SCOMM

#44:30

STATE OF ALASKA

JAY S. HAMMOND, GOVERNOR

DEPARTMENT OF COMMERCE &
ECONOMIC DEVELOPMENT
DIVISION OF ECONOMIC ENTERPRISE

POUCH EE
JUNEAU, ALASKA 99811

February 22, 1980

Mr. Mark Wittow
House Power Alternatives Committee
Pouch V
Juneau, Alaska 99811

Dear Mark:

Based on a whole series of considerations my idea of responsible optimistic forecasts of Alaska's economic performance for the next twenty years is (roughly) as follows:

(i) population and employment growth of 2.5 to 3.0 percent per year;

(ii) inflation of about 6.5 percent per year;

(iii) real per capita income growth of about 3.0 to 3.5 percent per year.

These are long-term averages.

Between 1980 and 1985 I look for population and employment growth to average about 5.5 percent per year. Between 1985 and 1990 this should dip to about 1.5 percent per year (wind down of gas pipeline, Prudhoe revenue begins to decline). After 1990 when we are face to face with the loss of Prudhoe revenue, the public should be ready for relatively bold moves on the development front (private nonpetroleum). If so, after 1990 the combination of further weakening of oil flows and growth elsewhere in the economy will probably leave us with about a 2.5 percent, or so, growth rate of population and employment through the year 2000 (1990 to 2000).

The Institute's method of asking for a judgemental assessment from each of a number of persons may have some merit, although not much. The reason is that the fate of many of the projects to which judgement was applied will be determined in the political arena, rather than solely on the basis of their economic merits. I have in mind ALPETCO, capital move, Beluga coal for export, the Northwest gas pipeline, and Fairbanks petrochemicals. With the exception of the Northwest gas pipeline project, none of these projects, in my opinion, are economically viable as private sector ventures. If they are to go, they will need subsidies. If they are to receive subsidies, a political judgement will need to be made. The ISER procedure amounts to a crude opinion poll of little, but not zero, merit.

I have enclosed a copy of a speech I drafted recently for Chuck Webber. It addresses some of the development issues of the 1980's. Let me know if I can be of further help, or if you would like more specific comments.

For the record, the problems facing Beluga coal are (1) Wyoming/Montana coal and (2) nuclear energy. I would not be surprised if within five years nuclear power was both cheaper than coal with respect to supplying Alaska's electricity needs and environmentally safer. President Carter has called for a crash program to solve the nuclear waste problem. If the program succeeds, the atmospheric pollution associated with coal may be more of a threat than the danger of nuclear accident.

Yours truly,

Dave

David M. Reaume
Principal Economist

DMR/jar4/13

THE ANSWERS TO FOUR QUESTIONS WILL LARGELY DETERMINE ALASKA'S ECONOMIC PERFORMANCE DURING THE 1980'S. QUESTION NO. 1: HOW MUCH OIL AND GAS WILL BE FOUND AND EXTRACTED? QUESTION NO. 2: HOW LARGE WILL ALASKA'S HARD ROCK MINING, FISHING, AND TOURIST INDUSTRIES BECOME? QUESTION NO. 3: HOW MUCH REVENUE WILL THE ALASKA STATE GOVERNMENT RECEIVE EACH YEAR? QUESTION NO. 4: HOW WILL STATE GOVERNMENT APPORTION ITS REVENUE ACROSS THE THREE CATEGORIES SPENDING/GIVING AWAY, PORTFOLIO INVESTMENT, AND REAL INVESTMENT?

THE ANSWERS TO THESE FOUR QUESTIONS DEPEND HEAVILY ON THREE FACTS OF LIFE.

FACT NO. 1: THE QUANTITY OF OIL PUMPED FROM PRUDHOE BAY WILL BEGIN TO DECLINE ABOUT MID-DECADE. FACT NO. 2: THERE WILL ALMOST CERTAINLY BE NO MORE DISCOVERIES LIKE PRUDHOE BAY. (BEAUFORT SEA ESTIMATED CRUDE OIL RESERVES ARE LESS THAN TEN PERCENT OF PRUDHOE BAY'S. AT PRESENT RATES OF FLOW, TAPS WOULD PUMP THE ENTIRE ESTIMATED RESERVES FROM NORTON SOUND IN 1.47 DAYS.)

FACT NO. 3: THE FEDERAL GOVERNMENT HAS THE AUTHORITY TO REGULATE ENERGY PRICES AT ANY TIME AND AT ANY LEVEL.

THE POSSIBLE COMBINATIONS THAT MIGHT UNFOLD FOR THE ALASKA ECONOMY OVER THE NEXT TEN YEARS ARE NUMEROUS. AT ONE EXTREME, NEW PETROLEUM DISCOVERIES AND SUSTAINED HIGH ENERGY PRICES MIGHT PRODUCE HUGE STATE REVENUE SURPLUSES THAT MIGHT BE USED TO BOTH INSURE THE STATE'S FINANCIAL FUTURE AND TO STIMULATE THE GROWTH OF NEW NONPETROLEUM INDUSTRIES. AT ANOTHER EXTREME, ALASKA'S ECONOMY MIGHT BECOME SERIOUSLY DEPRESSED IF EXPECTED PETROLEUM RESERVES IN THE BEAUFORT SEA AND ELSEWHERE FALL FAR SHORT OF EXPECTATIONS, AND IF A COMBINATION OF INTERNATIONAL CRISIS AND DOMESTIC OPPOSITION TO HIGH ENERGY PRICES LEADS THE FEDERAL GOVERNMENT TO LEGISLATE AN UNDULY LOW PRICE FOR ALASKAN OIL. AT THE PRESENT TIME, APPROXIMATELY FORTY PERCENT OF ALL JOBS IN ALASKA ARE DIRECTLY OR INDIRECTLY DEPENDENT ON PETROLEUM REVENUE. ANYTHING THAT JEOPARDIZES ALASKA'S OIL REVENUE JEOPARDIZES THESE JOBS.

CONSIDERABLE UNCERTAINTY ATTENDS

IT SHOULD BE CLEAR THAT ANY STATEMENT AS TO WHAT IS "LIKELY" TO TRANSPIRE ECONOMICALLY IN ALASKA OVER THE NEXT TEN YEARS. THE FARTHER AHEAD ONE LOOKS, THE MORE UNCERTAIN THE PICTURE BECOMES. WITH THIS CAUTION IN MIND, LET ME OFFER YOU WHAT CAN BE TERMED A "RESPONSIBLE BEST GUESS" AS TO WHAT THE 80'S WILL BRING.

SETTING THE STAGE, LET ME START BY OFFERING SEVERAL KEY ASSUMPTIONS: (1) THE BEAUFORT SEA WILL BE FOUND TO HAVE PROVEN CRUDE OIL RESERVES OF APPROXIMATELY 1 BILLION BARRELS AND IT WILL BE DEVELOPED; (2) A COMPROMISE D-2 BILL WILL PASS THIS YEAR; (3) ALASKA CRUDE OIL PRICES WILL RISE THREE PERCENT PER YEAR FASTER THAN THE OVERALL RATE OF INFLATION; (4) THE STATE OF ALASKA WILL SEEK TO STIMULATE NEW NON-PETROLEUM ECONOMIC GROWTH; AND, FINALLY, (5) THE ALASKA GAS PIPELINE PROJECT WILL BE DELAYED NO MORE THAN ONE YEAR FROM ITS PRESENT SCHEDULE.

GIVEN THESE ASSUMPTIONS, THE PERIOD FROM 1980 THROUGH 1985 WILL BE ONE OF EXTREMELY RAPID ECONOMIC GROWTH. THE PER YEAR JOB AND REAL INCOME GAIN WILL AVERAGE FIVE TO SIX PERCENT, AND WILL AFFECT ALL SECTORS AND ALL GEOGRAPHICAL SUBREGIONS OF THE STATE.

BETWEEN 1985 AND 1990, THE GROWTH RATE WILL TAPER OFF TO AN ANNUAL AVERAGE OF BETWEEN ONE AND TWO PERCENT, CAUSED LARGELY BY COMPLETION OF THE GAS PIPELINE AND THE SLOWING OF THE CRUDE OIL FLOW FROM PRUDHOE BAY. THE PERIOD WILL BE CHARACTERIZED BY A RECONSIDERATION OF OUR GOALS AND OBJECTIVES IN LIGHT OF THE LESSONS LEARNED DURING THE PREVIOUS FIVE YEARS OF HECTIC GROWTH, AND IN LIGHT OF NEW ADVANCES IN ENERGY USE TECHNOLOGY.

INFLATION WILL BE A PERSISTENT PROBLEM THROUGHT THE DECADE. THE CAUSE OF THE INFLATION WILL BE THE SME SAME AS IT IS TODAY, A STEADY REDISTRIBUTION OF THE WORLD'S WEALTH AWAY FROM MOST DEVELOPED WESTERN COUNTRIES AND TOWARD THE OIL RICH UNDERDEVELOPED COUNTRIES. ALASKA INFLATION WILL BE SOMEWHAT LESS THAN THAT IN THE REST OF THE UNITED STATES BECAUSE INCREASING ECONOMIC DEVELOPMENT WILL CONTINUE TO ERODE THE ALASKA COST OF LIVING DIFFERENTIAL. AN AVERAGE ANNUAL INCREASE OF ABOUT SEVEN PERCENT IN ALASKA CONSUMER PRICES CAN BE EXPECTED.

GROWTH IN THE ALASKA ECONOMY OVER THE NEXT TEN YEARS WILL BE FUELED BY PETROLEUM REVENUE BUT WILL ACTUALLY OCCUR IN OTHER SECTORS OF THE ECONOMY. HARD ROCK MINING, TOURISM, BOTTOMFISH, AND SUPPORT INDUSTRIES OFFER THE BEST INVESTMENT POTENTIAL BOTH FOR PUBLIC MONEY AND FOR PRIVATE INVESTORS.

HOWEVER, GROWTH IS NOT TO BE EXPECTED WITH CERTAINTY. TO A DEGREE THAT IS HARD TO OVER EMPHASIZE, ALASKA'S FUTURE IS IN THE HANDS OF GOVERNMENT DECISION MAKERS, BOTH FEDERAL AND STATE. WORLD EVENTS AND THE FEDERAL GOVERNMENT WILL SET THE CONDITIONS UNDER WHICH WE, IN ALASKA, WILL OPERATE. WE, IN TURN, WILL COLLECTIVELY DETERMINE OUR FATE WITHIN THE CONDITIONS LAID DOWN. THE POTENTIAL FOR GREAT GOOD AND THE POTENTIAL FOR GREAT ~~MISUE~~ MISUSE OF OPPORTUNITY ARE BOTH VERY REAL. WE MUST WORK TOGETHER TO MAKE THE MOST OF WHAT WE HAVE BEEN ARE GIVEN.

ROUGH DRAFT/sHN/1

ISER workshop 2/15

exogenous activities - resource / development project.

MAP model elements
single most important - future petroleum development in the state

Alaska population growth - from immigration
function of employment

demand - function of pop
need good idea of employment/pop ratio
- variables - # of females -
# of native population -
will these increase

immigration - changes ratio - traditionally working age w/o large families

current rate - probably as high as it will get
★ future employment increases → ~~to~~ has to be met by
future population growth

- what will happen to real (disposable) income
wages - taxes.
fed gov't - 40,000 - largest single employer
if real wages rise, result is large increase over time
fed income tax is rising slowly (its bite)
★ assumption - stabilization of fed income tax

structural change - import substitution

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some activities which were unprofitable in 60's, have become profitable
Some non-available, imported products now available
growth in market sector → import substitution/structural change

how will this continue into the future?

Alyeska pipeline effects

will approach national level of support ratio

but not within time frame

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state gov't - exogeneous or endogenous

(independent of economy / function of population ⇒ revenues (private sector)) ps

both are appropriate to a degree

☆ - problem is multiplier effect - growth in private ⇒ growth in public sector

(see Leuwe critique)

Above are critical elements in using this model

/ G Erickson - demographic parameters need to better figured

(eg - significant decline in birthrate since 1970)

/ cannot predict whether trend will continue

changes in public health in rural areas → more young people

Critical variables for outside state economy

① - How state will spend its $

② - level of resource development activity

① state + local employment - 35,000 / 180,000 total force

changing ratios / oil within state land

impact on OCS development

Permanent Fund share

ISER

③

Methods of prediction

Aim for year 2000

for 3 variables - gov't (state) spending / what it responds to /

employment in resource industries

- population

TO

Rep. Brian Rogers

Greuning Bldg.

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Susitna
[illegible]
ISER
~~Rep~~
Work Plan

DETAILED WORK PLAN

Electricity Requirements for the Railbelt

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

Scott Goldsmith
Assistant Professor of Economics
Institute of Social and Economic Research

November 14, 1979

(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

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

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

i = SINGLE FAMILY
DUPLEX
APARTMENT
TRAILER

j = space heat
water heat
refrigeration
cooking
clothes drying
other

COMMERCIAL ELECTRICITY REQUIREMENTS AT TIME T (KWH) = SAME FORMAT WITH AVERAGE BUILDING 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.

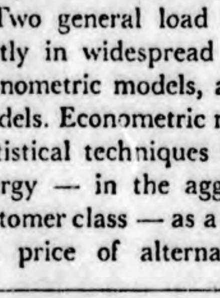
*2. Write summary report in nontechnical language presenting principal findings and conclusions of study.

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.



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.

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.

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.

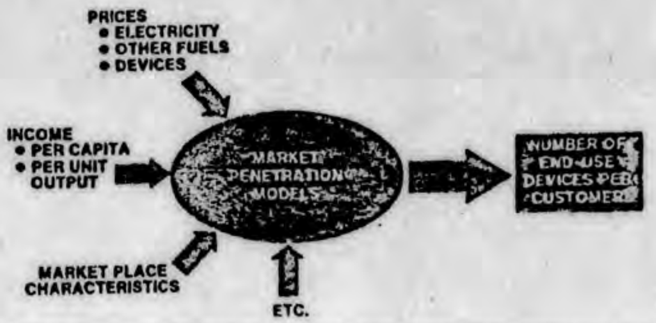
These NEA provisions could lead to a substantial near-term reduction in utilities' electric heating loads — though perhaps less than has been suggested because electric homes are typically quite efficient already. To account for this effect in its forecast, the utility would have to monitor the number 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 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.

FIGURE 2

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



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.

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.

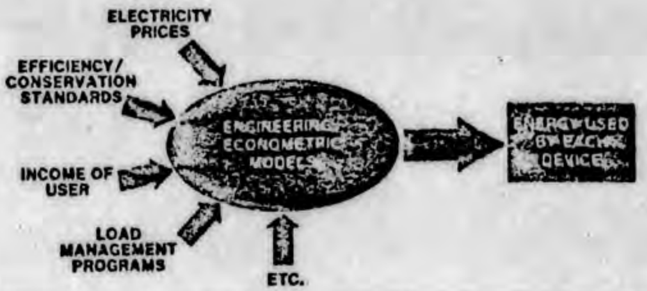
Dispersed Energy Sources. Not only are commercial buildings the prime targets of new energy-efficiency standards, they are also attractive candidates for pioneering the use of dispersed energy sources, including solar heating and cooling, total energy systems, and fuel cells. These innovations may penetrate 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.

FIGURE 3

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



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.

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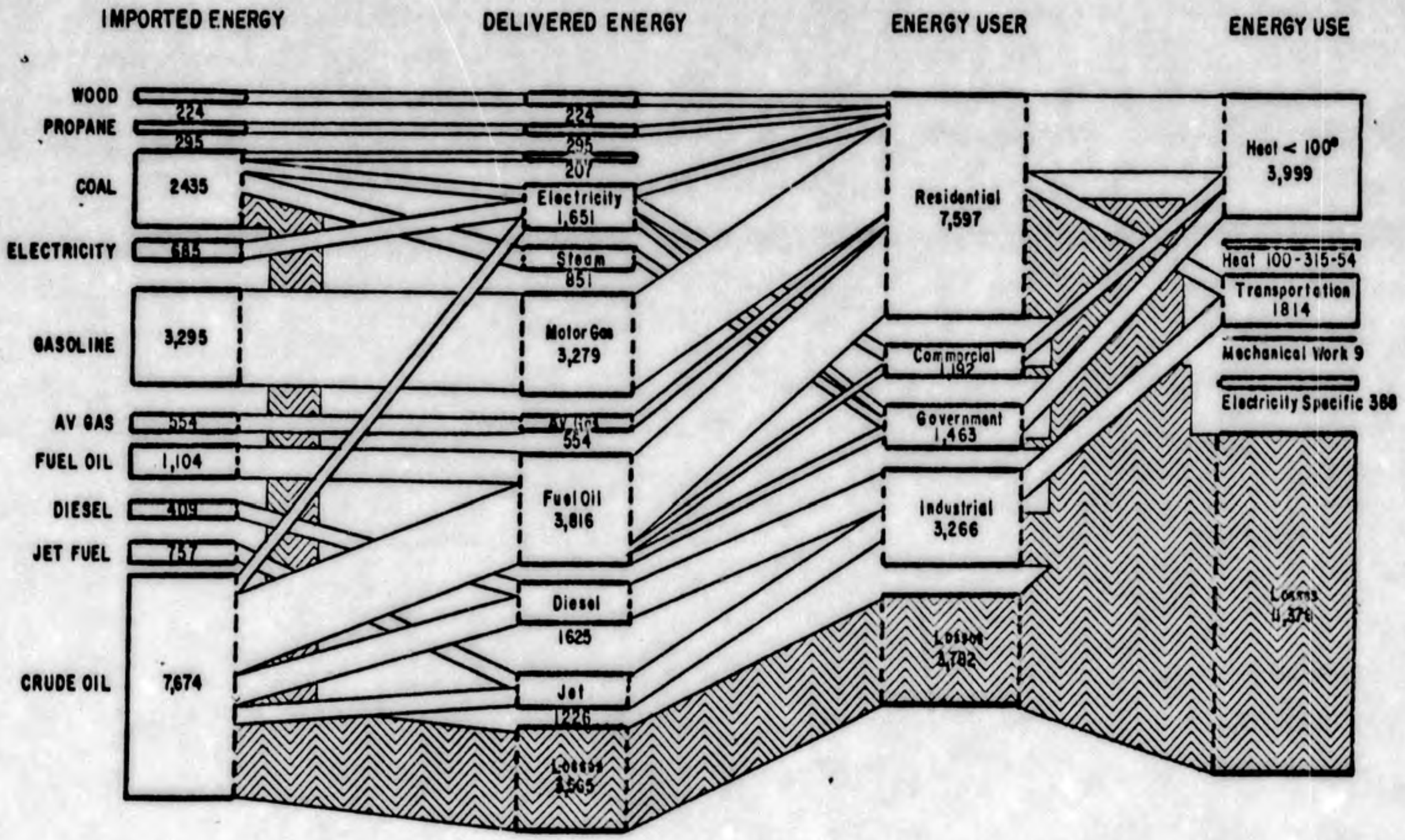
*"Electric Load Forecasting: Probing the Issues with Models," EMF Report 3, Vol. 1, Energy Modeling Forum, Stanford University, Stanford, California, April, 1979, p. 7. EMF is sponsored by the Electric Power Research Institute.

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.

Excluding
military

NET ENERGY BALANCE
Fairbanks North Star Borough - 1978
(Units = 1×10^9 BTU)



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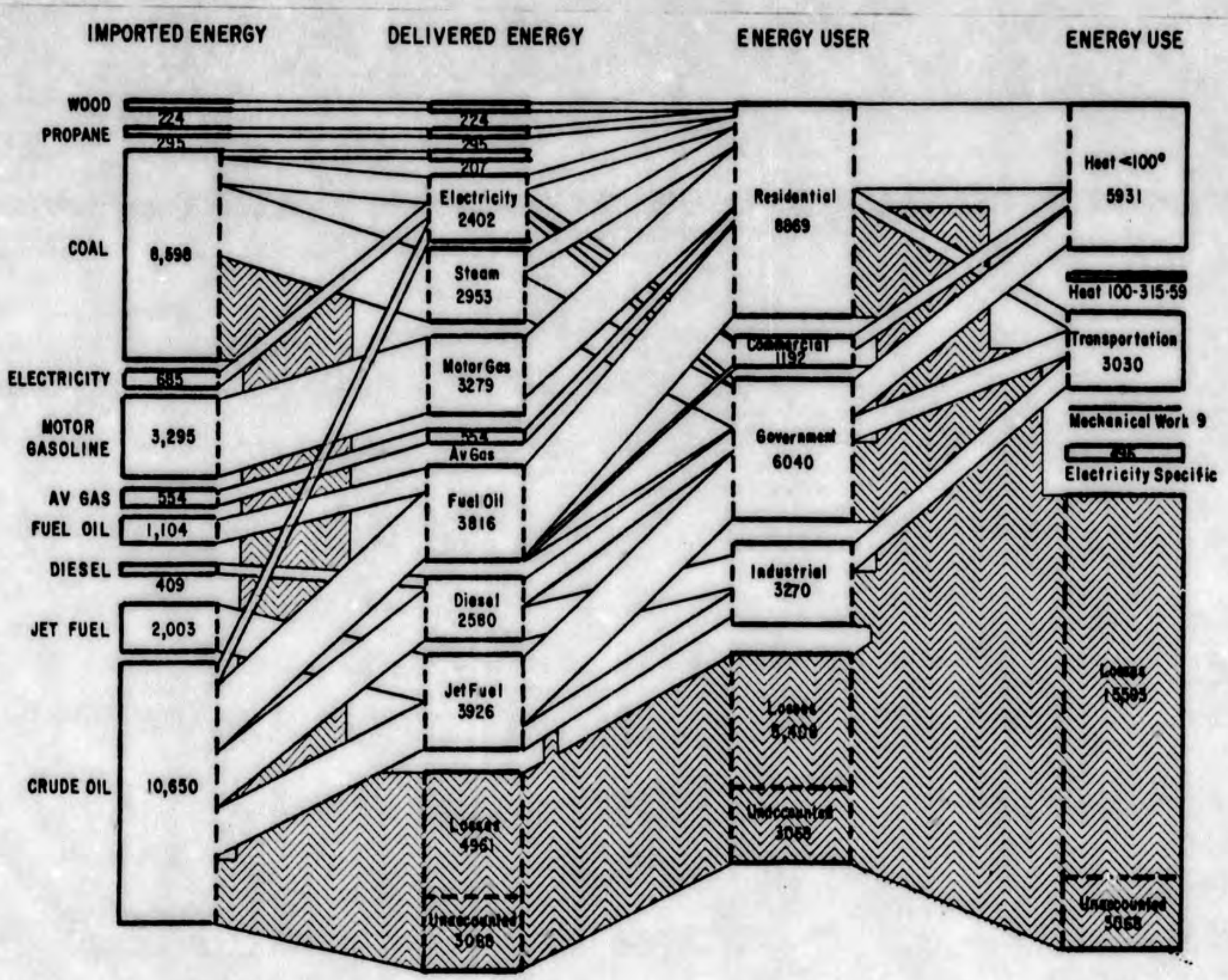

Power Alt

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GOLDEN VALLEY ELECTRIC ASSOCIATION INC. Box 1249, Fairbanks, Alaska 99707, Phone 907-452-1151

November 30, 1979

Mr. Oliver Scott Goldsmith
Institute of Social and Economic Research
University of Alaska
707 "A" Street
Anchorage, AK 99501

Dear Mr. Goldsmith:

Mr. Hufman has asked me to assist you by providing data which will facilitate your arriving at a reasonable and accurate projection for electrical load growth in our service area. Enclosed for openers is a copy of our 1978 annual report. Please contact me when you wish to set up a meeting.

Sincerely,

Mike Kelly

Michael P. Kelly
Administrative Assistant

MPK:es
Encl
cc: ✓Rep. Rogers
Mr. Yould, APA

ELECTRIC POWER DEMAND FORECASTS AND
THE SUSITNA HYDROELECTRIC PROJECT

A proposal by Bradford H. Tuck, Economic Consultant.

One of the central questions in the evaluation of the proposed Susitna Hydroelectric Project is that of future electric power demand in areas potentially served by the Project. Forecasts of electric power demand have been made by the Alaska Power Administration, ISER, and others, and there are significant differences among these forecasts. In addition, the divergence between high and low growth demand scenarios is so large as to raise questions regarding their usefulness. The proposed study is intended to provide an indepth review of relevant demand forecasts, as outlined below.

I. INTRODUCTION

A. General overview of study.
B. Identification of relevant demand forecasts.

II. ANALYSIS OF DEMAND FORECASTS

A. Review criteria:
The review criteria would include type of forecast and methodology used, quality and reliability of input data, critical assumptions, and level of detail in components of demand. Also of concern is whether or not price elasticity and conservation possibilities have been considered.

B. Review of specific demand forecasts:
The forecasts reviewed would include work done by the Alaska Power Administration, forecasts contained in the Interim Feasibility Report for the Susitna Project, forecasts by ISER, and other forecasts that may be relevant.

Particular emphasis will be given to ISER forecasts that will be under development concurrently with this study. Since the ISER forecasts will, in part, be dependent upon the MAP model, special attention will be given to the properties of the MAP model and to the data scenarios used to generate the forecasts.

III. SUMMARY AND CONCLUSIONS

A. Synopsis of findings.
B. Usefulness of findings for decision about Project.

DATE OF STUDY: To be completed by March 1, 1980.

COST: $5,500.00.

lump sum

interim
report
Jan. 28, 1979

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MIGRATION AND THE DYNAMIC
STABILITY OF REGIONAL ECONOMETRIC MODELS

David M. Reaume
State of Alaska
Department of Commerce
& Economic Development
July, 1979

A survey taken in 1975 by researchers at the University of North Carolina revealed that 125 out of 191 respondent U.S. cities, towns and other planning districts employed growth controls other than simple zoning (or in addition to).[1] Citizen groups in some parts of the country are reported to deliberately play down the attractiveness of their region in an attempt to discourage new migration.[2] In Alaska, up to one hundred million acres of land may be classified as nondevelopable by the federal government under section 17(D)2 of the Alaska Native Claims Settlement Act.

Because of such intense public concern over the possible negative effects of economic growth, public decision makers have increasingly called upon economists and other scientists to quantify the impact of proposed economic development on population growth, government spending, and the natural environment. For their part, economists have responded by creating new analytic tools with which to examine the problem. Prominent among these is the regional econometric model.[3]

Taken as a whole, professional testimony based in part on econometric simulations of proposed development projects has the potential to influence greatly the inter-regional distribution of economic activity, and, thereby, the efficiency with which we use our scarce natural resources.[4]

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[1] Godschalk, David et al (3).

[2] "Oregon Stops 'Em at the Border," Seattle Post Intelligencer, February 18, 1979, p. E2.

[3] A partial list of references is given below. Data Resources, Incorporated reports that fourteen large state econometric models are now on its computer.

[4] For example, the University of Alaska's MAP model, Siever (1975), has been used in producing a number of environmental and economic impact statements.

It is, therefore, most important that we gain an understanding of the strengths and weaknesses of our regional econometric models.

A model can be weak in a variety of ways and for a variety of reasons. The weakness examined here is inappropriate dynamic behavior, that is, a significant divergence between a model's dynamic properties and the "true" properties of the real world economy which has been modeled. Such a divergence would exist, for example, if a particular model was explosive or cyclic even though the regional economy itself had no such tendencies.

For several a priori reasons the migration equation (or block of equations) appeared to me to be a particularly likely source of inappropriate dynamic behavior and therefore a candidate for research. First, unless the labor force constraint is simply not modeled, an econometric model's long run rate of employment growth is clearly constrained by the rate of growth of the regional labor force, and, thus, by the level of induced net migration. Second, despite the fact that the literature on migration strongly suggests that gross migration flows are a better choice of dependent variable for regression purposes, net migration is usually used as a dependent variable because of the unavailability of time series data on inter-regional gross migration flows.[1] Third, since net migration is typically derived as a residual, relatively small percentage errors in population estimates can produce relatively large percentage errors in net migration.

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[1] See Vanderkamp (12). Many regional econometric models do not explicitly model migration. In these, migration is implicitly determined by a regression of population on a variety of determinants. An example is the Philadelphia model developed by Glickman (2).

This paper is a report on research into the role played by the migration equation in generating inappropriate dynamic behavior in regional econometric models. There are two principal sections. In the next section, three different versions of a model of population, employment, and induced spending are introduced. The conditions under which each version is explosive, stable, or cyclic are then derived as functions of the structural form parameters. In the next section, the third version is fit to time series data for Alaska, and then tested for sensitivity to slight variations in the migration parameters using the stability conditions previously derived. It is found that within the range of one estimated standard deviation on one migration parameter, the model moves from stability to explosive growth.

In short, what is shown here is that (i) the net migration equation is of critical importance in determining a model's behavior; (ii) relatively small changes in the migration equation's parameters produce marked differences in model behavior; and (iii) point estimates of the migration parameters cannot be held in much confidence. The implication is that policy prescriptions based on simulations of regional econometric models (particularly long run simulations) should be formulated with even greater care than one might normally presume is prudent.

II. Migration Dynamics

Consider a regional economy which is small relative to the outside economy from which it can draw migrants. What determines the economy's dynamic behavior when net migration is specified to be a function of regional economic growth? The answer, of course, is that many things do. Intuitively, however, it seems clear that the economy's steady state rate of positive growth will be limited by the rate of growth of the effective labor force, where the latter is determined both by increases in native labor and by the level of new migration.

Suppose now that in a given model of this economy population growth stimulates additional government spending, which results in additional public and private employment, which in turn induces new migration, further population growth, and so on. At first, one might conjecture that the government's propensity to spend (however measured) and the rate of new migration would be equally important in determining whether the model was stable, explosive or cyclic, especially if government spending is assumed to be financed by a (practically) unlimited exogenous revenue source. In this section I work out the dynamic properties of three versions of such a model. A very interesting result is that only the parameters of the migration equation appear in every stability condition. Parameters of other equations sometimes appear and sometimes do not.

The model developed here is explored in three successively more complex versions. The first two consist of four equations in the four endogenous variables -- population, net migration, total employment, and total public plus private spending. The third version of the model introduces the relative wage.

Though mathematically simple, the model's generality can best be appreciated by considering it to be an aggregated partial reduced form derived from a larger more disaggregated structural model. Exogenous spending and employment can be thought of as determined elsewhere in the larger model of which this is a part.

Version 1

Let N be population, NBD be net births and deaths, NMIG be net migration, E be total employment, and S be total government and private spending. Write the structural form as:

[1] $N = N(-1) + NBD + NMIG$

[2] $NMIG = \beta_1 (E-E(-1))$

[3] $E = \bar{E} + \beta_2 S$

[4] $S = \bar{S} + \beta_3 N$

Where $\bar{E}$ and $\bar{S}$ are exogenous components of employment and total government plus private spending, and β_1, β_2 and β_3 are strictly positive parameters.

Because Version 1 is fully simultaneous it has a single characteristic equation derived from the reduced form equation $N = N(-1) + f(\bar{E}, \bar{S}, NBD)$.

The characteristic equation is $X = 1$, where X is the latent root. Hence, the model is stable for all values of β_1, β_2, and β_3.

Admittedly, this is a much simplified model of the migration-development process. However, it does embody the important jointly determined relationship between employment creation and employment induced migration. The fact that the model in this form is stable for all values of β_1, β_2, and β_3 is only a little reassuring. Certainly, a specification that allowed for at least the possibility of explosive growth should be considered before any conclusions are drawn. One suspects that an explosive migration-development process should be at least theoretically possible.

Version 2

Potential instability is introduced by generalizing [2]. In addition, a one period lag is used in [3]. Version 2 is then [1], [2'], [3'], and [4] where

[2'] $NMIG = \beta_1 E + \beta_4 E(-1)$

[3'] $E = \bar{E} + \beta_5 S(-1)$

and where by assumption $\beta_4 < 0$[1], and β_1, β_5, and β_3 are strictly positive.

---

[1] From [2], $NMIG = \beta_1 E - \beta_1 E(-1)$. Equation [2'] generalizes equation [2] by allowing the coefficient on $E(-1)$ to differ in absolute value from that on E.

Straight forward substitution and simplification of Version 2 leads to the following reduced form equation for population.[1]

[5] $N = (1 + \beta_1\beta_5\beta_3)\ N(-1) + \beta_4\beta_5\beta_3\ N\ (-2)$ + exogenous terms

The homogeneous part of equation [5] is of the form $N = AN(-1) + BN(-2)$ where $A = 1 + \beta_1\beta_5\beta_3 > 0$ and $B = \beta_4\beta_5\beta_3 < 0$. The latent roots of its characteristic equation are X_1, X_2 where

[6A] $X_1 = (A + (A^2 + 4B)^{1/2})/2$

[6B] $X_2 = (A - (A^2 + 4B)^{1/2}/2$

These roots are real if $A^2 \geq -4B$, since β_4 and therefore B, is strictly negative; otherwise they are complex.[2] It is intuitively clear from inspection of [5] that β_1 and β_4, the parameters of the migration equation, are pivotal.

The model's dynamic properties are not difficult to describe. Assuming that the roots of the characteristic equation of [5] are real, the model is explosive if its largest root, X_1, exceeds unity.[3] But X_1 will exceed unity if and only if $(A^2 + 4B)^{1/2} > 2-A$, where $(A^2 + 4B)^{1/2}$ is the nonnegative square root. There are two subcases since, by assumption, $A > 1.0$.

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[1] The dynamic equation for population is: $N(t) = eX_1{}^t + gX_2{}^t + F$, where F is a particular solution and e and g are parameters determined by initial conditions. It is clear from [4] and [3'] that S and E will grow explosively if and only if N does so and will oscillate if and only if N does so.

[2] Note, however, if $\beta_4 > 0$ is allowed, then $A^2 < -4B$ is impossible and cyclic behavior is precluded.

[3] Given that $A > 0$ and $B < 0$, $X_2 < -1$ is ruled out, since this requires $B-A > 1.0$.

Subcase 1: $1 < A \leq 2$

Consider $(A^2 + 4B)^{1/2} > 2-A$

Squaring both sides does not change the direction of inequality since in this subcase both sides are nonnegative. The rule then becomes

$$A^2 + 4B > 4-4A+A^2$$

$$\text{or} \quad A + B > 1$$

But $\quad A + B = 1 + \beta_1\beta_5\beta_3 + \beta_4\beta_5\beta_3$

Hence, in this subcase, Version 2 is explosive if and only if $\beta_1 > -\beta_4$.

Subcase 2: $A > 2$

Here, $2 - A < 0$, and X_1 will exceed unity if $(A^2 + 4B)^{1/2} > 2 - A$. But

$$(A^2 + 4B)^{1/2} \geq 0 > 2 - A \qquad \text{for all } A.$$

Hence the model is explosive for all A greater than 2.0 if the roots of [5] are real.

From the definition of A, $A > 2$, implies

[7] $\beta_1 > (\beta_5\beta_3)^{-1}$ or $\beta_1\beta_5\beta_3 > 1.0$

It was noted above that the solutions to [6A] and [6B] are real if and only if $A^2 + 4B \geq 0$. This condition restated in terms of the structural parameters is:

$$[8] \quad -4\beta_4 \leq (\beta_5\beta_3)^{-1} + 2\beta_1 + \beta_1^2\beta_5\beta_3$$

Equation [8] gives the condition under which X_1 and X_2 are real. If the reverse inequality holds strictly, X_1 and X_2 are complex conjugates and the model is cyclic. The condition for damped oscillations, stated without proof, is $A^2 < 4(1 + B)$ or

$$[8A] \quad (1 + \beta_1\beta_5\beta_3)^2 < 4(1 + \beta_4\beta_5\beta_3)$$

Version 3

The final version of the model considered in this paper is Version 3. In this version, a relative wage term is added to the net migration equation, spending is specified to be a function of both the average wage and population, the wage is treated as an endogenous function of employment, and, finally, employment is taken to be a function of both current and lagged spending. The exogenous components of employment and spending are retained and an exogenous component of the average regional wage is introduced. The model then becomes:

[1] $N = N(-1) + NBD + NMIG$

[2"] $NMIG = \beta_1 E + \beta_4 E(-1) + \beta_6 W/WX$

[3"] $E = \bar{E} + \beta_2 S + \beta_5 S(-1)$

[4'] $S = \bar{S} + \beta_3 N + \beta_7 W$

[5] $W = \bar{W} + \beta_8 E$

Where all parameters except β_4 are specified to be positive, W is the average regional wage, WX the average wage in the economy from which migrants are drawn, and the remaining variables are defined as above.

By inserting [5] into [2"] and the result into [1], and also inserting [5] into [4'] and the result into [3"], the model is reduced to the following two simultaneous difference equations in N and E.

[9] $N = N(-1) + (\beta_1 + (\beta_6\beta_8/WX))E + \beta_4 E(-1) +$ exogenous terms

[10] $E = (1-\beta_2\beta_7\beta_8)^{-1}\beta_2\beta_3 N + (1-\beta_2\beta_7\beta_8)^{-1}\beta_5\beta_3 N(-1) + (1-\beta_2\beta_7\beta_8)^{-1}\beta_5\beta_7\beta_8 E(-1) +$
+ exogenous terms

These may be rewritten:

[9'] $N = N(-1) + c_1 E + c_2 E(-1) +$ exogenous terms

[10'] $E = c_3 N + c_4 N(-1) + c_5 E(-1) +$ exogenous terms

where the $\{c_i\}$ are defined by comparison with [9] and [10].

Solutions to the homogenous portions of [9'] and [10'] are of the form[1]

$$N(t) = p_1 X^t$$
$$E(t) = p_2 X^t$$

The characteristic equations are then

[11] $p_1 X^t = p_1 X^{t-1} + c_1 p_2 X^t + c_2 p_2 X^{t-1}$

---

[1] See Baumol (1) pp 327-331 for a discussion of the method of solution.

$$[12] \quad p_2X^t = c_3p_1X^t + c_4p_1X^{t-1} + c_5p_2X^{t-1}$$

Letting $p = p_1/p_2$, we can divide both sides of equations [11] and [12] by p_2X^{t-1} and p_1X^{t-1}, respectively, to obtain

$$[11'] \quad pX = p + c_1X + c_2$$

$$[12'] \quad p^{-1}X = c_3X + c_4 + c_5p^{-1}$$

or, upon solving [11'] for X

$$[11''] \quad X = (p + c_2)/(p-c_1)$$

Substitution of [11"] into [12'] produces a quadratic polynomial in p that can be solved in terms of the c_i. Its roots can then be successively substituted back into [11"] to produce the two values X_1 and X_2 that determine the model's fundamental dynamic properties.

The quadratic polynomial is

$$[13] \quad (c_3 + c_4)p^2 + (c_2c_3 - c_4c_1 + c_5 -1)p - (c_5c_1 + c_2) = 0$$

Equation [13] has two roots. Under what circumstances will these produce values of X_1 or X_2 that exceed unity? Assuming for the moment that the roots of [13] are real we have from [11"] that

$$X > 1.0 <=> (p + c_2)/(p - c_1) > 1.0$$

There are two subcases. First, if $p - c_1 > 0$, the model shows explosive positive growth if and only if $c_2 > - c_1$. Second, if $p - c_1 < 0$, the model shows explosive positive growth if and only if $c_2 < - c_1$. In either case, whether or not the model is explosive is effectively determined by the migration equation's parameters, since $c_1 = \beta_1 + \beta_6\beta_8/WX$, $c_2 = \beta_4$ and

β_8 can be made arbitrarily small by choice of the units of measurement of W and E.[1]

Consider now the case where the model oscillates. In this case, [13] has a pair of complex roots. We can therefore write

$$[14] \quad (p - (a + bi))(p - (a - bi)) = 0$$

where a + bi, a - bi are complex conjugates and a and b are real constants.

Expanding [14] leads to [14'] where

$$[14'] \quad p^2 - 2pa + b^2 = 0$$

Now, by comparison of [13] and [14'] it can be seen that if the roots of [13] are complex

$$[15] \quad c_3 + c_4 = 1$$

$$[16] \quad c_2c_3 + c_5 - 1 - c_4c_1 = -2a$$

$$[17] \quad -c_5c_1 - c_2 = b^2$$

In general, the solutions to [13] are of the form

$$[18] \quad p = (-(c_2c_3 - c_4c_1 + c_5 -1) \pm ((c_2c_3 - c_4c_1 + c_5 -1)^2 + 4(c_3 + c_4)(c_5c_1 + c_2))^{1/2})/2(c_3 + c_4)$$

---

[1] Notice also that normalization on either β_1 or β_4 in [2"] cannot change β_1/β_4.

But from [15] we see that complex p implies $c_3 + c_4 = 1$.

I conclude that the roots of [13] are complex and the model oscillates if and only if

[19] $$(c_2c_3 + c_5 - c_4c_1 - 1)^2 + 4(c_5c_1 + c_2) < 0$$

The oscillations are damped if

[19A] $$(c_2c_3 + c_5 - c_4c_1 - 1)^2 + 4(c_5c_1 + c_2)^2 < 4$$

These conditions can be readily expressed in terms of the structural parameters as shown below. The case of negative X will not be treated in this section for Version 3.

Summary of Stability Conditions

For convenience the stability conditions for the three Versions of the model are summarized here.

Version 1 - Stable for all values of the parameters.

Version 2 - Characteristic equation has real roots and is explosive if and only if

$$-4\beta_4 < (\beta_5\beta_3)^{-1} + 2\beta_1 + \beta_1^2\beta_5\beta_3 \qquad [8]$$

If the roots are real and $\beta_1 \leq -\beta_4$, the model is stable. If the roots are not real the model is cyclic. The cycles are damped if and only if

$$(1 + \beta_1\beta_5\beta_3)^2 < 4(1 + \beta_4\beta_5\beta_3) \qquad [8A]$$

Since the left hand side exceeds unity, it is clearly necessary that $\beta_4\beta_5\beta_3 > -0.75$

Version 3 - Characteristic equation has complex roots and oscillates if and only if

$$((1-\beta_2\beta_7\beta_8)^{-1}(\beta_2\beta_3\beta_4 + \beta_5\beta_7\beta_8)-1 - (\beta_1 + \beta_6\beta_8/WX)(1 - \beta_2\beta_7\beta_8)^{-1}\beta_5\beta_3)^2 +$$
$$4((1-\beta_2\beta_7\beta_8)^{-1}\beta_5\beta_7\beta_8(\beta_1 + \beta_6\beta_8/WX) + \beta_4) < 0 \qquad [20]$$

The oscillations are damped if the roots are complex and if

$$((1-\beta_2\beta_7\beta_8)^{-1}(\beta_2\beta_3\beta_4 + \beta_5\beta_7\beta_8)-1 - (\beta_1 + \beta_6\beta_8/WX)(1 - \beta_2\beta_7\beta_8)^{-1}\beta_5\beta_3)^2 +$$
$$4((1-\beta_2\beta_7\beta_8)^{-1}\beta_5\beta_7\beta_8(\beta_1 + \beta_6\beta_8/WX)+\beta_4)^2 < 4 \qquad [21]$$

Model shows explosive positive growth if and only if the roots of the characteristic equation are real and either

$$p > \beta_1 + \beta_6\beta_8/WX > - \beta_4 \qquad [22]$$

or $$p < \beta_1 + \beta_6\beta_8/WX < - \beta_4 \qquad [23]$$

where p is either the real root of [13] and may be found by solving [18].

III. EMPIRICAL RESULTS

Equations [2"], [3"], [4"], and [5] were fit to annual time series data for the state of Alaska. Because many, if not most, regional econometric models are fit using ordinary least squares, that method was used here. The purpose of this section is to demonstrate the sensitivity of a representative model's dynamic properties to relatively small changes in the values assigned to the parameters of the migration equation. Version 3 of the model as fitted is (t-statistics in parentheses):[1]

[1] $N = N(-1) + NBD + NMIG$

[2"] $NMIG = 1.831*10^{-6}*E - 2.663*10^{-6}*E(-1) + 36853.2*W/WX$

$$\qquad (2.5) \qquad\qquad (-3.3) \qquad\qquad (3.0)$$

$\bar{R}^2 = .84$

$DW = 2.40$

Period of fit: 1961 to 1976

[3"] $E = EFED + 25240.4 + 51881.7 *S - 25044.7 * S(-1)$

$$\qquad (7.4) \qquad (4.0) \qquad (-1.5)$$

$\bar{R}^2 = .99$

$DW = 1.77$

Period of fit: 1965 to 1976

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[1] The period of fit for [3"] and [4'] was shortened because of the unavailability of one component of S for the years prior to 1964. See appendix.

$$[4'] \ S = WFED - 5.37 + 20.93 *N + 45636.4 *W$$

$$(-8.0) \quad (6.1) \qquad (0.35)$$

$\bar{R}^2 = .98$

DW = 0.80

Period of fit: 1965 to 1976

$$[5] \ W = 9.106*10^{-6} + 3.122*10^{-11} *E$$

$$(33.1) \qquad (11.3)$$

$\bar{R}^2 = .89$

DW = 0.62

Period of fit: 1961 to 1976

The precise empirical definition of the variables is relegated to the appendix. Here I simply note that EFED and WFED are federal government civilian employment and payrolls in Alaska, respectively. Referring back to the analytic versions of these equations it can be seen that $\bar{E} \equiv EFED + 25240.4$; $\bar{S} \equiv WFED - 5.37$; and $\bar{W} \equiv 9.106 *10^{-6}$.

Using the fitted values of the β_i and solving [13] for p yields:

$$p_a = 4.033 * 10^{-6}$$
$$p_b = 1.120 * 10^{-6}$$

From [11"] and the definition of the $\{c_i\}$ these yield $X_1 = 0.6223$ and $X_2 = 2.166$, thus, the fitted model is unstable.

Consider, however, what happens when the coefficient on E(-1) in [2"] is raised by approximately one standard deviation and set equal to - β_1.

Solution of [13] gives $p_a = 1.810 *10^{-6}$, $p_b = 1.734 *10^{-6}$. By comparing [9] and [9'] it can be seen that $c_1 = \beta_1 + \beta_6\beta_8/WX$ and $c_2 = \beta_4$. Using the fitted values for β_1, β_6 and β_8 and using $\beta_4 = -\beta_1$, it follows that (at the 1976 value of WX)

$$c_1 = 1.999 *10^{-6}$$
$$c_2 = -1.864 *10^{-6}$$

Thus [22] now fails to holds and the model is therefore stable. In particular, solving [11"] yields:

$$X_1 = 0.948$$

$$X_2 = 0.988$$

<u>Varying one migration parameter approximately one estimated standard deviation transforms the model from explosive growth to stability</u>.

At least two actively used models of the Alaska economy constrain net migration to be a function of the year-to-year change in employment.[1] Because such a constraint can alter all of the fitted parameters in the regression equation, [2"] was refit under this constraint, namely that $\beta_4 = -\beta_1$. The fitted equation was

[2"'] NMIG@AK = 0.914 *10^{-6} (E - E(-1)) -493.0 * W/WX

(5.7) (-0.5)

$\bar{R}^2 = .71$

Period of fit: 1961 to 1976

The sign of the coefficient on W/WX is incorrect, since by a priori reasoning it should be positive. Furthermore, it is statistically insignificant at any reasonable level. It was, therefore, set equal to zero. We then have $\beta_1 = -\beta_4 = .914 * 10^{-6}$, $\beta_6 = 0$, and β_1, β_3, β_5, β_7, and β_8 as originally estimated. Further, $c_1 = 9.14 * 10^{-7} = -c_2$.

Given these parameter values, solution of [13] yields $p_a = 1.71 * 10^{-6}$. Substitution into [11"] yields

$X_1 = (1.71 - .914)/(1.71 - .914)$

or $X_1 = 1.0$

Similarly, $X_2 = 1.0$

The model is stable. However, now suppose $\beta_6 > 0$, as in Reaume (9), and Seiver (10). In particular let $\beta_6 = 493$, a change of approximately one standard deviation from the fitted value in [2"']. In this case, p_a = $1.715 * 10^{-6}$; $p_b = 0.914 * 10^{-6}$; $X_1 = 1.0$; and $X_2 = 8.08$. The model is now explosive since $X_2 > 1.0$. Again, a change of one standard deviation in one migration parameter converts the model from stability to explosive growth.

DATA PROBLEMS

It has been demonstrated that relatively minor (a priori) changes in specification, or relatively small variations in key migration parameters can markedly change this model's behavior. A reasonable conjecture is that the same is very likely true for other models. If for some reason the parameters of the net migration equation can be shown to vary greatly with normal data error or with the period of fit, then the case is closed. It will have been shown that (i) the net migration equation is of critical importance in determining a model's behavior; (ii) relatively small changes in the migration equation's parameters produce marked differences in model behavior; and (iii) point estimates of the migration parameters cannot be held in much confidence. The implication is that policy prescriptions based on simulations of regional econometric models (particularly long run simulations) should be formulated with even greater care than one might normally presume is prudent.

DATA ERROR

Adequate time series data on gross migration flows are not available for most states and local areas. For this reason, net migration is the usual regression variable and is typically defined as a residual using the identity

$$NMIG = N - N(-1) - NBD \qquad [1A]$$

Now annual net births and deaths (NBD) is (presumably) measured fairly accurately in most developed areas, with the numbers taken by count from birth certificates and death certificates. If so, a relatively small percentage error in estimating the year-to-year change in N can produce a much larger percentage error in NMIG. To see this let the true values of N, NMIG and NBD be asterisked. Then

$$\begin{aligned} NMIG^* &= N^* - N^*(-1) - NBD^* \\ &= \alpha 1 \cdot (N^* - N^*(-1)) \qquad [24] \end{aligned}$$

$$\text{where } \alpha 1 = 1 - NBD^*/(N^* - N^*(-1))$$

Suppose $N - N(-1) = \alpha 2 \cdot (N^* - N^*(-1))$ [25]

Then from [1A] and the above

$$NMIG = (\alpha 2/\alpha 1) \cdot NMIG^* - NBD \qquad [26]$$

Suppose $NBD = \alpha 3 \cdot NBD^*$ [27]

Since $NBD^* = N^* - N^*(-1) - NMIG^*$, it follows from [24], [26], and [27] that

$$NMIG = (\alpha 3 + (\alpha 2 - \alpha 3)/\alpha 1) \cdot NMIG^* \qquad [28]$$

In the special case where $\alpha 3 = 1.0$ (no error in NBD) the fact $\alpha 1 < 1.0$ assures that the percentage error in NMIG will be greater than that in N - N(-1).

A numerical example will help order magnitudes. For this example, let $\alpha 3 = 1.0$, $\alpha 2 = 1.01$, and $\alpha 1 = 0.5$. In this case, NBD is measured without error and accounts for one-half the true year-to-year change in population. Then NMIG = 1.02 · NMIG*. The percentage error in NMIG is double that of N - N(-1). If $\alpha 1 = 0.2$, NMIG = 1.05 · NMIG*.

Classical large sample errors-in-variables analysis suggests that measurement error in a dependent variable can be subsumed in the equation's random error term. If the measurement error is well behaved, the standard Gauss-Markov assumptions apply, if they did in the absence of measurement error. If the measurement error causes the Gauss-Markov assumptions to be violated, standard remedies such as Generalized Least Squares or some form of instrumental variables technique can be applied.[1]

If the sample is small, however, the problem is not so easily brushed off. In the case of annual net migration equations, sample sizes larger than thirty or forty are not often used. When they are, the problem of modeling structural change over long time periods enters the picture. In Alaska, net migration equations based on as few as fourteen annual observations are regularly used for forecasting and for policy simulation.[2] Given

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1. This is discussed in most econometric textbooks. See, for example, Johnston (4) or Malinvaud (7).

2. See Kresge and Siever (5), Reaume (9) and Siever (10).

such small samples, even relatively accurate estimates of population for inter-censal years can lead to major errors of measurement in net migration and highly misleading and unreliable econometric migration equations.[1]

ANOTHER ECONOMETRIC PROBLEM

The practice of using net migration as a dependent variable brings with it a problem other than measurement error. As Vanderkamp (12) has pointed out, the time period covered by the regression can have a significant influence on the estimates of the coefficients if the proportion of return migrants in the total varies over time. Vanderkamp emphasized simultaniety bias as the source of this problem. In brief, his point was that the existence of return migrants (people who had left the region and now are returning) can produce a net migration equation with variable coefficients.[2]

At this writing, the question of the proper choice of dependent variable in migration models is still being debated. At the very least, however, there is good reason to doubt the accuracy of coefficients estimated from a regression of net migration on its specified determinants.[3]

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[1] It is well known that errors-in-variables can be particularly troublesome in small sample situations where the sample weight on aberrant observations is relatively large.

[2] This problem can be solved in principle by modeling the coefficient structure or, if the variability is random, by using one of the methods of estimation discussed in Raj (8). To my knowledge, such steps have never been taken with respect to the net migration equation in regional models.

[3] On this, see also Kriesberg E.M. and Vining D.R., Jr. (6).

CONCLUSION

The central role played by the net migration equation in a regional econometric model and the unfortunate lack of time series data on gross migration flows, combine to dramatically lower the confidence one can have in individual simulations and forecasts.

Some, possibly most, regional models implicitly model migration by subsuming net migration and natural increase into a single regression of population on its determinants. While I have not explicitly considered that case here, it is clear that solving out for net migration in the population identity, [1], amounts to the same thing. The analysis here applies, therefore, to all regional models with endogenous population equations.

The cost of obtaining direct annual estimates of inter-regional gross migration flows would appear to be prohibitive. The Social Security Continuous Work History Sample (11) covers only job holders. A careful mingling of cross section results and time series regressions may prove to be the most cost effective solution to the problem. It may be possible to impose reasonable constraints on regional time series migration models after careful analysis of census and longitudinal data.

Whatever steps are taken it is clear that before policy prescriptions are offered, a range of sensitivity tests are called for. If simulation results are particularly sensitive to what can reasonably be judged to be minor changes in key parameters, then policy prescriptions should be appropriately hedged. It is not even enough that a particular simulation conform to one's a priori expections. Prejudice is hardly a firm basis for professional opinion.

APPENDIX

The variables used in the regressions of Section III are:

CPI	Consumer price index, all items, Anchorage, 1967 = 1.000. Source: U.S. Bureau of Labor Statistics.
E	Total nonagricultural wage and salary employment in Alaska, number of jobs. Source: Alaska Department of Labor.
EFED	Federal government nonagricultural wage and salary employment in Alaska, number of jobs. Source: Alaska Department of Labor.
N	Alaska resident population, millions of persons. Source: U.S. Bureau of Census.
NBD	Net births and deaths in Alaska, millions of persons. Source: Alaska Department of Health and Social Services.
NMIG	Defined by identity: $NMIG \equiv N - N(-1) - NBD$.
S	Spending in Alaska, billions of 1967 dollars, see below.
W	B.E.A. wage and salary disbursements in Alaska divided by E, billions of 1967 dollars per job. Source: U.S. Bureau of Economic Analysis (for wage and salary disbursements). $W \equiv WSD@AK/(CPI*E)$, where WSD@AK is B.E.A. Alaska wage and salary disbursement in billions of dollars.
WFED	Nonagricultural wage and salary payments to federal government workers in Alaska, billions of 1967 dollars. Source: Alaska Department of Labor.
WX	Same as W except defined for the U.S. as a whole.

Definition of S

The variable S is intended to be a measure of in-Alaska demand. As such, it is defined to have three components --- consumption, state and local government spending, and federal government spending. Measures of investment demand and net exports are omitted. Hence, an omitted variable problem exists. For the most part, however, this omission is characteristic of regional models. Furthermore, as a demand item, investment is a small component of the demand for Alaska produced goods and services. Most investment purchases by Alaskans are from out of state firms. Only construction wages and the change in inventories are likely to be large.

Prior to the startup of the flow of oil through the trans-Alaska pipeline (TAPS), Alaska probably ran a chronic trade deficit with the rest of the world. Since the startup of TAPS the reverse is undoubtedly true. To my knowledge, no attempt has been made to measure Alaska's balance of trade with the rest of the world (including other states in the U.S.). Hence, again, there is an omitted variables problem. However, as before, the omission parallels the assumption under which most regional models are built and thus, for the purpose of this paper, may be appropriate. Recall that the question asked in Section III is "How sensitive is a representative model to small changes in the values of key parameters?"

Alaska consumption spending, C, is defined by the following equation:

$$C = YD *(0.89 + .035 *E/E(-1)- .004 *YD/N)$$

Where the parameters are obtained from a regression of national consumption expenditure per dollar of national disposable personal income on national equivalents of the right hand side variables. The variable YD is Alaska resident personal income (B.E.A. definition) in billions of dollars less State, local and federal personal tax and nontax payments (B.E.A.) and less personal contributions for social insurance (B.E.A.). The national regression was run over the period 1961 to 1975 using annual data. The result was

$$\begin{aligned}(CUS/YDUS) = \underset{(6.2)}{0.89} + \underset{(0.25)}{.035} *EUS/EUS(-1) \\ - \underset{(-1.8)}{0.004} * YDUS/NUS\end{aligned}$$

$$\bar{R}^2 = .094$$
$$D.W.= 1.364$$

The variables CUS, EUS, NUS and YDUS are U.S. consumption, nonagricultural employment, population, and disposable personal income. The data sources are the U.S. Bureau of Economic Analysis (CUS and YDUS), the U.S. Bureau of Labor Statistics (EUS) and the U.S. Census Bureau (NUS). Care was taken to see that the units of measurement corresponded to those used for the Alaska variables.

The variable S was defined as follows:

$$S \equiv (C + WFED + SS\&L)/CPI$$

Where C and CPI are defined above and where:

> SS&L is total State and local government expenditure less State government intergovernmental expenditure, billions of dollars. The data were obtained from the Census Bureau's government series. Calendar year data were defined as the arithmetic mean of the partially overlapping fiscal year totals. i.e. SS&L(CY1974) = (SS&L(FY1974) + SS&L(FY1975))/2

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October 10, 1979

Electricity Requirements for the Railbelt

A Proposal by the Institute of Social
and Economic Research

total:
$60,000.00

Scope of Work

Detailed Work Plan

A. Methodological Review and Data Collection $5,000

Acres (WWC) + Energy Prove comments

Review methods available for projecting the level of economic activity in the railbelt and for estimating the level of electricity consumption. Review the existing work on both subjects with special reference to strengths and shortcomings and relevance to present study.

supporting choice of MAP model

Collect the economic and electricity consumption data required for the study. The economic data is readily available to the Institute, and it is only required that it be properly formatted for this study. The Institute has a large amount of historical data on electric power consumption in Alaska through 1974 which must be updated through more recent years. This data will be obtained directly from the utilities, the Alaska Public Utilities Commission, and the Federal Energy Regulatory Commission.

B. Economic Model Specification $10,000

Incorporate 1978 economic data into the Man-in-the-Arctic Program (MAP) econometric model which will be used to project economic activity in Alaska and the railbelt regions. The most recent economic data is important for providing the best information on the structure of the economy.

Develop a procedure which regionalizes the economic projections in a manner consistent with the three potential service areas of a Susitna hydroelectric facility. These regions will be:

1. Anchorage, Kenai Peninsula, Matanuska Valley Anchorage - Cook Inlet
2. Fairbanks and surroundings Tanana Valley
3. Glennallen and surroundings - Valdez

non-line areas

C. Economic Projections $8,000

public hearing
selected community

Develop the input scenarios required to run the economic model. Specify the assumptions upon which each scenario is built. Several alternative scenarios will be generated which will provide both a most likely case as well as a likely range of outcomes. The scenarios will include not only estimates of exogenous basic sector activity but also of state government activity. Oral presentation

Generate the economic projections from the scenarios. The projections will be by region and will be through the year 2005. The sensitivity of the results to both variations in the scenarios as well as the specification of the equations will be tested and reported. Brad writing report on assumptions

Prelim results. - interim report

interim

D. Assessment of Interfuel Substitution Possibilities $13,000

Conduct an econometric analysis of the sensitivity of electricity consumption to changes in prices of fuels and of income. This analysis will concentrate on the residential sector for which the best data is available. It is recognized that severe technical problems exist in attempting to estimate a "demand function" for electricity within Alaska, but the best and most appropriate techniques will be applied to this analysis. The results will be interpreted in relation to their relevance for the overall study objective.

Conduct an inventory-type analysis of interfuel substitution possibilities, again concentrating primarily on the residential component use. This study would attempt to define the relative fuel prices at which it becomes economically rational for consumers to substitute among fuels for various purposes. It will further attempt, on the basis of present and future inventories of durable goods used in energy-related functions, to determine the aggregate electricity-use impact such interfuel substitution could have. This analysis will concentrate on space heating which is the largest energy user in the home and which can be supplied by a variety of energy sources. This study will attempt to draw upon and integrate previous work done on this subject in Alaska and elsewhere.

regions

— electric space heating

— wood

E. Electricity Use Projections $14,000

Develop electricity use projections for the following categories of consumers:

1. Residential
2. Commercial
3. Non-self-supplied industrial
4. Self-supplied industrial, presently operating in railbelt market areas
5. Potential industrial consumers, not presently operating in the railbelt area

6. non-grid users

The projections, through the year 2005, will be for total kilowatt hours of electricity consumed. They will not include projections of peak load, capacity requirements, or the load curve over the year or for representative days during the ye Projections will be provided for each of the market areas described in Task B. Several electricity-use projections will necessarily be developed in order to incorporate the results of the analysis of interfuel substitutability. The sensitivity of projection results to this factor as well as to other factors affecting per-customer usage will be analyzed.

will be
interpreted
by
Ares

The analysis of electricity consumption requirements of potential industrial consumers will not be directly integrated into the results for other sectors since this is recognized to be a highly speculative and uncertain component of demand. Probable electric power requirements for more likely alternatives will be identified, but "scenarios" for such industrial development will not be generated. In this category will also fall estimates of energy requirements for unconventional uses of electricity such as railroad electrification.

The projections will be constructed in such a way that estimates of the impact of various conservation measures could be integrated into the analysis. Such measures would derive from other studies generated on a "per-user basis."

bad management

F. Assess Projection Probabilities $2,000

Subjectively evaluate the probability of each of the projections generated by a combination of an economic projection and an electricity-use projection. Choose a most likely case and analyze the sensitivity of that case to key economic and energy use factors.

Comparison with
previous forecasts
Power Adm.
Utilities
Batelle

As each task
is completed
a draft report
will be provided
to the project
director

G. Prepare Final Report $8,000

The final report will be written in nontechnical language with appendixes containing the required technical backup information necessary not only to critically evaluate the work but to serve as a guide for updating the analysis periodically.

The final report will include a discussion of all tasks outlined in the Scope of Work. It will specifically document the choice of methodology for the analysis including not only a discussion of its strengths but also of its weaknesses and indicating the proper interpretation of results that these weaknesses require.

Additional Considerations

A. Coordination

This analysis of electricity requirements forms a portion of a larger study of alternatives for supplying electricity to the railbelt market in future years. It is important for this analysis to be consistent with the requirements of this larger study and also for the methodology and assumptions used in the analysis to have as broad a consensus as possible. Thus, the Institute will seek to coordinate with the following groups and solicit suggestions and criticisms of methods and assumptions from them. Final decision on all matters discussed with regard to these efforts will remain with the Institute.

US
Army Corps of Engineers

1. Acres American Incorporated (or their representative) - review of methodologies used in economic projections and demand analysis.

2. Energy Probe (or other consultants of the project director's choosing) - review of methodologies used in economic projections and demand analysis.

3. Dr. Bradford Tuck (or other consultants of the project director's choosing) ~~--review the economic assumptions underlying the econometric model and its input scenarios.~~

4. Alaskan utilities - consultation concerning electricity demand projections.

B. Updating

The analysis will be conducted in a manner which, as much as possible, will allow for updating of the results in a straightforward and consistent manner as factors affecting the projections change over time. All relevant methodological steps will be outlined in technical appendixes to the final report.

C. Personnel

Principal Investigator for this project will be Dr. Scott Goldsmith. Also involved in the study will be Dr. Lee Huskey and Dr. Michael Scott. Resumes of these individuals are attached.

D. Period of Performance and Products

The period of performance shall run through June 30, 1980. A preliminary report of findings will be available March 1, 1980, for use during the legislative session. The final report with appendixes will be completed June 1, 1980.

February 15, 1979

push up

May 15, 1980

identify Schedule

E. Compensation and Method of Payment

The total cost for work specified under Tasks A through G will be $60,000. Payment will be on the basis of monthly billings to the committee. Included

Reimbursal for travel and state per diem for travel for data collection, coordination, and briefings will be at coach air fares.

Travel at the request of the committee will not $1,000.00

out of $60,000

reduce one other area

F. Project Director

The Project Director will be Rep. Brian Rogers. Coordination with the Alaska Power Authority + Div. of Energy + Power Dev. will be channeled through the legislative committee.

July 1979

OLIVER SCOTT GOLDSMITH

Assistant Professor of Economics
Institute of Social and Economic Research
University of Alaska
707 "A" Street, Suite 206
Anchorage, Alaska 99501
(907) 278-4621

RESUME

Education:

B.A., Economics, Princeton, 1967
M.S., Economics, University of Wisconsin, 1972
Ph.D., Economics, University of Wisconsin, 1976

Publications:

"A State Personal Income Tax Simulation Model," Annals of Regional Science, Vol. XIII, No. 1 (March 1979).

"Alaska's Revenue Forecasts and Expenditure Options," Alaska Review of Social and Economic Conditions, Vol. XV, No. 2 (July 1978).

"Alaska Electric Power Requirements--Review and Projections," Alaska Review of Business and Economic Conditions, Vol. XIV, No. 2 (June 1977).

"Market Allocation of Exhaustive Resources," Journal of Political Economy, Vol. 82, No. 5 (September-October 1974).

"1973 Survey of Energy Use in Wisconsin," with W. K. Foell, D. B. Shaver, and M. S. Caruso, Institute for Environmental Studies, Report #10, University of Wisconsin, Madison, Wisconsin (September 1973).

Reports:

"BAM3: A Fiscal Planning Model for Alaska," for State of Alaska, Office of the Governor, Division of Budget and Management, July 1979.

"The MAP Econometric Model of Alaska: A Documentation," for Alaska Outer Continental Shelf Office of Bureau of Land Management, June 1979.

"Energy Intensive Industry for Alaska," with Kent Miller, for State of Alaska, Division of Energy and Power Development, Department of Commerce and Economic Development, July 1978.

"The Alpetco Petrochemical Proposal: An Economic Impact Analysis," with Lee Huskey for State of Alaska, Legislative Affairs Agency, April 1978.

"Oil and Gas Consumption in Alaska: 1976-2000," with Tom Lane, for State of Alaska, Department of Natural Resources, January 1978.

"The Permanent Fund and the Growth of the Alaskan Economy: Selected Studies," with Lee Huskey for State of Alaska, Interim House Committee on the Permanent Fund, December 1977.

"Draft Regulations for Allocation of Federal Coastal Energy Impact Program," for State of Alaska, Department of Community and Regional Affairs, April 1977.

"Energy Consumption in Alaska, Estimate and Forecast," with Kent Miller, for State of Alaska, Department of Commerce and Economic Development, Division of Energy and Power Development, January 1977.

"Impact Problems and Intergovernmental Aids in Alaska," with Thomas A. Morehouse, for State of Alaska, Department of Community and Regional Affairs, November 1976.

"A Preliminary Overview of the Economic and Social Effects of the Proposed Northwest Gas Pipeline in Alaska," with John Kruse, Charles Logsdon, and Michael Scott, under contract for Gulf Interstate, Incorporated, Houston, Texas, June 1976.

"Electric Power in Alaska 1975-1995," with Arlon Tussing et. al., for State of Alaska, House Finance Committee, March 1976.

"Regulation of a Non-Renewable Resource: The Case of Natural Gas," Ph.D. Thesis, University of Wisconsin, 1976.

Papers:

"Structural Change in the Alaskan Economy: The Alyeska Experience," with Lee Huskey, presented at Alaska Section, American Association for the Advancement of Science, Fairbanks, Alaska, August 1978.

"Fiscal Planning and the Long-run Growth Pattern of Resource Based Open Economies," presented at Western Economic Association Annual Meetings, Kona, Hawaii, June 1978.

"Petroleum Tax Policy to Achieve Smooth Economic Growth in Alaska," presented at Pacific Northwest Regional Economics Conference, Seattle, Washington, May 1978.

"A Fiscal Model for Alaska: Structure and Policy Applications," presented at Western Economic Association Annual Meetings, Anaheim, California, June 1977.

"Fiscal Options and the Growth of the Alaskan Economy," presented at Pacific Northwest Regional Economics Conference, Eugene, Oregon, May 1977.

"Projecting Electricity Requirements in Alaska," presented at Alaska Section, American Association for Advancement of Science, Fairbanks, Alaska, August 1976.

"Future Electricity Requirements in Alaska," presented at Western Economic Association Annual Meetings, San Francisco, California, June 1976.

"Energy Shortages: The States Respond," invited paper with W. K. Foell and Paul Hayes. Presented at National Workshop on State and Local Decision Making on Energy Policy, Washington, D.C., sponsored by the Energy Policy Project of the Ford Foundation, September 1973.

"Oil and Gas: A Case Study of Institutional Irrationality," with Charles J. Cicchetti, presented at National Science Foundation RANN Energy Conference, M.I.T., February 1973.

Current Research Interests:

Optimal control in state financial planning, impacts of large projects on small economies, regional econometric modeling, Alaska energy demand, demand for subsistence activities, regulation of natural gas, geothermal energy resources.

Related Activities:

Teaching - Regional Economics

Consulting - Private and Nonprofit Legal Clients

Relevant Previous Employment:

Staff Economist, Nika Corp., 1619 Monroe, Madison, Wisconsin, 1975.

Consultant, State of Wisconsin Department of Revenue, Madison, Wisconsin, 1974.

Research Assistant, Environmental Defense Fund, Summer 1973.

Teaching Assistant, University of Wisconsin, 1973.

Volunteer, U.S. Peace Corps., Sarawak, Malaysia, 1967-1969.

Intern, Electricity Corporation of Nigeria, Lagos, Nigeria, Summer 1966.

Awards and Honors:

Ford Foundation Fellowship, 1971-1974
National Science Foundation Traineeship, 1970-1971
Graduated Cum Laude, Princeton

Foreign Languages: Russian, Indonesian, French

References:

Professor Charles Cicchetti, Department of Economics,
1180 Observatory Drive, University of Wisconsin,
Madison, Wisconsin 53706.

Professor Donald Nichols, Department of Economics,
(same as above).

Professor Leonard Weiss, Department of Economics,
(same as above).

References (continued):

Professor Wesley Foell, Department of Nuclear Engineering and Institute for Environmental Studies, University of Wisconsin, Madison, Wisconsin.

Professor Arlon Tussing, Institute of Social and Economic Research, University of Alaska, 707 "A" Street, Suite 206, Anchorage, Alaska 99501

Personal Information:

Date of Birth:	July 17, 1945
Marital Status:	Married; one daughter
Citizenship:	U.S.A.
Home Address:	5331 Sillary Circle Anchorage, Alaska 99504 (907) 337-2285

AUGUST 1, 1979

TERRY LEE HUSKEY

Assistant Professor of Economics
Institute of Social and Economic Research
University of Alaska
Anchorage, Alaska 99501
(907) 278-4621

RESUME

Education:

B.A., Economics, University of Missouri, 1969
M.A., Economics, Washington University, 1972
Ph.D., Economics, Washington University, 1977

Dissertation:

Park Characteristics and the Demand for Recreation Trips

Reports:

"Forecast and Analysis of the Cumulative Mean Case, Western Gulf of Alaska Impact Analysis", for the U.S. Bureau of Land Management, Alaska OCS Office, August, 1979.

"Western Gulf of Alaska Petroleum Development Scenarios, Economic and Demographic Impacts", with Will Nebesky, for the U.S. Bureau of Land Management, Alaska OCS Office, August, 1979.

"Design of a Population Distribution Model with William Serow, for the U. S. Bureau of Land Management, Alaska OCS Office, June, 1979.

"Northern Gulf of Alaska Petroleum Scenarios, Economic and Demographic Impacts", with Will Nebesky, for the U.S. Bureau of Land Management, Alaska OCS Office, June, 1979.

"The Growth of the Alaskan Economy: Future Conditions Without the Proposal" and "Northern Gulf of Alaska Statewide and Regional Population and Economic Systems Impact Analyses", with Will Nebesky, for the U.S. Bureau of Land Management, Alaska OCS Office, May, 1979.

"The Growth of the Alaskan Economy: Future Conditions Without the Proposal" and "Beaufort Sea Statewide and Regional Population and Economic Systems Impact Analysis" with Will Nebesky, for the Bureau of Land Management, Alaska OCS Office, December 1978.

"The Alpetco Petrochemical Proposal: An Economic Impact Analysis," with Scott Goldsmith for the Alaska State Legislature, April, 1978.

"Outer Continental Shelf Oil Development in the Beaufort Sea: The Economic Effects in Alaska," with Ed Porter, for the U.S. Bureau of Land Management, 1978.

"The Permanent Fund and the Growth of the Alaskan Economy: Selected Studies," with Scott Goldsmith for State of Alaska, Interim House Committee on the Permanent Fund, December, 1977.

Papers Presented:

"Structural Change in the Alaskan Economy: The Alyeska Experience," with Scott Goldsmith, presented at the 29th Alaska Science Conference, August 15, 1978.

"Congestion at Recreation Sites: Some Alternative Solutions," presented at the Western Economic Association Annual Meetings, Honolulu, Hawaii, June, 1978

Current Research:

Impact of resource development on developing regions, the effect of subsistence activities on the supply of labor, determinants of the price of land, capital markets in Alaska.

Teaching Interests:

Urban and Regional Economics, Economic Development, Microeconomics, Environmental Economics.

Previous Employment:

Economist, Planning Department, Municipality of Anchorage, Anchorage, Alaska, November 1974-October 1977.

Instructor, Microeconomics, Washington University, St. Louis, Mo., Summer 1974.

Instructor, Urban Economics, Washington University, St. Louis, Mo., Summer 1973.

Planning Intern, Municipality of Anchorage, Anchorage, Alaska, Summer 1972.

U.S. Army, Ft. Richardson, Alaska, October 1970-April 1972.

Awards or Honors:

University Fellow, Washington University, 1972-1974.

National Defense Education Act Fellow, Washington University, 1969-1970.

Phi Beta Kappa, University of Missouri, 1969.

References:

Professor Charles Leven, Dept. of Economics
Washington University, Lindell and Skinker
St. Louis, Missouri 63130

Professor Harold J. Barnett, Dept. of Economics
Washington University, Lindell and Skinker
St. Louis, Missouri 63130

Professor Edward Greenberg, Dept. of Economics
Washington University, Lindell and Skinker
St. Louis, Missouri 63130

Professor Lee Gorsuch, Director
Institute of Social and Economic Research
University of Alaska
707 A Street, Suite 206
Anchorage, Alaska 99501

Mr. William Beatty, former Director of Planning
Anchorage Municipality
Alaska Dept. of Natural Resources
Division of Lands
Anchorage, Alaska

Personal Information:

Date of Birth: September 8, 1947

Marital Status: Married, two children

Citizenship: United States

Home Address: 3628 Knik Dr.
Anchorage, Alaska 99503
(907) 272-4998

July 1979

VITA

Name: Michael James Scott

Date of Birth: January 5, 1948

Address: 6006 More Lane
Anchorage, Alaska 99504

Marital Status: Married;
one child

Office Telephone: (907) 278-4621

Citizenship: U.S.A.

Home Telephone: (907) 337-3546

Current Position: Assistant Professor of Economics; Institute of Social and Economic Research, University of Alaska, 707 "A" Street, Suite 206, Anchorage, Alaska 99501

Degrees:
B.A., Economics, Washington State University, 1970 (Highest Honors)
M.A., Economics, University of Washington, 1971
Ph.D., Economics, University of Washington, 1975

Dissertation Title: Some Implications of Petroleum Conservation Regulation

Fields: Natural Resources Economics, Regional Economics

Secondary Fields: Industrial Organization, Public Finance, Econometrics

Publications:

"Economic Criteria for Low Flow Standards," with James A. Crutchfield. Washington Water Research, Report No. 13, June 1973.

The Washington Baseline Study - Marine Economic Component, with James A. Crutchfield, Robert L. Stokes, and others. Institute for Marine Studies, University of Washington, 1975.

Alaskan Interregional Cost Differentials, Center for Northern Education Research, University of Alaska, 1977.

"Some Aspects of the Economic Impact of OCS Development in Alaska," Science in Alaska 1976. Volume II: Resource Development - Processes and Problems. Proceedings of the 27th Alaska Science Conference, Aug. 4-7, 1976. Alaska Division, American Association for the Advancement of Science, 1978.

"Analysis of the Costs of Delay in the Trans-Alaska Oil Pipeline Project," in Morehouse, Thomas A., et al. Fish and Wildlife Protection in the Planning and Construction of the Trans-Alaska Oil Pipeline. Fish and Wildlife Service Biological Services Program FWS/OBS-78/70 (Washington: U.S. Government Printing Office), October 1978.

The Permanent Fund and the Growth of the Alaskan Economy: Selected Studies. A report for the House Special Committee on the Alaska Permanent Fund. By Scott Goldsmith, with Lee Gorsuch, Lee Huskey, Mike Scott, and Arlon Tussing. Anchorage, Alaska: Institute of Social and Economic Research, December 15, 1977.

Practical Issues in Long Term Fiscal Planning for Alaska. Prepared under contract to the State of Alaska Division of Policy Development and Planning. Anchorage, Alaska: Institute of Social and Economic Research, April 1977.

Standards for Determining Child Support Obligations in Alaska. State of Alaska, Department of Revenue, Child Support Enforcement Agency, January 1978.

Southcentral Alaska's Economy and Population, 1965-2025: A Base Study and Projection. Final report of the Economics Task Force, Southcentral Alaska Water Resources Study (Level B) to the Alaska Water Study Committee. Institute of Social and Economic Research, January 31, 1979.

The Effects of Regional Population Growth on Hunting for Selected Big Game Species in Southcentral Alaska, 1976-2000. With William Alves, Thomas Lane, and Robert Childers. A Report for the Coastal Fish and Wildlife Resource Profile of Southcentral Alaska. U.S. F.W.S. Contract 14-16-0009-77-077. Arctic Environmental Information and Data Center, University of Alaska, August 4, 1978.

"Prices and Incomes--Alaska and the U.S." With Linda E. Leask. Alaska Review of Social and Economic Conditions, XV(3), December 1978.

Other Papers:

"Analysis of Economic and Social Impact of Alternative Routes to the Alaska Arctic Gas Pipeline: An Economic Analysis." Prepared for U.S. Department of Interior Bureau of Land Management Alaska Natural Gas Transportation System Task Force, Contract YA-512-CT6-68, December 1975.

"Electric Power in Alaska, 1975-1995." Report of the Electric Power Study for the State of Alaska, issued to the State House Finance Committee, Second Session, Ninth Legislature, State of Alaska, August 1976.

"Petroleum Conservation Regulation and the Economics of Oil Field Organization." Presented at the Western Economic Association 51st Annual Meeting, June 25, 1976.

"A Preliminary Overview of the Economic and Social Effects of the Proposed Northwest Gas Pipeline on Alaska," with O. Scott Goldsmith, John A. Kruse, Charles L. Logsdon. Contract to Gulf Interstate, Inc., of Houston, Texas, June 18, 1976.

"The Growth Consequences of Alternative Mineral Lands Leasing Policies." Presented at the Western Economic Association 52nd Annual Meeting, Anaheim, California, June 20, 1977.

"Behavioral Aspects of the State of Alaska's Operating Budget FY 1970 - FY 1977." An Analysis Funded by Legislative Affairs Agency, Alaska State Legislature and National Science Foundation Man in the Arctic Program, March 31, 1978.

"Fiscal Consequences of Energy Resource Development: Planning for Government Services in Alaska," Man in the Arctic Program Working Paper. Presented at the Western Economic Association 53rd Annual Meeting, Honolulu, Hawaii, June 22, 1978.

"Estimating Economies of Scale in Alaskan Industries." A paper presented to A Symposium on Economic Modeling in Alaska, Anchorage, Alaska, October 20-21, 1978.

"Estimating the Effects of Income Tax Reform on Development in Alaska." Presented at the Pacific Northwest Regional Economics Conference, Vancouver, British Columbia, May 4, 1979.

Current Research:

Institute of Social and Economic Research Man-in-the-Arctic Program. National Science Foundation.

Wealth Effects and Price Effects of Alaskan Growth. (Not funded)

Alaska Energy Policy Program. Ford Foundation.

Alaska OCS Impact Assessment. BLM, Alaska OCS Office.

References:

Professor James Crutchfield (Dissertation Chairman), Department of Economics, University of Washington, Seattle, Washington 98195.

Professor Gardner Brown, Department of Economics, University of Washington, Seattle, Washington 98195.

Dr. Robert L. Coughlin, Environmental Protection Agency, Region X, Seattle, Washington 98101.

Teaching and Research Experience:

Courses Taught:

Applied Price Theory, 1975	Federal Energy Administration Region X, Short Course
Introduction to Economics (Macro and Micro), 1973	Teaching Assistant (University of Washington)
Intermediate Price Theory, 1970	Teaching Assistant (Washington State University)

Research Experience:

Research Assistant for Professor James A. Crutchfield, University of Washington Department of Economics. Developed cost data and recommendations for the State of Washington Department of Ecology for managing streams and rivers at annual minimum flow.

Research Assistant for University of Washington Institute for Environmental Studies. Co-authored white paper on the economics of air and water pollution control costs for selected point sources in the State of Washington. Unpublished.

Student Assistant-Economist for Environmental Protection Agency, Region X, Seattle, Washington. Year-long project of reviewing technological literature and applying economic principles to derive costs of air pollution control for selected industries in EPA Region X (Washington, Oregon, Idaho, Alaska). Manuscripts available on request from Environmental Protection Agency, Region X, 1200 - 6th Avenue, Seattle, WA 98101.

Economist-Federal Energy Administration, Region X, Seattle, Washington, August 1974. Three-week project to help determine whether Alaskan oil could be absorbed on the United States Pacific Coast by displacing imports.

Predoctoral Researcher, Department of Economics, University of Washington. Co-researcher, Washington Baseline Study, which developed an environmental and economic baseline for Puget Sound of Washington State, to be used to evaluate impact of proposed industrial and petroleum development in the Pacific Northwest. Report, June 1975. Publication by Institute for Marine Studies, University of Washington, 1975.

Assistant Professor of Economics, Institute of Social and Economic Research, University of Alaska, Anchorage, Alaska.

Honors and Awards:

Phi Beta Kappa, 1969

Professional Memberships:

American Economic Association
Western Economic Association

A.5.2 - TASK 1: POWER STUDIES

(i) Task Objectives

To determine the need for power in the Alaska Railbelt Region, to develop forecasts for electric load growth in the area, to consider viable alternatives for meeting such load growth, to develop and rank a series of feasible, optimum expansion scenarios and finally to determine the environmental impacts of the selected optimum scenarios.

(ii) Task Output

The primary output of Task 1 will be a report dealing with the selection and ranking of optimum system expansion scenarios for the Alaska Railbelt Region. The final version of this report will be submitted for review and approval by Alaska Power Authority on or about Week 48 of the Study. Preliminary findings of the study will be discussed with Alaska Power Authority on or about Week 30 of the Study. Such a discussion will center on whether or not work on the Susitna Development should continue or whether another, possibly more viable alternative should be examined. Design Transmittals outlining intermediate stages of the power studies will also be issued as indicated on the logic diagram, Plate T1.1

(iii) List of Subtasks

Subtask 1.01 - Load Forecasting Methodology
Subtask 1.02 - Development of Load Growth Scenarios
Subtask 1.03 - Selection of Alternatives
Subtask 1.04 - Selection of Viable Expansion Sequences
Subtask 1.05 - Expansion Sequence Impact Assessments
Subtask 1.06 - Power Alternatives Study Report

(iv) Subtask Scope Statements

The primary purpose of Task 1 as discussed in Section (ii) above is the establishment and documentation of appropriate load forecasts for the Alaska Railbelt area and the development of optimum system expansion sequence scenarios to meet this forecast. The evaluation of these factors for the Railbelt Region and the relationship and scheduling of Task 1 to the remaining twelve tasks of the overall Plan of Study are illustrated in the master schedule, Plate A7.1. This portion of the study will be undertaken in essentially three parts. The initial phase will deal with the development of appropriate load forecast scenarios of low, medium and high peak loads. The second portion of Task 1 will deal with the development of optimum mixes and sequences of feasible alternative sources for meeting future power demands. These mixes will be developed with and without the Susitna Project, which at this stage will be assumed for study purposes to be that developed by the Corps of Engineers. The third section of the study will deal with the preliminary, comparative environmental and socioeconomic impacts of the developed optimum mixes on the Railbelt Region.

In order to meet the overall objectives of the Plan of Study as stated in Section A2 above, other activities of the program will proceed in parallel with Task 1. These will essentially involve Task 2 - Surveys and Site Facilities, Task 3 - Hydrology, Task 4 - Seismic Studies and Task 5 - Geotechnical Exploration. For logistical reasons, these activities will have been initiated on the assumption that the Susitna Project will be that which proves to be the optimum development for Alaska Power Authority. However, the Task 1 power studies may determine otherwise. Under such circumstances, the ongoing studies would be halted pending discussions with Alaska Power Authority to determine the future course of action most appropriate. On the other hand, should Task 1 studies confirm the earlier studies undertaken by the Corps of Engineers and others that the Susitna Project, with dams at Watana and Devil Canyon as the appropriate means of meeting future load growth in the Railbelt area, the study will continue as planned.

Subtask 1.01 - Load Forecasting Methodology

(a) Objective

Evaluate alternative forecasting methodologies in the context of the characteristics of the Alaska Railbelt Region, data requirements and availability, and select an appropriate method for load forecasting.

(b) Approach

Forecasting models can be divided into those based upon exponential growth models, those that employ multiple linear regression models and those which derive electrical demand as a result of multiplying estimates of customer usage by the number of customers.

An additional distinction can be made among the forecasting models according to whether the ultimate forecast is the result of a single component model in which annual peak demand is forecast directly, or a two-component model in which a base demand and a weather-sensitive demand are forecast separately and combined to determine the peak. A single component or a two-component model may be used by a utility employing a model in any of three categories listed above.

Much use will be made of econometric modelling work already undertaken in Alaska by the Institute of Social and Economic Research under the direction of Assistant Professors T.L. Husky and O.S. Goldsmith. Consideration will be given to using the Institute's econometric model or a modification of it in order to arrive at the most effective load forecasting tool.

(c) Discussion

The exponential growth models, despite fitting historical data extremely well, are not suitable for predicting the post 1973 growth. We will concentrate on examining several multiple regression models and derived demand models. Some of the candidate models include CILCO's derived-demand model, California's Energy Resources Conservation and Development Commission (ERCDC) model, and a current two-stage econometric model.

In evaluating the regression models, the three steps in their usage, namely model design, estimating the regression equations, and forecasting will be examined. Model design involves the selection of the independent variables and the formulation of the mathematical relationship between variables. The explanatory (independent) variables will be examined for their economic relevance.

Estimating the regression equation involves use of historical data. Limitations in these data may preclude the inclusion of variables even though they are relevant. Availability of data, as well as the regression model statistical validity will be examined.

The final step in using regression models involves the application of the estimated equation to forecasts for the explanatory variables and arrive at a forecast for the dependent variable. Note that the regression model requires forecasts for the explanatory variables before it can forecast the dependent variable. Thus the quality of the forecast for the dependent variable is contingent on the quality of other forecasts. While this may appear to be a significant limitation, the forecaster can test the sensitivity of the demand forecast to alternative assumptions about the future levels of explanatory variables.

In contrast to regression-type models, derived demand models do not rely upon observed macroeconomic relationships between demand for electricity and other variables. Rather, they employ a microeconomic approach and derive the total expected demand for electricity from the "bottom-up". In the simplest form, demand would be equal to the number of users of electricity times the expected usage per user. On a more sophisticated level, the users of electricity are broken down into many different categories (e.g., residential, industrial, commercial) and the consumption per user category is divided according to the source of the consumption (e.g., consumption by heating systems, refrigerators, etc.). Detailed demographic data are employed to determine trends in population growth and consumption patterns. Regression analysis is often used to determine the nature of many of the microeconomic relationships. Therefore, the above comments relating to multiple regression analysis may apply to derived demand models.

(d) Level of Effort

Task Force (WCC)	$40,000
Liaison and Review (Acres)	2,000
Total Subtask 1.01	$42,000

(e) Schedule

Weeks 0 through 10

Subtask 1.02 - Development of Load Growth Scenarios

(a) Objective

Derive a range of realistic load forecasts for the Alaska Railbelt Region through the year 2005.

(b) Approach

This subtask will be subdivided into four further work packages:

- Analysis of Energy Demand
- Scenario Generation
- Development of Forecasts
- Preparation of Design Transmittal

These packages will be undertaken essentially consecutively, the transmittal being used for the basis of input for subsequent development of Subtasks 1.04 and 1.05 activities.

(c) Analysis of the Energy Demand

This work package will consist of a detailed energy demand analysis to identify the main macro and micro socioeconomic, political, and technological factors (the energy demand determinants) which influence long-term evolution of energy demand in each of the different economic sectors in Alaska Railbelt area (i.e., residential, industrial, commercial, resale, and governmental).

The factors which influence demand include population, load management efforts, the electric rate schedule, voluntary conservation and reduction in utility demand due to direct usage of other forms of energy (i.e., solar, wind, geothermal), as well as weather and outside economic influences such as the price of substitute fuels, electrical appliances and machinery that use electricity, employment, labor force, wages and income, taxable sales, housing permits, and building insulation and appliance-efficiency standards. The possibility of the introduction of electric transportation systems will also be examined. These variables are relevant to the economic theory of energy use either directly or as proxies for the more frequently encountered variables for which data may not be available.

(d) Scenario Generation

In this work package, scenarios will be built based on a set of consistent and plausible assumptions and the likelihood of their occurrence will be assessed.

The use of scenarios is essential, as clearly the future of a society cannot be forecast over a long period of time. As a general rule, the scenario method implies a consistent description of a systems evolution by fixing, through exogenous assumptions, the evolution of certain variables characteristic of this system -- the scenario components. The difficulty lies in the selection of these components and in the formulation of consistent assumptions. To cope with this problem, the scenario components are first selected among the energy demand determinants (which have been identified in the first subtask) and organized in a hierarchical structure derived from the determinants' structure. Each scenario is based upon assumptions about the basic determinants describing a consistent pattern of development for the Alaska Railbelt.

The scenario generation is comprised of three steps:

- Construction of a scenario base - i.e., the identification and structure of the scenario components. Three types of basic determinants can be isolated, among which there are dependence relationships:

  (i) determinants describing the long-run trends of society,
  (ii) determinants characterizing the overall policy of public authorities and therefore the long-term orientation of societal development,
  (iii) determinants related to the energy supply (supply constraints, energy prices, availability of other energy sources).

- Specification of the scenario path - i.e., the defining of assumptions based on the evolution of all components so as to describe the various economic conditions of the system over time.

- Assessing the likelihood of occurrence of the various scenarios. The probability of the scenarios are computed by combining the single event probabilities of changes in the determinants. Sensitivity analysis is conducted to test how changes in the probabilities influence the ranking of the scenarios.

(e) Development of Forecasts

The final work package involves running the forecasting model under the different selected scenarios. The scenarios with the highest probability of occurrence are run first. The sensitivity of the forecast to changes in the determinants of the scenarios are determined.

The results of running the model under different scenarios are combined in a systematic manner to give a probability distribution over base and peak loads. The range can be broken down into different segments and the probabilities over these segments can be computed.

For a given scenario, a load duration curve is constructed by plotting against time the number of hours during which system demand exceeds a given level. The system energy demand is measured by the area under the load-duration curve. Combined wih the probability distributions over the scenarios, the probability distribution over energy demand can be constructed both for the annual demand and typical weekdays and weekend days of each month.

(f) Preparation of Design Transmittal

The design transmittal will document the results of Subtasks 1.01 and 1.02 activities, the sources of information and data used in the development of load forecasts, and present a recommendation for load growth scenarios to be considered in the development of alternative expansion sequences in Subtask 1.04.

(g) Level of Effort

Task Force (WCC)	$85,000
Liaison and Review (Acres)	3,000
Total Subtask 1.02	$88,000

(h) Schedule

Weeks 8 through 26

Subtask 1.03 - Selection of Power Alternatives

(a) Objective

Identify and select for evaluation purposes alternative power sources appropriate for inclusion in future Alaska Railbelt Region load-growth scenarios.

(b) Approach

This subtask will be subdivided into two further work packages:

- Non-hydro alternatives
- Hydro and tidal alternatives

These packages will be undertaken concurrently, non-hydro alternatives being developed by Woodward-Clyde Consultants, Anchorage and hydro and tidal alternatives by Acres American. Each package will include appropriate analyses to identify which (if any) energy sources would be viable alternatives to the Susitna Project. The evaluation will include an initial review of the March 1978 "Analysis of Future Requirements and Supply Alternatives for the Railbelt Region" published by Battelle Laboratories.

In deciding if a particular system or group of systems could be a viable alternative, five basic factors must be considered:

- Anticipated demand (location and amount) that the Susitna Project must supply,
- The maximum amount of power (or reduction in demand for power) that could be supplied to the Alaska Railbelt Region by each alternative,
- The cost per unit of electricity supplied by each alternative,
- Construction and licensing schedule of each alternative,
- The non-cost impact of implementing each alternative.

The intent will be to examine the widest possible range of alternatives while relying, as much as possible, on published data.

(c) Non-hydro Alternatives

The non-hydro alternatives to be examined include "traditional" energy sources such as coal or gas-fired steam turbines, combustion turbines (including combined cycle designs), diesel electric systems and nuclear power plants. (However, it is most unlikely that the nuclear alternative will receive serious consideration in Alaska) Studies undertaken to date for the Railbelt Region suggest that development of the Beluga and Nenana coal fields are likely to prove to be the largest viable alternative resources. Published data already developed by Woodward-Clyde Consultants on behalf of the Golden Valley Electric Association will be used in the proposed study. "Non-traditional" alternatives will include solar generation, wind, biomass, geothermal, and energy from wood and municipal waste. In addition, "non-structural" alternatives will be considered including time of day pricing, demand controls or more efficient use of existing system resources.

Consideration will also be given to the impact of possible changes in government policy with regard to uses of Alaskan natural gas, the possible "no-action" alternative and the construction of the Anchorage-Fairbanks transmission intertie alone, in lieu of the project.

(d) Hydro and Tidal Alternatives

The hydro alternative will not necessarily involve a single conventional hydro project and may consist of a group of smaller hydro projects with, for instance, a gas-turbine installation to provide firm capacity backup or some similar combination meeting the screening criteria--along with conservation measures which could serve to limit projected growth.

Within the Southcentral Railbelt of Alaska, the Susitna and Copper River drainage basins and other smaller rivers including Crescent, Chakachatna, Beluga, Yentna, Skiventna Chulitna, Talkeetna, Bradley (Creek) and Love were identified in the 1976 Alaska Power Survey by the Federal Power Commission as having significant conventional hydropower potentials. This study identified 23 projects, including Devils Canyon, Watana and Vee on the Susitna, with a potential installed capacity for all 23 sites of 8,419 megawatts. There are currently indications that the 70 MW Bradley Lake Project in the Kenai Peninsula may be developed in the foreseeble future. Current studies are also being undertaken by the Alaska Power Administration to identify "small hydro" potential.

The above references, in addition to other earlier work by the Bureau of Reclamation and Corps of Engineers and the most recent National Hydropower Study inventory by the Corps of Engineers, will be used to develop an overall scope of available hydro potential in the region. The sources will also be used to develop a specific alternative which could satisfy projected load demands at least as well as the Susitna Project. Published reports on the potential for development of the tidal power resources of the Cook Inlet Region will also be reviewed for consideration of this alternative.

(e) Discussion

This analysis of alternatives requires input from the task of forecasting electric load. The estimated demand, including amount, location and time distribution of demand, will be used as a basis for evaluating alternatives.

Concurrent with the demand estimation phase, an evaluation will be made of the amount of energy that can be supplied by each of the technologies considered. This will involve a preliminary review of the estimated amount of each energy resource available in Alaska, including such items as coal and oil reserves, solar, wind and tidal patterns and geothermal as well as other hydroelectric resources. The estimates for developing technologies will also include the availability date for commercial use. Preliminary cost estimates will be developed for each technology (cost/unit energy) based on the many existing studies (for example see "California Electricity Generation Methods Assessment Project", 1976). These cost estimates may vary with the amount of energy delivered, reflecting the necessity to use scarcer and scarcer resources.

The supply estimates for each alternative will be compared with the projected demand to determine what percentage of the demand each alternative can meet. It may be that some alternatives cannot supply any of the demand at reasonable cost. These can be immediately eliminated from consideration. Or, it may be that a technology is cost effective but cannot meet the total expected demand. In this case, several such technologies could be combined to make a single alternative system to compare with the Susitna project.

The most viable technologies (or groups of technologies) will then be reduced to a set of well-defined power generation alternatives for more detailed analysis. The analysis will include a detailed cost analysis of each alternative (still based primarily on published studies). This cost analysis will include capital costs (including transmission system), operation, maintenance and fuel costs, capacity factor estimation and potential for concurrent operations such as waste heat distribution. The emphasis will be on consolidating and correlating information from various sources to allow a consistent comparison of alternatives.

A scheduling analysis will be conducted to determine when the technology(s) for the alternative will be available and what leadtimes are necessary for construction. Finally, a comprehensive evaluation will be made to identify the non-cost impacts of each alternative. These impacts are likely to include environmental impacts (air quality, water quality and ecology); public health and safety impacts; socioeconomic impacts (such as a "boom-bust" cycle of population during plant construction); and the licenseability of specific alternatives to the extent that no insurmountable legal or environmental barriers are evident.

Non-cost concerns will be organized into a set of attributes for measuring the overall desirability of each alternative and combined with cost and scheduling concerns to evaluate each alternative.

These attributes will be designed to cover the range of identified concerns while not overlapping with one another. Each attribute will have an associated scale (or measure) to identify the level of achievement of each alternative with respect to each attribute.

Scales will be designed to be meaningful to decision makers and to be measurable using existing data as much as possible. If no natural scale (such as dollars for the cost attribute) exists, constructed (judgmental) scales will be used. The results of this analysis can be presented in a matrix showing the level achieved on each attribute for each alternative.

(f) Level of Effort

Task Force (WCC)	$65,000
Task Force (Acres)	20,000
Task Force (TES)	10,000
Liaison and Review (Acres)	2,000
Total Subtask 1.03	$97,000

(g) Schedule

Weeks 20 through 35

Subtask 1.04 - Selection of Viable Expansion Sequences

(a) Objective

Determine the total system costs of selected future Railbelt Region expansion sequences, both with and without incorporation of the Susitna Hydroelectric Project, and rank the preferred generation expansion scenarios.

(b) Approach

The most straightforward method of evaluating the potential economic benefit of a hydroelectric project in a given system expansion scenario is to compare capital investment and system operating costs on an annual basis, throughout the term of the study, for two scenarios: one without the benefit of the proposed hydro project; the other with it.

A number of mathematical models are available to facilitate the vast number of calculations involved in this type of study. In simplified terms, the user of such a model provides the program with data which includes the characteristics of the forecasted load and the characteristics, availability and costs of generation sources which will be available throughout the period of the study. The model then selects the generation sources available to it to satisfy the projected load in the most economical manner.

To evaluate the economics of a given project, a comparison may be made of total annual costs of the two system scenarios on a year-by-year basis throughout the study period. If the system with the hydro project available is less costly throughout the planning period, the project is obviously attractive. Conversely, if this system is more expensive in all years, then the project is unattractive.

It is possible, indeed likely, that the outcome of an economic evaluation would prove not to be so clear cut. It may be that the system incorporating the hydro plant would be more expensive in some years of the study, and less expensive in others, than the system without that project. In this situation, it would be necessary to perform comparisons between present worth values of operating costs for systems represented by the two scenarios.

good

Although such a strategy may provide a valid economic comparison, the results may be inconclusive. This is likely to occur in the case of a hydro project which has a capacity which is relatively small when compared to its connected system. The economic comparisons then may be a relatively small difference in two very large numbers.

(c) Selection of Model

In the search for a usable generation planning computer model, three characteristics of the model are paramount:

- Flexibility -- does the model allow for a varied combination of alternatives?
- Accessibility -- is the model presently available and can it be used with a minimum of learning time?
- Reliability -- is the model actively maintained by its supplier and has it been used by other utility planners?

A preliminary survey of the market has revealed one model which satisfies all three criteria. Other models may be available, but these are generally developed either by or for specific utilities to solve their particular problems or they are so intricate so as to require special training in their use.

The computer model selected by Acres for this study is the General Electric Optimized Generation Program, Version Five (OGP-V). Acres' staff are familiar with the use of this program on other studies similar to the Susitna alternatives evaluations. The model is currently in use for the evaluation of small hydro sites in the eastern U.S. Earlier versions of the model, OGP-III and OGP-IV were used in studies performed for the U.S. Army Corps of Engineers in evaluating alternatives for New England Power Supply scenarios through the year 2000. This study was part of the Environmental Impact Statement for the proposed 944 MW Dickey-Lincoln School Lakes Project in Maine.

Development of input data and operation of the OGP-V model is unavoidably costly and time-consuming. Thus, to facilitate the initial development of viable expansion mix scenarios, use will also be made of an Acres in-house "Generation Planning Program". The results of this initial analysis will permit the preliminary ranking of alternative generation expansion sequences in order of economic preference. Tests will be undertaken at this time on the preferred expansion sequences in order to check the sensitivity of the economic ranking to variations in:

- load demand forecast
- capital cost estimates
- fuel cost escalation
- discount rate.

As a result of this analysis, it will be possible to prepare a "short list" of preferred generation expansion sequences for more detailed analysis using OGP-V.

(d) OGP-V

The OGP-V program combines three main factors of the generation expansion planning decision process: system reliability evaluation; operations cost estimation; and investment cost estimation. The program begins by evaluating the power system reliability in the first study year by means of one of two methods -- either a percent reserves calculation or the computation of the loss of load probability (LOLP).

When the system demand level rises to the point at which either the user-specified reserve level or the LOLP criteria is violated, the program "installs" new generating capacity. The program will add generation capacity from a user-provided list of available sources. As each possible choice is evaluated, the program carries out a production cost calculation and an investment cost calculation, and eliminates those units or combinations of units whose addition to the system results in a higher annual cost than other units or combinations. The program continues in this manner until the least-cost system addition combination is determined for that year. In cases where operating cost inflation is present, or where outage rates vary with time, OGP-V has a look-ahead feature which develops levelized fuel and O&M costs and mature outage rates out to ten years ahead of the "present" time. Once the apparent least-cost additions to the system necessary to satisfy reserve or LOLP criteria have been established, the process is repeated for the next succeeding year of the study.

(e) Discussion

Load forecasting and daily load variation data generated in Subtask 1.02 will be used as input to the computer model together with the following technical and economic planning criteria:

- generation capacity and energy reserve requirements
- retirements of older units
- cost of money
- economic discount rate
- insurance and tax rates
- economic lifetime of equipment
- effects of cost escalation
- period of analysis

This data will be established in consultation with Alaska Power Authority, other utilities in the Railbelt Region and other pertinent agencies. Some of the above parameters, such as the discount rate, and perhaps cost escalation, will be determined as base rates with a possible variation over a given range. The analysis will be carried out at the base rate with sensitivity testing over the possible range for selected alternatives.

One of the benchmarks against which the economics of a power generating facility may be measured is the economics of its alternatives. In many cases, it is possible to identify specific alternatives against which a given project may be directly compared. Most generating projects are intended for a specific operating regime within the power system, such as base-, intermediate-, or peak-load operation. For such sources, it is a relatively straightforward task to evaluate the cost of operating a specific alternative.

Hydroelectric projects, due to their hydrologic characteristics, must be evaluated in a somewhat different manner. A hydro project can be subject to significant seasonal variations in its generation capacity. Factors such as rainfall patterns and springtime snowpack runoff can work to make baseload and peaking benefits available from the same hydroelectric project. Also, although initial studies of the Devil Canyon-Watana installations were based upon a fifty percent annual capacity factor (1,394 MW, 6,100,000 MWh/yr), some base-load (greater than 80 percent capacity factor) and some peak-load (less than 10 percent capacity factor) energy can be expected to be available. The way in which such additional capacities become available complicates the evaluation of a hydroelectric project.

Conventional base-load plants such as coal-fired or nuclear steam plants are commonly built to take advantage of the economies of scale available to large plants of this type. Conversely, peaking plants are usually relatively small (less than 100 MW). The base-load energy produced by even a large hydro plant may be available only at such a small capacity as to make comparison with the conventional alternatives meaningless. For example, if the Susitna project, with its 1,394 MW output at 50 percent can produce only 125 MW at capacity factors greater than 80 percent, it is difficult to make comparisons with base-load nuclear or coal plants with capacities on the order of 500 MW or larger. In the same sense, hydrologic conditions may make a great deal of capacity available at a given site for very short periods of time as peaking energy. Such large amounts of surplus energy may make meaningful comparisons between the hyro project and its conventional alternatives (combustion turbines) difficult.

Thus, the Susitna Project will be evaluated in the light of its effect upon the mix of alternatives in the power system and any possible deferment of capital expenditures for other facilities. To properly take into account the capacity variations of the project, its operation within a power system will be analyzed on a monthly, or at least a seasonal, basis. More detailed analyses could be performed to define exact operating procedures, but such detail is not justified in a long-term planning study.

(f) Level of Effort

Task Force (Acres) $30,000

(g) Schedule

Weeks 26 through 40

Subtask 1.05 - Expansion Sequence Impact Assessments

(a) Objective

Compare from an environmental standpoint, the consequences of developing the selected alternative expansion scenarios in the Alaska Railbelt Region, including historical, socioeconomic and other factors.

(b) Approach

The approach to review and assessment alternatives will be to primarily utilize existing data, and available aerial photography of the selected or potential source sites whenever and wherever sufficient information is already available. However, it may be necessary to gather limited site-specific data for the assessment, since the environmental resources of many of the more remote portions of the study corridor have not been inventoried. The key to this approach is the use of staff who have an in-depth knowledge of both fish and wildlife habitat requirements and the short-term and long-term effects of impact-producing actions of construction and operation of various facilities in Alaska.

The environmental consequences of developing alternative energy sources are highly dependent upon numerous factors including energy resource, collection method, site location characteristics, site fish and wildlife characteristics, land-use patterns, and facility construction and operation designs. A thorough assessment of the impacts of optimum generation expansion mixes is also dependent upon an understanding of the habitat requirements of local fish and wildlife during their life history; a knowledge of limiting habitat factors; and sensitivities such as fish overwintering areas, and nesting and feeding habitats of endangered or threatened fauna.

The significant impact-producing actions will vary with the alternative being assessed. At times, the selected site location will be the prime factor, while for other alternatives, the short-term or long-term air quality or water quality perturbations, or wildlife habitat degradation may be the overriding factor. Some of the more significant potential concerns are discussed below.

The environmental evaluation of the selected hydroelectric and tidal power development alternatives (if any) will identify the associated potential impact issues, and their relative magnitudes. Such issues will involve the relative sizes of reservoirs and impacts on water quality and fish and wildlife habitats in particular. The environmental analysis will be performed on the basis of available data, which will be compiled for this purpose. For the Task 1 studies, the comparative impact issues associated wtih the Susitna Project already identified in the current Corps of Engineers EIS, will be used as the yardstick against which all other alternatives will be measured. Transmission facilities associated with the hydro alternative sites will be included in this environmental analysis.

The intensity of analysis required for comparison of the hydroelectric alternatives will be less than that required for the primary alternative. Field investigations will not be undertaken to identify the potential magnitude of impacts of the alternatives.

With coal-fired power plants, such as those associated with the Beluga and Nenana fields, the collection of large quantities of coal through surface mining would create environmental concerns. These concerns are related primarily to large-scale, long-term habitat alterations affecting fish and wildlife. The operation of coal-fired plants would also create problems relating to air quality, cooling water discharges, and run-off from fly ash ponds. However, plants can be designed to successfully mitigate these concerns.

New gas or oil-fired power plants require construction of pipelines that at least lead to short-term concerns associated with river crossings, wetlands disturbance, and habitat alterations. On-site facilities can cover large acreages, and operation can create air quality problems related to nitrogen emissions and winter steam plumes.

Wood-produced energy would also cause air quality problems such as those currently found in the Fairbanks area. Such plants would furthermore require clear-cutting of vast acreages of timber. This is not considered environmentally wise due to the slow regeneration times required for timber production and hence would lead to long-term wildlife habitat alterations. Potentially severe impacts to stream habitats and local fish populations would also result.

(c) Land and Water Use

Land ownership in the vicinity of the alternatives will be identified as federal (including agency jurisdiction), state, private and Native Corporation. Land ownership status may be in transition due to the Alaska-Native Claims Settlement Act and State Selection under the Statehood Act. Land management plans and regulations affecting alternatives will be evaluated. The various federal and state agencies, and some Native Corporations will have land classification and management systems governing activities that are allowed on those lands and waters being managed. Stipulations concerning allowable activities could affect the feasibility of alternatives to Susitna. Land and water use patterns (historical, current and proposed) will be documented in order to evaluate impacts and potential use conflicts posed by Susitna alternatives.

Unique features in the vicinity of alternative projects, such as recreation areas and aesthetic/visual resources, also will be identified. The presence of popular recreation areas or unusual aesthetic quality may present impact and feasibility problems, particularly when on public lands.

(d) Socioeconomic Characteristics

Demographic data, historic, current and projected, will be evaluated to estimate the impact created by the influx of construction and operations work forces. Employment characteristics of the work force in the vicinity of alternative projects will also help evaluate positive and negative impacts created by project implementation. This information would include employment and unemployment by region and skill classification, and wage rates (also regional and skill specific).

Financial characteristics of any borough or municipal governments in alternative project areas will be considered. Tax revenue, mill rates, and tax base data will help estimate potential impacts. Housing characteristics, such as available stock (including rental units) and vacancy rates, will be utilized for impact evaluation. Community infrastructure could be impacted by implementing alternatives to the Susitna project. Current loads on infrastructural systems (i.e., electricity, water, sewage) service areas, and system capacity will therefore be considered.

Transportation systems potentially affected by project alternatives will be identified. Data will include current traffic estimates, capacity, area of service, and intermodal connections.

Sociocultural characteristics could be an issue in several project areas. Life style, ethnic traditions and subsistence use patterns of biological resources will be documented.

(e) Archaeological and Historical Resources

Existing archaeological and historical sites will be inventoried in alternative project areas, as available data allow. The State Historical Preservation Office maintains a statewide file of known sites and will be utilized in this effort.

(f) Level of Effort

Task Force (WCC)	$ 90,000
Task Force (TES)	45,000
Liaison and Review (Acres)	3,000
Total Subtask 1.05	$138,000

(g) Schedule

Weeks 30 through 45

Subtask 1.06 - Power Alternatives Study Report

(a) Objective

Prepare power alternatives study report for Susitna Hydroelectric Project.

(b) Approach

The power alternatives study report will address:

- Load forecasting for the Railbelt Region
- Selection of alternative energy and/or power generation scenarios
- Evaluation of viable expansion sequence scenarios
- Recommended expansion sequence

The report will document the findings of Subtasks 1.01 through 1.05 and incorporate the transmittal prepared under Subtask 1.02.

(c) Discussion

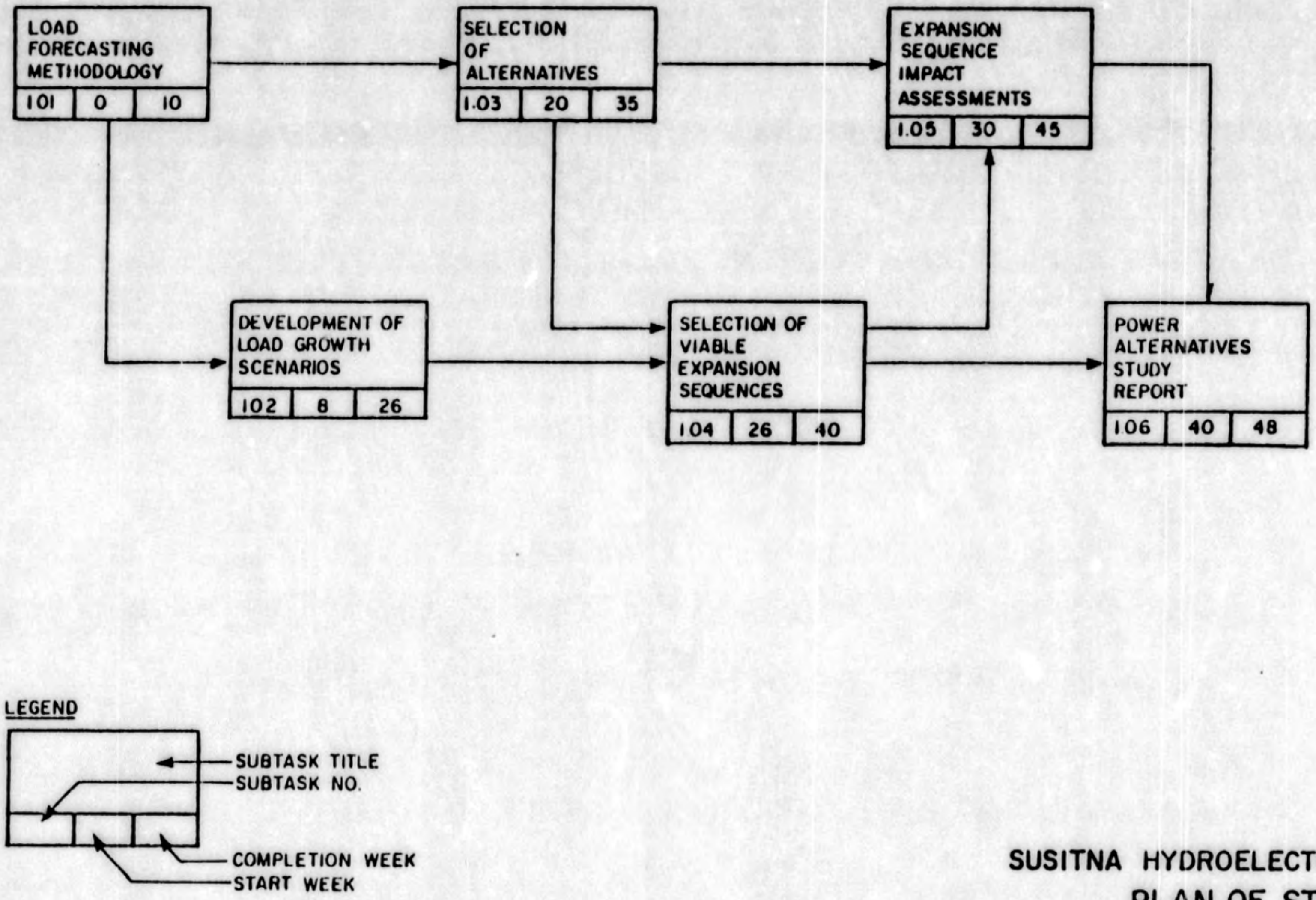
This report will seek to address the fundamental issues of the "need for power" and selection of the optimum future Railbelt Region electrical power supply scenario through the year 2005. If the Susitna Project is to be justified as a viable and licensable development, this report has to provide the fundamental basis for such justification. The report will initially be prepared in draft form for submission to Alaska Power Authority for review, and subsequently made available to all concerned parties for comment and discussion under the Task 12 Public Participation Program.

(d) Level of Effort

Task Force (Acres)	$12,000

(e) Schedule

Weeks 40 through 48



SUSITNA HYDROELECTRIC PROJECT

PLAN OF STUDY

PLATE T1.1: TASK 1 LOGIC

ATTACHMENT

1. Scope of Work

A. Methodological Review and Data Collection $5,000

Review methods available for projecting the level of economic activity in the railbelt and for estimating the level of electricity consumption. Review the existing work on both subjects with special reference to strengths and shortcomings and relevance to present study. Prepare a detailed work plan for review by the Project Director or consultant of his choice.

Collect the economic and electricity consumption data required for the study. The economic data is readily available to the Institute, and it is only required that it be properly formatted for this study. The Institute has a large amount of historical data on electric power consumption in Alaska through 1974 which must be updated through more recent years. This data will be obtained directly from the utilities, the Alaska Public Utilities Commission, and the Federal Energy Regulatory Commission.

B. Economic Model Specification $10,000

Incorporate 1978 economic data into the Man-in-the-Arctic Program (MAP) econometric model which will be used to project economic activity in Alaska and the railbelt regions. The most recent economic data is important for providing the best information on the structure of the economy.

Develop a procedure which regionalizes the economic projections in a manner consistent with the three potential service areas of a Susitna hydroelectric facility. These regions will be:

1. Anchorage-Cook Inlet
2. Fairbanks-Tanana Valley
3. Glennallen-Valdez

C. Economic Projections $8,000

Develop the input scenarios required to run the economic model. Specify the assumptions upon which each scenario is built. Several alternative scenarios will be generated which will provide both a most likely case as well as a likely range of outcomes. The scenarios will include not only estimates of exogenous basic sector activity but also of state government activity. A workshop will be held in early December to familiarize the Project Director with the scenarios and to obtain suggestions regarding corrections and additions to scenarios from invited experts on the various sectors of the Alaskan economy.

Generate the economic projections from the scenarios. The projections will be by region and will be through the year 2005. The sensitivity of the results to both variations in the scenarios as well as the specification of the equations will be tested and reported.

D. Assessment of Interfuel Substitution Possibilities $13,000

Conduct an econometric analysis of the sensitivity of electricity consumption to changes in prices of fuels and of income. This analysis will concentrate on the residential sector for which the best data is available. It is recognized that severe technical problems exist in attempting to estimate a "demand function" for electricity within Alaska, but the best and most appropriate techniques will be applied to this analysis. The results will be interpreted in relation to their relevance for the overall study objective.

Conduct a case study-type analysis of interfuel substitution possibilities, again concentrating primarily on the residential component use. This study will attempt to define the relative fuel prices at which it becomes economically rational for consumers to substitute among fuels for various purposes. It will further attempt, on the basis of present and future inventories of durable goods used in energy-related functions, to determine the aggregate electricity-use impact such interfuel substitution could have. This analysis will concentrate on space heating which is the largest energy user in the home and which can be supplied by a variety of energy sources. It will attempt to define the limits of substitution possibilities by investigating the extreme cases of all electric space heating and all gas (or other nonelectric alternative) space heating in the residential sector. This study will attempt to draw upon and integrate previous work done on this subject in Alaska and elsewhere.

E. Electricity Use Projections $14,000

Develop electricity use projections for the following categories of consumers:

1. Residential
2. Commercial
3. Non-self-supplied industrial

4. Self-supplied industrial, presently operating in railbelt market areas

5. Potential industrial consumers, not presently operating in the railbelt area

6. Residential and commercial electricity users who cannot be integrated into the urban power grid.

The projections, through the year 2005, will be for total kilowatt hours of electricity consumed. They will not include projections of peak load, capacity requirements, or the load curve over the year or for representative days during the year. Projections will be provided for each of the market areas described in Task B. Several electricity-use projections will necessarily be developed in order to incorporate the results of the analysis of interfuel substitutability. The sensitivity of projection results to this factor as well as to other factors affecting per-customer usage will be analyzed.

The analysis of electricity consumption requirements of potential industrial consumers will not be directly integrated into the results for other sectors since this is recognized to be a highly speculative and uncertain component of demand. Probable electric power requirements for more likely alternatives will be identified, but "scenarios" for such industrial development will not be generated. In this category will also fall estimates of energy requirements for unconventional uses of electricity such as railroad electrification.

The projections will be constructed in such a way that estimates of the impact of various conservation measures could be integrated into the analysis. Such measures would derive from other studies.

F. Assess Projection Probabilities $2,000

Subjectively evaluate the probability of each of the projections generated by a combination of an economic projection and an electricity-use projection. Choose a most likely case and analyze the sensitivity of that case to key economic and energy-use factors. Compare the results of the analysis to previous work.

G. Prepare Final Report $8,000

The final report will be written in nontechnical language with appendixes containing the required technical backup information necessary not only to critically evaluate the work but to serve as a guide for updating the analysis periodically. As Tasks A and C are completed, a draft of each will be written and made available to the Project Director.

The final report will include a discussion of all tasks outlined in the Scope of Work. It will specifically document the choice of methodology for the analysis including not only a discussion of its strengths but also of its weaknesses and indicating the proper interpretation of results that these weaknesses require.

2. Additional Considerations

A. Coordination

This analysis of electricity requirements forms a portion of a larger study of alternatives for supplying electricity to the railbelt market in future years. It is important for this analysis to be consistent with the requirements of this larger study and also for the methodology and assumptions used in the analysis to have as broad a consensus as possible. Thus, the Institute will seek to coordinate with the following groups and solicit suggestions and criticisms of methods and assumptions from them. Final decision on all matters discussed with regard to these efforts will remain with the Institute.

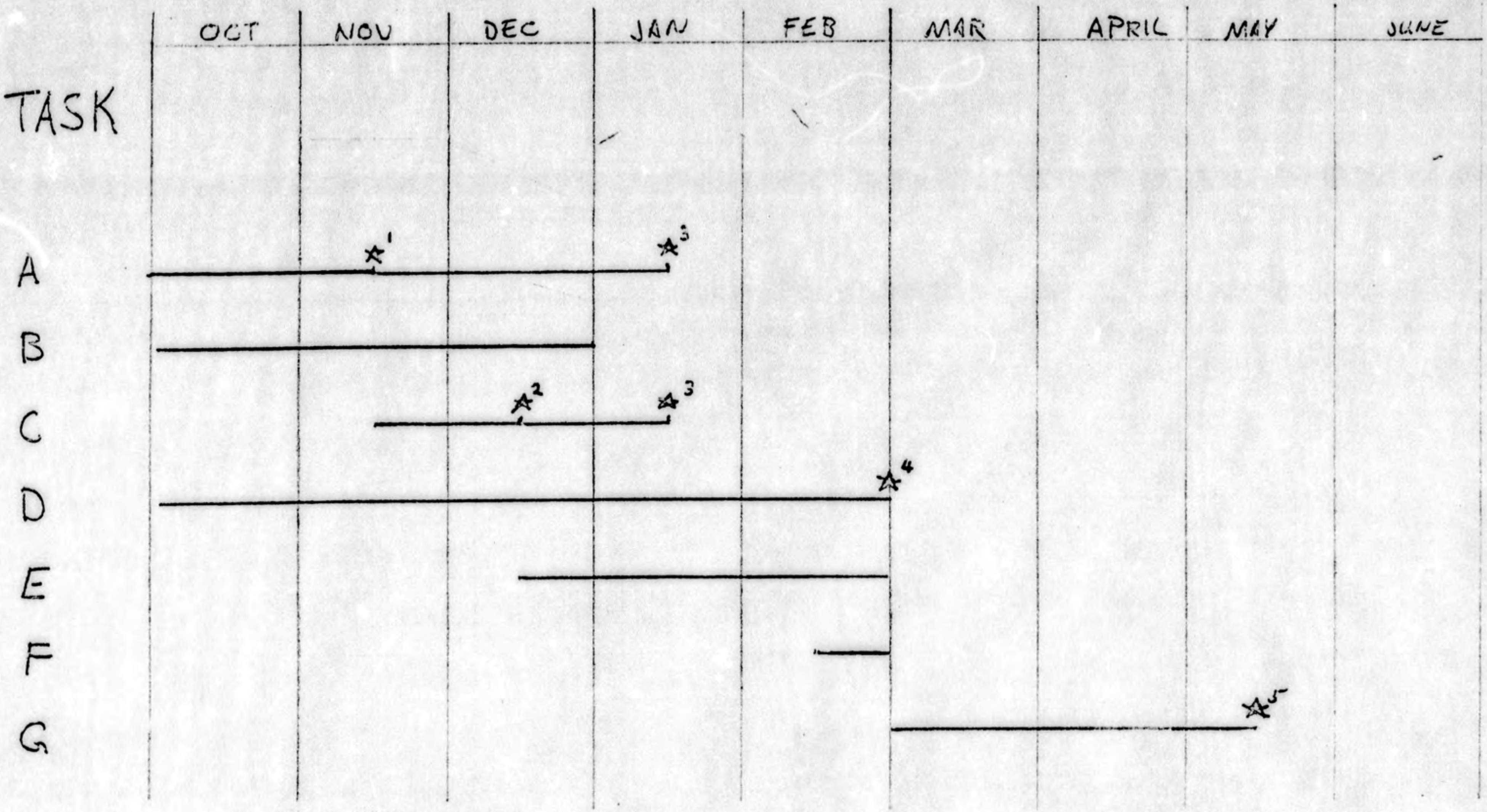
1. The Army Corps of Engineers (or their representative) or Acres American Incorporated (or their representative) - review of methodologies used in economic projections and demand analysis.
2. Energy Probe (or other consultants of the Project Director's choosing) - review of methodologies used in economic projections and demand analysis.
3. Dr. Bradford Tuck (or other consultants of the Project Director's choosing) - review the economic assumptions underlying the econometric model and the demand analysis.
4. Other consultants of the Project Director's choosing.
5. Alaskan utilities - consultation concerning electricity demand projections.
6. Center for Policy Studies - consultation concerning conservation possibilities.

In addition, the study will coordinate with the Alaska Power Authority and the Division of Energy and Power Development through the Project Director or his representative.

B. Updating

The analysis will be conducted in a manner which, as much as possible, will allow for updating of the results in a straightforward and consistent manner as factors affecting the projections change over time. All relevant methodological steps will be outlined in technical appendixes to the final report.

PROJECT SCHEDULING



1 Detailed work Plan
2 Input Assumptions Workshop
3 Tasks A & C reports
4 Interim Report
5 Final Report

☆ DATES WHEN PRODUCTS DUE.

A PRELIMINARY EVALUATION

OF

THE I.S.E.R. ELECTRICITY DEMAND FORECAST

(Working Paper #1)

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(416) 978-7014

In October 1979, Energy Probe was asked by The House Power Alternatives Study Committee (HPASC) of the Alaska State Legislature to submit a proposal for a study that would evaluate the electricity demand forecasting method developed by the University of Alaska's Institute for Social and Economic Research (ISER). This report is the first of three to be prepared by Energy Probe, and presents an initial evaluation of the ISER forecasting model and the Man in the Arctic Project (MAP) model on which, in part, the electricity demand forecast is based.

The present report draws on information contained within the Detailed Work Plan submitted November 14, 1979 by Dr. Scott Goldsmith of ISER; May 1979 MAP model documentation; various publications relevant to the future social and economic activity in the state of Alaska; and personal discussions with ISER personnel.

Further reports in this series will deal with the sensitivity of electricity growth in the Railbelt region of Alaska to policy and market induced changes in the social, economic and physical factors which influence electricity growth; and with an analysis of the appropriate role and interpretation of electricity demand forecasts within the broader context of state energy policy development.

Because this report is a working document intended only for use by HPASC members and consultants, it is written in relatively technical language. Our final report, to be prepared by May 1980, will detail the three areas mentioned above in less technical language.

The views expressed herein are those of the authors, and not necessarily the House Power Alternatives Study Committee.

for more information:

Mike Witton, coordinator

House Power Alternatives Study,

465-3711, 3779

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1. INTRODUCTION

Electricity demand forecasting, like all quantitative forecasting, is an effort to view the past and present in a systematic way with a view towards making reasonable statements about the future. The basic problem is that the future is not known, and indeed cannot be known, even in a probabilistic sense. As a matter of fact, pretending to forecast the future is an indictable offence under the New York State criminal code. 1. Similar provisions, we are certain, are in effect elsewhere.

However, analysts often find it necessary to fly in the face of strict legality when the viability of a large project hinges on the need for it in the future. Hence, forecasting has become an integral part of planning for investments in energy, transportation, housing and a myriad of other functional service delivery areas. Forecasting the demand for such services comprises a two-stage process. In the first stage, aggregate social and economic activity is projected into the future (using, for example, the ISER MAP model); the second stage translates this aggregate activity into a detailed forecast of the demand for the product or service in question.

Stage I models tend to be rather ubiquitous, finding application in a number of functional areas. MAP, for example, has been used in a variety of forecasting environments including energy impact analysis and fiscal forecasting. On the other hand, Stage II models are generally specialized and tailored to the problem at hand. In transportation planning, they are classified under the general heading of travel demand models. In energy demand forecasting, a number of different approaches have been developed, which have met with varying degrees of success. To the extent that a debate over appropriate forecasting <u>methods</u> exists, it is really a debate over the choice of a Stage II approach. In fact, as we argue below, the choice of a Stage II approach essentially dictates the output and hence the structure of the Stage I model to be used.

The argument over Stage II models centers on the extent to which the model should deal with two distinct but equally important aspects of the problem. Given an aggregate forecast from Stage I, should a Stage II model focus on the specific <u>activity</u> involved or should it focus on the <u>decision</u> of the consuming unit? In forecasting within a policy environment concerned with housing, for example, the latter dictates that we examine household budgets, prices and so on. However, a dwelling offers service far beyond simple shelter; amenity, proximity and opportunities for social interaction are but a few of these. Hence, the former approach would argue that the demand for housing is really a composite demand for the services offered by a structure. Transportation and energy are similar. Rarely are they required for their own sake; in reality they are crucial inputs into a number of satisfaction yielding activities.

In electricity demand forecasting it was once possible to do a reasonable job of prediction by looking at a historical rate of growth and simply plotting future levels of consumption against time. A draftsman with a French curve (or an engineer with semi-log paper) could make a reasonable guess at future demand by simple curve fitting and extrapolation. However, it is logically clear that the growth in the demand for electricity has little to do with the passage of time *per se*. Rather, it is related to individual *decisions* to engage in a growing number of electricity using *activities* over time.

2. STAGE II MODELLING APPROACHES

Attempts to deal seriously with this complexity became necessary in the early years of the 1970's when historical rates of electricity growth ceased to be realized by most electrical utilities in North America. The formation of OPEC and the 1973 Arab oil embargo, with its subsequent increases in petroleum prices, ended the era of cheap energy; and all fuels, including electricity, rose in price rather dramatically. Unfortunately, the econometric demand forecasting models in use at this time[2] were incapable of dealing with such rapid changes and continued to point to historic or near-historic rates of electricity growth. ISER's 1975 electricity demand forecast for the State of Alaska (with which, we might add, ISER itself was not comfortable) is a case in point. The most telling criticism of its strict time-series econometric approach is that potentially ludicrous activity forecasts result. In ISER's 1975 effort, initial results indicated a demand for electricity which implied 100% saturation of electric space heating in Fairbanks in the future. The point to be made here is that because individual activity levels are not explicitly identified in aggregate economic models, such models run the risk of implying physically unrealistic activity levels.

End use forecasting models in their pure form take the opposite approach by relying almost exclusively on activities, independent of the underlying economic conditions. The logic is simple: consuming units engage in various activities requiring energy. Energy growth can result from

(a) engaging in additional energy consuming activities;
(b) engaging in the same activities more intensively;
(c) engaging in the same activities less efficiently;
(d) any combination of the above.

The case of oral hygiene provides a humorous example. A household may switch from "manual" to electric toothbrushing, an additional energy using activity. Given an electric toothbrush, members of the household may wish to brush more regularly. When the toothbrush wears out it may be replaced with a model which delivers fewer brush strokes per unit of energy input. In any of these cases, electricity use increases. In principle, it is possible to examine all electricity use in this manner, noting that all energy is used in a final form such as heat, light, motion or sound, and that it is transformed from its input form to its final end use form by a "device".

Again, in principle, electricity demand can be projected by forecasting the characteristics of devices and activities. This has become known as the engineering or end use approach to demand forecasting. The most telling criticism of this method in its pure form is that it is not sensitive to changes in prices, incomes and preferences, i.e. the *decision* aspect of the process modelled in Stage II. This is a generally accurate criticism whose resolution requires an examination of policies affecting the decisions of the individual consuming unit. In further work for HPASC, we will be discussing this problem.

For functional forecasting purposes, an approach is emerging which seeks to overcome the inherent difficulties of both extremes of Stage II modelling methods. The econometric-end use approach (EEU) attempts to deal with electricity use at the level of the *activity* while recognizing that the *decision* to own and operate a device, i.e. to engage in an activity at some level of intensity, is inherently a problem of microeconomic choice and therefore sensitive to prices, incomes and the availability of alternatives.[3]

In our opinion, an EEU approach is the only sensible way to forecast electricity demand and to justify a huge expenditure of public funds.

We are pleased that ISER agrees in principle with this general philosophy. The detailed work schedule circulated by ISER lays out a rather impressive plan. We anticipate problems arising because of the extensive data requirements of EEU, which will be intensified by the basic data problems of Alaska: short time-series and a small population. However, we fully support ISER's desire to cast the net widely at first, while recognizing that data, and more importantly time and financial constraints will require the net to be drawn in somewhat.

At this point we would like to comment on the allocation of resources for independent demand forecasting relative to the magnitude of potential capital investments. Given the magnitude of the stakes for a project such as Susitna, i.e. a potential investment of billions of dollars, we fell that far too little money is being spent on this crucial element of project feasibility. ISER will likely argue, and justifiably so, that data is simply not available to construct a full scale EEU model. The missing data, however, is not of the variety which is impossible to collect. With additional resources made available, it could be gathered and incorporated into the forecast model, resulting in a forecast method with which all could be reasonably comfortable.

In the following pages we will review the EEU approach to Stage II and the requirements of a Stage I model to provide requisite inputs into EEU. Our goal is two fold: first to analyze and suggest approaches to particular problems for the benefit of ISER, and secondly to lay out the logic of ISER's forecasting proposal for the benefit of all consultants involved in HPASC activities. It is our hope that this will facilitate discussion and understanding of ISER's methods and in the longer term, identify avenues for potential policy intervention.

3. THE ECONOMETRIC - END USE APPROACH

EEU begins with the simple proposition that all energy is used in capital items or devices, which perform a specific task, i.e. an end use. Each device, by virtue of its design, has a specific energy input requirement for each unit of useful output, a concept similar to "First Law Efficiency". Devices are owned or rented and operated by consuming units. However, not all consuming units own all types of devices, nor do devices operate at all times. Further, many devices may be powered by more than one fuel. The decisions to own or lease and operate a device are economic decisions made by the consuming unit in light of prices, incomes, preferences and available options. For a given period, say a year, the total energy required by a consuming unit to power a given device is by definition its hours of operation times its power requirement. If the device is electrically powered, this energy demand will contribute to an electricity demand estimate.

Any portion of the electric power consumed by the economic unit which it generates itself, does not contribute to this utility forecast.

There are, of course, many consuming units and many devices. We may translate from the device level at the consuming unit by simply summing over devices and consuming units yielding the following expression for utility electric demand over a period of one year:

$$TUD = \sum_{k=1}^{N} \sum_{j=1}^{M} [D_{kj} \cdot E_{kj} \cdot I_{kj} \cdot R_{kj} - S_k] \qquad (1)$$

where

TUD = total utility demand (kW.h)

D_{kj} = 1 if consuming unit k has device j
0 if otherwise

E_{kj} = 1 if device j is powered by electricity in consuming unit k
0 if otherwise

I_{kj} = intensity of use of device j by consuming unit k (hours)

R_{kj} = power requirement of device j by consuming unit k (kW)

S_k = amount of self supplied electricity by consuming unit k (kW.h)

N = total number of consuming units

M = number of distinct devices

This is an accounting framework for utility demand.[4] To operationalize it for forecasting purposes, each of the components must be related to known or "knowable" variables. Engineering knowledge and economic theory suggest potential relationships. Econometric or other techniques are used to estimate their direction and strength.

For operational purposes it is necessary to group consuming units into classes on the basis of predominant activity within the unit (i.e. residential, commercial, etc.), similarity in patterns of device ownership or energy requirements, or some other appropriate criterion. Clearly, there are losses in precision due to this sort of aggregation. After grouping consuming units into classes, the demand for utility electricity is obtained by the following expression:

$$TUD = \sum_{i=1}^{Q} CUD_i = \sum_{i=1}^{Q} \sum_{j=1}^{M} [N_i \,.\, PD_{ij} \,.\, PE_{ij} \,.\, I_{ij} \,.\, R_{ij} - S_i] \quad (2)$$

where

CUD_i = demand for electricity by class i (kW.h)

N_i = number of consuming units in class i

PD_{ij} = proportion of class i consumers owning device j

PE_{ij} = proportion of devices j in class i that are electrically powered

I_{ij} = average intensity of use of device j by members of class i (hours)

R_{ij} = average power requirement of device j owned by members of class i (kW)

S_i = amount of electricity self supplied by class i members (kW.h)

Q = number of consuming classes

The advantage of examining end use demand in this manner is obvious. Not only is it less data intensive than Equation (1), but also, key parameters become easier to pinpoint. For example, in an analysis of a subclass comprised of mobile homes built before 1970, space heating requirements would be rather similar.

Time, of course, is also a crucial consideration which must enter the model in a forecasting environment. The advantage of an end use model is that the factors developed above exhaust the realm of demand factors, and each will change over time. As time passes, classes of consuming units grow or decline, devices become more or less prevalent and more or less "electrical", self - supplied electricity may become more widely used, devices may be used more or less intensively, and device efficiencies will undoubtedly change. The latter is particularly important since many devices will be replaced over the forecast period and those which are not may be "retrofitted" to improve their performance.

While the passage of time is itself not the reason for change, the argument above suggests that it may prove fruitful to view demand growth in a temporal sense. At a point in time we begin with a "stock" of consuming units equipped with devices. Over the ensuing year the consuming unit may disappear, change or modify its collection of devices or means of powering them. In addition, new consuming units may be formed complete with new devices. Presumably these new devices would have energy consumption characteristics different from "old" devices. At the end of the year we witness a revised "stock" of existing consuming units and devices comprised of the previous year's units plus net increases. This may be taken a year at a time for the entire forecast period yielding electricity requirements for specific annual points and annual increments in demand.

4. THE ISER MODEL AND SUGGESTED APPROACHES AND REVISIONS

In the context of the Railbelt region, EEU makes a great deal of sense for the residential and commercial sectors which, taken together, account for about 86% of Alaska's total electricity demand. Because industrial development in Alaska is largely of the major project variety, it is best to examine these in a case by case manner. Further, with the exception of block heating in vehicles, the transportation sector currently uses an insignificant amount of electricity. Again, this is best viewed as a special case.

ISER's EEU model, Figure 1 in their "Detailed Work Plan", incorporates most of the features of an ideal EEU discussed above. It is a stock/flow model which segregates consuming units into "new" and "old" and deals with four residential subclasses, and segregates devices into six categories including an"other" category for minor appliances.

The commercial sector should be divided into at least the following groups:

1) Public/Institutional Buildings;
2) Large shopping plazas/office buildings (say larger than 100,000 or 250,000 sq.ft.);
3) Other commerical buildings.

This would be fruitful for two reasons: within each group there are similar requirements for electricity, and policies/programs may be specifically tailored, at a later date, to this particular pattern of consumption and occupancy/ownership.

Missing in ISER's proposed model is a term to account for electricity or energy supplied by the consuming unit and hence not required from a central system. This should be added to the model even though it may not greatly affect the magnitude of the final forecast. A number of considerations warrant its inclusion, not the least of which is the possibility of co-generation of electricity and steam for space heating in large commercial establishments, schools, hospitals, and the like.

The present ISER formulation allows for the scrapping of dwelling units but not for the replacement of appliances within existing units. A number of appliances ISER intends to consider have useful lives of substantially fewer years than either the forecast period or the structure. In ISER's model, this problem could be solved by adjusting the average consumption of appliances on an annual basis. It is better, however, not to confound the effiency measure with the effect of new appliance stocks.

Given these structural refinements which we consider necessary, the ISER approach to residential and commercial electricity demand forecasting is methodologically sound. Since residential and commercial consumption in the railbelt are quite important, it is necessary to examine the components of the EEU model and to suggest possible approaches to modelling each component. In this case we refer initally to our formulation of EEU above, and explicitely to these elements pertaining to Stage II.

In Equation (2), total utility demand was expressed as the sum of class demands. Class demand is a function of the number of units in the class, the proportion owning various devices, the proportion of these devices powered by electricity, the average intensity of each device's use, the average power requirements of the various devices and the amount of self-supplied electricity. The number of consuming units in each class is essentially a modified form of the output of Stage I which we discuss below. The reamining factors are however, Stage II concerns which we deal with in turn.

PD_{ij}, the proportion of class i units owning device j, is obviously a variable whose value lies between 0 and 1. For certain end uses, i.e. space heating, its value equals unity and will continue to do so over the forecast period. In other cases like clothes drying and refrigeration, its value is a matter of choice, and while perhaps initially close to unity it is variable over the forecast period. In an ideal world we would hope to estimate this proportion on the basis of income level and distribution within the Railbelt Region, bearing in mind that the decision to own a "device" also *commits* the owner to operating expenses over its lifetime. Hence the general price level of all competing fuels may be important.

PE_{ij}, the proportion of device j owned by class i which are electrically powered is also a variable whose value ranges between 0 and 1. Again, for certain end uses, especially refrigeration, its value is close to unity and will likely remain so over the forecast period. However, a great deal of choice exists in this area. A useful way to look at this problem has been proposed by Fuss

who suggests the decision to engage in an activity with a specific fuel is essentially separable. In other words, given a decision to engage in an activity, the choice of fuel is essentially a separate question,[5] made on the basis of relative prices.

The question of the treatment of conservation arises in this instance. If conservation is factored into average energy requirements, then no more need be said. However, if we view each or any device as having a "base-line" energy requirement, then any effort to reduce it involves an explicit tradeoff of electricity for conservation. In this sense, conservation is self supply, and has an average supply price equal to the amortized annual cost of the conservation project divided by the number of kilowatt-hours displaced during a year. Marginal costs may be calculated by assuming, ideally, various levels of conservation and calculating, presumably, a step function for the fuel equivalent value of various conservation schemes. The same logic may be applied to renewable energy projects as well.

We feel it is useful to view conservation and renewables in this way when considering existing activities at a point in time. The major point is that given an existing activity, like space and water heating (the major ones) the consuming unit can choose not only to switch from one convential fuel to another but can also choose to supply a portion of its requirements with conservation. In an oil heated home, for example, the household may switch to gas, electricity, or conservation for all or part of its heating on the basis of relative prices. Considering conservation as an explicit fuel represents a useful modification of interfuel substitution analysis.

R_{ij}, the average power requirement of device j in class i, becomes basically an engineering design parameter when conservation is treated as a fuel. Consequently it is a function mainly of vintage, not confounded by retrofit. One item that should be examined is the trend in device efficiencies over time. This may well be an appropriate area for regulation.

I_{ij}, the average intensity of use of device j by class i members is also a consumer choice variable although to a limited extent in the major consumption categories. Actions like reducing inside temperatures and the like are evidence of the economizing behavior of households under this category; how much farther we can go in this area is certainly questionable. In this case, comfort and convenience bound choice from below. To the extnet that there is flexibility it is likely price and income related.

The final term in our formulation is S_i, the amount of self-supplied electricity by members of class i. In this instance we suggest that this term be kept pure in the sense that conservation not be viewed as self supply in this term. We include S_i in the model for the reasons stated above. There is a price at which self-generation or cogeneration becomes attractive whether by means of water power, wind, or conventional fuel. The model should be sensitive to this possibility.

The above relates to our formulation and also to ISER's model. The remaining terms in ISER's model relate to new household formation which we discuss below and the various "scrapping rates". Scrapping of a device involves not only physical deterioration but also economic considerations, one of which is the device's fuel requirements. Logically, the scrapping rate should increase with decreasing energy requirements for new models a particular device. This is extraordinarily difficult to measure and project over time; however, it is something to be kept in mind.

Generally speaking, we are impressed with ISER's proposed method for handling the Stage II modelling of the residential and commercial sectors. With the modifications suggested above we can wholeheartedly endorse ISER's approach and we look forward to working with ISER on further questions of approach and sensivity analysis. With respect to the ISER approach to non-residential and commercial use of electricity, we reserve judgement since the method has not yet been developed. We will, of course, comment at an appropriate time and we are confident that ISER will take a sound approach, based on their work to date.

5. STAGE I APPROACHES

We now turn to the merits of the MAP model of the Alaskan economy as a Stage I model for econometric end-use forecasting. Regional economic forecasting can take a variety of forms. Some approaches being considered in the "Detailed Work Plan" are input-output analysis, the economic base approach, Curtis Harris' locationally efficient model, and the Delphi technique. These all have strong and weak points but none is a serious contender to a moderately detailed econometric model like MAP.

What is required of the Stage I model? It must provide the number of consuming units in each class for the end use equation. That is, in the number of housing units of several types and the number of firms, employees, square footage, or business volume for commercial and institutional units. It must be sensitive to the scenarios of fast, likely, and slow growth mentioned in the "Detailed Work Plan". It must respond to changes in oil and gas pricing, energy and other major investment projects, national economic trends, and demographic realities including migration. Whiel the current MAP models incorporate most of the latter functions, the restriction of demographic projections to persons (not households or families), the introduction of housing only through the dollar volume of construction, and the lack of other physical measures of economic activity closely related to the number and type of consuming units *are major deficiencies*. As noted in the "Detailed Work Plan", data must be gathered and incorporated into new versions of MAP.

What regional techniques must be added? In our opinion none of the above mentioned techniques merit much effort.

Input - output analysis is appropriate when a region has a large industrial base which relies to a great extent on inter-industry sales. Alaska does not have such an economy yet, and the method's well-know data-intensity suggests that it need not be considered further. Shortcuts to true regional input-output data gathering -- such as the use of technical coefficients borrowed from other studies -- are inappropriate for an unusual state economy such as that of Alaska.

The strong points of economic base analysis -- a technique which is useful when the regional economy pivots on clearly defined basic industries -- are already contained within the MAP model. The simple economic base methods are too elementary; ISER is well beyond them already in its work. The same criticism holds for purely extrapolative methods. Just as ruler and graph paper are inappropriate for local forecasting, they are too simplistic for the economic part of econometric-end-use analysis.

Curtis C. Harris developed a regional forecasting model at the detailed industry level based on short time series changes in output by industry and state and incorporating transportation costs estimated by optimization techniques. Alaska clearly is not likely to exhibit consistent locational cost patterns of industrial development necessary to take Harris' approach.

Delphi, a technological and political forecasting technique developed first at the Rand Corporation is unlikely to yield the moderately detailed consuming unit forecasts needed here. However, it may always be considered for developing scenarios for energy projects, general ecomic growth levels, or energy policy decisions. Hence it is not a Stage I model but a *source* of *exogenous* and policy variable values for any forecasting method.

Among general methods for forecasting regional economic activity, one not yet mentioned is shift-share analysis. This method is based on statistical estimation of the contribution to a state's industrial growth of industry factors and regional factors. It is an excellent basic method which is sufficiently incorporated in a MAP-type econometric approach. While both input-output and shift-share methods are usually performed with a great deal of industry detail, such detail is not needed in our Stage I approach.

What is needed is more detail aimed at *household* characteristics and *building stock* characteristics. While data source end points for households are well-known and trusted, a region such as Alaska can have rapid and crucial post-Censal fluctuations in households and household size. As for buildings, only dwelling units are enumerated in the Census. Building stock estimates for non residential units are rare above the city level.[6] Land use surveys and Civil Defense surveys give spotty data sets, but the building stock is basically an unknown quantity for regions such as states. For the current research, increased information on the building stock is important.

As an expedient it is suggested that housing be looked at in detail (so as to allow better end use forecasts for space and water, heating, lighting, and appliance loads); that large commercial and institutional uses be examined through enumeration of structures; and that the rest be treated by the use of employment or sales estimates.

Recent efforts by others in energy forecasting suggests two approches: 1) macroeconomic econometric models such as MAP, and 2) microeconomic simulations of consuming unit responses to changes in price, income and the availability of alternatives. The former is necessary to introduce national and major regional trends. The latter is used to discover what the distributional effects of new pricing and supply levels will be.

A study commissioned by a number of New York consumer groups and carried out at Cornell University was used in testimony before the New York State Energy Master Plan Meetings in September 1979.[7] In this approach, Green, Moung, and Saltzman utilized a four-sector economic/demographic state econometric model with a partially integrated energy sub-model. The four sectors were residential, industrial, commercial and transportation. All major energy types - electricity, oil, gas and coal - were forecasted simultaneously. This Cornell model as well as another model developed with end use detail by the New York State Energy Office, predicted significantly lower electricity requirements than had previous state plans. It should be noted that while the Cornell Model is not extremely complicated (57 economic equations, 150 demographic equations) it contains <u>household formation functions</u> for each age-sex cohort. Unfortunately the Cornell Model does not give explicit place in its structure to self-supply wood space heating, or conservation.

Furthermore, in the Cornell approach, a microeconomic simulation was linked to the macro model in order to relate income and price changes and restrictions on fuel supply to consumer demand for the different fuels.[8] This, of course, requires an extensive data base of individual households studied by survey research methods. In this case a sample of 7000 households was utilized.

While such microsimulation may be beyond current possibilities in evaluating Susitna (and we are not convinced that such further study should be considered extravagant) it suggests again the need to make the energy forecasting version of MAP more oriented to consuming units, households, and to the biggest devices of all, buildings.

Looking in more detail at MAP, based on the May 31, 1979 documentation, we note that it has more than enough economic detail, but not enough demographic information because of households not appearing explicitly. Finally a housing and/or buildings component is lacking; this is a critical shortcoming.

In the "Detailed Work Plan" we support most strongly Items A 7 - 9 on electricity consumption; Item 10 on households, houses, and appliances. These are more important, in our estimation, than the refinement of the MAP economic model per se. They should receive top priority.

Regional disaggregation (Task B) is important, but less so than getting on to EEU forecasting for the Railbelt region as a whole. Thus the Items in D are crucial -- interfuel substitution plus the addition of conservation.

A general evaluation of the MAP models serves to reveal several strengths in addition to the above shortcomings. First despite the limited length of the Alaska data series, the resulting equations are adequate by conventional statistical benchmarks, at least for forecasting use. The detailed fiscal and native/non-native/military results, needed for earlier applications, are well developed, but may not be particularly helpful in the current application.

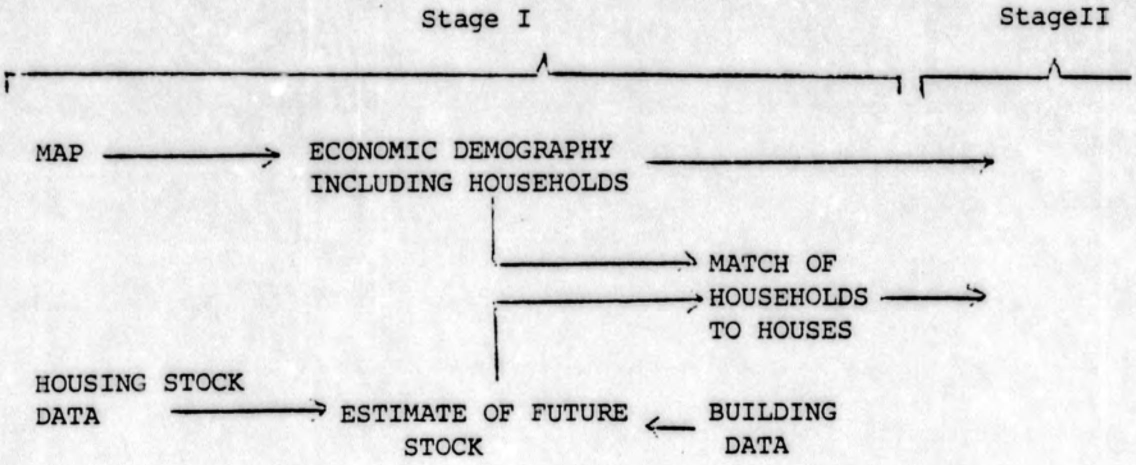
What is needed, more than any other modification, is a housing sub model. Whether the data can be gathered for such an addition remains to be seen. Lacking a formal housing model, some intermediate step is required based on the housing stock data from the decennial censuses. A brief outline of each alternative is in order.

A full-blown econometric sub model for housing would flow from the following modifications to MAP:

1) inclusion of household formation equations in the demographic sub model
2) a set of equations for the housing stock (or alternatively changes to that stock) by age and type of unit.

Some of the crucial right hand variables would be from the construction and investment functions of the economic model as well as the household formation results.

If the time series data are lacking for the housing modifications to MAP, then the available census benchmarks -- number of dwelling units by age and type -- should be combined with recent data on housing starts, mobile home sales, building permits, etc., to update the distribution of the housing stock. This results in the following structure:



6. CONCLUSIONS

Energy demand forecasting, the most crucial element of energy policy development, is difficult in the face of growing uncertainties. In order to maintain confidence in forecasting procedures, the analyst is faced with the need to develop what amount to relatively more sophisticated models and forecasts than has traditionally been the case.

Pure econometric and pure end use forecasts suffer inadequacies; hence, a blended approach combining the best elements of each is necessary. This blended EEU approach is difficult because of its data requirements and because modifications must be made to the structure of the underlying econometric and end use models on which it is based.

In the long run, an EEU forecasting system for Alaska can be developed with MAP, suitably modified, at its heart. Its data requirements are not yet attainable in a small region such as Alaska with a short data history. Therefore, in the short term, ad hoc forecasting must be carried out with the outputs of the current version of MAP. These outputs must be obtained by using a very wide range of input scenarios.

The most crucial shortcoming of the current version of MAP is the lack of a housing sector and this must be bridged by some reasonable if imperfect method of estimating Alaskan housing stock and characteristics in recent years.

7. FOOTNOTES

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1. Joan Robinson, "What are the Questions?", Journal of Economic Literature 15, December, 1977, p. 1322.

2. These are an extremely expensive and sophisticated version of semi-log paper. See Herman Daly,"Energy Demand Forecasting: Prediction of Planning?", Journal of the American Institute of Planners, January 1976.

3. Robert W. Shaw Jr., "New Factors in Utility Load Forecasting", Public Utilities Fortnightly, July 19, 1979, pp. 19 - 23.

4. Much as Dr. Goldsmith's is a stock/flow approach to accounting for demand.

5. M. A. Fuss, "The Demand for Energy in Canadian Manufacturing; An Example of the Estimation of Production Structures with Many Inputs", Journal of Econometrics 5, January 1977, pp. 89 - 116.

6. B. Jones, D. Manson, J. Mulford, M. Chain, The Estimation of Building Stocks and their Characteristics in Urban Areas, Program in Urban and Regional Studies, Cornell University, 1976.

7. W. Greene, T. Mount, and S. Saltzman, "Forecast of the Demand for Major Fuels in New York State 1980 - 1994", Technical Report, September 4, 1979.

8. S. Caldwell, W. Greene, T. Mount and S. Saltzman, "Forecasting Regional Energy Demand with Linked Macro/Micro Models", Working Paper in Planning #1, Department of City and Regional Planning, Cornell University, January 1979, forthcoming in Papers of the Regional Science Association 45.

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ALASKA ELECTRIC POWER REQUIREMENTS

A REVIEW AND PROJECTION

INTRODUCTION

Strong growth of Alaska's economy is causing demand for electric power in the state to grow approximately 12 percent annually, nearly double the historic national average. Meeting this demand in a timely manner, so that a lack of electricity does not act as a brake on economic development, will be a major concern in Alaska for many years to come. At the same time, however, planners, in attempting to meet this demand, must avoid building more power capacity than the future requires, since this could result in an unnecessary waste of capital and resources.

The danger of ending up with too little or too much electrical power capacity emphasizes the need for and the value of properly assessing and projecting electrical demand. Such projections are also important and necessary because of the several years lead time required to efficiently increase generating capacity.

The economic computer model used to make the projections presented in this *Review* was developed as part of the Man in the Arctic Program. Funded by the National Science Foundation and the State of Alaska, MAP is directed toward the identification, comparison, and forecasting of the social and economic effects of energy development in Alaska. For a comprehensive description of MAP, see David T. Kresge, "Alaska Growth to 1990," *Alaska Review of Business and Economic Conditions,* 13:1 (January 1976).

Projecting future electrical demand is a complicated task that requires consideration of many factors. Researchers must look far into the future and attempt to project the rate of economic growth and related population growth for which to provide electrical power. However, economic growth in Alaska will, to a large extent, depend on the level of future petroleum exploration and development, activities that are subject to a large amount of uncertainty. Therefore, before the economist can forecast electrical demand growth, he must first define the limits of this potential petroleum activity and determine how it will affect economic and population growth.

To overcome the complications involved in projecting electrical demand, ISER researchers used a methodology that allows for variability in both the rate of economic growth in Alaska as well as the rate of use by individual customers. In reporting the results of these efforts, this *Review* looks first at recent electrical use trends in Alaska and, second, presents consistent sets of regional and statewide projections of electrical demand through 1995.

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HISTORICAL OVERVIEW

Four basic sources supply Alaska's electrical power: (1) private industry, (2) the military, (3) home generators, and (4) utilities. In 1975, the generating capacities of these four sources were distributed as follows:

- Industry—108 megawatts (mw)
- Military—218 mw
- Private home generators (no figures)
- Utilities—738 mw

The first two of these, industrial and military electrical power, are of little interest to us here since they are essentially independent of state population and income levels. And while privately generated power for home use is important because of incomplete utility coverage, its use is declining, and existing programs of rural electrification will continue this trend. Therefore, our primary concern is with the remaining and largest component of electrical power in the state, that generated by utilities. In 1970, approximately 87 percent of Alaska households were connected to electric utilities. Those not connected included villages, households with access to electricity but no desire to consume, and households isolated from any power source or community.

Utility Generation

Utilities presently provide the largest percentage of electricity generated in the state. And, because military requirements will not expand appreciably and population increases will be concentrated in urban areas, utilities in the future are expected to supply an even larger proportion of the state's electricity.

Historic growth rates in electric power sales for the largest utilities in the state, calculated for the period 1965 through 1974, are shown in Table 1. In all regions except the Southeast (see **Figure 1**), growth has exceeded the long-run national average of 7 percent annually. Individual utilities have experienced much more rapid growth. Of the state's largest utilities, Golden Valley Electric Association in Fairbanks grew most rapidly, in excess of 20 percent annually.

Differences in growth rates of electricity use are only partially explained by differences in the rates of population increase. In addition, the number of electric hookups per 1,000 persons, or hookup saturation, has also been increasing, and consumption per customer has been increasing at different rates in different regions. Hookup saturation percentages for 1974 were:

Anchorage	31.1
Southcentral	32.7
Fairbanks	28.0
Southeast	24.9

Table 2 shows the increase by region in numbers of customers and the average annual consumption per customer in the residential sector; Table 3 gives the same information for the commercial and industrial sectors.

The different consumption levels for electricity vary not only across regions but also from community to community. This is shown in Table 4 for residential customers. In 1974, average sales per

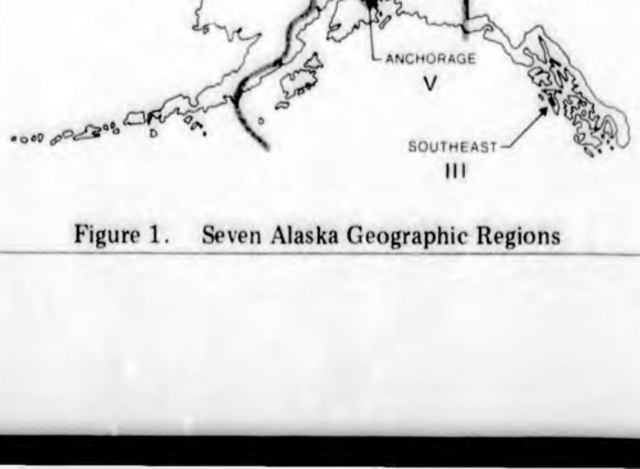

Figure 1. Seven Alaska Geographic Regions

Table 1

Historic Growth Rates of Sales to Final Consumers

Alaska Electric Utilities, 1965-1974

Map Regions and Census Divisions	Electric Utility	Annual Growth Rate (%)	1974 Total KWH Sales to Final Consumers
Region I Northwest Alaska			(Thousands)
Kobuk	Kotzebue Electric Assn.	8.90	4,859
Nome	Nome Light & Power	8.57	8,921
	Matanuska Electric Assn. (Unalakleet)	6.39	1,398
	Average	7.86	
Region II Southwest Alaska			
Bethel	Bethel Utilities Corp.	21.36	11,948
Bristol Bay	Nushagak Electric Coop. (Dillingham)	9.80	3,565
Bristol Bay Bor.	Naknek Electric Assn.	8.17	4,864*
Kuskokwim	McGrath Light & Power	1.11	1,102
	Average	11.49	
Region III Southeast Alaska			
Haines	Haines Light & Power Co.		
Juneau	Glacier Highway Electric (Auke Bay)	7.85	5,352
	Alaska Electric Light & Power (Juneau)	7.03	71,482
Ketchikan	City of Ketchikan Public Utilities	5.66	66,628*
Outer Ketchikan	Metlakatla Power & Light	5.31	16,435
Prince of Wales	Alaska Power & Telephone Co. (Craig)	14.60	1,054
	Alaska Power & Telephone Co. (Hydaburg)	23.27	466
Sitka	City & Borough of Sitka	4.45	29,467
Skagway-Yakutat	Pelican Utility Co.	1.10	Not available
	Alaska Power & Telephone Co. (Skagway)	10.20	3,708
Wrangell-Petersburg	Petersburg Municipal Light & Power	9.25	15,970
	Wrangell Municipal Power Plant	6.75	9,076
	Average	6.54	

(Continued, next page)

Table 1 (Cont.)

Map Regions and Census Divisions	Electric Utility	Annual Growth Rate (%)	1974 Total KWH Sales to Final Consumers
Region IV			
Southcentral Alaska			
Cordova-McCarthy	Cordova Public Utilities	9.36	9,577
Kenai-Cook Inlet	Homer Electric Assn. (Homer)	16.47	92,223
	Homer Electric Assn. (Kenai)	11.36	20,223
	Homer Electric Assn. (Port Graham)	34.47	217
	Homer Electric Assn. (Seldovia)	13.14	3,600
Kodiak	Kodiak Electric Assn. (Kodiak)	8.78	36,528
	Kodiak Electric Assn. (Port Lions)	10.20	1,580
Matanuska-Susitna	Matanuska Electric Assn. (Palmer)	12.43	92,073
	Matanuska Electric Assn. (Talketna)	17.09	plant closed
Seward	Seward Electric System	10.14	14,152
Valdez-Chitina-Whittier	Copper Valley Electric Assn. (Glenallen)	6.83	5,576
	Copper Valley Electric Assn. (Valdez)	12.81	8,464
	Average	11.93	
Region V			
Anchorage			
Anchorage	Anchorage Municipal Light & Power	12.05	350,302
	Chugach Electric Assn.	14.31	516,830
	Average	12.53	
Region VI			
Interior	(No reporting utilities)		
Region VII			
Fairbanks			
Fairbanks	Fairbanks Municipal Utilities	7.06	88,135
	Golden Valley Electric Assn.	20.18	230,618
	University of Alaska	Not available	10,212
Southeast Fairbanks	Alaska Power & Telephone Co. (Tok)	8.69	2,996
	Average	14.11	

SOURCE: FPC data for the period 1965-1974.

*1973 total

customer varied from a low of 1,381 kilowatt hours (kwh) in Fort Yukon to 21,109 kwh in Metlakatla. The statewide average of 8,860 kwh is consistent with the past trend in Alaskan residential usage, which is between 5 and 10 percent greater than the national average.

Factors Affecting Consumption Levels

Regression analysis indicates that electricity price, income, and average temperatures are important determinants of the average level of residential electricity consumption in Alaska.[1] "Heating degree days" are commonly used to indicate the severity of the weather. One heating degree day is recorded each day for every degree Fahrenheit (F.)[2] by which the temperature falls below 65 degrees F. Heating degree days for Alaskan communities are shown in Table 5.

Residential prices for electricity, which are generally a decreasing function of the quantity consumed, show a large variation from community to community within the state. As shown by Table 6, the 1975 cost of 500 kwh per month varied between $13.00 in Anchorage and $131.94 in Deadhorse (2.6 cents versus 26.4 cents for one kwh).

Compared to prices nationally, the average for Alaska is high, but during the decade of the sixties, it fell in real terms and also relatively. The Alaska average in 1960 was 4.32 cents/kwh, while nationally, it was 2.47 cents/kwh. By 1972, the Alaska average was 3.33 cents/kwh. To a large extent, this downward trend reflects the price of electricity in Anchorage, since more than half of the state's electrical consumption occurs in the Anchorage area.

More recently, the downward trend in prices has reversed as a result of increasing costs of fuel, construction, and capital. Changes in fuel costs can dramatically affect the cost of electricity, but these cost changes are not rapidly translated into rate changes. A temporary expedient, which avoids the necessity of a rate hearing, is the automatic fuel cost rate adjustment surcharge, which is added to the base rate as fuel costs increase. Table 7 shows the adjustments on file with the Alaska Public Utilities Commission as of October 1, 1975. These adjustments change monthly.

Prices for commercial and industrial consumers, when different from residential rates, are generally lower and trends have tended to follow those of the residential sector.

ELECTRICAL DEMAND PROJECTIONS

Economic Growth

Because growth in electricity requirements will closely follow growth in the state's economy, electrical demand projections must necessarily be based on economic projections. Institute researchers used the MAP regional econometric model (see Appendix 1) to obtain the economic projection results discussed below.

The MAP computer model (See box, page 1)

Table 2

Average Annual Residential Electricity Use

	Southeast		Southcentral		Anchorage		Fairbanks	
Year	Number of Customers	Average Annual KWH per Customer	Number of Customers	Average Annual KWH per Customer	Number of Customers	Average Annual KWH per Customer	Number of Customers	Average Annual KWH per Customer
65	9,050	6,067	7,336	4,946	22,110	6,614	8,183	4,804
66	9,291	6,309	6,677	5,726	23,003	7,110	8,170	5,712
67	9,354	6,472	7,792	5,453	23,931	7,246	8,574	6,055
68	9,314	6,865	8,698	5,719	27,437	6,977	9,344	6,569
69	9,570	7,121	9,278	6,187	30,079	7,112	10,023	7,672
70	9,877	7,459	10,800	6,401	33,159	7,641	10,756	8,418
71	10,419	7,593	11,467	7,287	35,056	8,555	11,184	9,515
72	10,995	7,719	11,899	7,773	38,817	8,817	11,487	10,529
73	11,677	7,472	12,617	8,175	39,915	9,273	11,825	11,233
74	11,940	7,623	14,507	8,029	43,453	9,106	13,261	11,597

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[1] Scott Goldsmith, "Future Electricity Requirements in Alaska," paper presented at the Western Economic Association Annual Meeting, San Francisco, June 17, 1976.

[2] In other words, if on a particular day, the temperature dropped to 30 degrees F., or 35 degrees below 65 degrees F., this would amount to 35 heating degree days.

Table 3

Average Annual Commercial-Industrial Electricity Use Per Customer

	Southeast Commercial		Southeast Industrial		Southcentral Commerical/Industrial	
Year	Number of Customers	Average Annual MWH Usage per Customer	Number of Customers	Average Annual MWH Usage per Customer	Number of Customers	Average Annual MWH Usage per Customer
65	1,608	20.345	*	*	1,575	35.594
66	1,662	21.227	*	*	1,399	41.924
67	1.650	21.932	*	*	1,559	40.880
68	1,657	22.749	*	*	1,703	49.342
69	1,704	22.700	*	*	1,687	58.618
70	1,761	25.117	57	457.912	2,447	49.412
71	1,783	26.515	54	522.870	2,331	56.280
72	1,857	27.607	89	322.101	2,403	54.420
73	1,943	29.440	52	549.442	2,636	54.961
74	1,359	28.852	13	1,401.385	2,839	53.583

	Anchorage Commercial/Industrial		Fairbanks Commercial/Industrial	
Year	Number of Customers	Average Annual MWH Usage per Customer	Number of Customers	Average Annual MWH Usage per Customer
65	3,035	46.997	1,318	25.181
66	3,105	51.790	1,467	23.910
67	3,195	56.794	1,452	25.363
68	3,488	56.865	1,469	33.665
69	3,793	58.475	1,579	35.269
70	4,093	63.260	1,717	62.087
71	4,245	70.804	1,772	69.268
72	4,652	75.654	1,800	69.773
73	4,815	84.714	1,883	73.167
74	5,132	85.395	2,073	71.449

*No customer figures available.

along with two sets of assumptions (limited and accelerated petroleum development) was used to generate two projections of the future level of economic activity in the state. These are not predictions of the level of any particular variable, because future levels for the basic variables cannot be known with certainty. Rather, they are projections which describe the general expected levels of activity, if petroleum development and other basic activities take a certain course.

Results from the two cases are presented in Table 8. Two factors primarily account for the rapid growth observed in both cases. The first is the continued expansion of the petroleum industry, which has had an annual average increase in real gross product of 17 percent since statehood. The second is the continuing important role of state and local government in the economy, stimulated by petroleum revenues.

In the limited case, annual population growth between 1974 and 1990 averages 3.8 percent, employment growth 4.3 percent, real wages and salaries 6.1 percent, and state and local government expenditures 12.2 percent. Accelerated development results in population growth of 4.8 percent, employment 5.2 percent, real wages and salaries 7.1 percent, and state and local government expenditures 13.7 percent.

Alaskan economic growth will be strong even in the limited development case, primarily because of

Table 4

1974 Residential Electricity Consumption by Region and Community

Map Region, Census Division	Utility Locations	(A) 1974 Residential Customers	(B) 1974 KWH Residential Sales by Utilities	(C) (B/A) Annual KWH Sales/Customers
Region I				
Northwest Alaska				
Barrow	Barrow	377	915,896	2,429
Kobuk	Kotzebue	369	1,553,676	4,210
Nome	Nome, Unalakleet	748	6,454,067	8,628
Region II				
Southwest Alaska				
Aleutian Islands		---	---	---
Bethel	Bethel	670	2,470,288	3,687
Bristol Bay Bor.	Naknek	190	980,821	5,162
Bristol Bay	Dillingham	301	1,200,571	3,989
Kuskokwim	McGrath	54	97,283	1,802
Wade Hampton		---	---	---
Region III				
Southeast Alaska				
Angoon		---	---	---
Haines	Haines	596	5,346,132	8,970
Juneau	Auke Bay, Juneau	5,266	35,392,244	6,721
Ketchikan	Ketchikan	3,569[a]	30,957,853[a]	8,674[a]
Outer Ketchikan	Metlakatla	326	6,881,403	21,109
Prince of Wales	Craig, Hydaburg	b	742,597	b
Sitka	Sitka	1,666	11,656,608	6,997
Skagway-Yakutat	Pelican, Skagway	b	1,205,185	b
Wrangell-Petersburg	Wrangell, Petersburg	1,532	9,482,975	6,190
Region IV				
Southcentral Alaska				
Cordova-McCarthy	Cordova	534	3,159,042	5,916
Kenai-Cook Inlet	Homer	2,023	14,494,954	7,165
Kodiak	Kodiak	1,774	10,596,414	5,973
Matanuska-Susitna	Palmer	1,087	5,940,733	5,465
Seward	Seward	785	4,664,360	5,942

(Continued, next page)

Table 4 (Cont.)

Map Region, Census Division	Utility Locations	1974 Residential Customers	1974 KWH Residential Sales by Utilities	(B/A) Annual KWH Sales/Customers
Valdez-Chitina-Whittier	Valdez	935	3,750,993	4,012
Region V Anchorage				
Anchorage	Anchorage	43,456	395,854,136	9,109
Region VI Interior				
Upper Yukon	Ft. Yukon	130	179,650	1,381
Yukon-Koyukuk	Manley Hot Springs	9	48,764	5,418
Region VII Fairbanks				
Fairbanks	Fairbanks	13,261	153,781,613	11,597
Southeast Fairbanks	Dot Lake, Tok	b	674,870	b
TOTAL		79,062	700,514,344	8,860

SOURCE: FPC reports and Alaska Public Utilities Commission Annual Reports.

[a] 1973 figures

[b] Consumption figures not complete

the projected continued growth in the state and local government sectors. The two cases parallel one another closely until 1980, at which time the accelerated development case begins expanding much more rapidly.

Tables 9 and 10 present the projection results for population, employment, and real wages and salaries (which is closely related to personal income) on a regional basis for the two cases. The impact of development does not fall evenly across the regions of the state. A basic indicator of this is the difference in population growth rates among the regions and between cases as shown in Table 11.

In comparison with the projected rate of population increase in the United States of under 1 percent annually, these figures indicate significant population growth.

Electricity Demand Projection Results

Four different sets of electricity-use assumptions (use-intensity scenarios) described in Appendix 2 were developed and combined with the two sets of economic projections (see Tables 9 and 10) to yield, for each region of the state, eight separate projections of utility electricity requirements through 1995. The different use-intensity scenarios reflect different assumptions regarding the future relative attractiveness of electricity as a source of energy. The highest and lowest of these projected requirements for each region were combined to yield the range of values for the state as a whole as shown in Table 12.

One can see in Table 12 that under the most restrictive assumptions regarding limited economic growth and electricity use, the long-run growth rate of electricity demand in Alaska is projected to exceed 8 percent. At the other extreme of accelerated economic development and continued historical rates of increase in electricity consumption, the long-run growth rate for electricity demand approaches 14 percent. Whatever the long-range growth rate actually turns out to be, Alaska requirements are expected to be considerably higher than the historic national growth rate of 7 percent.

The larger component of variation among the different projections is in the intensity of electricity use rather than in the assumptions regarding economic growth. The long-run growth rate varies between 9.0 percent and 12.9 percent among the use-intensity scenarios within the accelerated economic development case, but only between 11.2 percent and 12.9 percent between economic development scenarios in the highest use-intensity case. The primary reason for this seems to be that the economic growth of the state is projected to largely depend upon state government activity which will grow steadily over the period under either economic growth assumption. This underscores the importance of the average consumption of electricity by the individual in the determination of total demand in a rapidly growing region. Electricity consumption occurs through use of appliances, the purchase of which is a long-term investment. A rapidly growing population means a rapid growth in appliance stocks not only in the residential but the commercial and industrial sectors as well. Type of appliance (gas, oil, or electricity) decisions by these new customers will strongly influence the growth rate of electricity use.

Table 5
Heating Degree Days for Alaskan Communities 20 Year Averages (1955-1974)

	Heating Degree Days (Fahrenheit)
Anchorage	10,960
Annette (S.E.)	7,054
Barrow	20,426
Barter Island (Int.)	20,197
Bethel	13,372
Bettles (Int.)	16,107
Cold Bay	9,885
Fairbanks	14,439
Gulkana	14,250
Homer	10,443
Juneau	9,184
King Salmon (S.W.)	11,701
Kodiak	8,890
Kotzebue (N.W.)	16,171
McGrath (S.W.)	14,667
Nome (N.W.)	14,512
St. Paul Island	11,205
Shemya (S.W.)	9,574
Summit (S.C.)	14,603
Talkeetna	12,024
Unalakleet (N.W.)	14,162
Yakutat (S.E.)	9,711

SOURCE: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, "Local Climatological Data," various issues, Asheville, N.C., 1974.

A regional comparison of projected electricity requirements is shown in Table 13. This comparison shows that not only is present electricity consumption concentrated in the railbelt area of the state (Anchorage, Southcentral, and Fairbanks regions), but future growth will further concentrate electricity use in that part of the state.

Some indication of the magnitude of electricity requirements for the railbelt area is provided by a comparison of peak demand, measured in megawatts, with the installed capacity of 1,568 megawatts, which would be available from the Devil's Canyon Hydroelectric project proposed for the Susitna River by the Corps of Engineers. Total requirements in the railbelt would exceed this amount by 1995 in even the lowest growth case.

Growth of electricity requirements in Anchorage, which has the most diversified economy in the state, will be most rapid in the long run and relatively insensitive to the rate of economic development statewide. Southcentral growth will be most rapid in the short run and will moderate somewhat over the longer period. The projected range of variability for Fairbanks is larger due to the larger relative impact of direct petroleum-related activity in that community. By contrast, growth in the Southeast is the most stable in the state, showing little variation among projections. This stability largely arises from the lower population growth rate projected for that region. In the other regions of the state, projected growth rates are highly variable, but are below the statewide average, which is strongly influenced by Anchorage. Data for the utilities in these regions are sparse; some communities are still in the process of becoming electrified, so that the largest variation in projections is to be expected for those regions.

Detailed projections of sales and peak demand by region under each set of assumptions are presented in Tables 14 and 15. In addition, underlying assumptions regarding the ratio of consumers to population in each case as well as the average rate of consumption are presented in Table 16 for those regions where the data is available.

Analysis of Table 16 provides some additional insight into the plausibility of each set of projections.

Table 6

Typical Monthly Bills for Residential Electricity

Map Region, Census Division	Utility Location	Minimum Bill ($)	50 KWH Bill ($)	Price per KWH (cents)	100 KWH Bill ($)	Price per KWH (cents)	500 KWH Bill ($)	Price per KWH (cents
Region I Northwest Alaska								
Barrow	Barrow	10.00	10.00	20.0	15.00	15.0	66.00	13.2
Kobuk	Kotzebue	10.00	10.00	20.0	17.50	17.5	67.50	13.5
Nome	Nome	5.00	5.00	10.0	10.00	10.0	50.00	10.0
	Teller		10.00	20.0	20.00	20.0	100.00	20.0
	Unalakleet	10.00	12.00	24.0	18.00	18.0	54.00	10.8
Region II Southwest Alaska								
Aleutian Islands	Cold Bay	10.00	10.00	20.0	10.00	10.0	41.00	8.2
Bethel	Bethel	5.00	6.00	12.0	11.00	11.0	44.75	9.0
Bristol Bay	Dillingham	14.00	14.00	28.0	14.00	14.0	50.00	10.0
	Egegik	7.50	7.50	15.0	13.50	13.5	44.50	8.9
Bristol Bay Borough	King Salmon	7.50	7.50	15.0	13.50	13.5	44.50	8.9
	Naknek	7.50	7.50	15.0	13.50	13.5	44.50	8.9
Kuskokwim	Aniak	20.00	20.00	40.0	20.00	20.0	95.00	19.0
	McGrath	5.00	6.75	13.5	12.50	12.5	57.00	11.4
Region III Southeast Alaska								
Haines	Haines	5.50	5.50	11.0	7.50	7.5	23.50	4.7
Juneau	Auke Bay	10.00	10.00	20.0	10.00	10.0	35.00	7.0
	Juneau	4.00	4.00	8.0	5.00	5.0	20.80	4.2
Ketchikan	Ketchikan	4.50	6.00	12.0	7.50	7.5	18.25	3.7
Outer Ketchikan	Metlakatla*							
Prince of Wales	Craig	3.30	5.30	10.6	9.80	9.8	37.80	7.6
	Hydaburg	3.30	5.30	10.6	9.80	9.8	37.80	7.6
Sitka	Sitka	5.00	5.00	10.0	5.00	5.0	19.00	3.8
Skagway-Yakutat	Hoonah	--	5.00	10.0	10.00	10.0	50.00	10.0
	Pelican	2.50	3.75	7.5	6.00	6.0	26.00	5.2
	Skagway	3.50	5.00	10.0	10.00	10.0	31.50	6.3
	Yakutat	5.00	5.00	10.0	10.00	10.0	40.00	8.0
Wrangell-Petersburg	Petersburg*							
	Wrangell	5.50	5.50	11.0	9.35	9.4	24.75	5.0
Region IV Southcentral Alaska								
Cordova-McCarthy	Cordova	4.00	6.50	13.0	9.50	9.5	27.50	5.5
Kenai-Cook Inlet	Homer	7.50	7.50	15.0	8.00	8.0	25.00	5.0
	Kenai	5.00	5.00	10.0	7.50	7.5	23.50	4.7
	Port Graham*							
	Seldovia	7.50	7.50	15.0	11.50	11.5	33.50	6.7
	Soldotna	7.50	7.50	15.0	8.00	8.0	25.00	5.0
Kodiak	Kodiak	3.00	5.50	11.0	9.13	9.1	24.63	4.9
	Port Lions	9.00	7.00	14.0	14.00	14.0	44.00	8.8

(Continued, next page)

Table 6 (Cont.)

Map Region, Census Division	Utility Location	Minimum Bill ($)	50 KWH Bill ($)	Price per KWH (cents)	100 KWH Bill ($)	Price per KWH (cents)	500 KWH Bill ($)	Price per KWH (cents)
Matanuska-Susitna	Palmer	9.00	9.00	18.0	9.00	9.0	31.25	6.3
Seward	Seward	6.00	7.80	15.6	12.30	12.3	23.30	4.7
Valdez-Chitina-Whittier	Chitina	--	7.50	15.0	15.00	15.0	75.00	15.0
	Glennallen	7.50	8.00	16.0	13.50	13.5	45.50	9.1
	Valdez	5.00	5.00	10.0	9.75	9.8	41.75	8.4
	Paxson Lodge	5.00	8.00	16.0	13.50	13.5	53.50	10.7
Region V Anchorage								
Anchorage	Eagle River	9.00	9.00	18.0	9.00	9.0	31.25	6.3
	Municipal	2.00	2.75	5.5	4.25	4.3	13.00	2.6
	Chugach	2.00	2.75	5.5	4.25	4.3	13.75	2.8
Region VI Interior								
Upper Yukon	Deadhorse	--	13.20	26.4	26.39	26.4	131.94	26.4
	Fort Yukon	3.00	12.50	25.0	25.00	25.0	85.00	17.0
Yukon-Koyukuk	Bettles	--	12.00	24.0	24.00	24.0	120.00	24.0
	Manley Hot Springs	10.00	12.50	25.0	25.00	25.0	125.00	25.0
	Nenana	7.00	7.00	14.0	13.00	13.0	61.00	12.2
	Tanana	7.80	7.80	15.6	13.00	13.0	61.00	12.2
Region VII Fairbanks								
Fairbanks	Municipal	1.80	4.00	8.0	7.50	7.5	22.50	4.5
	Golden Valley	10.00	10.00	20.0	10.00	10.0	37.96	7.6
Southeast Fairbanks	Delta Junction	10.00	10.00	20.0	10.00	10.0	30.38	6.1
	Dot Lake	--	7.50	15.0	15.00	15.0	63.00	12.6
	Northway	10.00	10.00	20.0	13.00	13.0	55.00	11.0
	Tok	7.50	7.50	15.0	13.00	13.0	53.50	10.7
Alaska Village Electric Cooperative (AVEC)		--	10.00	20.0	18.75	18.8	72.75	14.6

*Information not available.

SOURCE: Electric utility rate files, Alaska Public Utilities Commission, as of October 1975. These are the rates on file at the commission and do not include either interim rate increases or automatic fuel cost rate adjustments which increase actual prices paid. For utilities with more than one residential rate, the base rate without specific appliances was reported.

In particular, in the growth-as-usual use-intensity projections, the ratios of residential customers to population and average annual consumption continue to grow quite rapidly. The most striking example of this occurs in the Fairbanks region, where by 1990, assuming accelerated economic growth, average annual residential consumption exceeds 40,000 kwh per year. At present, the typical all-electric home in the Fairbanks area (including space heat) consumes approximately 40,000 kwh. Thus, the unlikely assumption implied for Fairbanks in the growth-as-usual case is that the entire housing stock will, by 1990, convert to all-electric appliances. Also during this period, the ratio of residential customers to population is projected to increase from 28 to over 37 percent. This implies either a drastic reduction in average family size or a substantial increase in the incidence of second homes.

Neither of these implied assumptions appears likely to the author. It seems, therefore, that the growth-as-usual assumptions should not be seriously considered as a possible future growth pattern in electricity consumption.

CONCLUSION

This paper has attempted to delineate the possible range of growth of electricity requirements for the state. The range is wide, both because of the uncertainty surrounding economic growth and also the uncertainty of response by future customers to variables affecting consumption rates. Within the broad range of growth possibilities, however, the variation seems to be between rapid growth of requirements and very rapid growth. Clearly, to adequately respond to this growth with an efficient investment strategy to develop necessary additional capacity is a challenging prospect, given the many options available to the state.

* * * *

Table 7

Automatic Fuel Cost Rate Adjustment Clause Surcharges as of October 1, 1975

Utility	Surcharge in cents/KWH
Aniak Power Company	2.89
Craig (AP&T)	2.06
Egegik (Naknek Electric Association)	4.5
Fort Yukon Utilities	1.082
Golden Valley Electric Association	.5973
Haines Light & Power	1.33
Homer Electric Association	1.32
Hydaburg (AP&T)	2.49
Juneau (AELP)	.48
Kodiak Electric Association	1.34
Kotzebue Electric Association	1.518
Matanuska Electric Association	1.74
Naknek Electric Association	1.5
Northern Commercial Company	1.87
Northern Power and Engineering	1.76
Northway Power and Light	1.63
Nushagak Electric	1.502
Skagway (AP&T)	.35
Tok (AP&T)	1.96
Yakutat Power Company	1.604

SOURCE: Alaska Public Utilities Commission

Table 8

MAP Projection Results for Selected Variables

	Limited Development	Accelerated Development
1974		
Population (x 1000)	350.7	350.7
Employment (x 1000)	159.9	159.9
Wages and Salaries (real millions of 1967 $)	973.9	973.9
Petroleum Production (thousand b/d)	200	200
State and Local Government Expenditures (nominal million $)	793.2	793.2
1980		
Population (x 1000)	456.9	471.4
Employment (x 1000)	219.7	229.2
Wages and Salaries (real millions of 1967 $)	1,506.9	1,586.3
Petroleum Production (thousand b/d)	2,066	2,066
State and Local Government Expenditures (nominal million $)	1,973.3	2,058.1
1985		
Population (x 1000)	547.9	614.8
Employment (x 1000)	265.4	300.9
Wages and Salaries (real millions of 1967 $)	1,970.0	2,260.8
Petroleum Production (thousand b/d)	3,033	4,930
State and Local Government Expenditures (nominal million $)	3,408.8	4,084.4
1990		
Population (x 1000)	641.3	738.0
Employment (x 1000)	312.7	361.4
Wages and Salaries (real millions of 1967 $)	2,506.2	2,919.2
Petroleum Production (thousand b/d)	3,597	7,299
State and Local Government Expenditures (nominal million $)	5,026.1	6,197.1

Table 9

MAP Model Economic Projection Values for Limited Development Case

Population

(Thousands of Persons)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	13.499	27.563	48.615	45.283	153.118	8.562	54.020	350.659
75	13.748	27.647	51.466	53.601	163.909	9.967	57.800	378.137
76	14.051	28.042	53.956	56.240	173.753	9.831	59.161	395.034
77	14.226	28.534	54.610	53.252	179.760	9.067	57.867	397.315
78	14.362	28.801	55.765	54.812	187.411	9.386	58.735	409.272
79	14.589	29.078	57.982	57.252	198.372	9.387	59.912	426.571
80	14.919	29.362	61.555	64.246	214.927	9.764	62.154	456.927
81	15.254	29.879	64.112	68.273	225.612	9.798	64.218	477.145
82	15.503	30.192	66.534	71.557	236.992	9.008	65.962	495.747
83	15.621	30.379	67.842	76.951	247.200	8.736	66.938	513.667
84	15.818	30.710	69.595	79.078	259.264	8.670	68.388	531.523
85	16.039	31.125	71.297	78.763	271.972	8.759	69.957	547.913
86	16.234	31.500	72.870	79.301	284.590	8.767	71.415	564.478
87	16.393	31.833	74.182	80.670	297.139	8.795	72.683	581.693
88	16.549	32.160	75.546	81.495	311.223	8.802	73.992	599.767
89	16.699	32.471	76.911	83.251	325.999	8.821	75.352	619.503
90	16.857	32.778	78.427	85.146	342.414	8.875	76.847	641.344

Employment

(Thousands of Persons)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	4.085	10.654	24.627	17.929	72.475	5.344	24.772	159.886
75	4.471	11.183	27.006	21.492	79.244	8.687	27.542	179.625
56	4.723	11.567	28.624	22.490	84.200	8.279	28.294	188.177
77	4.682	11.626	28.482	20.964	85.874	6.236	26.932	184.796
78	4.766	11.829	29.138	21.502	89.515	6.830	27.336	190.916
79	5.003	12.210	30.709	22.487	95.351	6.862	28.099	200.720
80	5.446	12.830	33.521	25.427	104.854	7.872	29.760	219.712
81	5.693	13.237	35.040	26.847	109.713	7.800	30.781	229.111
82	5.990	13.705	36.848	28.191	115.906	6.125	31.933	238.696
83	6.159	14.036	37.891	30.396	121.570	5.634	32.629	248.313
84	6.344	14.392	39.056	31.173	127.680	5.476	33.449	257.569
85	6.495	14.714	39.999	30.865	133.607	5.546	34.186	265.412
86	6.639	15.036	40.906	30.933	139.613	5.488	34.904	273.520
87	6.755	15.334	41.659	31.851	145.664	5.477	35.531	281.771
88	6.879	15.649	42.477	31.570	152.579	5.439	36.207	290.799
89	7.020	15.997	43.360	32.189	160.037	5.438	36.968	301.010
90	7.185	16.376	44.394	32.883	168.476	5.515	37.849	312.677

Real Wages and Salaries

(Millions of Dollars)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	24.9	56.5	150.5	102.5	441.1	48.1	150.2	973.9
75	27.7	60.9	168.8	130.3	493.5	82.5	174.9	1138.6
76	29.8	64.4	182.9	138.1	535.0	78.1	183.2	1211.5
77	30.2	66.0	185.9	128.1	556.1	54.4	175.1	1195.8
78	31.4	68.4	194.0	134.1	590.2	59.3	181.2	1258.5
79	33.5	72.1	208.7	142.9	640.0	59.4	190.0	1346.6
80	37.1	77.4	232.6	168.1	716.1	69.4	206.2	1506.9
81	39.5	81.5	247.9	180.6	761.6	69.2	218.0	1598.3
82	42.4	86.0	265.7	192.2	817.7	51.8	231.2	1687.0
83	44.4	89.7	278.4	212.7	871.1	47.2	241.1	1784.8
84	46.7	93.7	292.5	221.0	929.4	46.0	242.6	1881.9
85	48.8	97.6	305.3	220.3	987.2	47.2	263.6	1970.0
86	50.9	101.4	318.1	222.9	1046.8	47.0	274.7	2061.9
87	52.9	105.2	329.9	229.0	1107.9	47.5	285.4	2157.8
88	55.0	109.2	342.6	233.7	1176.7	47.6	296.7	2261.7
89	57.3	113.4	356.1	241.5	1251.0	48.2	309.1	2376.6
90	59.9	118.0	371.3	249.8	1334.6	49.5	323.1	2506.2

Table 10

MAP Model Economic Projection Values for Accelerated Development Case

Population

(Thousands of Persons)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	13.499	27.563	48.615	45.283	153.118	8.562	54.020	350.659
75	13.748	27.647	51.466	53.601	163.909	9.967	57.800	378.137
76	14.051	27.042	53.956	56.240	173.753	9.831	59.161	395.034
77	14.387	28.483	53.738	55.478	186.201	9.035	59.081	409.402
78	14.357	28.710	56.059	58.860	190.077	9.352	58.948	416.363
79	14.632	29.040	58.654	61.233	202.266	9.257	60.115	435.196
80	16.055	29.550	62.410	69.002	221.208	10.172	63.032	471.429
81	18.138	30.278	65.145	78.349	236.062	11.291	66.297	505.560
82	20.409	31.006	69.286	88.024	257.630	12.058	70.672	549.083
83	20.601	31.625	72.957	94.871	278.020	11.778	73.391	583.243
84	19.079	32.419	76.424	91.155	294.060	10.166	74.951	598.253
85	18.881	33.225	78.392	89.892	307.794	10.035	76.592	614.811
86	18.610	33.912	80.392	89.975	323.307	9.851	78.212	634.258
87	18.867	34.602	82.150	91.668	340.177	10.031	79.950	657.445
88	19.177	35.267	84.073	93.211	359.740	10.191	81.827	683.484
89	19.289	35.660	86.067	95.613	379.584	10.233	83.718	710.163
90	19.414	35.911	88.027	98.147	400.593	10.305	85.607	738.004

Employment

(Thousands of Persons)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	4.085	10.654	24.627	17.929	72.475	5.344	24.772	159.886
75	4.471	11.183	27.006	21.492	79.244	8.687	27.542	179.625
76	4.723	11.567	28.624	22.490	84.200	8.279	28.294	188.177
77	5.009	11.995	30.439	22.119	90.473	6.408	28.133	194.575
78	4.835	11.906	29.547	23.213	91.439	6.868	27.660	195.467
79	5.114	12.336	31.373	24.169	97.903	6.682	28.403	205.981
80	6.743	13.147	34.226	27.378	108.429	8.935	30.392	229.249
81	9.326	13.746	35.777	30.844	115.221	11.838	32.079	248.830
82	13.009	14.590	38.613	34.597	126.224	14.241	34.710	275.983
83	13.358	15.430	41.278	37.319	136.987	13.274	36.429	294.075
84	10.514	16.289	43.509	35.614	144.590	8.455	37.114	296.114
85	9.845	16.871	44.248	34.670	149.853	7.845	37.586	300.916
86	9.242	17.526	45.288	34.444	156.764	7.273	38.252	308.797
87	9.470	18.274	46.233	34.896	164.570	7.542	39.062	320.047
88	9.811	19.080	47.393	35.344	174.012	7.804	40.037	333.481
89	9.906	19.558	48.695	36.172	183.844	7.838	41.096	347.108
90	10.031	19.838	49.998	37.061	194.348	7.948	42.176	361.399

Real Wages and Salaries

(Millions of Dollars)

Year	RGN 1	RGN 2	RGN 3	RGN 4	RGN 5	RGN 6	RGN 7	STATE
74	24.9	56.5	150.5	102.5	441.1	48.1	150.2	973.9
75	27.7	60.9	168.8	130.3	493.5	82.5	174.9	1138.6
76	29.8	64.4	182.9	138.1	535.0	78.1	183.2	1211.5
77	32.2	68.3	198.8	135.3	586.6	55.3	183.7	1260.1
78	31.8	68.9	196.8	149.8	603.2	59.5	183.6	1293.6
79	34.3	72.9	213.3	158.3	657.4	57.2	192.2	1385.5
80	51.8	79.7	237.5	186.2	740.9	78.8	211.3	1586.3
81	82.7	85.3	253.2	216.6	800.3	107.8	229.1	1775.1
82	125.8	92.8	278.7	247.4	890.9	129.7	255.9	2020.3
83	129.2	100.4	303.9	270.9	982.0	121.4	273.5	2181.2
84	94.5	108.5	326.8	256.6	1052.5	75.3	283.8	2197.8
85	87.1	114.7	338.6	251.0	1107.3	69.4	292.8	2260.8
86	80.3	121.5	353.1	251.7	1175.1	63.7	303.9	2349.4
87	83.8	129.3	367.3	258.2	1251.0	67.0	316.7	2473.3
88	88.9	137.7	383.6	265.2	1231.0	70.2	331.3	2617.9
39	90.7	143.4	401.5	274.8	1435.4	71.2	347.1	2764.0
90	93.0	147.5	419.9	285.2	1537.2	72.9	363.5	2919.2

Table 11

Projected Average Annual Population Growth Rates

	Northwest	Southwest	Southeast	Southcentral	Anchorage	Interior	Fairbanks	State
Limited Development	1.4	1.1	3.0	4.0	5.2	.0	2.2	3.8
Accelerated Development	2.3	1.7	3.8	5.0	6.2	1.2	2.9	4.8

Table 12

State Electricity Demand Projections Summary

	Thousands of MWH Demanded				Annual Growth Rates Calculated from 1974 (%)							
	Limited Economic Development		Accelerated Economic Development		Limited Economic Development		Accelerated Economic Development		MW Peak Capacity @ 50% Load			
Year	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest				
1974	1,715	1,715	1,715	1,715	--	--	--	--	392	392	392	392
1980	3,909	2,830	4,286	2,941	14.7	8.7	16.5	9.4	892	646	979	671
1985	6,581	4,147	8,358	4,712	13.0	8.4	15.5	9.6	1,503	947	1,908	1,076
1990	10,158	5,975	13,450	6,961	11.8	8.1	13.7	9.2	2,319	1,364	3,071	1,589
1995	15,799	8,765	21,929	10,524	11.2	8.1	12.9	9.0	3,607	2,001	5,007	2,403

Table 13

Summary of the Range of Alaska Electricity Demand Projections, 1985 and 1995

		Peak Demand (MW)			Total Energy Sales (Thousand MWH)			Average Annual Growth Rates		
Region		1974 (actual)	1985	1995	1974 (actual)	1985	1995	1975 to 1980	1975 to 1985	1975 to 1995
Anchorage (v)	Lowest	199	538	1300	867	2347	5679	9.9	9.4	9.4
	Highest	199	1104	3515	867	4822	15350	17.5	16.9	14.7
Southcentral (except Anchorage) (iv)	Lowest	62	164	372	282	748	1325	10.1	9.2	7.6
	Highest	62	290	611	282	1701	2791	21.9	17.7	11.5
Anchorage, Southcentral	Lowest	261	702	1672	1149	3095	7004	9.9	9.4	9.0
	Highest	261	1394	4126	1149	6523	18141	18.7	17.1	14.0
Fairbanks (vii)	Lowest	76	144	260	319	602	1088	5.8	5.9	6.0
	Highest	76	297	677	319	1244	2843	12.8	13.2	11.0
Anchorage, Southcentral, and Fairbanks	Lowest	337	846	1932	1468	3697	8092	9.1	8.8	8.5
	Highest	337	1691	4803	1468	7787	20984	17.6	16.4	13.5
Southeast (iii)	Lowest	48	93	141	215	417	634	6.7	6.2	5.3
	Highest	48	112	184	215	505	827	8.7	8.1	6.6
Northwest plus Southwest (i & ii)	Lowest	8	9	10	31	36	44	2.0	1.3	1.6
	Highest	8	21	31	31	86	127	9.7	9.7	6.9
Alaska Statewide	Lowest	393	948	2083	1715	4147	8765	8.6	8.4	8.1
	Highest	393	1824	5018	1715	8358	21938	16.5	15.5	12.5

Note: There are no significant electric utilities in the Interior Region.

Table 14

Projected Net Sales of Electric Utilities to Final Consumers (Thousand MWH)

Electricity Use Intensity Scenario

	Case 1		Case 2		Case 3		Case 4	
Electricity Intensity Scenario	Growth As Usual		Moderate Residential Electrification Commercial/Industrial Growth As Usual		Low Residential Electrification Commercial/Industrial Minimum Electrification		Minimum Growth	
Economic Scenario	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth
Northwest[a]								
1974 (Actual)	15.178	15.178					15.178	15.178
1980	20	24					17	18
1985	24	34					17	21
1990	27	36					19	22
1995	30	37					20	23
Southwest[b]								
1974 (Actual	16.615	16.615					16.615	16.615
1980	28	30					18	18
1985	40	52					19	21
1990	51	69					20	23
1995	63	90					22	25
Southeast[c]								
1974 (Actual)	215.088	215.088	215.088	215.088	215.088	215.088	215.088	215.088
1980	328	338	344	355	340	350	318	326
1985	432	487	443	505	449	502	417	465
1990	529	611	527	617	561	639	523	594
1995	656	777	634	763	713	827	667	768
Southcentral[d]								
1974 (Actual)	282.417	282.417	282.417	282.417	282.417	282.417	282.417	282.417
1980	762	933	717	849	563	612	503	544
1985	1,302	1,701	1,131	1,432	835	966	748	857
1990	1,659	2,178	1,390	1,774	1,087	1,267	987	1,142
1995	2,114	2,791	1,716	2,205	1,436	1,686	1,323	1,545
Anchorage								
1974 (Actual)	867.132	867.132	867.132	867.132	867.132	867.132	867.132	867.132
1980	2,124	2,286	2,012	2,147	1,664	1,723	1,529	1,580
1985	3,734	4,822	3,245	4,076	2,550	2,924	2,347	2,679
1990	6,326	8,637	5,096	6,749	3,910	4,628	3,625	4,273
1995	10,633	15,350	7,982	11,154	6,071	7,416	5,679	6,918
Fairbanks								
1974 (Actual)	318.751	318.751	318.751	318.751	318.751	318.751	318.751	318.751
1980	631	658	598	616	485	495	446	455
1985	1,032	1,244	833	950	650	727	602	669
1990	1,534	1,891	1,090	1,256	861	977	803	907
1995	2,247	2,834	1,410	1,640	1,157	1,334	1,088	1,250

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[a] Includes utilities at Kotzebue, Nome, and Unalakleet.

[b] Bethel, McGrath, Naknek, and Nushagak.

[c] Juneau, Ketchikan, Metlakatla, Petersburg, Sitka, and Wrangell.

[d] Includes Cordova, Glennallen, Homer, Kenai, Kodiak, Palmer, Seldovia, Seward, Talkeetna, and Valdez.

Table 15

Projected Electricity Peak Demand (MW)

Electricity Intensity Scenario	Case 1 Growth As Usual		Case 2 Moderate Residential Electrification Commercial/Industrial Growth As Usual		Case 3 Low Residential Electrification Commercial/Industrial Minimum Electrification		Case 4 Minimum Growth	
Economic Scenario	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth	Limited Growth	Accelerated Growth
Northwest								
1974	3.6	3.6					3.6	3.6
1980	4.8	5.7					4.0	4.3
1985	5.7	8.1					4.0	5.0
1990	6.4	8.6					4.5	5.2
1995	7.1	8.8					4.8	5.5
Southwest								
1974	4.1	4.2					4.1	4.1
1980	7.0	7.5					4.5	4.5
1985	10.0	12.9					4.7	5.2
1990	12.7	17.2					5.0	5.7
1995	15.7	22.4					5.5	6.2
Southeast								
1974	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
1980	73.1	75.4	76.7	79.2	75.8	78.1	70.9	72.7
1985	96.3	108.6	98.8	112.6	100.1	111.9	93.0	103.7
1990	118.0	136.3	117.5	137.6	125.1	142.5	116.6	132.5
1995	146.3	173.3	141.4	170.1	159.0	184.4	148.7	171.3
Southcentral								
1974	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8
1980	166.9	204.3	157.0	185.9	123.3	134.0	110.2	119.1
1985	285.1	372.5	247.7	313.6	182.9	211.6	163.8	187.7
1990	363.3	477.0	304.4	388.5	238.1	277.5	216.2	250.1
1995	463.0	611.2	375.8	482.9	314.5	369.2	289.7	338.4
Anchorage								
1974	198.6	198.6	198.6	198.6	198.6	198.6	198.6	198.6
1980	486.4	523.5	460.7	491.7	381.1	394.6	350.1	361.8
1985	855.1	1,104.2	743.1	933.4	584.0	669.6	537.5	613.5
1990	1,448.7	1,977.9	1,167.0	1545.5	895.4	1,059.8	830.1	978.5
1995	2.435.0	3.515.2	1,827.9	2,554.3	1,390.3	1,698.3	1,300.5	1,584.2
Fairbanks								
1974	76.2	76.2	76.2	76.2	76.2	76.2	76.2	76.2
1980	150.8	157.3	142.9	147.2	115.9	118.3	106.6	108.7
1985	246.6	297.3	199.1	227.1	155.4	173.8	143.9	159.9
1990	366.6	451.9	260.5	300.2	205.8	233.5	191.9	216.8
1995	537.0	677.3	337.0	392.0	276.5	318.8	260.0	298.8

Load factor: Northwest .53, Southwest .51, Southeast .56, Southcentral .56, Anchorage .55, Fairbanks .53.

System losses: Northwest 10.5%, Southwest 11.6%, Southeast 9.2%, Southcentral 7.4%, Anchorage 10.4%, Fairbanks 11.0%.

Table 16

Projected Residential Consumption Parameters

Electricity Intensity Use Scenario

Economic Scenario	Growth as Usual				Moderate Electrification				Low Electrification			
	Limited Growth		Accelerated Growth		Limited Growth		Accelerated Growth		Limited Growth		Accelerated Growth	
	hookup saturation	kwh/ consumer	hookup saturation	kwh/ consumer	hookup saturation	kwh/ consumer	hookup saturation	kwh/ consumer	hookup saturation	kwh/ consumer	hookup saturation	kwh/ consumer
Southeast												
1974	24.9%	7,623	24.9%	7,623	24.9%	7,623	24.9%	7,623	24.9%	7,623	24.9%	7,623
1980	24.5	8,520	25.9	8,555	27.0	9,137	27.0	9,232	27.0	8,394	27.0	8,422
1985	26.9	9,181	26.7	9,226	27.0	9,690	27.0	10,009	27.0	8,675	27.0	8,808
1990	27.9	9,776	27.7	9,818	27.0	10,008	27.0	10,340	27.0	8,837	27.0	8,972
1995	29.1	10,435	28.8	10,472	27.0	10,296	27.0	10,635	27.0	8,983	27.0	9,118
Southcentral												
1974	32.7%	8,026	32.7%	8,026	32.7%	8,026	32.7%	8,026	32.7%	8,026	32.7%	8,026
1980	37.4	12,896	38.3	14,240	37.0	11,076	37.0	11,422	37.0	9,639	37.0	9,822
1985	40.0	16,771	40.1	19,050	37.0	11,999	37.0	12,502	37.0	10,127	37.0	10,394
1990	40.8	18,961	41.2	21,589	37.0	12,304	37.0	12,801	37.0	10,289	37.0	10,552
1995	42.1	21,448	42.3	24,477	37.0	12,585	37.0	13,075	37.0	10,438	37.0	10,696
Anchorage												
1974	31.1%	9,106	31.1%	9,106	31.1%	9,106	31.1%	9,106	31.1%	9,106	31.1%	9,106
1980	35.8	12,614	36.1	12,931	35.0	11,317	35.0	11,425	35.0	10,010	35.0	10,054
1985	38.1	16,073	39.1	17,605	3.50	12,102	35.0	12,439	35.0	10,331	35.0	10,469
1990	39.9	20,505	40.9	23.090	35.0	12,695	35.0	13,023	35.0	10,573	35.0	10,707
1995	41.3	26,498	42.2	30,704	35.0	13,162	35.0	13,466	35.0	10,794	35.0	10,888
Fairbanks												
1974	28.0%	11,597	28.0%	11,597	28.0%	11,597	28.0%	11,597	28.0%	11,597	28.0%	11,597
1980	31.5	19,112	31.8	19,797	32.0	16,987	32.0	17,235	32.0	12,310	32.0	12,343
1985	34.3	26,816	34.9	30,735	32.0	18,952	32.0	20,278	32.0	12,509	32.0	12,746
1990	36.9	34,801	37.3	40,223	32.0	20,324	32.0	21,723	32.0	12,752	32.0	12,937
1995	39.6	44,585	40.0	52,006	32.0	21,561	32.0	23,002	32.0	12,916	32.0	13,107

Note: The no-growth case assumes no change over time in either hookup saturation or average KWH consumption per customer and is, therefore, omitted.
Hookup saturation is defined as residential customers/civilian population.

APPENDIX 1. THE MAP ECONOMIC MODEL

Growth in electricity requirements will closely follow growth in the state's economy. Projections of the state's future economic growth are provided by the Man-in-the-Arctic Program (MAP) regional econometric model of the state.

Model Description

The MAP model[1] allows the researcher to develop projections of key economic and demographic variables for seven regions of Alaska (Figure 1), based upon a set of assumptions about factors outside state control but impacting the state economy. Researchers constructed the model using multiple linear regression techniques with historic Alaskan data covering the period 1961 to the present.

Treatment of individual industries in the model depends upon whether the industry is basic or nonbasic. A basic industry is one in which the level of economic activity (as measured by employment, wages and salaries, and gross product) is determined by forces outside the Alaskan private economy. The basic determinants of activity in these industries are national and international markets, the physical availability of resources, and federal government policies impacting the state. Industries which fall into this category are mining (including petroleum), agriculture, forestry and fisheries, and manufacturing. Construction industry activity is partially determined by forces external to the Alaska economy and partially by instate economic activity.

The level of activity in nonbasic industries is essentially a function of the amount of income generated instate by both the basic and nonbasic industries. This category includes services, trade, finance, transportation, communications, and public utilities.

Government activity at the federal level is determined by forces outside state control, but state and local government revenues and expenditures are a function of Alaska economic conditions. State population is related not only to employment but also to relative disposable income in the state.

Development Scenarios

In order to project annual economic values using the MAP model, a set of assumptions must first be provided which indicates levels of expected activity within the basic industry sectors. Most important within this set are the assumptions of the petroleum industry, because activity in this industry will have the most impact on economic growth in the state during the next 20 years. This impact will occur both through employment in the petroleum and related industries (such as construction) and through state revenues generated by petroleum exploration, development, and production.

In developing the electric power requirements, two different sets of assumptions were used regarding petroleum industry activities within the state. Each is a consistent scenario describing the level and pace of new discoveries. The average wellhead price of new oil discoveries is assumed to be $5 per barrel in either case. The two cases are known as limited development and accelerated development.

Limited Development. This case represents the minimum expected level of petroleum leasing activity between the present and 1990. In addition to Cook Inlet and Prudhoe Bay, the federal government leases in Lower Cook Inlet and the Gulf of Alaska. In leasing the Outer Continental Shelf (OCS), the federal government effectively determines where state and private, primarily Native, development can occur. Thus, these parties are assumed to develop adjacent areas, and along the route of the oil pipeline. In addition, a gas line from Prudhoe Bay through Canada via the McKenzie Valley is constructed with minimum instate impact. In this scenario, petroleum production increases to 2 million barrels per day (mbd) in 1980 and 3.6 mbd in 1990.

Accelerated Development. This case incorporates all limited development activities. In addition, National Petroleum Reserve Alaska and several other OCS areas are developed through federal initiative. State and private development again follows the geographic lead of these activities. Petroleum development in this case increases more rapidly after 1980 and reaches 7.3 mbd by 1990. The OCS leasing schedule in this scenario is rapid but does not correspond to the schedule of leasing proposed as a part of Project Independence, nor does it include all OCS provinces identified and included in that schedule.

In addition to petroleum development assumptions, assumptions must be made regarding other basic industries. These other industries are assumed to experience mild growth, which does not vary between cases. This does not imply that

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[1] See box on page 1.

nonpetroleum basic industries are not important to the future of the state or that there will not be future growth in these industries. Developments in other basic industries will be of central importance, particularly on a community level. However, on a statewide and regional basis, the activities associated with petroleum development will be greater than those of other industries by an order of magnitude—thus, the choice to concentrate on petroleum development.

Finally, policy decisions by the state regarding the disposition of the revenues generated by petroleum development will affect the level of economic activity in the state. State government is assumed to place in a permanent fund 25 percent of recurrent and 50 percent of nonrecurrent petroleum revenues in both the limited and accelerated cases. This reflects the effect which the permanent fund will have on the level of expenditures.

APPENDIX 2. ELECTRICITY USE PROJECTION METHODOLOGY

The level of electricity requirements in future years will depend both upon the number of customers and the intensity of use per customer. These factors will in turn be related to the price of electricity, alternative types of energy available, and the level of income of the potential consumers. In Alaska, as elsewhere, there is evidence of a negative consumption response to price increases and a positive response to income increases. Although the relationship observed is only for one time period and only for the residential type of consumer, it is reasonable to expect that the same qualitative relationship will exist in other years and among other consumer types. [1]

The MAP econometric model projects increases in real wages and salaries (closely related to personal income) but does not provide estimates of the future prices of electricity and other fuels. This is because these prices will increasingly be determined by national and international, as opposed to purely local, market conditions.

Because of this uncertainty both in price and in consumers' response to price as it affects consumption, several sets of projections must be made, each corresponding to a different set of assumptions regarding these variables. Since each set of assumptions is essentially independent of the growth rate of the economy, each of the projections of electricity use is linked to both sets of economic projections (slow growth and accelerated growth). In this way, the projections cover the likely range of requirements for electricity.

The four sets of assumptions are: (1) *no growth*, (2) *low electrification*, (3) *moderate electrification*, and (4) *growth as usual*. Each is briefly described in the remainder of this section.

No-growth. This assumption provides the lowest estimate of future electricity use. The ratio of new residential customers to new population is assumed to be equal to the present ratio in each region. The average annual rate of consumption of existing customers is unchanged and new customers consume at the average rate of old customers. In the commercial and industrial sectors, new customers are projected at the same ratio to new population as existing customers. However, annual average consumption is allowed to grow at 5.8 percent, which was the national rate for the decade 1962-1972. These assumptions correspond to a very restrictive climate for electricity demand increase. Such a climate could result from substantial and continuing relative price increases for electricity, as well as from restrictions on electricity use, which would hold down or reduce consumer use.

Low-electrification. This case allows a gradual increase in the ratio of residential customers to population. Present customers will continue to consume at existing average rates, while consumption by new customers will be determined by the mix of appliances they choose and the average consumption rate of those appliances. New customers in each region are assumed to acquire major electric appliances (space heaters, water heaters, and stoves) in the same ratio as existing customers in that region. Other appliances in new households are all electric. The average consumption for a new customer will thus vary among regions, based not only upon differences in the existing ratio of particular electric appliances to consumers in the region, but also upon implicit regional differences in the average consumption rate of electricity in the different appliances. The commercial and industrial sectors are, because of scarcity of data, projected using the same methodology as in the *no-growth* case. However, the rationale behind this set of assumptions is a

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[1] A detailed analysis of this relationship is presented in Scott Goldsmith, "Future Electricity Requirements in Alaska," paper presented at the Western Economic Association Annual Meeting, San Francisco, June 17, 1976.

somewhat less restrictive atmosphere for the development of increased electricity demand than the *no-growth* case.

National average electricity requirements for the most common household appliances used in the development of these projections are shown in Table 2-1. Data on the percentage of households with major electric appliances is shown in Table 2-2.

Table 2-1

Household Appliance Electricity Consumption

Major Appliances	Average Wattage	Estimated Annual KWH Use
Dishwasher	1,201	100
Range (with oven)	12,200	1,175
Range (self-cleaning)	12,200	1,205
Freezer (15 cu. ft.)	341	1,195
Freezer (Frostless, 15 cu. ft.)	440	1,761
Refrigerator (12 cu. ft.)	241	728
Refrigerator (Frostless, 12 cu. ft.)	321	1,217
Clothes dryer	4,856	993
Water heater	2,475	4,219
Water heater (quick-recovery)	4,474	4,811
Air conditioner (room)	860	860
Dehumidifier	257	377
TV (black & white, tube)	160	350
TV (black & white, solid st.)	55	120
TV (Color, tube)	300	660
TV (color, solid st.)	200	440
Other Common Appliances		
Broiler	1,436	100
Coffee maker	894	106
Deep fryer	1,448	83
Frying pan	1,196	186
Hot plate	1,257	90
Oven (microwave)	1,450	190
Roaster	1,333	205
Toaster	1,146	39
Trash compactor	400	50
Iron (hand)	1,008	144
Wash machine (automatic)	512	103
Wash machine (nonautomatic)	286	76
Bed covering	177	147
Heater (portable)	1,322	176
Humidifier	177	163
Hair dryer	381	14
Heat lamp (infrared)	250	13
Radio	71	86
Clock	2	17
Sewing machine	75	11
Vacuum cleaner	630	46
Toothbrush	7	½

SOURCE: Electric Energy Association.

Moderate electrification. This case differs from low electrification in two respects. First, all new consumers in the residential sector acquire electric water heaters and stoves. Second, the projections of both commercial and industrial customers, as well as average consumption level per customer, are based upon regression analysis employing historical time series data for the individual region. This case reflects an atmosphere more conducive to electricity consumption growth than the former cases.

Growth-as-Usual. Finally, this case is based entirely upon regression analysis using observed historical relationships between the demographic and economic variables of the economic model and electric power consumed through utilities. Implicit in this case is the assumption of a continuing reduction in the relative price of electricity within Alaska.

Table 2-2

Percentages of Households With Selected Appliances – 1970

CENSUS DIVISION	**Number of Occupied Housing Units**	**Percent Modern Space Heat**	**Percent Electric Space Heat**	**Percent Modern Water Heat**	**Percent Electric Water Heat**	**Percent Modern Cooking Fuel**	**Percent Electric Cooking Fuel**	**Percent Clothes Dryers**	**Percent Electric Clothes Dryers**	**Percent Dish-washers**	**Percent Clothes Washing Machines**	**Percent Freezers**	**Percent Television Sets**
ANCHORAGE REGION													
Anchorage	35,021	94.9	6.4	95.6	34.6	99.4	64.5	59.4	54.2	29.0	63.2	39.1	94.6
SOUTHCENTRAL REGION													
Cordova-McCarthy	563	100.0	0.0	90.4	11.5	100.0	51.9	49.2	34.3	10.8	48.3	68.7	62.5
Kenai-Cook Inlet	3,881	90.8	3.6	86.1	33.0	97.4	23.6	54.6	42.8	17.4	61.6	50.8	70.5
Kodiak	2,535	96.1	0.8	93.1	21.9	100.0	54.7	66.8	61.9	12.9	78.3	51.5	80.7
Matanuska-Susitna	1,797	68.8	1.1	63.2	31.3	82.1	44.0	47.5	44.0	19.3	47.3	66.5	75.0
Seward	534	95.5	3.9	87.5	30.9	100.0	47.0	53.0	36.9	26.2	75.3	71.3	90.6
Valdez-Chitina-Whittier	1,017	78.9	0.9	56.5	20.2	93.6	17.9	35.0	17.5	5.5	30.5	40.0	36.0
INTERIOR REGION													
Upper Yukon	3.65	36.7	0.0	0.0	0.0	38.1	0.0	0.0	0.0	0.0	12.1	27.1	14.0
Yukon-Koyukuk	1,030	73.6	5.9	48.5	28.0	81.8	35.2	32.6	30.8	3.7	47.9	42.3	50.1
FAIRBANKS REGION													
Fairbanks	11,630	72.6	6.9	75.8	33.7	98.9	77.7	47.6	46.5	21.7	56.7	38.5	91.4
Southeast Fairbanks	982	73.1	6.2	83.0	45.8	92.4	59.0	54.7	54.7	17.1	60.9	45.9	67.9
SOUTHEAST REGION													
Angoon	116	79.3	0.0	15.5	0.0	79.3	0.0	0.0	0.0	0.0	0.0	15.5	0.0
Haines	362	92.5	0.0	72.1	26.2	92.5	48.9	56.9	56.9	13.0	69.1	52.5	41.4
Juneau	4,293	99.0	0.6	98.2	27.5	97.7	79.6	57.4	57.0	24.2	59.4	38.5	81.6
Ketchikan	2,820	99.3	3.5	98.7	66.4	100.0	87.8	64.3	64.3	21.8	63.2	40.6	78.3
Outer Ketchikan	412	100.0	16.9	100.0	83.5	100.0	89.1	74.0	74.0	11.7	94.9	69.7	88.8
Prince of Wales	528	96.4	0.0	79.0	7.4	93.4	6.6	31.6	13.8	7.0	64.8	43.4	16.3
Sitka	1,873	100.0	0.0	97.0	42.3	100.0	59.7	62.1	59.2	20.1	71.1	48.6	83.0
Skagway-Yakutat	626	90.7	3.6	87.6	20.5	90.7	34.8	33.7	24.3	7.0	40.9	47.1	24.3
Wrangell-Petersburg	1,395	96.5	3.4	86.5	51.0	90.6	60.9	45.4	45.4	19.6	64.2	53.8	66.8
NORTHWEST REGION (Rural)													
Barrow	513	100.0	0.0	25.0	0.0	95.9	7.6	21.6	18.1	0.0	17.5	14.6	28.1
Kobuk	955	81.4	2.2	19.3	6.6	74.9	17.6	19.3	19.3	4.6	15.6	30.2	4.5
Nome	1,238	85.5	1.8	34.0	5.6	87.6	9.5	12.6	11.1	5.1	15.1	12.9	1.4
SOUTHWEST REGION													
Aleutian Islands	1,192	88.3	5.7	82.8	52.3	100.0	62.2	66.1	62.8	15.0	73.2	45.7	53.9
Bethel	1,439	86.7	0.0	19.7	2.6	81.8	13.1	9.1	8.1	1.5	25.6	28.1	0.0
Bristol Bay	655	89.9	0.0	37.3	3.5	93.1	18.5	18.2	18.2	3.4	34.4	37.9	0.0
Bristol Bay Borough	213	100.0	0.0	72.3	29.1	100.0	38.0	84.5	48.4	17.8	56.8	82.1	93.4
Kuskokwim	401	29.9	0.0	24.4	9.5	39.7	14.0	14.7	14.7	0.0	24.4	24.4	14.9
Wade-Hampton	773	46.2	0.0	5.8	0.0	46.6	6.2	8.9	8.9	0.0	21.2	9.4	6.2
TOTAL	79,059	89.0	4.8	83.6	32.5	96.2	58.9	52.5	48.3	21.9	58.5	41.3	78.9

SOURCE: U.S. Bureau of the Census, Department of Commerce, *1970 Census of Housing.*

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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 nancial planning, utility load forecasters must be able project electric energy sales and peak loads fifteen or enty years into the future. Yet load forecasting has come an increasingly difficult challenge as social, nomic, demographic, and political forces converge to m an ever-changing pattern of complexity. The tively primitive trend line forecasting methods of t decades — which were adequate in their time —are ay being replaced with more sophisticated approaches needed to cope with the "new factors" which forecaster must address.

wo general load forecasting approaches are cur-y in widespread use in the utility industry: (1) ometric models, and (2) end-use (or engineering) els. Econometric models rely on historical data and tical techniques to forecast future use of electric gy — in the aggregate for a service area or by omer class — as a function of the price of electricity, 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.

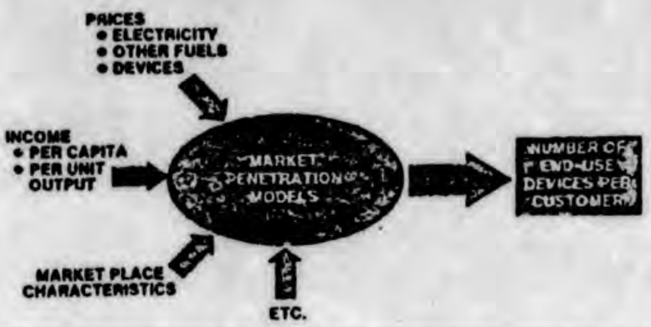
These NEA provisions could lead to a substantial near-term reduction in utilities' electric heating loads — though perhaps less than has been suggested because electric homes are typically quite efficient already. To account for this effect in its forecast, the utility would have to monitor the number 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 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.

FIGURE 2

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



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.

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.

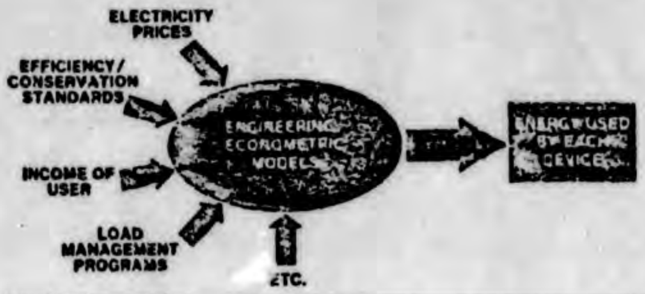
To account for the possible introduction of dispersed energy sources, the utility load forecaster must construct market models to estimate penetration rates, based on historical experience with similar new technologies (such as central air conditioning). Load profiles for the new devices will have to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

FIGURE 3

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



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.

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*"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.

2/15/80

Agenda

Introduction & Reasons for Meeting
    a. discussion of model structure
    b. develop probability distribution for key scenario items

Critical elements in long run model structure and testing model
    a. employment/population ratio
    b. real income growth (disposable)
    c. structural change
    d. specification of government

Critical elements in long run model scenarios
    a. growth of government
    b. exogenous construction and resource development employment (Oil)

Methods of prediction and their shortcomings
    a. extrapolation – changing ^problem conditions
    b. scenario building – problem myopia

Technique of assigning probabilities – example

itial determination of year 2000 probability distributions for exogenous employment, government spending, and population

Second round determination of probability distributions with ISER inputs

HISTORICAL INDICATORS

ALASKAN ECONOMY

				AVERAGE ANNUAL GROWTH		
	1960	1970	1980	60-70	70-80	60-80
EMPLOYMENT						
NON-AG W&S	56.9	92.5	168.2[A]	5.0	6.2	5.6
GOVT (NON-MIL)	22.7	35.6	54.6[A]	4.6	4.4	4.5
CONSTRUCTION	5.9	6.9	11.1[A]	1.6	4.9	3.2
MINING	1.1	3.0	6.9[A]	10.6	8.7	9.6
MANUFACTURING	5.8	7.8	12.0[A]	3.0	4.4	3.7
TRADE, SERVICE, FIR	14.7	29.9	65.7[A]	7.4	8.2	7.8
TRANS, COM., P.U.	6.8	9.1	17.0[A]	3.0	6.5	4.7
POPULATION	226.2	302.2	418.8[A]	2.9	3.3	3.1
EMPLOY / POPULATION w/o military - would be smaller	25%	Critical ratio 31%	40% (female participation)	—	—	—
PERSONAL INCOME	643	1412	5544[A]	8.2	14.7	11.4
BANK ASSETS	227	707	2463[A]	12.0	13.3	12.7
(GEN. APPROPRIATIONS) STATE EXPENDITURES	41	173	1200[C]	15.5	21.4	18.4
FED. OUTLAYS	156	729	1545[B]	16.7	7.8	12.2
REAL PI / POP	3097	4191	5741[A]	3.1	3.2	3.1
REAL ST. EX / POP	197	513	1242[A]	10.0	9.2	9.6
RELATIVE AK. PRICES	147	135	137[D]	-0.9	0.2	-0.4
RELATIVE AK. INCOMES	.81	.85	1.01[D]	—	—	—

FY1977

SIMPLE EXAMPLE OF PROBABILITY CALCULATION

	OUTCOME	①	②	③
Input	PROBABILITY	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
EVENT X State space	OUTCOME VALUE	6	12	18
	PROBABILITY	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$
EVENT Y employees	OUTCOME VALUE	4	8	12

EVENT Z output (pop)

Map Model

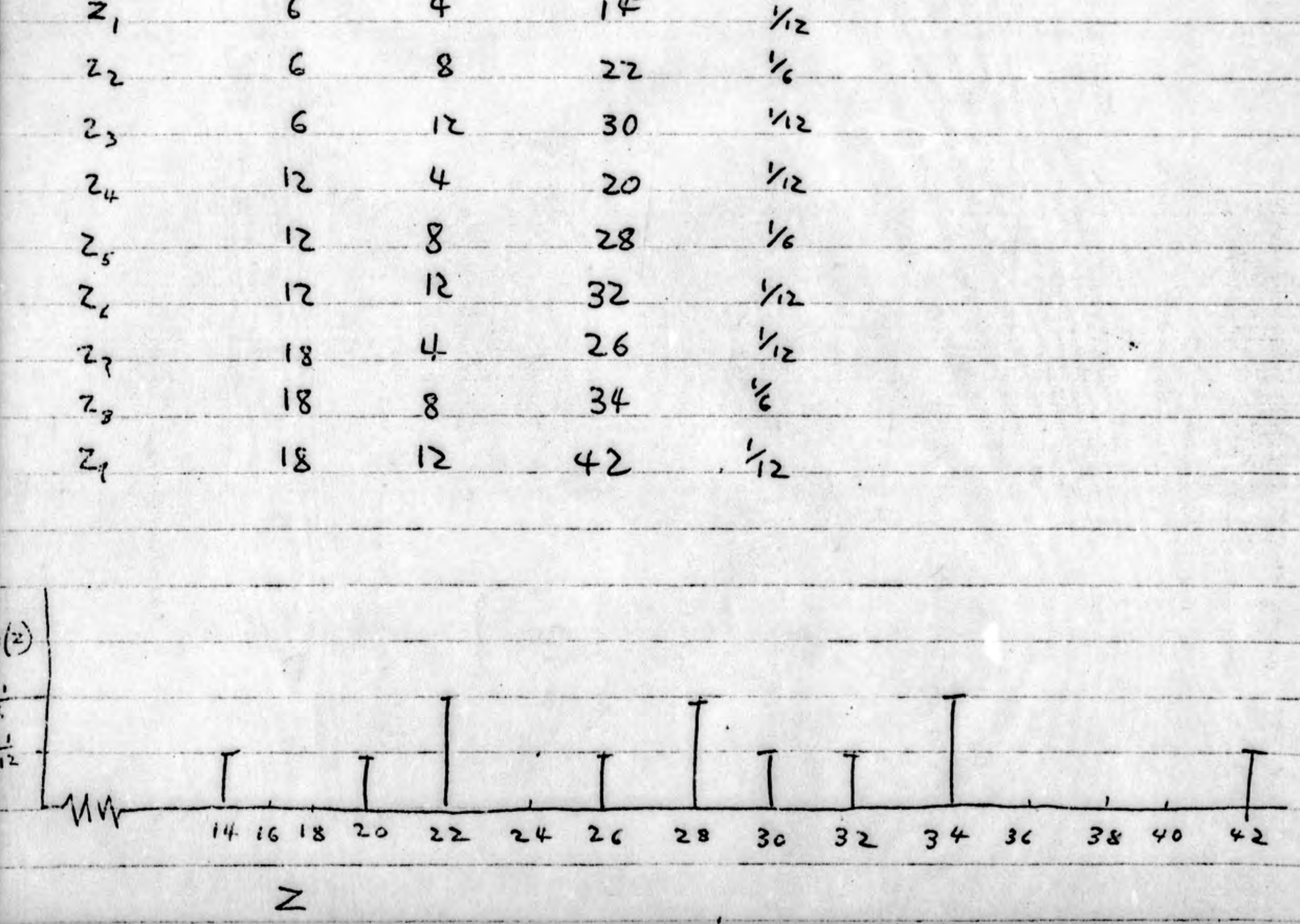
$$z = f(x,y) = x + 2y$$

~~Map Mo~~

~~so~~ $Z_k = f(x_i, y_j)$

$$p(Z_k) = p\left[f(x_i, y_j)\right]$$

outcome	x	y	f(x y)	p [f(x y)]
z_1	6	4	14	$\frac{1}{12}$
z_2	6	8	22	$\frac{1}{6}$
z_3	6	12	30	$\frac{1}{12}$
z_4	12	4	20	$\frac{1}{12}$
z_5	12	8	28	$\frac{1}{6}$
z_6	12	12	32	$\frac{1}{12}$
z_7	18	4	26	$\frac{1}{12}$
z_8	18	8	34	$\frac{1}{6}$
z_9	18	12	42	$\frac{1}{12}$



Kertulla - how long have you been here?
[Expo:
Env. supported Devils Canyon as alt to [illegible]

---

instead, use Waste heat for Algeako
1) postpone action until studies done
2) fund GVEA wasteheat project
3) check Chackachamna (?) site feasibility
4) other Interior sites

Jeff ? - F Env C

---

downstream impacts of Susitna great

Healy, Beluga
geothermal, tidal, wind / all available in Railbelt

---

great flexibility in meeting energy needs

SB 294 - mockery of judgement

---

usurps feasibility study process
forces negligence in review of costs

Susitna - greatest contributor to Cook Inlet salmon
F&G - year round siltation will occur
road head hunting

---

alternative hydro sites have not been studied

---

active faults

Intertie - no need for next 10 yrs.
advantages minimal
SB 385 - back door approach
too expensive for live communities
no showing of capacity available to Fb from Anch

PROJECT

? 1. ALPETCO

? 2. PACIFIC ALASKA LNG

N 3. STATE CAPITAL MOVE

✓ 4. BELUGA COAL FOR EXPORT

? 5. NW ALASKA GAS PIPELINE

N 6. TAPS PIPELINE - expansion

N 7. FAIRBANKS PETROCHEMICALS - fat chance

? 8. U.S. BORAX

Y 9. PRUDHOE BAY - secondary recovery + expansion

N 10. UPPER COOK OIL & GAS

11. OCS DEVELOPMENTS

~~Lower Cook 1976~~

N. ~~Gulf~~ (2 Sales)

~~W. Gulf~~

~~Lower Cook~~

Bering Norton

~~St. George Basin~~

Navarin Basin

~~N. Aleutian Shelf~~

~~Beaufort I~~

Beaufort II

~~Chuckchi Sea~~

State sales:

Native Corp
Renewable Resource
Tourism
RR

Gould - ^to^ APA Bd.

project goes back 40 yrs.

only 4 months ago - private sector/state

Feds have studied project very little

lots of smoke, little fire

Bud - #9 on list of hydro

8.2m - more than feds have spent to date

30m over the next 2 yrs.

$ already out to Alaskans

Corps - US hydro power potential - 930 billion kwh

430 in Alaska

90% precluded under HR 39

2% would provide for Alaska

2½m Terror Lake - USF&W intervened

~~[illegible]~~

remember other communities around state

700m in small projects (revenue bonds)

Gould

Cost - 40 - 50 mils - now

double by the time it's built

but gas cost & availability is in question

leave flexibility open to use variety of financing mechanisms

PROJECT

N 12. NPRA

N 13. WESTERN GULF LNG > contingent on significant NG dev't

14. NW ALASKA LNG

petro

15. AGRICULTURE / barley

16. FORESTRY

17. FISHERIES / bottomfish

18. FEDERAL GOVERNMENT

19. OTHER

secondary importance

aggregate impact will be small

42,000

fed, inc.

military

$ MEA manager - need lead, possible date

Vince O'Reilly -
inflated dollars ?

CEA - provide cheap power to HEA & MEA
20-25 year contract
Susitna should be considered along w/other alternatives

CEA - will support (when?)
└ hasn't supported project yet

current cost - 14 mils
Q. - cost & availability of gas

costs of Susitna not yet known -
estimated $ bw 40 or 50 mils,

Lee Wareham -
stabilize kW costs
legacy to future
intertie

Gravel
Sheffield

---

need construction employment in MatSu

— Windfall profits

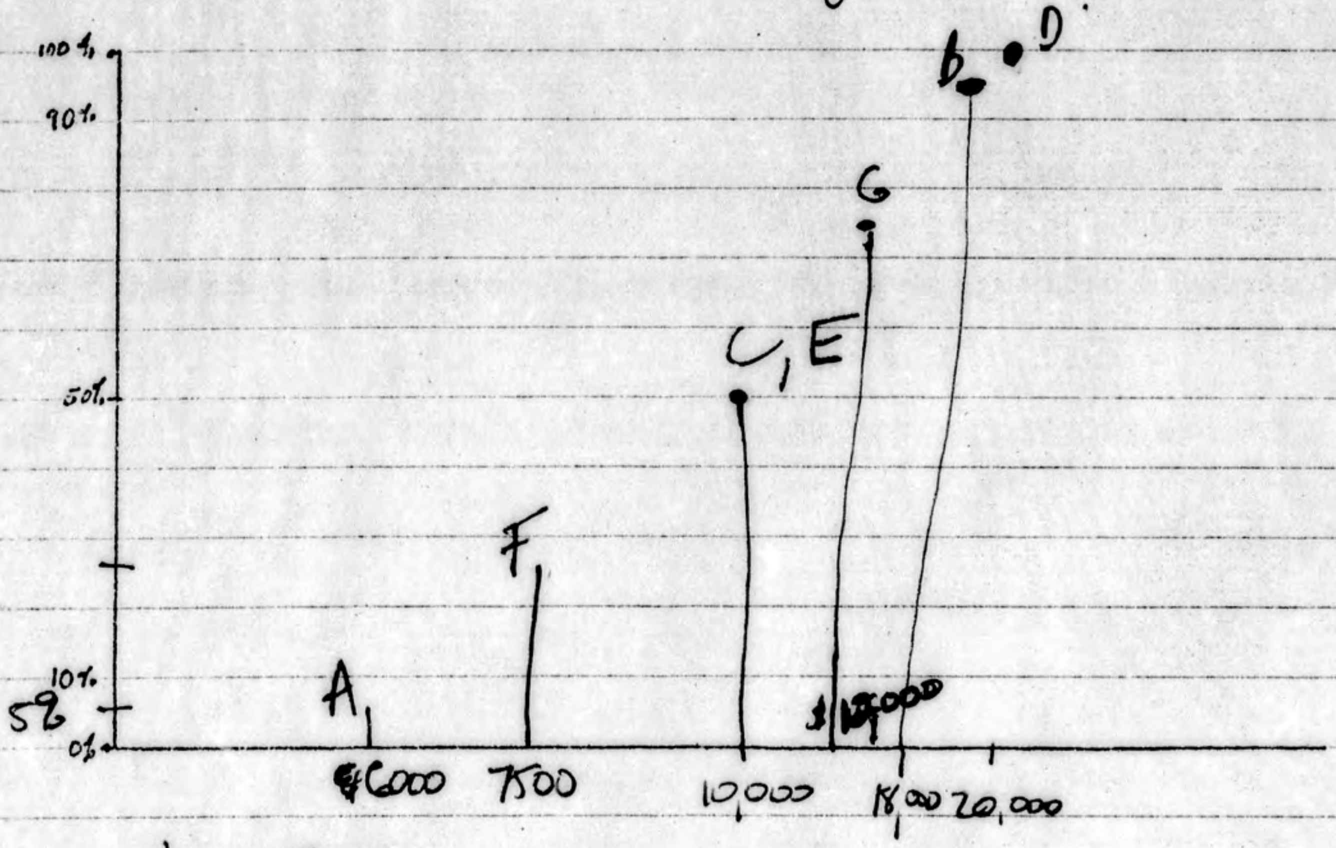
IDB status · small hydro
all hydro - tax exempt

Gravel - "decimate the cost
of energy

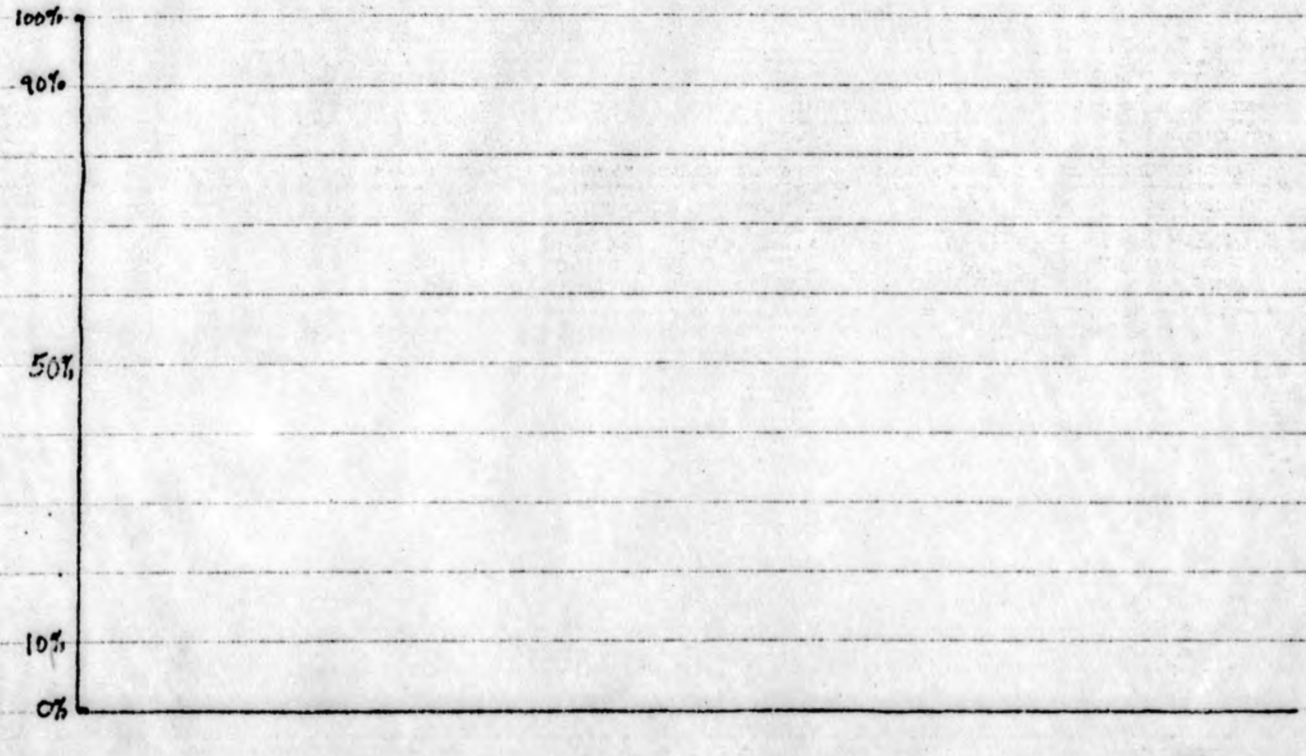
goal - equalize cost of energy across state

Cumulative Probability Distribution
for
Exogenous Employment in 2000

mining, extractive resource development + related const. + man.



base 7,000



Mark Witten

B.1

No Growth Case

	Exogenous Employment	state op. ex. real per capita	Population	state cap. ex. real per capita
	EMX	SXORPC	POP	SXCRPC
1977	10.3	700.819	407.342	262.338
1978	5.5	714.665	404.436	235.211
1979	4.2	774.49	413.701	224.692
1980	4.4	783.547	419.867	246.51
1981	4.	780.196	425.277	357.824
1982	4.	768.181	431.363	357.737
1983	4.	760.543	437.767	354.164
1984	4.	749.748	444.084	350.844
1985	4.	739.532	450.519	346.095
1986	4.	731.944	457.334	342.843
1987	4.	721.978	463.713	339.836
1988	4.	712.772	469.491	335.548
1989	4.	701.919	476.808	330.316
1990	4.	692.292	483.647	325.927
1991	4.	685.207	490.854	322.82
1992	4.	675.793	497.595	319.895
1993	4.	666.447	504.455	315.473
1994	4.	657.427	511.352	311.149
1995	4.	648.5	518.303	306.981
1996	4.	642.477	525.687	304.129
1997	4.	633.642	532.973	301.458
1998	4.	624.926	540.359	297.345
1999	4.	616.414	547.864	293.246

2000 -
550,000 / population would probably be less in No growth

B.2

① Effect on Growth of State Spending

POPULATION

② High Growth Case

real = 6.11

double income increase

INCOME ELASTICITY OF STATE SPENDING → 0 1 2

0		1	2
ELH.GL		ELH.GM	ELH.GH
407.342	1977	407.342	407.342
404.436	1978	404.436	404.436
417.249	1979	417.249	417.249
428.76	1980	428.76	428.76
449.326	1981	450.033	450.748
480.138	1982	485.329	490.639
524.89	1983	535.732	547.947
552.198	1984	574.373	601.399
558.983	1985	589.264	630.341
580.552	1986	614.786	663.625
612.99	1987	650.919	707.067
637.084	1988	681.65	748.501
656.5	1989	707.069	784.91
675.806	1990	731.752	820.303
696.575	1991	756.436	853.675
715.737	1992	779.346	884.517
731.448	1993	798.25	910.282
745.688	1994	816.275	935.811
752.373	1995	827.001	954.426
766.786	1996	843.751	976.239
779.123	1997	859.467	998.182
795.794	1998	878.249	1021.28
812.294	1999	898.69	1048.71
828.712	2000	919.474	1077.6
846.163	2001	941.955	1109.83
864.408	2002	965.771	1145.08
884.031	2003	991.38	1183.73
904.704	2004	1018.8	1223.41
925.031	2005	1046.83	1272.41

Effect on Growth of State Spending

REAL PER CAPITA STATE OPERATING EXPENDITURES

INCOME ELASTICITY OF STATE SPENDING

0		1	2
ELH.GL		ELH.GM	ELH.GH
700.961	1977	700.961	700.961
714.666	1978	714.666	714.666
768.117	1979	768.117	768.117
765.323	1980	765.323	765.323
735.714	1981	748.125	760.445
721.508	1982	804.688	888.17
687.449	1983	827.156	981.783
747.62	1984	989.365	1271.27
771.717	1985	1033.85	1371.86
748.24	1986	984.631	1300.35
731.58	1987	968.892	1285.26
746.405	1988	1024.59	1385.05
748.908	1989	1044.24	1434.94
756.528	1990	1051.38	1452.41
753.424	1991	1038.59	1435.93
753.32	1992	1034.73	1429.3
750.643	1993	1029.24	1421.88
753.328	1994	1035.32	1431.84
766.698	1995	1051.71	1451.98
754.587	1996	1027.97	1415.22
763.496	1997	1038.09	1422.62
749.973	1998	1016.96	1392.62
752.609	1999	1027.75	1408.85
751.115	2000	1034.29	1426.08
750.161	2001	1040.69	1444.32
749.209	2002	1048.22	1467.33
746.7	2003	1054.15	1490.85
744.772	2004	1063.1	1521.81
744.157	2005	1075.58	1561.27

Moderate Growth Cases (Median)

Exogenous Employment

real per capita operating expenditures of state

Population (0 income elasticity)

employment / population

Population (1 income elasticity)

ELL.GL

	EMX	SXORPC	POP	ER	POP
1977	9.9	700.961	407.342	0.478378	407.342
1978	5.632	714.666	404.436	0.478437	404.436
1979	5.776	768.117	417.248	0.470818	417.248
1980	7.656	765.324	428.758	0.473365	428.758
1981	12.342	735.613	449.375	0.48436	450.081
1982	17.233	722.083	479.931	0.498205	485.135
1983	23.107	689.386	523.723	0.514091	534.575
1984	20.03	750.737	549.022	0.518922	571.22
1985	12.187	775.127	552.896	0.512647	582.96
1986	13.095	758.75	569.029	0.5098	603.51
1987	15.65	755.222	588.87	0.507536	626.298
1988	15.222	762.627	600.411	0.504592	640.977
1989	12.843	765.762	607.338	0.499873	650.675
1990	12.586	765.762	618.245	0.497785	663.463
1991	11.486	771.249	625.894	0.492441	672.355
1992	10.689	766.161	635.023	0.488788	682.137
1993	10.012	764.165	643.544	0.485447	691.502
1994	9.426	761.004	653.533	0.48344	702.818
1995	8.64	762.645	663.763	0.481846	715.103
1996	8.649	760.709	676.388	0.481866	729.792
1997	8.615	761.768	689.25	0.482022	745.668
1998	8.525	758.708	702.935	0.482696	762.767
1999	8.466	757.592	717.329	0.483635	781.287
2000	8.431	756.217	732.47	0.484911	801.187
2001	8.409	754.973	748.202	0.486297	822.242
2002	8.394	753.694	764.539	0.487717	844.376
2003	8.376	752.515	781.413	0.489185	867.573
2004	8.358	751.247	798.895	0.490734	891.895
2005	8.341	750.14	816.861	0.492277	917.247