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DETAILED WORK PLAN

Electricity Requirements for the Railbelt

A Study for the House Special Committee
And the Alaska Power Authority

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(comments welcome)

Task A. Methodological Review and Data Collection

Subtasks

1. Review existing models of Alaska economy for applicability to projecting relevant economic variables for electric power demand analysis.

   a. MAP econometric model
   b. State of Alaska, Department of Commerce and Economic Development, Econometric Forecasting Model
   c. State of Alaska, Department of Labor, Econometric Forecasting Model

2. Review alternative potential economic projecting techniques.

   a. Extrapolation
   b. Input-output model
   c. Economic base model
   d. Harris regional model
   e. Delphi technique

*3. Choose a projection technique and document both its strengths and weaknesses as well as those of economic projections in general.

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*Indicates a written product

4. Review methods for projecting the level of electricity consumption within a region.

   a. Extrapolation
   b. Econometric analysis
   c. End-use analysis

5. Review the existing studies of electric power requirements for the railbelt and other parts of Alaska.

   a. Institute of Social and Economic Research, Electric Power in Alaska 1976-1995
   b. Alaska Power Administration, Alaska Power Survey, 1976
   c. ________. Upper Susitna River Project Power Market Analyses, 1979.
   d. ________. Devils Canyon Status Report, 1974
   e. Southcentral Alaska Water Resources Study, Electric Power Needs Assessment, 1979
   f. Battelle Pacific Northwest Laboratories, Alaskan Electric Power 1978
   g. U.S. Corps of Engineers, Susitna River Basin Feasibility Study, 1976

*6. Choose a load growth projection technique and document its strengths and weaknesses.

7. Collect annual electricity consumption data by user type from Alaska Public Utilities Commission and Federal Energy Regulatory Commission filings for the following utilities:

   a. Chugach Electric Association
   b. Anchorage Municipal Light and Power
   c. Golden Valley Electric Association
   d. Fairbanks Municipal Utility System
   e. Cordova Public Utilities
   f. Copper Valley Electric Association
   g. Homer Electric Association
   h. Matanuska Electric Association
   i. Seward Electric System

   This will include total consumption, number of customers, average price, large consumers, and usage by all-electric homes.

8. Collect electricity consumption data from the military for railbelt facilities. This will include:

   a. Elmendorf Air Force Base
   b. Fort Richardson Army Base
   c. Eilson Air Force Base
   d. Fort Wainwright
   e. Clear Air Force Base
   g. Greely Air Force Base

9. Collect electricity consumption data from existing industrial consumers of electricity who presently generate their own power and energy consumption data from industrial consumers of energy who could potentially switch to electricity consumption should conditions warrant such a change. These users would include:

   a. Refineries
   b. Pipelines
   c. LNG plants
   d. Ammonia-Urea producers
   e. University of Alaska
   f. Others as identified during the course of the study

w/k by us under what conditions, price, would they switch?

10. Collect data from various sources on the number of households in the railbelt, type of space heating and other major appliances in use, age distribution of the housing stock, other quality characteristics, and space heating requirements. Data sources will include:

   a. 1960-1970 Census
   b. 1975 Anchorage Housing Survey
   c. Real estate industry sources
   d. National Association of Homebuilders
   e. Anchorage Borough
   f. Matanuska-Susitna Borough
   g. Fairbanks Borough
   h. Kenai Borough
   i. Anchorage Natural Gas Utility
   j. Electric Utilities
   k. University of Alaska Cooperative Extension Service
   l. End-use studies conducted in other states and regions
   m. Other sources which are identified during the course of the study

11. Collect economic data necessary to update economic component of MAP econometric model through 1978. Sources of this data are Alaska Department of Labor and Bureau of Economic Analysis of U.S. Department of Commerce.

12. Collect time series data on relevant economic, social, and other variables necessary for econometric analysis of demand for electricity in railbelt. In addition to data collected under sub-task A.1., this would include:

   a. Heating-degree days
   b. Price of alternative fuels--gas, fuel oil
   c. Personal income
   d. Population
   e. Employment

*13. Write a report indicating the sources of all data collected as well as the possible uses and limitations of that data.

Task B. Economic Model Specification

Subtasks

1. Add 1978 economic data to the MAP statewide econometric model data base within TROLL.

2. Calculate 1978 values for gross state product by industry for incorporation within the model.

3. Investigate the potential for updating the income tax sector of the state revenue component of the model.

4. Reestimate wage rate, gross product, and employment by industry equations as well as price and personal income equations with new data.

5. Test the validity of the updated version of the model through statistical analysis of the individual equations and the behavior of the simulations.

6. Make changes in model specification necessitated by structural change in the Alaskan economy.

7. Calibrate the model with updated startup values and exogenous variables.

8. Extend the exogenous data series to the year 2005.

9. Evaluate the validity of the economic projections on the basis of analysis of the most important and critical variables and relationships within the model. These include:

   a. The ratio of residentiary employment to basic sector employment
   b. Migration response to economic activity in the state and nation
   c. Labor force participation rate and unemployment rate
   d. Growth of and size distribution of real wages
   e. Relationship between government expenditures and employment
   f. Relationship between private sector economic activity and government spending

*10. Prepare a report documenting the changes made to update the state model and the results of the analysis of the plausibility of model output, including sensitivity to model structure and assumptions.

11. Test the validity of the MAP regional econometric model in allocating the level of statewide economic activity to the existing regions utilized within the MAP regional model. This will be done on the basis of ex-post simulation of the recent past.

12. Adjust the population allocation mechanism or other equations as necessary in the regional economic model to produce satisfactory tracking results for the recent past.

13. Develop a procedure for allocating the economic activity within the Southcentral Region of the state as defined in the MAP econometric model to the following subregions:

    a. Greater Anchorage market
    b. Greater Fairbanks market
    c. Valdez-Glennallen
    d. Non-railbelt

        1) Kodiak
        2) Seward?
        3) Other small communities not linked to public electric utilities

    This procedure will be based upon a historical analysis of the relative growth rates of employment in these subregions.

14. Validate this technique where possible by independent analysis of the growth patterns and prospects of these subregions.

*15. Prepare a report documenting the theory underlying the allocation method chosen as well as a description of that method itself.

Task C. Economic Projections

Subtasks

1. Review the input scenarios developed for previous projects utilizing the MAP econometric model, in particular the Southcentral Water Study.

2. Update the input scenarios for the basic sectors and develop three scenarios which can be described as follows:

   a. A low case which is, in the judgment of the authors, the least likely possible level of future exogenous economic activity in the state

   b. A high case which is, in the judgment of the authors, the highest likely possible level of future economic activity in the state

   c. A likely case which, in the judgment of the authors, is the most likely level of future economic activity.

3. Develop updated projections of petroleum revenues and state and local government expenditure patterns in response to both population growth and revenue availability. Examine three cases of state government growth.

   a. Growth at an exogenous rate
   b. Growth related to population increase
   c. Growth related to availability of revenues

4. Use the input scenarios to generate projections of Alaskan economic activity using the MAP model.

5. Test the relative sensitivity of the economic projections to variation in both individual components of the basic sector input scenarios and the government spending scenarios.

6. Hold a workshop at which the projections as well as the input scenario assumptions for the basic sectors and the government sector are presented to the Project Director and to invited experts.

7. Revise the input scenarios on the basis of comments received at the workshop.

8. Using the MAP model, generate economic projections for the statewide economy on an annual basis through the year 2005. Also generate projections for the three railbelt areas indicated under Task B.12. Nine projections will be obtained combining the assumptions of C.2. and C.3.

*9. Document the input scenarios and the economic projections as well as the sensitivity of projections to variation of input scenario assumptions.

Task D. Assessment of Interfuel Substitution Possibilities

Subtasks

1. Review the literature on econometric studies of electricity demand (load).

2. Assess the value of such studies and appropriateness of such a technique in the estimation of electricity load for the railbelt.

3. Utilizing an econometric procedure, analyze the price and income elasticity of residential electric power requirements in the railbelt area. This must utilize a time series analysis because of the lack of data to do a cross-section analysis. The Institute previously attempted a cross-section econometric analysis with limited success. This is documented in "Future Electricity Requirements in Alaska," by Scott Goldsmith. Based upon that analysis, the most important variables will likely be electricity price, natural gas price, income, and heating-degree days.

*4. Report and interpret the results of this analysis.

5. Develop "econometric-end-use" model to be used in forecasting residential and commercial railbelt electricity load requirements (see attached article by Robert W. Shaw). The essential feature of the model is the end-use detail which is explicitly incorporated within the analysis. This approach offers the advantage of being able to evaluate the effects of a large variety of factors in addition to price on electricity requirements. Policy-regulatory factors and technical factors causing demand to change can be considered. The problem with such a model lies in the amount of data necessary to implement the model.

   The idea behind such a model is that electricity use is a derived demand--derived from the demand for end uses which electricity as well as alternative fuels or conservation can meet. To determine electricity requirements, one must calculate the number of electricity-using appliances and the amount of electricity consumed in each. The most important factors in this analysis include:

a. Population
b. Income
c. Initial capital stock
d. Age of capital stock
e. Price of electricity and alternate fuels
f. Relative efficiency of new additions to capital stock
g. Utilization rate of capital stock
h. Economic structure
i. Regulations restricting the free choice of alternatives

The basic model structure is presented diagrammatically as Figure 1.

6. For each of the three areas of the railbelt indicated in Task B, develop a base line inventory of existing end-use patterns in the residential, military, and commercial markets.

   a. Number of housing units, distribution by type, distribution by age
   b. Square feet of floor space and insulation properties by type and age and trends over time
   c. Average household size and trends over time in this parameter
   d. Electricity residential hookups relative to households and trends
   e. Vacancy rate of housing stock
   f. Depletion rate of housing stock
   g. Average and incremental percentage of consumers by housing type utilizing electricity, gas, oil, wood, coal, and propane for space heating
   h. Saturation levels and percentages supplied by electricity for modern cooking, refrigeration, clothes drying, water heating, and other appliances
   i. Electricity consumption per unit in as much detail as possible
   j. Number of commercial units (nonresidential apartments, etc.)
   k. Square feet of floor space and insulation properties of buildings as well as trends over time
   l. Historical relationship between income, households, population, and commercial space
   m. Commercial vacancy rates and depletion rate
   n. Electricity use for space heating
   o. Electricity use for other activities

7. Develop parameters for estimating the saturation levels and rates of growth to those levels of:

   a. Electricity hookups
   b. Modern space heating
   c. Modern cooking facilities
   d. Modern refrigeration facilities
   e. Modern clothes drying facilities
   f. Small electric appliances

Figure 1. Electricity End-Use Model

$$
\begin{aligned}
&\text{RESIDENTIAL ELECTRICITY REQUIREMENES AT TIME } T \text{ (KWH)} = \\
&\sum_i \Bigg(\text{INITIAL HOUSING UNITS TYPE } i * \left(1 - \text{RATE OF SCRAPPING } i\right)^T * \sum_j \Bigg\{ \left(\text{\% OF INITIAL UNITS } i \text{ WITH ELECTRIC APPLIANCE } j\right) * \\
&\quad \left(\text{AVERAGE ELECTRICITY CONSUMPTION IN APPLIANCE } j \text{ IN UNITS IN INITIAL HOUSING TYPE } i \text{ (KWH)}\right) * \left(1 - \text{CONVERSION RATE TO NON-ELECTRIC APPLIANCE } j\right)^T + \\
&\quad \left(\text{SATURATION FUNCTION FOR APPLIANCE TYPE } j\right) * \left(\text{\% OF INCREMENTAL APPLIANCED OF TYPE } j \text{ FUELED BY ELECTRICITY}\right) * \\
&\quad \left(\text{AVERAGE ELECTRICITY CONSUMPTION IN INCREMENTAL APPLIANCE } j \text{ IN INITIAL HOUSING UNITS TYPE } i\right) \Bigg\} \Bigg) \\
&+ \Bigg\{ \left[\left(\text{POPULATION AT TIME } T\right) \Big/ \left(\text{AVERAGE SIZE OF HOUSEHOLD AT TIME } T\right) \right] - \left[\left(\text{INITIAL HOUSING UNITS}\right) * \left(1 - \text{RATE OF SCRAPPING}\right)^T \right] \Bigg\} * \\
&\sum_i \Bigg[\left(\text{\% OF NEW HOUSING UNITS OF TYPE } i\right) * \sum_j \Bigg(\left(\text{\% OF NEW UNITS WITH ELECTRIC APPLIANCE } j\right) * \left(\text{AVERAGE ELECTRICITY CONSUMPTION IN APPLIANCE } j \text{ IN NEW UNITS } i\right) * \\
&\quad \left(\text{SATURATION FUNCTION FOR APPLIANCE TYPE } j \text{ IN NEW HOUSING UNIT S}\right)
\end{aligned}
$$

i = SINGLE FAMILY, DUPLEX, APARTMENT, TRAILER

j = space heat, water heat, refrigeration, cooking, clothes drying, other

$$
\text{COMMERCIAL ELECTRICITY REQUIREMENTS AT TIME } T \text{ (KWH)} =
$$

SAME FORMAT WITH AVERAGE BUILDNG SIZE IN SQ FEET AN ADDITIONAL VARIABLE

8. Develop parameters for estimating the depletion rate of the housing and commercial building stock.

9. Develop parameters for estimating the scrapping rate for major appliances in the residential and commercial sectors.

10. Develop parameters for estimating the percentage of specific end uses which will be supplied by electricity as a function of price of electricity and other fuels. Different parameters will apply to the present stock of appliances and to the new stock.

*11. Write a report summarizing the base line study, describing the model, and indicating the sources for all parameter and variable estimates.

Task E. Electricity Use Projections

Subtasks

1. Inventory the present level of industrial and other non-residential or commercial (such as government) electricity consumption in the railbelt, both purchased and self-generated.

2. Develop assumptions for the growth in electricity consumption of these consumers.

3. Inventory present industrial and other residents presently consuming energy not in the form of electricity. Estimate the potential electricity load requirements of each.

4. Identify major commercial and industrial uses of electricity which may be technically feasible within the projection period and estimate the load requirements of each.

5. Develop a set of energy price scenarios which will be used in the determination of appliance saturation levels, relative percentages of different fuel-using appliances, and growth in energy use in the industrial sector.

*6. Write a short report describing these price scenarios.

7. Using the MAP econometric model and the end-use model developed under Task D, estimate electric power requirements for the residential and commercial components of the railbelt electricity market by five-year increments to 2005. Individual projections will be based upon the following sets of end-use assumptions:

   a. Increasing saturation in appliance use, existing intensity of appliance utilization, and moderate increases in the prices of coal and natural gas relative to oil (approaching BTU parity). This implies an increase for Anchorage in the relative price of natural gas space heating. For Fairbanks, the outcome is less clear because of the alternative electric power generating modes possible for the community.

   b. Conservation in intensity of use in new installation based upon presently available technology, increasing saturation in appliance use, and same relative price assumptions as in (a).

   c. High electricity-use case where electricity substitutes for other fuels where possible over time.

   d. Low electricity use where alternatives substitute for electricity where possible.

8. Analyze the problem of attempting this type of price-sensitive end-use analysis over long time horizons when changes in relative prices of fuels may occur several times during the period and thus influence the appliance stock in ways different than if the time period had a fixed set of relative prices.

9. To these projections, add military and industrial load requirements, divided into probable purchased and produced components to obtain total load requirements.

10. Using the end-use model, analyze additional special cases as indicated by other components of the study.

11. Separately estimate on the basis of a simplified version of the end-use model the requirements of electricity consumers not connected to the present or projective grid.

*12. Prepare a report describing the analysis carried out under this task and the results.

Task F. Assess Projection Probabilities

Subtasks

1. Identify the range of electric power requirements forecasts based upon the previous analysis.

2. Develop a subjective probability distribution for the forecasts.

3. Identify those specific assumptions regarding economic growth and electricity use growth which are most sensitive to the load growth forecast.

4. Choose a forecast which appears the most probable.

*5. Prepare a report describing this sensitivity analysis.

Task G. Prepare Final Report

Subtasks

1. Present study results to legislative committee as directed by the Project Director.

*2. Write summary report in nontechnical language presenting principal findings and conclusions of study.

New Factors in Utility Load Forecasting

By ROBERT W. SHAW, JR.

LOAD forecasting is the cornerstone of all utility planning. To provide useful input to facility and financial planning, utility load forecasters must be able to project electric energy sales and peak loads fifteen or twenty years into the future. Yet load forecasting has become an increasingly difficult challenge as social, economic, demographic, and political forces converge to form an ever-changing pattern of complexity. The relatively primitive trend line forecasting methods of past decades — which were adequate in their time —are today being replaced with more sophisticated approaches needed to cope with the "new factors" which the forecaster must address.

Two general load forecasting approaches are currently in widespread use in the utility industry: (1) econometric models, and (2) end-use (or engineering) models. Econometric models rely on historical data and statistical techniques to forecast future use of electric energy — in the aggregate for a service area or by customer class — as a function of the price of electricity, the price of alternate energy sources, population, personal income, and other economic-demographic variables. These models are based on the assumption that customer response to changes in these variables will be the same in the future as it was in the past. They cannot deal explicitly with factors such as technological change or regulatory initiatives other than those affecting prices.

The author suggests that the deficiencies in two existing general approaches to utility load forecasting — econometric models and end-use engineering models — may be corrected through a combination of the best features of both. The utility load forecaster would, as one result, be given greater flexibility in assessing the many factors with which he is confronted. This article identifies many of those factors — which constitute a changing forecast environment — and provides a schematic description of the kind of econometric end-use forecasing approach proposed by the author.

End-use models build a forecast on detailed information regarding the way electric energy is used in each consuming sector of the utility's service area. Although these models frequently suffer from a severe lack of data, they do provide a way to deal with the multitude of factors which can cause end-use patterns to change. These models have a serious drawback, however, in that they usually do not explicitly consider the effect of price on the consumption of electricity. This is not an essential flaw in the model structure, but merely an indication that forecasters have not yet pushed the modeling art far enough.

Robert W. Shaw, Jr., is a vice president of Booz, Allen & Hamilton Inc., where he manages the firm's technical and planning practice for electric utilities. He has directed projects on load forecasting, corporate planning, and technology assessment. **Dr. Shaw** received his PhD degree in applied physics from Stanford University, a Master's degree in electrical engineering, and a Bachelor's degree in engineering physics from Cornell University. He is serving as executive director of the Electric Power Research Institute's utility modeling forum.

Econometric End-use Forecasting Models

To correct the deficiencies in both general approaches and give the utility forecaster greater flexibility in addressing the new factors he must consider, a forecasting approach which combines the most important features of both econometric and end-use models has been suggested. The basic elements of the method are shown in Figure 1 (this page). In simplified terms, the forecast of electric energy consumed during a particular year is the product of the number of utility customers (disaggregated into categories such as residential, commercial, industrial, etc.), the number of electricity-consuming devices that each customer has connected to the grid, and the amount of electricity consumed by each device during the year. Econometric relations are developed to describe the projected change in these three basic components as a function of price and other economic and demographic variables. This type of "econometric end-use models" has recently been used by several utilities to improve their forecasting capability.

The econometric end-use model is simple to describe in concept but much more difficult to execute in practice, because it requires an extensive data base defining the structure of end-use patterns in detail. Very few utilities have such a data base at their disposal. The first and most challenging task in the forecasting effort is to assemble and refine the necessary data over a period of years.

Once the end-use data have been assembled, price and income effects are built into the model — as indicated schematically in Figure 2 (page 21). The econometric methods used in the analysis are essentially identical to those used in market-penetration models. The models describe how the number of different devices used by customers in each sector depends on: price of electricity, prices of alternative fuels that could operate comparable devices, marketplace price of the devices, income (personal or corporate), and characteristics of the sector; i.e., for the residential sector, number of persons per household.

The final step is to develop models such as those illustrated in Figure 3 (page 22) which link the amount of energy consumed by typical devices with:

- The price of the electricity used to run them
- The income of the user
- The efficiency of the device
- The characteristics of present or planned load management programs
- Other socioeconomic and technical variables.

This schematic and highly simplified description of the econometric end-use forecasting approach masks the complexity of the models involved and gives little indication of the extraordinary level of effort required to assemble the necessary data base. To overcome these problems in the early stages of forecast development, the level of disaggregation used in the models can be tailored to fit the data base available. In later years, as the data base expands, the level of disaggregation can be increased.

FIGURE 1

AN ECONOMETRIC END-USE MODEL COMBINES THE BEST FEATURES OF BOTH

The Changing Forecast Environment

The econometric end-use approach to utility load forecasting has the capability to deal with the changing social and economic environment which influences load growth. The "new factors" which characterize this uncertain environment were of little importance in the past, but they must now be taken into account if forecasts of electric energy consumption and peak demand are to be useful in utility decision making. These new factors fall into three generic groups: policy-regulatory factors, technical factors, and economic-demographic factors.

Policy-regulatory factors include fuel price and use controls, efficiency standards, mandatory conservation regulations, load management programs, incentives to adoption of alternative technologies, and changes in rate structure. Changes in policies and regulations can occur at almost any time, taking the forecaster by surprise, and sometimes causing an immediate impact on load growth.

Technical factors, on the other hand, are easier to deal with because changes in technology typically do not penetrate the market very rapidly. Technical factors important to load forecasting include: new end-use devices, improved efficiency of traditional devices, dispersed energy supply technologies (such as solar heating or cogeneration), and new systems for load control and management.

Sometimes these first two categories overlap. For instance, technical advances in solar heating may occur over time, but the use of solar heating may be accelerated by economic incentive mechanisms and government-supported research and development. A similar relationship exists with technical achievements in appliance efficiency, and government-imposed efficiency standards.

Economic-demographic factors also are important to accurate load forecasting. Like technical and policy developments, regional economic and demographic characteristics are changing more rapidly than they did in the past. These factors can best be addressed by constructing a regional economic-demographic model of a utility's service territory, accounting for population shifts, employment, personal and corporate income, etc. Such models are difficult to create and specify, but they have been built and they work reasonably well.

New Factors Affecting Residential Load Growth

For the remainder of this discussion, we shall assume that a state of the art regional model exists and produces acceptable forecasts of population, employment, and so on in the utility's service area. Our major concern will be to examine specific new factors in the areas of policy regulation and technology as they impact the residential, commercial, and industrial components of a utility's load and energy sales.

There are many new factors which could affect residential load growth over the rest of this century, including improvements in the efficiency of buildings and appliances, greater use of solar heating systems, load management programs, and new energy-consuming devices.

Building Shell Efficiency Improvements. The recently legislated National Energy Act (NEA) requires utilities to help home owners install improved attic and wall insulation, caulking, weather stripping, etc., to decrease heat loss from their homes. Technically it is feasible to make the typical residential building far more efficient than it currently is — reductions in energy use by factors of two or three are possible. The economics of various levels of improvements are the subject of much debate. The results depend strongly on regional differences and on assumptions regarding fuel price increases. It is generally accepted that a modest investment in ceiling insulation, for example, can lead to a significant energy savings (up to 25 per cent of the heating load) and pay off in a year or two.

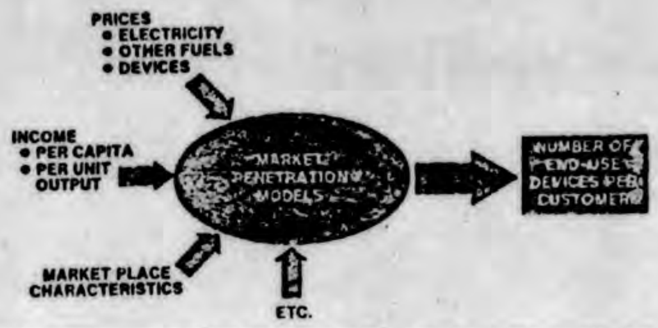
These NEA provisions could lead to a substantial near-term reduction in utilities' electric heating loads — though perhaps less than has been suggested because electric homes are typically quite efficient already. To account for this effect in its forecast, the utility would have to monitor the number of retrofit installations in its service area, conduct measurements to determine the average reduction in energy use per building, and project the eventual saturation level of retrofit installations. It also would be desirable to obtain data on the energy efficiency of new homes in the service area.

Appliance Efficiency. Appliances are a major component of residential electric load. The NEA mandates improvements in the efficiency of major appliances, but the standards will not become effective for several years. To account for these future appliance efficiency improvements, the utility forecaster must differentiate between old and new appliances after the early 1980's, and develop new data on electric consumption levels for the new appliances which enter the market.

Although the use of more efficient appliances will tend to decrease energy consumption, net energy use will increase if people continue to buy more and more electricity-consuming devices. The introduction of

FIGURE 2

MARKET MODELS CAN BE USED TO PROJECT HOW MANY END-USE DEVICES THERE WILL BE



entirely new devices — such as electric vehicles — could also result in sharp growth of electric energy sales. The consequences of an increasingly electrified economy must be accounted for in the load forecast, as new electricity-consuming devices enter the marketplace over the next few decades.

Solar Heating Systems. Another factor of concern to utility forecasters is the market penetration of solar heating systems. Although solar heating currently is not economical in most parts of the country, it is possible that the NEA's solar incentives coupled with rising fuel prices could cause significant market penetration of solar heating systems within the next decade. In many cases the backup for solar heating systems will be electric. As a result, it is conceivable that increased use of solar systems could reduce electric energy consumption on an annual basis, but exacerbate the peak-load problems.

To account for increased use of solar heating systems, the forecaster must use market models to predict how rapidly solar technology will penetrate the service area, as a function of various price and policy factors. Measurements must be made to determine the annual electric energy consumption — and the impact at peak — of solar systems with electric backup. A similar approach can be used to account for the possible introduction of passive solar designs in new homes.

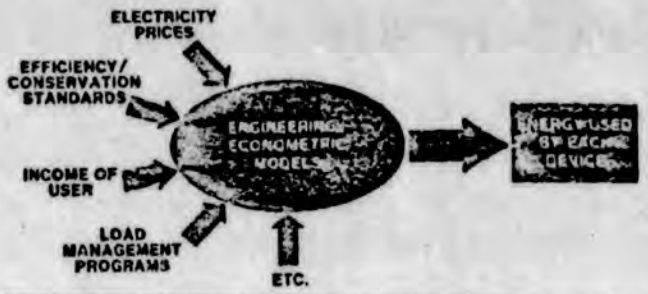
Load Management. While increased use of solar heating systems may be detrimental to utilities' load factors, improved load management programs will likely offset these effects and benefit the entire utility industry. A variety of schemes has been recommended to help flatten the load duration curve, ranging from ripple controls on water heaters to time-of-day rates. Many of these schemes are being tested now, and there is already evidence that poorly designed load management programs can have adverse effects on load shape. For example, time-of-day rates can lead to a new and even higher peak in the hour after the peak rate ends, if there is no "shoulder" rate.

Dealing with load management options in the forecast is extremely difficult, because little data are available to help predict how customers will respond to load management efforts. It is important, therefore, for utilities to gather and disseminate data from the experiments which are now being conducted. These data will help predict the average usage rate per controlled appliances; the impact of storage, feedback meters, etc., on usage levels; and response of customers to various rate structures.

In principle, the econometric end-use forecasting model has the flexibility to deal with both rate changes and engineering-oriented load management options. The problem is lack of data; but this problem should be resolved as the results of ongoing experiments are disseminated, and new experiments are initiated. The importance of load management cannot be overstated. Improved load management means more efficient use of the industry's capital stock — its generating plants and transmission lines — and that is good business.

FIGURE 3

ENGINEERING/ECONOMETRIC MODELS CAN BE DEVELOPED TO PROJECT CHANGES IN CONSUMPTION OF VARIOUS DEVICES



New Factors Affecting Commercial Load Growth

The nonmanufacturing or commercial sector often represents the fastest-growing component of load in a utility's service area. Yet it is the most difficult component to deal with in forecasting, because it includes a broad spectrum of customers — ranging from restaurants, to shopping centers, to high-rise office buildings — using energy in a variety of ways.

The new factors which could have a major impact on commercial sector load growth include building efficiency standards, dispersed energy sources, and improved equipment efficiency.

Building Efficiency. Among the conservation-related provisions of the National Energy Act are standards to improve the energy efficiency of commercial buildings. These standards, which are not expected to be in place until the mid-1980's, will not have an immediate effect because the building stock turns over slowly. In the long run, however, the impact of these standards on load growth may be substantial, reducing the energy consumption of new office buildings by a factor of two or more. Even now, many states are in the process of adopting the voluntary ASHRAE 90-75 standard, and advanced building-design concepts are being developed with the aim of attaining even greater reductions in the energy consumption of new buildings.

Dispersed Energy Sources. Not only are commercial buildings the prime targets of new energy-efficiency standards, they are also attractive candidates for pioneering the use of dispersed energy sources, including solar heating and cooling, total energy systems, and fuel cells. These innovations may penetrate the market rapidly, particularly if the commercial sector becomes subject to interruptible service as part of state or federal load management policies. There are two crucial issues which the forecaster must address in dealing with these new sources:

- The penetration rate of each type of device on a standard industrial code specific basis
- The impact of each device on the utility's load, particularly at the peak.

To account for the possible introduction of dispersed energy sources, the utility load forecaster must construct market models to estimate penetration rates, based on historical experience with similar new technologies (such as central air conditioning). Load profiles for the new devices will have to be established through field measurements of early users.

Equipment Efficiency. A third factor important in forecasting commercial sector load is the improved efficiency of lighting, office machines, compressors, pumps, commercial ranges and ovens, and other equipment. The approach used in dealing with these efficiency improvements is similar to forecasting the impact of appliance efficiency improvements in the residential sector, but is complicated by the heterogeneity of commercial sector users.

The commercial sector will also be influenced — perhaps more strongly than the residential sector — by changes in the way electricity is priced, and by the prices of competing energy sources. Econometric models which incorporate price explicitly into the penetration and consumption models — for both current and future end uses — are of particular importance in the commercial sector. The same point holds true for the industrial sector.

New Factors Affecting Industrial Load Growth

Projecting load growth in the industrial sector is complicated by three factors. When a new industrial facility locates in the service territory, or leaves it, the load can change by a large increment at one time. Also of importance is the fact that industrial energy use is strongly dependent on the health of the national economy — it was the industrial load that dropped most sharply in the recession that followed the 1973 oil embargo. A third factor is that fuel shifting and process changes, initiated for economic or regulatory reasons, can create large new loads in a short time period.

In order to understand better their industrial load, most utilities are moving toward highly disaggregated industry (or plant) specific forecasting techniques. These techniques address end uses at the process level, and account for industrial output in the service territory as a function of national as well as regional economic indicators. Once these models are in place, it is a relatively straightforward task to deal with new factors such as energy conservation standards, process efficiency improvements, regulations constraining the use of oil and gas, and alternative energy sources.

Energy Conservation Standards. Although the federal government has promulgated a set of energy-efficiency targets for the ten most energy-intensive industries, compliance is still voluntary, and may remain so. Industry's primary concern is not the cost of energy, but the certainty of supply — the efficiency of end use is of secondary importance. Thus in order to pursue conservation targets, industries may switch to electricity-based processes, shifting the burden of inefficient fossil fuel conversion to the utility.

Process Efficiency. Improvements in process efficiency, although part of the overall conservation effort, warrant special attention because they are the focus for substantial research and development effort on the part of both industry and the federal government. Dealing with process efficiency improvements is not much different, in principle, than examining the efficiency of specific appliances in the residential sector. Because there is so much room for process efficiency improvements in most industries, it behooves the utility forecaster to disaggregate his models to the point where these improvements can be captured when there is evidence that they are occurring.

Coal Conversion. A highly disaggregate model is also desirable in order to capture the influences of new NEA-mandated regulations providing for industrial use of coal instead of oil or gas. In many cases, industrial users may choose to convert to electric energy rather than cope with the problems inherent with coal use, including environmental effects and supply uncertainties. As with process efficiency improvements, a highly disaggregated end-use model is essential if these effects are to be addressed correctly in the forecast.

Alternative Sources. The NEA also provides incentives for industrial use of cogeneration, as well as for the use of solar energy, geothermal resources, and other advanced technologies. Increased use of such technologies could reduce electric energy sales to the industrial sector significantly. Again, detailed end-use models — reflecting specifically the potential for use of alternative sources in industrial process applications —will be necessary to account for switchovers in the load forecast.

Limitations of Models

This discussion has stressed the use of analytical models to address the new factors affecting electric load growth. It is important, however, to remember that models are only a tool. They are intrinsically:

- Nothing more than a systematic way to structure the available data and information about a situation. They can in no way transcend the data used to create them, although they may occasionally help the forecaster to discover relationships which were not intuitively evident.
- Limited by the "boundaries of the modeler's understanding"* of what is happening in the world around him. If he does not know, for example, how customers will respond to changes in regulation or technology based on past experience, then models cannot help the forecaster out of the bind imposed by his ignorance.

The art and science of load forecasting will have taken a major step forward when it progresses to the point where accounting — in an explicit way — for the types of factors discussed here is truly feasible. But the challenge of trying to foresee what new factors —beyond those we already envision — will emerge in the years ahead is even more forbidding. Unfortunately, anticipating basic changes in the course of society is something that no utility forecaster will ever be able to do. The tool of sensitivity analysis, which can help him address the "what-if" questions, is perhaps the most effective way of assessing the potential impacts of events such as new regulations or potential technological breakthroughs on load growth.

Dealing with the new factors affecting load growth requires a commitment on the part of utility managers to the development of analytical tools and the data necessary to understand what is going on in the service territory, and to specify the forecasting models. It is legitimate to ask if the investment in data and models is worth the return. There is no simple answer to this question. The returns from improved forecasting come both in reduced levels of uncertainty and in a better understanding of the potential impacts which various futures could have on the utility. Only senior management can decide when an incremental improvement in its perspective on the future is outweighed by the marginal cost of achieving it.

*"Electric Load Forecasting: Probing the Issues with Models," EMF Report 3, Vol. 1, Energy Modeling Forum, Stanford University, Stanford, California, April, 1979, p. 7. EMF is sponsored by the Electric Power Research Institute.

Telecommunications Policy Conference: Call for Papers

The eighth annual Telecommunications Policy Research Conference (scheduled for spring, 1980) will provide a forum for analysis and discussion of important telecommunications policy issues. Participants will include researchers and policymakers from academia, government, and industry. Those engaged in research which has implications for telecommunications policy are invited to submit abstracts (500 words or less) by December 1, 1979. Authors of papers selected for presentation at the conference will be reimbursed for travel and conference living expenses if no alternative source of funding is available. Please send abstracts to: TPRC Organizing Committee, c/o Robert Dansby, American Telephone and Telegraph Company, 195 Broadway, Room 1942B, New York, N. Y. 10007.

ALASKA CENTER FOR POLICY STUDIES
204 E. 5TH AVE., SUITE #201, ANCHORAGE, AK 99501 (907) 272-6113

November 15, 1979

ALTERNATIVE ENERGY/CONSERVATION STUDY

for the

HOUSE POWER ALTERNATIVES STUDY COMMITTEE

Phase II: Workplan for
Reconnaisance Study of Conservation and Renewable
Resource Potentials

Part 1. End Use Structure.............Alaska Federation for Community Self-Reliance
- a. Residential
- b. Commercial
- c. Industrial
- d. Transportation

Part 2. Conservation Potential........Alaska Federation for Community Self-Reliance

Part 3. Alternative Energy Source Potential.....................Mark Fryer and Associates
- a. Geothermal
- b. Waste Heat
- c. Solid Waste
- d. Wind
- e. Wood
- f. Hydro
- g. Solar (active, passive, and photovoltaic).........Rich Seifert, Institute of Water Resources

Part 4. Implementation and Management Considerations................Alaska Public Interest Research Group
- a. State law
- b. State agencies
- c. Utilities
- d. Financing
- e. Local government
- f. Research & Demonstration
- g. Values and attitudes
- h. Marketing
- i. Employment

Legislative Recommendations, January 7, 1980

Final Report, April 1, 1980

Part 1 - END USE STRUCTURE - Responsibility: Alaska Federation for Community Self-Reliance.

The Federation will provide an analysis of the energy end use structure of the railbelt area. End use data for the north of the Alaska Range shall be gathered by the Federation, while data for the part south of the Range shall be gathered by ISER in cooperation with the Federation.

The Federation will estimate total regional energy consumption and break down this total according to the amounts of energy used in the various sectors. The sectors are:

residential
commercial
industrial
government
military
transportation

Within each sector are several subsectors. Depending on the data available, we will further break down the energy consumed in each sector to the appropriate subsector. We will identify sources of energy supply heat below 100 C and those which supply heat over 100 C.

The following sectors shall be investigated in the manner described:

Residential Sector - The Federation shall determine quantitative estimates for the energy end use structure broken into heat and electricity consumption. Subsectors such as space heat, water heat, lighting, etc, shall be and quantified as possible.

Information to be gathered will include: 1) number of housing units, broken down according to type 2) heating degree days, and 3) heating requirements for a standard house.

Commercial Sector - This sector includes retail stores, office buildings, hospitals, restaurants, and the like. The Federation shall determine quantitative estimates for the end use structure broken into heaat and electricity consumption with subsectors such as space heat, water heat, lighting, etc, identified as possible.

Government Sector - End use structure will be analyzed in terms of heat and electrical consumption with subsectors identified as possible.

Industrial Sector - This sector includes manufacturing, moning, agriculture and construction as well as petroleum refining and other processes. The Federation will break down the end use structure according to type of industry and fuel sources required.

Military Sector - For the purposes of this study, the military reservations will be regarded as a totally independent entity with its own source and end use structure. Subsector breakdown of end use shall be provided as possible with information available from the reservations.

Generally, energy requirements of the subsector will involve educated "guesstimates." The Federation may base these "guesstimates" on energy intensities per square foot or intensities per employee.

Transportation Sector - The Federation will quantify vehicle miles travelled for Alaska automobiles, trucks, boats, buses, barges, airplanes, and the Alaska Railroad. Comparisons of fuel efficiencies will be made.

Work Product: Final Draft Report - January 15, 1980
Final Report - February 1, 1980

Part 2 - CONSERVATION - Responsibility: Alaska Federation for Community Self-Reliance.

The Federation will identify ways in which to increase the energy productivity of the energy being applied to various tasks in the railbelt area. Concentration will be on "technical fixes."

The Federation shall:

- discuss energy use efficiency in terms of the Second Law of Thermodynamics.
- quantify current energy uses for performing certain tasks.
- identify opportunities to increase present efficiencies.
- estimate capital costs of implementing technical fixes to raise energy productivity (comparative economic advantages of different efficiency technologies will be estimated using methodology agreed upon and used commonly by all subcontractors).
- quantify the resultant increases in energy productivity.
- estimate the indirect benefits of conservation in terms of economic multipliers and the creation of new workplaces.

The Federation shall examine the conservation potential in each sector and provide quantitative estimates of potential savings. In the case of transportation, discussion of conservation will be limited to decisions that can be made in Alaska.

Work Product: Draft Report - February 15, 1980
Final Report - March 1, 1980

Part 3 - ALTERNATIVE ENERGY SOURCE POTENTIAL - Responsibility: Mark Fryer and Associates.

The work will analyze renewable energy resources along the railbelt:

1. Geothermal
2. Solar
3. Waste Heat
4. Solid Waste
5. Wind
6. Wood
7. Hydro

Three maps will be drafted, each containing renewable energy resource "opportunity" isolines (Solar, Wind, & Waste Heat). The isoline "opportunity index" for each resource map will contain:

* Cost of non-renewable resource currently in use
* Climate factors
* Availability of renewable resource at current costs

The level of independence upon the non-renewable resource will be determined for each of the options examined. This analysis will be developed on a unit model basis, through the construction of generic and use consumption machines:

* Residential model
* Institutional model
* Commercial model

Work Product:

A. Draft Reports, due January 1, 1980, on;

1. Small hydro, geothermal, tidal power, solid waste and waste heat
2. Solar study
3. Wood resources
4. Wind Power

B. Railbelt Map on Resource Potential, due March 1, 1980, for:

1. Wind

2. Solar

3. Waste heat

C. Final Intra-Project Report on Alternate Energy Sources Potential, due March 1, 1980

Part 4 - Implementation and Management - Responsibility: Alaska Public Interest Research Group (AkPIRG).

AkPIRG will address the management, regulatory, and legal issues presented by a program to encourage conservation and the use of alternative renewable energy resources, looking at the institutional and financial barriers to wider acceptance and use. Specifically:

1. State law. Alaska statutes and pending legislation will be analyzed to determine their effects on the acceptance of alternative energy sources and conservation efforts. In conducting this review, AkPIRG will examine the laws of other states and Canadian provinces/territories. Of particular concern will be:

a) building codes and standards
b) public facility procurement policy
c) solar access rights
d) waste heat recovery
e) electrical efficiency standards

2. State agencies. Examine the organization, management, funding, and mandates of state agencies with responsibility for conservation or alternative energy. Review:

a) level of coordination between agencies
b) short and long range goals
c) planning capabilities
d) staffing and funding levels
e) sensitivity to community needs

3. Utilities. Among other things, AkPIRG will consider:

a) existing utility involvement in conservation and alternative energy programs
b) implications of the National Energy Act
c) role of the APUC

4. Finance Mechanisms. The how and who of paying for energy programs, including:

a) private market
b) government loans and subsidies
   - -AHFC
   - -APA
   - -REA
   - -other agencies and approaches
c) tax incentives

5. Local government. Programs involving energy conservation and alternative energy may have to depend upon local governments to require better use of existing resources and to develop new ones. This may include building standards, zoning for cogeneration, or government-run winterization programs. We will look at communities of different sizes in different areas and climates of the railbelt.

6. Research and demonstration. Key to any Alaskan soft energy path will be R&D efforts to eliminate information gaps and demonstrate the viability of new approaches to heating and power generation. AkPIRG will:

a) describe state R&D programs
b) identify specific data problems
c) suggest priorities for additional research
d) identify needed pilot and demonstration projects

7. Values and attitudes. The perceptions of key energy players, including public officials, utility managers, financers, builders, and consumers, have an important part in determining the availability of conservation and alternative sources of energy. AkPIRG will interview and survey these groups to determine their perceptions of the barriers to an effective soft energy path program for Alaska.

8. Marketing. If attitudes or lack of information are a barrier to the acceptance of conservation and alternative energy, new or expanded marketing efforts may be important. We will look at the type of marketing problems these energy approaches encounter and discuss possible responses.

9. Employment impacts. AkPIRG will undertake a review of the employment benefits of an aggressive solar and conservation program, as compared to more centralized, capital-intensive energy production strategies.

Work Product: The AkPIRG work relating to current, proposed and needed legislative modifications shall be provided in two parts. The first shall be completed on or before January 7, 1979. This part of AkPIRG's work shall be completed on or before January 7, 1979. This part of AkPIRG's work will consist of explicit legislative recommendations that can be embodied in legislation to be introduced during the 1980 session of the legislature. The final version of AkPIRG's work will include these recommendations as well as findings concerning other legislative modifications deemed appropriate.

These elements of AkPIRG's work shall be provided to the Center for inclusion in the overall report on or before March 1, 1980 for the drafts, and by March 15, 1980, for the final versions.

Jamie Love

CSHB-364 Energy conservation policy

Utility law: utility payments for private home energy audits, insulation or home energy systems may be included in ratebase. Utilities may make loans from Alaska Energy Ex Conservation Bank. State pays 20 % of utility bill for residences meeting minimum energy efficiency standards & offers free audit and conservation loans to meet those standards. Utilities required to purchase excess electricity from on-site small power generators. Utility energy conservation information programs may be taken as tax credit to $25,000. XYRYMXRX

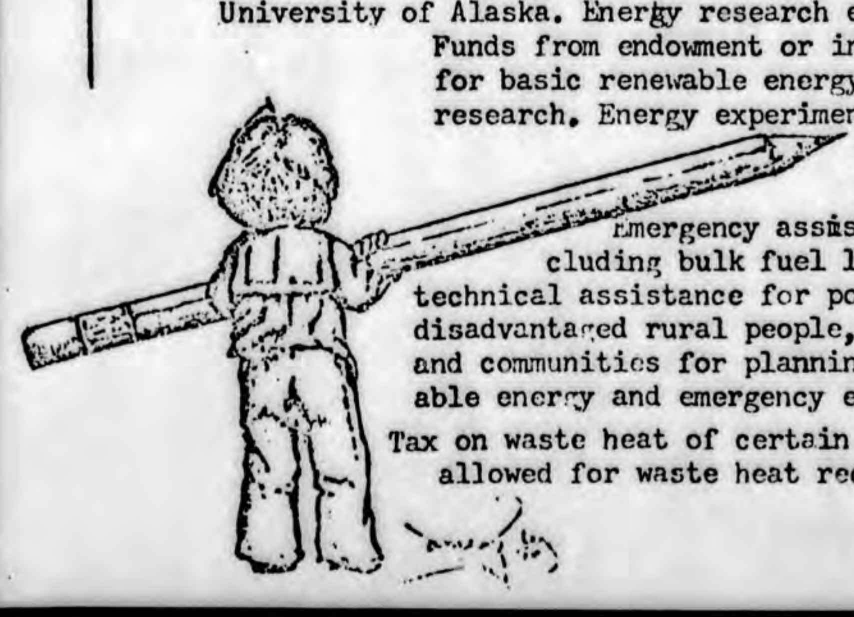
Financing Mechanisms. Alaska Energy Conservation Bank established. (Separate $100 million appropriation bill). Makes loans for energy conservation improvements to homes and businesses. 9½ per cent interest. Guarantees loans made by banks, credit unions, savings and loans, and utilities subject to APUC jurisdiction to 95% of loan. Self-insures for fire and theft losses. Alaska Housing fix Finance Corp and regional housing authorities allowed to directly or indirectly finance energy conservation in housing. Energy conservation improvements include insulation, vapor barriers, thermal mass, on-site renewable energy production, weatherstripping, solar greenhouses, waste heat conversion. State accepts energy conservation lien against property as collateral if energy audit shows payback possible within 10 years. Businesses may expense/accelerated depreciate e.c. improvements.

Research and Development. State purchase of equipment for renewable energy and energy conservation research, including anemometers, pyranometers, geothermal drilling equipment, heat transfer testing equipment. Build by competitive bidding in each of 20 largest cities 4 prototype conservation houses - xxxx bidders eligible for no more than one per city and 10 total. Establishment of Alaska Center for Innovation to offer r&d consultation for Alakka and Yukon residents.

Marketing. State pays transportation costs to and within Alaska for energy conservation and renewable energy technology to equalize costs. Public radio and television programs on energy funded - perhaps series. State funding of additional cooperative extension/energy extension publications. DEPD may make grants to local organizations for renewable energy/energy conservation workshops, conferences, public meetings and demonstrations.

Information and Education: Funds for purchase by local, school, regional, or community and college and University libraries of energy libraries. Funds for energy information translations into Native languages, curriculum development, traveling energy shows, appropriate to Alaska. University research funded to include dissemination of results.

University of Alaska. Energy research endowment established, funded at $25 million. Funds from endowment or income from endowment administered by A.C.S.T. for basic renewable energy resource, climatologic, energy conservation research. Energy experiment station, Arctic engineering experiment station established. Energy economist positions established at UAA and ISER. Compile catalog of local energy.



Emergency assistance: program of financial assistance including bulk fuel loans, free energy conservation materials and technical assistance for poor, employment and training of economically disadvantaged rural people, DOT/PF coordination with regional agencies and communities for planning and routing of energy conservation, renewable energy and emergency energy assistance.

Tax on waste heat of certain volume assessed on heat wasters. Tax credit allowed for waste heat recovery systems.

IWR 80-8

REVISED
RESEARCH PROPOSAL

TO

THE CENTER FOR POLICY STUDIES
ANCHORAGE, ALASKA

SOLAR ENERGY IN ALASKA'S RAILBELT
A BRIEF REVIEW OF ITS POTENTIAL

Richard D. Seifert
Institute of water Resources
University of Alaska
Fairbanks, Alaska

November 1979

The Problem:

The plan to build the Susitna Hydroelectric project has presented a series of political controversies to the state government. Because of the inevitable uncertainty surrounding the actual level of need for electrical energy in the future, it was decided that a study of the alternatives to hydroelectricity was in order. A specific component of those alternatives is solar energy. The possible (hypothetical) and probable levels of development of the solar component of energy use for Alaska's railbelt will be the focus of this study.

Results will be given for each type of solar energy in a "tally sheet" fashion according to its possible and probable application and contribution to railbelt energy requirements. Types of solar energy application to be analyzed and the end use they can best meet are listed below:

APPLICATION	END USE
1. Solar Energy in the Residential Sector	
a. Active space heating	Heat (< 100°C)
b. Active water heating	Hot Water (< 100°C)
C. Photovoltaic	Electricity
d. Passive space heating	Heat (< 100°C)
2. Solar Energy in the Commercial Sector	
a. Active space heating	Heat (< 100°C)
b. Active water heating	Hot Water (< 100°C)
c. Photovoltaic	Electricity
d. Passive solar heating	Heat (< 100°C)
e. Greenhouse agriculture	Food and Heat
3. Solar Energy in the Industrial Sector	
a. Heat applications	Heat, Hot water (< 100°C) Steam (> 100°C)
b. Photovoltaic	Electricity
4. Technically undeveloped or unproven concepts	(Varied)

It is important to recognize that solar energy best provides a synergistic source of energy when coupled with extensive and appropriate energy conservation measures. The two technologies used together are

FAIRBANKS AK 64.82

****THERMAL ANALYSIS****

TIME	PERCENT SOLAR	INCIDENT SOLAR (MMBTU)	HEATING LOAD (MMBTU)	WATER LOAD (MMBTU)	DEGREE DAYS (F-DAY)	AMBIENT TEMP (F)
JAN	0.	2.35	28.60	2.72	2383.	-11.2
FEB	9.9	8.35	22.68	2.46	1890.	-2.2
MAR	32.1	17.40	20.65	2.72	1721.	10.4
APR	49.7	18.70	13.00	2.63	1084.	28.4
MAY	70.7	17.98	6.59	2.72	549.	46.4
JUN	95.7	17.08	2.53	2.63	211.	59.0
JUL	96.6	16.12	1.77	2.72	148.	60.8
AUG	73.0	13.83	3.65	2.72	304.	55.4
SEP	45.9	12.19	7.41	2.63	617.	44.6
OCT	17.0	9.09	14.82	2.72	1235.	24.8
NOV	1.6	5.20	22.40	2.63	1867.	3.2
DEC	0.	0.11	28.04	2.72	2336.	-11.2
YR	22.7	138.40	172.13	32.02	14344.	

****ECONOMIC ANALYSIS****

OPTIMIZED COLLECTOR AREA = 390. FT2

INITIAL COST OF SOLAR SYSTEM = $ 12700.

THE ANNUAL MORTGAGE PAYMENT FOR 20 YEARS = $	1530.
YRS UNTIL UNDISC. FUEL SAVINGS = INVESTMENT	9.
YRS UNTIL UNDISC. SOLAR SAVINGS = MORTGAGE PRINCIPAL	13.
UNDISCOUNTED CUMULATIVE SOLAR SAVINGS = $	27652.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $	101045.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR = $	108571.
PRESENT WORTH OF CUMULATIVE SOLAR SAVINGS = $	7526.

Table 3: An analysis of solar energy compared to electricity used for space heating and domestic hot water for a case in Fairbanks, Alaska, (GVEA electricity @ 8¢/kwh). The solar system would provide 22.7% of the total annual heat loads.

YR	INTRST PAID	END OF YR PRINC	DEPRC DEDUCT	PROP TAX PAID	INC TAX SAVED	BACKUP FUEL COST	INSUR, MAINT COST	COST WITH SOLAR	SAVNGS WITH SOLAR	PW OF SOLARSAVNGS
0	0	4464	0	0	0	0	0	496	-496	-496
1	535	4402	0	99	222	391	49	915	-147	-136
2	528	4332	0	105	221	430	52	963	-118	-101
3	519	4254	0	111	220	473	55	1016	-87	-69
4	510	4167	0	118	220	520	59	1075	-52	-38
5	500	4070	0	125	218	572	62	1139	-14	-9
6	488	3961	0	132	217	629	66	1209	27	17
7	475	3838	0	140	215	692	70	1285	74	43
8	460	3701	0	149	213	761	74	1369	126	68
9	444	3548	0	158	210	838	79	1462	184	92
10	425	3376	0	167	207	922	83	1563	247	114
11	405	3184	0	177	204	1014	88	1674	317	136
12	382	2968	0	188	199	1115	94	1796	395	156
13	356	2727	0	199	194	1227	99	1929	480	176
14	327	2457	0	211	188	1349	105	2076	575	195
15	294	2154	0	224	181	1484	112	2237	679	214
16	258	1815	0	237	173	1633	118	2413	794	231
17	217	1435	0	252	164	1796	126	2607	921	249
18	172	1010	0	267	153	1976	133	2820	1061	265
19	121	533	0	283	141	2174	141	3054	1215	281
20	64	0	0	300	127	2391	150	3311	1385	297

YRS UNTIL UNDISC. FUEL SAVINGS = INVESTMENT 9.
YRS UNTIL UNDISC. SOLAR SAVINGS = MORTGAGE PRINCIPAL 15.
UNDISCOUNTED CUMULATIVE SOLAR SAVINGS = $ 7572.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $ 15337.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR = $ 17027.

Table 2: This table shows the year-by-year economic analysis of a solar domestic hot water optimum system for Fairbanks, in Autumn, 1979. Physical and economic assumptions for this example are fully described in the text.

The following conditions and physical characteristics apply to this example:

Collector Tilt: 65°

Water use: 100 gal/day @ 140°F

Backup fuel costs: \$23.99 per million BTU (equivalent to GVEA 8¢/kwh electricity)

Amortization: 20 yr mortgage @ 12%

Cost/ft^2 collectors: \$30

No tax credit is considered.

The results of this optimization show the percentages by month which solar energy can <u>economically</u> provide for a Fairbanks residence. Note that a detailed economic analysis is possible using F-Chart. The results are presented in Table 2. These results can be matched if one considers both domestic hot water and space heat. The results of this type of simulation are shown in Table 3 for an average house of "1970" vintage, which requires 12000 BTU/°F-day for heating.

The results show that at \$30 per square foot for collector costs, 49% of the annual hot water load can be supplied from solar energy. For the case of solar energy for both space and hot water heating, the annual fraction is less impressive, approximately 22.7%. Both these examples do <u>not</u> include the effect of the present federal tax incentives which would result in bottom-line, first year credits of \$1,180 for the Table 1 case, hot water only, and \$2,200 the space heating and hot water example shown in Table 3. This will obviously decrease the payback period substantially, and makes the solar investment much more appealing.

The examples given are also easily adapted to commercial applications analysis, which will be done using F-Chart to show their competitive position, need for tax incentives, and probable end use effect as a percentage of space and hot water users.

The photovoltaic generation of electric power will be examined. When considering photovoltaic power, the only situations where stand-alone operation of a photovoltaic plant are likely to be possible are in modest, energy conservation houses in high solar radiation areas utilizing eith^er^ individual or communal facilities for energy storage. In all other cases (in Alaska as well as elsewhere) some interconnection essential to the satisfactory application of solar energy. Analysis of the solar component for Alaska's railbelt will necessarily assume a strong component of energy conservation. This is however, wholly in order for the study, and should also be reflected in the energy conservation report and other renewable resource analysis elements of this report, as they all are enhanced by energy conservation practices.

Tools available for modelling solar energy applications and their performance include the F-Chart and TRNSYS computer models. Data is available for Fairbanks, Summit (in Broad Pass), Matanuska (Palmer Ag. Station), Homer, Big Delta, and McGrath, for use with F-Chart. Tapes of the solar radiation data for hourly modelling using TRNSYS are abailable for Fairbanks, Barrow, Bethel, Matanuska, and Annette Island.

F-Chart enables the economic optimization of active solar energy applications by comparing their costs to the life-cycle cost of alternative and conventional fuels. One can also predict the monthly average performance of solar energy systems for heating and for domestic hot water. This information will be reported in the sutdy.

The goal of this study is to determine the extent to which solar energy can substitute the present end-uses of energy in Alaska's railbelt, expecially for space heating and hot water. For this reason it is essential that the economic projections from the Institute for Social and Economic Research be made available at the earliest convenience. At that point, using the economic projections as a basis, the rate of replacement of the housing stock can be estimated. This will be a key piece of information to enable calculation of the most probable rate of construction incorporating solar alternatives. It will do so for both active and passive applications. The economic optimization provided by F-Chart enables the quantification of the solar contribution given both as a total sum of BTU's and as a percentage of the total for an individual home or as a percentage of sectoral end use (i.e. all home space heating).

As an example of the type of detailed analysis that will be provided, included here is an optimization of domestic hot water heating using solar energy in Fairbanks, Alaska (Table 1).

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****THERMAL ANALYSIS****

TIME	PERCENT SOLAR	INCIDENT SOLAR (MMBTU)	HEATING LOAD (MMBTU)	WATER LOAD (MMBTU)	DEGREE DAYS (F-DAY)	AMBIENT TEMP (F)
JAN	0.	0.80	0.	2.72	2383.	-11.2
FEB	27.7	2.83	0.	2.46	1890.	-2.2
MAR	69.5	5.89	0.	2.72	1721.	10.4
APR	80.6	6.33	0.	2.63	1084.	28.4
MAY	81.3	6.09	0.	2.72	549.	46.4
JUN	83.9	5.78	0.	2.63	211.	59.0
JUL	78.6	5.46	0.	2.72	148.	60.8
AUG	67.6	4.68	0.	2.72	304.	55.4
SEP	59.3	4.13	0.	2.63	617.	44.6
OCT	34.6	3.08	0.	2.72	1235.	24.8
NOV	5.1	1.76	0.	2.63	1867.	3.2
DEC	0.	0.04	0.	2.72	2336.	-11.2
YR	49.1	46.84	0.	32.02	14344.	

****ECONOMIC ANALYSIS****

OPTIMIZED COLLECTOR AREA = 132. FT2
INITIAL COST OF SOLAR SYSTEM = $ 4960.
THE ANNUAL MORTGAGE PAYMENT FOR 20 YEARS = $ 598.
YRS UNTIL UNDISC. FUEL SAVINGS = INVESTMENT 9.
YRS UNTIL UNDISC. SOLAR SAVINGS = MORTGAGE PRINCIPAL 15.
UNDISCOUNTED CUMULATIVE SOLAR SAVINGS = $ 7572.
PRESENT WORTH OF YEARLY TOTAL COSTS WITH SOLAR = $ 15337.
PRESENT WORTH OF YEARLY TOTAL COSTS W/O SOLAR = $ 17027.
PRESENT WORTH OF CUMULATIVE SOLAR SAVINGS = $ 1690.

Table 1: A thermal and economic analysis of solar energy for domestic hot water heating compared to Golden Valley Electric Association. Autumn, 1979, electricity rates (residential).

with the existing electric utility will likely be sought. In this study, the utility attitude, costs of solar photovoltaic electricity, and its future will be assessed conservatively. Presently the engineering firm of CH2M-Hill is conducting a study for the National Solar Energy Research Institute for applications potential in the Pacific Northwest Region, which includes Alaska. The results of this latest study will be analyzed and included in this study, as will information form the many studies of the U.S. Department of Energy.

Conjunctive Studies:

This is a proposal to provide a one component analysis in a study involving the many possible alternatives to the Susitna Hydroelectric Project. The projections of this (solar component) study are critically dependent upon timely and complete assessments of two other elements of the total study: The population/economic growth projections, and the energy conservation analysis. The proposer will need to use these data extensively and will need to have access to it quickly, as the deadline for submission of the report on the solar component is April 15, 1980. In addition, travel to organizational meetings to establish a communications network among the consultants for each element of the study is included in the budget (2 round trips to Anchorage).

Final Report:

A final report will be submitted on or before April 15, 1980. It will be suitable for submission to the legislature as an element of the Susitna Alternatives Study. It will include quantitative estimates of solar energy end use in the Alaskan railbelt area to the year 2001. Figures will be based on solar radiation data for Fairbanks, Homer, and Matanuska (Palmer), projections of economic and population growth such as building unit construction, energy prices, tax incentives, and other relevent information from the projections study, and the influence of several different scenarios of energy conservation.

Methodologies which will be employed include end use analysis, F-CHART computer analysis of active solar systems, TRNSYS computer analysis of passive solar options, and analyses of photovoltaic and some unproven technologies.

Recommendations of policy for improving the competitive position and consumer acceptance will also be provided.

A budget follows.

BUDGET FOR SOLAR COMPONENT
SUSITNA ALTERNATIVES STUDY

1. SALARY:

1.1	R. Seifert 1.0 month @ $2450/month	$2,450.
1.2	Annual Leave/Sick Leave (15.9% of 1.1)	390.
1.3	Total Salary and leave benefits	2,840.
1.4	Staff Benefits (22.1% of 1.3)	628.
1.5	Total Salaries and Benefits	$3,468.

2. OVERHEAD CHARGES:

2.1	Overhead charges, Institute of Water Resources rate (50.8% of 1.3)	$1,443.

3. TRAVEL:

2	R.T. Fairbanks - Anchorage	$ 256.
1	R.T. Fairbanks - Juneau	254.
2	days per diem @ $55/day	110.
		$ 620.

TOTAL REQUESTED FUNDS	$5,531.