6.46	50.00	647.05
1994	302.47	298.17	6.54	50.00	657.18
1995	309.13	301.55	6.62	50.00	667.31
1996	314.48	306.81	6.74	50.00	678.02
1997	319.82	312.06	6.85	50.00	688.73
1998	325.17	317.32	6.96	50.00	699.45
1999	330.52	322.58	7.07	50.00	710.16
2000	335.86	327.84	7.18	50.00	720.88
2001	342.13	335.09	7.32	50.00	734.54
2002	348.40	342.34	7.46	50.00	748.20
2003	354.66	349.59	7.61	50.00	761.85
2004	360.93	356.84	7.75	50.00	775.51
2005	367.20	364.08	7.89	50.00	789.17
2006	375.05	373.94	8.09	50.00	807.08
2007	382.91	383.79	8.28	50.00	824.98
2008	390.76	393.64	8.48	50.00	842.89
2009	398.62	403.50	8.68	50.00	860.79
2010	406.48	413.35	8.87	50.00	878.70

SCENARIO: MED : H10--DOR 30%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2070.17	423.36	2493.52
1982	2177.14	446.40	2623.54
1983	2284.11	469.45	2753.56
1984	2391.08	492.50	2883.58
1985	2498.06	515.54	3013.60
1986	2547.92	535.77	3083.69
1987	2597.79	555.99	3153.78
1988	2647.65	576.21	3223.87
1989	2697.52	596.44	3293.96
1990	2747.38	616.66	3364.05
1991	2776.43	626.79	3403.22
1992	2805.47	636.92	3442.39
1993	2834.52	647.05	3481.57
1994	2863.56	657.18	3520.74
1995	2892.61	667.31	3559.92
1996	2947.87	678.02	3625.89
1997	3003.13	688.74	3691.87
1998	3058.39	699.45	3757.84
1999	3113.65	710.16	3823.82
2000	3168.91	720.88	3889.79
2001	3245.83	734.54	3980.37
2002	3322.75	748.20	4070.95
2003	3399.67	761.85	4161.52
2004	3476.59	775.51	4252.10
2005	3553.50	789.17	4342.68
2006	3656.98	807.08	4464.06
2007	3760.46	824.98	4585.44
2008	3863.94	842.89	4706.83
2009	3967.42	860.79	4828.21
2010	4070.90	878.70	4949.60

SCENARIO: MED ; H10--DOR 30%--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	418.09	96.66	514.75
1982	439.68	101.92	541.60
1983	461.26	107.18	568.44
1984	482.85	112.44	595.29
1985	504.43	117.70	622.13
1986	515.24	122.32	637.56
1987	526.04	126.93	652.98
1988	536.85	131.55	668.40
1989	547.66	136.16	683.82
1990	558.46	140.77	699.24
1991	564.30	143.09	707.39
1992	570.14	145.40	715.54
1993	575.98	147.71	723.70
1994	581.82	150.03	731.85
1995	587.66	152.34	740.00
1996	598.75	154.78	753.53
1997	609.83	157.23	767.06
1998	620.91	159.68	780.59
1999	632.00	162.12	794.12
2000	643.08	164.57	807.65
2001	658.57	167.69	826.25
2002	674.06	170.81	844.86
2003	689.55	173.92	863.47
2004	705.04	177.04	882.08
2005	720.53	180.16	900.69
2006	741.41	184.25	925.65
2007	762.28	188.34	950.62
2008	783.16	192.42	975.59
2009	804.04	196.51	1000.56
2010	824.92	200.60	1025.52

H13--DRI SCENARIO

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	46221.	26204.	10957.	8567.	91950.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	57890.	25877.	13301.	8460.	105528.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	65477.	30424.	15120.	8333.	119354.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	73969.	35452.	17215.	8532.	135167.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	83357.	40267.	19580.	9644.	152848.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	95227.	46455.	22589.	11057.	175327.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220.	5287.	1189.	1617.	15313.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	10646.	5866.	2130.	1764.	20406.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	11458.	7960.	2204.	2375.	23997.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	14936.	7841.	3392.	2339.	28507.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	17610.	8272.	4112.	2298.	32292.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	19820.	9636.	4672.	2349.	36477.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	22579.	11088.	5375.	2686.	41728.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; H13--DRI SCENARIO--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089.	7666.	1991.	1463.	16209.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	508.	1496.	121.	292.	2417.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	637.	1477.	146.	289.	2549.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	720.	1643.	166.	284.	2814.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	814.	1914.	189.	282.	3199.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	917.	2174.	215.	318.	3625.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	1048.	2509.	249.	365.	4169.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2655.	24.	722.	3519.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	126.	454.	24.	81.	686.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	164.	448.	37.	80.	729.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	194.	447.	45.	78.	764.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	218.	520.	51.	78.	867.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	248.	599.	59.	89.	995.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.054	0.051	0.092	0.087
1995	0.063	0.060	0.094	0.089
2000	0.069	0.066	0.096	0.091
2005	0.072	0.069	0.098	0.093
2010	0.075	0.072	0.100	0.095

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	1.730	1.500	12.730	11.290
1985	2.030	1.800	11.690	10.240
1990	3.450	3.220	16.010	14.560
1995	5.100	4.870	19.840	18.390
2000	5.750	5.520	23.120	21.670
2005	6.010	5.780	24.470	23.020
2010	6.360	6.130	26.230	24.780

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7.750	7.200	7.830	7.500
1985	7.120	6.570	7.180	6.850
1990	9.750	9.200	9.840	9.510
1995	12.080	11.530	12.190	11.860
2000	14.080	13.530	14.210	13.880
2005	14.900	14.350	15.040	14.710
2010	15.970	15.420	16.120	15.790

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6151.49	4821.87	13133.37
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	6020.51	4586.63	12817.14
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5960.28	4518.86	12739.14
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5993.14	4453.51	12756.65
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6062.51	4422.21	12844.72
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6127.20	4450.64	12987.84
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; H13--DRI SCENARIO--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2536.00	6178.98	3606.28	12321.25
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6448.88	3867.33	12922.21
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.00	6669.27	4051.73	13397.00
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.01	6792.94	4336.15	13875.10
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2815.99	6838.54	4543.84	14198.38
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.01	6886.76	4659.68	14432.46
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04	7495.70
	(0.000)	(0.000)
1985	9580.13	7972.03
	(0.000)	(0.000)
1990	10261.11	8300.29
	(0.000)	(0.000)
1995	11037.01	8695.07
	(0.000)	(0.000)
2000	11855.84	9088.00
	(0.000)	(0.000)
2005	12748.53	9500.23
	(0.000)	(0.000)
2010	13841.57	9968.76
	(0.000)	(0.000)

SCENARIO: MED : HI3--DRI SCENARIO--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE = COOK INLET

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.215	0.000	-1.763	9.359	0.000	-0.398
1982	12.429	0.000	-3.525	18.719	0.000	-0.796
1983	18.644	0.000	-5.288	28.078	0.000	-1.194
1984	24.858	0.000	-7.051	37.438	0.000	-1.592
1985	31.073	0.000	-8.814	46.797	0.000	-1.990
1986	12.181	0.000	5.970	60.349	0.000	-9.204
1987	-6.710	0.000	20.753	73.900	0.000	-16.418
1988	-25.601	0.000	35.536	87.452	0.000	-23.631
1989	-44.493	0.000	50.319	101.004	0.000	-30.845
1990	-63.384	0.000	65.102	114.555	0.000	-38.059
1991	-34.229	0.000	30.178	138.998	0.000	-50.751
1992	-5.073	0.000	-4.746	163.440	0.000	-63.443
1993	24.083	0.000	-39.670	187.882	0.000	-76.135
1994	53.238	0.000	-74.594	212.324	0.000	-88.827
1995	82.394	0.000	-109.518	236.766	0.000	-101.518
1996	88.961	0.000	-120.011	267.917	0.000	-116.816
1997	95.528	0.000	-130.505	299.068	0.000	-132.113
1998	102.095	0.000	-140.998	330.219	0.000	-147.410
1999	108.662	0.000	-151.491	361.370	0.000	-162.707
2000	115.229	0.000	-161.985	392.521	0.000	-178.004
2001	120.413	0.000	-169.698	427.317	0.000	-194.306
2002	125.597	0.000	-177.411	462.113	0.000	-210.608
2003	130.781	0.000	-185.124	496.909	0.000	-226.911
2004	135.964	0.000	-192.838	531.705	0.000	-243.213
2005	141.148	0.000	-200.551	566.502	0.000	-259.515
2006	146.608	0.000	-208.430	613.068	0.000	-280.912
2007	152.068	0.000	-216.308	659.634	0.000	-302.310
2008	157.529	0.000	-224.187	706.201	0.000	-323.707
2009	162.989	0.000	-232.065	752.767	0.000	-345.105
2010	168.449	0.000	-239.944	799.334	0.000	-366.502

SCENARIO: MED ; H13--ORI SCENARIO--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	0.357	0.000	0.000	0.243
1982	0.000	0.000	0.713	0.000	0.000	0.485
1983	0.000	0.000	1.070	0.000	0.000	0.728
1984	0.000	0.000	1.427	0.000	0.000	0.971
1985	0.000	0.000	1.784	0.000	0.000	1.213
1986	-0.197	0.000	0.414	-0.333	0.000	0.346
1987	-0.394	0.000	-0.956	-0.665	0.000	-0.521
1988	-0.590	0.000	-2.325	-0.998	0.000	-1.388
1989	-0.787	0.000	-3.695	-1.330	0.000	-2.256
1990	-0.984	0.000	-5.065	-1.663	0.000	-3.123
1991	-0.997	0.000	-7.697	-1.657	0.000	-4.584
1992	-1.010	0.000	-10.330	-1.651	0.000	-6.046
1993	-1.023	0.000	-12.962	-1.645	0.000	-7.507
1994	-1.036	0.000	-15.595	-1.639	0.000	-8.968
1995	-1.049	0.000	-18.228	-1.632	0.000	-10.430
1996	-0.877	0.000	-21.578	-1.343	0.000	-12.209
1997	-0.704	0.000	-24.929	-1.054	0.000	-13.989
1998	-0.532	0.000	-28.280	-0.765	0.000	-15.768
1999	-0.360	0.000	-31.631	-0.476	0.000	-17.548
2000	-0.187	0.000	-34.981	-0.187	0.000	-19.327
2001	0.148	0.000	-38.268	0.348	0.000	-21.050
2002	0.484	0.000	-41.555	0.883	0.000	-22.773
2003	0.820	0.000	-44.841	1.418	0.000	-24.496
2004	1.155	0.000	-48.128	1.954	0.000	-26.219
2005	1.491	0.000	-51.414	2.489	0.000	-27.942
2006	1.992	0.000	-55.168	3.300	0.000	-30.034
2007	2.494	0.000	-58.922	4.112	0.000	-32.126
2008	2.995	0.000	-62.676	4.924	0.000	-34.217
2009	3.496	0.000	-66.430	5.735	0.000	-36.309
2010	3.998	0.000	-70.183	6.547	0.000	-38.401

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1020.70	947.42	24.66	92.08	2084.86
1982	1061.86	1019.48	25.02	100.16	2206.52
1983	1103.02	1091.55	25.37	108.24	2328.18
1984	1144.19	1163.61	25.73	116.32	2449.85
1985	1185.35	1235.67	26.08	124.40	2571.51
1986	1218.45	1277.98	26.88	137.89	2661.21
1987	1251.55	1320.30	27.68	151.38	2750.91
1988	1284.65	1362.61	28.47	164.88	2840.61
1989	1317.75	1404.92	29.27	178.37	2930.30
1990	1350.85	1447.23	30.06	191.86	3020.00
1991	1390.20	1498.51	31.02	195.13	3114.86
1992	1429.55	1549.79	31.98	198.40	3209.71
1993	1468.89	1601.07	32.93	201.66	3304.57
1994	1508.24	1652.36	33.89	204.93	3399.42
1995	1547.59	1703.64	34.85	208.20	3494.28
1996	1592.28	1761.89	35.94	214.14	3604.25
1997	1636.97	1820.15	37.03	220.08	3714.23
1998	1681.66	1878.40	38.12	226.02	3824.21
1999	1726.34	1936.66	39.22	231.96	3934.18
2000	1771.03	1994.92	40.31	237.90	4044.16
2001	1821.37	2067.29	41.61	244.96	4175.22
2002	1871.70	2139.66	42.90	252.02	4306.28
2003	1922.03	2212.03	44.20	259.08	4437.34
2004	1972.36	2284.41	45.50	266.14	4568.41
2005	2022.69	2356.78	46.79	273.20	4699.47
2006	2087.88	2462.19	48.59	281.58	4880.23
2007	2153.06	2567.59	50.38	289.96	5061.00
2008	2218.25	2673.00	52.18	298.34	5241.77
2009	2283.43	2778.41	53.97	306.72	5422.53
2010	2348.61	2883.82	55.77	315.10	5603.30

SCENARIO: MED ; H13--ORI SCENARIO--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	191.04	230.11	6.75	0.00	427.90
1982	205.69	243.08	6.72	0.00	455.50
1983	220.34	256.05	6.69	0.00	483.09
1984	234.99	269.03	6.66	0.00	510.68
1985	249.65	282.00	6.63	0.00	538.27
1986	262.95	290.40	6.68	10.00	570.03
1987	276.24	298.79	6.74	20.00	601.78
1988	289.54	307.19	6.80	30.00	633.53
1989	302.84	315.59	6.85	40.00	665.28
1990	316.14	323.98	6.91	50.00	697.03
1991	333.15	336.63	7.22	50.00	727.00
1992	350.16	349.29	7.53	50.00	756.98
1993	367.17	361.94	7.84	50.00	786.95
1994	384.18	374.59	8.15	50.00	816.92
1995	401.18	387.25	8.46	50.00	846.89
1996	417.59	400.54	8.77	50.00	876.90
1997	434.00	413.82	9.08	50.00	906.90
1998	450.41	427.11	9.38	50.00	936.91
1999	466.81	440.40	9.69	50.00	966.91
2000	483.22	453.69	10.00	50.00	996.92
2001	500.15	468.65	10.34	50.00	1029.13
2002	517.07	483.60	10.67	50.00	1061.34
2003	533.99	498.55	11.01	50.00	1093.56
2004	550.92	513.51	11.34	50.00	1125.77
2005	567.84	528.46	11.68	50.00	1157.98
2006	587.96	548.76	12.10	50.00	1198.82
2007	608.07	569.05	12.53	50.00	1239.65
2008	628.19	589.35	12.95	50.00	1280.49
2009	648.31	609.64	13.38	50.00	1321.33
2010	668.42	629.94	13.80	50.00	1362.17

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2084.86	427.90	2512.76
1982	2206.52	455.50	2662.02
1983	2328.19	483.09	2811.27
1984	2449.85	510.68	2960.53
1985	2571.51	538.27	3109.79
1986	2661.21	570.03	3231.24
1987	2750.91	601.78	3352.69
1988	2840.61	633.53	3474.13
1989	2930.30	665.28	3595.58
1990	3020.00	697.03	3717.03
1991	3114.86	727.00	3841.86
1992	3209.71	756.98	3966.69
1993	3304.57	786.95	4091.52
1994	3399.42	816.92	4216.34
1995	3494.28	846.89	4341.17
1996	3604.25	876.90	4481.15
1997	3714.23	906.90	4621.13
1998	3824.21	936.91	4761.11
1999	3934.18	966.91	4901.09
2000	4044.16	996.92	5041.07
2001	4175.22	1029.13	5204.35
2002	4306.28	1061.34	5367.62
2003	4437.34	1093.56	5530.90
2004	4568.41	1125.77	5694.17
2005	4699.47	1157.98	5857.45
2006	4880.23	1198.82	6079.05
2007	5061.00	1239.65	6300.65
2008	5241.77	1280.49	6522.26
2009	5422.53	1321.33	6743.86
2010	5603.30	1362.16	6965.46

SCENARIO: MED : H13--DRI SCENARIO--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	421.10	97.69	518.80
1982	445.70	103.99	549.69
1983	470.29	110.29	580.58
1984	494.88	116.59	611.48
1985	519.48	122.89	642.37
1986	538.44	130.14	668.58
1987	557.41	137.39	694.79
1988	576.37	144.63	721.01
1989	595.34	151.88	747.22
1990	614.31	159.12	773.43
1991	633.63	165.97	799.59
1992	652.95	172.81	825.76
1993	672.27	179.65	851.92
1994	691.59	186.50	878.08
1995	710.91	193.34	904.25
1996	733.20	200.19	933.39
1997	755.49	207.04	962.53
1998	777.78	213.89	991.67
1999	800.07	220.74	1020.81
2000	822.36	227.59	1049.95
2001	848.94	234.95	1083.89
2002	875.52	242.30	1117.82
2003	902.10	249.65	1151.75
2004	928.68	257.01	1185.69
2005	955.26	264.36	1219.62
2006	991.97	273.69	1265.66
2007	1028.68	283.01	1311.69
2008	1065.39	292.33	1357.73
2009	1102.10	301.66	1403.76
2010	1138.81	310.98	1449.80

HE4--FERC +2%

SCENARIO: MED : HE4--FERC +2%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	49087.	26204.	11492.	8567.	95350.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	60172.	27154.	13825.	8460.	109610.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	68038.	32432.	15710.	7838.	124018.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	77967.	37415.	18157.	9000.	142539.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	83688.	40234.	19609.	9652.	153183.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	89784.	43445.	21214.	10374.	164816.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220. (0.000)	5287. (0.000)	1189. (0.000)	1617. (0.000)	15313. (0.000)
1985	10646. (0.000)	5868. (0.000)	2130. (0.000)	1765. (0.000)	20408. (0.000)
1990	11471. (0.000)	7960. (0.000)	2208. (0.000)	2375. (0.000)	24013. (0.000)
1995	14934. (0.000)	7841. (0.000)	3391. (0.000)	2339. (0.000)	28505. (0.000)
2000	17859. (0.000)	8432. (0.000)	4173. (0.000)	2298. (0.000)	32762. (0.000)
2005	19118. (0.000)	9257. (0.000)	4496. (0.000)	2259. (0.000)	35129. (0.000)
2010	20455. (0.000)	9976. (0.000)	4852. (0.000)	2422. (0.000)	37705. (0.000)

SCENARIO: MED ; HE4--FERC +2X--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089. (0.000)	7666. (0.000)	1991. (0.000)	1463. (0.000)	16209. (0.000)
1985	540. (0.000)	1496. (0.000)	126. (0.000)	292. (0.000)	2455. (0.000)
1990	662. (0.000)	200. (0.000)	152. (0.000)	289. (0.000)	1303. (0.000)
1995	748. (0.000)	1751. (0.000)	173. (0.000)	780. (0.000)	3452. (0.000)
2000	858. (0.000)	2020. (0.000)	200. (0.000)	297. (0.000)	3375. (0.000)
2005	921. (0.000)	2173. (0.000)	216. (0.000)	319. (0.000)	3627. (0.000)
2010	988. (0.000)	2346. (0.000)	233. (0.000)	342. (0.000)	3909. (0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653. (0.000)	3320. (0.000)	986. (0.000)	895. (0.000)	8854. (0.000)
1985	118. (0.000)	2653. (0.000)	24. (0.000)	722. (0.000)	3517. (0.000)
1990	126. (0.000)	454. (0.000)	24. (0.000)	81. (0.000)	686. (0.000)
1995	164. (0.000)	448. (0.000)	37. (0.000)	80. (0.000)	729. (0.000)
2000	196. (0.000)	455. (0.000)	46. (0.000)	78. (0.000)	776. (0.000)
2005	210. (0.000)	500. (0.000)	50. (0.000)	70. (0.000)	830. (0.000)
2010	225. (0.000)	539. (0.000)	53. (0.000)	80. (0.000)	897. (0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	0.037	0.034	0.095	0.091
1985	0.048	0.045	0.095	0.090
1990	0.053	0.050	0.092	0.087
1995	0.058	0.055	0.094	0.089
2000	0.062	0.059	0.096	0.091
2005	0.065	0.062	0.098	0.093
2010	0.067	0.064	0.100	0.095

SCENARIO: MED : HE4--FERC +2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.740	11.290
1985	2.030	1.800	13.040	11.640
1990	3.190	2.960	14.390	12.850
1995	4.260	4.030	15.890	14.190
2000	4.590	4.360	17.540	15.670
2005	4.950	4.720	19.370	17.300
2010	5.340	5.110	21.390	19.100

SCENARIO: MED : HE4--FERC +2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7,750	7.200	7,830	7.500
1985	7.940	7.420	8.010	7.730
1990	8.760	8.190	8.840	8.530
1995	9.680	9,040	9,760	9.420
2000	10.680	9.980	10.780	10.400
2005	11.790	11.020	11.900	11.480
2010	13.020	12.170	13,140	12.680

SCENARIO: MED : HE4--FERC +2%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6092.53	4771.61	13024.14
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	5975.94	4579.46	12765.40
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5921.30	4533.47	12714.77
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5957.22	4447.64	12714.86
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6020.37	4409.15	12789.53
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6082.00	4436.52	12928.52
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6178.92	3606.37	12321.28
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6449.03	3867.59	12922.62
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.01	6669.22	4051.72	13396.95
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2745.99	6792.90	4343.48	13882.37
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.01	6834.89	4530.64	14181.53
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.00	6882.97	4649.81	14418.78
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9580.61 (0.000)	7972.19 (0.000)
1990	10265.04 (0.000)	8301.47 (0.000)
1995	11033.75 (0.000)	8694.21 (0.000)
2000	11962.09 (0.000)	9116.49 (0.000)
2005	12402.03 (0.000)	9396.87 (0.000)
2010	13012.53 (0.000)	9734.70 (0.000)

SCENARIO: MED : HE4--FERC +2%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.432	0.000	-2.535	9.395	0.000	-1.192
1982	12.864	0.000	-5.070	18.791	0.000	-2.384
1983	19.295	0.000	-7.605	28.186	0.000	-3.577
1984	25.727	0.000	-10.140	37.581	0.000	-4.769
1985	32.159	0.000	-12.675	46.977	0.000	-5.961
1986	48.583	0.000	-31.447	59.313	0.000	-11.184
1987	65.006	0.000	-50.219	71.648	0.000	-16.406
1988	81.430	0.000	-68.991	83.984	0.000	-21.629
1989	97.854	0.000	-87.764	96.320	0.000	-26.852
1990	114.278	0.000	-106.536	108.656	0.000	-32.074
1991	104.421	0.000	-100.885	126.217	0.000	-40.346
1992	94.563	0.000	-95.233	143.778	0.000	-48.617
1993	84.706	0.000	-89.582	161.340	0.000	-56.888
1994	74.848	0.000	-83.931	178.901	0.000	-65.160
1995	64.991	0.000	-78.280	196.462	0.000	-73.431
1996	70.999	0.000	-86.893	220.462	0.000	-83.796
1997	77.007	0.000	-95.505	244.461	0.000	-94.160
1998	83.015	0.000	-104.118	268.460	0.000	-104.525
1999	89.023	0.000	-112.731	292.459	0.000	-114.890
2000	95.031	0.000	-121.343	316.458	0.000	-125.255
2001	99.122	0.000	-127.484	333.871	0.000	-133.350
2002	103.212	0.000	-133.625	351.284	0.000	-141.445
2003	107.303	0.000	-139.766	368.697	0.000	-149.540
2004	111.393	0.000	-145.907	386.110	0.000	-157.636
2005	115.483	0.000	-152.048	403.523	0.000	-165.731
2006	120.229	0.000	-159.608	424.148	0.000	-176.140
2007	124.974	0.000	-167.168	444.773	0.000	-186.548
2008	129.719	0.000	-174.728	465.398	0.000	-196.957
2009	134.464	0.000	-182.288	486.024	0.000	-207.366
2010	139.210	0.000	-189.848	506.649	0.000	-217.775

SCENARIO: MED : HE4--FERC +2%--6/24/1983 ITERATIONS = 1

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	-0.097	-0.097	0.000	-0.080
1982	0.000	0.000	-0.195	-0.194	0.000	-0.159
1983	0.000	0.000	-0.292	-0.292	0.000	-0.239
1984	0.000	0.000	-0.390	-0.389	0.000	-0.319
1985	0.000	0.000	-0.487	-0.486	0.000	-0.398
1986	-0.197	0.000	-1.095	-0.886	0.000	-0.750
1987	-0.394	0.000	-1.702	-1.286	0.000	-1.102
1988	-0.591	0.000	-2.310	-1.686	0.000	-1.453
1989	-0.788	0.000	-2.918	-2.086	0.000	-1.805
1990	-0.984	0.000	-3.525	-2.486	0.000	-2.157
1991	-0.997	0.000	-4.723	-2.543	0.000	-2.786
1992	-1.010	0.000	-5.921	-2.599	0.000	-3.414
1993	-1.023	0.000	-7.119	-2.655	0.000	-4.043
1994	-1.036	0.000	-8.317	-2.711	0.000	-4.672
1995	-1.049	0.000	-9.515	-2.767	0.000	-5.301
1996	-0.877	0.000	-11.313	-2.541	0.000	-6.240
1997	-0.705	0.000	-13.110	-2.315	0.000	-7.179
1998	-0.534	0.000	-14.908	-2.089	0.000	-8.117
1999	-0.362	0.000	-16.705	-1.862	0.000	-9.056
2000	-0.190	0.000	-18.503	-1.636	0.000	-9.994
2001	0.135	0.000	-20.543	-1.160	0.000	-10.919
2002	0.460	0.000	-22.582	-0.684	0.000	-11.844
2003	0.784	0.000	-24.622	-0.207	0.000	-12.769
2004	1.109	0.000	-26.662	0.269	0.000	-13.694
2005	1.434	0.000	-28.702	0.745	0.000	-14.619
2006	1.869	0.000	-31.132	1.366	0.000	-15.783
2007	2.304	0.000	-33.562	1.987	0.000	-16.947
2008	2.738	0.000	-35.992	2.607	0.000	-18.112
2009	3.173	0.000	-38.422	3.228	0.000	-19.276
2010	3.608	0.000	-40.852	3.849	0.000	-20.440

SCENARIO: MED : HE4--FERC +2%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1028.10	948.22	24.75	92.08	2093.15
1982	1076.67	1021.08	25.20	100.16	2223.11
1983	1125.23	1093.95	25.65	108.24	2353.07
1984	1173.80	1166.81	26.10	116.32	2483.03
1985	1222.37	1239.67	26.55	124.40	2612.99
1986	1256.19	1281.56	27.27	137.89	2702.91
1987	1290.01	1323.44	28.00	151.38	2792.83
1988	1323.83	1365.32	28.72	164.88	2882.75
1989	1357.65	1407.21	29.44	178.37	2972.67
1990	1391.47	1449.09	30.17	191.86	3062.59
1991	1431.21	1502.08	31.26	195.13	3159.68
1992	1470.94	1555.07	32.35	198.40	3256.76
1993	1510.68	1608.06	33.44	201.66	3353.85
1994	1550.41	1661.05	34.54	204.93	3450.93
1995	1590.15	1714.04	35.63	208.20	3548.02
1996	1639.85	1788.21	36.91	214.14	3679.12
1997	1689.56	1862.38	38.19	220.08	3810.21
1998	1739.27	1936.55	39.47	226.02	3941.31
1999	1788.97	2010.73	40.75	231.96	4072.41
2000	1838.68	2084.90	42.03	237.90	4203.50
2001	1870.08	2106.37	42.60	244.96	4264.02
2002	1901.49	2127.85	43.17	252.02	4324.53
2003	1932.89	2149.33	43.74	259.08	4385.04
2004	1964.30	2170.81	44.31	266.14	4445.56
2005	1995.70	2192.29	44.88	273.20	4506.07
2006	2032.86	2236.00	45.74	281.58	4596.17
2007	2070.01	2279.72	46.59	289.96	4686.28
2008	2107.16	2323.43	47.45	298.34	4776.38
2009	2144.31	2367.15	48.30	306.72	4866.48
2010	2181.47	2410.86	49.16	315.10	4956.58

SCENARIO: MED : ME4--FERC +2X--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	191.50	230.54	6.76	0.00	428.80
1982	206.61	243.94	6.74	0.00	457.29
1983	221.72	257.34	6.72	0.00	485.77
1984	236.83	270.74	6.69	0.00	514.26
1985	251.94	284.14	6.67	0.00	542.75
1986	264.52	292.14	6.72	10.00	573.37
1987	277.09	300.14	6.76	20.00	604.00
1988	289.67	308.14	6.81	30.00	634.62
1989	302.25	316.15	6.85	40.00	665.25
1990	314.83	324.15	6.90	50.00	695.87
1991	330.35	335.92	7.18	50.00	723.45
1992	345.87	347.69	7.47	50.00	751.03
1993	361.40	359.46	7.76	50.00	778.61
1994	376.92	371.23	8.04	50.00	806.19
1995	392.44	383.00	8.33	50.00	833.77
1996	408.66	397.45	8.65	50.00	864.75
1997	424.87	411.90	8.97	50.00	895.74
1998	441.08	426.35	9.29	50.00	926.72
1999	457.30	440.80	9.61	50.00	957.70
2000	473.51	455.25	9.93	50.00	988.69
2001	483.90	460.29	10.09	50.00	1004.28
2002	494.29	465.33	10.26	50.00	1019.87
2003	504.67	470.37	10.42	50.00	1035.47
2004	515.06	475.41	10.58	50.00	1051.06
2005	525.45	480.46	10.75	50.00	1066.65
2006	536.54	489.28	10.96	50.00	1086.78
2007	547.63	498.10	11.17	50.00	1106.90
2008	558.72	506.93	11.38	50.00	1127.03
2009	569.81	515.75	11.59	50.00	1147.15
2010	580.90	524.58	11.80	50.00	1167.28

SCENARIO: MED ; HE4--FERC +2%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2093.15	428.80	2521.95
1982	2223.11	457.29	2680.40
1983	2353.07	485.77	2838.84
1984	2483.03	514.26	2997.29
1985	2612.99	542.75	3155.74
1986	2702.91	573.37	3276.28
1987	2792.83	604.00	3396.83
1988	2882.75	634.62	3517.37
1989	2972.67	665.25	3637.92
1990	3062.59	695.87	3758.46
1991	3159.68	723.45	3883.13
1992	3256.76	751.03	4007.79
1993	3353.85	778.61	4132.46
1994	3450.93	806.19	4257.13
1995	3548.02	833.77	4381.79
1996	3679.12	864.75	4543.87
1997	3810.21	895.74	4705.95
1998	3941.31	926.72	4868.03
1999	4072.41	957.70	5030.11
2000	4203.50	988.69	5192.19
2001	4264.02	1004.28	5268.30
2002	4324.53	1019.87	5344.40
2003	4385.04	1035.47	5420.51
2004	4445.56	1051.06	5496.62
2005	4506.07	1066.65	5572.73
2006	4596.17	1086.78	5682.95
2007	4686.28	1106.90	5793.18
2008	4776.38	1127.03	5903.41
2009	4866.48	1147.15	6013.63
2010	4956.58	1167.28	6123.86

SCENARIO: MED : HE4--FERC +2%--6/29/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	422.80	97.90	520.70
1982	449.09	104.40	553.50
1983	475.39	110.91	586.29
1984	501.68	117.41	619.09
1985	527.97	123.91	651.89
1986	546.98	130.90	677.89
1987	566.00	137.89	703.89
1988	585.01	144.88	729.89
1989	604.02	151.87	755.89
1990	623.03	158.86	781.89
1991	642.81	165.16	807.96
1992	662.58	171.45	834.04
1993	682.36	177.75	860.11
1994	702.14	184.05	886.19
1995	721.92	190.34	912.26
1996	748.53	197.42	945.95
1997	775.15	204.49	979.64
1998	801.77	211.56	1013.33
1999	828.38	218.64	1047.02
2000	855.00	225.71	1080.71
2001	867.13	229.27	1096.40
2002	879.26	232.83	1112.09
2003	891.39	236.39	1127.78
2004	903.52	239.95	1143.47
2005	915.65	243.51	1159.16
2006	933.79	248.11	1181.89
2007	951.93	252.70	1204.63
2008	970.06	257.30	1227.36
2009	988.20	261.89	1250.10
2010	1006.34	266.49	1272.83

HE6--FERC 0%

SCENARIO: MED : HE6--FERC 0%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	46227.	26204.	10958.	8567.	91956.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	57906.	25877.	13305.	8460.	105548.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	66094.	30810.	15267.	8333.	120504.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	69668.	33140.	16151.	7996.	126955.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	74507.	35689.	17432.	8579.	136207.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	80943.	39158.	19133.	9360.	148594.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE6--FERC 0%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220. (0.000)	5287. (0.000)	1189. (0.000)	1617. (0.000)	15313. (0.000)
1985	10646. (0.000)	5867. (0.000)	2130. (0.000)	1765. (0.000)	20407. (0.000)
1990	11463. (0.000)	7960. (0.000)	2206. (0.000)	2375. (0.000)	24003. (0.000)
1995	15138. (0.000)	7841. (0.000)	3448. (0.000)	2339. (0.000)	28766. (0.000)
2000	16384. (0.000)	7703. (0.000)	3807. (0.000)	2298. (0.000)	30192. (0.000)
2005	17555. (0.000)	8293. (0.000)	4123. (0.000)	2252. (0.000)	32223. (0.000)
2010	18976. (0.000)	9253. (0.000)	4503. (0.000)	2249. (0.000)	34981. (0.000)

SCENARIO: MED : HE6--FERC 0%--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089.	7666.	1991.	1463.	16209.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	508.	1496.	121.	292.	2417.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	637.	1477.	146.	289.	2549.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	727.	1664.	168.	284.	2843.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	766.	1790.	178.	471.	3204.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	820.	1927.	192.	283.	3222.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	890.	2115.	211.	309.	3524.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; HE6--FERC 0%--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2654.	24.	722.	3518.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	126.	454.	24.	81.	686.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	167.	448.	38.	80.	732.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	180.	440.	42.	78.	740.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	193.	448.	45.	77.	763.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	209.	500.	50.	28.	786.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE6--FERC 0%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.090	0.090
1990	0.052	0.049	0.090	0.085
1995	0.057	0.054	0.090	0.085
2000	0.059	0.056	0.090	0.085
2005	0.061	0.058	0.090	0.085
2010	0.063	0.060	0.090	0.085

SCENARIO: MED ; HE6--FERC 0%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.740	11.290
1985	2.010	1.780	12.530	11.190
1990	2.960	2.730	12.530	11.190
1995	3.600	3.370	12.530	11.190
2000	3.600	3.370	12.530	11.190
2005	3.600	3.370	12.530	11.190
2010	3.600	3.370	12.530	11.190

SCENARIO: MED : HE6--FERC 0%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	7.750	7.200	7.830	7.500
1985	7.630	7.130	7.700	7.430
1990	7.630	7.130	7.700	7.430
1995	7.630	7.130	7.700	7.430
2000	7.630	7.130	7.700	7.430
2005	7.630	7.130	7.700	7.430
2010	7.630	7.130	7.700	7.430

SCENARIO: MED : HE6--FERC 0%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00 (0.000)	6500.63 (0.000)	5088.52 (0.000)	13699.15 (0.000)
1985	2160.00 (0.000)	6151.46 (0.000)	4821.78 (0.000)	13133.24 (0.000)
1990	2210.00 (0.000)	6020.48 (0.000)	4586.40 (0.000)	12816.88 (0.000)
1995	2260.00 (0.000)	5960.98 (0.000)	4519.96 (0.000)	12740.94 (0.000)
2000	2310.00 (0.000)	5988.06 (0.000)	4448.08 (0.000)	12746.15 (0.000)
2005	2360.00 (0.000)	6058.34 (0.000)	4418.39 (0.000)	12836.73 (0.000)
2010	2410.00 (0.000)	6123.00 (0.000)	4442.09 (0.000)	12975.09 (0.000)

SCENARIO: MED ; HE6--FERC 0%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6178.96	3606.31	12321.26
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6448.89	3867.42	12922.31
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.01	6671.50	4053.33	13400.83
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.00	6793.18	4305.72	13844.90
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6845.70	4517.20	14178.90
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.00	6887.94	4656.67	14430.61
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE6--FERC 0%--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9580.53 (0.000)	7972.14 (0.000)
1990	10261.82 (0.000)	8300.55 (0.000)
1995	11085.42 (0.000)	8707.76 (0.000)
2000	11354.10 (0.000)	8933.71 (0.000)
2005	11929.05 (0.000)	9252.44 (0.000)
2010	12707.16 (0.000)	9636.33 (0.000)

SCENARIO: MED : HE6--FERC 0%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.230	0.000	-2.058	9.380	0.000	-0.867
1982	12.460	0.000	-4.115	18.761	0.000	-1.734
1983	18.690	0.000	-6.173	28.141	0.000	-2.601
1984	24.921	0.000	-8.231	37.521	0.000	-3.468
1985	31.151	0.000	-10.289	46.901	0.000	-4.335
1986	39.633	0.000	-19.595	57.965	0.000	-7.924
1987	48.114	0.000	-28.901	69.028	0.000	-11.514
1988	56.596	0.000	-38.207	80.091	0.000	-15.104
1989	65.078	0.000	-47.513	91.154	0.000	-18.694
1990	73.560	0.000	-56.819	102.217	0.000	-22.284
1991	97.694	0.000	-81.498	118.837	0.000	-27.222
1992	121.827	0.000	-106.177	135.456	0.000	-32.160
1993	145.961	0.000	-130.856	152.075	0.000	-37.098
1994	170.095	0.000	-155.535	168.695	0.000	-42.036
1995	194.228	0.000	-180.213	185.314	0.000	-46.974
1996	214.849	0.000	-199.927	194.644	0.000	-49.288
1997	235.469	0.000	-219.640	203.973	0.000	-51.601
1998	256.089	0.000	-239.353	213.303	0.000	-53.914
1999	276.709	0.000	-259.067	222.633	0.000	-56.227
2000	297.330	0.000	-278.780	231.963	0.000	-58.541
2001	300.545	0.000	-279.925	244.670	0.000	-61.072
2002	303.760	0.000	-281.070	257.377	0.000	-63.603
2003	306.975	0.000	-282.216	270.084	0.000	-66.134
2004	310.189	0.000	-283.361	282.791	0.000	-68.665
2005	313.404	0.000	-284.506	295.498	0.000	-71.196
2006	316.619	0.000	-284.681	312.729	0.000	-74.282
2007	319.833	0.000	-284.856	329.960	0.000	-77.368
2008	323.047	0.000	-285.030	347.190	0.000	-80.453
2009	326.261	0.000	-285.205	364.421	0.000	-83.539
2010	329.476	0.000	-285.380	381.652	0.000	-86.625

SCENARIO: MED : HE6--FERC 0X--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	-0.267	0.000	0.070	0.000	0.000	0.024
1982	-0.533	0.000	0.140	0.000	0.000	0.048
1983	-0.800	0.000	0.209	0.000	0.000	0.072
1984	-1.066	0.000	0.279	0.000	0.000	0.096
1985	-1.333	0.000	0.349	0.000	0.000	0.120
1986	-1.572	0.000	0.412	-0.552	0.000	0.136
1987	-1.812	0.000	0.474	-1.105	0.000	0.153
1988	-2.051	0.000	0.537	-1.657	0.000	0.170
1989	-2.291	0.000	0.599	-2.210	0.000	0.186
1990	-2.530	0.000	0.662	-2.762	0.000	0.203
1991	-2.772	0.000	0.725	-3.201	0.000	0.219
1992	-3.013	0.000	0.788	-3.640	0.000	0.234
1993	-3.254	0.000	0.851	-4.079	0.000	0.250
1994	-3.496	0.000	0.914	-4.517	0.000	0.266
1995	-3.737	0.000	0.977	-4.956	0.000	0.282
1996	-3.869	0.000	1.012	-5.147	0.000	0.287
1997	-4.001	0.000	1.046	-5.338	0.000	0.292
1998	-4.133	0.000	1.081	-5.529	0.000	0.297
1999	-4.266	0.000	1.115	-5.720	0.000	0.303
2000	-4.398	0.000	1.150	-5.911	0.000	0.308
2001	-4.520	0.000	1.182	-6.109	0.000	0.315
2002	-4.643	0.000	1.214	-6.306	0.000	0.323
2003	-4.766	0.000	1.246	-6.504	0.000	0.331
2004	-4.888	0.000	1.278	-6.701	0.000	0.338
2005	-5.011	0.000	1.310	-6.898	0.000	0.346
2006	-5.140	0.000	1.344	-7.131	0.000	0.356
2007	-5.269	0.000	1.377	-7.364	0.000	0.367
2008	-5.399	0.000	1.411	-7.596	0.000	0.377
2009	-5.528	0.000	1.445	-7.829	0.000	0.387
2010	-5.657	0.000	1.479	-8.062	0.000	0.397

SCENARIO: MED : HE6--FERC 0%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1020.99	947.90	24.67	92.08	2085.64
1982	1062.45	1020.45	25.03	100.16	2208.09
1983	1103.90	1093.00	25.40	108.24	2330.54
1984	1145.36	1165.55	25.76	116.32	2452.99
1985	1186.82	1238.09	26.12	124.40	2575.43
1986	1216.67	1279.30	26.88	137.89	2660.74
1987	1246.51	1320.51	27.63	151.38	2746.04
1988	1276.36	1361.72	28.38	164.88	2831.34
1989	1306.21	1402.93	29.13	178.37	2916.64
1990	1336.06	1444.14	29.89	191.86	3001.94
1991	1373.11	1500.82	30.88	195.13	3099.94
1992	1410.16	1557.51	31.87	198.40	3197.94
1993	1447.21	1614.19	32.86	201.66	3295.93
1994	1484.27	1670.88	33.86	204.93	3393.93
1995	1521.32	1727.56	34.85	208.20	3491.93
1996	1536.98	1729.95	35.07	214.14	3516.14
1997	1552.65	1732.35	35.28	220.08	3540.36
1998	1568.31	1734.74	35.50	226.02	3564.57
1999	1583.97	1737.13	35.72	231.96	3588.79
2000	1599.64	1739.53	35.94	237.90	3613.00
2001	1623.62	1773.72	36.55	244.96	3678.84
2002	1647.60	1807.91	37.15	252.02	3744.68
2003	1671.59	1842.09	37.76	259.08	3810.52
2004	1695.57	1876.28	38.36	266.14	3876.36
2005	1719.55	1910.47	38.97	273.20	3942.20
2006	1752.43	1968.24	39.92	281.58	4042.17
2007	1785.30	2026.01	40.88	289.96	4142.15
2008	1818.18	2083.78	41.84	298.34	4242.13
2009	1851.05	2141.54	42.79	306.72	4342.11
2010	1883.92	2199.31	43.75	315.10	4442.08

SCENARIO: MED : HE6--FERC 0%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	191.60	230.33	6.76	0.00	428.69
1982	206.81	243.53	6.74	0.00	457.07
1983	222.01	256.73	6.71	0.00	485.45
1984	237.22	269.93	6.69	0.00	513.83
1985	252.43	283.12	6.67	0.00	542.21
1986	264.35	290.86	6.70	10.00	571.91
1987	276.27	298.60	6.74	20.00	601.61
1988	288.19	306.34	6.77	30.00	631.31
1989	300.12	314.08	6.81	40.00	661.01
1990	312.04	321.82	6.84	50.00	690.71
1991	327.28	334.19	7.14	50.00	718.60
1992	342.52	346.55	7.43	50.00	746.50
1993	357.76	358.91	7.72	50.00	774.39
1994	373.01	371.27	8.01	50.00	802.29
1995	388.25	383.64	8.30	50.00	830.18
1996	394.85	385.23	8.38	50.00	838.46
1997	401.45	386.82	8.47	50.00	846.74
1998	408.05	388.41	8.56	50.00	855.01
1999	414.65	390.00	8.64	50.00	863.29
2000	421.25	391.58	8.73	50.00	871.57
2001	429.12	398.47	8.88	50.00	886.47
2002	436.99	405.36	9.04	50.00	901.38
2003	444.85	412.25	9.19	50.00	916.29
2004	452.72	419.13	9.34	50.00	931.20
2005	460.59	426.02	9.50	50.00	946.11
2006	470.27	437.10	9.71	50.00	967.08
2007	479.94	448.17	9.93	50.00	988.05
2008	489.62	459.25	10.15	50.00	1009.02
2009	499.30	470.33	10.36	50.00	1029.99
2010	508.98	481.41	10.58	50.00	1050.96

SCENARIO: MED : HE6--FERC 0%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2085.64	428.69	2514.33
1982	2208.09	457.07	2665.16
1983	2330.54	485.45	2815.99
1984	2452.99	513.83	2966.82
1985	2575.43	542.21	3117.65
1986	2660.74	571.91	3232.65
1987	2746.04	601.61	3347.65
1988	2831.34	631.31	3462.65
1989	2916.64	661.01	3577.65
1990	3001.94	690.71	3692.65
1991	3099.94	718.60	3818.54
1992	3197.94	746.50	3944.43
1993	3295.93	774.39	4070.33
1994	3393.93	802.29	4196.22
1995	3491.93	830.18	4322.11
1996	3516.14	838.46	4354.60
1997	3540.36	846.74	4387.09
1998	3564.57	855.01	4419.59
1999	3588.79	863.29	4452.08
2000	3613.00	871.57	4484.57
2001	3678.84	886.47	4565.32
2002	3744.68	901.38	4646.06
2003	3810.52	916.29	4726.81
2004	3876.36	931.20	4807.56
2005	3942.20	946.11	4888.30
2006	4042.17	967.08	5009.25
2007	4142.15	988.05	5130.20
2008	4242.13	1009.02	5251.15
2009	4342.11	1029.99	5372.09
2010	4442.08	1050.96	5493.04

SCENARIO: MED : HE6--FERC 0%--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	421.26	97.87	519.14
1982	446.02	104.35	550.37
1983	470.77	110.83	581.61
1984	495.53	117.31	612.84
1985	520.28	123.79	644.07
1986	538.35	130.57	668.92
1987	556.41	137.35	693.76
1988	574.48	144.13	718.60
1989	592.54	150.90	743.44
1990	610.61	157.68	768.29
1991	630.57	164.05	794.62
1992	650.53	170.42	820.95
1993	670.50	176.79	847.29
1994	690.46	183.15	873.62
1995	710.43	189.52	899.95
1996	715.15	191.41	906.56
1997	719.87	193.30	913.18
1998	724.60	195.19	919.79
1999	729.32	197.08	926.40
2000	734.04	198.97	933.02
2001	747.26	202.38	949.64
2002	760.48	205.78	966.26
2003	773.70	209.18	982.89
2004	786.92	212.59	999.51
2005	800.14	215.99	1016.13
2006	820.31	220.78	1041.08
2007	840.47	225.57	1066.03
2008	860.63	230.35	1090.98
2009	880.79	235.14	1115.93
2010	900.96	239.93	1140.88

HE7--FERC -1%

SCENARIO: MED : HE7--FERC -1%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	49138.	26204.	11502.	8567.	95412.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	60347.	27257.	13865.	8460.	109929.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	66718.	31004.	15372.	8333.	121426.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	70748.	33608.	16393.	8115.	128863.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	75730.	36263.	17719.	8721.	138432.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	82347.	39840.	19469.	9526.	151181.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE7--FERC -1%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220. (0.000)	5287. (0.000)	1189. (0.000)	1617. (0.000)	15313. (0.000)
1985	10646. (0.000)	5880. (0.000)	2130. (0.000)	1768. (0.000)	20424. (0.000)
1990	11533. (0.000)	7960. (0.000)	2222. (0.000)	2375. (0.000)	24090. (0.000)
1995	14407. (0.000)	7841. (0.000)	3236. (0.000)	2339. (0.000)	27823. (0.000)
2000	15712. (0.000)	7703. (0.000)	3634. (0.000)	2298. (0.000)	29348. (0.000)
2005	17104. (0.000)	8020. (0.000)	4017. (0.000)	2252. (0.000)	31393. (0.000)
2010	18524. (0.000)	9033. (0.000)	4397. (0.000)	2196. (0.000)	34150. (0.000)

SCENARIO: MED : HE7--FERC -1X--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089.	7666.	1991.	1463.	16209.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	541.	1496.	127.	292.	2455.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	664.	97.	153.	289.	1202.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	734.	1674.	169.	284.	2861.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	778.	1815.	180.	352.	3126.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	833.	1958.	195.	288.	3274.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	906.	2151.	214.	314.	3586.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE7--FERC -1X--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653.	3320.	986.	895.	8854.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	118.	2641.	24.	719.	3502.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	127.	454.	25.	81.	687.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	159.	448.	36.	80.	722.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	173.	440.	40.	78.	731.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	188.	433.	44.	77.	742.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	204.	488.	48.	81.	821.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE7--FERC -1%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.052	0.049	0.090	0.085
1995	0.054	0.051	0.090	0.085
2000	0.055	0.052	0.090	0.085
2005	0.057	0.054	0.090	0.085
2010	0.059	0.056	0.090	0.085

SCENARIO: MED ; HE7--FERC -1%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	1.730	1.500	12.740	11.290
1985	2.000	1.770	12.280	10.980
1990	2.870	2.640	11.680	10.430
1995	3.320	3.090	11.110	9.920
2000	3.060	2.830	10.560	9.430
2005	2.960	2.730	10.040	8.970
2010	2.860	2.630	9.550	8.530

SCENARIO: MED : HE7--FERC -1%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	7.750	7.200	7.830	7.500
1985	7.480	6.990	7.550	7.280
1990	7.110	6.650	7.180	6.930
1995	6.760	6.320	6.820	6.590
2000	6.430	6.010	6.490	6.260
2005	6.120	5.720	6.170	5.960
2010	5.820	5.440	5.870	5.660

SCENARIO: MED : HE7--FERC -1%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00 (0.000)	6500.63 (0.000)	5088.52 (0.000)	13699.15 (0.000)
1985	2160.00 (0.000)	6092.34 (0.000)	4770.71 (0.000)	13023.05 (0.000)
1990	2210.00 (0.000)	5975.60 (0.000)	4579.19 (0.000)	12764.79 (0.000)
1995	2260.00 (0.000)	5919.57 (0.000)	4513.35 (0.000)	12692.92 (0.000)
2000	2310.00 (0.000)	5949.22 (0.000)	4446.94 (0.000)	12706.16 (0.000)
2005	2360.00 (0.000)	6019.13 (0.000)	4416.38 (0.000)	12795.51 (0.000)
2010	2410.00 (0.000)	6084.07 (0.000)	4440.68 (0.000)	12934.75 (0.000)

SCENARIO: MED ; HE7--FERC -1X--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6178.78	3607.23	12322.00
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6449.91	3868.80	12924.71
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.01	6664.68	4048.33	13389.02
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.01	6792.07	4308.98	13847.06
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6849.00	4510.10	14175.10
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.00	6889.70	4656.39	14432.09
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; HE7--FERC -1%--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04	7495.70
	(0.000)	(0.000)
1985	9585.43	7973.75
	(0.000)	(0.000)
1990	10273.36	8304.16
	(0.000)	(0.000)
1995	10823.38	8626.08
	(0.000)	(0.000)
2000	11223.18	8889.85
	(0.000)	(0.000)
2005	11829.69	9219.02
	(0.000)	(0.000)
2010	12613.95	9605.75
	(0.000)	(0.000)

SCENARIO: MED : HE7--FERC -1%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.399	0.000	-1.910	9.389	0.000	-0.707
1982	12.798	0.000	-3.820	18.779	0.000	-1.415
1983	19.197	0.000	-5.730	28.168	0.000	-2.122
1984	25.596	0.000	-7.640	37.557	0.000	-2.829
1985	31.996	0.000	-9.550	46.946	0.000	-3.536
1986	40.087	0.000	-17.528	57.988	0.000	-6.398
1987	48.179	0.000	-25.505	69.030	0.000	-9.260
1988	56.271	0.000	-33.483	80.072	0.000	-12.122
1989	64.363	0.000	-41.461	91.114	0.000	-14.984
1990	72.454	0.000	-49.438	102.156	0.000	-17.846
1991	83.429	0.000	-60.976	112.153	0.000	-20.591
1992	94.403	0.000	-72.513	122.150	0.000	-23.336
1993	105.378	0.000	-84.050	132.146	0.000	-26.081
1994	116.352	0.000	-95.587	142.143	0.000	-28.826
1995	127.327	0.000	-107.125	152.140	0.000	-31.571
1996	131.978	0.000	-109.556	159.141	0.000	-32.044
1997	136.629	0.000	-111.987	166.142	0.000	-32.518
1998	141.281	0.000	-114.419	173.143	0.000	-32.992
1999	145.932	0.000	-116.850	180.144	0.000	-33.465
2000	150.583	0.000	-119.281	187.145	0.000	-33.939
2001	154.551	0.000	-119.165	197.246	0.000	-33.954
2002	158.518	0.000	-119.049	207.347	0.000	-33.969
2003	162.486	0.000	-118.933	217.448	0.000	-33.984
2004	166.454	0.000	-118.817	227.549	0.000	-33.999
2005	170.421	0.000	-118.701	237.650	0.000	-34.014
2006	175.812	0.000	-118.280	251.735	0.000	-33.645
2007	181.204	0.000	-117.859	265.819	0.000	-33.275
2008	186.595	0.000	-117.437	279.904	0.000	-32.906
2009	191.986	0.000	-117.016	293.989	0.000	-32.536
2010	197.378	0.000	-116.595	308.074	0.000	-32.167

GREATER FAIRBANKS

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	0.154	0.000	0.000	0.075
1982	0.000	0.000	0.307	0.000	0.000	0.151
1983	0.000	0.000	0.461	0.000	0.000	0.226
1984	0.000	0.000	0.615	0.000	0.000	0.302
1985	0.000	0.000	0.768	0.000	0.000	0.377
1986	-0.335	0.000	1.174	-0.550	0.000	0.575
1987	-0.670	0.000	1.579	-1.099	0.000	0.773
1988	-1.005	0.000	1.984	-1.649	0.000	0.971
1989	-1.341	0.000	2.389	-2.199	0.000	1.169
1990	-1.676	0.000	2.795	-2.748	0.000	1.366
1991	-1.960	0.000	3.459	-3.109	0.000	1.657
1992	-2.245	0.000	4.124	-3.469	0.000	1.947
1993	-2.529	0.000	4.788	-3.829	0.000	2.237
1994	-2.814	0.000	5.453	-4.190	0.000	2.527
1995	-3.098	0.000	6.118	-4.550	0.000	2.817
1996	-3.282	0.000	6.896	-4.711	0.000	3.117
1997	-3.466	0.000	7.674	-4.872	0.000	3.417
1998	-3.650	0.000	8.452	-5.033	0.000	3.717
1999	-3.833	0.000	9.230	-5.194	0.000	4.016
2000	-4.017	0.000	10.008	-5.356	0.000	4.316
2001	-4.168	0.000	10.964	-6.896	0.000	6.111
2002	-4.319	0.000	11.920	-8.437	0.000	7.907
2003	-4.471	0.000	12.876	-9.978	0.000	9.702
2004	-4.622	0.000	13.833	-11.518	0.000	11.497
2005	-4.773	0.000	14.789	-13.059	0.000	13.292
2006	-4.920	0.000	15.971	-12.161	0.000	12.776
2007	-5.067	0.000	17.152	-11.262	0.000	12.259
2008	-5.214	0.000	18.334	-10.363	0.000	11.743
2009	-5.361	0.000	19.516	-9.465	0.000	11.226
2010	-5.508	0.000	20.698	-8.566	0.000	10.710

SCENARIO: MED : HE7--FERC -1%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1027.65	948.17	24.75	92.08	2092.65
1982	1075.76	1020.99	25.19	100.16	2222.10
1983	1123.88	1093.80	25.64	108.24	2351.55
1984	1171.99	1166.61	26.08	116.32	2481.01
1985	1220.11	1239.43	26.52	124.40	2610.46
1986	1252.13	1280.64	27.22	137.89	2697.88
1987	1284.15	1321.85	27.91	151.38	2785.29
1988	1316.17	1363.06	28.60	164.88	2872.71
1989	1348.19	1404.27	29.30	178.37	2960.13
1990	1380.21	1445.49	29.99	191.86	3047.54
1991	1408.37	1476.86	30.72	195.13	3111.08
1992	1436.54	1508.24	31.44	198.40	3174.61
1993	1464.71	1539.61	32.16	201.66	3238.15
1994	1492.88	1570.99	32.89	204.93	3301.68
1995	1521.05	1602.36	33.61	208.20	3365.22
1996	1538.05	1619.34	33.98	214.14	3405.51
1997	1555.05	1636.31	34.36	220.08	3445.80
1998	1572.05	1653.29	34.73	226.02	3486.09
1999	1589.05	1670.26	35.11	231.96	3526.38
2000	1606.05	1687.24	35.48	237.90	3566.67
2001	1628.76	1724.28	36.11	244.96	3634.11
2002	1651.47	1761.33	36.74	252.02	3701.56
2003	1674.17	1798.37	37.37	259.08	3769.00
2004	1696.88	1835.42	38.00	266.14	3836.44
2005	1719.59	1872.46	38.63	273.20	3903.88
2006	1750.61	1929.57	39.56	281.58	4001.32
2007	1781.63	1986.67	40.50	289.96	4098.76
2008	1812.66	2043.77	41.43	298.34	4196.20
2009	1843.68	2100.88	42.36	306.72	4293.64
2010	1874.70	2157.98	43.29	315.10	4391.08

SCENARIO: MED : HE7--FERC -1%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	191.29	230.36	6.76	0.00	428.41
1982	206.19	243.58	6.73	0.00	456.51
1983	221.09	256.81	6.70	0.00	484.60
1984	235.99	270.03	6.67	0.00	512.70
1985	250.89	283.26	6.65	0.00	540.80
1986	262.76	290.93	6.68	10.00	570.37
1987	274.63	298.59	6.72	20.00	599.94
1988	286.50	306.26	6.75	30.00	629.52
1989	298.37	313.93	6.79	40.00	659.09
1990	310.24	321.60	6.83	50.00	688.66
1991	322.09	328.66	7.03	50.00	707.78
1992	333.94	335.73	7.23	50.00	726.90
1993	345.80	342.80	7.43	50.00	746.02
1994	357.65	349.86	7.63	50.00	765.14
1995	369.50	356.93	7.83	50.00	784.26
1996	375.68	360.38	7.93	50.00	793.99
1997	381.86	363.83	8.03	50.00	803.72
1998	388.04	367.28	8.13	50.00	813.45
1999	394.21	370.73	8.23	50.00	823.18
2000	400.39	374.18	8.33	50.00	832.91
2001	407.31	381.13	8.48	50.00	846.92
2002	414.23	388.08	8.62	50.00	860.93
2003	421.15	395.03	8.77	50.00	874.95
2004	428.06	401.98	8.91	50.00	888.96
2005	434.98	408.93	9.05	50.00	902.97
2006	443.52	419.42	9.26	50.00	922.20
2007	452.06	429.91	9.46	50.00	941.42
2008	460.59	440.39	9.66	50.00	960.64
2009	469.13	450.88	9.86	50.00	979.87
2010	477.67	461.36	10.06	50.00	999.09

SCENARIO: MED ; HE7--FERC -1%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2092.65	428.41	2521.06
1982	2222.10	456.51	2678.61
1983	2351.55	484.60	2836.16
1984	2481.01	512.70	2993.71
1985	2610.46	540.80	3151.26
1986	2697.88	570.37	3268.25
1987	2785.29	599.94	3385.24
1988	2872.71	629.52	3502.23
1989	2960.13	659.09	3619.22
1990	3047.54	688.66	3736.21
1991	3111.08	707.78	3818.86
1992	3174.61	726.90	3901.52
1993	3238.15	746.02	3984.17
1994	3301.68	765.14	4066.82
1995	3365.22	784.26	4149.48
1996	3405.51	793.99	4199.50
1997	3445.80	803.72	4249.52
1998	3486.09	813.45	4299.54
1999	3526.38	823.18	4349.56
2000	3566.67	832.91	4399.58
2001	3634.11	846.92	4481.03
2002	3701.56	860.93	4562.49
2003	3769.00	874.95	4643.94
2004	3836.44	888.96	4725.40
2005	3903.88	902.97	4806.86
2006	4001.32	922.20	4923.52
2007	4098.76	941.42	5040.18
2008	4196.20	960.64	5156.84
2009	4293.64	979.87	5273.51
2010	4391.08	999.09	5390.17

SCENARIO: MED : HE7--FERC -1X--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	422.70	97.81	520.51
1982	448.89	104.23	553.11
1983	475.08	110.64	585.72
1984	501.27	117.05	618.32
1985	527.46	123.47	650.93
1986	545.95	130.22	676.17
1987	564.45	136.97	701.42
1988	582.95	143.72	726.67
1989	601.45	150.46	751.91
1990	619.95	157.21	777.16
1991	632.85	161.58	794.43
1992	645.76	165.94	811.70
1993	658.66	170.31	828.97
1994	671.57	174.67	846.24
1995	684.47	179.04	863.51
1996	692.49	181.26	873.75
1997	700.50	183.48	883.99
1998	708.52	185.70	894.22
1999	716.54	187.92	904.46
2000	724.55	190.15	914.70
2001	738.10	193.34	931.45
2002	751.65	196.54	948.19
2003	765.20	199.74	964.94
2004	778.75	202.94	981.69
2005	792.30	206.14	998.44
2006	811.94	210.53	1022.47
2007	831.58	214.92	1046.50
2008	851.22	219.31	1070.53
2009	870.87	223.70	1094.56
2010	890.51	228.09	1118.60

HE8--FERC -2%

SCENARIO: MED : HES--FERC -2%--6/24/1983

HOUSEHOLDS SERVED

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	35473.	20314.	8230.	7486.	71503.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	49086.	26204.	11492.	8567.	95349.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	60469.	27347.	13897.	8460.	110173.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	65245.	30063.	15018.	8333.	118659.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	69296.	32903.	16055.	7948.	126201.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	74286.	35573.	17384.	8557.	135800.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	80912.	39156.	19134.	9363.	148565.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE8--FERC =2%--6/24/1983

HOUSEHOLDS SERVED

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	7220.	5287.	1189.	1617.	15313.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	10646.	5867.	2130.	1765.	20407.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	11575.	7960.	2233.	2375.	24142.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	13886.	7841.	3083.	2339.	27149.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	15152.	7703.	3487.	2298.	28640.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	16727.	7794.	3929.	2252.	30702.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	18155.	8855.	4310.	2153.	33472.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HE8--FERC -2%--6/24/1983

HOUSING VACANCIES

ANCHORAGE - COOK INLET

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	5089.	7666.	1991.	1463.	16209.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1985	540.	1496.	126.	292.	2455.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1990	665.	7.	153.	289.	1114.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1995	718.	1623.	165.	284.	2790.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2000	762.	1777.	177.	519.	3235.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2005	817.	1921.	191.	282.	3212.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2010	890.	2115.	211.	309.	3524.
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; HE8--FERC -2%--6/24/1983

HOUSING VACANCIES

GREATER FAIRBANKS

YEAR	SINGLE FAMILY	MULTIFAMILY	MOBILE HOMES	DUPLEXES	TOTAL
1980	3653. (0.000)	3320. (0.000)	986. (0.000)	895. (0.000)	8854. (0.000)
1985	118. (0.000)	2654. (0.000)	24. (0.000)	722. (0.000)	3518. (0.000)
1990	127. (0.000)	454. (0.000)	25. (0.000)	81. (0.000)	687. (0.000)
1995	153. (0.000)	448. (0.000)	34. (0.000)	80. (0.000)	714. (0.000)
2000	167. (0.000)	440. (0.000)	38. (0.000)	78. (0.000)	723. (0.000)
2005	184. (0.000)	187. (0.000)	43. (0.000)	77. (0.000)	491. (0.000)
2010	200. (0.000)	478. (0.000)	47. (0.000)	124. (0.000)	849. (0.000)

SCENARIO: MED : HES--FERC -2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

ELECTRICITY ($ / KWH)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	0.037	0.034	0.095	0.090
1985	0.048	0.045	0.095	0.090
1990	0.051	0.048	0.090	0.085
1995	0.053	0.050	0.090	0.085
2000	0.055	0.052	0.090	0.085
2005	0.056	0.053	0.090	0.085
2010	0.057	0.054	0.090	0.085

SCENARIO: MED : HES--FERC -2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

NATURAL GAS ($/MMBTU)

YEAR	ANCHORAGE - COOK INLET RESIDENTIAL	ANCHORAGE - COOK INLET BUSINESS	GREATER FAIRBANKS RESIDENTIAL	GREATER FAIRBANKS BUSINESS
1980	1.730	1.500	12.530	11.290
1985	1.980	1.750	12.030	10.750
1990	2.770	2.540	10.880	9.710
1995	3.070	2.840	9.830	8.780
2000	2.880	2.650	8.890	7.940
2005	2.720	2.490	8.030	7.170
2010	2.560	2.330	7.260	6.480

SCENARIO: MED : HES--FERC -2%--6/24/1983

FUEL PRICE FORECASTS EMPLOYED

FUEL OIL ($/MMBTU)

	ANCHORAGE - COOK INLET		GREATER FAIRBANKS	
YEAR	RESIDENTIAL	BUSINESS	RESIDENTIAL	BUSINESS
1980	7.750	7.200	7.830	7.500
1985	7.320	6.850	7.390	7.130
1990	6.620	6.190	6.680	6.450
1995	5.990	5.600	6.040	5.830
2000	5.410	5.060	5.460	5.270
2005	4.890	4.570	4.940	4.760
2010	4.420	4.130	4.460	4.310

SCENARIO: MED : HES--FERC -2%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

ANCHORAGE - COOK INLET

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2110.00	6500.63	5088.52	13699.15
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2160.00	6092.53	4771.63	13024.17
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2210.00	5976.22	4579.27	12765.49
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2260.00	5918.59	4510.05	12688.64
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2310.00	5949.30	4451.13	12710.43
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2360.00	6019.52	4417.03	12796.55
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2410.00	6085.02	4440.21	12935.22
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED : HES--FERC -2%--6/24/1983

RESIDENTIAL USE PER HOUSEHOLD (KWH)
(WITHOUT ADJUSTMENT FOR PRICE)

GREATER FAIRBANKS

YEAR	SMALL APPLIANCES	LARGE APPLIANCES	SPACE HEAT	TOTAL
1980	2466.00	5739.52	3313.66	11519.18
	(0.000)	(0.000)	(0.000)	(0.000)
1985	2535.99	6178.96	3606.32	12321.26
	(0.000)	(0.000)	(0.000)	(0.000)
1990	2606.00	6450.94	3869.59	12926.53
	(0.000)	(0.000)	(0.000)	(0.000)
1995	2676.01	6660.15	4045.07	13381.23
	(0.000)	(0.000)	(0.000)	(0.000)
2000	2746.00	6791.29	4311.59	13848.88
	(0.000)	(0.000)	(0.000)	(0.000)
2005	2816.00	6852.56	4504.39	14172.94
	(0.000)	(0.000)	(0.000)	(0.000)
2010	2886.00	6891.75	4656.59	14434.35
	(0.000)	(0.000)	(0.000)	(0.000)

SCENARIO: MED ; HE8--FERC -2%--6/24/1983

BUSINESS USE PER EMPLOYEE (KWH)
(WITHOUT LARGE INDUSTRIAL)
(WITHOUT ADJUSTMENT FOR PRICE)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS
1980	8407.04 (0.000)	7495.70 (0.000)
1985	9580.48 (0.000)	7972.14 (0.000)
1990	10304.51 (0.000)	8313.01 (0.000)
1995	10690.46 (0.000)	8585.26 (0.000)
2000	11134.65 (0.000)	8859.70 (0.000)
2005	11752.91 (0.000)	9193.17 (0.000)
2010	12539.23 (0.000)	9581.36 (0.000)

SCENARIO: MED : HE8--FERC -2%--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

ANCHORAGE - COOK INLET

	RESIDENTIAL			BUSINESS		
YEAR	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION	OWN-PRICE REDUCTION	PROGRAM-INDUCED CONSERVATION	CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	6.382	0.000	-1.616	9.365	0.000	-0.512
1982	12.763	0.000	-3.232	18.730	0.000	-1.024
1983	19.145	0.000	-4.847	28.095	0.000	-1.535
1984	25.526	0.000	-6.463	37.460	0.000	-2.047
1985	31.908	0.000	-8.079	46.825	0.000	-2.559
1986	39.052	0.000	-14.689	56.968	0.000	-4.684
1987	46.196	0.000	-21.299	67.110	0.000	-6.809
1988	53.339	0.000	-27.909	77.252	0.000	-8.935
1989	60.483	0.000	-34.519	87.395	0.000	-11.060
1990	67.627	0.000	-41.129	97.537	0.000	-13.185
1991	74.471	0.000	-47.290	105.367	0.000	-14.388
1992	81.315	0.000	-53.451	113.196	0.000	-15.590
1993	88.159	0.000	-59.612	121.026	0.000	-16.792
1994	95.003	0.000	-65.773	128.856	0.000	-17.994
1995	101.847	0.000	-71.934	136.685	0.000	-19.196
1996	106.637	0.000	-72.942	144.571	0.000	-18.592
1997	111.427	0.000	-73.949	152.458	0.000	-17.988
1998	116.217	0.000	-74.956	160.344	0.000	-17.383
1999	121.007	0.000	-75.963	168.230	0.000	-16.779
2000	125.797	0.000	-76.970	176.116	0.000	-16.175
2001	129.907	0.000	-75.725	184.945	0.000	-14.479
2002	134.018	0.000	-74.479	193.774	0.000	-12.784
2003	138.128	0.000	-73.234	202.602	0.000	-11.088
2004	142.238	0.000	-71.988	211.431	0.000	-9.392
2005	146.349	0.000	-70.743	220.260	0.000	-7.696
2006	150.975	0.000	-68.217	231.601	0.000	-4.837
2007	155.601	0.000	-65.691	242.942	0.000	-1.978
2008	160.227	0.000	-63.165	254.283	0.000	0.881
2009	164.853	0.000	-60.638	265.625	0.000	3.740
2010	169.479	0.000	-58.112	276.966	0.000	6.599

SCENARIO: MED ; HE8--FERC -2X--6/24/1983

SUMMARY OF PRICE EFFECTS AND PROGRAMATIC CONSERVATION
IN GWH

GREATER FAIRBANKS

YEAR	RESIDENTIAL OWN-PRICE REDUCTION	RESIDENTIAL PROGRAM-INDUCED CONSERVATION	RESIDENTIAL CROSS-PRICE REDUCTION	BUSINESS OWN-PRICE REDUCTION	BUSINESS PROGRAM-INDUCED CONSERVATION	BUSINESS CROSS-PRICE REDUCTION
1980	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	0.000	0.192	0.000	0.000	0.130
1982	0.000	0.000	0.385	0.000	0.000	0.259
1983	0.000	0.000	0.577	0.000	0.000	0.389
1984	0.000	0.000	0.769	0.000	0.000	0.519
1985	0.000	0.000	0.962	0.000	0.000	0.648
1986	-0.334	0.000	1.662	-0.495	0.000	0.979
1987	-0.669	0.000	2.362	-0.990	0.000	1.309
1988	-1.003	0.000	3.062	-1.485	0.000	1.639
1989	-1.337	0.000	3.762	-1.981	0.000	1.970
1990	-1.672	0.000	4.463	-2.476	0.000	2.300
1991	-1.939	0.000	5.631	-2.956	0.000	2.997
1992	-2.206	0.000	6.799	-3.436	0.000	3.693
1993	-2.473	0.000	7.967	-3.916	0.000	4.390
1994	-2.739	0.000	9.135	-4.396	0.000	5.086
1995	-3.006	0.000	10.303	-4.876	0.000	5.783
1996	-3.186	0.000	11.749	-5.066	0.000	6.440
1997	-3.366	0.000	13.195	-5.256	0.000	7.097
1998	-3.546	0.000	14.641	-5.447	0.000	7.753
1999	-3.726	0.000	16.087	-5.637	0.000	8.410
2000	-3.906	0.000	17.533	-5.827	0.000	9.067
2001	-4.056	0.000	19.334	-6.027	0.000	9.960
2002	-4.206	0.000	21.134	-6.227	0.000	10.853
2003	-4.355	0.000	22.935	-6.426	0.000	11.745
2004	-4.505	0.000	24.735	-6.626	0.000	12.638
2005	-4.654	0.000	26.536	-6.826	0.000	13.530
2006	-4.801	0.000	28.784	-7.057	0.000	14.717
2007	-4.948	0.000	31.032	-7.288	0.000	15.904
2008	-5.094	0.000	33.279	-7.519	0.000	17.091
2009	-5.241	0.000	35.527	-7.750	0.000	18.278
2010	-5.388	0.000	37.775	-7.982	0.000	19.465

SCENARIO: MED ; HES--FERC -2%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

ANCHORAGE - COOK INLET

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	979.53	875.36	24.31	84.00	1963.19
1981	1027.23	947.56	24.74	92.08	2091.60
1982	1074.92	1019.76	25.17	100.16	2220.02
1983	1122.62	1091.96	25.61	108.24	2348.43
1984	1170.31	1164.16	26.04	116.32	2476.84
1985	1218.01	1236.37	26.47	124.40	2605.25
1986	1250.39	1281.28	27.20	137.89	2696.77
1987	1282.77	1326.20	27.93	151.38	2788.29
1988	1315.15	1371.12	28.66	164.88	2879.81
1989	1347.53	1416.04	29.39	178.37	2971.33
1990	1379.91	1460.95	30.12	191.86	3062.85
1991	1399.07	1475.95	30.58	195.13	3100.74
1992	1418.23	1490.95	31.05	198.40	3138.63
1993	1437.39	1505.95	31.51	201.66	3176.52
1994	1456.55	1520.95	31.97	204.93	3214.41
1995	1475.71	1535.95	32.44	208.20	3252.30
1996	1491.62	1555.27	32.83	214.14	3293.87
1997	1507.52	1574.60	33.23	220.08	3335.43
1998	1523.43	1593.92	33.63	226.02	3377.00
1999	1539.34	1613.25	34.03	231.96	3418.57
2000	1555.24	1632.57	34.43	237.90	3460.14
2001	1576.63	1669.85	35.04	244.96	3526.47
2002	1598.01	1707.13	35.64	252.02	3592.81
2003	1619.40	1744.41	36.25	259.08	3659.14
2004	1640.78	1781.69	36.86	266.14	3725.48
2005	1662.17	1818.97	37.47	273.20	3791.81
2006	1691.80	1875.70	38.39	281.58	3887.47
2007	1721.44	1932.43	39.30	289.96	3983.13
2008	1751.08	1989.16	40.22	298.34	4078.79
2009	1780.72	2045.89	41.13	306.72	4174.45
2010	1810.36	2102.61	42.04	315.10	4270.11

SCENARIO: MED : HE8--FERC -2%--6/24/1983

BREAKDOWN OF ELECTRICITY REQUIREMENTS (GWH)
(TOTAL INCLUDES LARGE INDUSTRIAL CONSUMPTION)

GREATER FAIRBANKS

MEDIUM RANGE (PR=.5)

YEAR	RESIDENTIAL REQUIREMENTS	BUSINESS REQUIREMENTS	MISCELLANEOUS REQUIREMENTS	EXOG. INDUSTRIAL LOAD	TOTAL
1980	176.39	217.14	6.78	0.00	400.31
1981	191.21	230.23	6.75	0.00	428.19
1982	206.03	243.32	6.73	0.00	456.07
1983	220.84	256.41	6.70	0.00	483.95
1984	235.66	269.50	6.67	0.00	511.83
1985	250.48	282.59	6.64	0.00	539.71
1986	262.24	290.62	6.68	10.00	569.54
1987	274.00	298.65	6.72	20.00	599.37
1988	285.76	306.68	6.75	30.00	629.20
1989	297.52	314.71	6.79	40.00	659.03
1990	309.28	322.75	6.83	50.00	688.86
1991	318.62	326.78	6.97	50.00	702.37
1992	327.97	330.81	7.11	50.00	715.89
1993	337.31	334.84	7.26	50.00	729.40
1994	346.65	338.87	7.40	50.00	742.92
1995	355.99	342.90	7.54	50.00	756.43
1996	361.39	346.58	7.64	50.00	765.61
1997	366.80	350.26	7.73	50.00	774.78
1998	372.20	353.93	7.83	50.00	783.96
1999	377.60	357.61	7.92	50.00	793.14
2000	383.01	361.29	8.02	50.00	802.32
2001	389.06	367.96	8.14	50.00	815.15
2002	395.11	374.63	8.25	50.00	827.99
2003	401.16	381.30	8.37	50.00	840.83
2004	407.21	387.97	8.49	50.00	853.67
2005	413.26	394.64	8.61	50.00	866.51
2006	420.76	404.51	8.81	50.00	884.08
2007	428.26	414.38	9.01	50.00	901.65
2008	435.76	424.25	9.22	50.00	919.23
2009	443.26	434.12	9.42	50.00	936.80
2010	450.76	443.99	9.62	50.00	954.37

SCENARIO: MED : HE8--FERC -2%--6/24/1983

TOTAL ELECTRICITY REQUIREMENTS (GWH)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL CONSUMPTION)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	1963.19	400.31	2363.51
1981	2091.60	428.19	2519.80
1982	2220.02	456.07	2676.09
1983	2348.43	483.95	2832.38
1984	2476.84	511.83	2988.67
1985	2605.25	539.71	3144.96
1986	2696.77	569.54	3266.31
1987	2788.29	599.37	3387.66
1988	2879.81	629.20	3509.01
1989	2971.33	659.03	3630.36
1990	3062.85	688.86	3751.71
1991	3100.74	702.37	3803.11
1992	3138.63	715.89	3854.51
1993	3176.52	729.40	3905.92
1994	3214.41	742.92	3957.32
1995	3252.30	756.43	4008.73
1996	3293.87	765.61	4059.47
1997	3335.43	774.78	4110.22
1998	3377.00	783.96	4160.96
1999	3418.57	793.14	4211.71
2000	3460.14	802.32	4262.45
2001	3526.47	815.15	4341.63
2002	3592.81	827.99	4420.80
2003	3659.14	840.83	4499.97
2004	3725.48	853.67	4579.15
2005	3791.81	866.51	4658.32
2006	3887.47	884.08	4771.55
2007	3983.13	901.65	4884.79
2008	4078.79	919.23	4998.02
2009	4174.45	936.80	5111.25
2010	4270.11	954.37	5224.49

SCENARIO: MED : HE8--FERC -2X--6/24/1983

PEAK ELECTRIC REQUIREMENTS (MW)
(NET OF CONSERVATION)
(INCLUDES LARGE INDUSTRIAL DEMAND)

MEDIUM RANGE (PR = .5)

YEAR	ANCHORAGE - COOK INLET	GREATER FAIRBANKS	TOTAL
1980	396.51	91.40	487.90
1981	422.48	97.76	520.24
1982	448.46	104.13	552.59
1983	474.44	110.49	584.93
1984	500.41	116.86	617.27
1985	526.39	123.22	649.61
1986	545.73	130.03	675.76
1987	565.07	136.84	701.90
1988	584.40	143.64	728.05
1989	603.74	150.45	754.19
1990	623.08	157.26	780.34
1991	630.73	160.34	791.08
1992	638.39	163.43	801.82
1993	646.04	166.51	812.55
1994	653.69	169.60	823.29
1995	661.34	172.69	834.03
1996	669.62	174.78	844.40
1997	677.90	176.88	854.77
1998	686.18	178.97	865.15
1999	694.45	181.07	875.52
2000	702.73	183.16	885.89
2001	716.05	186.09	902.15
2002	729.37	189.02	918.40
2003	742.70	191.95	934.65
2004	756.02	194.89	950.90
2005	769.34	197.82	967.16
2006	788.62	201.83	990.45
2007	807.90	205.84	1013.74
2008	827.17	209.85	1037.03
2009	846.45	213.87	1060.32
2010	865.73	217.88	1083.61

APPENDIX B3

EXECUTIVE SUMMARY

The Railbelt Electricity Demand (RED) Model was utilized in July, 1983 to produce forecasts of electricity demand for the two Railbelt load centers of southcentral and interior Alaska: Anchorage-Cook Inlet and Fairbanks-Tanana Valley. These were contained in the July, 1983 Susitna Hydroelectric Project License Application to the Federal Energy Regulatory Commission (FERC). The July, 1983 version of the model has since undergone independent review by FERC staff and by Dr. T. J. Tyrrell, a consulting economist from Wakefield, Rhode Island whose 1973 electricity demand article provided part of the basis for RED. As a result of this ongoing review and updating of the model a number of refinements have been made. The following refinements of the RED model are the most important: 1) the mechanism utilized in RED to adjust electricity consumption for future changes in the real prices of electricity, natural gas, and fuel oil was simplified; 2) some of the values utilized in RED for market saturations, fuel-mode splits, and energy consumption in residential appliances were adjusted; 3) more refined data concerning the building stock and electricity consumption were used to project Railbelt electricity demand in the commercial-light industrial-government sector; 4) the Fairbanks-Tanana Valley peak load factor was revised upward. The new, August 1985 version of the model is known as RED85A.

Additional research and data collection has been undertaken as part of this effort. In general, the research has confirmed the July, 1983 approach although certain computational details in RED have been changed to more closely reflect Railbelt electricity demand conditions. The new version of the model has also been run for several electricity demand cases contained in the July, 1983 license application and the forecasts compared to those produced in July, 1983. The overall effect on the July, 1983 forecasts has been to decrease the July, 1983 reference case forecast for the year 2010 by 0.1%; some cases featuring higher fuel prices are reduced; cases with lower price forecasts are increased by a larger percentage.

PRICE ADJUSTMENT

Our analysis of the RED price adjustment mechanism, additional model testing, and Dr. Tyrrell's evaluation of the model led us to the conclusion that the price adjustment mechanism could be refined and simplified. Recent literature on the estimates of both short- and long-run price elasticities show that in recent years, the demand for electricity has become less price responsive. Accordingly, the price elasticities were reduced. Secondly, we concluded that a simpler and improved method for including price elasticities in the RED model would be more understandable to model users. Taken together, these combined refinements, which have been included in the current RED85A version, increase the price responsiveness of the RED model. Dr. Tyrrell has confirmed the approach and the range of elasticity values used in the model.

RESIDENTIAL PARAMETERS

The parameters of the Residential Consumption Module were reexamined to confirm their consistency with known data concerning Railbelt electricity consumption. In addition, we reviewed our assumptions to make certain that forecasted changes in market saturations of appliances, percentages of given appliances using electricity (electric fuel mode splits), and electricity consumption rates for each type of appliance were consistent with values we would expect if the real (inflation-adjusted) fuel prices in the Railbelt did not change in the future. This is necessary because the Residential Consumption Module first forecasts residential consumption in the absence of price changes, then adjusts the forecast for price impacts. The detailed saturations, fuel mode splits, and consumption rates must be selected to avoid double-counting of price effects.

The review showed that increasing some preliminary electricity consumption rates would eliminate an overcorrection for price effects in the July 1983 version of the model. Minor adjustments were made in a few appliance market saturations. No base year (1980) saturations, fuel mode splits or consumption rates were changed as a result of the review. Taken together, these changes increased residential consumption.

BUSINESS PARAMETERS

The structure and parameters of the Business Consumption Module were also reviewed for compatibility with data that became available to us during 1984 and 1985 concerning electricity consumption in the business sector in the Railbelt and elsewhere. We determined in the course of our ongoing model review that the national floorspace per employee estimate utilized by the model in 1983 contained categories of employment and floorspace not present in the Railbelt, so that a comparison of national and Railbelt floorspace per employee would be misleading. The national estimate was refined so that it only included those categories of floorspace and employment actually present in the Railbelt. The Railbelt estimate was double-checked against the U.S. Department of Energy's 1979 and 1983 national Nonresidential Building Energy Consumption Survey and found consistent.

The Railbelt estimates of floorspace per employee were previously assumed to converge over time to the national estimate at a constant exponential rate; however, a preferred procedure is that such estimates be based on conditions in the Railbelt and to merely double-check the Railbelt estimates against national estimates. This became possible in 1984 with our acquisition of additional data on the Railbelt business sector. Consequently, the historical Anchorage linear growth path was adopted in place of the previous exponential path for the RED85A version and checked against national data. Floorspace per employee was about the same, regardless of whether Anchorage or national data were used.

The final change to the Business Consumption Module was that the electricity consumption equations were reestimated to take into account more refined data that became available in 1984. Both load centers' historical data series for business electricity consumption and business building space were revised to incorporate the new data. The equation having the best statistical fit was virtually unchanged from the July, 1983 version.

PEAK LOAD

Recent utility data from the Railbelt show that the assumed value of the Fairbanks-Tanana Valley load center's annual load factor was too low. It was revised upward in RED85A to reflect the most recent load data available.

Table 1 shows the effect of all the changes, taken together, on the reference forecast for the Railbelt from the Susitna license application as accepted by FERC in July, 1983 (July 1983 Susitna license application).

Table 1 shows that the July, 1983 reference forecast is affected very little by the model changes. This finding tends to hold up for other cases as well. Figures 1 and 2 show that for the DRI case, the highest fuel price run in the July, 1983 Susitna license application, the forecast changes are noticeable but small. This is also true of the FERC -2% case, which contained the lowest fuel price forecast. In summary, although the details of the forecast change, the overall forecast is little affected.

TABLE 1. Comparison of July 1983 Reference Case Forecasts of the RED Model, RED85A Versus July 1983

	RED85A	July 1983	% Difference
Total Consumption, Year 2010 (GWh)	5854	5858	-0.1
Total Peak Demand, Year 2010 (MW)	1195	1217	-1.8
Total Residential Consumption, Year 2010 (GWh)	2403	2572	-6.6
Total Business Consumption, Year 2010 (GWh)	3028	2863	+5.8
Total Other Consumption, Year 2010 (GWh)	423	423	+0.0

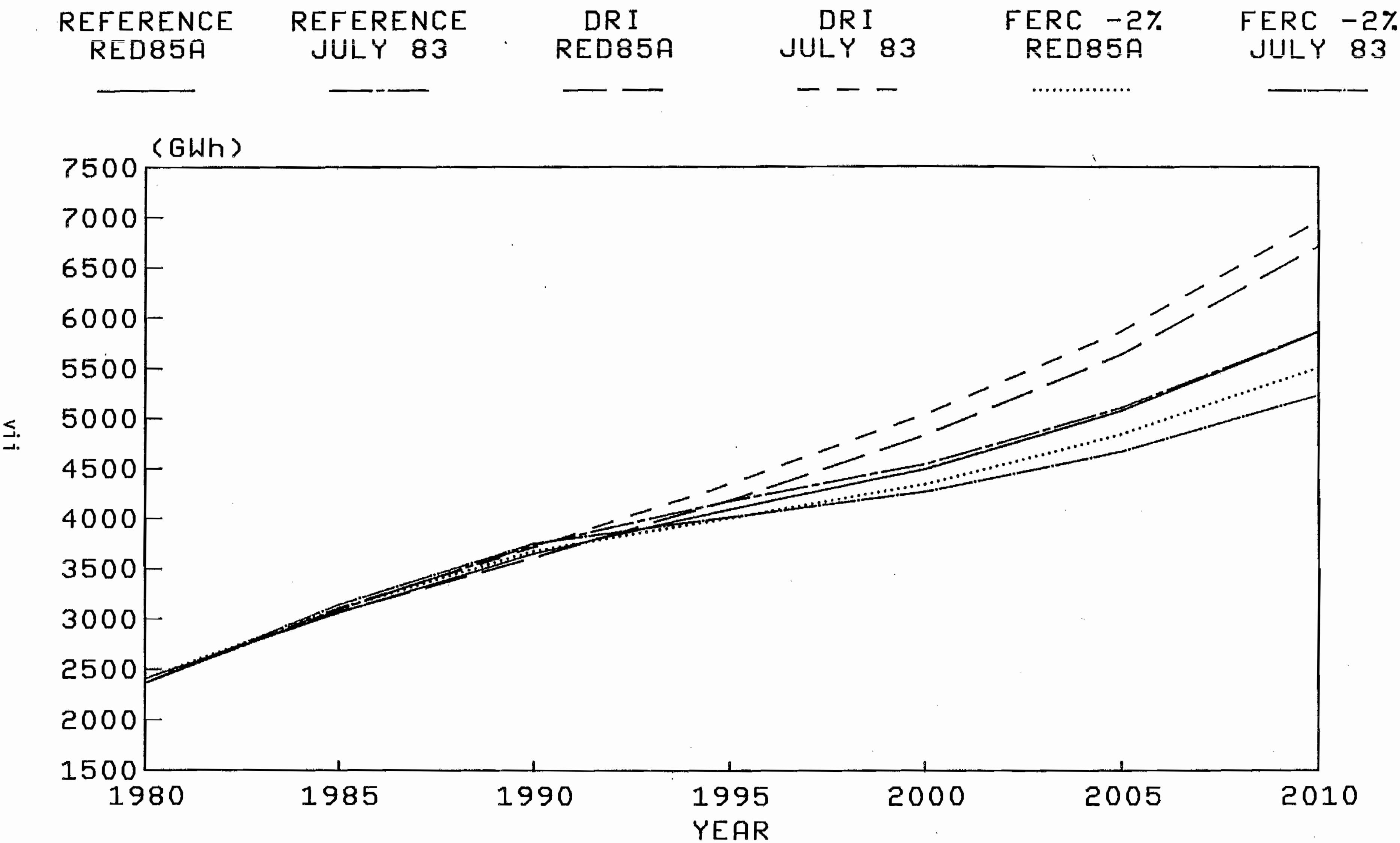

FIGURE 1. Comparison of Railbelt Total Electricity Consumption Forecasts RED85A Versus July 1983 Red Model

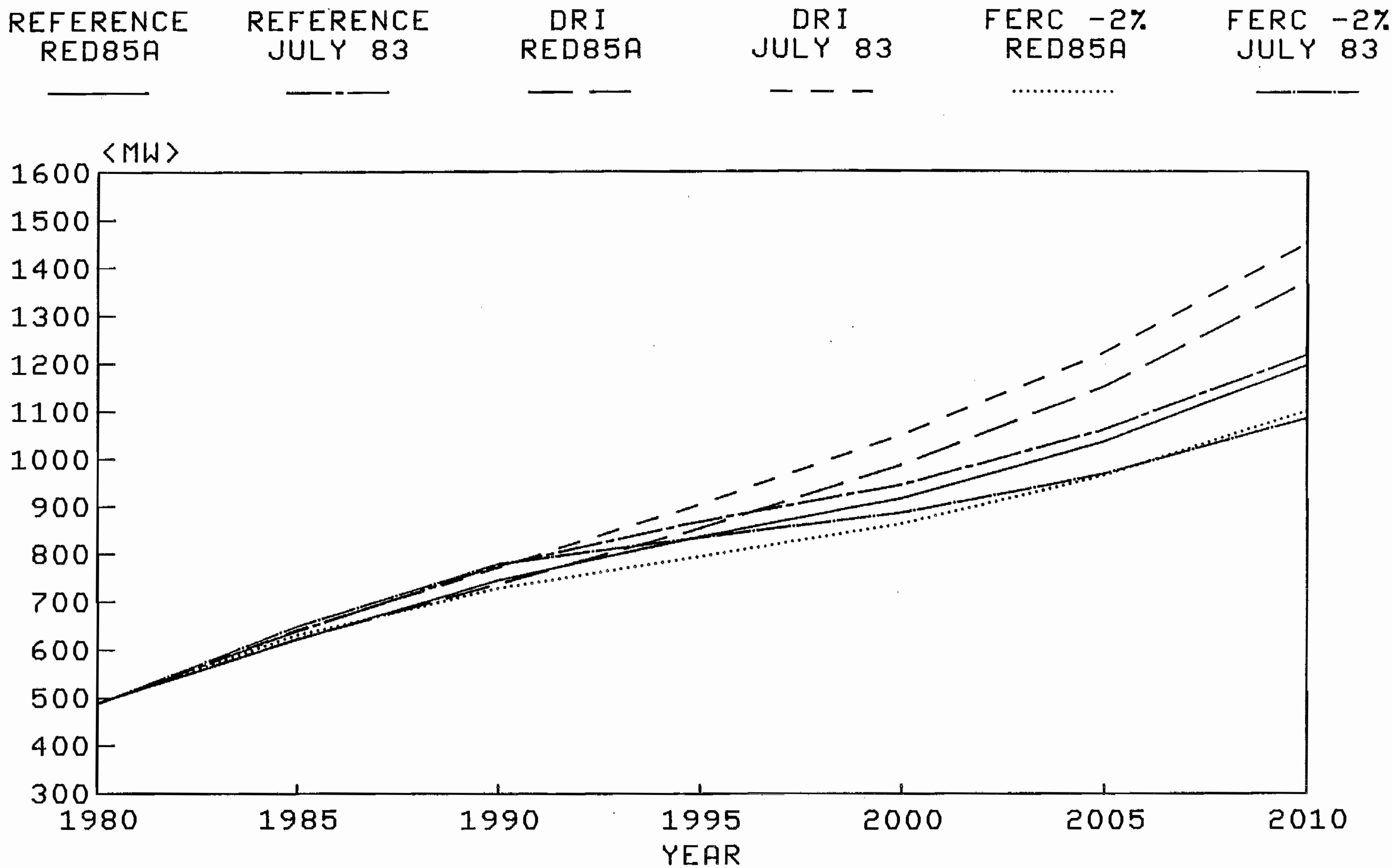

FIGURE 2. Comparison of Railbelt Total Peak Demand Forecasts RED85A Versus July 1983 RED Model

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CHANGES IN THE RAILBELT ELECTRICITY DEMAND MODEL,
JULY 1983 TO AUGUST 1985

1.0 INTRODUCTION

The Railbelt Electricity Demand (RED) Model was utilized in July, 1983 to produce forecasts of electricity demand for the two Railbelt load centers of southcentral and interior Alaska: Anchorage-Cook Inlet and Fairbanks-Tanana Valley. These were contained in the July, 1983 Susitna Hydroelectric Project License Application to the Federal Energy Regulatory Commission (FERC). The July, 1983 version of the model has since undergone independent review by FERC staff and Dr. T. J. Tyrrell, a consulting economist from Wakefield, Rhode Island who provided an independent assessment of the RED model (Tyrrell 1984). Dr. Tyrrell is a pioneer in the estimation of electricity demand models. In addition to review, he provided key modeling insights and additional information to the Battelle-Northwest staff. His review confirmed the modeling approach and parameter values used in the August 1985 version of RED, called RED85A. As a result of Dr. Tyrrell's review and other work, it was concluded that some refinements could be made to the July 1983 version of RED. The following refinements were the most important: 1) the mechanism utilized in RED to adjust electricity consumption for future changes in the real prices of electricity, natural gas, and fuel oil was to be simplified and improved; 2) some of the values utilized in RED for market saturations, fuel-mode splits, and energy consumption in residential appliances were to be adjusted; 3) more refined data concerning the building stock and electricity consumption were to be used to project Railbelt electricity demand in the commercial-light industrial-government sector; 4) the peak load factor in Fairbanks was to be revised upward.

As a result of the ongoing review process since the July 1983 Susitna license application, Battelle-Northwest researchers have undertaken the above series of refinements to the July 1983 version of the Railbelt Electricity Demand Model, both to improve forecasts of future electricity consumption in the Railbelt load centers and to streamline the model. We developed a more straightforward method to compute the model's fuel price adjustment, and modified values of mathematical constants contained in the fuel price adjustment equations to reflect latest available studies of electricity demand. The change has been included in the RED85A version, and is described in Chapter 2.0. We also reviewed and in a few cases changed other parameter values in the Residential Consumption Module. The results of the review and changes are given in Chapter 3.0. The overall effect is to reduce forecasted residential electricity consumption as discussed in Chapter 6.0.

Another change from the July 1983 version is a revised set of assumptions concerning square footage of commercial-light industrial-government floorspace per employee. We conducted additional data collection efforts in the Railbelt on commercial building stock and electricity consumption and acquired and analyzed the F. W. Dodge Construction Potentials data set, the best available data set on commercial building stock. We also reviewed the 1979 and 1983 National Non-Residential Buildings Energy Consumption Surveys, published in March 1983 and July 1985 by the U.S. Department of Energy. As a result of these reviews, end year (2010) square footage per employee was adjusted upward from values used in the July 1983 version of RED. At the same time, the growth path to reach the end year value was adjusted from a constant (exponential) growth rate based on national data to a linear rate based on Railbelt data, consistent with gradual satisfaction of the demand for commercial floorspace. The parameters of the electricity consumption equations were also reviewed and adjusted slightly. The adjustments are described in Chapter 4.0. The overall effect in the Business Consumption Module is an increase in business electricity consumption, discussed in Chapter 6.0.

Finally, the annual load factor in the Fairbanks-Tanana Valley load center was increased by about 10% to reflect recent load data for this load center. This is discussed in Chapter 5.0. Peak load in Fairbanks is reduced as a result, as discussed in Chapter 6.0.

The remainder of this report is organized as follows. The next section discusses changes made to the price adjustment mechanism and the reasons for those changes. The third section deals with Residential Consumption Module parameters, and the fourth section with changes to the Business Consumption Module. The fifth section describes a minor change made to the Peak Demand

Module. No changes were made to the other RED modules between July, 1983 and August, 1985. A final section of the paper describes the impact of the model changes on the forecasts. Appendix A describes the Railbelt data collection effort. Appendix B discusses the analysis of the F. W. Dodge Construction Potentials data.

REFERENCES

Tyrrell, T. J. 1984. Review and Analysis of the Treatment of Price Elasticities of Demand in the Susitna Hydroelectric Project RED Model (1983 Version with Revisions). Prepared for Harza-Ebasco Susitna Joint Venture, Anchorage, Alaska.

2.0 RED MODEL PRICE ADJUSTMENT REVISIONS

The RED Model price adjustment mechanism was specified and documented in July, 1983, and was based on an empirical study performed in 1973 by Mount, Chapman, and Tyrrell. Since that time, Battelle-Northwest has continued its process of internal and external model review, which has led to two conclusions. First, recent empirical studies have showed sharply reduced price elasticities in both the short run and long run compared to those in the Mount, Chapman, and Tyrrell study and other studies of its vintage. Almost as significant are the apparent reasons for these reduced estimates, which appear to be particularly applicable in the Railbelt. Second, we concluded that a more direct method for including price elasticities in the RED model would be more understandable by model users. This chapter discusses these modifications.

REVIEW OF PARAMETER VALUES

The parameter values contained in the June 1983 model were taken from a study performed by Mount, Chapman, and Tyrrell in 1973. Using annual data on consumption, prices and other variables in the 48 contiguous states for the 1947-1970 period and multiple regression analysis, they estimated econometric demand equations for the residential, commercial and industrial sectors. The natural logarithm of annual state consumption in each sector was regressed on the corresponding fuel prices and income (in logarithms and reciprocals), the lagged consumption (logarithm), and several other variables (but not the appliance/equipment stock). They obtained estimates of the short-run own-price and cross-price elasticities, which represent the percentage change in this year's consumption caused by a 1% change in this year's electricity and other fuel's prices, respectively, where the change can be interpreted as over time or across scenarios. They also obtained estimates of the lagged adjustment coefficient, λ, which represents the proportion of the complete, long-run adjustment to a permanent electricity price change that occurs after the year of the initial change ($1-\lambda$ represents the proportion of the long-run response occurring in the first year, or the ratio of the short-run to the long-run elasticity). These estimates were obtained for each sector; given them, long-run elasticities can be calculated as well. Since the appliance-equipment stocks do not appear as independent variables in the Mount, Chapman, and Tyrrell equations, these stocks are not held constant, so the short-run elasticities include the first-year effect of adjusting the appliance-equipment stock to price changes/differences.

The effect of appliance stock changes is not a serious problem in estimating the short-run elasticities. Short-run elasticities primarily reflect changes in the utilization of the existing stock of appliances. Very little appliance/equipment/building stock adjustment occurs on the basis of current prices (this is also reflected in the low values for cross-price elasticities typically found in empirical studies of electricity demand), so the short-run elasticities estimated when stocks are allowed to vary are similar to the estimates that are derived when stocks are held constant.

The long-run price elasticities, or the lagged adjustment coefficients, are likely to be different when stocks are held constant. The value of λ in a model holding appliance stocks constant, for example, would be significantly smaller than in a similar model in which stocks were not held constant because equipment capacity could not be reduced and efficiency increased in response to increased electricity prices. When appliance stocks are not significantly altered, a greater proportion of the total, long-run response to price impacts will occur in the year of the price change. The long-run effect of the price change would still be larger in magnitude than the short-run effect, but the ratio of the two would be smaller when there are few substitution possibilities.

Long-run modification of the appliance stock has three components: 1) replacement of single appliances to increase the level of consumer services per unit of fuel used (usually, by reducing fuel use per unit of service); 2) replacement of the stock in such a way as to reduce the amount of service purchased (e.g., by using smaller houses or less water heater capacity); and 3) changing the number of appliances using the fuel (e.g., either through reduced market saturations or through fuel switching). Except for fuel switching or reduced market saturation, the long run effects show up as reduced "utilization" (e.g., reduced fuel use) of the appliance stock rather than as a change in the stock.

There are two basic reasons that the RED model should consider changes in the appliance stock separately from utilization of the stock. First, projected price increases are not expected to result in much fuel switching beyond that which would take place at current prices.

In the Railbelt region of Alaska, electricity historically has been about two times more expensive than fossil fuel substitutes, even on a service (or converted Btu) adjusted basis. The future energy price forecasts show electricity remaining significantly more expensive than fossil substitutes. The net result of this is that there are few additional fuel substitution possibilities in the existing stock from electricity to alternative energy sources that would not be undertaken at existing relative prices; however, there are possibilities for improving the efficiency of the existing electricity-using capital stock. The appropriate long-run elasticity for the region, therefore, lies between a long-run elasticity which allows fuel switching and an elasticity which holds the appliance stock fixed in both number of units and capacity.

Second, available national econometric studies that can be used to determine RED model price effects were performed on data that requires adaptation of the study to the RED model structure and Railbelt economic conditions. For example, econometric studies that do not adjust the estimates for changes in the quality of appliances available may have overestimated price elasticity. In addition, there are theoretical reasons for believing that price elasticities measured for increases in price (future Railbelt conditions) would be less than elasticities measured for decreases in price (true for much of the U.S. during the period many national econometric studies were done).

The RED model distinguishes between those changes in the number and capacity of appliances that take place because of changes in the cost of fuel and those changes that occur because of other reasons, such as improvements in the quality of appliances, changes in tastes, increased household incomes, etc. Most econometric models in the literature do not make this distinction, and as a consequence they appear to produce biased estimates of price effects on consumption. In these models, for example, the effects on residential consumption of increased appliance quality, convenience, and durability experienced in the

U.S. between 1950 and 1970 are mixed together with the compounding effects of declines in the real prices of electricity and of electric appliances. If a given econometric model estimated the effect of electricity prices on electrical consumption primarily from data for this period (and most of these models have), but did not hold constant the effects of increased quality, convenience, and durability, then the estimated long run price elasticity will be too large in absolute value, resulting in too large a price effect. Holding appliance stock constant as measured by the number of appliance units to adjust for the bias would result in too low a price elasticity, of course, since future electricity prices in reality could cause some changes in market saturations of electrical appliances. However, since in national studies much of the measured historical change in consumption was due to market penetration of new types of appliances and new levels of service from electrical appliances, it is likely that a long term price elasticity of demand estimated with appliance stocks constant will be closer to current reality than one in which appliance stocks are not controlled. It also suggests recent studies are more accurate than older studies.

In addition, the literature has raised theoretical concerns about the possible asymmetry of consumer responses for price decreases as opposed to price increases. According to this argument, when electricity prices decrease new uses for electricity previously thought to be "luxuries" will be widely adopted. When the price increases, many of these same uses, once experienced, may tend to be viewed more as "necessities" so people are more reluctant to abandon them than to adopt them in the first place. Therefore, the demand for electricity may be less elastic for price increases in the future than for price decreases experienced during much of the historical period. The difference between the upward and downward elasticities can be approximated by holding appliance stocks constant to capture the effect of past price decreases on market saturations of appliances.

In order to test the parameter values in July 1983 version of RED against these assumptions, we performed an additional brief survey of the electricity demand literature. Our focus was on studies which explicitly held the appliance-equipment stock constant in the process of estimating the (long-run or short-run) price elasticities and lagged adjustment coefficients. Studies which had been reviewed in the July 1983 parameter selection process were included in this review, as were several studies which have since become available to us.

RESIDENTIAL SECTOR

Three recent studies of residential electrical demand appeared to be particularly relevant. The first was by Chern and Bouis in 1982. They econometrically estimated the structural change in the demand for electricity during the period 1955 to 1980 for 48 states. The demand equation estimated by Chern and Bouis was similar to that utilized by Mount, Chapman, and Tyrrell in that the equation form was multiplicative in its arguments and included many of the same variables: logarithms of electricity and gas prices, income, population, and lagged consumption. The equation was also estimated with pooled time - series and cross-sectional state data, using state dummy variables to capture the effects of left-out variables. The Chern-Bouis equation was somewhat different in that price elasticity did not explicitly vary with price of electricity and in that heating and cooling degree days were explicitly included in the equation. However, it is likely that the Chern-Bouis findings on the change in price elasticity over time would also hold for a variable elasticity form of the equation.

The Mount-Chapman-Tyrrell approach can be implemented in either a variable elasticity form, where price elasticity varies with price, or in a constant elasticity form, where elasticity does not vary with price. Virtually all econometric studies of electricity demand other than the Mount-Chapman-Tyrrell 1973 study use the constant elasticity form. Also, examination of the July 1983 output of RED revealed little variation in price elasticity over the range of electricity prices expected to prevail in the Railbelt between 1980 and 2010, so the Chern-Bouis constant form appeared to be appropriate for use in RED85A.

Chern and Bouis utilized their 24 years of data to perform 15 estimates of the demand equation for successive 10-year intervals. Statistically significant and substantial decreases were found in both the long run and short run elasticities of demand. For the period 1955 to 1964, for example, the estimated long run elasticity of demand was -1.36 while the short run elasticity was -.801. For the period 1969-1978, Chern and Bouis found that the short run elasticity had become only -.133 (Mount-Chapman-Tyrrell had found about -.140 at the mean of U.S. electricity prices in 1971) and that λ, the coefficient on lagged consumption, was .733 (Mount-Chapman-Tyrrell had found .884). This resulted in a long run elasticity for Chern and Bouis of -.498 for the most recent period, compared to -1.21 in Mount-Chapman-Tyrrell. There was no clear trend in the elasticity on natural gas price in Chern and Bouis's work. The average value for the five most recent periods was about .02. Table 2.1 compares Chern and Bouis's results with Mount-Chapman-Tyrrell.

Chern and Bouis interpreted the observed decline in price elasticity as being caused partly by increased penetration of more durable heating and cooling electrical appliances into the market place (reducing the speed of adjustment and increasing λ) and partly by the almost complete saturation of existing

TABLE 2.1. Comparison of Parameter Values for Residential Electricity Demand, Chern-Bouis (1982) Versus Mount-Chapman-Tyrrell (1973)

	Mount-Chapman-Tyrrell (1973)	Chern-Bouis (1982) 1955-64 Period	Chern-Bouis (1982) 1969-78 Period
Price of Electricity:			
Short Run	-.140	-.801	-.133
Long Run	-1.21	-1.360	-.498
Price of Natural Gas:			
Short Run	.0225	.015[a]	.060[b]
Long Run	.193	.026	.224
Lagged Consumption	.8837	.411	.733

(a) Not significantly different from zero.
(b) In the last five periods, 3 out of 5 observed values were not significantly different from zero and two were negative. An average of the 5 short-run values is .025; long run is .094.

markets for electric appliances. With higher durability and near-complete saturation, recent changes in demand tend to reflect only relatively slow changes in the average use by existing customers and increases in the customer base rather than increased market penetration. This tended to reduce the estimated price elasticity during recent periods.

Taking all of these factors together, the following conclusions are apparent. First, the short-run price elasticity is clearly less in recent years than it was during the periods used to calibrate the July 1983 version of the RED model. Moreover, the rapidly declining use of electricity for space heat in the Railbelt and the virtual absence of residential air conditioning means that "thermostat adjustments" available nationally to conserve electricity as price rises would be unavailable in the Railbelt, leaving less adjustable uses such as water heating, clothes drying, lighting, and cooking as the end uses which would have to be reduced in response to price increases in the short run. This implies that the Railbelt price elasticity in the short run is thus less than the most recent national average in Chern and Bouis's work. The RED85A version of RED therefore contains the slightly lower value of -.12 for the residential sector. This is also within the range specified in Tyrrell (1984) and is slightly less, in absolute value, than the average short run elasticity of -0.152 in the 1983 version of RED.

Second, Chern and Bouis estimated a value for λ, the lagged consumption coefficient, that was lower than that estimated by Mount-Chapman-Tyrrell (0.733 versus 0.8837). They also concluded that λ has increased over time, due to increased durability of appliances such as those for heating and cooling. However, several calls to heating and cooling firms and building contractors in the Railbelt indicated that market saturations of electric heat are apparently declining in that region, and that air conditioning is not significant. Therefore, the special mix of appliances in the Railbelt should tend to reduce the effects of increased durability observed by Chern and Bouis, making λ less than they estimated. Accordingly, the RED85A version of RED contains the slightly lower value of 0.7. The relatively high value of λ in Mount-Chapman-Tyrrell and other early work can be attributed to the increased long-term market penetration of major new end uses of electricity during a period of declining electricity prices. Market penetration effects should be much less under current Railbelt conditions.

A second study was performed by Taylor, Blattenberger, and Rennhack of Data Resources, Inc., for the Electric Power Research Institute in 1982. Using annual data for the 48 contiguous states for the years 1960-1974, they estimated demand equations which explicitly held the appliance stock constant. Independent variables included lagged consumption and the marginal price of electricity. The estimated elasticities themselves are not of use because the RED model utilizes average, not marginal prices (and elasticities with respect to average prices tend to be higher than those with respect to marginal prices).[a] What is interesting is the coefficient on lagged consumption variable, which represents λ: in the equation having the best statistical fit, its value was .700, with a standard error of 0.031. Using either the Mount, Chapman, Tyrrell short-run elasticities evaluated at 1980 prices, or the Chern and Bouis elasticities, this λ value implies long-run elasticities in the vicinity of -.40 to -.50 in Anchorage and in Fairbanks. These long-run elasticities appear reasonable, given that they primarily represent responses in utilization rates, with only modest fuel switching in response to price changes.

We note also that stock-held constant short-run price elasticities obtained by Taylor, Blattenberger and Rennhack are not very different from those estimated from the Mount-Chapman-Tyrrell (1973) framework. This is shown in Table 2.2. Taylor, Blattenberger and Rennhack obtained short-run elasticities in their preferred equation similar to those of Mount-Chapman-Tyrrell

(a) Although economic theory states that both average price and marginal price affect the demand for electricity, most researchers have encountered serious econometric problems in attempting to use both in regression equations. Halvorsen (1978, pp. 9-12) demonstrates that by pairing a demand equation of double-logarithmic form with an electricity price-determination equation of the same form in a two-stage least squares procedure, the average price and marginal price of electricity produce the same estimate of own-price elasticity. In general, however, this is not the case. Most researchers have used average price because of its availability.

TABLE 2.2. Effect of Holding Appliance Stock Constant on Elasticity Estimates

	Lagged Consumption: Mount-Chapman-Tyrrell (1973)[a]	Lagged Consumption: Taylor-Blattenberger-Rennhack (1982)[a]	Stock and Lagged Consumption: Blattenberger-Rennhack (1982)[a,b]
Price of Electricity			
Short Run	-.140	-.101	-.051
Long Run	-1.21	-1.052	NA
Price of Natural Gas			
Short Run	.0225	.002	-.00095
Long Run	.193	.018	NA
Lagged Consumption	.8837	.904	.631

(a) Price coefficients are for average prices in Mount-Chapman-Tyrrell, for marginal prices in Taylor-Blattenberger-Rennhack. Marginal and average series can be expected to be highly correlated over time in individual regions.
(b) The stock-held-constant equation reported here is the most exact comparison with the lagged consumption model; however, a slightly better-fitting equation was used to derive λ.

when using lagged consumption alone. When they held stock constant, the coefficients on lagged consumption and price all decreased in absolute value, but the short-run elasticities were relatively unaffected.

The third study also supports reduced long-run elasticity values. Moe, Owzarski, and Streit of Pacific Northwest Laboratory estimated Pacific Northwest residential winter electricity demand equations in a 1983 study performed for the Bonneville Power Administration. Using a sample of 1,437 individual Northwest single-family residences with data on November 1976 through April 1977 consumption, prices, appliance stocks, and other variables, they estimated a demand equation relating the logarithm of electricity consumption to the logarithms of average price and appliance stock (measured in kilowatt hours of "normal" use) and obtained an own-price elasticity estimate of -.424, with a standard error of .051. Both Pacific Northwest electricity prices and Anchorage electricity prices are below the national average. These estimates therefore may be applicable to the RED study region.

Interpretation of the elasticity estimates produced from cross-sectional data, however, depends on the nature of cross-sectional differences between variables. If differences in the explanatory variables across the cross-sectional observations have existed for some time, then the cross-sectional observations will all either be at equilibrium or the same point of disequilibrium. In either case, the observed differences in the capital stock of appliances and utilization of that stock should reflect long-term differences between cross-sectional observational units and estimated cross-sectional elasticities can be interpreted as long run elasticities (Halvorsen 1978, pp. 11-12). Kmenta (1978, pp. 114-117) has worked out the bias in the estimated coefficients for a simple model where adjustment to the long run may be incomplete. In the usual case, this amounts to a left-out variable problem, where not much can be said about either the existence or direction of bias in the estimated coefficients. The survey data for the Pacific Northwest used in Moe, Owzarski, and Streit (1983) was collected for 1976 through 1977 prior to recent rounds of sharp increases in fuel oil, natural gas, and electricity prices that may have differentially affected individual customers. Thus, it is likely that the individuals in the data set were, on average, equally adjusted to long-run differences in their circumstances and that the coefficients estimated in Moe, Owzarski, and Streit can be interpreted as long-run elasticities.

On the basis of these three studies, RED85A version of the RED model contains a value of 0.700 for λ in the residential sector. Several other studies incorporating the appliance stock as an independent variable were considered. In all cases, however, the estimates from these studies were deemed inappropriate, either because of study date (Kaysen and Fisher 1962), estimation technique (Anderson 1974), or study region (McFadden, Puig, and Kirshner 1977). Tyrrell (1984) confirms that 0.7 is a reasonable value.

COMMERCIAL SECTOR

Our review of the commercial electricity demand literature revealed two studies which provided a perspective on the value of the RED business sector lagged adjustment parameter (λ). We reviewed a study performed by Chern and his associates at Oak Ridge National Laboratory in 1982 (Chern et al. 1982), as well as an update of the study in 1983 (Bouis, Brown, and Chern 1983). Using annual data for the 48 contiguous states for the years 1955-1978, they estimated separate demand equations for each of the nine U.S. Census Divisions. The equations were estimated in double logarithmic form, with average price and lagged consumption appearing as independent variables. Values of λ range from .07 to .88; the arithmetic average is .618 and values in relatively low-price regions are generally below the average. These λ estimates may, of course, overstate the utilization-only price response, since equipment stocks are not held constant in any of the nine equations.[a] They suggest, however, that a value of .700 is appropriate in the commercial sector.

A short-run elasticity value for the commercial sector from Mount-Chapman-Tyrrell (1973) had been used in the July 1983 version of RED to determine the short-run elasticity of demand for electricity in the business sector. They had found a commercial short-run price elasticity of about -.18 to -.20. A strong result of the Chern and Bouis residential work is that both short-run and long-run residential price elasticities have declined relative to those in the period investigated by Mount-Chapman-Tyrrell and that recent periods show lower values than the 1955-78 period as a whole because of structural changes in demand. A parallel decline in price elasticity in the commercial sector would be expected because of similar structural changes in demand. Because there is little electric heating and air conditioning in the Railbelt, the short run elasticity ought to be toward the lower end of the observed range. The value of -.15 in the RED85A version of RED is in the lower part of Bouis, Brown, and Chern's observed range, and is within the range in Tyrrell (1984).

(a) The review of the commercial electricity demand literature indicated that there were no studies in which commercial equipment stocks were explicitly held constant.

It is consistent with the theoretical and empirical literature and appeared appropriate for the business sector in the Railbelt.

Table 2.3 provides a comparison of price adjustment parameter values in RED85A and the July, 1983 versions of RED. In both the residential and business sectors the average short-run and long-run price elasticity values are lower in the RED85A version than in the July 1983 version.

STRUCTURE OF THE PRICE ADJUSTMENT MECHANISM

In the July 1983 version of RED, an approximate mathematical expression was used to estimate the change that would occur in a given future year in the quantity of electricity demanded resulting from a change in price at an earlier

TABLE 2.3. Comparison of Parameter Values for Residential and Business Electricity Demand, RED85A Versus July 1983

Sector and Variable	RED85A	July 1983
Residential Elasticities		
Short-Run Elasticities		
Own-Price	-0.12	$-0.1552 + 0.3304/p$ [a]
Natural Gas	0.0225	0.0225
Oil	0.01	0.01
Lagged Adjustment (λ)	0.700	0.8837
Business Sector		
Short-Run Elasticities		
Own-Price	-0.15	$-0.2925 + 2.4014/p$ [a]
Natural Gas	0.0082	0.0082
Oil	0.01	0.01
Lagged Adjustment (λ)	0.700	0.8724

(a) Measured in mills per kWh, 1970 dollars.

point in the forecast. Specifically, the mechanism employed in the July 1983 version approximated the percentage change in quantity of electricity consumed in a forecast period K:[a]

$$OPA_{iK\ell} = \lambda^5 \, OPA_{i,K-1,\ell}$$

$$+\sum_{m=1}^{K} PCPEA_{im\ell} \Big[\lambda^4 \, ESR_{i,K1,\ell} \tag{2.1}$$

$$+ \lambda^3 \, ESR_{i,K2,\ell} + \lambda^2 ESR_{i,K3,\ell}$$

$$+ \lambda \, ESR_{i,K4,\ell} + ESR_{i,K5,\ell} \Big]$$

where $PCPEA_{im\ell}$ denotes the annual percentage change in the price of electricity in region i, time period m, and sector ℓ, while ESR denotes the short-run variable own price elasticity, calculated as:

$$ESR_{i,K,\ell} = BETA_{\ell} + .5 \frac{GAMMA}{P_{i,K,\ell}} + .5 \frac{GAMMA}{P_{i,K-1\ell}} \tag{2.2}$$

where BETA and GAMMA were parameters estimated by Mount-Chapman-Tyrrell. Similarly, price adjustment factors for oil (PPA) and natural gas price changes (GPA) were derived, with one simplification - the oil and gas cross-price elasticities were constant. Thus,

$$PPA_{iK\ell} = \lambda^5 \, PPA_{i,K-1,\ell}$$

(a) There are several subscripts in RED denoting time periods. In Equation (2.1), K denotes a future forecast period 1985, 1990, 1995, ..., 2010. Small m also denotes a future forecast period, but is less than or equal to K. K1, K2, etc. denote individual years within a forecast period. Small t, which appears in Equation 2.5, denotes individual years 1981-2010.

$$+ \sum_{m=1}^{K} PCPOA_{im\ell} \left[PSR_{\ell} \right.$$

$$\left. (\lambda^4 + 2\lambda^3 + 3\lambda^2 + 4\lambda + 5) \right] \qquad (2.3)$$

$$GPA_{iK\ell} = \lambda^5 \; GPA_{i,K-1,\ell}$$

$$+ \sum_{m=1}^{K} PCPGA_{im\ell} \left[GSR_{\ell} \right.$$

$$\left. (\lambda^4 + 2\lambda^3 + 3\lambda^2 + 4\lambda + 5) \right] \qquad (2.4)$$

where OSR_{ℓ} is the short-run oil cross-price elasticity in sector ℓ, GSR_{ℓ} is the short-run gas cross-price elasticity in sector ℓ and PCPOA and PCPGA are the annual percentage changes in the prices of fuel oil and natural gas, respectively.

This complex formulation of the own-price and cross-price effects was adopted in the July, 1983 version of RED to directly translate the Mount-Chapman-Tyrrell price effects (estimated on an annual basis) into five-year stepped electricity consumption differences for various price scenarios. A more straightforward way of calculating the quantity adjustment index, however, is to directly use a partial adjustment specification.[a] The required formulation (with oil prices added) for a constant price elasticity is:

$$Q_t = Q_{t-1}^{\lambda} \; P_t^{\beta} \; PG_t^{GSR} \; PO_t^{OSR} \; e^{\alpha i \ell} \qquad (2.5)$$

(a) At the same time, the model was modified from a variable elasticity form (the more general form estimated by Mount-Chapman-Tyrrell) to a constant elasticity form (which is a special case) because data were not sufficient to estimate changes in GAMMA in Equation 2.2. In addition, price elasticities did not vary greatly with the Mount-Chapman-Tyrell variable elasticity formulation over the fuel price range expected to prevail in the Railbelt.

where Q_t is the quantity of electricity consumed in year t, P_t is the price of electricity in year t, PG_t the price of gas, PO_t the price of oil and e the constant which is the base of natural logarithms. Lambda (λ) is defined as before, as is GSR and OSR; $\alpha_{i\ell}$ is an estimated constant, and β is the short-run electricity price elasticity.

Since Equation 2.5 is multiplicative in form, we can derive separate quantity adjustment indices for each fuel. The total quantity adjustment index is the product of the three indices:

$$QI_{iK\ell} = OPA_{iK\ell} \cdot PPA_{iK\ell} \cdot GPA_{iK\ell} \tag{2.6}$$

where $Q_{ik\ell}$ is the total price adjustment index in region i, time period k and sector ℓ, and OPA, GPA, and PPA are the price adjustment indices for changes in electricity, natural gas, and oil prices, respectively. The own-price adjustment (OPA) index is derived by holding the gas and oil price terms from Equation 2.5 constant at 1.0 and defining price of electricity as an index RP with its 1980 value equal to 1.0:

$$OPA_{iK\ell} = OPA^{\lambda}_{iK-1\ell} \cdot RP^{\beta}_{iK\ell} \tag{2.7}$$

Similarly, holding electricity prices constant in Equation 2.5, we can derive quantity adjustment indexes for gas and oil. The prices are normalized into relative price indices RPG and RPO, with 1980 equal to 1.0 in each case.

$$GPA_{i,K,\ell} = GPA^{\lambda}_{i,K-1,\ell} \cdot RPG^{GSR}_{i,K,\ell} \tag{2.8}$$

$$PPA_{i,K,\ell} = PPA^{\lambda}_{i,K-1,\ell} \cdot RPO^{OSR}_{i,K,\ell} \tag{2.9}$$

Preliminary consumption (sales in the absence of price changes, PRECON) is finally adjusted by the product of the quantity indices derived above to determine predicted, price adjusted consumption, $Q_{ik\ell}$.

$$Q_{iK\ell} = PRECON_{iK\ell} \cdot OPA_{iK\ell} \cdot GPA_{iK\ell} \cdot PPA_{iK\ell} \quad (2.10)$$

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3.0 RESIDENTIAL CONSUMPTION MODULE

In response to comments by FERC staff at a meeting in Anchorage in October 1983 and comments subsequently received from Dr. T. J. Tyrrell, we reexamined several of the parameters of the July, 1983 version of the RED Residential Consumption Module to confirm that the values of these parameters best reflected Railbelt conditions. This review included appliance saturations, 1980 electricity consumption estimates, fuel mode splits in new and replacement appliances, and electricity consumption growth in the absence of fuel price changes. The actual changes to RED made as a result of the review are shown in Tables 3.1, 3.2, and 3.3. The results of the review are shown in the following subsections.

APPLIANCE SATURATIONS

In his review of the July, 1983 version of RED, Dr. Tyrrell noted that the pattern of market saturation rates of appliances would ordinarily be expected to follow the traditional S-shaped pattern, increasing at a decreasing rate as the maximum saturation rate was approached. The saturations for a few appliances in the July, 1983 version of RED did not follow this pattern--clothes driers in multifamily dwellings in both Anchorage and Fairbanks appeared to follow an irregular pattern. Dishwashers in single-family housing in Fairbanks followed an abruptly declining pattern while dishwashers in Fairbanks multifamily housing followed an almost linear pattern.

The assumptions underlying these saturation patterns were reexamined for the RED85A, version of RED. Dishwashers' saturation patterns were not changed. Historically, the rate of market penetration of dishwashers in Anchorage and Fairbanks has been very rapid, as revealed by the 1970 Census and the 1981 Battelle Railbelt residential energy survey. The existing ceiling of 90% saturation appeared to be appropriate, given the large number of two-worker families in both Anchorage and Fairbanks. The historical growth rates in saturation were simply projected forward until 90% was reached (in cases of low initial saturation rates); or alternatively, 90% was assumed to be achieved by

1990 (a growth rate slower than historical rates in most cases), at decreasing rates. In the case of dishwashers in Fairbanks, this results in a traditional S-shaped curve.

In the July, 1983 version of RED, clothes driers' saturation rates were tied very closely to clothes washer market penetration in all housing types. The time path for market penetration in the RED85A version in multifamily housing has been smoothed as shown in Table 3.1. At the same time, clothes

TABLE 3.1. Changes in Market Saturations of Clothes Driers, RED85A Versus July 1983 RED Model (% of served households)

	RED85A		July 1983	
	Default[a]	Range	Default[a]	Range
Anchorage Multifamily:				
1980	75.7	--	75.7	--
1985	83.0	82-84	83.0	82-84
1990	87.0	84-90	83.5	85-90
1995	90.0	83-93	84.0	88-92
2000	92.0	89-95	85.0	90-94
2005	94.0	90-98	90.0	91-97
2010	95.0	91-99	95.0	92-97
Fairbanks Multifamily:				
1980	61.0	--	61.0	--
1985	67.0	63-71	65.0	61-69
1990	74.0	70-79	70.0	65-75
1995	80.0	75-85	80.0	75-85
2000	85.0	80-90	85.0	80-90
2005	90.0	85-95	90.0	85-95
2010	95.0	92-97	95.0	92-97

(a) Value used by the model when run in certainty mode (that is, when the Uncertainty Module does not select random values for model parameters). Default values were used in the forecasts.

washer saturations in Fairbanks multifamily homes and mobile homes were revised. These revisions are shown in Table 3.2. The impact of all these changes on the forecast is expected to be insignificant.

TABLE 3.2. Changes in Market Saturations of Clothes Washers, RED85A Versus July 1983 RED Model (% of served households)

	RED85A		July 1983	
	Default	Range	Default	Range
Fairbanks Multifamily:				
1980	63.8	--	63.8	--
1985	70.0	65-75	68.0	63-72
1990	75.0	70-80	70.0	65-75
1995	80.0	75-85	80.0	75-85
2000	85.0	80-90	85.0	80-90
2005	90.0	85-95	90.0	85-95
2010	95.0	90-100	95.0	92-98
Fairbanks: Mobile Homes:	(one year changed only.)			
1990	93.5	91-96	92.5	91-96

1980 ELECTRICITY CONSUMPTION ESTIMATES

Electricity consumption estimates for residential space heat in the 1980 housing stock are referenced in July, 1983 documentation of RED as coming from the 1980 study of Railbelt electricity demand by Goldsmith and Huskey of the University of Alaska Institute of Social and Economic Research. Electricity use rates in space heating are up to four times greater than those reported in other studies for the Lower 48. Therefore, these estimates were reviewed to confirm their accuracy. In addition, a 10% downward adjustment had been assumed for initial electricity conservation in the building stock between 1978 (Goldsmith and Huskey's base year) and 1980 (the base year for RED forecasts). The July 1983 version also contained a 15% upward adjustment in RED for energy used in water heating to allow for cold inlet water temperatures in Railbelt locations. Both of these assumptions were reviewed in light of additional data. Finally, we reexamined the estimate of electricity consumption in cooking.

All the original assumptions are supportable and require no changes. We deal with each of the issues below.

Space Heat. The difference between space heating electrical consumption in the Railbelt and Lower 48 study areas is, as far as we can determine, real and accurately portrayed in RED. The following was the procedure utilized by Goldsmith and Huskey in deriving the original estimates of electricity consumption.

Step 1. The beginning point of the analysis was 1970-1979 Alaska Gas and Service Company (now ENSTAR) residential customer data that show 1979 consumption per customer was 202.5 mcf. Goldsmith and Huskey estimated that about 84% of the load (the part that varied by temperature) was for space heat. Alaska Gas and Service Company used national data to estimate about 75% of the total was for space heat. The two figures were averaged to yield 80%, or 162 mcf per customer for space heat, averaged across single family, mobile home, and duplex units. (Multifamily fall under commercial schedules for gas.)

Step 2. The gas heat load was converted to kWh of electricity by assuming 65% efficiency for gas, 95% for electric heat. This results in an average 32,400 kWh for single family, mobile homes, duplexes. Using an assumed 1979 distribution of structures, average floorspace per unit, and average heat requirement per square foot based on surface-area-per-square foot ratios and Alaska energy studies, Goldsmith and Huskey worked out implied average space heating loads:

	Average Floor Space	Relative Average Heat Requirement Per Square Foot	Average Load (kWh)
Single Family	1,480	1.0	34,823
Duplex	1,085	0.9	22,976
Mobile Home	820	1.38	26,626
Total	1,350	1.02	32,400

The multifamily unit electricity requirements were also calculated using average building surface area/floorspace ratios.

Step 3. Heating requirements per unit in other parts of the Railbelt were next determined from Anchorage values using information on relative size of units (smaller in Kenai Peninsula and Matanuska-Susitna Boroughs) and relative heating degree-days. Average unit size was assumed to be 20% smaller in the Kenai Peninsula Borough and 15% smaller in the Matanuska-Susitna Borough than in Anchorage, based on 1970 Census median number of rooms per housing unit. Fairbanks housing was assumed 8% smaller than Anchorage, based on an actual 1979 Fairbanks Community Information Center energy survey data of Fairbanks for single family, duplex, and mobile home units. Heating degree days from 1977 and 1978 heating seasons were used to proportionately adjust Fairbanks consumption per square foot upward from Anchorage values. No heating degree day adjustments were made for outlying areas of Anchorage-Cook Inlet. The results are shown below for 1978.

	kWh			
	Single Family	Duplex	Multifamily	Mobile Home
Anchorage-Cook Inlet				
Anchorage	34,800	23,000	15,300	26,600
Kenai-Cook Inlet	27,800	18,400	12,200	21,300
Matanuska-Susitna	29,600	19,600	13,000	22,600
Seward	27,800	18,400	12,200	21,300
Fairbanks/Tanana Valley				
Fairbanks/ Southeast Fairbanks	45,900	30,400	20,200	35,100

Step 4. The 1978 average consumption figures were then weighted by the numbers of "first home" units of each type in each location having electric space heat in 1978. The product of the number of first homes of each type, the estimated 1978 fuel mode split, and the use per household by type of house was added across types and divided by the total estimated number of households having space heat. The total was then adjusted to a normal degree-day year. This results in consumption figures as follows:

	kWh			
	Single Family	Duplex	Multifamily	Mobile Home
Anchorage-Cook Inlet	36,500	24,200	17,100	27,300
Fairbanks-Tanana Valley	48,200	26,600	18,800	30,000

Step 5. This estimate of consumption in space heating can be independently verified from three other sources. First, Axel Carlson of the University of Alaska Cooperative Extension Service estimated "typical" house heating requirements for six types of houses in Fairbanks and one type in Anchorage (Fairbanks North Star Borough Community Information Center Special Report No. 2, 1978 and Special Report No. 4, 1976). His findings were:

		Anchorage	Fairbanks
1.	Single Family	40,917 kWh	52,392 kWh
	a. 2300 square feet (incl. daylight basement)		
	b. 768 square feet (closed crawl space)	--	29,042
	c. 768 square feet (heated crawl space)	--	26,620
2.	Mobile Home		
	a. 768 square feet (closed crawl space)	--	34,873
	b. 768 square feet (heated crawl space)	--	32,671

Adjusted for housing size, these estimates are compatible with the ISER estimates from Step 4.

A second source of data for comparison was the "heating only" electrical consumption figures for Chugach Electric from the Federal Power Commission's annual publication <u>All Electric Homes</u>, from 1963 to 1974. The average use rate in all Chugach electrically space-heated homes was between 29 thousand and 30 thousand kWh, very similar to the ISER estimates for single family and mobile homes.

A third source used by ISER also gave similar, but somewhat higher estimates of consumption in space heating. When national average electrical requirements from the U.S. Department of Energy Office of Community Systems were applied to Anchorage, the following estimates were obtained:

Type	Thermal Requirement (Btu/sq. ft/heating degree-day)	Average Size (sq ft)	Annual Anchorage Electrical Requirement (kWh)
Single Family Detached	11.3	1,570	56,716
Single Family Attached	6.2	1,370	27,154
Multifamily High Rise	4.5	900	12,947
Multifamily Low Rise	5.0	800	14,386
Mobile Home	15.0	720	34,526

Ten Percent Space Heat Conservation Adjustment

The base year electricity consumption used in the ISER predecessor to the RED model was based on 1978, adjusted to normal heating degree days (10,911 in Anchorage; 14,344 in Fairbanks). The base year used in the RED model was 1980, also adjusted to normal heating degree days.

As shown in the following table, combining the ISER 1978 space heating estimates with the RED model's 1980 estimates for housing stock and fuel mode split the model would produce a normalized estimate for electricity consumption per household much higher than actual values for 1980. On the other hand, adjusting for 10% conservation between 1978 and 1980 produces a value much closer to the actual 1980 consumption per household. Given that some non-space heat loads may also be weather-sensitive, and probably contribute to the difference between RED estimated and actual consumption, the 10% adjustment appears appropriate and has not been changed.

Annual Use Rates in Residential Sector for Actual 1980 Degree Days

	(kWh) Anchorage	(kWh) Fairbanks
1. With ISER 1978 use rates	13,534	11,454
2. With RED adjusted use rates (ISER 1978 rates, minus 10%)	13,031	11,214
3. Actual consumption per household	13,090	10,449

Fifteen Percent Adjustment for Lower Water Temperature in Water Heating

We examined a number of studies that gave estimates of electrical consumption in water heaters for Lower 48 locations. Other things equal (insulation of the heater and water use rates), one would expect that lower inlet water temperatures would cause proportionately higher electrical use rates in Alaska. The question is: how much higher?

The basic study used to calibrate the water heating estimate was the California Energy Commission's (CEC) 1976 estimate (See in Table 5.14 of Volume 2C of the July 1983 Susitna license application). The original source was adjusted upward by 15% to allow for lower Alaska water temperatures. Data supplied by David Myers of Battelle-Northwest's Geosciences Research and Engineering Department reveals that groundwater temperatures in the Anchorage area average 2° to 3°C (36° to 37°F) and about 1°C (33°F) in the Tanana Basin.[a] Peter Poray, of the Anchorage Municipal Energy Coordinator's Office, confirms that surface water temperatures in Ship Creek (which supplies about half of Anchorage's needs) average 33°F.[b] In contrast, ground water temperatures in much of the U.S. are in the high 50° to low 70°s (see Ground Water and Wells, Johnson Division, UOP, Inc., St Paul, Minnesota, 1975, p. 12). In particular, this is true for CEC's region.

Even allowing for no difference in standby heat loss in water heaters between Alaska and the CEC study, the 15% adjustment appears conservative, in view of the 50% difference in inlet temperature. The 500 KWh/year/unit downward adjustment of water heater electrical use made in the RED model in 1983 in Anchorage to allow for heating of Anchorage's water supply at the Municipality's power plant also appears conservative. Although the temperature at the plant is increased by as much as 15°F, only half of the supply is heated; only Anchorage (not the Matanuska-Susitna Borough or Kenai Peninsula) is involved, and no studies have been done to see how far into the Municipality's water system the added heat penetrates.

(a) Telephone communication, David Myers, Battelle Northwest Geosciences Research and Engineering Department to Michael Scott, May 17, 1984.
(b) Telephone communication, Peter Poray, Municipality of Anchorage to Michael Scott, May 18, 1984.

Another sign that the water heat estimate is appropriate is a series of Pacific Northwest submetering studies of domestic hot water system whose results were reported in Appendix K to the Regional Conservation and Electric Power Plan of the Pacific Northwest Power Planning Council in 1983. The average use in 120 units in 8 studies was 6318 kWh per year, with a standard deviation of 2600. In spite of the warmer average inlet water temperatures in these studies (e.g., about 47° in Seattle), almost all the studies showed higher use rates than was assumed for the Railbelt. Adopting the range of 3.5 to 5.6 kWh per day per household occupant in those studies and standardizing at the Railbelt average household size of about 2.9 in Anchorage, the studies (unadjusted for water temperature) would show a range of 3704 to 5928 kWh per year for Railbelt size households compared to the 4800 kWh actually fore-casted. This supports the original 15% adjustment for cold water in the Railbelt.

Cooking Ranges

Cooking ranges were assumed in the July 1983 license application to have electric consumption rates that were "the average of several studies." In fact, the 850 kWh assumed is the simple arithmetic average of the rates shown in Table 5.14 of Volume 2C, rounded to the nearest ten kWh. This was not changed in the RED85A version of RED.

Fuel Mode Splits in Replacements and New Housing

In the July, 1983 license application, incremental fuel mode splits for space heat and water heat in Anchorage-Cook Inlet were set at low values relative to the existing (1980) stock to reflect the fact of large-scale movement to natural gas. This reflected information obtained from several telephone interviews with Anchorage area builders and real estate firms in May 1983. At that time, the incremental water heating fuel mode splits were set equal to the incremental space heating splits except in mobile homes, where about half the existing units appeared to have electric water heaters even though the space heat units were overwhelmingly gas.

Since July 1983, we have again reviewed the assumptions concerning the incremental fuel mode splits. The incremental splits should reflect not only new construction practices but fuel switching at the retirement of existing systems. Additional telephone interviews with Anchorage area plumbing and heating firms have confirmed current large-scale conversions of both space heat and water heat to natural gas in all types of housing in areas where gas is available. Conversions are occurring on both relatively new systems as well as old all-electric systems. Accordingly, there appears to be no reason to change the incremental fuel mode splits from their conservative July 1983 values, which continue to reflect some electric space and water heat in areas beyond the reach of gas pipeline systems. It is still assumed that pipeline gas will not be available in the Fairbanks-Tanana Valley load center, so no adjustments are made to existing fuel mode splits in that area.

A difference between the 1981 Battelle residential survey and the 1980 Census for Fairbanks fuel mode split in water heating was noted. The Fairbanks water heating fuel mode split reported in the survey had been adjusted to a figure much closer to the Census value, not because it "disagreed" with the 1980 Census, but because the 1980 residential consumption calibration required it. The Census did not report the fuel mode split for hot water by type of housing. However, model calibration coincidentally brought the average Fairbanks fuel mode split for water heating close to the Census figure. The average fuel mode splits for the 1981 Battelle survey and 1980 Census are shown below:

Electric Fuel Mode Splits (%)

	1981 Battelle	1980 Census
Space Heat:		
Anchorage-Cook Inlet	23.0	20.2
Fairbanks-Tanana Valley	10.9	11.6
Water Heat:		
Anchorage-Cook Inlet	45.5	36.2
Fairbanks-Tanana Valley	30.5[a]	36.1
Cooking:		
Anchorage-Cook Inlet	73.3	68.6
Fairbanks-Tanana Valley	84.3	83.4

(a) Adjusted value.

The only place where the 95% confidence intervals of the Battelle and Census estimates do not overlap is water heat in Anchorage. Even there, the results of the Census sample and Battelle survey are in fairly close agreement. The lower 95% confidence bound on the Battelle estimate is about 39% for the electric fuel mode split. The upper bound on the Census electric fuel mode split is estimated at 37%. Given that both the Battelle Census and estimates are based on samples and that the Census does not report fuel mode splits by type of dwelling, fuel mode split in Anchorage-Cook Inlet was not adjusted.[a]

Annual Consumption, 1985 and After

The 1985 electricity consumption rates for residential appliances in the July, 1983 license application were also reviewed. Except in a few cases, the 1985 consumption rate assumptions are clearly stated in the July, 1983 license application and require no further explanation. Broadly stated, up to 1985 the consumption rates of electricity by residential appliances reflect pre-existent trends in the efficiency improvements that are partly or wholly offset by increasing trends in size or energy-using features that are expected to prevail in the Railbelt. The only appliance which exhibits an apparent large unexplained change between 1980 and 1985 consumption is cooking (ranges). In 1980 the value for annual consumption of electricity in cooking is 850 kWh. For replacement stock and new units it is 1200 kWh. This "rapid increase" is designed to take care of two factors: 1) The wide range of values for annual consumption reflected in the various studies in Table 5.14 of Volume 2C of the July 1983 license application reflects varying ages of appliance stock in the studies and varying presence of features such as automatic timers and self-cleaning ovens. It is assumed that most replacement and new stock will contain these features, which will increase incremental energy use. 2) There are several convenience kitchen appliances, not directly accounted for in the RED model, that are directly related to food preparation and could add to "cooking" energy use as their market saturation increases. Included are separate

(a) Had we adjusted to the Census value, the impact on the 2010 forecast of changing the fuel mode split would have been about a 32 GWh decrease in consumption, or approximately -.5 percent.

electric ovens (Association of Home Appliance Manufacturers rated at 373 kWh per year), electric cooktops (365 kWh per year) and microwave ovens (98 kWh per year). In addition there are food processors, food waste disposers, and trash compactors, all becoming more common in Railbelt kitchens.

Electricity use in space heating reflects increasing average size of homes being built in the Railbelt region. While the 1980 consumption rate was based on 1980 average floorspace for the then-existing stock, 1985 consumption rates reflect the size of units being added. Table 3.3 shows the differences

Size of Houses in Railbelt Region
(%)

Size Class (sq ft)	Anchorage-Cook Inlet Average	Anchorage-Cook Inlet Post-1975	Fairbanks-Tanana Valley Average	Fairbanks-Tanana Valley Post-1975
1. Less than 700	8.1	6.9	11.3	10.2
2. 701-1000	18.1	14.1	21.1	17.3
3. 1000-1300	14.2	17.6	19.3	16.5
4. 1301-1600	12.9	12.2	13.1	15.0
5. 1601-2000	20.8	21.5	16.6	18.1
6. 2001-2400	14.6	14.6	9.8	12.6
7. 2401 and over	11.1	12.9	8.8	10.2

revealed in the Battelle 1981 Railbelt residential survey (see Appendix A, Volume 2C of the Susitna license application) between the size of housing units added after 1975 and average unit size. The figures shown below do not account for several sources of size increase in new 1985 stock. The figures do not reflect renovations and additions which also increase average size of dwelling units built before 1975, nor post-1980 size increases in new units, nor average size increases within specific classes of housing (single family, for instance). In spite of this, the 1981 survey shows a clear trend toward larger units in the post-1975 stock.

The increases in stock size implied in Table 5.13 of Volume 2C of the July, 1983, license application are about 22% over the 1980 average stock

TABLE 3.3. Post-1985 Annual Growth Rates in Electricity Consumption for Residential Appliances

	RED85A	July 1983
Space Heat		
Single Family	0.005	0.005
Mobile Homes	0.005	0.005
Duplexes	0.005	0.005
Multifamily	0.005	0.005
Water Heaters	0.0	0.005
Clothes Dryers	0.01	0.00
Cooking Ranges	0.01	0.00
Saunas-Jacuzzis	0.01	0.00
Refrigerators	0.01	0.00
Freezers	0.01	0.00
Dishwashers	0.01	0.00
Additional Water Heating	0.005	0.005
Clothes Washers	0.01	0.00
Additional Water heating	0.005	0.005
Small Appliances and Lighting:[a]		
Anchorage	80 kWh	50 kWh
Fairbanks	100 kWh	70 kWh

(a) Change per five-year period.

size. In Anchorage, for example, this implies new single family detached units would be about 1830 square feet, versus 1500 assumed in the 1980 stock if energy consumption per square foot were the same in 1980 and 1985 stock. Similarly, new duplexes would be about 1300 square feet; new mobile homes, about 1000 square feet; new multifamily units, 1100 square feet. In Fairbanks, the new single family units would average about 1700 square feet versus 1350 in the existing 1980 stock, 1000 square feet in new duplexes versus 800 in the 1980 stock; 1000 square feet in new multifamily versus 850 in the 1980 stock; and 1100 square feet in new mobile homes versus 900 in the 1980 stock. In comparison, U.S. Department of Energy gives the following, generally larger, 1981 average unit sizes for the nation: single family detached, 2093 square feet; single family attached, 1946; 2-4 units, 1126; 5 or more units, 826; mobile homes, 880.[a]

In summary, there is no reason to change any of the 1985 electricity consumption rates for the RED85A version of RED, since the 1985 consumption rates still appear reasonable.

Post-1985 growth rates in energy consumption are changed between the July, 1983 and RED85A versions of RED. The July, 1983 version assumed that increases in post-1985 energy-using features of most major appliances would be just offset by increases in appliance efficiencies. The RED85A version no longer assumes the post-1985 trends would be offsetting. There are two major reasons. The first is that average consumption rates in new appliances in the absence of electricity price changes in the Railbelt reflect the menu of appliance choices available to Railbelt residents after 1985. The efficiency of this appliance stock will in turn reflect electricity prices in national markets, while choices made from the menu will reflect local prices. April 1983 Energy Information Administration long-term forecasts of national electricity prices show modest national rates of increase (about 0.9% per year, 1980 to 1990; 1.6% per year from 1985 to 1990).[b] Also, appliance energy conservation has been so successful to date (see Table 5.15 of the Volume 2C of July, 1983 application) that further improvements in the available stock after 1985 may be difficult to achieve. These factors will tend to restrict somewhat the choices in efficiency of appliances available for purchase in the Railbelt after 1985. On the other hand, as incomes rise and the wealth of Railbelt households increase, they will demand a greater level of services from their

(a) U.S. Energy Information Administration, Residential Energy Consumption Survey, Housing Characteristics, 1981, August 1983, Table 5.
(b) U.S. Energy Information Administration, 1982 Annual Energy Outlook, with Projections to 1990, DOE/EIA-0383(82), April 1983, Table 4.

appliance stocks. Accompanying the demand for services growth will be a general increase in the capacity and, hence, energy use, of appliances. Since efficiencies are expected to change little in absence of price changes, the average consumption rates should rise over the forecast period to reflect the wealth gains.

The second reason for increasing energy use is that long-term elasticities estimated in national econometric studies such as those in the RED model measure, to some extent, the effect of national electricity price trends on technological change in the energy efficiency of the appliances available for purchase. However, for the RED model this effect must be held constant because the market is too small to influence national appliance stock efficiencies. Put another way, it is necessary in small markets like the Railbelt to offset that portion of the long-term price elasticity effect measured in national studies that accounts for general price-induced technological change in appliance efficiency. The July 1983 version of RED over-corrected for the price-induced technological change by holding the growth rates in electricity consumption constant, while including an elasticity that incorporated the same effect. The RED85A version of RED adjusts for this by increasing the post-1985 growth rates in appliance electricity consumption for all appliances except water heaters and space heating units. These are assumed to be more influenced by local conditions. A conservative growth figure of 1.0% per year is used, up from 0.0% in the July, 1983 version.

Miscellaneous appliances were also reviewed. A number of new appliances became available in the late 1970s and early 1980s whose market penetration is clearly increasing, but whose effect on total usage is not clear at this time. These include video cassette recorders, home computers, video games, central vacuum systems for cleaning, security alarm systems, and central air filtration systems. In addition, Fairbanks area utility interviews in February 1984 confirmed that in Fairbanks additional emphasis has been given to controlling environmental carbon monoxide pollution at low temperatures by the U.S. Environmental Protection Agency and the North Star Borough government. This has taken the form of an ordinance prohibiting cars and trucks from being left idling and mandating the plugging in of car engine block heaters at temperatures as high as 20°F to improve engine performance. This could increase the use of engine block heaters at warmer (0° to 20°F) temperatures than has been the case in the past. The growth rate in miscellaneous consumption has been increased slightly to account for these phenomena in Table 3.3.

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4.0 BUSINESS SECTOR

The ongoing review of the RED model has generally supported the structure of the model's Business Consumption Module. Additional data have been collected from both Railbelt and national sources which have permitted further refinements to both the structure and selected parameter values.[a]

This section contains a discussion of the changes made in the July, 1983 version of the Business Consumption Module. We first review the calculations in the July, 1983 version. Next, we discuss the way in which floorspace per employee is forecasted, and finally, discuss minor adjustments made to the equations that determine preliminary electricity requirements prior to price effects.

STRUCTURE OF THE JULY, 1983 BUSINESS CONSUMPTION MODULE

Using regional employment, the Business Consumption Module first constructed estimates of the regional stock of floorspace by five-year forecast period. The predicted floorspace stock was then fed into an electricity consumption equation that is econometrically derived to yield a preliminary forecast of business electricity requirements, which was then adjusted for price impacts.

After an investigation of several alternative methods for forecasting business floorspace, a simple formulation of the floorspace forecasting equation was used in the July, 1983 version of RED. The floorspace per employee was assumed to increase at an exponential constant rate to the 1979 national level reported by the U.S. Energy Information Administration (1983) by the year 2010, or cumulatively increase about 10% and 15% in Anchorage and Fairbanks,

(a) During February and March, 1984 we conducted additional interviews with Railbelt utility staff, state and local government planning groups, public and private building managers, and realtors. The results are reported in Imhoff and Scott, 1984 included in this document as Appendix A. The data we found suggests that the utilities themselves are oriented toward either a per-customer or per-square foot approach to estimating business electricity consumption. Available data are consistent with both the 1980 building stock per employee and 1980 consumption per square foot data contained in the July 1983 version of RED.

respectively. This took into account both the evidence of historic increase in floorspace per employee in Railbelt load centers and the historic lower levels of floorspace per employee in Alaska compared with the nation as a whole. This assumption was still quite conservative, since Alaska's commercial floorspace per employee is far below the national average and has been growing faster historically than the projected rate. The forecasting equation is shown as Equation 4.1.

$$STOCK_{iK} = a_i \cdot (b_i)^{t-1} \cdot TEMP_{it} \qquad (4.1)$$

where

STOCK = floorspace in business sector

a = initial (1980) floorspace per employee

b = annual growth factor (1 plus growth rate) in floorspace per employee

TEMP = total employment

i = index for the region (Anchorage-Cook Inlet or Fairbanks-Tanana Valley)

K = time index, K=1,2,3,...,7 (forecast periods)

t = time index, t=1,2,3,...,31 (years).

Once the forecast of the stock of floorspace was found, the module then predicted the annual business electricity requirements before price adjustments, based on a regression equation:

$$PRECON_{iK} = \exp[BETA_i + BBETA_i \times \ln(STOCK_{iK})] \qquad (4.2)$$

where

PRECON = nonprice adjusted business consumption (MWh)

BETA = parameter equal to regression equation intercept

BBETA = percentage change in business consumption for a 1% change in stock (floorspace elasticity).

exp,ln = exponentiation, logarithmic operators

Finally, price adjustments were made with the price adjustment mechanism structure identical to that in the Residential Consumption Module, however, different in the parameters:

$$BUSCON_{iK} = PRECON_{iK} \cdot OPA_{iK} \cdot PPA_{iK} \cdot GPA_{iK} \qquad (4.3)$$

where

BUSCON = price-adjusted business requirements (MWh)

OPA = own-price adjustment factor

PPA = cross-price adjustment factor for fuel oil

GPA = cross-price adjustment factor for natural gas.

In summary, the forecast of electricity demand in the business sector was directly tied to a forecast of floorspace stock via a regression equation. Floorspace stock, on the other hand, was derived by an explicit assumption of the level of floorspace per employee in the year 2010--floorspace was then derived by providing an exogenous forecast of employment.

PREDICTING FLOORSPACE STOCK

As can readily be seen in Equation 4.1, the level of floorspace per employee in a given forecast year was assumed in the July, 1983 version of RED to exponentially approach the national 1979 level. The RED85A version assumes that the past historical trend of square feet of business space per employee will continue. This results in a year 2010 value for the Anchorage load center that is slightly less than the national 1979 value. It also is less than the 1979-1983 national growth rate in business floorspace per employee. (The 1983 value was 676.7 square feet per employee compared to 623 in 1979. The national difference was 53.7 square feet per employee, or 13.4 square feet per employee per year (U.S. Department of Energy 1985). The projected rate of increase in Anchorage is only 5.8 square feet per employee per year.

The exponential growth path in July 1983 version of RED assumed that the increments by which business space per employee grew increased with time. The current version of the model results in constant increments, which implies a slowly decreasing growth rate.[a] Because of differences in the respective economies and the labor and materials cost differential between Anchorage and Fairbanks, it is assumed that floorspace (STOCK) per employee in Fairbanks grows at the same rate as in Anchorage, but from a lower base so that it does not reach the 1979 national level by 2010. Equation 4.1, therefore, was replaced with the following form in the RED85A version of the model:

$$STOCK_{it} = (a_i + b \cdot t) \cdot TEMP_{it} \qquad (4.1')$$

where

a_i = intercept (1972 value) square footage per employee in each load center

b = growth rate parameter

t = forecast year ($t=1,2,\ldots, 38$).

PARAMETER VALUES

In the July, 1983 version of RED, the national average number of square feet per employee was derived using the 1979 Energy Information Administration (EIA) Nonresidential Buildings Survey and U.S. Department of Commerce, Bureau of Economic Analysis (BEA) definitions of total employment. In the Railbelt, however, an alternative measure of total employment can be found using the State of Alaska, Department of Labor data series as edited by the University of Alaska, Institute of Social and Economic Research (ISER). Furthermore, since

(a) As progressively more categories of commercial floorspace become available in adequate amounts in Anchorage, we expect there will be fewer categories growing rapidly, contributing to an overall decline in the growth rate.

the RED model relies on a forecast of this measure of total employment, as generated by ISER's Man in the Arctic Program (MAP) regional economic model, consistency in the final forecast requires consistency between the two models' definitions of employment.

In the RED85A version of RED, the ISER definition of total employment was used to adjust 1979 BEA national total nonagricultural employment figures to more closely represent the employment distribution in the Railbelt Region. This was done by adjusting the national square feet per employee: netting out industrial (heavy manufacturing) and mining employment, and adding in military employment to the national figure. Industrial employment is netted out because there is little industrial employment or floorspace in the Railbelt region, and because industrial electricity demand is exogenously predicted in RED. National mining employment was deleted from the national total because the lower 48 figures primarily represent individuals working in mines, while in the Railbelt, mining workers are mostly headquarters staff working in offices. Military employment is included because the MAP definition includes military employees. Table 4.1 documents the 1979 national stock per employee calculation, as modified. The 613.1 square feet per employee matches fairly well with the 623 square feet per employee derived by EIA for their entire 1979 sample of nonresidential buildings (which includes industrial buildings and some buildings that have both residential and nonresidential uses).

The value of b in Equation 4.1' is econometrically derived from historical employment and estimated building stock data described in Appendix B. The "intercept" coefficient a was derived by solving the equation for the 1980 Anchorage and Fairbanks estimated values of square feet per employee. In 1980, the variable t had the value of 8, since 1973 = 1 in Equation 4.1'. Table 4.2 shows the values for these parameters for Anchorage and Fairbanks. When utilized to predict a value of square feet per employee in the year 2010, Equation 4.1' produces values of 603.8 in Anchorage and 538.4 in Fairbanks, both less than the 1979 national values of 613.1 (as calculated) or 623 (as reported for the sample buildings).

TABLE 4.1. Calculation of 1979 National Square Footage Per Employee

Employment (Thousands):		
1979 Nonfarm Employment[a]	93,600	
Less:[b]		
Industrial	22,137	
Mining	865	
Plus:		
Military[a]	2,100	
Total Adjusted National Employment		72,698
Square Feet (Thousands):		
Total Nonresidential[c]	54,825,000	
Less:		
Residential	3,115,000	
Industrial	7,140,000	
Total National Business Square Feet		44,570,000
Average Square Feet per Employee		613.1

(a) Source: 1981 Statistical Abstract of the United States, Table 634.
(b) Ibid., Table 658.
(c) "Nonresidential" buildings are buildings used for some purpose other than residential. Those buildings used primarily as residences (residential) were removed from the business total, as well as industrial buildings (which are much more heavily represented in national than in Railbelt floorspace).

TABLE 4.2. Parameter Values for Business Floorspace Equation, RED85A

Coefficient	Anchorage Cook Inlet	Fairbanks-Tanana Valley[b]
a. Value	383.023[a]	317.562[a,b]
Standard Error	--	--
b. Value	5.811	5.811
Standard Error	1.718	--

(a) The coefficient value was adjusted in 1980 so that the estimated 1980 values of 429.5 square feet per employee in Anchorage-Cook Inlet and 364 in Fairbanks-Tanana Valley were reached in year t = 8 (the years 1973-1982 were used in the regression). The original value in the Anchorage equation was 316.22, with a standard error of 10.661.
(b) The Fairbanks equation is not econometric. See text.

PREDICTING BUSINESS CONSUMPTION

In the July, 1983 version of RED, business preliminary electricity consumption (that is, in the absence of price effects) was estimated by regressing historical commercial-industrial-government electricity consumption in the two load centers on the corresponding estimated historical stock of business floorspace and other selected parameters. In his March, 1984 review of the RED model, Dr. Tyrrell suggested that we attempt to introduce fuel prices directly into our regression equations to hold price effects constant. At the same time, we felt the historical commercial-industrial-government electricity consumption data series could be refined. First, heavy industrial electricity consumption was removed from the Anchorage-Cook Inlet series so that only commercial-light industrial-government consumption was estimated by the equation for that load center, consistent with the RED definition of the business sector. Next the Fairbanks city government consumption of electricity data were edited to attain consistent reporting of this category within the business sector.

The second adjustment made in the data for the RED85A version of RED was in the historical building stock for Anchorage and Fairbanks. During the summer of 1984 the FW Dodge Construction Potentials data series for Alaska was acquired, giving us access to the most complete data set on commercial building starts. Documentation of the analysis of the F. W. Dodge data is shown in Appendix B. The resulting estimates of total commercial building stock for 1973-1983 are shown in Table 4.3.[a]

Following Dr. Tyrrell's suggestion, historical data series on fuel prices in the Railbelt were used to estimate consumption equations for electricity in the business sector. No price series were available for natural gas or fuel oil and the best series for electricity contained some gaps. In the resulting regression equations the electricity price did not contribute to the explanation of electricity consumption. Following standard econometric procedures,

(a) It was assumed that the average Railbelt commercial building took from 1 to 2 years to complete, once begun, to estimate construction completions.

TABLE 4.3. Estimated Commercial Floorspace, Anchorage-Cook Inlet and Fairbanks-Tanana Valley Load Centers, 1973-1983 (million square feet)

Year	Anchorage Cook Inlet[a]	Fairbanks-Tanana Valley[b]
1973	26.2	3.8
1974	29.0	4.4
1975	33.1	5.4
1976	36.8	7.5
1977	39.6	8.7
1978	41.4	9.8
1979	42.8	10.1
1980	44.1	10.4
1981	44.9	10.6
1982	47.6	10.8
1983	49.8	11.2

(a) 1978 estimated stock (Goldsmith and Huskey 1980), plus or minus F. W. Dodge gross additions, lagged one year.
(b) 1983 estimated stock (Scott and Imhoff 1984. See Appendix A), minus F. W. Dodge gross additions to stock, lagged one year. See Appendix B.

price was dropped from the final equation in both load centers. There was virtually no effect in either region on the coefficient BBETA (the effect of business floorspace) from dropping electricity price.

The effect of reestimating the business electricity consumption equation was to reduce the business forecast to some degree relative to the July 1983 version. In combination with the higher business space estimate and larger (negative) price effect, the net effect on the forecast is an increase in the forecast.

Table 4.4 reports the differences between the RED85A version of the business electricity consumption equation for Anchorage-Cook Inlet load center, while Table 4.5 reports the differences in Fairbanks.

TABLE 4.4. Differences in Equations for Business Electricity Consumption in Anchorage-Cook Inlet, RED85A Versus July 1983[a]

	RED85A	July 1983
BETA	-6.320[b]	-4.7963
standard error	.0622	0.6280
t-statistic	101.60	-7.6368
BBETA	1.224	1.4288
standard error	.062	0.0491
t-statistic	19.74	29.1159
$\bar{R}^2$	.98	.9906

(a) Both equations take the form

$$\ln(CON_t) = BETA + BBETA * \ln(STOCK_t) + \varepsilon_t$$

where:

CON = business consumption (but excluding large industrial in the 1985 version)

STOCK = predicted stock of floorspace

(b) To calibrate to 1980, the intercept BETA is reset to -2.2118 in the model.

The July, 1983 version of RED used a predicted stock series (the best available at the time) that showed less rapid and less variable growth in building stock than that indicated by more recent actual construction data. For example, actual 1975 commercial construction starts in Fairbanks represented almost 48% as much space as the entire commercial building stock available in 1974. At the same time, rapid electricity price increases after 1973 caused many building owners and managers to drop electric space heat. The consequence was that historically, Fairbanks showed a building stock elasticity of demand of only 0.4 to 0.5, whether or not the Fairbanks electricity price series was included in the equation. This is not representative of current (post-1980) conditions, since most of the electric space heat conversion has been accomplished. Therefore, an elasticity of 1.0 for the period after 1980 was assumed. The intercept of the Fairbanks consumption equation was calibrated to actual 1980 consumption per square foot. This implies Fairbanks-Tanana Valley business consumption would grow in proportion to commercial building space in the absence of price effects, a somewhat slower rate of growth than that projected in Anchorage.

TABLE 4.5. Differences in Equations for Business Electricity Consumption Equations in Fairbanks-Tanana Valley, RED85A Versus July 1983[a]

	RED85A	July 1983
BETA	-.7980	-0.9611
standard error	--	3.6314
t-statistic	--	-0.2647
BBETA	1.0	1.1703
standard error	--	0.3293
t-statistic	--	3.5538
GAMMA	--	0.1629
standard error	--	0.0535
t-statistic	--	3.0444
THETA	--	-0.0028
standard error	--	0.0024
t-statistic	--	-1.1547
$\bar{R}^2$	--	0.9121

(a) The July 1983 version of the equation is

$$\ln (CON_t) = BETA + BBETA * \ln (STOCK_t) + GAMMA * V + THETA * D_t T_t + \varepsilon_t$$

where
CON, BETA, BBETA, and STOCK are defined in Table 4.4 and where
D = Dummy variable (1974-1981 = 1)
V = Pipeline period dummy variable (1975-1977 = 1)
T = Time trend for T = 1-9 (1973-81)

(b) The RED85A version of the Fairbanks-Tanana Valley consumption equation is not econometric and contains only two variables. See Appendix B, Section B.5.0.

Source: Appendix B.

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5.0 PEAK DEMAND

Review of recent annual load factors for the Fairbanks-Tanana Valley load center showed that the load factor assumed for the Fairbanks-Tanana Valley load center in the July 1983 version of the model was too low by about 10%. The July 1983 assumed value was 0.50. Recent historical load factors are shown in Table 5.1.

The average of the 1980-1983 estimated load factors is 0.553. We used 0.55 as the value for the RED85A version of the RED.

TABLE 5.1. Historical Annual Load Factors, Fairbanks-Tanana Valley Load Center

Year	Annual Sales to Final Customers[a] (GWh)	Final Customer Peak Load[b] (MW)	Load Factor
1980	412	90	0.522
1981	421	87	0.552
1982	446	88	0.579
1983	461	94	0.560

(a) From Alaska Power Administration, Alaska Electric Power Statistics, [Annual].
(b) Reported Peak from Alaska Electric Power Statistics, September 1984, less 7% for line loss.

6.0 EFFECT OF THE MODEL CHANGES ON THE FORECASTS

This section of the paper details how the RED model forecasts are affected by the changes made to the model in the RED85A version. In order to compare the RED85A and July, 1983 versions we ran simulations of the RED85A version for three cases contained in the July 1983 Susitna License Application. These cases were:

- H12 - Sherman Clark No Supply Disruption Reference Case
- H13 - DRI Case
- HE8 - FERC -2% Case

The H12 reference case was chosen to see how the base case utilized in July 1983 to plan the Susitna project would be affected. DRI and FERC -2% cases were chosen because they previously represented the highest and lowest fossil fuel price (and Alaskan economic growth) paths reported in the license application. There was enough price variation among these cases to determine how responsive the new model was to very different price scenarios. In the reference case, real residential fuel oil prices grow by 59% from their 1980 base to the year 2010 (1.6% per year, averaged over 30 years); in the DRI case, the growth is 106% (2.4% per year average); in the FERC -2% case, prices fall 43% (about -1.9% per year).

Table 6.1 summarizes the overall effect on the forecasts. In general, compared to the 1983 forecasts, the new forecasts are more price-responsive, but grow more quickly in the absence of price effects. The overall effect is to narrow the range of the forecasts to some extent. Long run price responsiveness of demand dominates at high prices (DRI case), dampening the forecast of 1983. At low prices, the non-price factors (e.g. economic drivers) dominate and the forecasts are increased over 1983. The RED85A version of the model shows about 0.1% lower consumption in 2010 than the July, 1983 version.

Table 6.2 shows a more detailed comparison of the RED85A reference case forecast with the July, 1983 forecast for the year 2010 by sector and load center. Generally speaking, the price-adjusted Anchorage load forecast in the

TABLE 6.1. Comparison of Railbelt Total Electricity Consumption Forecasts, RED85A Versus July 1983 RED Model

Case and Year	RED85A GWh	RED85A MW	July 1983 GWh	July 1983 MW
Reference Case (H12):				
1980	2409	489	2364	488
1985	3063	622	3096	640
1990	3650	746	3737	777
1995	4087	836	4171	868
2000	4486	916	4542	945
2005	5063	1034	5093	1059
2010	5854	1195	5858	1217
DRI Case (H13):				
1980	2409	489	2364	488
1985	3074	624	3110	642
1990	3609	738	3717	773
1995	4176	854	4341	904
2000	4829	987	5041	1050
2005	5626	1149	5857	1220
2010	6709	1370	6965	1450
FERC -2% Case (HE8):				
1980	2409	489	2364	488
1985	3108	631	3145	650
1990	3677	729	3752	780
1995	4000	795	4009	834
2000	4339	863	4262	886
2005	4829	963	4658	967
2010	5499	1099	5224	1084

RED85A version has been reduced due to increased long run price responsiveness of the model. The Fairbanks-Tanana Valley load center experiences very little electricity price change, so the non-price effects increase the forecast over

TABLE 6.2. Detailed Comparison of Reference Case Forecasts, Year 2010, RED85A Versus July 1983

	Anchorage			Fairbanks		
Residential	RED85A	July 1983	% Diff.	RED85A	July 1983	% Diff.
Total Consumption (GWh)	1,863	2,021	-7.8	540	551	-2.0
Consumption, Before Price Effects (GWh)	2,135	1,987	7.4	526	524	0.4
Total Consumption per Household (KWh)	12,167	13,198	-7.8	14,888	15,176	-1.9
Total Consumption per Household, Before Price Effects (kWh)	13,941	12,978	7.4	14,501	14,429	0.5
Business						
Total Consumption (GWh)	2,410	2,352	2.5	618	511	20.9
Consumption, Before Price Effects (GWh)	3,130	2,645	18.4	615	500	23.1
Total Consumption per Employee (kWh)	11,785	11,502	2.5	12,001	9,929	20.9
Consumption per Employee, Before Price Effects (kWh)	15,307	12,932	18.4	11,958	9,712	23.1
Total Consumption per Square Foot (kWh)	19.52	27.38	-28.7	22.29	23.64	-5.7
Consumption per Square Foot, Before Price Effects (kWh)	25.35	30.79	-17.7	22.20	23.12	-4.0
Total Forecast						
Total Consumption (GWh)	4,634	4,735	-2.1	1,220	1,123	8.6
Peak Demand (MW)	940	960	-2.1	254	257	-1.2
Average Growth Rate in Consumption from 1980 (%)	2.9	3.0	-0.1	3.6	3.5	0.1
Growth Rate in per Capita Consumption (%)	0.6	0.7	-0.1	1.6	1.5	0.1

the 1983 forecast. Additionally, in Fairbanks rising fuel oil and gas (propane) prices cause electricity to become increasingly attractive, so the price effects on electricity consumption are more positive than in 1983.

The detailed comparison in the Anchorage residential sector in Table 6.2 shows a decrease in consumption per household in the year 2010 compared to the July, 1983 forecast even though the preliminary forecast of consumption per household is higher. This reflects the increased long run price sensitivity of the model. Fairbanks also shows increased conservation due to price effects.

The difference between the price-adjusted forecasts is a decrease in consumption of about 2.0% as opposed to a 0.4% increase before price adjustments.

In business, RED85A forecasts of total consumption and total consumption per employee are increased slightly (2.5%) in Anchorage compared to the July 1983 forecast. The forecast in Fairbanks is 20.9% higher. However, electricity consumption per square foot of business floorspace, both before and after price adjustments, is significantly below that in the 1983 forecast in both load centers. This is due to the increased long-term price responsiveness of the model and to the adjustments made in the historical business consumption and building stock data series (and, hence, the business consumption equation). The increase in consumption per employee prior to price effects shown in Table 6.2 is due mostly to the increased floorspace per employee projected in the RED85A version.

Overall, the reference case forecast is reduced by 2.1% in Anchorage and increased by 8.6% in Fairbanks. The net effect is an increase of less than 0.1% in Railbelt consumption and a decrease in peak demand of 1.9% or about 23 MW. The 30-year average growth rate in electricity consumption per capita is reduced from 0.7% to 0.6% in Anchorage, and increases from 1.5 to 1.6% in Fairbanks.

Table 6.3 compares price-impacted electricity consumption in the Anchorage-Cook Inlet load center for the reference case, DRI case, and FERC-2% case to demonstrate how price scenarios now affect the details of the forecast compared to 1983. In the reference and DRI cases, electric, gas, and oil prices on a conversion-efficiency-adjusted basis all rise significantly; in the FERC-2% case, electricity and gas experience much more modest increases while oil falls in price. The key price is electricity, because electricity is not cost-competitive on an efficiency adjusted Btu basis with gas in the Anchorage-Cook Inlet load center in any of the cases. The availability of cheaper oil and gas in the FERC-2% case makes some difference in the RED85A residential forecast (the price-adjusted forecast is lower than in the reference case even though the electricity price is lower). However, it is clear that increased electricity prices are having a bigger influence than in the 1983's forecast. Price responsiveness in the residential sector is sufficient to cause

TABLE 6.3. Comparison of Price-Impacted Consumption, RED85A Versus July 1983 Forecasts, Anchorage-Cook Inlet

Residential	Cost of Energy ($\$/10^6$ Btu)[a]			Consumption Per Household (kWh)	
	Electric	Oil	Gas	RED85A	July 1983
1. Reference Case:					
1980	$10.84	$11.92	$2.66	13,699	13,699
2010	19.64	19.00	8.28	12,167	13,198
2. DRI (High Price) Case:					
1980	$10.84	$11.92	$2.66	13,699	13,699
2010	21.98	24.57	9.78	11,943	13,396
3. FERC-2% (Low Price) Case:					
1980	$10.84	$11.92	$2.66	13,699	13,699
2010	16.71	6.80	3.94	11,895	12,186

Business:	Cost of Energy ($\$/10^6$ Btu)[a]			Consumption Per Employee (kWh)	
	Electric	Oil	Gas	RED85A	July 1983
1. Reference Case:					
1980	$9.96	$11.08	$2.31	8,672	8,407
2010	18.76	18.15	7.92	11,785	11,502
2. DRI (High Price) Case:					
1980	$9.96	$11.08	$2.31	8,672	8,407
2010	21.10	23.72	9.43	11,716	12,035
3. FERC (Low Price) Case:					
1980	$9.96	$11.08	$2.31	8,672	8,479
2010	15.83	6.35	3.59	11,956	11,049

(a) Prices are in 1980 constant dollars for fuel delivered to the customer, adjusted for average conversion efficiency of end-use appliance using the fuels.

consumption per household in the DRI case to drop below that in the reference case. Previously, non-price effects on consumption caused by higher growth in the housing stock dominated, so that high consumption was associated with high prices and vice versa.

Business consumption per employee is also shown in Table 6.3. The price elasticities of demand are somewhat larger in business now than in the July 1983 forecast. This is reflected in the fact that the order of 2010 consumption per employee among the three cases is reversed from the 1983 forecasts. In the July, 1983 version of RED, non-price effects on consumption (growth in floorspace per employee and growth in consumption per square foot) more than offset the conservation effects of higher prices in the DRI case. Then, lower electricity prices did not result in enough extra consumption to offset the effect of lower growth in the FERC-2% case. Now, however, higher (lower) prices more than offset the relatively higher (lower) growth in the DRI (FERC) case, so that consumption per employee is highest when the prices are lowest, and vice versa.

Table 6.4 shows the details of the three forecasts in the Fairbanks-Tanana Valley load center. In this case, the price of all three fuels rises in the reference and DRI cases and declines in the FERC-2% case. However, note that electricity prices are virtually constant in all three cases. By contrast, oil increases in cost to nearly the level of electricity in the first two cases, but falls by to about a quarter of the cost in the third. Thus, the effect of the level of electricity cost and changes in electricity cost are minimal, while cross-price effects of changes in oil prices are relatively important.

Comparing residential consumption per household forecasts with the July, 1983 forecasts, one may note that one out of three forecasts has increased, while the other two decreased. This primarily is due to larger impacts from price effects in the higher price cases. The (positive) impact of rapidly rising oil prices on consumption of electricity (substitution of electricity for oil) is especially evident in the DRI case, boosting consumption per household in the former from 14,510 kWh/yr without price adjustments to 15,376 KWh with price adjustments. In contrast, although the effect is not directly shown in the table, cross-price effects reduce electricity consumption per household

TABLE 6.4. Comparison of Price-Impacted Consumption, RED85A Versus July 1983 Forecasts, Fairbanks-Tanana Valley

	Cost of Energy ($/10⁶ Btu)[a] Electric	Oil	Gas	Consumption Per Household (kWh) RED85A	July 1983
Residential					
1. Reference Case:					
1980	$27.84	$12.05	$19.60	11,519	11,519
2010	29.31	19.20	31.25	14,888	15,176
2. DRI (High Price) Case:					
1980	$27.84	$12.05	$19.60	11,519	11,519
2010	29.30	24.80	40.35	15,376	16,019
3. FERC-2% (Low Price) Case:					
1980	$27.84	12.05	19.60	11,519	11,519
2010	26.38	6.86	11.16	14,032	13,467

	Cost of Energy ($/10⁶ Btu)[a] Electric	Oil	Gas	Consumption Per Employee (kWh) RED85A	July 1983
Business:					
1. Reference Case:					
1980	$26.38	$11.54	$17.37	8,009	7,496
2010	27.84	18.69	29.02	12,001	9,929
2. DRI (High Price) Case:					
1980	$26.38	$11.54	$17.37	8,009	7,496
2010	27.84	24.29	38.12	12,226	10,500
3. FERC (Low Price) Case:					
1980	$26.38	$11.53	$17.37	8,009	7,496
2010	24.91	6.63	9.97	11,931	9,340

(a) Prices are in constant 1980 dollars for fuel delivered to the customer, adjusted for average conversion efficiency of end-use appliances using the fuels.

in the FERC-2% case, from 14,502 (without price effects) to 14,032 kWh. This is because oil's price advantage increases over electricity in this case, reducing electrical consumption. The overall price effect is to increase the dispersion of the residential forecasts in Fairbanks.

In the Fairbanks business sector, per-employee electricity consumption in all three forecasts has increased due to non-price effects. Because Fairbanks business electricity consumption in the absence of price effects now increases proportionately with increases in business floorspace in the RED85A model, which is in turn proportional to employment, the consumption per employee before price effects is identical in all three cases (11,958 kWh). Next, although the own-price effects of rising electricity prices are minimal and offset by the cross-price effects in both the DRI and reference cases, in the FERC-2% case falling electricity prices are also more than offset by the cross-price effect of falling gas and oil prices. The (positive) cross-price effect of rapidly rising oil and gas prices outstrips the (negative) own-price effect in the DRI case and to a lesser extent in the reference case, with its smaller oil and gas price increase. The signs of the effects are reversed in the FERC case. Consequently, in the RED85A per-employee forecast, the FERC case is the lowest of the three and DRI, the highest. In July, 1983, the ranking of the cases were ordered the same way. The ranking of total business consumption is also unaffected between RED85A and July, 1983. Highest business consumption still occurs in the DRI case due to higher economic growth and cross-price effects while lowest consumption still occurs in the FERC-2% case. Dispersion among the forecasts is reduced.

APPENDIX A

RAILBELT COMMERCIAL BUILDING STOCK AND ENERGY USE DATA

CONTENTS

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TABLES

A.1.0 INTRODUCTION

This document presents a review of recent patterns of commercial building energy use and building stock in the Alaska's Railbelt region. The information was collected to address questions concerning the availability of additional information about the Railbelt Electricity Demand (RED) model business sector structure. The questions were received at a workshop conducted in Anchorage in September 1983 to explain the RED model to Federal Energy Regulatory Commission (FERC) staff. FERC staff wondered whether local utility customers, utilities, and government units 1) had counts or estimates of the current commercial building stock and trends in the stock; 2) had done studies of historical or current electrical consumption that would relate building stock to electricity demand. In response to these questions, Battelle-Northwest and Harza-Ebasco technical staff set up a short data collection project designed to determine the availability and usefulness of information from Railbelt sources on:

- the current total stock of buildings in the commercial sector and the composition of the stock;
- recent changes in the type of buildings being constructed that might affect average electrical consumption per square foot of floorspace, per employee, or per customer;
- actual electricity use per business customer, per customer, per square foot of business space, and per employee;
- the types and intensities of electrical end uses and known recent trends in these end uses.

The purpose of this project was to either provide additional data that could be used to improve the electricity demand model in the Railbelt business sector or, alternatively, to demonstrate what critical data items were still missing and would have to be assumed in order to forecast business electrical consumption.

APPROACH

In most regions of the U.S., the primary sources of commercial building stock and energy use information are usually utilities. During the last 10 years, many public and private utilities have initiated energy auditing programs for commercial customers to support conservation programs. Typical types of information collected include:

- number of commercial customers by 4-digit Standard Industrial Classification (SIC) code
- annual energy use by customer type
- building characteristics of representative customers, including square footage, construction characteristics, type of HVAC system, and occupancy trends.

Therefore, our initial target for collecting commercial building information in the Railbelt region was the utilities. Interviews were conducted with managers of the four main urban Railbelt electricity utilities by representatives of the Harza-Ebasco Susitna Joint Venture and Battelle Northwest Laboratories during late February-early March, 1984. The discussions addressed: 1) commercial building stock data, 2) the types of energy use in the commercial sector, and 3) data describing energy use by building type. Our questions were submitted to the utilities in advance. The interview guideline used in our interviews of the utilities is displayed in Exhibit A.1.

To insure that all data sources were identified, similar interviews were conducted with government officials, commercial realtors, and with the building managers of representative commercial buildings in Fairbanks and Anchorage. Additional information sources identified during the interviews were also reviewed to insure that all available data describing commercial building stock and energy use in the Railbelt region were identified and characterized. The interview guide for the building managers is displayed in Exhibit A.2.

Once the interviews were completed, the information collected from the region was analyzed to determine 1) the quality of the data collected, and 2) whether the original RED business sector model parameters should be revised in light of the new data.

RESULTS

The results of the data collection effort are reported in greater detail in the next two chapters. This section summarizes those results, however, as they relate to FERC staff questions.

- The original RED model relied on benchmark estimates of the commercial building stock prepared in 1980 by the University of Alaska Institute of Social and Economic Research (ISER) for the year 1978 to test our historical a time series on commercial building stock. A sufficient body of information was available on the Fairbanks-Tanana Valley load center to allow production of a new benchmark estimate of 11.2 million square feet for the 1983 building stock in that load center. There was insufficient coverage of the Anchorage-Cook Inlet load center or agreement among data sources to develop a new benchmark estimate of commercial space in that load center. However, the available partial stock counts and estimates were consistent with the sum of commercial construction between 1978 and 1983, plus ISER's benchmark stock for 1978. We therefore retained that benchmark estimate as the basis for the Anchorage stock series.

- Only anecdotal information was available on trends in the commercial building stock by type of building. Anecdotal information included estimates that high-rise class "A" office space was becoming more common in Anchorage, while strip-type suburban developments featuring office and retail space were becoming more common in Fairbanks. This information was not necessarily considered indicative of significant changes in the types of building being constructed. F. W. Dodge Construction Potentials data set published by McGraw-Hill were acquired in order to answer FERC's questions in a more precise manner.

- There was no comprehensive data source in the Railbelt on current electricity use per square foot of business space or per employee in either load center, although all the utilities contacted could estimate use per customer. Portions of the commercial stock were covered by various data sets, however. It proved possible to collect consumption data on several individual customers which could be matched with floor space data from a variety of sources. In general, it appears from the buildings examined that the RED model's average use per square foot is approximately correct. However, use per square foot and per employee is at least as variable within classes and types of buildings as it is between classes. Thus, even if it were determined that there was a significant trend in certain types of buildings being built, this would not imply that average electricity consumption per square must change as a result.

- Likewise, only anecdotal information was available on trends in electricity consumption in the business sector. Very few businesses were taking extraordinary measures to conserve. Most were cutting down lighting or changing over to fluorescent fixtures, insulating, setting back temperatures, and reducing window area. In some "special opportunity" situations such as supermarkets, heat was being conserved or recovered off process loads. Little or no information was available on the success of these measures in reducing electrical loads, however.

In summary, although a considerable fragmented body of information exists, there is no comprehensive body of data in the Railbelt on commercial buildings and their electricity use. The evidence that does exist for portions of the stock suggests that the estimates of total commercial stock and electricity consumption per square foot used in the Railbelt Electricity Demand Model are approximately correct.

The remainder of this report is organized as follows. The second chapter describes the study's findings on business electricity consumption and commercial building stock data. It begins with the previous estimates from the RED model which the FERC staff had reviewed, including data sources and limitations. The chapter then describes the results of the current data collection effort concerning building stock counts and energy use in the business sector. The final section of the chapter evaluates the current results in light of FERC staff questions and describes how the new data have been used to refine the RED model. The last chapter provides summaries of the individual interviews conducted as part of the data collection effort.

A.2.0 COMMERCIAL BUILDING STOCK AND ENERGY USE DATA

NATURE OF THE INITIAL DATA

In the July 1983 version of the RED model, commercial-light industrial-government (business) electricity consumption was forecasted using a four-step process: 1) A "predicted" historical building stock series was constructed for the two Railbelt load centers, using an econometric equation derived from pooled national data. 2) Historical commercial-industrial-government electricity consumption in Railbelt load centers was regressed on this historical "predicted" stock to estimate a consumption equation. 3) Building stock was next forecasted into the future in each load center and business electricity consumption was then derived using the equation in Step 2. 4) Finally, this preliminary consumption estimate was adjusted for price effects. Because of the importance of the "predicted" stock series to the analysis, it was necessary to check its accuracy. This was done in the July 1983 version of the model by constructing an independent benchmark estimate of the 1978 commercial building stock from locally available data (shown in Table A.2.1) and then using the F. W. Dodge Construction Potentials data series on total square feet of construction starts to derive an "actual" (really, estimated) building stock series. This actual series was then compared to the predicted historical series.[a] This comparison is shown in Table A.2.2. In some years, particularly in Fairbanks-Tanana Valley, the "predicted" series appears to be a significant underestimate. However, the Fairbanks "actual" series was based on the assumption made by ISER that square footage per employee was identical in Anchorage and Fairbanks in 1978. In fact, because of higher building costs and energy prices it is likely that Fairbanks-Tanana Valley building stock per employee was less than in Anchorage in 1978. Thus the "predicted" building

(a) The predicted series was used for forecasting because of certain restrictions contained in the Battelle-Northwest agreement with McGraw-Hill for access to the Construction Potentials Data. The testing was actually done as part of the project that developed a stock prediction equation for the U.S. Department of Energy.

TABLE A.2.1. Anchorage-Cook Inlet and Fairbanks-Tanana Valley Benchmark 1978 Commercial Building Stock, July 1983 Version of RED (10^6 Square Feet)

Anchorage-Cook Inlet:	
Anchorage Metropolitan Area Transportation Study Survey	42.1
Less: Non-Energy Using (Parking lots, etc.)	18.9
Plus: Undercount (20%)	4.6
Plus: Excluded Sectors in Anchorage	
1. Gridwood/Indian[a]	0.05
2. Eagle River/Chugiak[b]	0.3
3. Hotels/Motels[c]	1.0
4. Assorted Cultural Buildings[d]	0.5
Plus: Growth Between 1975 and 1978[e]	7.4
1978 Anchorage Commercial-Industrial Floorspace	37.0
Less: Manufacturing[f]	0.9
Plus: Other Areas in Load Center	
1. Kenai-Cook Inlet[g]	3.2
2. Matanuska-Susitna[g]	1.5
3. Seward[g]	0.6
1978 Anchorage-Cook Inlet Total	41.4
Fairbanks-Tanana Valley	
Fairbanks-North Star Borough[g]	10.4
Southeast Fairbanks Census Division[g]	0.4
1978 Fairbanks-Tanana Valley Total	10.8

(a) Twenty-five businesses from telephone book; 2,500 square feet assumed per business.
(b) Ratio of Eagle River/Chugiak housing stock to that of Anchorage, times Anchorage commercial stock.
(c) Assumes 2000 rooms at 500 square feet/room.
(d) Forty-six establishments at 10,000 square feet per establishment.
(e) Twenty-five percent growth, based on 1975-78 growth in civilian employment (10%) and assessed value (48%), plus assumed crowding during 1975 because of rapid 1974-75 employment growth.
(f) Allocated to manufacturing in original source, probably by relative employment in the sector.
(g) Based on Anchorage square feet per nonagricultural civilian employee.

Source: Goldsmith and Huskey 1980.

TABLE A.2.2. Estimated Commercial Building Stock Series for 1973-1981, July 1983 Version of RED

Year	Anchorage-Cook Inlet Predicted[a]	Anchorage-Cook Inlet Actual[b]	Fairbanks-Tanana Valley Predicted[a]	Fairbanks-Tanana Valley Actual[b]
1973	27.1	27.1	5.4	5.4
1974	29.7	29.7	6.0	6.0
1975	31.2	33.6	6.6	6.9
1976	33.8	37.2	7.2	8.8
1977	37.0	39.7	7.8	10.1
1978	40.5	41.4	8.2	10.8
1979	42.3	42.7	9.4	11.1
1980	43.8	44.1	9.9	11.4
1981	44.7	44.9	10.4	11.5

(a) Based on stock prediction equation:

$$\text{Pct. Change (STOCK)} = f(\text{GNPD}, \text{POP}, \text{INC}, r)$$

where:
GNPD = Gross national product deflator
POP = Regional population
INC = Income
r = nominal interest rate
For the exact formulation, see Susitna Hydroelectric Project FERC License Application, Volume 2C: RED Model (1983 Version) Technical Documentation Report, pp. 6.13 to 6.16.

(b) Based on the 1978 estimate in Table A.2.1, plus F. W. Dodge construction starts, not edited for completions of construction projects that were started and later abandoned or modified.

stock series may provide an adequate basis for forecasting in Fairbanks-Tanana Valley. There was little difference between the "predicted" and "actual" series in Anchorage-Cook Inlet.

The initial data utilized to benchmark building stock in the RED model came from a number of sources. The basic source for the Anchorage area was the Anchorage Metropolitan Area Transportation Study (AMATS) conducted in 1975. This study, conducted by the Municipality of Anchorage, counted the commercial, industrial, and government building stock in the Municipality. The University of Alaska Institute of Social and Economic Research (ISER) updated this 1975 estimate to 1978 by taking account of 1) non-energy using building stock 2) building stock in areas outside of Anchorage and 3) growth in employment, 1975 to 1978. The Fairbanks 1978 benchmark stock was estimated by ISER by assuming square footage per employee was the same in Fairbanks as in Anchorage.

Rationale for Additional Data Collection

The model was tested in the Railbelt using F. W. Dodge Construction Potentials data on annual commercial construction in Railbelt locations. The "predicted" stock series obtained by using the model had been considered close to the "actual" stock series obtained by combining F. W. Dodge construction with the 1978 benchmark stock estimate from ISER; however, no independent verification had ever been obtained of the 1978 benchmark estimated building stock or the implied average business electricity consumption rates, which appeared high in comparison to national figures (~20 kWh per square foot per year, versus 13.75 kWh per square foot in the U.S.). In addition, since all commercial, light industrial, and government building space had been combined in the 1978 stock estimate and the predicted stock series, FERC staff were interested in possible recent historical changes to the mix of building stock that could have resulted in changes to energy use characteristics. The Railbelt interviews were directed both toward verifying or revising the earlier stock estimates and toward verifying or revising estimates of commercial-light industrial-government electricity consumption at the most detailed end-use level possible.

Usefulness of the New Data Search

The search for better building stock and energy use data focused upon the electric utilities, government agencies, planning agencies, and commercial building owners in the Railbelt region. Interviews were conducted primarily in the Fairbanks and Anchorage areas, with other contacts being made by telephone and/or mail. The primary goal was to identify the availability and quality of data which described building stock and/or energy use for the commercial sector. Pertinent data was collected and analyzed; the objective was to determine if the original forecasted stock and energy use data could be improved with utility and government data.

The search for better stock and energy use data produced some useful, aggregate figures for specialized subsets of the commercial sector. In general, the Railbelt utilities maintain information of electricity sales by customer name only; no existing data bases could provide summaries of building stock and energy use for each customer type and area. The utilities also had no formal auditing or conservation programs for their commercial customers, thus, minimal information describing the building stock (square footage, construction type, heating data, etc.) was available.

Additional data describing commercial building stock and business electricity consumption data was recovered from a variety of public and private sources other than the utilities. However, no comprehensive data set on building stock and business electricity consumption could be found. The main reason is that the various data sources we evaluated necessarily have specific missions and objectives that caused them to collect the data in the first place. These missions and objectives did not include forecasting electricity demand for the Railbelt using building stock as an independent variable, however, so the data contained several gaps. For example, a survey of 1983 Fairbanks commercial building stock was described as "comprehensive." Further examination revealed that the survey was designed to focus only on the supply of office, retail, and business park (warehousing and distribution) space in the immediate Fairbanks vicinity. The survey excluded more of what we defined as commercial space in the Fairbanks-Tanana Valley load center than it included. Missing were all public buildings, lodging facilities, assembly halls, hospitals, and transportation-related facilities such as repair shops. The outlying towns of North Pole, Nenana, and the Delta Junction area were also excluded. Finally, there was a significant undercount in the categories of stock that were addressed. Thus, although the survey was "comprehensive," given its purpose, it was necessary to bridge several data gaps with other sources and by assumption to arrive at a more comprehensive stock estimate.

In Anchorage-Cook Inlet, the only counts of commercial stock were even more limited. One count by the Municipality of Anchorage Community Planning Department covered only office and some retail space in the city core ("Downtown" and "Midtown" areas), excluding suburban Anchorage, Eagle River, Chugiak, Kenai, and Matanuska-Susitna areas. There was no comprehensive source for electricity used per square foot. Federal, state, and local governments covered this for their own facilities, but these records were not always complete. A handful of private buildings had been surveyed by one Anchorage utility for energy use and was available. Where possible, we also combined utility-reported consumption data in both load centers for some individual larger customers with building square footage identified from the 1983 Fairbanks and Anchorage surveys. In summary, while the data collected were suggestive, they were by no means complete.

RAILBELT COMMERCIAL BUILDING STOCK

The data search in Fairbanks began with interviews with utility staff at two local utilities (see interview results with FMUS and GVEA in Chapter A.3.0). Since neither utility maintained information on floorspace or energy use for the basic types of commercial buildings, additional sources were sought. The Fairbanks Development Authority made available a survey of several commercial building types in the core area of Fairbanks. This survey, performed by Mundy-Jarvis and Associates, Inc., included about 2.0 million square feet of office, retail, and business park space in downtown Fairbanks (see Table A.2.3). The survey, however, excluded 1) other types of commercial buildings such as public, lodging, health, and assembly buildings and 2) outlying areas such as North Pole, Nenana, Delta Junction, and recent development towards the airport. These shortcomings led to additional interviews to obtain stock data for the areas and building types not included in the Mundy-Jarvis survey. Descriptions of floorspace for North Star Borough buildings were obtained along with estimates for the major state and federal buildings in Fairbanks. These data are also shown in Table A.2.3. The cumulative floorspace described in these three sources was approximately 5 million square feet, which was still far lower than the original RED estimates and did not include many commercial building types in the Fairbanks area.

Other sources were sought to describe the remaining areas and building types that were not included in the above data bases. The remaining building stock was not covered by any other comprehensive data source. Therefore, to

TABLE A.2.3. Collected Building Stock Data in the Fairbanks Area[a]

	Counted Square Feet[a]	Total, Including Estimate of Missed[d]
Office	419,458	557,879
Mixed Use	108,324	140,821
Retail (Core)	146,073[b]	189,984
Retail (Sub)	445,000[b]	600,750
Office/Warehouse (owner)	285,016[c]	688,768
Office/Warehouse (renter)	599,060[c]	688,919
	2,002,931	2,867,121
North Star Borough Buildings[e] (1984)		
Schools	1,395,753	1,395,753
Others	258,853	258,853
State and Federal Buildings (1984)		
Federal[f]	157,000	157,000
State[g]	1,186,420	1,186,420
Total	5,000,957	5,865,147

(a) Not complete. Excludes lodging, health care, laundry, churches, auto supplies/sales, and all types outside of the downtown area. Source: Mundy-Jarvis Associates (1983).
(b) Not complete. Retail core is 5 buildings, Retail suburb is 5 malls.
(c) Not complete. Excludes buildings under 7,500 square feet.
(d) Estimate of percent missed supplied by Mundy-Jarvis Associates.
(e) Source: North Star Borough Engineering Department.
(f) Source: U.S. General Services Administration.
(g) Source: Alaska Department of Administration.

obtain an approximation of the balance of building stock, Battelle Northwest conducted a count of commercial businesses in the phone book by type of business. These counts were combined with conservative U.S. median values for square footage (about one half the mean values) by business type (U.S. Energy Information Administration, 1983) to estimate the building stock of these businesses. The results, displayed in Table A.2.4, totaled about 5.7 million square feet. A total figure was developed by combining the counted stock in Table A.2.3 with the estimated stock in Table A.2.4 and subtracting one-third of the construction between 1984 and 1983 to allow for stock changes between the 1983 average, the Mundy-Jarvis counts, and our early 1984 estimates. The total estimated square footage for 1983 from all the identified sources was 11.2 million square feet; this compares favorably with the predicted stock of 10.4 million square feet for 1981 shown in Table 6.7, Volume 2C of the July 1983 Susitna license application.[a]

The data collection situation in the Anchorage area was similar to that in Fairbanks. The utilities offered no auditing or commercial conservation

TABLE A.2.4. Fairbanks 1983 Building Stock Estimate

Total, Table A.2.3		5,865,147
Lodgings	870,450[a]	
Churches/Social Grange	774,000[a]	
Transportation/Mobile Home	1,188,000[a]	
City of Fairbanks Buildings	260,463[b]	
North Pole	2,432,000[a]	
Hospital	201,000[c]	
Subtotal		5,725,913
Total[d]		11,201,060

(a) Calculated from business counts (phone book) and national median (approximately 0.5 mean) space per business by type.
(b) Count incomplete. No figures are available on City Hall or Alaskaland buildings. Source: City of Fairbanks Fire Marshall.
(c) Source: Fairbanks Memorial Hospital.
(d) Adjusted downward by 390,000 to account for dates of estimates (early 1984), Mundy-Jarvis count (late 1983).

(a) F. W. Dodge Construction Potentials data collected for this project showed about 554 thousand square feet of commercial construction from 1981 to 1983. Our estimated stock for 1981 thus would have been 10.6 million square feet (11.2 million, less 1981-83 construction).

programs, and little building stock data was maintained. The main sources of data were 1) the Anchorage Community Planning Department, 2) the Anchorage School District, and 3) the State Department of Administration. These three sources provided limited coverage of the Anchorage bowl, city schools, and State buildings. Significant commercial development in retail and warehouse buildings, especially outside of the downtown Anchorage area, are not covered in any data base, leaving a large portion of the total commercial space unaccounted for in any accessible data base.[a] Overall, the available building stock data for Anchorage did not adequately cover many areas of the Anchorage-Cook Inlet load center, particularly areas that have recently experienced rapid development. This allows only general comparisons to the Anchorage-Cook Inlet stock data used in the RED model. The first conclusion is that the commercial building stock has grown since 1978 - almost 9.7 million square feet added between 1978 and 1983, according to F. W. Dodge. Several areas have experienced significant growth during the last few years. Second, the 1983 and 1984 stock data that were obtained are broadly consistent with the 1978 estimates for the covered areas (primarily the core area, including State and public school buildings).[b] More specific comparisons are not possible. The information in these three sources is summarized in Table A.2.5.

(a) A new private firm in Anchorage estimates about 10 million square feet of retail, office, and warehouse space in Anchorage for a data base of 350 buildings. The Community Planning Department's data base was 455 buildings for the core area alone.
(b) ISER's 1978 estimate of the Anchorage Municipality commercial was 36.1 million square feet. F. W. Dodge commercial construction statistics show 9.7 million square feet added between 1978 and 1983, for a 1983 estimated total of 45.8 million. F. W. Dodge also shows about 27 percent on average of all space added in Anchorage-Cook Inlet is office space. This implies 12.4 million square feet of office buildings in Anchorage. Twelve point four million is slightly less than we got by multiplying the 9.96 million estimate of 1983 office building stock from the Municipality times the ratio of business telephone main stations covered by the survey area to adjust for unsurveyed buildings in the municipality. This total was 13.0 million.

TABLE A.2.5. Available Commercial Building Stock Data for Anchorage

Municipality of Anchorage Planning Department--1983 Commercial Office Inventory	
	Square Footage
"Core Area" Offices (455 buildings)	9,960,232[a]
Anchorage School Board of Education	
	1983 Stock
Elementary, Secondary and Special Services	4,246,252
State of Alaska Building Index--Anchorage Load Center	
	1984 Square Footage
	2,353,930

(a) Tim Lowe (Lakeland Corp.) estimate was 6.5 million office for the whole Municipality; Jack White Company estimate was 7.4 million. This is probably net office space rather than the building total. Offices comprised 7.1 million square feet of the space in the buildings shown. The "core area" is the area south of Elmendorf AFB, north of Dowling, east of Minnesota, and west of Bragaw.

RAILBELT ENERGY USE DATA BY BUILDING TYPE

The existence of energy use data for the main types of commercial buildings was also reviewed. The main goal was to examine the accuracy of the original RED model estimates for electricity consumption. This accuracy check, however, depends upon the availability of recent energy use per square foot data for the commercial buildings. The initial sources interviewed about the existence of such data were again the utilities and government planning groups.

The utility interviews revealed that the four urban utilities had collected minimal information describing the energy use of their commercial customers. The Fairbanks utilities (FMUS and GVEA) maintained monthly energy use records only according to the customer name; there was no classification by customer type such as SIC code that would enable analysis by commercial building type. The records also contained no information on building size, thus eliminating the possibility of estimating energy use per square foot. The Anchorage utilities (AML&P and Chugach) also had minimal information on energy use and building size for their commercial customers. AML&P had developed energy use data for their customers with connected loads greater than 300 KvA. Unfortunately, not all of these customers were included in available building surveys; those customers for which building space data were available are reported in the Anchorage results shown in Table A.2.6.

The overall value of the utility data is as a check on aggregate energy use per unit area for major types of commercial buildings. The values were generally consistent with the previous RED 1980 average values of about 20 kWh per square foot in both load centers. However, the small number of actual buildings for which energy use and building space information was available resulted in significant variance in energy use per square foot between individual buildings of the same type. This small sample size limits the value of the data to simply serving as an aggregate check of the original RED data.

The only governmental groups that maintained similar data were the North Star Borough Engineering Department in Fairbanks and the U.S. General Services Administration (GSA) in Anchorage. The Borough Engineering group provided energy use and building size data for a small set of Borough buildings. The GSA office maintained data for the Federal Building in Fairbanks and the Federal Building in Anchorage. The other government groups only maintained stock data which was discussed earlier.

In order to estimate the energy use per square foot of building space and/or per employee for major types of commercial buildings, annual energy consumption of commercial buildings was also collected when available. Energy use information was collected in both Anchorage and Fairbanks; the results are displayed in Table A.2.6. The utilities maintained monthly and (usually) annual energy consumption information yet the value of this information was minimal unless the building floorspace data for each customer was available.

TABLE A.2.6. Building Energy Use Data (kWh/square foot)

Building Type	Anchorage	Fairbanks	U.S. Average (1979)[a]	AML&P Average[b]
Assembly	26.19	18.48	7.03	NA
Auto Sales and Service	NA	NA	10.26	NA
Education	--	--	8.21	NA
School 1	11.72	--	--	--
Library 1	19.17	--	--	--
School 2	--	16.68	--	--
Library 2	--	18.49	--	--
School 3	--	13.83	--	--
Food Sales	NA	NA	29.31	NA
Food Store 1		19.66		
Bakery 1		26.02		
Health Care	NA	NA	20.22	30.66
Medical-Dental Prof. Building Part.		14.93		
Lodging	--	NA	16.71	15.8
Motel 1	12.67	--	--	--
Office	--	--	17.29	20.4
Federal Building	16.73	--	--	--
Borough Building	--	26.5	--	--
Bank 1		9.70		
Courthouse Square		45.75		
Bank 2		56.01		
Retail/Services	--	NA	11.14	20.4
Retail 1	17.59	--	--	--
Retail 2		15.48		
Retail 3		16.04		
Retail 4		12.21		
Retail 5		29.88		
Retail 6		35.54		
Warehouse/Storage	NA	NA	12.9	24.35
Other	NA	NA	18.46	NA
Vacant	NA	--	9.67	NA

(a) U.S. Energy Information Administration, Non Residential Buildings Energy Consumption Survey, 1979 Consumption and Expenditures.
(b) Anchorage Municipal Light and Power, "Emergency Power Report." These are averages for several Anchorage buildings in the given category.

The Fairbanks energy use data were provided by the North Star Borough Engineering Department FMUS and GVEA (only for customers for which building area information had been collected from other sources), the GSA, and the State of Alaska Building Inventory. The Anchorage data were obtained from the Chugach power requirements study, the AML&P internal review of municipal buildings, and phone calls to building owners.

Table A.2.6 indicates the limited availability of energy use data for the Railbelt which could be readily combined with building space information. This limited availability resulted in small samples for each major commercial building type (sometimes only one example was obtained for a building type in each major load center); thus, there was variability in the energy use values among each building type. The primary benefit of these results is limited to providing a rough check of the original estimates. The new data did appear consistent with the RED estimates for 1980, and the limited nature of the new data permitted the original RED estimates to still be used as the best estimates of energy use per square foot in Railbelt commercial buildings.

The interviews verified that data in existing data bases describing commercial building stock and energy use in the Railbelt region is limited. Unlike many larger utilities in the Lower 48 states, the Alaskan utilities have little useful information on building size and energy use according to customer type and maintain no auditing programs. Only scattered data collected by planning and government organizations was available, and this data covered only certain customer types. The information was, however, generally consistent with the data used in the initial RED model forecasts. No trends were identified in the interviews in either building stocks or energy consumption that were significantly different from previously forecasted data.

EVALUATION OF COMMERCIAL BUILDING STOCK AND ELECTRICITY CONSUMPTION DATA

The renewed business sector data collection effort was successful in addressing many of the FERC staff questions regarding the RED model. As a result of this effort we can say with reasonable confidence that no comprehensive data base exists in the Railbelt on commercial building stock, changes in the stock, or energy use characteristics of that stock. Neither the utilities themselves nor other public and private agencies collect the necessary data in usable form. Limited data do exist on portions of the commercial building stock which we were able to use. In the Fairbanks-Tanana Valley load center enough buildings were counted that, by making some assumptions about missing data, we were able to construct an improved benchmark estimate of the commercial building stock for 1983. The data coverage from available sources would not support a new benchmark estimate in Anchorage-Cook Inlet; however, the previous benchmark was found consistent with new data collected on portions of the stock. No quantitative information was available from either load center on trends in the building stock. Electricity consumption data likewise were limited. Utilities kept consumption data only by customer name; no quantitative information was available from this source for end uses of the electricity or trends in consumption per employee or per square foot of building stock. Through building owner interviews and through matching customer consumption records and square footage information from a number of sources, it was possible to estimate total electricity consumption per square foot for a few dozen commercial buildings for one recent year. These limited data on consumption suggest that electricity consumption per square foot is likely well above the U.S. average, as had been previously estimated in Volume 2C of the July 1983 Susitna License Application. The detailed data are consistent with the previous estimates of about 20 kWh of electricity consumption per square foot per year average for the business sector. No information is available on historical changes in the intensity of use per square foot from Railbelt sources. The F. W. Dodge construction potentials data set was acquired to help answer that question. Analysis of the Dodge data appears in Appendix B, The Effect of F. W. Dodge Construction Data on Railbelt Electricity Demand Forecasts.

A.3.0 INTERVIEW SUMMARIES

A major element of the RED model is the estimates of both existing and future square footage of commercial buildings. One element of the data collection effort in the Railbelt was to gauge the accuracy of the initial square footage or "building stock" estimates used in the RED model. The interviews were used to identify available data bases describing building stock by customer type. The strategy was to begin by determining what information the utilities had acquired, and then interview other sources such as city, state, and federal government officials, and developers/realtors. The interviews targeted contacts primarily in the Fairbanks and Anchorage areas; brief descriptions of the interview results are presented below for each area.

FAIRBANKS AREA INTERVIEWS

Power supply in the Fairbanks area is provided by the Fairbanks Municipal Utilities System (FMUS) and the Golden Valley Electric Association (GVEA). The interviews indicated that neither utility had any useful commercial building stock data; thus numerous other government and private groups were contacted. We found that several segments of the commercial building inventory were covered in various studies, yet significant portions of the commercial building categories were not covered. The specific results are described below.

Fairbanks Municipal Utilities System

FMUS categorizes commercial customers in two groups. Small commercial customers have less than 15 Kw connected load while large customers have greater than or equal to 15 Kw. There are about 300 large commercial customers in their service area, and about 66 percent of these have connected loads greater than 50 Kw. FMUS customer accounts are identified by customer name; no information such as the SIC code or building size is maintained on their records. The customer data that FMUS could provide to us included the customer name, demand for one month, kWh usage for one year, load factors, and monthly power costs. FMUS has no auditing program for the commercial customers; thus they have no data on building stock, building size, building construction characteristics, etc. They mentioned that several large retail buildings had been audited by the customer (e.g., the J. C. Penney department store at the request of corporate headquarters), but FMUS did not have copies of the audits.

FMUS offers no formal commercial conservation program and, since no auditing program is provided, no studies of trends in energy use were available. The staff mentioned that refrigerated cooling of office space is increasing, and that one local food market chain is experimenting with conservation and energy management systems (see discussion with the building manager of Market Basket Stores).

Golden Valley Electric Association

GVEA categorizes commercial customers in two groups; the dividing point is a connected load of 50 Kw. The utility identified the customer by name in the billing records, but no information on the customer type (SIC code) or on the size of the building was available. The commercial customer data that GVEA could provide included monthly electricity demand and consumption for 1980 through 1982. This information was keyed by customer name only; no assessment of consumption by customer type could be conducted.

The GVEA staff indicated that GVEA offered no formal commercial conservation programs; they felt that conservation in newer buildings was simply the result of owner interest in reduced energy costs. Several trends they identified include 1) a reduction in electric heating and 2) an increase in air conditioning. The reduction in electric space heating was due to rules restricting the installation of electric heat in buildings built after the mid 1970s.

Fairbanks North Star Borough Assessor's Office

The Assessor's Office maintains standard property records in manual physical files. No compilations of property by type and by square footage have been completed. The forms contain information on the type of building (see Table A.3.1) and on building characteristics (see Table A.3.2).

TABLE A.3.1. Building Type Designations on Fairbanks Assessor Forms

LODGING	HOSPITAL	APARTMENT
WAREHOUSE	CHURCH	STORE
THEATER	BANK	GAS STATION
GARAGE	INDUSTRIAL	GREENHOUSE
RESTAURANT		

TABLE A.3.2. Building Characteristics on Fairbanks Assessor Forms

FOUNDATION TYPE	HEATING SYSTEM TYPE
EXTERIOR TYPE	ELEVATORS
ROOFING TYPE	NUMBER OF STORIES
FRAME TYPE	FLOORING TYPE

The property records are scheduled to be transferred to a computerized filing system within the next several years. Once these records are placed into such a system, extraction of the building stock data might be possible.

North Star Borough Engineering

This organization maintains square footage data for all Borough buildings, including schools. The data includes monthly energy usage and costs and includes consumption per square foot normalized to correct for the degree days.

The total number of Borough buildings is about 35, and 15 to 20 buildings have had conservation retrofits. Typical activities include the following:

INCANDESCENT LAMP REPLACEMENT WITH FLUORESCENT LAMPS
REDUCED WINDOW AREA
NIGHT SETBACK OF THERMOSTATS
INSULATION RETROFITS.

Realty, Inc.

We interviewed a realtor recommended by the utilities as being the foremost local authority on commercial development trends, both past and future, in the Fairbanks area. The first discussion topic was the availability of data describing building space by type of establishment. We learned that no such data is maintained in a central form. Realtors simply follow recent sales and construction trends to estimate near-term growth patterns. The growth has apparently slowed down since the boom in the 1970s, with a steady trend to shopping centers and small shopping malls.

Information on energy use trends was also based solely upon the personal experience of the realtor; no data base of energy information is maintained or used by the realtors/developers in Fairbanks. Conservation options such as added insulation and efficient lighting are being used in new buildings; the impetus for these actions are simply owner interest in lower energy costs. A common feature of new buildings are 6"-10" walls with vapor barriers. New buildings are also smaller than in the past, with higher density development becoming more common. If potential buyers wish to know past energy use performance of a building, the relator reviews past utility bills from the current owner; again, the relators have no central source of information to use.

Fairbanks Development Authority

Al DeKrey of the Fairbanks Development Authority (FDA) discussed his organization's activities, including a recent survey of office space in the "core area" (downtown or more developed area) of the Fairbanks North Star Borough. This survey, titled "A Comprehensive Space Inventory for the Fairbanks Development Authority" was prepared by Mundy, Jarvis and Associates Inc. in August 1982 and was updated in November, 1983. It updates a similar survey performed in 1980. The building types covered in the survey are listed below:

OFFICE SPACE
RETAIL
MIXED USE
WAREHOUSE.

Several limitations of the data are 1) a twenty-to-thirty percent undercount of some building types (e.g., C and D class office space) 2) the exclusion of commercial building space outside the "core area" and 3) the exclusion of several building types important to the RED modeling effort. The building types not covered in the FDA survey include public buildings, hotels/motels, churches, automotive/service stations, and aircraft-related businesses.

The FDA representative also discussed the planned development activities in downtown Fairbanks. The main project is the possible construction of a large motel/convention center. This proposed project will add significantly to lodging capacity and to the retail and office space needed to provide the services such as food, small retail stores, etc. The planned size of the convention center is "about the same size" as the Sheraton hotel in Anchorage: 8 stories tall, recommended for 250 rooms plus first class facilities (see Laventhol and Horwath 1983). The added load of this center merits consideration in the RED business sector if the project is actually built.

Market Basket Food Stores

The building engineer for Market Basket Food Stores discussed conservation activities that his company is pursuing in the Fairbanks area. Because no utility sponsored conservation programs are available, Market Basket has initiated several programs of their own. All stores are experimenting with reduced lighting loads. New stores are having heat recovery installed on their refrigeration equipment. This has been very successful; apparently most of the stores' heating loads have been met by the reclaimed heat system. All new buildings have 10" ceilings and 6" walls with installed vapor barriers. No submetering of electrical loads has been performed; thus, they could provide no information on energy consumption for individual end-uses in their stores.

Department of Transportation and Public Facilities (DOTPF)

A listing of Fairbanks area buildings operated by the Alaska DOTPF was obtained from the maintenance and operations staff at the Peger Road DOTPF offices in Fairbanks. Included in the information base were the building name, total square feet, and electrical consumption for the first eight months of FY-1984. Twenty-eight buildings, totaling 371 thousand square feet, were listed. About 4.3 million kWh were used during the eight months. Annual electrical consumption was not available.

ANCHORAGE AREA INTERVIEWS

The Anchorage area receives electricity primarily from the Anchorage Municipal Light and Power (AML&P) and from the Chugach Electric Association.

As in Fairbanks, neither of the Anchorage urban utilities categorized their commercial customers by either customer type (SIC codes) or by building size. Several small studies of their major customers had been performed, however, and the Municipality of Anchorage performed a survey of commercial building stock for the downtown area. Not included in any studies were the buildings in the new growth areas outside the city center. The Federal buildings were not covered in a central database either; each agency is responsible for its property. State building stock data is maintained in a central data base; we have received summaries of this data. The results of the interviews are outlined below.

Anchorage Municipal Light and Power

Anchorage Municipal Light and Power (AML&P) has no comprehensive data base describing energy use and building characteristics by customer type for their commercial customers. Their commercial customers are divided into two classes; the dividing point is a connected load of 25 Kw. The only available data on building stock was from a survey of their top 250 customers (down to 100 Kw), and included information on the number of occupants, the square footage of the building, billing demand, and projected power requirements during severe service disruption. About 60 to 70 usable responses were available from this survey for inclusion in the floorspace estimates. The latest (1983) AML&P Power Requirements Study was obtained; however, no information was available relating consumption to building stock or employment.

Several general trends in energy use were identified in the interview. First, cooling requirements are creating peak load problems in the summer. Second, AML&P and Chugach are exchanging several small service areas, thus some system power requirements changes are foreseen. AML&P also has a formal conservation plan. This plan addresses the following conservation activities:

CONSUMER INFORMATION PROGRAM
MUNICIPAL WEATHERIZATION PROGRAM
SUPPORTED STATE PROGRAMS
WATER FLOW RESTRICTORS
WASTE HEAT RECOVERY IN CITY WATER
HOT WATER HEATER WRAP PROGRAM

STREET LIGHT CONVERSION

TRANSMISSION VOLTAGE CONVERSION

STEAM DRIVEN BOILER FEED/CIRCULATING PUMPS.

The emphasis of these programs is on residential home owners and on city facilities such as street lighting.

<u>Chugach Electric Association</u>

The Chugach Electric Association (CEA) has no commercial customer information that could provide either energy use trends by customer type or information on customer building stock by customer type. The utility provides no auditing program for the commercial customers, either.

Chugach has collected limited load data from a survey of customers that had greater than 350 KVA loads. They found that commercial energy use was extremely diverse, even within the same customer group. The survey was designed to identify where voluntary load reduction actions might be possible. The survey included information on the following topics:

OPERATION HOURS

FUEL TYPE

HVAC SYSTEM TYPE

BACKUP ELECTRICITY AVAILABILITY

BUILDING MINIMUM POWER REQUIREMENTS

POSSIBLE LOAD REDUCTIONS (TYPE AND MAGNITUDE).

Better information may become available when Chugach switches to a new computer system later in 1984, yet no customer classification by SIC code is planned.

The Chugach personnel indicated that several locally important energy use trends merit attention. As noted by the other utilities, there is a significant increase in cooling load. Most of this increase on the Chugach system is due to the large new buildings being built in the Anchorage area. There is a steady increase in construction of office buildings and shopping centers, yet some of this commercial load will be lost in the planned service area switches with AML&P.

Anchorage Telephone Utility

The Anchorage Telephone Utility (ATU) maintains a count of commercial customers (business main stations) by geographic area (i.e., wire center). They could provide no classification of these customers by type of building/customer, and their records did not distinguish between single and multiple customers in a building. Therefore, this data was useful only as an approximate indication of commercial activity in different areas of the city.

Municipality of Anchorage Community Planning Department

The Anchorage Community Planning Department maintains a computerized list of commercial office space in the downtown area of Anchorage (south of Elmendorf Air Force Base, north of Dowling Avenue, east of Minnesota Street, and west of Bragaw Street). The survey contains the property parcel number, building location, manager name, manager location, building square footage, and office square footage. The survey was subjected to no cross checking to verify accuracy, yet the results are viewed as being reasonable.

Anchorage School District

The Anchorage School District provided their annual report which contained current square footage estimates for all the city schools. The representative indicated that energy conservation is considered when new schools are built, yet could provide no indication of energy conservation programs in the existing schools.

Municipality of Anchorage Energy Coordinator

Peter Poray, the Anchorage Energy Coordinator indicated that the only central data base on Anchorage building stock was the survey done by the Anchorage Community Planning Department (see discussion above). He mentioned that there are about 200 municipal buildings, yet only 50 to 60 of these buildings are significant in size and energy use. He also indicated that the State of Alaska maintains a central data base of state buildings.

Department of Administration - The State of Alaska

The Department of Administration office maintains a summary of building stock in local municipalities that is leased by the State of Alaska. The data for the major Railbelt communities is listed below:

Anchorage	892,610	sq ft
Delta Junction	8,518	"
Eagle River	1,287	"
Fairbanks	100,588	"
Homer	14,247	"
Kenai	139,584	"
Palmer	31,109	"
Seward	109,897	"
Wasilla	11,354	"

Data are also available for state-owned buildings in the smaller communities, e.g., Moose Pass, Talkeetna, etc..

Department of Transportation and Public Facilities - The State of Alaska

Harry Dullinger of the Department of Transportation and Public Facilities (DOTPF) was able to provide square footage and annual energy use data for the buildings under his control. This was only a subset of state buildings in the region; he indicated that a complete survey of state buildings was published until 1977. The current survey is maintained by the General Services and Supply office of DOTPF in Juneau (see following discussions).

Mr. Dullinger indicated that funding for investment in conservation is scarce, yet he has experimented with the buildings under his control. Actions implemented include 1) incandescent lamp replacement with fluorescent lamps, 2) flue dampers, 3) efficient burners for furnaces, and 4) ceiling fans in maintenance shops.

Sears - Anchorage

Roger Wallis, the building manager of Sears, discussed the energy use patterns of this large retail building and his energy conservation activities. The building has 120,000 square feet of retail floorspace with 30,000 square feet of office and cafeteria space on the second floor. The walls are insulated with standard batt-type fiberglass insulation. The HVAC systems operate

24 hours a day, yet the lighting is reduced to 5 percent of normal load during the evening (from 9:30 P.M. to 8:00 A.M). Space heat is provided by natural gas, and cooling is provided by a 320 ton air-cooled chiller. This chiller operates only 50 hours per year on the average.

The Sears maintenance staff has implemented lighting conservation by 1) reducing lighting levels at night, 2) replacing some incandescent lamps with fluorescent lamps, and 3) removing some of the high-intensity display lamps on the retail floor. The energy use data for the Sears store is in the Chugach sales data and is shown in Table A.2.6 in the previous chapter.

State of Alaska Buildings

The General Services and Supply office of the Department of Administration in Juneau maintains a computerized listing of all state buildings. The information includes building number, facility name, age, cost, and a description that includes the square footage. A listing of the survey was obtained.

U.S. General Services Administration - Federal Buildings

The U.S. General Services Administration was contacted to determine the square footage of Federal buildings in the Railbelt Region. The GSA representative indicated that each Federal agency is responsible for maintaining records of their own buildings; GSA only maintains information on their own buildings. Several calls were made to representative Federal agencies to obtain information yet most never provided the requested data. Agencies that were called are listed below:

U.S. Department of Interior
U.S. Fish and Wildlife Service
Corps of Engineers
The National Park Service
The U.S. National Forest Service.

Realtors/Developers

Two realtors/developers were contacted to determine their opinion of future trends in the commercial sector of Anchorage. Tim Lowe of the Lakeland Corporation estimated that current office vacancy in Anchorage is 700,000 to

1,000,000 square feet. He estimated that current base office space is 6.5 million square feet, and that retail space is between 3 and 4 million square feet.

Norm Rokburg of Jack White and Associates estimated the base inventory of office and all commercial at 7.4 million square feet. He indicated that average annual addition of new space is 350,000 square feet. About 1.3 million square feet was built in 1983, and about 500,000 square feet will be added in 1984.

Note that these estimates covered office and large retail space only; public buildings such as schools and small businesses were excluded from the estimates.

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EXHIBIT A.1

INTERVIEW GUIDE FOR UTILITY MANAGERS

EXHIBIT A.1

INTERVIEW GUIDE FOR UTILITY MANAGERS

1. Boundaries of service area/population/households.
2. Commercial customer identity:
   a. who are the small customers (50kVA), medium (50 to 350 kVA), and large customers (over 350kVA)
   b. mix of customers by type of business, size
   c. growth/change in the mix of customers by type, size.
3. Electricity use by commercial customers:
   a. use of electricity by customer class - how much used for heating, ventilation systems, lighting, process loads.
   b. trends in electrical use by type of commercial customer--recent changes, if any
   c. trends and recent changes in use by large customers
   d. conservation, trends and programs
4. Forecasting electricity use in the commercial sector:
   a. techniques used by the utility in forecasting commercial load
   b. what relationships (e.g. use/square foot of commercial space; use/employee) seem most appropriate
   c. annual load factors, especially in comparison to residential customers
   d. trends in building space/employee in the commercial sector.
5. Billing data - commercial sector:
   a. uses to which this data has been put for electric load forecasting in the commercial sector

b. aggregations of billing data (have they attempted to estimate loads by type of business or type of load)

c. release of actual billing data for selected customers or types of customers (e.g. office building, strip development, etc.)

6. Related matters - commercial sector:

   a. conservation incorporated in (commercial) building codes, compliance procedures

   b. key contacts in the commercial sector to discuss "typical" energy use

   c. local authorities to contact on energy use in the commercial sector

7. Residential sector:

   a. recent data on appliance saturations
   b. recent data on fuel mode splits
   c. recent data on energy use/appliance
   d. recent data on amount of conservation due to fuel costs/conservation programs

EXHIBIT A.2

INTERVIEW GUIDE FOR BUILDING MANAGERS

EXHIBIT A.2

INTERVIEW GUIDE FOR BUILDING MANAGERS

1. Building characteristics
   a. size (square feet)
   b. insulation
   c. heating plant and HVAC system size and type.
2. Energy usage, especially electric.
3. Energy audit results if one has been conducted.
4. Conservation actions taken/planned.
5. Building occupancy characteristics.
   a. number of people working in building
   b. hours of building operation
   c. off-hours operations--are lights left on--heating plant turned back?
6. Trends noticed in construction/operating practices of commercial buildings.

APPENDIX B

THE EFFECT OF F.W. DODGE CONSTRUCTION DATA ON RAILBELT ELECTRICITY DEMAND FORECASTS

CONTENTS

TABLES

B.1.0 INTRODUCTION

The Railbelt Electricity Demand (RED) Model is a computer simulation model designed to forecast electricity consumption for the residential, commercial-light industrial-government (business), heavy industrial, and miscellaneous sectors of Alaska's Railbelt region. A key feature of this model is that it employs the stock of commercial, light industrial, and government floorspace in order to forecast the future demand for electricity in the business sector. Documentation of the original approach for forecasting business floorspace and electricity consumption was provided in the RED Model (1983 Version) Technical Documentation Report, Volume 2C of the Susitna Hydroelectric Project Federal Energy Regulatory Commission License Application, Project No. 7144-000, July 1983.

During September, 1983 a workshop on the model was held by Harza-Ebasco Susitna Joint Venture, and Battelle, Pacific Northwest Laboratories (Battelle-Northwest) in Anchorage, Alaska to brief staff members of the Federal Energy Regulatory Commission (FERC), on the structure and assumptions of the RED model. The workshop was also attended by the Alaska Power Authority and the Power Authority's attorneys (Pillsbury, Madison, and Sutro of Washington, D.C.).

In the course of the workshop, the FERC staff asked whether additional information existed concerning past changes in the mix of Railbelt commercial building stock and effects this may have had on the RED model's estimated relationship between commercial building stock and electricity demand. In addition, it became clear that the approach employed in the July 1983 version of RED could be simplified.

As a result, the Battelle-Northwest and Harza-Ebasco technical staff laid out a short research plan to

- interview utility managers, building managers, and other sources of data to estimate the current types and rates of uses of electricity in the Railbelt commercial sector; the current stock of commercial buildings and past changes in the stock of buildings; and electrical use;

- acquire and analyze the F. W. Dodge Construction Potentials data set published by McGraw Hill, Inc. to determine the rate of change in the level and composition of Railbelt commercial building stock during the 1970s; and
- utilize the Dodge data to reestimate business electricity consumption equations, as appropriate, to simplify the approach.

The first of these items was documented in a previous report to Harza-Ebasco from Battelle-Northwest entitled Railbelt Commercial Building Stock and Energy Use Data by C. H. Imhoff and M. J. Scott (Appendix A). The use of the Dodge data is covered by the current report.

The remainder of this report is organized as follows. Chapter B.2.0 discusses the principal findings of the study. Chapter B.3.0 is a brief introduction to the F. W. Dodge Construction Potentials data set. Chapter B.4.0 discusses the effect the analysis of this data set has had on the estimates of commercial building space in the RED model. Chapter B.5.0 discusses the effect of the revised commercial stock estimates on the business electricity consumption equations.

B.2.0 CONCLUSIONS

The brief study of available data sources on Railbelt commercial building stock resulted in five major conclusions. The study results are stated briefly below.

Based on the analysis of other available data sets, we concluded that the Construction Potential data set published by the F. W. Dodge Division of McGraw-Hill, Inc. was the best data series available for estimating the Railbelt commercial building stock. While local governments in the Railbelt do keep records of building permit activity, these were not available in a form that would enable us to estimate building completions, cancellations, and size or type of building. In many cases, building stock data locally available in the Railbelt would have required extensive collection and compilation.

The analysis of the Dodge data showed that there was very little year-to-year consistency in the type of buildings constructed during the period 1973 to 1983, although Anchorage-Cook Inlet load center showed a more consistent pattern of additions than did Fairbanks-Tanana Valley. The Fairbanks data did not indicate a consistent historical pattern in construction activity.

The analysis of the Dodge data showed no obvious trends in types of buildings being built in either load center, although information received from utilities staff in the Railbelt suggested that there was a trend toward strip-type development in Fairbanks and large office buildings in Anchorage (see Appendix A.) The Dodge categories we analyzed did not reflect such trends. In Anchorage-Cook Inlet for example, office space was a fairly constant 26 to 27 percent of total construction during the period 1973 to 1983.

Based on our findings in the two load centers, we concluded that the Dodge data should be utilized to estimate historical commercial building stock in the Anchorage-Cook Inlet and Fairbanks-Tanana Valley load centers but that no attempt should be made to differentiate between types of commercial buildings.

Finally, we concluded that the resulting estimated building stock should be used to derive new business electricity consumption equations in Anchorage-Cook Inlet. We concluded that this should not be done in Fairbanks-Tanana

Valley because the historical record does not appear to be applicable to probable future conditions in this load center. These conclusions were taken into account in the RED85A version of RED.

B.3.0 F. W. DODGE CONSTRUCTION POTENTIALS DATA

The F. W. Dodge Division of McGraw-Hill Information Systems Company compiles and publishes a proprietary data set known as Dodge Construction Potential Service. This service provides a month-by-month listing of individual construction projects by county, type of intended use (e.g., shipping center, refrigerated warehouse, primary school), framing code, number of floors, floor area, and value. The data set also indicates whether a project is new construction, an addition, or an alteration of an existing structure. For residential construction, Dodge also reports the number of dwelling units constructed.

The Dodge Construction Potential Service is available by subscription or purchase in machine-readable form for all counties in the United States. A continuous data series is available for Railbelt census divisions from January 1973 forward through 1983. The covered projects are edited periodically to account for errors and omissions and to account for later information on a given project's being abandoned, deferred, or put into abeyance. Dodge publishes a standard procedure for accomplishing this editing. This procedure was followed in processing the data tapes for this project.

The Dodge construction statistics that result from aggregating these individual projects represent information on construction starts. For energy planning, a more useful data set would be one of project completion or building occupancy, since a building begins significant energy use when it is completed and especially after it is occupied. No such completion data series was available. The F. W. Dodge Division technical staff indicated that the lag period from project start to building completion depends on the size and type of building. For their own purposes in providing complete tape processing services on a subscription basis, Dodge uses the date at which the last construction step is begun (usually, wall coverings and exterior paints), plus one to two months as the date of completion. Standard lags from project initiation to initiation of this last construction step are available.[a] Because standard construction time lags do not necessarily apply in the Alaska construction environment, we adopted a simplified assumption that buildings on average took between one and two years to complete and were available for occupancy on average in the year following their start date. This may result in some upward bias in construction completions for some categories of buildings such as large office buildings and hotels in the early years of the period (when the projects were started) and a downward bias in construction completions later on (when they were actually completed). Overall, the expected impact of the simplifying assumption is small.

The Dodge construction statistics represent the best available construction statistics for the Railbelt region. Imhoff and Scott (1984) found that only fragmentary data exist on building stock in either Anchorage or Fairbanks; no comprehensive data base is available. Imhoff and Scott note, for example, that the Fairbanks North Star Borough Assessor's Office maintains its standard property records in manual physical files with no compilation of the type needed for this project. Neither Anchorage nor Fairbanks authorities have a complete count of the current building stock; nor do they have accessible records for changes in the stock over time.

Battelle-Northwest compiled information on completed commercial buildings by type and year for the Anchorage-Cook Inlet load center (Anchorage, Kenai-Cook Inlet, Matanuska-Susitna, and Seward 1970 Census Divisions) and for Fairbanks-Tanana Valley (Fairbanks and Southeast Fairbanks 1970 Census Divisions) from the Dodge data. Minor geographical mismatches exist in these data

(a) These standard lags indicate that buildings under $250 thousand in value, the least costly group, take an average of about 5 months to complete while buildings costing over $25 million (the most expensive class) take an average of 27 months to complete. Buildings from $250 thousand to $1.25 million take 9 months; buildings $1.25 million to 8 million take 15 months; and buildings from $8 million to $25 million take 22 months on average to complete.

in the Fairbanks-Tanana Valley load center because the combined census divisions do not match the boundaries of the combined Fairbanks Municipal Utilities System and Golden Valley Electric Association service areas; however, the expected discrepancies are insignificant.[a]

(a) The difference between the 1980 populations of the areas served by the Fairbanks-Tanana Valley utilities and the 1980 census areas used as a proxy was only 150 people. Personal communication, Scott Goldsmith, ISER, November 6, 1984.

B.4.0 EFFECT OF DODGE CONSTRUCTION DATA ON COMMERCIAL BUILDING STOCK ESTIMATES

The Dodge Construction Potentials data were used by Battelle-Northwest to provide additional information concerning the Railbelt commercial (including government and light industrial) building stock. The first item of information to be collected was changes in the stock of commercial buildings in the Railbelt load centers in years past. The second item was the changes in the mix of buildings in the load centers.

THE RAILBELT COMMERCIAL BUILDING STOCK

The commercial building stock in a given area can be described as an inventory of building space to which new construction and additions are adding space, and from which demolitions are removing space. No information is available on building removals in the Railbelt, although some removal is taking place. For the most part, however, Railbelt commercial building space is of very recent vintage with few demolitions so that the chief difference in the stock from year to year is new construction and additions to existing buildings. Thus, the building stock in any year can be approximated by taking the stock in a year when it is known and then subtracting or adding construction completions to account for the changes in stock between the given year and the year for which a count is available. The process is described below for the Railbelt load centers.

Anchorage-Cook Inlet

In the Anchorage-Cook Inlet load center, the best comprehensive estimate of the building stock is for 1978. The estimate was made by the University of Alaska Institute of Social and Economic Research (ISER). This estimate was based on the 1975 Anchorage Metropolitan Area Transportation Study (AMATS), with several adjustments for outlying areas, non-energy-using buildings and other miscellaneous items. This estimate is shown in Table B.4.1.

The 1978 building stock estimate for the Anchorage-Cook Inlet load center was converted into a time series on building stock by adding commercial construction from the Dodge Construction Potentials data for the years 1978 and

TABLE B.4.1. Calculation of 1978 Anchorage Commercial Floorspace

AMATS Survey (Anchorage Bowl 1975)			42,067
Less:	Non-Energy Using (parking lots, cemeteries, etc.		18,918
Plus:	20 Percent for Underreporting		4,630
			27,779
Plus:	Sectors not included in AMATS		
	1. Girdwood/Indian[a]		53
	2. Eagle River/Chugiak[b]		300
	3. Hotels/Motels[c]		1,000
	4. Assorted Cultural Buildings[d]		500
			29,632
Plus:	Growth between 1975 and 1978 (about 25%)[e]		7,400
1978 Commercial-Industrial Floorspace[f]			37,000
	General	25,120	
	Education	5,000	
	Warehousing	4,520	
	Hotels	1,500	
	Manufacturing	860	
Less:	Manufacturing		860
1978 Commercial Total, Anchorage			36,140
Plus:	Kenia-Cook Inlet[g]		3,200
	Matanuska-Susitna[g]		1,500
	Seward[g]		600
Total, 1978, Anchorage-Cook Inlet			41,440

Source: Goldsmith and Huskey 1980.

(a) Twenty-five businesses in 1975 according to telephone book. Assume 2,500 square feet/business.

(b) Based on the ratio of the housing stock in 1978 between Eagle River/Chugiak and Anchorage.

(c) Assumes 2,000 rooms at 500 square feet/room. Based on Jackson and Johnson 1978, p. 40.

(d) Forty-six establishments identified in 1975 telephone book. Average size assumed to be 10,000 square feet.

(e) This is based upon two indicators. The first is the growth in employment between 1974-75 and 1978. Civilian employment was as follows: 1974 - 58,700, 1975 - 69,650, and 1978 - 76,900. Employment growth was 31% in the period 1974 to 1978 and 10% in the period 1975 to 1978 (State of Alaska, Department of Labor, Alaska Labor Force Estimates by Industry and Area, various issues). The second is the growth in the appraised value of buildings over the period 1975 to 1978. After adjusting for inflation, the increase was 48%. Based on the assumption that the rapid employment increase in 1975 resulted in undersupply of floorspace in that year, Goldsmith and Huskey assume a 25% growth in floorspace between the summer of 1975 and 1978.

(f) Independent estimates of floorspace in 1978 in the educational category and the hotel/motel category were available from the Anchorage School District and Anchorage Chamber of Commerce, respectively. The remaining growth was allocated proportionately among the other categories.

(g) Based on the Anchorage value of 480 square feet/non-agricultural civilian employee.

after; commercial construction was subtracted to determine building stock before 1978. In adding or subtracting construction, it was assumed that, as stated in Chapter B.3.0, on average a building begun in one year would be finished and available for occupancy in the following year. Thus, 1978 construction starts are added to 1978 building stock to obtain 1979 building stock. The resulting Anchorage-Cook Inlet building stock series is shown in Table B.4.2.

TABLE B.4.2. Anchorage-Cook Inlet Estimated Building Stock, 1973-1984

	(10^3 Square Feet)
1973	26,236.0
1974	28,970.5
1975	33,086.6
1976	36,848.1
1977	39,563.5
1978	41,440.0
1979	42,761.9
1980	44,110.5
1981	44,964.2
1982	47,553.8
1983	49,795.5
1984	54,331.5

Source: Table B.4.1 and F.W. Dodge Construction Potentials.

Fairbanks-Tanana Valley

ISER also produced an estimate of the 1978 Fairbanks-Tanana Valley load center commercial floorspace based on an assumption that Fairbanks-Tanana Valley square footage per employee equaled Anchorage square footage per employee.[a] A preferred approach to estimating the amount of commercial

(a) Goldsmith and Huskey, 1980, Tables D.39 and D.40.

building space in Fairbanks-Tanana Valley load center for 1983 is to combine a partial central Fairbanks building stock count by Mundy-Jarvis Associates prepared in November 1983 with other counts of certain public buildings and our own estimates for some of the remaining categories.

This preferred process is documented in Imhoff and Scott (1984) (Appendix A) and is summarized in Table B.4.3.

The estimate of Fairbanks-Tanana Valley 1983 building stock count was then converted into a time series by subtracting commercial construction in each year in the same way as in Anchorage-Cook Inlet. The results are shown in Table B.4.4.

DISTRIBUTION OF BUILDING STOCK BY TYPE

There are no obvious trends to be noted in the types of commercial buildings being constructed in the Railbelt load centers. In both load centers, commercial construction showed considerable year-to-year variability in all types, both in total square feet constructed and in the percentages of total construction accounted for by each building type. The annual percentages for selected major categories comprising the bulk of Railbelt commercial construction activity are reported in Table B.4.5 and B.4.6. As can be seen from the table, there is no obvious trend in types of buildings being constructed in either load center. This answers directly a question asked by the FERC staff in their review of the July 1983 version of the RED model; namely, are there trends in the type of commercial space being constructed? FERC staff were interested in the differing degree to which electricity-using capital equipment is used in various subsectors of the commercial building stock (e.g., computers are being added in offices, but more efficient heat recovery and cooling systems are being added in supermarkets). If the intensity or mix of energy uses were changing dramatically in certain building types and their proportion of the stock is also changing, then it might not be appropriate to estimate energy consumption on the basis of aggregate commercial building stock. Tables B.4.5 and B.4.6 show, however, that the mix of the stock is not obviously changing, so intensity of electrical consumption can be estimated on an aggregate basis.

TABLE B.4.3. Fairbanks-Tanana Valley 1983 Building Stock (10^3 Square Feet)

Mundy Jarvis Associates count, Adjusted for missed buildings[a]			2,867
Plus:	North Star Borough Buildings[b]		1,655
	Federal Buildings[c]		157
	State Buildings[d]		1,186
	City of Fairbanks Buildings[e]		260
	Subtotal: Count		6,125
Plus:	Estimated Stock (early 1984)		
	Lodgings/Hotel/Motel[f]	870	
	Churches/Social/Grange[f]	774	
	Transportation[f]	1,188	
	North Pole Area, Nenana, Delta[f]	2,432	
	Hospital[g]	201	
			5,465
			11,590
Less:	Adjustment for 1984/1983 difference (Approximately 3.3%)[h]		390
1983 Estimated Stock, Fairbanks-Tanana Valley			11,200

(a) Source: Mundy-Jarvis Associates, Comprehensive Space Inventory of Fairbanks, Alaska, November, 1983. Estimates of missing data supplied by Mundy-Jarvis Associates. Personal Communication, Jeff Wollen to Michael Scott, March 20, 1984.
(b) Source: Fairbanks North Start Borough Engineering Department, March 1984.
(c) Source: U.S. General Services Administration, Anchorage, Alaska, March 1984.
(d) Source: Alaska Department of Administration.
(e) Source: City of Fairbanks Fire Marshall, March 1984.
(f) Calculated by counts of businesses from Fairbanks telephone directory and national median space per building by type, March 1984.
(g) Source: Fairbanks Memorial Hospital, March 1984.
(h) F. W. Dodge Construction started in 1983 would have increased stock by about 10% by 1984. One third of that amount adjusted for differences between the November 1983 stock and the estimated stock in approximately March 1984, about one-third of a year later. The final figure was rounded to the nearest hundred thousand square feet.

TABLE B.4.4. Fairbanks-Tanana Valley Estimated Building Stock, 1973-1984 (10^3 Square Feet)

	(10^3 Square Feet)
1973	3,764.8
1974	4,417.2
1975	5,407.1
1976	7,468.3
1977	8,691.5
1978	9,806.3
1979	10,145.3
1980	10,385.6
1981	10,634.8
1982	10,777.0
1983	11,200.0
1984	12,288.9

Sources: Imhoff and Scott and F.W. Dodge Construction Potential.

This is also true whether we examine the year-by-year figures or group them into economic subperiods. Both tables show average percentages for the Trans-Alaska oil pipeline period (1973-1977), the post-pipeline period (1978-1983), and the period since the 1979 Iranian oil price shock (1980-1983). These subperiod averages also show no obvious trend when compared to the 1973-1983 period as a whole. In Anchorage-Cook Inlet the subperiod and year-to-year percentages vary less than in Fairbanks-Tanana Valley; however, even in Anchorage the subperiod averages tend to be dominated by very large scale construction in one or two years. For example, in Anchorage warehouses there appears to be declining trend in warehouse construction; however, in the two most recent years construction was at or above the ten-year average for this category of construction in both absolute and percentage terms. Similarly, there is an apparent recent decline in public construction in Fairbanks as a percentage of the total. However, public construction was among the more important categories in both 1979 and 1982. It is only the large amount of

TABLE B.4.5. Anchorage-Cook Inlet Commercial Building Construction by Type as a Percentage of Total Commercial Construction 1973-1983 (Percent of Total)

Year	Office	Retail/ Wholesale	Warehouse	Education	Public	Miscellaneous	Subtotal	All Other Types
1973	14.0	9.6	8.9	33.9	4.3	16.3	87.0	13.0
1974	31.2	4.0	18.5	3.7	9.3	27.7	94.4	5.6
1975	15.8	8.6	23.6	15.0	6.4	24.2	93.6	6.4
1976	36.5	16.8	4.7	8.6	0.6	17.3	84.5	15.5
1977	46.8	6.0	10.2	1.0	6.8	12.0	82.8	17.2
1978	33.0	10.4	16.0	23.3	1.8	11.7	96.2	3.8
1979	13.7	34.1	15.0	15.1	0.5	12.1	90.5	9.5
1980	2.7	11.4	1.8	15.5	8.9	39.2	79.5	20.5
1981	52.0	15.7	4.9	2.8	5.6	18.2	90.2	0.8
1982	20.1	13.5	14.4	20.1	8.3	17.0	93.4	6.6
1983	21.3	20.7	12.9	20.5	0.9	9.8	86.1	13.9
Averages								
73-77	27.2	8.7	14.6	12.5	5.8	21.0	89.8	10.2
78-83	26.5	18.2	11.4	16.3	3.7	15.1	91.2	8.8
80-83	27.3	17.1	10.3	15.5	4.4	15.9	90.5	9.5
73-83	26.8	13.1	13.1	14.2	4.8	18.3	90.3	9.7
Range, 1973-1983	2.7-52.0	4.0-34.1	1.8-23.6	1.0-33.9	0.5-8.9	9.8-39.2	79.5-99.2	0.8-20.5

Source: Dodge Construction Potentials.

TABLE B.4.6. Fairbanks-Tanana Valley Commercial Building Construction by Type as a Percentage of Total Commercial Construction 1973-1983 (Percent of Total)

Year	Office	Retail/ Wholesale	Warehouse	Education	Public	Miscellaneous	Subtotal	All Other Types
1973	18.7	19.2	14.2	14.9	7.2	14.1	88.3	11.7
1974	4.3	12.2	25.3	11.1	7.9	17.7	78.5	21.5
1975	20.3	3.4	22.1	21.9	1.2	14.0	82.9	17.1
1976	1.2	37.8	0.0	8.4	16.0	22.6	86.0	14.0
1977	1.0	21.2	8.3	12.1	42.0	13.1	97.7	2.3
1978	5.9	28.5	5.9	21.0	0.0	36.9	98.2	1.8
1979	22.6	36.2	0.0	4.5	24.9	1.8	90.0	10.0
1980	0.0	2.3	10.0	10.3	1.4	75.4	99.4	0.6
1981	0.8	0.0	31.6	47.2	4.2	9.6	93.4	6.6
1982	1.5	6.6	8.8	47.7	14.1	20.0	98.7	1.3
1983	24.6	7.4	4.5	24.4	1.9	12.4	75.2	24.8
Averages								
73-77	10.1	16.8	14.8	14.8	13.5	16.2	86.2	13.8
78-83	14.1	12.0	7.1	25.9	6.0	22.1	87.2	12.8
80-83	14.4	6.0	8.2	29.4	4.7	22.0	84.7	15.3
73-83	11.2	15.4	12.5	18.1	11.3	17.9	86.4	13.6
Range, 1973-1983	0.0-24.6	0.0-37.8	0.0-31.6	4.5-47.7	0.0-42.0	1.8-75.4	75.2-98.7	0.6-24.8

Source: Dodge Construction Potentials.

such construction in 1976 and 1977 that creates the apparent "trend." The burst of pipeline-related activity in 1976-1979 (especially 1976-1977) is also the sole cause of the apparent trend in Fairbanks-Tanana Valley retail-wholesale construction. The percentages are lower both before and after this period. Office and education space is apparently added in large blocks at irregular intervals in Fairbanks-Tanana; thus the subperiod averages mean very little.

In general, the construction patterns in the two Railbelt load centers appear to be quite irregular. There is no single set of percentages in Tables B.4.5 and B.4.6 that could be used to characterize trends in construction by type. Nor are there any apparent trends in construction by type that on closer examination appear to be real or significant. As a consequence, the simplifying assumption used in the RED model that all types of commercial stock are growing at about the same rate is supported by the data.

B.5.0 EFFECT OF DODGE CONSTRUCTION DATA ON ELECTRICITY CONSUMPTION FORECASTS

The commercial building stock estimates developed in the previous chapter were utilized to estimate electricity demand equations for the two Railbelt load centers. The relative stability of floorspace and employment as predictors of electricity consumption in the business sector were examined. As a consequence of this analysis, floorspace was identified as the preferable predictor of electricity consumption. Next, we econometrically estimated consumption equations. In Anchorage-Cook Inlet, the econometric approach worked well and produced estimates compatible with economic theory and the historical record of consumption for the load center. In Fairbanks-Tanana Valley, this approach produced a reasonably close fit to historical data; however, the derived forecasting equation did not produce plausible forecasts of electricity consumption. The forecast was one of a rapidly declining rate of electricity use. Historically, this declining use actually occurred; however, it was caused by a combination of events unlikely to be repeated. Consequently, a simplified non-econometric equation was used to predict future business consumption of electricity for Fairbanks.

FLOORSPACE VERSUS EMPLOYMENT

The first step in estimating business electrical consumption was to test the historical data to see which of the available time series was the better predictor of electrical consumption, square feet of business space or employment. Table B.5.1 shows historical trends in business electrical use per square foot of commercial floorspace, floorspace per employee and electrical use per square foot in the two load centers. Both Anchorage-Cook Inlet and Fairbanks-Tanana Valley show increasing consumption per employee over the period as a whole, although there is short term variation around the trend. In the case of Anchorage, this trend appears to be composed of a slowly increasing trends in use per square foot and a varying growth rate in square feet of space

TABLE B.5.1. Commercial Consumption Trends 1973-1983

Year	Anchorage-Cook Inlet			Fairbanks-Tanana Valley		
	kWh[a]/Employee[b]	Ft^2[c]/Employee[b]	kWh/Ft^2	kWh[a]/Employee[b]	Ft^2[c]/Employee	kWh/Ft^2
1973	5941	321.8	18.46	6631	150.5	40.06
1974	5788	322.1	17.98	5399	147.6	36.59
1975	5758	318.4	18.09	5368	167.6	38.98
1976	6403	337.5	18.97	5641	192.2	29.35
1977	6714	348.2	19.28	6922	250.2	27.67
1978	7218	367.9	19.62	7550	305.1	24.75
1979	7176	375.6	19.10	7577	318.6	23.78
1980	7772	379.4	22.73	7510	332.9	22.56
1981	7285	363.7	20.03	7807	321.4	24.29
1982	7388	347.2	21.28	7209	295.6	24.40
1983	NA	NA	NA	NA	NA	NA

Sources:
(a) Commercial-government industrial use from FERC form 12s and Alaska Power Administration.
(b) U.S. Bureau of Economic Analysis (BEA), Regional Economic Information System, provided employment data.
(c) See Chapter B.4, Tables B.4.2 and B.4.4.

per employee.[a] In the case of Fairbanks, the trend masks a rapid increase in the stock of building space per employee (which shows recent signs of slowing down), combined with a rapid decrease and then stabilization in electrical consumption per square foot of commercial floorspace. Since the decline in electrical use per square foot appears to have halted in Fairbanks and electrical use is starting once again to increase in response to demand for more business services, then using either the trend of business use per employee or an econometric equation with employment as the independent variable is likely to give misleading results. Consequently, a two-step approach of forecasting square feet per employee and kWh per square foot was employed.

BUILDING STOCK

Both simple trend equations and regression equations based on historical Alaska experience were considered for forecasting commercial building stock in the Railbelt load centers. Neither linear, exponential, nor logarithmic equation forms produced acceptable forecasts for both load centers of commercial building stock per employee. For example, consider the time trends in building space per employee calculated from Railbelt data in Table B.5.2.

Table B.5.2 shows predicted values for three possible time trend lines fitted to historical data on commercial floorspace per employee by regression analysis. The three trend lines are:

- Linear: $Ft^2/Employee = a + b \cdot (time)$
- Exponential: $Ft^2/Employee = e^{(a + b \cdot time)}$
- Logarithmic: $Ft^2/Employee = a + b \cdot \ln (time)$

In the fourth column of the table shows the estimated actual commercial floorspace per employee for the period 1973 to 1982. In comparing each of the trends to the actual values, one notices several things.

1. All three time trends appear to perform about equally well during the historical period.

(a) In particular, the growth rate even becomes negative during periods of rapid employment growth such as 1975 and 1981-1982. BEA employment figures were not available for 1983 but a considerable amount of commercial building occurred in that year.

TABLE B.5.2. Time Trends in Commercial Building Stock Per Employee, Railbelt Load Centers (Ft^2/Employee)[a]

Anchorage-Cook Inlet:

Year	Linear Trend	Exponential Trend	Logarithmic Trend	Actual[b]
1973	322.8	322.0	310.4	321.8
1974	327.8	327.6	327.9	322.1
1975	333.6	333.1	338.0	318.4
1976	339.5	338.8	345.1	337.5
1977	345.3	344.6	350.6	348.2
1978	351.1	350.4	355.2	367.9
1979	356.9	356.4	359.0	375.6
1980	362.7	362.5	362.3	379.4
1981	368.5	368.7	365.3	363.7
1982	374.3	374.9	367.8	347.2
1983	380.1	381.3	370.2	-
1984	386.0	387.8	372.3	-
1985	391.8	394.4	374.3	-
1990	420.8	429.1	382.4	-
1995	449.9	467.0	388.5	-
2000	478.9	508.1	393.3	-
2005	502.2	543.6	396.7	-
2010	537.0	601.6	400.9	-

Fairbanks-Tanana Valley:

Year	Linear Trend	Exponential Trend	Logarithmic Trend	Actual[b]
1973	145.0	150.2	106.7	150.5
1974	167.9	166.2	171.6	147.6
1975	190.9	183.8	209.6	167.6
1976	213.8	203.4	236.5	192.2
1977	236.7	225.0	257.4	250.2
1978	259.6	248.9	274.5	305.1
1979	282.6	275.3	288.9	318.6
1980	305.5	304.6	301.4	332.9
1981	328.4	337.0	312.5	321.4
1982	351.3	372.8	322.3	295.6
1983	374.3	412.4	331.3	-
1984	397.2	456.4	339.4	-
1985	420.1	504.8	346.9	-
1990	534.8	836.5	377.4	-
1995	649.4	1386.2	400.3	-
2000	764.0	2297.3	418.8	-
2005	855.7	3441.2	431.3	-
2010	993.3	6308.7	447.3	-

(a) Employees are estimated by the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Information System. There are differences in definition between this source's definition and that used by ISER. See text.

(b) Estimate from building stock in Chapter B.4. See also Table B.5.1.

2. Time trends based on historical Railbelt data all predict higher future floorspace per employee in Fairbanks-Tanana Valley than in Anchorage-Cook Inlet. This is contrary to historic evidence and contrary to economic incentives, since higher construction and heating costs should keep space per employee in Fairbanks-Tanana Valley relatively low compared to Anchorage-Cook Inlet.

3. In view of the 1979 national average of commercial floorspace per employee of about 613.1,[a] the unadjusted linear and exponential trends appear to be forecasting unreasonably low in Anchorage and unreasonably high in Fairbanks-Tanana Valley. Once adjusted for differences between total employment as reported by the U.S. Department of Commerce, Bureau of Economic Analysis and total employment as estimated by ISER, the linear trend in Anchorage produces a year 2010 value of 603.8, close to the 1979 national value.

4. On the other hand, the logarithmic growth rates based on Railbelt load center data appear unreasonably low in both load centers when extrapolated for 30 years. Historical commercial construction figures indicate that even in the post-pipeline period of 1978-1980, the commercial stock per employee continued to increase at a rate of 1.6% per year in Anchorage-Cook Inlet and 4.5% in Fairbanks-Tanana Valley.[b] In contrast, the logarithmic trend yields 30-year annual average growth rates of 0.18 and 0.99% respectively.

Because of the results obtained by trending Railbelt historical data, Anchorage-Cook Inlet commercial building stock per employee was assumed to

(a) See U.S. Energy Information Administration, 1983 for square footage data. U.S. Statistical Abstract figures for total nonfarm civilian employment for 1979 were modified to be consistent with Railbelt total employment estimates as follows: industrial and mining (field) employees were subtracted and military added. Unadjusted average commercial building occupancy in 1979 was one employee per 623 square feet.

(b) Downturns are shown in 1981 and 1982 in both Anchorage and Fairbanks. However, this is due primarily to rapid employment growth rather than a construction slowdown. 1983 construction continued under "boom" conditions.

increase linearly at its historical rate, to yield 603.8 square feet per employee by the year 2010. This is still fairly conservative, since it implies an average growth rate of 1.1%, less than the 1973-1980 rate of 1.7% measured at the endpoints. In order to have the growth rate decline as the national average was approached and building stock needs were satisfied, it was assumed that stock per employee follows a linear path beginning from a 1980 adjusted base value.[a]

Historical data were not used to extrapolate the Fairbanks-Tanana Valley growth rate in stock per employee. For Fairbanks Tanana Valley, it was assumed that the very rapid past growth rate in square feet per employee would not apply after the Anchorage-Cook Inlet value was approached. Moreover, this slowing-down process already may have begun (see Table B.5.2). Because of the higher relative cost of building and heating the commercial building stock in Fairbanks, the space per employee in Fairbanks-Tanana Valley is not expected to catch up to the Anchorage-Cook Inlet value. Instead, it is assumed that the future growth rate in Fairbanks-Tanana Valley building stock per employee parallels Anchorage-Cook Inlet growth, reaching about 538.4 square feet in the year 2010. This is about 10.8% than Anchorage-Cook Inlet and implies a 30-year average annual growth rate of 1.3%. The forecasted square feet of commercial floorspace per employee and the average growth rates by forecast period are shown in Table B.5.3 for the two load centers.[b] Because a different employment base was used in Table B.5.3 than in Table B.5.2, floorspace per employee in the early forecast years will not equal the values in Table B.5.2.

(a) The path in Anchorage is defined as y = 383.023 + 5.811.t, where t takes on values 1,2,3,...,7 corresponding to 1973, 1974, ..., 2010. In Fairbanks, the intercept term is 314.562. Square feet per employee for 1980 were calculated using the best estimate of total employment available in the July 1983 version of RED. The coefficient was not updated in RED85A. The July 1983 estimate of square feet per employee was based on the ISER definition of total employment, which is lower than the BEA definition. This is due to different treatment of military reservists and some categories of service workers.

(b) The end year value of 603.8 is quite conservative, compared to the nation as a whole. Based on the forecasted commercial square footage from the U.S. Energy Information Administration's 1983 Annual Energy Outlook and Data Resources, Incorporated U.S. Long Term Review (Winter 1983-84) forecast values for employment, the national value for 1995 would be 723.6 square feet per employee, about 120 square feet more than the Anchorage value for 15 years later.

TABLE B.5.3. Forecasted Commercial Floorspace per Employee and Average Growth Rates 1980 to 2010

	Anchorage-Cook Inlet		Fairbanks-Tanana Valley	
	Ft^2/ Employee	Annual Growth Rate(%)	Ft^2/ Employee	Annual Growth Rate(%)
1980	429.5[(a)]	-	364.0[(a)]	-
1981	435.3	1.4	369.8	1.6
1982	441.1	1.3	375.6	1.6
1983	446.9	1.3	381.4	1.5
1984	452.7	1.3	387.2	1.5
1985	458.5	1.3	393.0	1.4
1990	487.6	1.2	422.1	1.3
1995	516.6	1.2	451.1	1.3
2000	545.7	1.1	480.2	1.2
2005	574.7	1.0	509.2	1.2
2010	603.8	1.0	538.4	1.1

(a) Using the ISER definition of total employment rather than the Bureau of Economic Analysis definition in Table B.5.2, Anchorage-Cook Inlet Ft^2/Employee equals 429.5, Fairbanks-Tanana Valley equals 364.0. These figures were used for projection purposes in the model so that RED will forecast commercial floorspace consistent with the ISER definition of employment used as RED model input in the FERC license application.

KWH PER SQUARE FOOT

The intensity of electrical consumption per square foot was investigated in some depth. Many econometric specifications were tried on historical data for the Railbelt load centers in order to select an equation having both theoretical consistency and close statistical fit. Among tests attempted were:

- including and excluding the price of electricity as an explanatory variable;
- utilizing dummy variables to account for left-out variables and structural shifts in the econometric relationships;

- utilizing heating degree-days and cooling degree-days to adjust for weather conditions;
- linear, log-linear, and exponential equation forms.

A number of criteria were used for judging whether an equation was appropriate. Examined were the sign, size, and statistical significance of the coefficients and the implied elasticity of demand with respect to the size of the commercial building stock. For example, since economic theory predicts that the marginal effect of electricity price on electrical consumption should be negative, equations were rejected where electricity price came in with a positive sign or a value not statistically different from zero, as measured by the Student t ratio. The $\bar{R}^2$ statistic was examined to determine goodness of fit to the data and the Durbin-Watson statistic for evidence of autocorrelation and misspecification. The equations were also tested by excluding a given variable such as electricity price to determine if such exclusion had any significant effect on the remaining coefficients in the equation. Finally, use was made of supplementary information on the historical relationship between commercial building stock and commercial-light industrial-government electrical consumption. In Anchorage-Cook Inlet, for example, the level of use per square foot has increased slowly for several years. In the absence of further increases in energy prices, there is no reason to anticipate either a major reversal of this recent trend or a major acceleration. Equations showing a stock elasticity dramatically less than 1.0 were rejected because such a value implies either declining demand for electricity in the absence of price changes in new construction or significant additional conservation retrofits of the existing stock, or both. While modest amounts of this type of activity have occurred historically in Anchorage (Imhoff and Scott 1984), large amounts of such conservation activity are not expected at prevailing prices. Increased energy consciousness in the commercial sector, on the other hand, probably precludes rapid increases in energy use per square foot and stock elasticities significantly greater than 1.0.

Available supplementary information on the Fairbanks-Tanana Valley load center was less conclusive. The historical period was marked by very significant increases in the prices of electricity and fuel oil, as well as by a moratorium in the installation of electric space heat. As a consequence, during the historical period there apparently was a significant decline in electrical use per square foot. Since much of today's commercial stock was built during the period of rising or high electrical prices and electric space heat moratorium, we expect that electrical use per square foot is near a minimum value given current electricity prices. Additions to stock would probably have use rates near current levels or slightly higher or lower. Econometric electricity consumption equations having implied stock elasticities much higher or lower than 1.0 were thus rejected.

Table B.5.4 shows the results of the two econometric estimates having best theoretical consistency and statistical fit. It was found that including either electricity price or heating and cooling degree-days generally had little effect on the stock coefficients in the two load centers. Moreover, in most cases these auxiliary explanatory variables came in with the theoretically "wrong" sign (e.g., positive effect of electricity price) or were not statistically significant, or both. Table B.5.4 results show that as commercial stock increases by 1% in Anchorage-Cook Inlet, electricity use increases by about 1.22% in the absence of future changes in the prices of gas, oil, and electricity. This is consistent with a slowly accelerating use per square foot, which in turn is consistent with the lower 48-style building stock being constructed in Anchorage at this time. When the equation was used to forecast electricity consumption for the historical period, the difference between the forecast and actual consumption was small, as shown in Table B.5.5. In Fairbanks-Tanana Valley, even the "best" equation had to be rejected because of the very low reported elasticity with respect to commercial stock, even though historical forecast errors were reasonable. The low elasticity appears to be due to the rapid historical decline in use per square foot in Fairbanks, a trend that could not be forecasted for 30 years into the future, given the supplementary information discussed above. Instead, a stock elasticity of 1.0 was assumed for Fairbanks, which implies constant electrical use per square foot in the absence of future changes in electricity and fuel oil prices. For both equations, the intercept value was adjusted to calibrate the forecasting

TABLE B.5.4. Econometric Results for "Best" Business Electricity Consumption Equations, Railbelt Load Centers[a]
(standard error in parenthesis)

	Anchorage-Cook Inlet	Fairbanks-Tanana Valley
BETA	-6.320 (0.656)	1.512 (0.469)
BBETA	1.224 (0.062)	0.435 (0.053)
$\bar{R}^2$	0.980	0.906
D.W.	1.692	1.988
F	387.7	67.6
Degrees of freedom	8	7

(a) The estimated equation was:

$$\ln(PRECON_{it}) = BETA_i + BBETA_i * \ln(STOCK)_{it})$$

where:

$(PRECON_{it})$ = estimated commercial light industrial-government electricity consumption in load center i and year t

BETA,BBETA = estimated coefficients

$STOCK_{it}$ = commercial building stock

ln = logarithmic operator

$\bar{R}^2$ = multiple correlation coefficient, corrected for degrees of freedom

D.W.= Durbin-Watson statistic

F = Snedecor "F" statistic

TABLE B.5.5. Business Electricity Consumption Equation Historical Test (GWh)

	Anchorage-Cook Inlet			Fairbanks-Tanana Valley		
	Actual	Forecast	Percent Error of Forecast	Actual	Forecast	Percent Error of Forecast
1973	483	463	-4.1	151	159	5.3
1974	519	523	0.8	162	170	4.9
1975	596	616	3.4	211	186	-11.8
1976	697	702	0.7	219	215	-1.8
1977	762	766	0.5	240	230	-4.2
1978	801	811	1.2	243	244	0.4
1979	790	843	6.7	241	248	2.9
1980	903	875	-3.1	234	251	7.3
1981	900	896	-0.4	258	253	-1.9
1982	1012	960	-5.1	--	--	--
Mean Absolute Percent Error			2.9			4.5
Root Mean Square Error			3.3			5.6

equation for 1980 consumption. The required values for the intercepts were -2.2118 in Anchorage-Cook Inlet and 0.7980 in Fairbanks-Tanana Valley. Table B.5.6 shows the forecasted values of electrical use per square foot for the July 1983 reference case.

TABLE B.5.6. Forecasted Business Sector Electrical Use Per Square Foot, July 1983 Reference Case (kWh/square foot)

	Anchorage-Cook Inlet		Fairbanks-Tanana Valley	
	Before Price Effects	With Price Effects	Before Price Effects	With Price Effects
1980	20.19	20.19	22.20	22.20
1985	22.04	20.20	22.21	22.05
1990	23.06	19.82	22.21	22.24
1995	23.68	19.50	22.21	22.35
2000	24.14	19.22	22.21	22.35
2005	24.73	19.27	22.21	22.32
2010	25.44	19.59	22.21	22.30

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