

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILES 86 / 2

991 SCOMM44: HOUSE POWER ALTERNATIVES STUDY COMM. 1979-80

appropriately hedged. It is not even enough that a particular simulation conform to one's a priori expectations. 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

$$(CUS/YDUS) = 0.89 + .035 * EUS/EUS(-1) \\ (6.2) \quad (0.25)$$

$$- 0.004 * YDUS/NUS \\ (-1.8)$$

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

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. $SS\&L(CY1974) = (SS\&L(FY1974) + SS\&L(FY1975))/2$

REFERENCES

1. Baumol, W.J., Economic Dynamics; third edition (Macmillan, New York), 1970.
2. Glickman, N.J., Econometric Analysis of Regional Systems, (Academic Press, New York), 1977.
3. Godschalk, D., Brower D., McBennett L., and Vestal B., Constitutional Issues of Growth Management, (ASPO Press, Chicago, Illinois), 1977.
4. Johnston, J., Econometric Methods, (McGraw Hill, New York), 1963.
5. Kresge, D.T. and Siever, D.A., "Planning for a Resource-Rich Region: The Case of Alaska," in A.E.A Papers and Proceedings, May 1978, pp 99-104.
6. Kriesberg, E.M. and Vining, D.R., Jr., "On the Contribution of Out-Migration to Changes in Net Migration: A time Series Confirmation of Beale's Cross-Sectional Results," in Annals of Regional Science, November 1978, pp 1-11.
7. Malinvaud, E., Statistical Methods of Econometrics, second edition (North Holland, New York-Amsterdam), 1970.
8. Raj B, "Linear Regression With Random Coefficients: The Finite Sample and Convergence Properties," in Journals of the American Statistical Association, March 1975, pp 127-137.
9. Reaume, D.M., "State of Alaska Quarterly Econometric Model," (mimeograph), Alaska Division of Economic Enterprise, Juneau, revised January, 1979.
10. Siever, D.A., "Alaskan Economic Growth: A Regional Model With Induced Migration," paper presented at the Annual Meeting of the Regional Science Association, Cambridge, Mass., November 1975.
11. U.S. Department of Commerce, Bureau of Economic Analysis, Regional Work Force Characteristics and Migration Data: A Handbook on the Social Security Continuous Work History Sample and its Application, (U.S. Government Printing Office, Washington, D.C.) December 1976.
12. Vanderkamp, J., "Migration Flows, Their Determinants and the Effects of Return Migration," in Journal of Political Economy, September/October 1971, pp 1012-1031.

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

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.

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.

supporting
choice
of
MAP
model

Area
(WWC)
+
Energy
Probe
Comments

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

Develop the input scenarios required to run the economic model.

Public hearing selected comments

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.

Bad writing report on assumptions

interim ~~Preliminary results - interim report~~

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

E. Electricity Use Projections \$14,000

- wood

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 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.

*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 Plan.
Utilities
Bartelle*

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.

*As Cash task
is completed
a draft report
will be presented
to the project
director*

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
May 15, 1980

push
up

E. Compensation and Method of Payment

Identify
Schedule

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

F. Project Director

The Project Director will be Rep. Brian Rogers. Coordination with the Alaska Power Authority will be channeled through the legislative committee.

+ Div. of
Energy & Power Dev.

out of
\$ 60,000
reduce our
other work

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

R E S U M E

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.

Oliver Scott Goldsmith
Page Four

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).

Oliver Scott Goldsmith
Page Five

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

R E S U M E

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.

TERRY LEE HUSKEY

Page 2

August 1, 1979

"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.

Michael James Scott
Page Four

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.

Michael James Scott
Page Five

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)	<u>2,000</u>
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 with 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)	<u>3,000</u>
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 foreseeable 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)	<u>2,000</u>
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.

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 hydro 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 with 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)	<u>3,000</u>
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

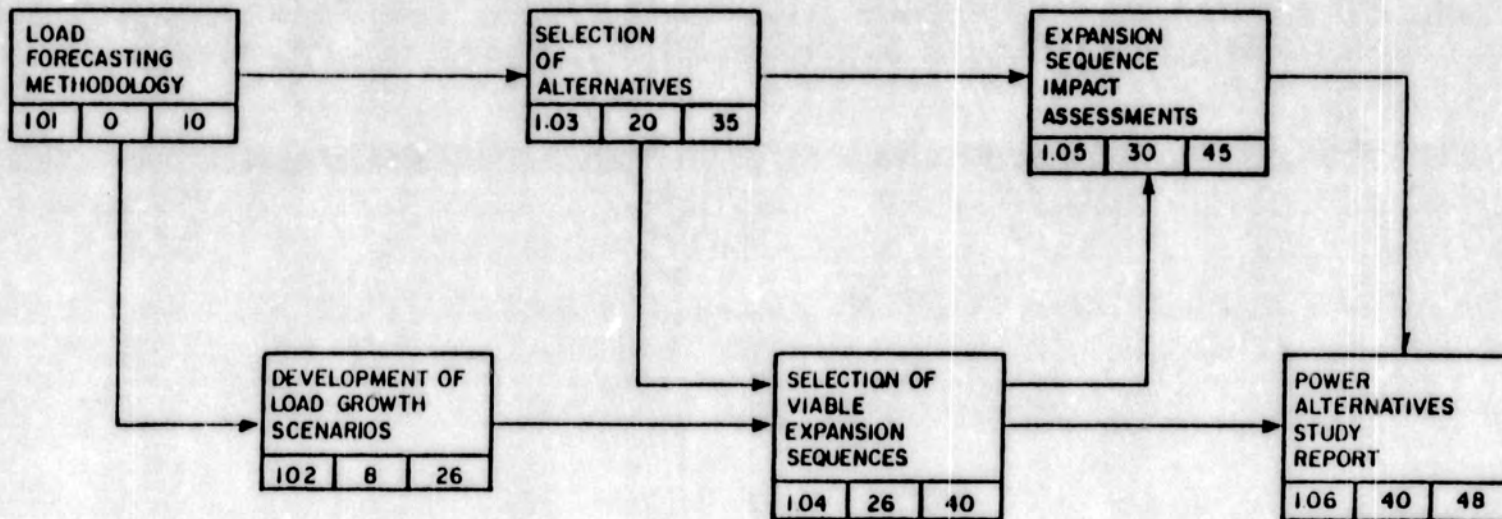
This report will seek to address the fundamental issues of the "need for power" and selection of the optimum future Railbelt Region electrical power supply scenario through the year 2005. If the Susitna Project is to be justified as a viable and licensable development, this report has to provide the 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

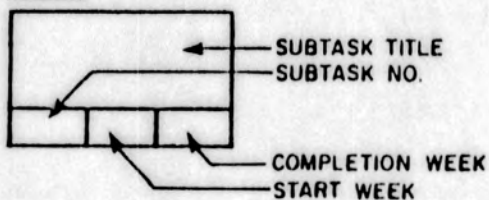
Task Force (Acres) \$12,000

(e) Schedule

Weeks 40 through 48



LEGEND



SUSITNA HYDROELECTRIC PROJECT
 PLAN OF STUDY
 PLATE TI.1: TASK 1 LOGIC

ACRES

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.

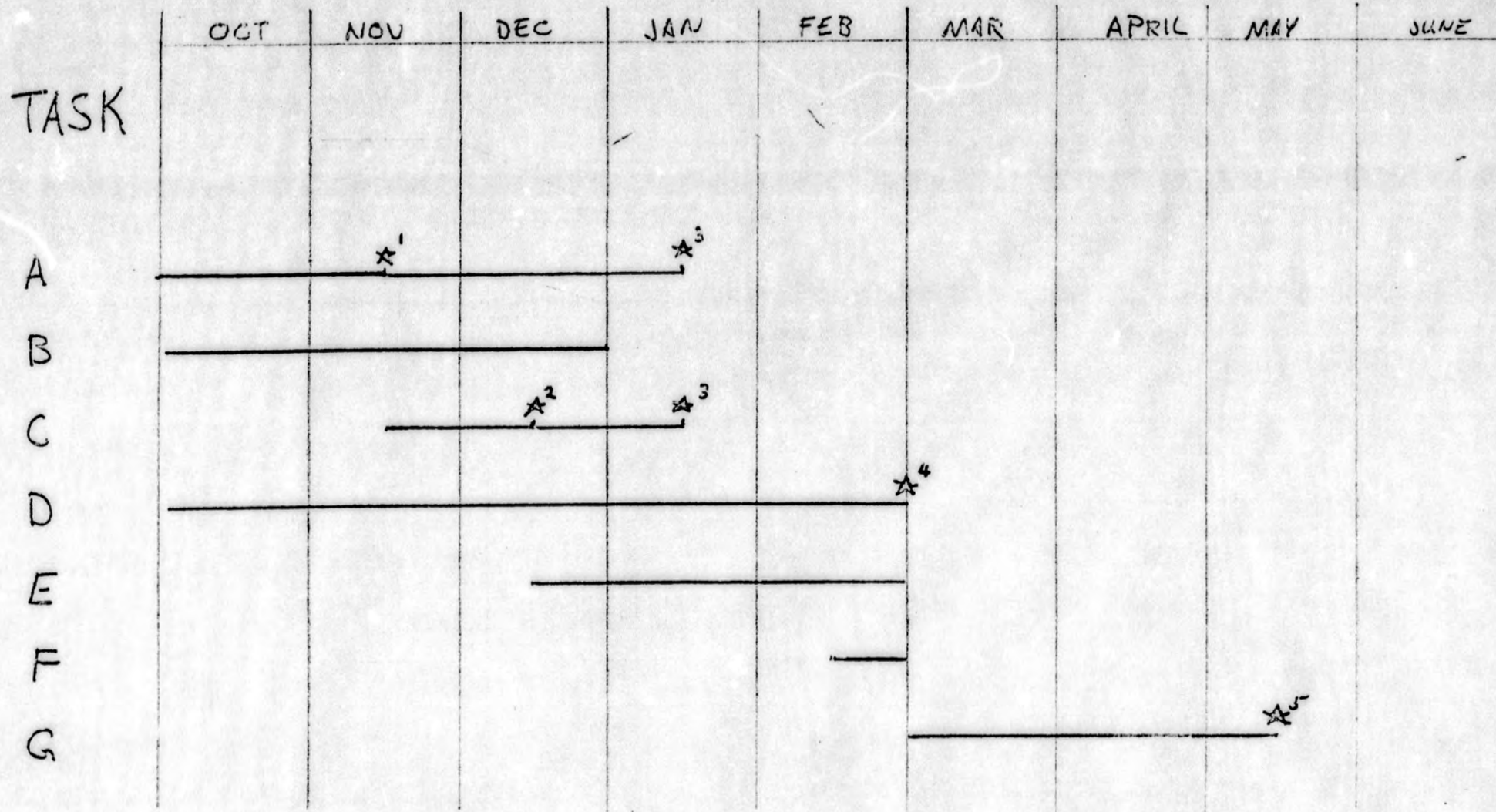
1. The Army Corps of Engineers (or their representative) or Acres American Incorporated (or their representative) - review of methodologies used in economic projections and demand analysis.
2. Energy Probe (or other consultants of the Project Director's choosing) - review of methodologies used in economic 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



★ DATES WHEN PRODUCTS DUE.

1 Detailed work Plan

2 Input Assumptions Workshop

3 Tasks A & C reports

4 Interim Report

5 Final Report

A PRELIMINARY EVALUATION
OF
THE I.S.E.R. ELECTRICITY DEMAND FORECAST

(Working Paper #1)

Robert E. Crow
Dr. James H. Mars
Christopher J. Conway

Energy Probe,
43 Queen's Park Crescent East,
Toronto, Canada, M5S 2C3.
(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 Withrow, coordinator

House Power Alternatives Study

905-3711, 3719

TABLE OF CONTENTS

1. Introduction	1
2. Stage II Modelling Approaches	3
3. The Econometric - End Use Approach	7
4. The ISER Model and Suggested Approaches and Revisions	11
5. Stage I Approaches	17
6. Conclusions	24

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 methods 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 activity involved or should it focus on the decision 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
3.
alternatives.

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 felt 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:

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

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:

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

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 commercial 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 efficiency 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 initially to our formulation of EEU above, and explicitly 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 remaining 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 conventional 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 extent 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 sensitivity 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. While 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-known 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 ^asame 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 economic 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 approaches: 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, Mounq, 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 household formation functions 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.

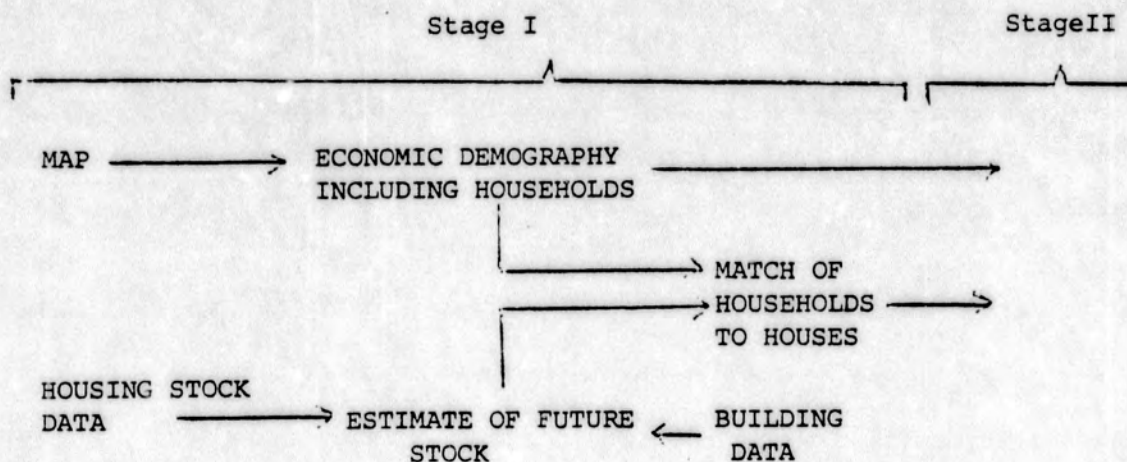
What is needed, more than any other modification, is a housing sub model. Whether the data can be gathered for such an addition remains to be seen. Lacking a formal housing model, some intermediate step is required based on the housing stock data from the decennial censuses. A brief outline of each alternative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

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.



REVIEW OF BUSINESS AND ECONOMIC CONDITIONS

UNIVERSITY OF ALASKA, INSTITUTE OF SOCIAL AND ECONOMIC RESEARCH, JUNE 1977, Vol. XIV, No. 2

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.

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.

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).

**ALASKA REVIEW OF BUSINESS
AND ECONOMIC CONDITIONS**

VOL. XIV, No. 2
June 1977

Published by the

Institute of Social and Economic Research
University of Alaska
Anchorage • Fairbanks • Juneau

Charles O. Ferguson—Interim President,
University of Alaska
Lee Gorsuch—Director, ISER

Editor: Ronald Crowe
ISER, University of Alaska
Fairbanks 99701

Author: Oliver S. Goldsmith
Assistant Professor
of Economics, ISER

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

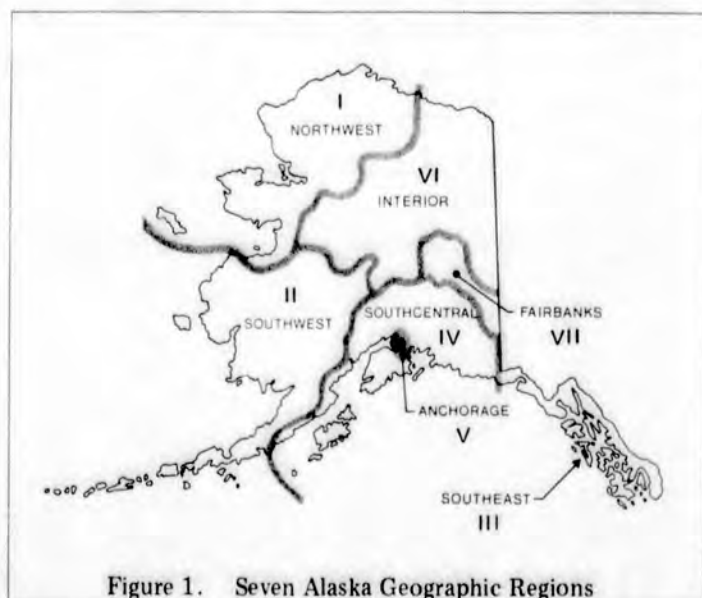


Figure 1. Seven Alaska Geographic Regions

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			(Thousands)
Northwest Alaska			
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 & Tele- phone Co. (Craig)	14.60	1,054
	Alaska Power & Tele- phone 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

Year	Southeast		Southcentral		Anchorage		Fairbanks	
	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

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

²In 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.