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An Econometric Simulation Model of Income and Electricity Demand in Alaska's Railbelt, 1982-2022

Ruth J. Maddigan
Lawrence J. Hill
Daniel M. Hamblin
James W. Van Dyke
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Energy Division

AN ECONOMETRIC SIMULATION MODEL OF INCOME AND ELECTRICITY DEMAND IN ALASKA'S RAILBELT, 1982-2022

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ABSTRACT

AN ECONOMETRIC SIMULATION MODEL OF INCOME AND ELECTRICITY DEMAND IN ALASKA'S RAILBELT, 1982-2022

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This report describes the specification of--and forecasts derived from--the Alaska Railbelt Electricity Load, Macroeconomic (ARELM) model. ARELM was developed as an independent, modeling tool for the evaluation of the need for power from the Susitna Hydroelectric Project which has been proposed by the Alaska Power Authority.

ARELM is an econometric simulation model consisting of 61 equations--46 behavioral equations and 15 identities. The system includes two components: (1) ARELM-MACRO which is a system of equations that simulates the performance of both the total Alaskan and Railbelt macroeconomies and (2) ARELM-LOAD which projects electricity-related activity in the Alaskan Railbelt region. The modeling system is block-recursive in the sense that forecasts of population, personal income, and employment in the Railbelt derived from ARELM-MACRO are used as explanatory variables in ARELM-LOAD to simulate electricity demand, the real average price of electricity, and the number of customers in the Railbelt.

Three scenarios based on assumptions about the future price of crude oil are simulated and documented in the report. The simulations, which do not include the cost-of-power impacts of Susitna-based generation, show that the growth rate in Railbelt electricity load is between 2.5 and 2.7 percent over the 1982 to 2022 forecast period. The forecasting results are consistent with other projections of load growth in the region using different modeling approaches.

1. INTRODUCTION

This report describes the Alaska Railbelt Electricity Load, Macroeconomic (ARELM) model. ARELM was developed as an independent modeling tool for evaluation of the need for power from the Susitna Hydroelectric Project.

The Alaska Power Authority (APA) has applied for a license to construct and operate two hydroelectric dams on the Susitna River.[1] The proposed facilities at Watana and Devil Canyon would have an installed capacity of 1,620 megawatts, increasing the total electric generating capacity of Alaska by over 70 percent.[2] The two dams would be located approximately 140 miles northeast of Anchorage and would generate electricity to serve the Railbelt region of Alaska. The region includes Anchorage, Fairbanks, and the Kenai Peninsula.

The Federal Energy Regulatory Commission (FERC) must review APA's license application. This review includes the examination of a number of issues dealing with environmental impacts and alternative capacity options. One of the most prominent concerns is whether or not there is a need for the proposed electric generating capacity in the region. The need-for-power issue is analyzed through use of forecasting models.

In the license application, APA developed forecasts of electricity sales in the Railbelt using two models: the Man-in-the-Arctic Program (MAP), developed by the Institute for Social and Economic Research of

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[1]Susitna Hydroelectric Project, Federal Energy Regulatory Commission, Project No. 7114, 1984.

[2]U.S. Department of Energy, Alaska Power Administration, Alaska Electric Power Statistics, 1960-1983, September 1984.

the University of Alaska, and the Railbelt Electric Demand (RED) model developed by Battelle.[3] MAP is a regional model which produces forecasts of a number of variables, including those needed to simulate RED: (1) the number of households in the Railbelt; (2) the number of people employed in the Railbelt; and (3) the distribution of the age of household heads in Alaska. RED forecasts electricity sales for two load centers--Alaska and Fairbanks. The forecast for the residential sector is based on survey data and an end-use approach. The commercial sector forecasts are derived from econometrically estimated parameters. Large industrial sales are projected independently.

Although FERC employed the MAP/RED modeling system in their examination of the need for power, there were concerns that the specification of some of the models' components might be inappropriate for this investigation.[4] In addition, it appeared that the MAP/RED forecasts were insensitive to alternative assumptions about the world price of oil. Since the scenarios that FERC examined reflected different world oil prices, this insensitivity resulted in narrow ranges for the projected growth rates of electricity demand. Moreover, FERC staff were unable to model "worst case" scenarios (declining real world oil prices) within the MAP/RED framework.

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[3]Institute of Social and Economic Research, University of Alaska, Susitna Hydroelectric Project, Man-in-the-Arctic Program (MAP) Technical Documentation Report, Alaska Power Authority, July 1983; Battelle Pacific Northwest Laboratories, Susitna Hydroelectric Project, RED Model (1983 Version) Technical Documentation Report, Alaska Power Authority, July 1983.

[4]H.W. Herzog Jr. and A.M. Schlottman, "An Evaluation of the Man-in-the-Arctic Program (MAP) Regional Economic Forecasting Model of the Alaskan Economy," Draft working paper, February 11, 1985; T. Dinan, "AN Analysis of RED," ORNL draft working paper, February 1985.

For these reasons, it was decided that a relatively simple, econometrically estimated simulation model should be developed to provide an alternative to the MAP/RED forecasts. The model would be used to address two main issues: (1) the insensitivity of the Alaskan economy to changes in the world price of oil and (2) the forecasted level of electricity demand in the Railbelt.

The model developed to address these issues, ARELM, contains two submodels: MACRO and LOAD. MACRO focuses on the components of the Alaskan macroeconomy that directly affect electricity consumption--population, per-capita income, and employment. LOAD captures the interrelationships between electricity sales, average prices, and consumers by class of service. LOAD is specified in a manner similar to that of ORNL-SLED (the State-Level Electricity Demand model)[5] developed for the Nuclear Regulatory Commission and ORNL-REED (the Rural Electric Energy Demand model)[6] developed for the Rural Electrification Administration.

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[5]W.S. Chern, R.E. Just, B.D. Holcomb, and H.D. Nguyen, Regional Econometric Model for Forecasting Electricity Demand by Sector and State, ORNL/NUREG-40, Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 1978; W.S. Chern, J.W. Dick, C.A. Gallagher, B.D. Holcomb, R.E. Just, and H.D. Nguyen, The ORNL State-Level Electricity Demand Forecasting Model, ORNL/NUREG-63, Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1980; W.S. Chern and R.E. Just, "Regional Analysis of Electricity Demand Growth," Energy, Vol. 5, January 1980; and W.S. Chern and R.E. Just, "A Regional Econometric Model for Assessing the Need for Power," Energy Economics, October 1982.

[6]R.J. Maddigan, W.S. Chern, C.A. Gallagher, B.D. Holcomb, and J.C. Cobbs, The ORNL Rural Electric Energy Demand Forecasting Model, ORNL/TM-7863, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 1981; R.J. Maddigan and C.G. Rizy, "Modeling Demand and Supply Interactions to Forecast Load Growth for Electricity Distribution Systems," Energy, Vol. 9, February 1984; and R.J. Maddigan, W.S. Chern, and C.G. Rizy, "Residential Demand for Electricity," Land Economics, Vol. 59, May 1983.

ARELM was estimated using annual data published by the Federal government and the state of Alaska. The model includes 46 behavioral equations and 15 identities. ARELM produces forecasts of a number of endogenous variables, including electricity sales in the Railbelt to the year 2022. Such an extended forecast horizon was required for the investigation of a hydroelectric plant whose life can be expected to extend for at least 40 years. To develop a forecast, ARELM requires projections of the world price of oil; national variables, such as real gross national product and per-capita income; and state variables, such as oil production in Alaska. In preliminary simulations using ARELM (which do not include the cost-of-power impacts of Susitna-based generation), the forecasts of average annual growth in electricity demand between 1982 and 2022 range from 2.5 percent to 2.7 percent.

The remaining chapters describe ARELM and three forecast scenarios in more detail. Chapter 2 provides a perspective on the economy of Alaska and the Railbelt region. The description emphasizes the historical patterns of data on which the estimation of ARELM is based. Chapter 3 provides an overview of the modeling system. The estimation of ARELM is presented in Chapter 4. Chapter 5 outlines the input assumptions employed for the three world oil price scenarios on which the simulations are based. Model forecasts are presented in Chapter 6. The final chapter makes a few concluding remarks.

2. BACKGROUND ON ALASKA AND THE RAILBELT

2.1 ALASKA'S ECONOMY

Alaska's economy reflects its unusual climate and geography. With more than 365 million acres of land area, Alaska is the largest state in the union. It is also the northernmost state with a large part of its territory above the Arctic Circle. Largely because of its harsh climate, Alaska has the lowest population density per unit of land area in the United States. The Federal government has a relatively large presence in the state, reflecting Alaska's strategic importance near the Soviet Union.

A comparison of Alaska's land with that of the entire United States highlights its differences from the other states. Less than 0.1 percent of Alaska's land area is classified as urban, compared to 2.1 percent for the United States as a whole.[1] Yet only 0.5 percent of Alaska's acreage is in cultivated farmland, well below the 45.6 percent of land in farms in the United States.[2] Alaska has the highest percentage of total land area owned by the Federal government (89.5 percent), representing 44.8 percent of all Federally owned land.[3] Over 19 million acres are in forest land in Alaska, representing 16.2 percent of total

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[1] U.S. Department of Agriculture, Economic Research Service, Expansion of Urban Area: 1960-1980. Urban areas include central cities and adjacent urbanized fringe zones of urbanized areas plus all incorporated and unincorporated places of 2,500 or more inhabitants outside urban areas.

[2] U.S. Department of Agriculture, Statistical Reporting Service, Crop Production, August 1984 (1983 data is preliminary).

[3] U.S. General Services Administration, Inventory Report on Real Property Owned by the United States Throughout the World, September 1982.

forest land in the United States.[4] In 1977, 188.9 billion board feet of net saw timber were cut in Alaska, making it the fourth largest producer of lumber in the United States.[5]

In addition to timber, major developed resources in Alaska include fish and petroleum. Alaskan fishing fleets caught 879 million pounds of fish in 1982, down from a peak of 1,054 million pounds in 1979. In 1982, Alaska earned more than any other state from fishing, accounting for 24.1 percent of the total value of fish caught in the United States.[6] Alaska is second only to Texas in the production of crude petroleum, producing 619 million barrels in 1982.[7] The dramatic rise in oil production was brought about by the building of the oil pipeline transportation system from the North Slope. The pipeline, which cost more than $8 billion to construct, extends 800 miles (1,300 kilometers) from Prudhoe Bay on the northern coast of Alaska to the northern-most ice-free harbor in the United States at Port Valdez in the south-central region of the state on the Gulf of Alaska. Construction of the pipeline began in 1974 and was completed in 1977. Oil production in Alaska rose at an average annual rate of 31.0 percent between 1975 and 1983.[8]

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[4]U.S. Forest Service, An Analysis of the Timber Situation in the United States, 1952-2030, Appendix 3.

[5]Ibid. The largest lumber producers are Oregon, Washington, and California.

[6]U.S. National Oceanic and Atmospheric Administration, Fishery Statistics of the United States, 1983.

[7]U.S. Energy Information Administration, Petroleum Supply Annual, State Energy Overview, 1983.

[8]Reported to the Alaska Oil Conservation Commission.

Alaska holds large reserves of undeveloped coal and natural gas resources. Total demonstrated coal resources are reported to be 9,180 million tons, which is equivalent to 3.5 times total U.S. consumption of energy in 1982. Estimates of possible coal resources range from 129 to 5,660 billion tons.[9] Major reserves are located in the Cook Inlet region and on the North Slope. Coal is now being mined at Healy and Matanuska Valley, but there is currently only a small market for Alaskan coal because of relatively high costs of production. However, there exists the potential for expanded sales to Japan and Korea, creating an impetus for further coal development in the state.

There are 31.8 trillion cubic feet of reserve or identified conventional natural gas in Alaska, representing nearly twice the amount of U.S. gas production in 1982. Estimated natural gas resources are as much as 134 trillion cubic feet.[10] Because of high production costs and inaccessibility, natural gas production has been relatively low. In 1982, 255 billion cubic feet were marketed.[11]

The land and its resources have contributed to the patterns of economic development in Alaska and the Railbelt. To describe those patterns, it is important to examine trends in the growth of population, income, and employment.

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[9]Statistical Office of the United Nations, Yearbook of World Energy Statistics, 1984; Neil Davis, Energy/Alaska, University of Alaska Press, Fairbanks, Alaska, 1984, p. 140.

[10]Ibid., Davis, p. 192.

[11]U.S. Energy Information Administration, Petroleum Supply Annual, State Energy Overview, 1983.

2.2 THE ECONOMY OF THE RAILBELT

Although Alaska is very large in land area, most of the population and commercial activity is concentrated in an area known as the Railbelt region. This region is loosely defined by the Alaska Railroad which provides a major transportation link in the area. The Railbelt accounts for approximately 25 percent of Alaska's land area, stretching from the Kenai Peninsula on the Gulf of Alaska and Cook Inlet in the south to Fairbanks and the surrounding military installations in the north (see Figure 2.1).

A comparison of the total state of Alaska with the Railbelt shows that historical trends in population, income, and employment are similar (see Figures 2.2 through 2.5). This is not surprising given that in 1982 the Railbelt region contained about 69 percent of Alaska's population and 73 percent of total state income. Growth rates of population, income, and employment have also been similar.

The population of Alaska grew at an average annual rate of 2.9 percent between 1965 and 1982 (see Figure 2.2).[12] The total U.S. population grew at only 1.0 percent per year over the same period.[13] The Railbelt grew slightly faster than the state, recording a 3.6 percent average annual growth for these 18 years.[14]

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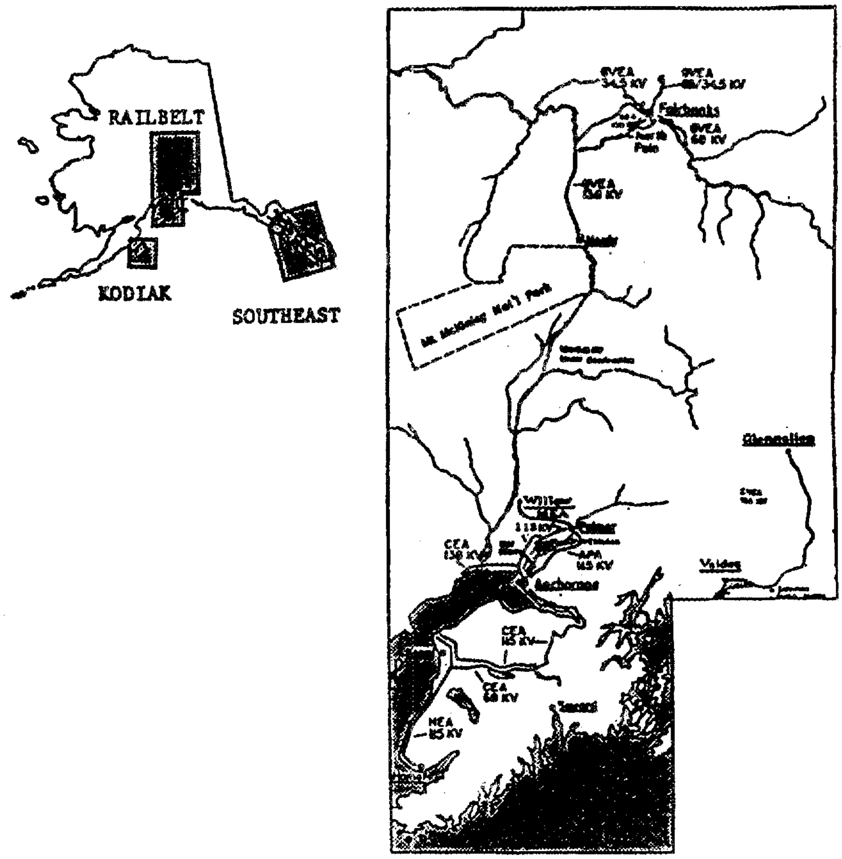
[12] U.S. Department of Commerce, Bureau of Economic Analysis, <u>Local Area Personal Income</u>, 1969-1982 (annual) and unpublished data, 1965-1968.

[13] U.S. Bureau of the Census, <u>Current Population Reports</u>, July 1984, p. 25, no. 929.

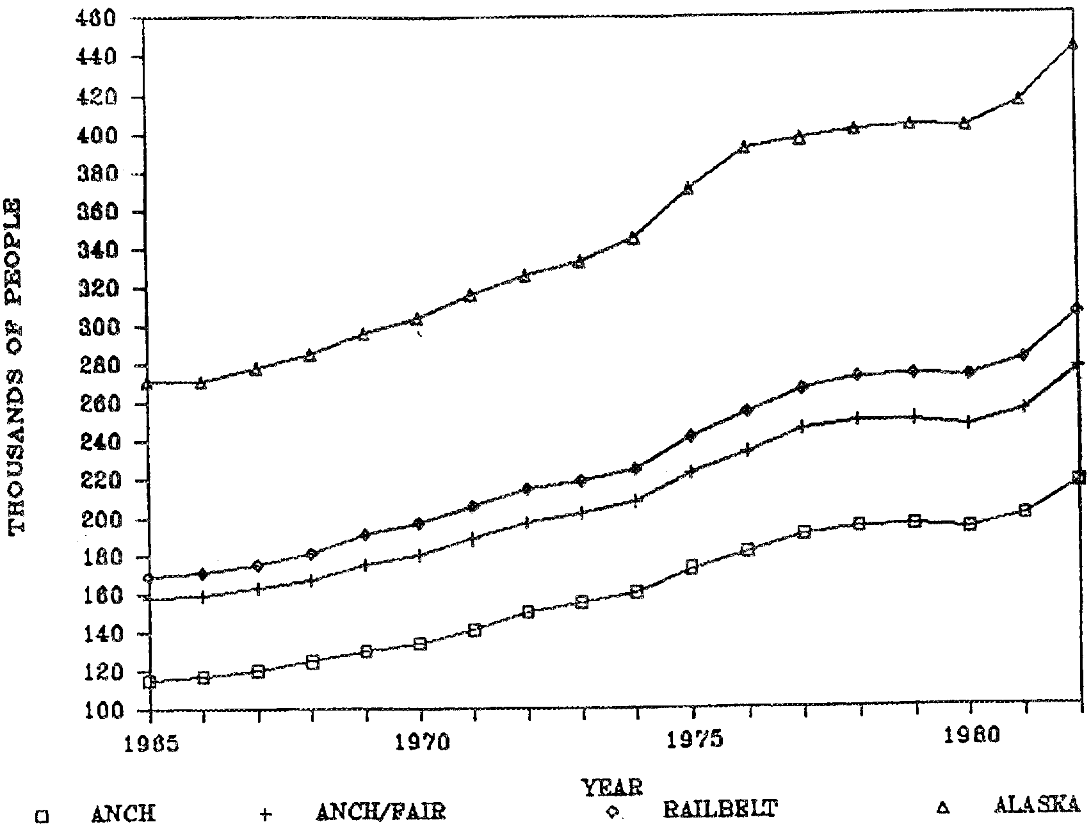
[14] The statistics for the Railbelt are aggregated for Anchorage (which includes Anchorage and Matanuska/Susitna), Fairbanks, and the Kenai Peninsula (formerly Kenai-Cook Inlet and Seward).

Figure 2.1
The Railbelt Region of Alaska



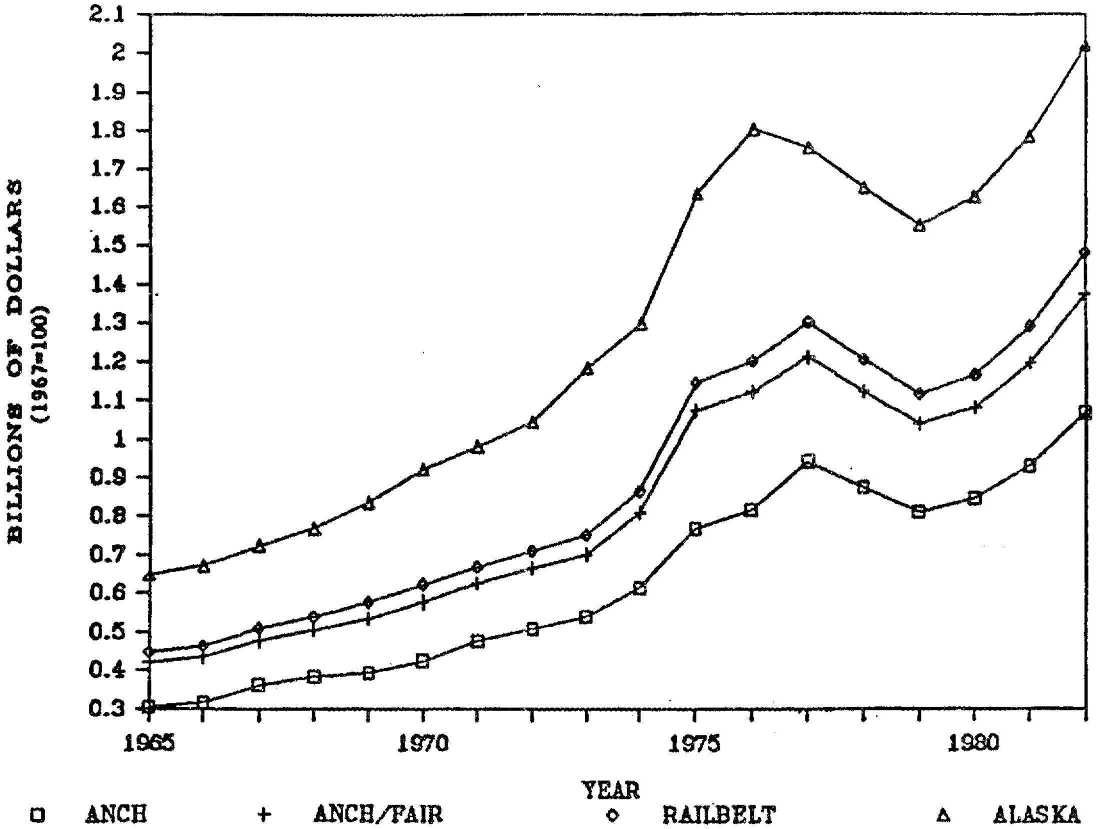
SOURCE: U.S. Department of Energy, Alaska Power Administration, Alaska Electric Power Statistics, 1960-1983 (September 1984), p. 35.

Figure 2.2
Population in Alaska and the Railbelt
1965-1982



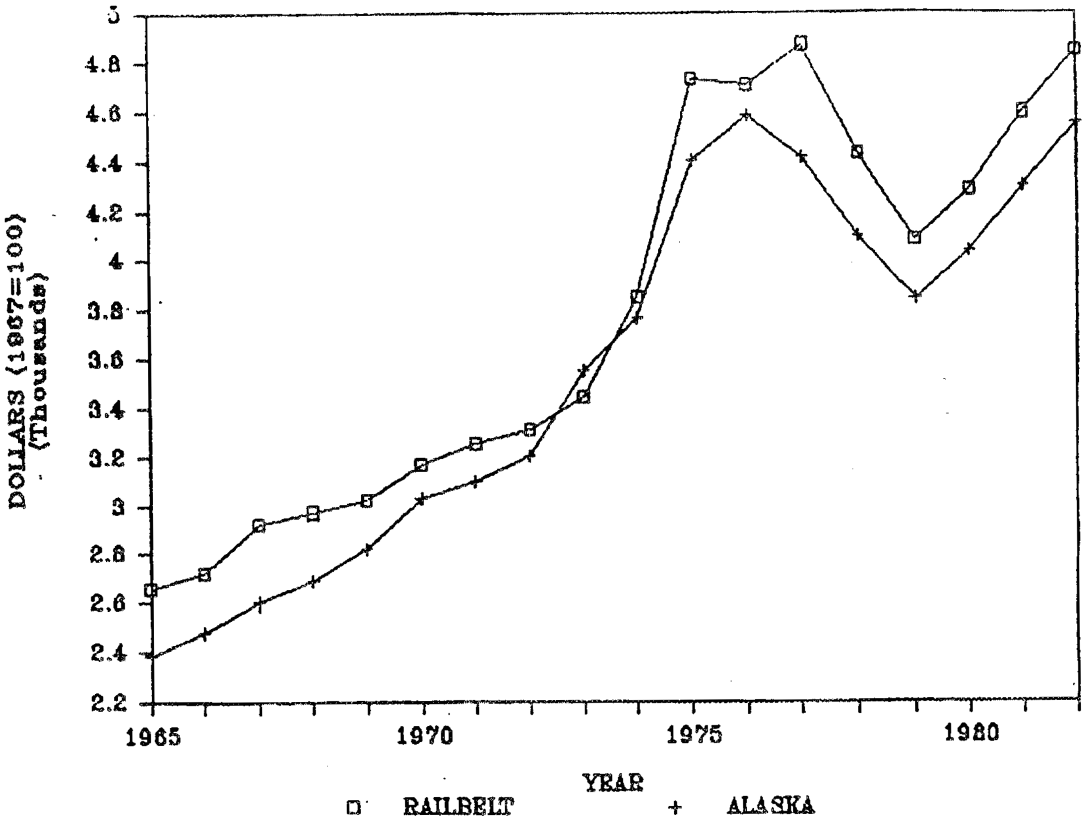
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income, Annual, 1969-1982, and unpublished data, 1965-1968.

Figure 2.3
Real Income in Alaska and the Railbelt
1965-1982



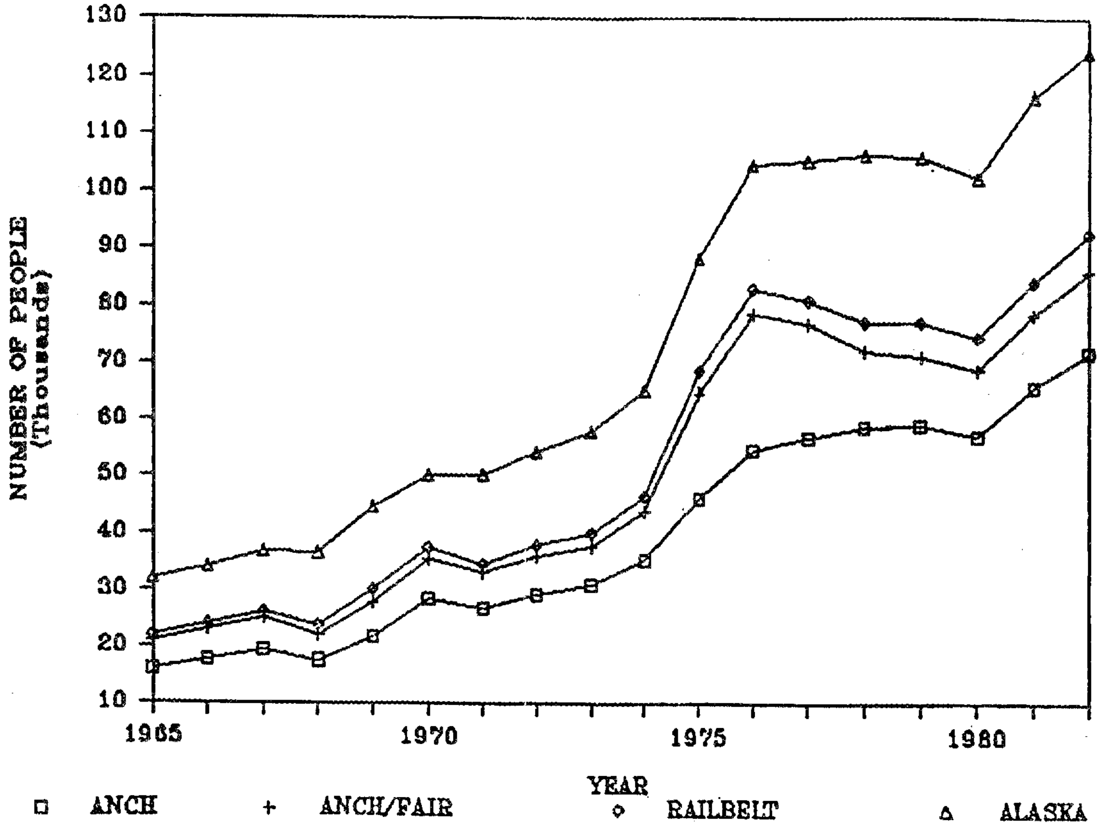
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income, Annual, 1969-1982, and unpublished data, 1965-1968.

Figure 2.4
Per Capita Income in Alaska and the Railbelt
1965-1982



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income, Annual, 1969-1982, and unpublished data, 1965-1968.

Figure 2.5
Employment in Alaska and the Railbelt
1965-1982



SOURCE: U.S. Department of Commerce, Bureau of the Census, County Business Patterns, Alaska, 1965-1982. Excludes agricultural, governmental, and military employment.

Real income in Alaska grew at an average annual rate of 6.9 percent between 1965 and 1982; the comparable rate for the Railbelt was 7.3 percent (see Figure 2.3).[15] Income growth was especially rapid between 1974 and 1976 because of the oil pipeline construction activity. Although income growth declined slightly between 1976 and 1979, real income has continued its historical upward trend since 1980. The Railbelt accounted for 73.3 percent of total real income earned in Alaska in 1982. Before construction of the pipeline, the average per-capita income in the Railbelt was slightly lower than the average for the state (see Figure 2.4). However, since 1974, per-capita income has been higher in the Railbelt. In 1982, per-capita income in the Railbelt was 4 percent higher than the state average.

The pattern of employment growth also shows the impact of the pipeline construction years (see Figure 2.5). The average annual growth in employment (excluding government, military, and agricultural employment) was 8.3 percent in Alaska from 1965 to 1982. The corresponding figure for the Railbelt was 8.8 percent.[16] Employment in the United States grew at an average rate of only 2.0 percent per year over the same period.[17] The Railbelt represented 66.4 percent of business employment in Alaska in 1981, almost the same share as in 1971 (see Figure 2.6).

The distribution of employment by sector is very similar for Alaska and the Railbelt (see Figure 2.7). In Alaska, the major employer is the

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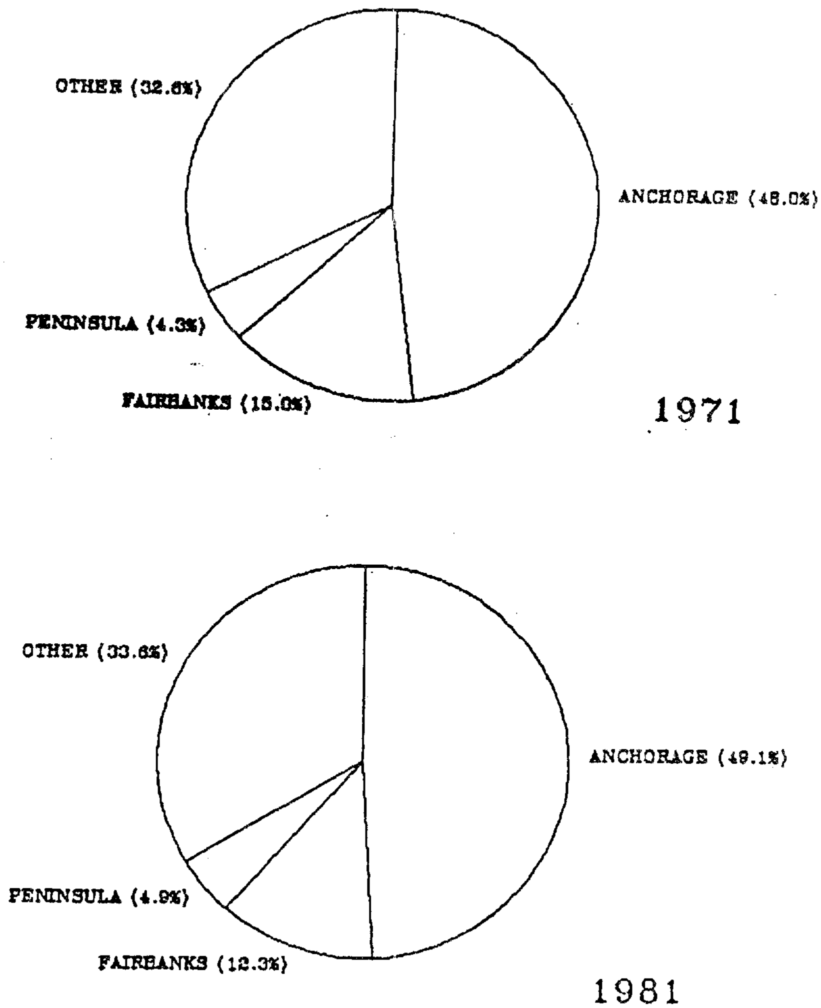
[15]Reference 12.

[16]U.S. Department of Commerce, Bureau of the Census, County Business Patterns, Alaska, 1965-1982 (annual).

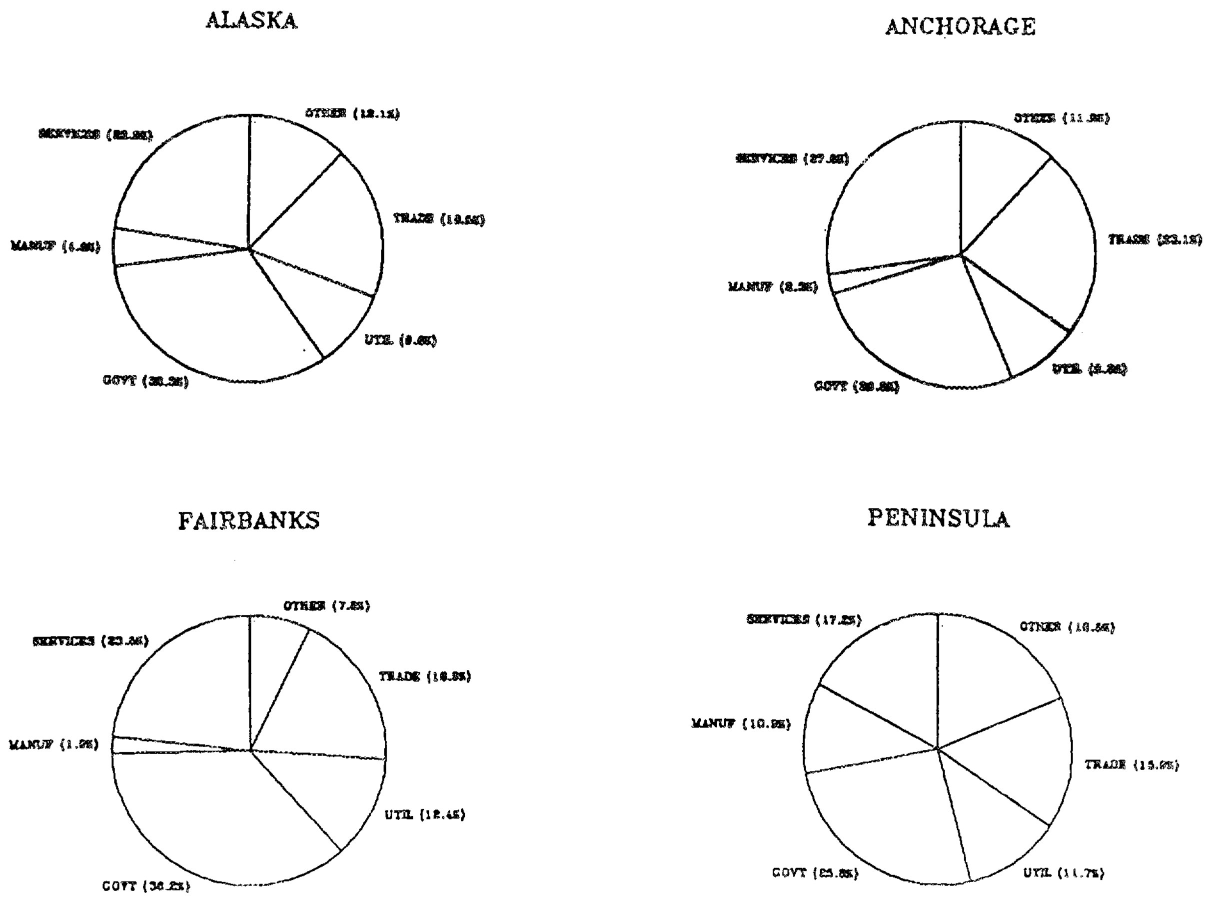
[17]U.S. Bureau of Labor Statistics, Employment and Earnings, 1965-1982 (monthly).

Figure 2.6
Distribution of Employment in Alaska
By Region
1971 and 1981



SOURCE: Alaska Department of Labor, Statistical Quarterly, 1971 and 1981.

Figure 2.7
Distribution of Employment in Alaska
By Sector and the Railbelt Regions of
Anchorage, Fairbanks, and the Peninsula
1982



SOURCE: Alaska Department of Labor, <u>Statistical Quarterly</u>, First Quarter, 1982.

government--federal, state, and local. In the first quarter of 1982, 32.3 percent (58,669 employees) of nonagricultural employment in the state as a whole was in the government (nonmilitary) sector.[18] The share of government employment was slightly lower in the Railbelt at 28.2 percent. The share for Fairbanks was 36.2 percent. The Railbelt showed a higher share of employment in the services and trade sector--47.9 percent in comparison with 41.4 percent for Alaska as a whole. Manufacturing workers accounted for 2.8 percent of employment in the Railbelt in comparison with 4.8 percent for the entire Alaskan economy. Alaska is very unusual in that such a large share of its employment is in the government sector. Growth in governmental employment has been at an average annual rate of 4.1 percent between 1965 and 1982, providing a substantial base for stable growth in Alaska's overall employment.

If military personnel were included in the employment statistics for Alaska, they would have accounted for nearly 12 percent of the state's total employment in 1982.[19] This employment has been a manifestation of national defense needs rather than economic conditions in Alaska. The military presence is considered independent of the growth pattern of the Alaskan civilian population.

The similarity between the state of Alaska and the Railbelt has important implications for the state's electricity planning. Because of the historical economic and population dominance of the Railbelt, anticipating demand for electricity in that region is a crucial factor in the

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[18] Alaska Department of Labor, Statistical Quarterly, 1st Quarter, 1982.

[19] U.S. Department of Defense, Distribution of Personnel by State--By Selected Locations, 1982.

future development of Alaska. The next section discusses electric power demand in Alaska, focusing on electricity demand in the Railbelt region.

2.3 ELECTRICITY USE IN ALASKA AND THE RAILBELT

As with economic and population trends, demand for electricity in the Railbelt has closely paralled overall demand for electricity in the state. Figure 2.8 shows the comparative trends in electricity sales from 1965 to 1982. In 1982, utility sales of electricity in the Railbelt[20] were approximately 87 percent of total utility sales in Alaska.[21] The percentage is larger than expected, based on the proportion of total state population and economic activity in the Railbelt.

In 1982, the composition of Railbelt electricity sales was approximately 46.5 percent residential, 32.5 percent commercial, and 21.0 percent industrial (Figure 2.9). The average annual growth in electricity sales from 1965 to 1982 in the Railbelt was 10.7 percent. The three major electricity-using sectors have grown at annual rates somewhat above 10 percent. The industrial sector has been the fastest growing component of Railbelt demand, increasing at an annual rate of 13.1 percent from 1965 to 1982. Over this period, industrial use increased from 14.4 percent of Railbelt sales in 1965 to 20.6 percent in 1982. The

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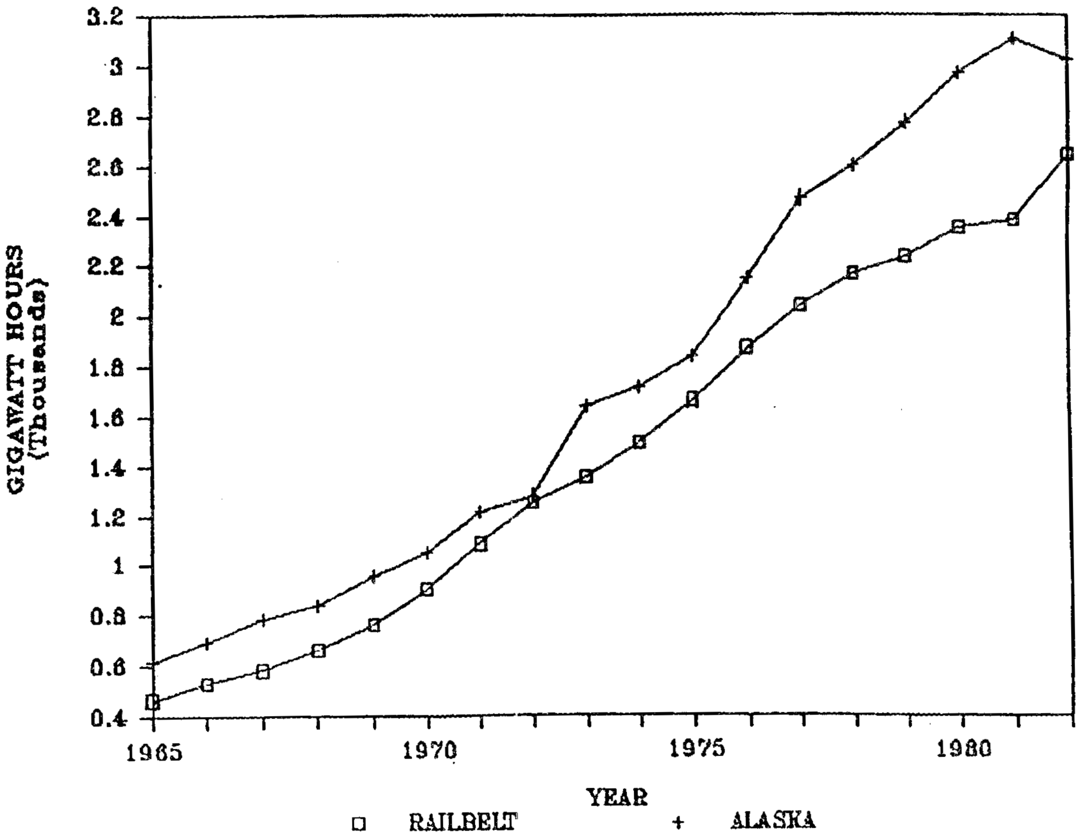
[20]Utility sales include those of Anchorage Municipal Light and Power, Chugach Electric Association, Inc., Matanuska Electric Association, Fairbanks Municipal Utilities, Golden Valley Electric, Homer Electric Association, and Seward Electric.

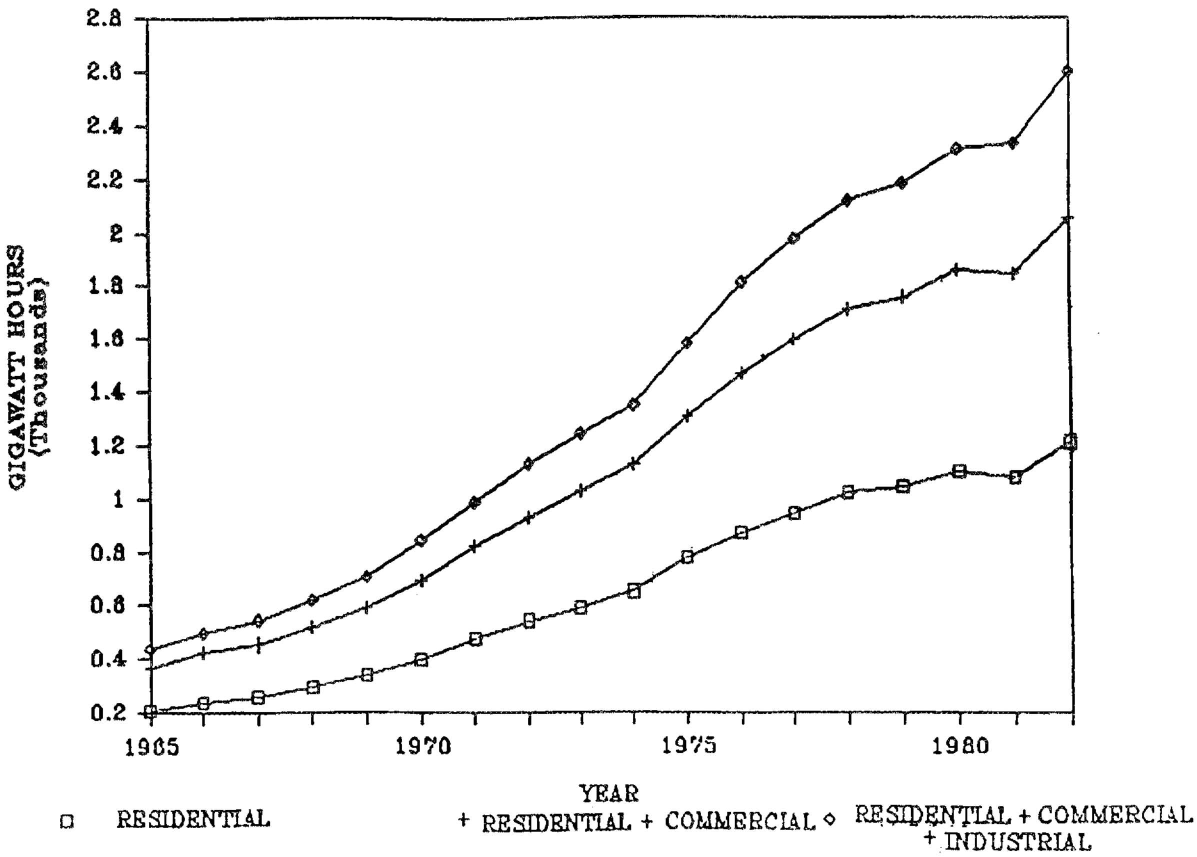
[21]U.S. Department of Energy, Alaska Power Administration, Alaska Electric Power Statistics, 1960-1983, September 1984; U.S. Department of Agriculture, Rural Electrification Administration, Statistics of Rural Electric Borrowers, annual; and U.S. Energy Information Administration, Statistics of Publicly Owned Electric Utilities in the United States, annual.

Figure 2.8
Electricity Sales in the Railbelt and Alaska
1965-1982



SOURCE: U.S. Department of Energy, Alaska Power Administration, Alaska Electric Power Statistics, 1960-1983, September 1984; U.S. Department of Agriculture, Rural Electrification Administration, Statistics of Rural Electric Borrowers, Annual; and U.S. Department of Energy, Energy Information Administration, Statistics of Publicly Owned Electric Utilities in the United States, Annual.

Figure 2.9
Electricity Sales in the Railbelt
Residential, Commercial, and Industrial Sectors
1965-1982



SOURCE: U.S. Department of Agriculture, Rural Electrification Administration, Statistics of Rural Electric Borrowers, Annual; and U.S. Department of Energy, Energy Information Administration, Statistics of Publicly Owned Electric Utilities in the United States, Annual.

small size of industrial sector electricity sales can be explained by industry's heavy reliance on self-generation (see Table 2.1). As shown in Figure 2.10, industrial customers have represented a very small share of the total number of customers served by electric utilities. Residential customers accounted for more than 87.7 percent of the total in 1982.[22]

Table 2.1
Net Electricity Generation in Alaska
By Source and Prime Mover
1983

(In Gigawatt-Hours)

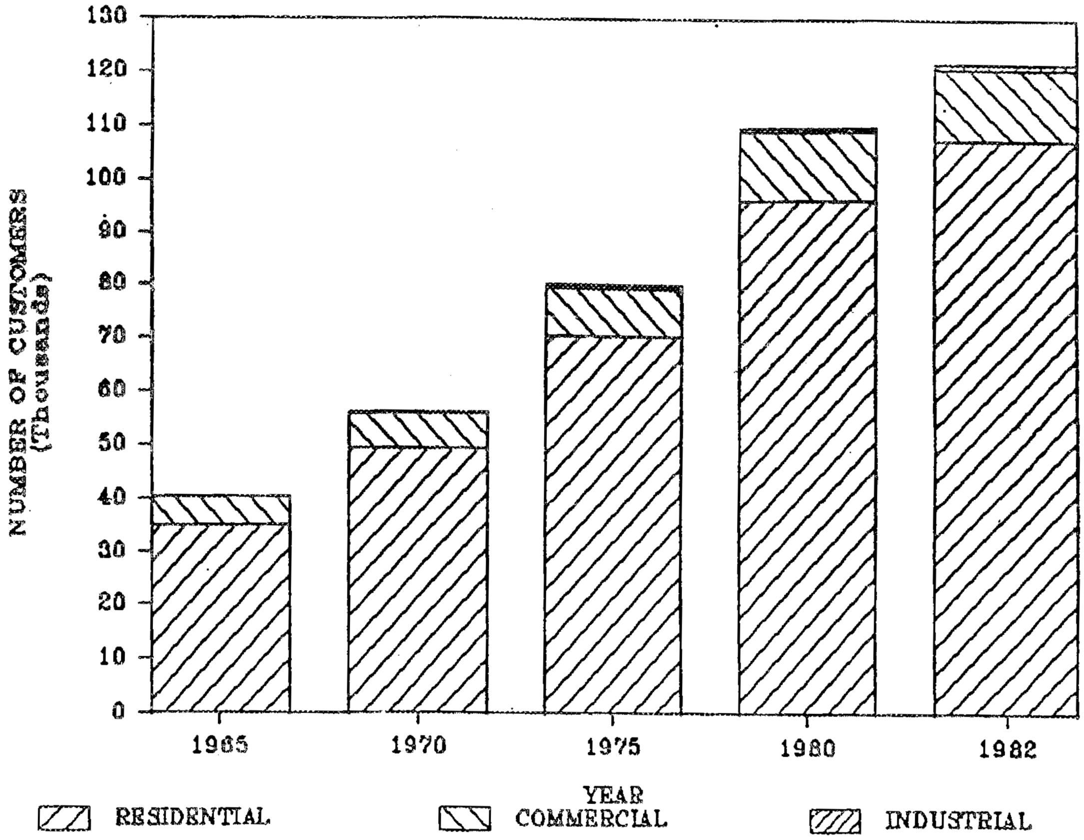
Source	Hydro	Gas	Oil	Coal	Wood/Oil	Total
Utilities	592.2	2,390.8	543.0	334.3	0.0	3,860.3
Industrial	0.0	1,069.5	220.0	30.0	288.3	1,607.8
Defense	0.0	152.4	167.4	212.9	0.0	532.7
Total	592.2	3,612.7	930.4	577.2	288.3	6,000.8

SOURCE: Alaska Power Administration, Alaska Electric Power Statistics, 1960-1983, Ninth Edition, September 1984.

Per capita use of electricity in the Railbelt was 8.67 megawatt-hours (Mwh) in 1982. This was up from 6.90 Mwh per capita in 1975 and 2.79 Mwh per capita in 1965. This increasingly intensive use of electricity stretched across sectors. Average use per residential customer increased by 3.7 percent per year between 1965 and 1982. In the commercial sector, average use per customer increased at an average annual rate of 4.3 percent. The industrial average increased by 2.1 percent.

[22]Ibid.

Figure 2.10
Electricity Customers in the Railbelt
By Sector
1965, 1970, 1975, 1980, and 1982



SOURCE: U.S. Department of Agriculture, Rural Electrification Administration, Statistics of Rural Electric Borrowers, Annual; and U.S. Department of Energy, Energy Information Administration, Statistics of Publicly Owned Electric Utilities in the United States, Annual.

The real average price of electricity in the Railbelt has been declining. The real average residential price of electricity declined at an average annual rate of 2.7 percent from 1965 to 1982. Commercial and industrial electricity prices declined at an average annual rate of 3.0 percent and 2.4 percent, respectively, over this period.[23] The decline in electricity prices in the Railbelt over this period contrasts with trends of generally increasing electricity prices in the United States as a whole. The downward trend in the Railbelt can be explained by decreasing natural gas prices in the Railbelt and the heavy reliance on natural gas-fired generating capacity in the region.

In 1983, a total of approximately 6,000.8 Gwh of net electricity was generated in Alaska (Table 2.1). Of this total, 64.3 percent was generated by utilities, 26.8 percent was generated by industry, and 8.9 percent was generated by the Federal government for national defense. Fuels used in generation included natural gas (60.1 percent), oil (15.6 percent), hydro (9.9 percent), coal (9.6 percent), and wood/oil (4.8 percent). The most prominent type of generation mode was the gas turbine, which accounted for approximately 54.0 percent of net generation. Other prime movers were system turbines (24.0 percent), internal combustion (13.0 percent), and hydro (10.0 percent).[24]

Generating capacity in the Railbelt is consistent with the state pattern of heavy reliance on natural gas and gas turbines. The trend toward gas-fired capacity began in the early 1960's. Hydroelectric

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[23]Ibid.

[24]U.S. Department of Energy, Alaska Power Administration, <u>Alaska Electric Power Statistics, 1960-1983</u>, September 1984.

generation was the most prominent type in 1956, followed by coal. However, the relative importance of hydro and coal generation dwindled as total generating capacity expanded with heavy utilization of natural gas in gas turbine generators. Perhaps the most important factor in this shift toward the use of natural gas as a fuel was a large inexpensive supply near the major load centers.[25] Short construction lead times and low capital costs are factors influencing use of gas turbines, which may be designed to use natural gas or fuel oil.

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[25]U.S. Federal Power Commission, The 1976 Alaska Power Survey, Volumes 1 and 2, 1976.

3. AN OVERVIEW OF THE MODELING SYSTEM

3.1 INTRODUCTION

The purpose of this chapter is to provide an overview of the Alaska Railbelt Electricity Load, Macroeconomic (ARELM) modeling system, an econometric model used to simulate electric load growth in Alaska's Railbelt. The following sections discuss the motivation for development of the model and provide a description of the multiequation system, including the rationale behind the specification of individual components of the system and the interactions between these components. Chapter 4 addresses technical aspects of the model, including the estimation technique, the values of the estimated coefficients, and the associated statistics of goodness of fit.

3.2 MODEL OBJECTIVES

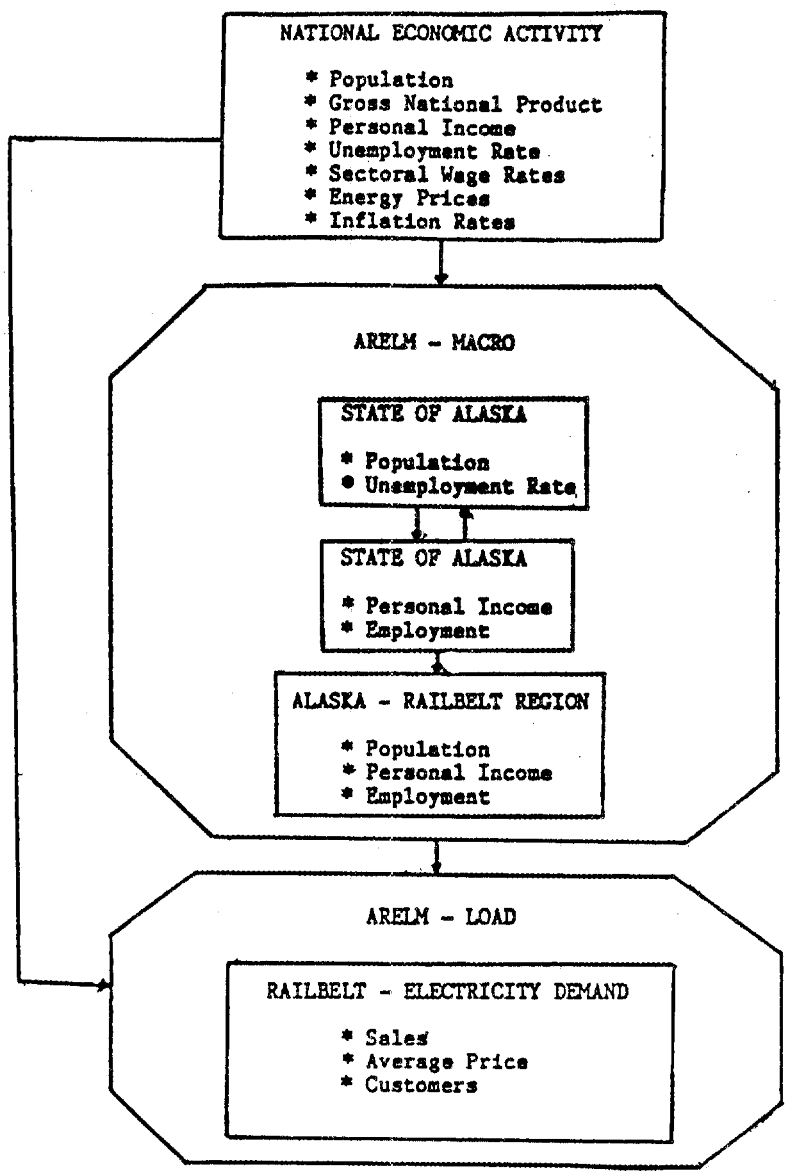
The motivating force for construction of ARELM was the need for a relatively simple modeling tool that could be used to simulate electricity load growth in the Railbelt under a variety of alternative assumptions about economic factors that influence that growth. Included among these factors are the interactions between population growth, changes in employment, changes in the world price of oil, the output of crude oil in Alaska, and overall economic activity in the region. To systematically capture the impact of these influences on Railbelt electricity growth, a macroeconomic model of the Alaskan Railbelt (ARELM-MACRO) was developed and linked to equations reflecting electricity load growth (ARELM-LOAD). Since data limitations preclude estimation of a macroeconomic model of the Railbelt region alone, the total Alaskan macroeconomy was modeled. The economic variables of population, income, and employment were disaggregated to the Railbelt. This characterization of the the macroeconomy and load growth in the Railbelt affords a simple method to simulate exogenous forces that influence Railbelt macroeconomic growth and the concomitant impact on electricity demand. A schematic representation of the entire system is provided in Figure 3.1.

3.3 MODEL DESCRIPTION

The ARELM modeling system is composed of two broad components: (1) ARELM-MACRO incorporates variables that reflect the state of Alaska's macroeconomic activity and macroeconomic indicators for the Railbelt, and (2) ARELM-LOAD projects electricity demand in the Railbelt. ARELM is block-recursive in the sense that the state of Alaska's macroeconomic performance determines indicators of economic activity in the Railbelt as measured by population, personal income, and employment. These variables in turn are used to explain electricity load growth in the Railbelt. The exogenous national macroeconomic activity variables that are used in each of the blocks were obtained from forecasts provided by the Data Resources, Incorporated long-term economic model.

Incorporation of national economic variables reflects the assumption that, in concert with many other factors, the performance of the Alaskan economy is influenced by economic activity in the nation as a whole. As shown in Figure 3.1, the forecasted population and unemployment rate are used in determining the values of those variables for the State of Alaska. Personal income and its components (e.g., dividends, interest, and rent and transfer payments) are used to derive the respective values for the Alaskan economy. Forecasted values of total real

Figure 3.1
A Schematic Representation of ARELM



U.S. GNP are used in the determination of the number of industrial customers in the Railbelt.

The equations estimated for the state of Alaska are specified to determine personal income and its components. That is, wages and salaries are determined for seven aggregated sectors of the Alaskan economy and are combined with other components of personal income to determine total Alaskan personal income. The seven aggregated sectors included for individual treatment are: (1) wholesale and retail trade; (2) transportation, communications, and other public utilities; (3) finance, insurance, real estate, and services; (4) construction; (5) government; (6) manufacturing; and (7) mining

Each of the sectors is specified to determine endogenous levels of employment and the wage rate. The product of the two determines wages and salaries originating by sector. Wages and salaries plus the other components of personal income that are estimated in ARELM-MACRO provide an estimate of personal income--a proxy for aggregate economic activity in the Alaskan economy. Additionally, estimated employment levels in the seven sectors are combined to provide an estimate of total Alaskan employment in the commercial sectors (transportation, communications, and other public utilities; wholesale and retail trade; finance, insurance, real estate, and services; and government) and the industrial sectors (mining, construction, and manufacturing).

Four of the employment sectors included in determination of wages and salaries for the Alaskan economy--wholesale and retail trade; transportation, communications, and other public utilities; construction; and finance, insurance, real estate, and services--were modeled as individual, local labor markets. For each of these sectors, employment levels and the corresponding average wage rate were estimated simultaneously as interactive labor demand and supply equations. The equations were specified on the basis of variables theorized to influence their behavior. The wage rate and a measure of output were used as explanatory variables in the employment demand equation; employment was an independent variable in the wage formation equation. These four sectors are assumed to depict local markets that are influenced only indirectly by economic activity outside the state.

The other three employment sectors--government, manufacturing, and mining--were not specified as individual, local labor markets. For each of these three sectors, a labor supply equation and a wage formation equation were estimated. The rationale for this specification in the mining and manufacturing sectors is the belief that the oil and pipeline activity in Alaska in the 1970's required that wage rates be set at levels high enough to attract a sufficient number of migrants to the state to engage in oil-related activity. The government sector was specified similarly to reflect the concomitant increase in government employment as a result of increased oil-related activity. Consequently, we have specified the employment equation for these three sectors on the basis of the average wage rate, gross oil output, and other variables theorized to influence the supply of labor. The wage formation equations for the mining and manufacturing sectors are based on the total U.S. average wage rate for those sectors and the U.S. unemployment rate. The wage formation equation for the government sector is specified on the basis of lagged wages and the overall Alaskan price level.

The macroeconomic model of Alaska estimated in this system represents a highly aggregated characterization of the Alaskan economy. Since the primary purpose for development of ARELM-MACRO was to obtain estimates of total Alaskan macroeconomic indicators (personal income, population, and employment) for use in determining electric load growth, other aspects of the Alaskan economy such as government revenues and expenditures and private capital formation have not been incorporated in the system. In a taxonomy of various approaces to modeling a regional or state economy, the system developed here can be categorized as an aggregated, simultaneous-equation, econometric model. Approaches that have been used in other regional/state modeling applications include export-based models and input-output models.[1] These modeling approahes were considered inappropriate for purposes of the present study.

The simulated outputs of the Alaskan macroeconomic model--Alaskan population, personal income, and commercial and industrial employment--are used to determine those respective values for the Anchorage, Fairbanks, and Peninsula areas of the Railbelt. The methodology employed is simple econometric disaggregation of the state values into regional components.

Railbelt macroeconomic activity is then used in ARELM-LOAD to determine electricity load growth, real average price, and the number of customers in the Railbelt. The residential, commercial, and industrial sectors are modeled separately. Electricity demand and average price in

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[1]For a discussion of various regional modeling approaches, see, for example, Norman J. Glickman, Econometric Analysis of Regional Systems: Explorations in Model Building and Policy Analysis, Academic Press, New York, 1977.

each of the sectors is determined simultaneously. Electricity demand is based on its own real average price, real per capita income, and other variables theorized to influence electricity use (e.g., heating-degree days, the price of natural gas). The price formation equation is based in large measure on the cost of producing electricity in the Railbelt.

4. ESTIMATION OF ARELM

4.1 INTRODUCTION

The following discussion presents details of the estimation of ARELM. The major components of ARELM-MACRO are discussed first: population, unemploment, employment by sector, personal income, and regionalization. This discussion is followed by a description of ARELM-LOAD, which includes submodels for the residential, commercial, and industrial sectors plus estimates of average cost.

4.2 MACRO SUBMODEL

MACRO can be characterized as an extension to the state level of macroeconomic models used to forecast activity in the nation as a whole (such as the Wharton or Brookings models). It focuses on the components of income, employment, and population for Alaska and the Railbelt.

Most of the equations in MACRO were estimated using annual data from 1959 to 1982. Because of data limitations, some equations were estimated using observations from 1964 to 1982. The equations were estimated assuming linearity. Except for the employment sectors, most equations were estimated using ordinary least squares. A moving average component was added if there were problems with serial correlation.

Employment was divided into seven sectors: (1) mining, (2) manufacturing, (3) government, (4) construction, (5) transportation, communications, and other public utilities, (6) wholesale and retail trade, and (7) finance, insurance, real estate, and services. Employment and wages were considered endogenous. The two equations were estimated simultaneously using two-stage least squares for each sector.

Disaggregation from state-level population, per capita income, commercial employment, and industrial employment values was accomplished for three regions: (1) Anchorage (which includes Anchorage and Matanuska-Susitna); (2) Fairbanks; and (3) the Peninsula (Kenai Peninsula, formerly Kenai-Cook Inlet and Seward). The disaggregated values were then used as inputs in the LOAD submodel.

4.2.1 Alaskan Population

Alaskan population (AKPOP) was estimated as a function of lagged population, U.S. population (USPOP), and relative per capita incomes in Alaska and the United States (RELPCI). The following equation was estimated using annual data from 1965 to 1982 (t-statistics in parentheses):

$$\mathrm{AKPOP}_t = \underset{(-2.331)}{-219.1904} + \underset{(4.376)}{0.6038}\ \mathrm{AKPOP}_{t-1} + \underset{(2.124)}{1.4006}\ \mathrm{USPOP}_t + \underset{(4.563)}{65.7274}\ \mathrm{RELPCI}_t + \underset{(1.120)}{0.4435}\ E_{t-1} + E_t \qquad (1)$$

$$\text{Adjusted } R^2 = 0.99 \qquad h = 0.71\ ,$$

where E and t denote the residual and time, respectively.

The Durbin h statistic is a test for serial correlation when a lagged dependent variable is present in the estimation. It is a function of the Durbin-Watson statistic, the number of observations, and the sampling variable of the coefficient on the lagged dependent variable. The statistic h is assumed to represent a standard normal deviate. For values of h less than 1.65, the hypothesis of zero autocorrelation at the 0.05 level would not be rejected.

The estimated equation in (1) represents a simple net migration relationship and does not attempt to capture cohort survival and natural increase, out-migration rates, or in-migration by age-sex cohorts. By basing population growth on aggregate historical relationships, the equation is limited in its ability to forecast circumstances which might dramatically alter the underlying distribution of Alaskan population by such categories as age or the distribution between military, civilian, and native populations.

The signs of the coefficients in the population equation correspond to a priori expectations. Alaskan population is shown to grow when the U.S. population is growing. In addition, increasing per capita income in Alaska relative to the United States has a positive impact on Alaskan population, with more people migrating to Alaska because of relatively higher per capita income.

4.2.2 Alaskan Unemploment

The unemployment rate in Alaska (AKUE) was estimated as a function of population in Alaska (AKPOP), total employment (EMP), and the U.S. unemployment rate (USUE). The following equation was estimated using annual data from 1958 to 1982 (t-statistics in parentheses):

$$\begin{aligned} AKUE_t = & \underset{(-1.208)}{-4.7989} + \underset{(3.002)}{0.0648}\ AKPOP_t - \underset{(-2.891)}{0.0000893}\ EMP_t + \underset{(0.723)}{0.1068}\ USUE_t + \\ & \underset{(2.960)}{0.4088}\ USUE_{t-1} - \underset{(-2.876)}{0.6820}\ DPIPE_t - \underset{(-2.239)}{0.5776}\ E_{t-1} + E_t \qquad (2) \end{aligned}$$

Adjusted $R^2 = 0.61$ Durbin-Watson = 1.98 ,

where DPIPE is a dummy variable for the construction of the pipeline (DPIPE= 1 in 1974, 2 in 1975, 3 in 1976, 0 for all other years); E is the residual; and t is time.

As in the population equation, several simplifying assumptions were evoked in the specification of the unemployment equation in (2). There is no direct estimation of the labor force. Instead, the relationships between unemployment, population, and employment are considered in a reduced-form framework. As population increases, other things equal, the unemployment rate increases, reflecting a larger number of people in the labor force with the number of jobs constant. As total employment increases, the unemploment rate decreases (assuming that the population and labor force remain constant). The impact of the U.S. unemployment rate on the Alaskan economy captures the link between the two economies. As unemployment in the United States rises, so does unemployment in Alaska. However, only lagged U.S. unemployment is significant at the 0.05 level, indicating that it takes at least a year for Alaska to experience the downturns and upturns of the U.S. economy. The dummy variable characterizing construction of the pipeline is significant and negative in the unemployment equation. The unemployment rate was lower in these years because of the construction activity.

4.2.3 Alaskan Employment and Wages--Export Sectors

Total employment is disaggregated into seven sectors: (1) mining, (2) manufacturing, (3) government, (4) construction, (5) transportation, communications, and other public utilities, (6) wholesale and retail trade, and (7) finance, insurance, real estate, and services. The first three sectors were considered dependent on decisions made outside the

Alaskan economy. Mining is heavily dependent on the world price and demand for oil. Manufacturing depends on demand for major Alaskan products such as lumber and fish. Government is dependent to a large extent on Federal decisions about programs in Alaska.

Therefore, it is assumed that wages in these three sectors are not the result of the interaction of local demand and supply, but are instead determined by exogenous factors outside of Alaska. Employment in these sectors was estimated as an offer curve relationship in which increasing wages produce increasing employment because people migrate to Alaska in order to accept employment at the prevailing wage.

4.2.3.1 Mining

The mining sector is represented by two equations in which the number of people employed in mining (AKMINE) and real average monthly wages earned by miners (RWAKMINE) are endogenous. The following equations were estimated using two-stage least squares and annual data from 1959 to 1982 (t-statistics in parentheses):

$$AKMINE_t = \underset{(-9.334)}{-392.2381} + \underset{(60.568)}{0.7150}\, AKMINE_{t-1} + \underset{(19.763)}{1.2009}\, RWAKMINE_t + \underset{(30.646)}{0.00296}\, OILOUT_t + \underset{(3.369)}{0.7631}\, E_{t-1} + E_t \quad (3)$$

Adjusted $R^2 = 0.99$ $\quad h = 0.05$

$$RWAKMINE_t = \underset{(-27.245)}{-1271.3345} + \underset{(40.221)}{647.6147}\, RWUSMINE_t - \underset{(-0.174)}{0.6094}\, USUE_t + \underset{(3.435)}{0.8529}\, E_{t-1} + E_t \quad (4)$$

Adjusted $R^2 = 0.99$ $\quad$ Durbin-Watson = 1.98 , where OILOUT is the number of barrels of oil produced in Alaska; E is the residual term; RWUSMINE is the real average monthly wage paid to employees in the mining sector in the United States; and USUE is the unemployment rate in the United States.

The average real wage in Alaskan mining increases with increasing wages in the United States. The U.S. unemployment rate is not significant in determining wages for this sector in Alaska. Mining employment increases with increasing production. Although employment and wages in the sector are defined as functions of only a few exogenous variables, the system leaves a relatively small portion of the historical variation unexplained.

4.2.3.2 Manufacturing

The specification of the manufacturing sector includes employment (AKMAN) and real average monthly wages (RWAKMAN) as endogenous. Using two-stage least squares and annual data from 1959 to 1982, the equations' coefficients are as follows (t-statistics in parentheses):

$$AKMAN_t = \underset{(-8.457)}{-5470.8533} + \underset{(11.757)}{0.6626}\, AKMAN_{t-1} + \underset{(3.927)}{9.337}\, RWAKMAN_t +$$

$$\underset{(4.237)}{0.00269}\, OILOUT_t + \underset{(3.268)}{0.1649}\, USMAN_t + \underset{(0.358)}{0.0986}\, E_{t-1} + E_t \qquad (5)$$

Adjusted $R^2 = 0.99$ $\qquad h = 0.00$

$$RWAKMAN_t = \underset{(-4.511)}{-53.5131} + \underset{(61.479)}{226.0155}\, RWUSMAN_t - \underset{(-8.918)}{6.1792}\, AKUE_t +$$

$$\underset{(3.050)}{0.7302}\, E_{t-1} + E_t \qquad (6)$$

Adjusted $R^2 = 0.99$ $\qquad$ Durbin-Watson = 1.89 , where OILOUT is the number of barrels of oil produced in Alaska; USMAN is the number of people employed in manufacturing in the United States; E is the residual term; RWUSMAN is the real average monthly wage paid to employees in the U.S. manufacturing sector; and AKUE is the Alaskan unemploment rate.

The manufacturing wage equation indicates that the average wage earned by manufacturing workers in the United States is significant at the 0.01 level in explaining manufacturing wages in Alaska. The Alaskan unemployment rate is also significant with a negative coefficient. As unemployment increases in Alaska, the increased pool of labor acts to dampen the real wage in manufacturing.

The wage coefficient is positive in the employment equation [equation (5)]. As the real wage increases, more people are attracted to employment in Alaskan manufacturing. The equation highlights the flexibility of the labor force in Alaska: people move into the state to accept the relatively higher real wages, but then are ready to leave the relatively harsh living conditions when real wages decline. Alaskan oil production was included in the manufacturing employment equation to capture the secondary sector growth effects caused by construction of the pipeline. Oil production in Alaska and employment in U.S. manufacturing are both positive and significant at the 0.05 level in explaining Alaskan manufacturing employment.

4.2.3.3 Government

The employment and wage equations for the government sector were estimated using data from 1964 to 1982. The real wage (RWAKGOV) and government employment (AKGOV) are endogenous in the system. The following equations were estimated (t-statistics in parentheses):

$$AKGOV_t = \underset{(-12.514)}{-18719.741} + \underset{(6.372)}{38.9700}\ RWAKGOV_t + \underset{(9.658)}{0.00854}\ OILOUT_t +$$

$$\underset{(14.723)}{109.2881}\ AKPOP_t + \underset{(1.103)}{0.3146}\ E_{t-1} + E_t \qquad (7)$$

$$\text{Adjusted } R^2 = 0.99 \qquad \text{Durbin-Watson} = 1.99$$

$$RWAKGOV_t = \underset{(8.495)}{75.3381} + \underset{(42.449)}{0.8642}\ RWAKGOV_{t-1} + \underset{(2.862)}{4.6540}\ PALASKA_t +$$

$$\underset{(3.399)}{0.9380}\ E_{t-1} + E_t \qquad (8)$$

$$\text{Adjusted } R^2 = 0.99 \qquad h = 0.26\ ,$$

where OILOUT is the number of barrels of oil produced in Alaska; AKPOP is the population in Alaska; E is the residual term; and PALASKA is the price deflator for Alaska. The latter variable converts Alaskan nominal dollar values to real U.S. dollar-value equivalents.

The wage equation for this sector shows that real wages of government employees have followed a strong upward trend. In addition to lagged wages, the price deflator for Alaska (developed by the Institute for Social and Economic Research at the University of Alaska for the Man-in-the-Arctic Program) is also significant at the 0.05 level in determining governmental workers' real average wages.

As with the two sectors presented above, the coefficients of real wages and oil production are positive and significant. Oil production is used as a proxy for the hypothesized impact that increasing oil revenues have had on governmental activities in the state. The population variable reflects the increasing need for governmental services as more people migrate to the state.

4.2.4 Alaskan Employment and Wages--Local Markets

Employment and wages in the remaining four employment sectors are assumed to be determined in local labor markets. For these sectors, one would expect a demand-curve relationship between the number of people employed and the real wage.

4.2.4.1 Construction

Construction is a support sector for the mining and manufacturing export-based sectors. Employment in this sector (AKCON) and real average monthly wages (RWAKCON) were considered endogenous in a two-equation system. Annual observations from 1958 to 1982 were used to estimate the following coefficients using two-stage least squares (t-statistics in parentheses):

$$
\begin{aligned}
AKCON_t = {} & \underset{(1.763)}{3964.9202} + \underset{(9.686)}{0.6563}\ AKCON_{t-1} - \underset{(-1.983)}{7.0634}\ RWAKCON_t + \\
& \underset{(3.045)}{223.3160}\ OILPRICE_t + \underset{(9.073)}{248.6113}\ AKINCNG_t + \\
& \underset{(9.439)}{5030.5688}\ DPIPE_t + \underset{(3.398)}{195.2742}\ DT_t + E_t \qquad (9)
\end{aligned}
$$

Adjusted $R^2 = 0.99$ $h = 0.29$

$$
\begin{aligned}
RWAKCON_t = {} & \underset{(16.234)}{679.0386} + \underset{(3.892)}{0.1789}\ RWAKCON_t + \underset{(7.051)}{0.0290}\ AKCON_t \\
& \underset{(-6.982)}{-37.1681}\ USUE_t + \underset{(1.804)}{39.2526}\ DPIPE_t + \underset{(4.664)}{4.6725}\ DT_t + E_t \qquad (10)
\end{aligned}
$$

Adjusted $R^2 = 0.99$ $h = 0.62$,

where OILPRICE is the real U.S. refiners' acquisition price for crude oil (composite of domestic and foreign); AKINCNG is the percentage change in Alaskan real personal income; DPIPE is the pipeline dummy variable (DPIPE= 1 in 1974, 2 in 1975, 3 in 1976, and 0 in all other years); DT is a time trend dummy variable (DT= 2 in 1958, 3 in 1959, ... 26 in 1982); E is a residual term; and USUE is the U.S. unemployment rate.

Equations (9) and (10) can be interpreted in a labor market context. The negative wage coefficient in the employment equation determines a demand curve relationship: increasing the cost of labor decreases its demand. The positive employment coefficient in the wage equation represents a supply curve relationship: increasing the price employers are willing to pay for labor results in an increased supply of labor. The dummy variable representing the years of pipeline construction is significant and positive in both the employment and wage equations. Wages and the number of construction workers were abnormally high during the period. The impact of world demand for oil on Alaskan construction employment is captured by including the real price of oil. In construction, the change in income--rather than the absolute value of income--is significant, highlighting construction as an activity associated with growth rather than wealth.

4.2.4.2 Transportation, Communications, and Other Public Utilities

The transportation, communications, and other public utilities sector was estimated using annual data from 1958 to 1982. Employment (AKUTIL) and real average monthly wages (RWAKUTIL) were endogenous. The estimated equation is (t-statistics in parentheses):

$$AKUTIL_t = \underset{(1.886)}{1930.9388} + \underset{(7.234)}{0.3992}\ AKUTIL_{t-1} - \underset{(-3.789)}{5.2718}\ RWAKUTIL_t +$$

$$\underset{(8.173)}{0.00545}\ RAKINC_t + \underset{(1.397)}{7.8041}\ AKPOP_t + E_t \qquad (11)$$

Adjusted $R^2 = 0.99$ $\quad h = 0.49$

$$RWAKUTIL_t = \underset{(8.847)}{253.3296} + \underset{(13.436)}{0.7242}\ RWAKUTIL_{t-1} + \underset{(4.281)}{0.00672}\ AKUTIL_t$$

$$\underset{(-5.135)}{-14.7101}\ AKUE_t + \underset{(3.058)}{0.6925}\ E_{t-1} + E_t \qquad (12)$$

Adjusted $R^2 = 0.99$ $\quad h = -0.13$,

where RAKINC is Alaskan real personal income; AKPOP is Alaskan population; E is the residual term; and AKUE is the Alaskan unemployment rate.

For the transportation, communications, and other utilities sector, the value of real personal income in Alaska is significant in explaining employment. The interrelationship between wages and employment is captured in equations (11) and (12) with the negative employment coefficient in the wage equation. The employment rate in Alaska enters with an expected negative coefficient and is significant at the 0.01 level.

4.2.4.3 Wholesale and Retail Trade

The following equations for employment (AKTRADE) and real average monthly wages (RWAKTRADE) in wholesale and retail trade were estimated using annual data from 1958 to 1982 (t-statistics in parentheses):

$$AKTRADE_t = \underset{(3.392)}{2221.8938} - \underset{(-45.042)}{60.9083}\ RWAKTRADE_t + \underset{(28.684)}{4.4558}\ RAKPCINC_t +$$

$$\underset{(45.268)}{89.0112}\ AKPOP_t + E_t \qquad (13)$$

Adjusted $R_2 = 0.99$ $\quad$ Durbin-Watson = 1.85

$$RWAKTRADE_t = \underset{(2.488)}{46.7692} + \underset{(24.182)}{0.9507}\ RWAKTRADE_{t-1} + \underset{(1.457)}{0.000639}\ AKTRADE_t$$

$$\underset{(-2.221)}{-1.8709}\ AKUE_t - \underset{(-9.018)}{11.2947}\ DPPIPE_t - \underset{(-1.726)}{1.0807}\ DT_t +$$

$$\underset{(2.481)}{0.6380}\ E_{t-1} + E_t \qquad (14)$$

$$\text{Adjusted } R^2 = 0.98 \qquad h = 0.23\ ,$$

where RAKPCINC is real average per capita income in Alaska; AKPOP is the population in Alaska; E is the residual term; AKUE is the Alaskan unemployment rate; DPPIPE is a post-pipeline construction dummy variable (DPPIPE= 1 in 1977, 2 in 1978, 3 in 1979, and 0 in all other years); and DT is a time trend dummy variable (DT= 2 in 1958, 3 in 1959, ... 26 in 1982).

Employment in wholesale and retail trade is positively related to the level of economic activity in the Alaskan economy, represented by per capita income and population. Wages are explained by the influence of the Alaskan unemployment rate and the level of employment. The wage equation for wholesale and retail trade is the only one in which a post-pipeline dummy variable was significant. In the trade sector, there was a dramatic decline in real wages over the period 1977 to 1979. It is hypothesized that workers involved in short-term employment associated with pipeline construction may have found employment in the wholesale and retail trade sector, hoping that a new construction project might develop in Alaska. These workers may have driven down the real wage in the trade sector and temporarily created a disequilibrium in the labor market over the period. When a new project was not initiated, these workers may have left Alaska, reducing the supply of labor in the trade sector and restoring the market to an equilibrium position.

4.2.4.4 Finance, Insurance, Real Estate, and Services

A two-equation system was estimated to capture employment (AKSERV) and real average monthly wages (RWAKSERV) in the finance, insurance, real estate, and services sector. Using two-stage least squares with annual data from 1964 to 1982, the estimated equations are as follows (t-statistics in parentheses):

$$AKSERV_t = \underset{(14.747)}{3611.9531} + \underset{(107.883)}{0.5574}\ AKSERV_{t-1} - \underset{(-34.735)}{25.0148}\ RWAKSERV_t + \underset{(71.648)}{0.4842}\ AKEMI_t + \underset{(44.595)}{441.8046}\ DT_t + E_t \qquad (15)$$

Adjusted $R^2 = 0.99$ $\quad h = 0.04$

$$RWAKSERV_t = \underset{(5.159)}{330.1591} + \underset{(4.581)}{0.6136}\ RWAKSERV_{t-1} + \underset{(2.413)}{0.00169}\ AKSERV_t - \underset{(-3.836)}{20.8796}\ AKUE_t + \underset{(1.441)}{0.4281}\ E_{t-1} + E_t \qquad (16)$$

Adjusted $R^2 = 0.86$ $\quad h = 0.05$,

where AKEMI is the number of people employed in mining, construction, and manufacturing in Alaska; DT is a time trend dummy variable (DT= 8 in 1964, 9 in 1965, ... 26 in 1982); and AKUE is the Alaskan unemployment rate.

Employment in the service sectors is directly related to employment in the mining, construction, and manufacturing sectors, reflecting the multiplier effect of employment in the basic sectors. The wage equation in this sector has the same formulation as the wage equations in public utilities, with lagged wages, employment, and the unemployment rate all significant at the 0.05 level.

4.2.5 Alaskan Income Components and Total Personal Income

Employment and wages are the major components in the calculation of total personal income. However, there are other components to income: dividends, interest, and rent; proprietors' income; transfer payments; and other labor income, as examples. To derive estimates of some of these non-wage components of personal income, the assumption was made that the U.S. values of these variables would provide an adequate explanation of the trends for Alaska. The following discussion provides the approach that was used to estimate these components of personal income.

4.2.5.1 Wage Income

The seven employment sectors discussed above represent more than 95 percent of total wages and salaries in Alaska. There is a category denoted "other" by the Alaska Department of Labor (ADOL) that is not included in these sectors. There was a data problem that also had to be addressed. The detail on employment and wages was available from ADOL. However, the information on the components of personal income is provided by the Bureau of Economic Analysis, U.S. Department of Commerce (BEA). To account for "other" employment and to ensure consistency between total wage and salary data from the BEA and wage and salary aggregations using the average annual employment and average monthly wage data by sector from the ADOL, an additional equation was incorporated in the determination of personal income. The following equation was estimated using annual data from 1963 to 1982 (t-statistics in parentheses):

$$RAKWAGE_t = \underset{(17.610)}{155912.91} + \underset{(113.181)}{0.9967}\ RTSQWAGE_t = \underset{(4.479)}{0.9767}\ E_{t-1} + E_t \qquad (17)$$

Adjusted $R^2 = 0.99$ Durbin-Watson = 1.96 ,

where RAKWAGE is the real value of wages and Salaries in Alaska, published by the BEA; RTSQWAGE is the real value of total annual wages and salaries in mining, construction, manufacturing, transportation, communications, and other public utilities, wholesale and retail trade, finance, insurance, and real estate, services, and government (excluding other) as reported by the ADOL in the Statistical Quarterly (which is modeled in equations 3 through 16); and E is the residual term.

4.2.5.2 Dividends, Interest, and Rent

The relationship between state and national dividends, interest, and rent were estimated using annual data from 1958 to 1982 (t-statistics in parentheses):

$$\underset{}{RAKDIR_t} = \underset{(-9.080)}{-111928.18} + \underset{(6.984)}{2040.9948}\ RUSDIR_t - \underset{(-0.505)}{642.9510}\ DT_t + \underset{(4.711)}{0.9711}\ E_{t-1} + E_t \qquad (18)$$

Adjusted $R^2 = 0.97$ Durbin-Watson = 1.97 ,

where RAKDIR is the real value of dividends, interest, and rent earned in Alaska; RUSDIR is the corresponding U.S. total; DT is a time trend dummy (DT= 2 in 1958, 3 in 1959, ... 26 in 1982); and E is the residual term.

4.2.5.3 Proprietors' Nonfarm Income

The real value of proprietors' nonfarm income in Alaska (RAKPRN) is estimated as a function of the real value of proprietors' nonfarm income in the United States (RUSPRN). The following equation was estimated using annual data from 1958 to 1982 (t-statistics in parentheses):

$$RAKPRN_t = \underset{(-0.069)}{-853.9443} + \underset{(2.650)}{711.6826}\ RUSPRN_t + \underset{(10.793)}{1771.7045}\ DT_t +$$

$$\underset{(4.474)}{1.0032}\ E_{t-1} + E_t \qquad (19)$$

Adjusted $R^2 = 0.86$ Durbin-Watson = 1.99 ,

where DT and E are defined in conjunction with equation (18).

4.2.5.4 Transfer Payments

Real transfer payments in Alaska (RAKTRN) were estimated as a function of the real value of transfer income in the United States (RUSTRN). Annual data from 1958 to 1982 were used to estimate the following relationship (t-statistics in parentheses):

$$RAKTRN_t = \underset{(-4.296)}{-43302.830} + \underset{(13.085)}{1648.4450}\ RUSTRN_t + \underset{(0.996)}{0.2967}\ E_{t-1} + E_t \qquad (20)$$

Adjusted $R^2 = 0.88$ Durbin-Watson = 1.56 ,

where E is the residual term.

4.2.5.5 Other Labor Income

The real value of other labor income in the United States (RUSOLI) is used to predict the real value of other labor income in Alaska (RAKOLI). The following equation was estimated using annual data from 1958 to 1982 (t-statistics in parentheses):

$$RAKOLI_t = \underset{(-8.578)}{-29009.707} + \underset{(6.056)}{3565.9394}\ RUSOLI_t \underset{(-2.000)}{-2456.5854}\ DT_t +$$

$$\underset{(4.376)}{0.9818}\ E_{t-1} + E_t \qquad (21)$$

Adjusted $R^2 = 0.96$ Durbin-Watson = 1.98 ,

where DT is a time trend dummy variable (DT= 2 in 1958, 3 in 1959, ... 26 in 1982) and E is the residual term.

4.2.5.6 Total Personal Income

The individual components of personal income were combined and regressed against total personal income in Alaska using annual data from 1958 to 1982 (t-statistics in parentheses):

$$RAKINC_t = \underset{(3.948)}{65719.407} + \underset{(66.948)}{0.8345}\ RAKEST_t + \underset{(4.067)}{0.8692}\ E_{t-1} + E_t \qquad (22)$$

Adjusted $R^2 = 0.99$ Durbin-Watson = 1.99 ,

where RAKINC is the real value of total personal income in Alaska; RAKEST is the summation of the estimated income components (wages and salaries, dividends, interest, and rent, proprietors' nonfarm income, transfer payments, and other labor income); and E is the residual term.

4.2.6 Railbelt Regionalization of Population, Income, and BFO Employment

The equations estimated above provide a framework for forecasting population, income, and employment in Alaska. However, to use the econometric simulation of state-level economic activity as an input to the electricity demand model of the Railbelt, the state-level variables must be translated into values for the three substate regions--Anchorage, Fairbanks, and the Peninsula. The methodology employed here was to estimate elasticities for each region, relating state activity to local activity.

4.2.6.1 Railbelt Population

The following population equations were estimated using annual data from 1965 to 1982 (t-statistics in parentheses):

$$ANCHPOP_t = \underset{(-23.881)}{-41.1944} + \underset{(118.711)}{0.5827}\ AKPOP_t + \underset{(4.291)}{0.9359}\ E_{t-1} + E_t \qquad (23)$$

Adjusted $R^2 = 0.99$ Durbin-Watson = 1.72

$$FAIRPOP_t = \underset{(13.968)}{14.1466} + \underset{(32.820)}{0.1017}\ AKPOP_t + \underset{(3.272)}{0.9391}\ E_{t-1} + E_t \qquad (24)$$

Adjusted $R^2 = 0.99$ Durbin-Watson = 1.90

$$PENIPOP_t = \underset{(-8.183)}{-12.4725} + \underset{(20.765)}{0.0905}\ AKPOP_t + \underset{(3.545)}{0.9280}\ E_{t-1} + E_t \qquad (25)$$

Adjusted $R^2 = 0.96$ Durbin-Watson = 1.85 ,

where ANCHPOP, FAIRPOP, and PENIPOP are the populations of Anchorage, Fairbanks, and Peninsula, respectively; AKPOP is the population in Alaska; and E is the residual term.

4.2.6.2 Railbelt Income

The income equations were estimated using annual data from 1965 to 1982. Since a log-linear specification performed better in terms of decreasing the unexplained variation, it was chosen over a linear specification. The following equations were estimated (t-statistics in parentheses):

$$\ln RANCHPCINC_t = \underset{(2.053)}{0.6185} + \underset{(25.238)}{0.9333}\ \ln RAKPCINC_t + \underset{(2.553)}{0.6632}\ E_{t-1} + E_t \qquad (26)$$

Adjusted $R^2 = 0.97$ Durbin-Watson = 1.98

$$\ln RFAIRPCINC_t = \underset{(-1.328)}{-0.7028} + \underset{(16.919)}{1.0992} \ln RAKPCINC_t + \underset{(3.5165)}{0.9142} E_{t-1} + E_t \quad (27)$$

Adjusted $R^2 = 0.95$ Durbin-Watson = 1.92

$$\ln RPENIPCINC_t = \underset{(3.312)}{1.2688} + \underset{(17.611)}{0.8280} \ln RAKPCINC_t + \underset{(2.024)}{0.5308} E_{t-1} + E_t \quad (28)$$

Adjusted $R^2 = 0.95$ Durbin-Watson = 1.96 ,

where ln is the natural logarithm; RANCHPCINC, RFAIRPCINC, and RPENIPCINC are the real values of average per capita income in Anchorage, Fairbanks, and the Peninsula, respectively; RAKPCINC is the real value of average per capita income in Alaska; and E is the residual term.

4.2.6.3 Railbelt Employment--Commercial

The following employment equations were estimated using annual data from 1965 to 1982 (t-statistics in parentheses):

$$ANCHEMC_t = \underset{(-9.666)}{-12355.643} + \underset{(36.586)}{0.4341} AKEMC_t + \underset{(2.181)}{0.6008} E_{t-1} + E_t \quad (29)$$

Adjusted $R^2 = 0.99$ Durbin-Watson = 1.89

$$FAIREMC_t = \underset{(-2.317)}{-1014.0042} + \underset{(1.145)}{0.01094} AKEMC_t + \underset{(9.055)}{0.3057} AKEMI_t +$$

$$\underset{(3.404)}{0.9763} E_{t-1} + E_t \quad (30)$$

Adjusted $R^2 = 0.97$ Durbin-Watson = 1.90

$$PENIEMC_t = \underset{(-4.532)}{-1034.4555} + \underset{(4.383)}{0.0494} AKEMC_t - \underset{(-2.711)}{218.828} DPIPE_t$$

$$\underset{(-1.530)}{-111.2281} DT_t + \underset{(0.244)}{0.0704} E_{t-1} + E_t \quad (31)$$

Adjusted $R^2 = 0.96$ Durbin-Watson = 2.00 ,

where ANCHEMC, FAIREMC, and PENIEMC are the numbers of people employed in commercial establishments in Anchorage, Fairbanks, and the Peninsula, respectively, calculated as total employment less employment in mining, construction, manufacturing, and government; AKEMC is the number of people employed in commercial establishments in Alaska, calculated as total employment less employment in mining, construction, manufacturing, and government; AKEMI is the number of people employed in mining, construction, and manufacturing in Alaska; DPIPE is a dummy variable for the pipeline construction years (DPIPE= 1 in 1974, 2 in 1975, 3 in 1976, and 0 in all other years); DT is a time trend dummy variable (DT= 2 in 1958, 3 in 1959, ... 26 in 1982); and E is the residual term.

The specification of equations for the three regions varies slightly, reflecting different forces affecting commercial employment. Commercial employment in Anchorage is explained to a large extent by commercial employment in the state. In the Fairbanks equation, commercial employment in Alaska is not significant, but Alaskan industrial employment does have a significant impact. The importance of the basic sector in determining support services is highlighted in this specification. The equation for the Peninsula is the only one that showed the impact of pipeline construction, with employment in the commercial sector lower than would be expected from the corresponding level of total Alaskan employment in commercial activities.

4.2.6.4 Railbelt Employment--Industrial

The estimated equations for the number of people employed in mining, construction, and manufacturing in Anchorage (ANCHEMI), Fairbanks

(FAIREMI), and the Peninsula (PENIEMI) are as follows (t-statistics in parentheses):

$$ANCHEMI_t = \underset{(-5.173)}{-3459.9609} + \underset{(5.809)}{0.0805}\ AKEMC_t + \underset{(2.077)}{0.1024}\ AKEMI_t + \underset{(3.307)}{0.9490}\ E_{t-1} + E_t \qquad (32)$$

Adjusted $R^2 = 0.94$ Durbin-Watson = 1.74

$$FAIREMI_t = \underset{(-0.602)}{-503.1848} + \underset{(3.779)}{0.4238}\ FAIREMI_{t-1} + \underset{(1.431)}{0.0535}\ AKEMI_t + \underset{(4.741)}{1799.6477}\ DPIPE_t + E_t \qquad (33)$$

Adjusted $R^2 = 0.86$ $h = 2.02$

$$PENIEMI_t = \underset{(-0.019)}{-4.6814} + \underset{(3.792)}{0.6835}\ PENIEMI_{t-1} + \underset{(1.440)}{0.0192}\ AKEMI_t + E_t \qquad (34)$$

Adjusted $R^2 = 0.77$ $h = 0.40$,

where AKEMC is the number of people employed in commercial establishments in Alaska, calculated as total employment less employment in mining, construction, manufacturing, and government; AKEMI is the number of people employed in mining, construction, and manufacturing in Alaska; DPIPE is a pipeline construction dummy (DPIPE= 1 in 1974, 2 in 1975, 3 in 1976, and 0 in all other years); and E is the residual term.

Equations (1) through (34) provide the specification of the MACRO submodel. The following section describes the equations estimated to capture electricity demand in the Railbelt.

4.3 LOAD SUBMODEL

The LOAD submodel includes equations for forecasting electricity sales, average price, and customers for the residential, commercial, and industrial sectors. The submodel's equations were estimated using annual, cross-sectional, time series data from 1965 to 1982 for utilities in the Railbelt, aggregated into the three regions identified in the MACRO submodel. Anchorage includes operating statistics from Anchorage Municipal Light and Power Department, Chugach Electric Association, and Matanuska Electric Association, Inc. Fairbanks includes data from Fairbanks Municipal Utilities System and Golden Valley Electric Association. The Peninsula includes Homer Electric Association, Inc. and Seward Electric System.

The estimated equations are log-linear. The three equations for each sector were estimated using two-stage least squares. Each demand equation uses a Koyck distributed-lag specification, allowing for the estimation of both short- and long-run demand elasticities.

4.3.1 Residential Electricity Demand

The average annual use of electricity per residential customer (RUSE), the average real price of electricity in the residential sector (RPER), and the number of residential customers (RCUST) are endogenous in the estimation of equations for the residential sector. These variables are interdependent: average use is a function of the number of customers and the total number of megawatt-hours sold; average price affects average usage in a traditional demand-curve relationship; and average usage affects average price because of the manner in which rate schedules are determined--marginal price is less than average price. Since most electricity rates are developed using a demand charge and an energy charge--or, alternatively, declining block rates--average price varies with the quantity of electricity consumed (the higher the quantity consumed, the lower the average price). As in a model for the demand for any commodity, the quantity of electricity consumed is expected to vary with price (the higher the price, the less consumed). Because of this simultaneous relationship between price and quantity, usage, price, and customers should be endogenous.

The pooled cross-section, time series approach uses data on the three regions (i=Anchorage, Fairbanks, and Peninsula) for the years 1965 to 1982. The following equations were estimated using two-stage least squares (t-statistics in parentheses):

$$\ln RUSE_{it} = \underset{(-2.299)}{-1.2326} + \underset{(20.913)}{0.6754} \ln RUSE_{i,t-1} - \underset{(-8.138)}{0.2491} \ln RPER_{it} +$$

$$\underset{(3.054)}{0.1027} \ln RPCINC_{it} + \underset{(2.541)}{0.1554} \ln HHZ_{it} +$$

$$\underset{(5.342)}{0.2453} \ln HDD_{it} + \underset{(0.162)}{0.0061} \ln RPGR_{it} - \underset{(-9.110)}{0.1256} DANCH_{it}$$

$$\underset{(-2.937)}{-0.0673} DFAIR_{it} + E_{it} \qquad (35)$$

Adjusted $R^2 = 0.99$

$$\ln RPER_{it} = \underset{(6.551)}{2.1227} + \underset{(10.421)}{0.6860} \ln RATOC_{it} - \underset{(-5.001)}{0.3075} \ln RUSE_{it}$$

$$\underset{(-3.726)}{-0.1659} \ln DENSITY_{it} + \underset{(2.495)}{0.1509} DANCH_{it} +$$

$$\underset{(3.079)}{0.1352} DFAIR_{it} + E_{it} \qquad (36)$$

Adjusted $R^2 = 0.98$

$$\ln RCUST_{it} = \underset{(13.747)}{3.7294} + \underset{(14.112)}{1.5709} \ln POP_{it} + \underset{(4.108)}{0.1226} DT_{it}$$

$$-\underset{(-4.979)}{1.208} DANCH_{it} - \underset{(-5.595)}{0.6431} DFAIR_{it} + E_{it} \qquad (37)$$

$$\text{Adjusted } R^2 = 0.99$$

where RPCINC is real average per capita income; HHZ is an estimation of average household size; HDD is the estimated value of heating degree-days for the region; RPGR is the real price of natural gas in the residential sector (available only at the state level, not the substate level); DANCH is a dummy variable for the Anchorage region (DANCH=1 for observations from Anchorage, DANCH=0 otherwise); DFAIR is a dummy variable for the Fairbanks region (DFAIR=1 for observations from Fairbanks, DFAIR=0 otherwise); RATOC represents the real average operating cost per megawatt-hour; DENSITY is the average number of customers per mile of distribution line; POP is the population of the region; DT is a time trend dummy variable (DT= 1 in 1965, 2 in 1966, ... 18 in 1982); and E is the residual term.

All of the coefficients in the three equations have the anticipated sign, and all are significant at the 0.05 level with the exception of the coefficient on the real price of natural gas in the residential sector. The variable RPGR is a state-level average, and does not capture the cross-sectional differences in the price of an alternative fuel. If substate data on alternative energy prices in the residential sector were available, the value of an alternative fuel price coefficient might be significant.

The short-run, own-price elasticity of demand for the Railbelt region is -0.25, indicating that in the short run a 10 percent increase in the real average residential price of electricity would result in a 2.5 percent decline in average usage, other variables constant. The long-run, own-price elasticity is -0.77, indicating that after households have had a chance to make adjustments in their stock of appliances, a 10 percent increase in the real average residential price of electricity would result in a 7.7 percent decline in average use.

4.3.2 Commercial/Industrial (Small) Sales

Sales to the commercial/industrial (small) sector (CSALE), real average price of electricity to these customers (RPEC), and the number of commercial/industrial (small) customers (CCUST) are endogenous in the following three-equation system (t-statistics in parentheses):

$$\ln CSALE_{it} = \underset{(-1.566)}{-1.0952} + \underset{(15.312)}{0.7758} \ln CSALE_{i,t-1} - \underset{(-3.765)}{0.2312} \ln RPEC_{it} +$$

$$\underset{(1.587)}{0.0943} \ln CCUST_{it} + \underset{(3.267)}{0.1109} \ln RPCINC_{it} +$$

$$\underset{(4.912)}{0.2792} \ln HDD_{it} + \underset{(6.206)}{0.2359} DANCH_{it} +$$

$$\underset{(1.600)}{0.0798} DFAIR_{it} + E_{it} \qquad (38)$$

Adjusted $R^2 = 0.99$

$$\ln RPEC_{it} = \underset{(5.350)}{1.508} + \underset{(11.858)}{0.5091} \ln RATOC_{it} - \underset{(-5.812)}{0.2553} \ln CUSE_{it}$$

$$\underset{(-15.101)}{-0.3287} \ln DENSITY_{it} + \underset{(8.699)}{0.2543} DANCH_{it} +$$

$$\underset{(10.291)}{0.3726} DFAIR_{it} + E_{it} \qquad (39)$$

Adjusted $R^2 = 0.99$

$$\ln CCUST_{it} = \underset{(4.350)}{0.2886} + \underset{(33.902)}{0.864} \ln CCUST_{i,t-1} + \underset{(5.494)}{0.0947} \ln EMC_{it}$$

$$-\underset{(-2.230)}{0.0386} DANCH_{it} - \underset{(-5.058)}{0.0591} DFAIR_{it} + E_{it} \qquad (40)$$

$$\text{Adjusted } R^2 = 0.99 \text{ ,}$$

where RPCINC is real average per capita income; HDD is heating degree-days; DANCH is a dummy variable for Anchorage (DANCH=1 for an observation from Anchorage, DANCH=0 otherwise); DFAIR is a dummy variable for Fairbanks (DFAIR=1 for an observation from Fairbanks, DFAIR=0 otherwise); RATOC is the value of real average operating costs per megawatt-hour; DENSITY is the average number of customers per mile of distribution line; EMC is the number of employees in the commercial sector; and E is the residual term.

The short-run, own-price elasticity in the commercial sector is -0.23 which is almost the same as the residential sector. However, the long-run elasticity is -1.03, indicating that commercial establishments are more willing to make changes in the long run to cut back usage in response to price changes.

4.3.3 Commercial/Industrial (Large) Sales

Sales to the commercial/industrial (large) sector (ISALE), real average price of electricity to these customers (RPEI), and the number of commercial/industrial (large) customers (ICUST) are endogenous in the following three equation system (t-statistics in parentheses):

$$\ln ISALE_{it} = \underset{(8.894)}{1.7181} + \underset{(55.477)}{0.8524} \ln ISALE_{i,t-1} - \underset{(-0.813)}{0.0302} \ln RPEI_{it} +$$

$$\underset{(8.493)}{0.1298} \ln EMI_{it} - \underset{(-5.838)}{0.1643} DANCH_{it}$$

$$\underset{(-2.499)}{-0.0699} DFAIR_{it} + E_{it} \tag{41}$$

Adjusted $R^2 = 0.99$

$$\ln RPEI_{it} = \underset{(-2.710)}{-0.3816} + \underset{(28.937)}{0.9700} \ln RATOC_{it} + \underset{(16.951)}{0.4354} DANCH_{it} +$$

$$\underset{(13.023)}{0.2737} DFAIR_{it} + E_{it} \tag{42}$$

Adjusted $R^2 = 0.97$

$$\ln ICUST_{it} = \underset{(-0.916)}{-2.8752} + \underset{(8.214)}{0.5128} \ln ICUST_{i,t-1} + \underset{(1.227)}{0.5958} \ln RGNP_{it} +$$

$$\underset{(4.296)}{0.3267} DT_{it} + \underset{(3.111)}{0.0761} DPIPE_{it} + \underset{(7.275)}{0.6818} DANCH_{it} +$$

$$\underset{(4.523)}{0.2193} DFAIR_{it} + E_{it} \tag{43}$$

Adjusted $R^2 = 0.98$,

where EMI is the number of employees in mining, construction, and manufacturing; DANCH is a dummy variable for Anchorage (DANCH=1 when the observation is for Anachorage, DANCH=0 otherwise); DFAIR is a dummy variable for Fairbanks (DFAIR=1 when the observation is for Fairbanks, DFAIR=0 otherwise); RATOC is the real value of average operating costs per megawatt-hour; RGNP is the real value of U.S. Gross National Product; DT is a time dummy variable (DT= 1 in 1965, 2 in 1966, ... 18 in 1982); DPIPE is a dummy variable for construction of the pipeline (DPIPE= 1 in 1974, 2 in 1975, 3 in 1976, and 0 in all other years); and E is the residual term.

The industrial sector is difficult to model using the relationships between usage and average price because there are special pricing arrangements (such as interruptible rates) that make average price a poor proxy for the firm's decision price. The results above indicate that industrial sales have been relatively insensitive to changes in real average prices: the short-run, own-price elasticity is -0.03 and the long-run, own-price elasticity is -0.20. The major impact on sales has been the increase in the number of people employed in mining, construction, and manufacturing.

4.3.4 Preliminary Average Cost Estimation

The demand system described above has been formulated to interact with a cost model which includes the cost of each category of capacity. To provide an initial iteration, a simple relationship between average cost of generating electricity and the price of oil has been estimated. This specification is reasonable because oil and gas are used in the generation of approximately 75 percent of the electricity of the utilities in Alaska and the correlation between oil and gas prices is more than 0.9.

$$\ln ANCHRATOC_t = \underset{(-76.981)}{-4.4886} + \underset{(3.924)}{0.2847} \ln OILPRICE_t - \underset{(-8.019)}{0.0595} DT_t + \underset{(3.149)}{0.9119} E_{t-1} + E_t \qquad (44)$$

Adjusted $R^2 = 0.90$ Durbin-Watson = 1.90

$$\ln FAIRRATOC_t = \underset{(-44.365)}{-4.1244} + \underset{(4.007)}{0.4695} \ln OILPRICE_t - \underset{(-4.366)}{0.0524} DT_t + \underset{(2.610)}{0.7184} E_{t-1} + E_t \quad (45)$$

Adjusted $R^2 = 0.61$ Durbin-Watson = 1.97

$$\ln PENIRATOC_t = \underset{(-64.480)}{-3.7478} + \underset{(2.745)}{0.1959} \ln OILPRICE_t - \underset{(-9.712)}{0.0709} DT_t + \underset{(2.977)}{0.8557} E_{t-1} + E_t \quad (46)$$

Adjusted $R^2 = 0.95$ Durbin-Watson = 1.91 ,

where ANCHRATOC, FAIRRATOC, and PENIRATOC are the real average operating costs of the Anchorage, Fairbanks, and Peninsula utilities, respectively; OILPRICE is the real U.S. refiners' acquisition price for crude oil (composite of domestic and foreign); DT is a time trend dummy variable (DT= 1 in 1965, 2 in 1966, ... 18 in 1982); and E is the residual term.

This section concludes the description of the model estimation. The next chapter summarizes the assumptions used in developing three scenarios for examining future electricity load growth in Alaska's Railbelt.

5. EXOGENOUS INPUT ASSUMPTIONS

5.1 INTRODUCTION

In examining load growth in the Railbelt, the Alaska Power Authority (APA) developed a number of scenarios based on different projections of the world price of oil. There are three major reasons why this variable was chosen for developing a range of forecasts of electricity demand. First, revenues for the state of Alaska are largley dependent on severance taxes and royalty payments made by petroleum companies in the state. The amount that the state collects from these companies is in turn dependent on the price of oil and the amount of oil produced in Alaska. Second, the price of oil affects the price of electricity because oil and natural gas are the major fuels used in the generation of electricity in Alaska. Finally, to the extent that electricity and oil are substitutes in some circumstances, changes in their relative prices can have an impact on the demand for electricity. Since ARELM was developed to provide a perspective on the models and assumptions employed by APA, three scenarios based on alternative projections of world oil prices were developed. The following discussion describes the input assumptions for these scenarios.

5.2 NATIONAL AND STATE INPUTS

The exogenous inputs of national- and state-level variables not dealing with oil prices or production costs were published by Data Resources, Inc. (DRI) and the Alaska Department of Revenue (ADOR). The value of these input growth rates remained the same for the three oil price scenarios examined here.

The DRI forecasts are based on the output of an econometric simulation model of national activity. DRI projects economic growth only to 1995. Therefore, it was necessary to extend DRI's growth rates to 2022 for this analysis. The simplifying assumption used was that the DRI growth rates from 1990 to 1995 for the exogenous variables would remain constant until 2022. These growth rates are shown in Table 5.1.

The DRI forecast chosen for this analysis is the TRENDLONG projection published in the summer of 1984.[1] The projections reflect the assumption that there is no major shock to the economy (such as an oil embargo) over the next 11 years and that actual and potential output are approximately equal over the period. Therefore, a balanced growth path is projected, with inflation rates averaging between 5.7 and 6.2 percent. The growth in population is consistent with the Bureau of the Census' middle-growth projections, representing average annual growth of slightly less than 1.0 percent. TRENDLONG reflects a continuation of high federal deficits, ranging between $145 and $209 billion annually over the projection period. The unemployment rate is forecasted to average 7.3 percent. This scenario leaves an average annual growth in real GNP of 3.1 percent between 1984 and 1995 .

The Alaska Department of Revenues (ADOR) has published forecasts of inflation in Alaska until 2001. These forecasts are similar to DRI's forecasts of changes in the U.S. price level. To extend the price level projections out until 2022, it was assumed that inflation would increase at an average annual rate of 6.0 percent per annum. This is the same average rate of inflation projected by DRI between 1984 and 1995 for the

[1]Data Resources, Inc., U.S. Long-Term Review, Summer 1984, McGraw Hill, New York, 1984.

Table 5.1
ARELM Input Assumptions
Historical and Projected
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
U.S. Population	1.0	1.0	0.9	0.8	0.8	0.8
Real U.S. GNP	2.8	3.8	3.2	2.6	2.6	2.7
U.S. Unemployment Rate	4.6	-7.8	-1.6	-0.3	-0.3	-1.0
Real U.S. Dividends, Interest and Rents	4.3	3.5	3.8	0.8	0.8	1.4
Real U.S. Other Labor Income	6.4	6.9	6.8	2.8	2.8	3.6
Real U.S. Transfer Payments	6.7	1.6	3.9	1.8	1.8	2.1
Real U.S. Proprietors Income, Nonfarm	-2.5	10.8	2.1	-0.7	-0.7	0.5
Real U.S. Personal Income	1.6	2.7	1.3	1.3	1.3	1.4
Real Wages in U.S. Mining	1.1	1.7	1.7	1.7	1.7	1.7
Employment in U.S. Manufacturing	0.3	2.5	0.7	0.1	0.1	0.4
Real Wages in U.S. Manufacturing	0.4	2.4	2.4	2.4	2.4	2.4
Alaska Price Deflation	6.1	4.1	5.9	6.4	6.0	5.9
Real Alaska Residential Natural Gas Price	-4.1	3.0	1.6	3.0	3.0	2.8

United States in the steady growth path forecasted in TRENDLONG. It is also close to the 6.1 percent historical growth in prices in Alaska between 1965 and 1982.

5.3 OIL PRICE AND PRODUCTION PROJECTIONS

Projections of world oil prices and Alaskan oil production were developed by Oak Ridge National Laboratory for three scenarios: Low, Mid, and High.[2] Table 5.2 provides a summary of these growth rates.

Table 5.2
ORNL Oil Price/Production Scenarios
1982-2022
Average Annual Growth Rates

(In Percentages)

Years	World Price of Oil			Alaskan Oil Production		
	Low	Mid	High	Low	Mid	High
1982-1985	-16.53	7.51	0.03	-1.95	0.27	1.90
1985-1990	0.00	0.00	0.00	0.83	0.78	0.74
1990-1995	1.79	2.00	2.12	-8.55	-7.85	-7.40
1995-2000	1.78	2.00	2.12	-12.08	-10.49	-9.54
2000-2005	0.86	2.00	2.63	-10.79	-7.67	-6.27
2005-2010	0.60	2.00	2.68	-16.82	-8.65	-6.26
2010-2020	3.01	2.00	1.50	-22.92	-13.84	-5.35
2020-2022	2.83	1.99	1.54	-65.70	-2.15	-3.82

The forecasts of oil prices are based on projections of more than 35 models of world oil markets.[3] In general, the Mid Scenario is based

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[2]These assumptions are used in the MAP/RED scenarios documented in Federal Energy Regulatory Commission, Susitna Hydroelectric Project Final Environmental Impact Statement, Project No. 7114, 1985.

[3]T.R. Curlee, Future World Oil Prices: Modeling Methodologies and Summary of Forecasts, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/TM-9521, April 1985.

on the assumption that there are no shocks in the oil market such as production curtailments because of war in the Middle East. Oil prices are projected to be stable between 1985 and 1990. Curlee points out that there are several reasons for this stability.[4] First, adjustments to the price increases of the 1970s are still taking place in a number of countries. The process of switching away from oil will contribute to decreasing growth in world demand. Second, the world economies are projected to grow on a steady--but relatively low--path, again dampening the demand for oil. Third, there is a substantial amount of excess capacity held by the major OPEC producers of oil. The combination of low demand and high supply indicates that there will not be an upward push on prices, at least until 1990. However, the decade of the 1990s is expected to be characterized by price increases because of resource depletion. The general consensus is that these price increases will be approximately 2.0 percent per year.

The Low and High oil price projections were developed to provide a range around the base-case, Mid scenario. Using the estimated distribution of the forecasts reported by the International Energy Workshop, a standard deviation from these values was subtracted (added) from the Mid case to produce the Low (High) scenarios.[5]

The growth in Alaskan oil production used in the simulations is consistent with the world oil price projections. The Mid case projec-

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[4]Ibid.

[5]Ibid., p.72.

tions are similar to those developed by ADOR.[6] The range of values for the Low and High scenarios were estimated on the basis of a simple relationship between Alaskan oil production, world oil prices, and anticipated depletion rates.

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[6]State of Alaska, Department of Revenues, Office of the Commissioner, Petroleum Production Revenue Forecasts, Quarterly Report, December 1984 (November 30, 1984).

6. FORECASTS TO THE YEAR 2022

6.1 ARELM-MACRO PROJECTIONS

ARELM-MACRO was executed using the input assumptions described in the previous chapter. Table 6.1 provides a summary of the forecasts for the key variables that are used as inputs in ARELM-LOAD: population, per capita income, and commercial and industrial employment. More detail on these simulations is provided in Appendix A, Tables A.1 through A.6.

There are two important observations on the forecasts in Table 6.1. The first is that the projected growth rates for the three scenarios are lower than actual growth between 1965 and 1982. All of the scenarios are based on much lower future growth rates in world oil prices and Alaskan oil production than have been experienced in the recent past. Between 1965 and 1982, the average annual increase in real world oil prices was 7.6 percent, and Alaskan oil output increased at an average annual rate of 26.7 percent per year. These historical trends are projected to be greatly changed. For example, in the High case, oil prices are projected to increase at an average annual rate of 1.6 percent between 1982 and 2022, while oil production in Alaska is projected to decline at an average rate of 5.0 percent per year.

The second observation is that there is very little difference in the forecasted values across scenarios. Although the projections of world oil prices are substantially different for the period 1982 to 1985 (-16.5 percent for the Low case, -7.5 percent for the Mid case, and 0.0 percent for the High case), their estimated growth rates for the entire forecast period are very similar (0.1 percent per year for the Low case,

Table 6.1
ARELM Forecasts of
Population, Per Capita Income, and Employment
By Region and Scenario
Average Annual Growth Rates

(In Percentages)

Case	Population	Per Capita Income	Commercial Employment	Industrial Employment
Historical, 1965-1982				
Anchorage	3.8	3.7	9.2	9.2
Fairbanks	2.0	3.7	6.4	5.9
Peninsula	5.8	2.9	10.6	15.5
Railbelt	3.6	3.6	8.7	9.1
Alaska	2.9	3.9	6.4*	6.2
MID, 1982-2022				
Anchorage	1.6	1.3	2.7	2.3
Fairbanks	1.1	1.5	1.9	2.1
Peninsula	1.9	1.1	2.7	1.7
Railbelt	1.6	1.3	2.6	2.2
Alaska	1.4	1.4	2.4*	1.6
LOW, 1982-2022				
Anchorage	1.6	1.2	2.7	2.3
Fairbanks	1.1	1.5	1.8	2.0
Peninsula	1.9	1.1	2.7	1.6
Railbelt	1.6	1.3	2.6	2.2
Alaska	1.4	1.3	2.4*	1.5
HIGH, 1982-2022				
Anchorage	1.7	1.3	2.8	2.4
Fairbanks	1.2	1.5	2.0	2.3
Peninsula	1.9	1.2	2.8	1.3
Railbelt	1.6	1.3	2.6	2.3
Alaska	1.5	1.4	2.4*	1.7

* Alaska Commercial Employment includes government.

1.0 percent for the Mid case, and 1.6 percent for the High case). Given this relatively narrow range in the assumed growth of oil prices, ARELM-MACRO simulates a narrow band of projections over the entire forecast period.

The patterns of relative growth within the Railbelt show that population grows the fastest in the Peninsula and per capita income grows the fastest in Fairbanks. Anchorage employment is expected to grow at a faster rate than the other two regions. Only in Fairbanks is industrial employment projected to grow faster than commercial.

6.2 ARELM-LOAD PROJECTION

Tables 6.2 through 6.4 summarize the growth rates derived from ARELM-LOAD in electricity sales, real average prices, and numbers of customers for the three consuming sectors by scenario. More detail on the forecasts is provided in Appendix A, Tables A.7 through A.15. As would be expected from the projections of population and macroeconomic activity in Table 6.1, the projected growth rates of electricity sales and customers are much lower than the historical rates. Since the number of customers is a function of population and employment--which change very little across scenarios--there is no variability in these growth rates. Real average prices do display some variability, because of the effect of different oil price projections on generation costs.

Table 6.5 summarizes the projections of total electricity sales in the Railbelt for the three scenarios. This same information is shown graphically in Figure 6.1. Forecasts are highest in the Low oil price case and lowest in High oil price case. This result reflects the net

Table 6.2
ARELM Load Forecasts
By Region and Consuming Sector
Average Annual Growth Rates

(In Percentages)

Case	Residential	Commercial	Industrial	Total
Historical, 1965-1982				
Anchorage	10.5	10.7	11.8	10.3
Fairbanks	9.5	8.2	13.3	10.0
Peninsula	17.5	12.4	13.3	15.7
MID, 1982-2022				
Anchorage	2.7	1.8	3.2	2.5
Fairbanks	1.9	2.8	2.5	2.4
Peninsula	3.2	0.9	2.9	2.8
LOW, 1982-2022				
Anchorage	2.9	2.0	3.2	2.7
Fairbanks	2.2	3.1	2.5	2.6
Peninsula	3.3	1.0	2.8	2.9
HIGH, 1982-2022				
Anchorage	2.6	1.7	3.1	2.4
Fairbanks	1.8	2.6	2.6	2.3
Peninsula	3.2	0.9	2.9	2.8

Table 6.3
ARELM Forecasts of Real Average Price
By Region and Consuming Sector
Average Annual Growth Rates

(In Percentages)

Case	Residential	Commercial	Industrial	Total
Historical, 1965-1982				
Anchorage	-2.4	-2.8	-2.7	-2.6
Fairbanks	-1.8	-2.7	-0.2	-1.9
Peninsula	-5.8	-4.8	-0.2	-5.0
MID, 1982-2022				
Anchorage	0.2	0.2	0.3	0.3
Fairbanks	0.3	0.0	0.5	0.3
Peninsula	0.1	0.0	0.2	0.1
LOW, 1982-2022				
Anchorage	0.0	0.1	0.0	0.1
Fairbanks	0.0	-0.2	0.1	-0.1
Peninsula	0.0	-0.1	0.0	0.0
HIGH, 1982-2022				
Anchorage	0.4	0.4	0.5	0.4
Fairbanks	0.5	0.2	0.7	0.5
Peninsula	0.2	0.1	0.3	0.2

Table 6.4
ARELM Forecasts of the Number of Customers
By Region and Consuming Sector
Average Annual Growth Rates

(In Percentages)

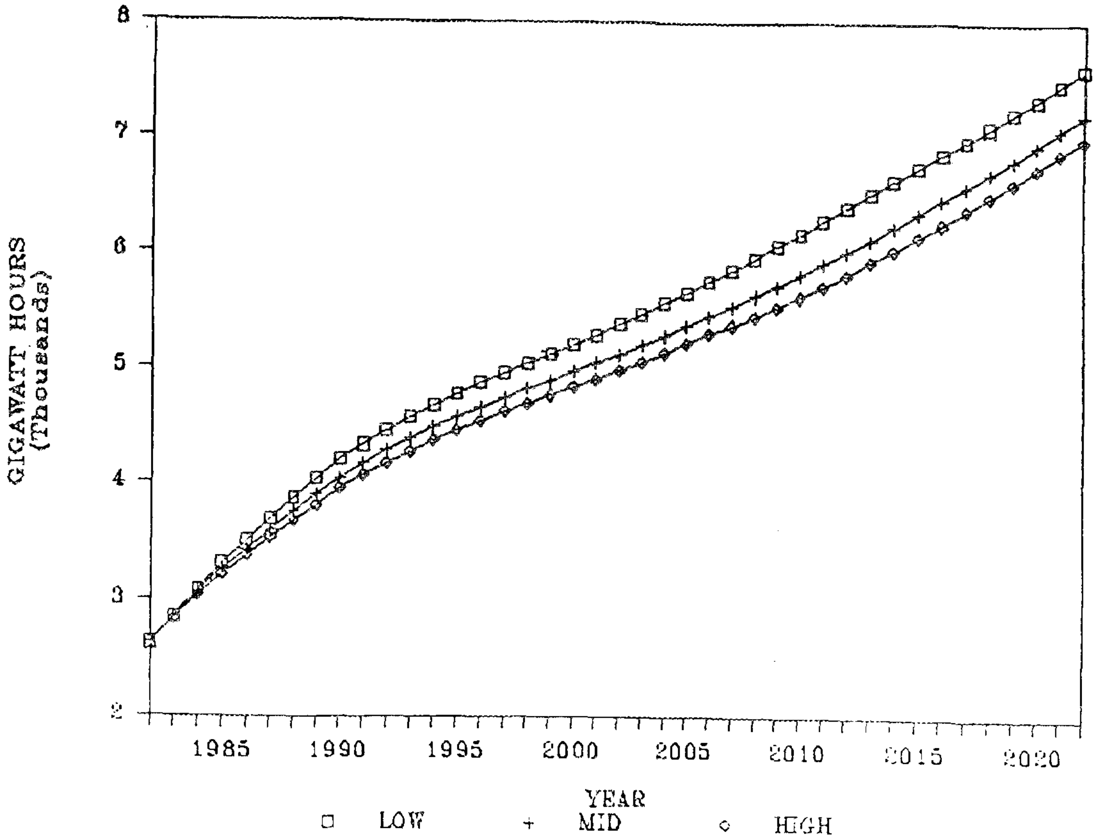
Case	Residential	Commercial	Industrial	Total
Historical, 1965-1982				
Anchorage	6.7	5.9	10.3	6.7
Fairbanks	5.7	5.0	10.3	5.6
Peninsula	10.5	7.6	7.6	9.9
MID, 1982-2022				
Anchorage	3.0	2.3	5.5	2.9
Fairbanks	2.2	2.0	5.4	2.2
Peninsula	3.3	0.6	5.3	3.1
LOW, 1982-2022				
Anchorage	3.0	2.3	5.5	2.9
Fairbanks	2.2	2.0	5.4	2.2
Peninsula	3.3	0.6	5.3	3.1
HIGH, 1982-2022				
Anchorage	3.0	2.3	5.5	2.9
Fairbanks	2.2	2.1	5.4	2.2
Peninsula	3.3	0.6	5.3	3.1

Table 6.5
Summary of ARELM Forecasts of Electricity Sales
By Scenario
1982-2022

(In Gigawatt-Hours)

Year	MID	LOW	HIGH
1982	2,625	2,625	2,625
1985	3,263	3,319	3,220
1990	4,050	4,201	3,956
1995	4,579	4,775	4,460
2000	4,970	5,207	4,835
2005	5,369	5,656	5,216
2010	5,812	6,173	5,628
2015	6,344	6,744	6,144
2020	6,946	7,350	6,746
2022	7,211	7,613	7,003

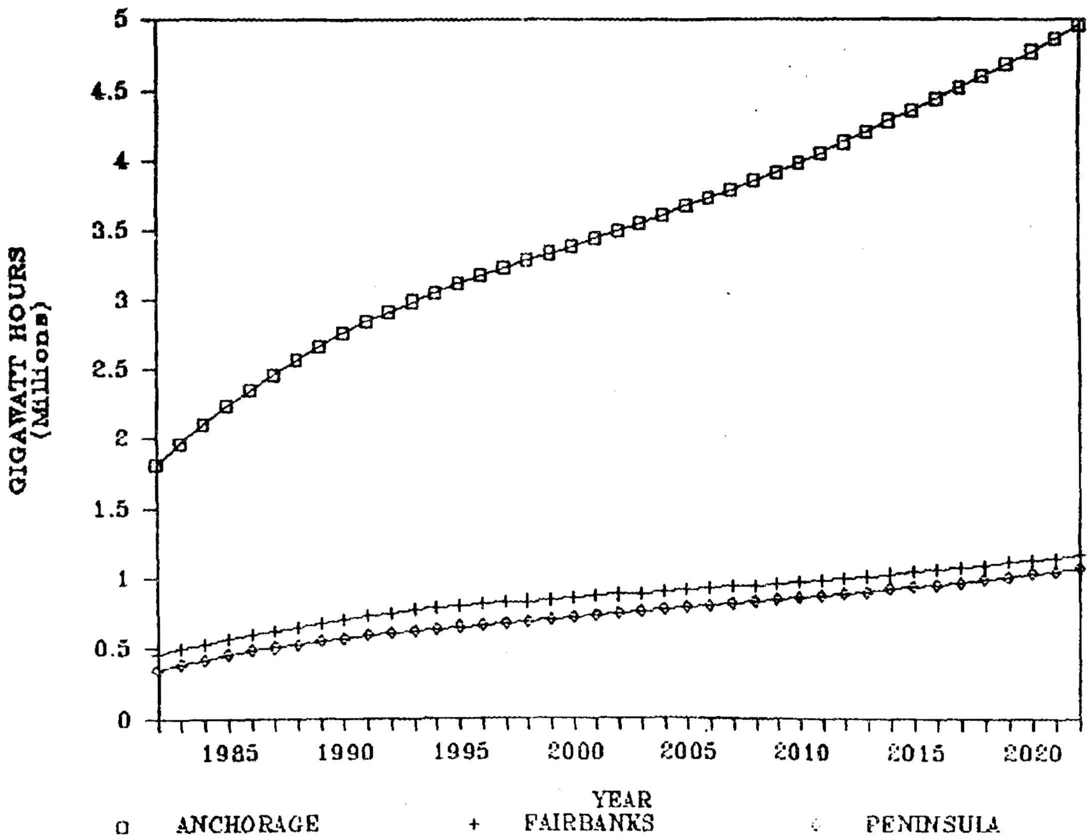
Figure 6.1
ARELM Forecasts of Electricity Sales
Three World Oil Price Scenarios



effect of conflicting impacts of oil price changes. As oil prices increase, income increases in Alaska. In these simulations, however, there was almost no differential income effect. In addition, increasing oil prices produce increases in the cost of generation. As discussed in Chapter 2, 75 percent of net electricity generated in Alaska consisted of oil- and gas-fired units in 1983. Since the income elasticity with respect to electricity sales is positive but the price elasticity is negative, the net result of an oil price change depends on the relative size of these impacts. In the three scenarios presented here, relative increases in electricity prices in response to changing oil prices dominate, producing higher forecasts in the Low oil price case. Total sales are projected to grow at an average annual rate of between 2.5 percent (High case) and 2.7 percent (Low) case in the period from 1982 to 2022.

Figure 6.2 presents a breakdown of the sales projections for the Mid world oil price case for the three regions of the Railbelt. The growth rates for the three regions are similar (2.5 percent for Anchorage, 2.4 percent for Fairbanks, and 2.8 percent for Peninsula), and the share of Anchorage sales in the Railbelt remains relatively constant over the forecast period (69.1 percent in 1982 and 68.8 percent in 2022.

Figure 6.2
ARELM Forecasts of Electricity Sales
Mid Price Case
By Region



7. CONCLUSION

This report has described the estimation of an econometric simulation model of income and electricity demand for Alaska's Railbelt. The motivation behind development of ARELM was to provide an independent modeling tool. It was to be used as an aid in interpreting the results of models applied by the Alaska Power Authority (APA) and the Federal Energy Regulatory Commission (FERC) in the need for power assessments for the Susitna Hydroelectric Project.

There were two major issues that ARELM was to address: (1) the sensitivity of the Alaskan economy to projected slower growth in oil prices and (2) a comparison of the forecasts of ARELM with the MAP/RED framework. Each issue will be discussed in turn.

7.1 INSENSITIVITY TO OIL PRICE SCENARIOS

As in MAP, ARELM-MACRO shows little difference in projected per capita incomes across the world oil price scenarios. This relative insensitivity is shown by the three simulations discussed in the previous chapter, despite the inclusion of the world oil price and Alaskan oil output as variables affecting employment in four sectors--mining, construction, manufacturing, and government.

There a number of possible explanations why ARELM shows little variability across the scenarios. One is that projected future growth in oil prices and production is dramatically different from historical growth in these two variables. If the relationship between Alaskan employment and world oil markets is undergoing a structural change, then the coefficients estimated using historical data may be inappropriate for forecasting. With more years of data, it would be possible to verify this possibility.

A second possibility is that the Alaskan economy is much less dependent on what happens in the world oil market than what was hypothesized by APA and FERC when they chose oil price as the variable on which to perform the sensitivity analyses. Looking at the historical patterns of real income and employment growth in Alaska, there was unquestionably a rapid escalation in both series between 1974 and 1976 when the pipeline was under construction. However, real income and employment have continued to increase since 1979. There are a number of reasons why population and income may grow independently of the extraction of oil resources. For example, more people could decide to migrate to Alaska, viewing the state as the last frontier with a number of opportunities for development.

A third possibility is that the three oil price scenarios did not provide a large enough variation--especially in comaprison with the historical growth--for the model to pick up substantial differences. It may be that if the scenarios had a wider range of growth rates in oil prices, so would the projected values of income.

7.2 LEVELS OF THE FORECASTS

The second issue to be addressed by ARELM was whether or not the forecasts from MAP/RED were high or low in comparison with the results from a relatively simple econometric model. The ARELM forecasts of electricity sales in the Railbelt project annual average growth of 2.5 to 2.7 percent over the 1982 to 2022 period. Comparable APA forecasts ranged from 2.3 to 3.4 percent, while FERC's projections were between 2.3 and 2.4 percent.[1] Therefore, it appears as though there is not a substantial difference between the modeling results using ARELM and MAP/RED.

However, there is an additional step that should be considered in using the ARELM forecasts for investigation of the need for the Susitna Hydroelectric Project. This step is to consider the impact of Susitna on the distribution systems' cost of power. The cost projections in the forecasts reported here are based on: (1) a continuing use of oil and gas for electricity generation and (2) a relatively small growth in oil prices. If Susitna is expected to substantially change average operating costs, ARELM should be simulated with those cost projections.

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[1]These growth rates were calculated by extending the Alaska Power Authority's forecasts from 2010 to 2022 using the average annual growth for the period 2000-2010; Federal Energy Regulatory Commission, Draft Environmental Imapct Statement, May 1984, pp. A-8 to A-11.

APPENDIX A

ARELM SIMULATION RESULTS BY SCENARIO

1982-2022

Table A.1
ARELM-MACRO Endogenous State-Level Variables
Historical and Projected for the Mid World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
Population	2.9	2.8	1.7	1.3	1.3	1.4
Real Personal Income	6.9	3.0	3.6	2.0	2.8	2.8
Unemployment Rate	0.8	5.1	0.0	0.4	1.7	1.6
Employment	6.3	2.6	2.6	1.7	2.2	2.2
Mining Employment	13.1	0.6	1.9	-0.7	0.7	0.7
Mining Wages	2.6	3.5	3.2	3.0	2.6	2.8
Construction Employment	5.8	-1.5	0.8	0.9	1.7	1.2
Construction Wages	1.4	2.4	1.3	1.0	1.3	1.3
Manufacturing Employment	4.2	-2.5	3.4	2.2	2.8	2.4
Manufacturing Wages	-0.1	2.4	2.9	2.8	2.6	2.7
Trans/Comm/Util Employment	5.6	3.4	3.7	2.3	2.8	2.9
Trans/Comm/Util Wages	1.8	-0.4	0.7	0.4	0.4	0.4
Wholesale/Retail Trade Employment	8.1	3.9	3.3	2.1	2.2	2.4
Wholesale/Retail Trade Wages	-0.4	-1.3	-1.3	-1.5	-3.2	-2.6
FIR-Services Employment	9.4	4.0	2.8	2.2	2.5	2.6
FIR-Services Wages	1.4	-1.3	0.9	0.8	-0.6	-0.3
Government Employment	4.1	2.9	1.9	1.1	1.9	1.9
Government Wages	1.8	1.3	1.2	1.4	2.6	2.2
Real Dividends, Interest and Rents	10.2	5.1	5.3	0.9	0.9	1.7
Real Nonfarm Proprietors Income	1.2	7.3	3.3	1.9	1.5	2.2
Real Transfer Income	13.5	1.5	3.7	1.7	1.8	2.0
Real Other Labor Income	10.8	9.6	8.9	3.0	3.2	4.3
Real Per Capita Income	3.9	0.2	1.8	0.7	1.5	1.4

Table A.2
ARELM-MACRO Endogenous State-Level Variables
Historical and Projected for the Low World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
Population	2.9	2.7	1.7	1.3	1.3	1.4
Real Personal Income	6.9	2.6	3.6	2.0	2.8	2.8
Unemployment Rate	0.8	5.5	0.1	0.4	1.7	1.7
Employment	6.3	2.2	2.5	1.7	2.2	2.2
Mining Employment	13.1	-0.2	1.6	-0.8	0.7	0.6
Mining Wages	2.6	3.5	3.2	3.0	2.6	2.8
Construction Employment	5.8	-3.2	0.8	0.9	1.7	1.1
Construction Wages	1.4	1.6	1.3	0.9	1.3	1.2
Manufacturing Employment	4.2	-3.0	3.2	2.2	2.8	2.4
Manufacturing Wages	-0.1	2.3	2.9	2.8	2.6	2.7
Trans/Comm/Util Employment	5.6	3.1	3.7	2.3	2.8	2.9
Trans/Comm/Util Wages	1.8	-0.6	0.6	0.4	0.4	0.4
Wholesale/Retail Trade Employment	8.1	3.7	3.3	2.2	2.2	2.5
Wholesale/Retail Trade Wages	-0.4	-1.4	-1.4	-1.6	-3.2	-2.8
FIR-Services Employment	9.4	3.6	2.7	2.2	2.5	2.6
FIR-Services Wages	1.4	-1.7	0.6	0.7	-0.6	-0.5
Government Employment	4.1	2.6	2.0	1.1	1.9	1.9
Government Wages	1.8	1.3	1.2	1.4	2.6	2.2
Real Dividends, Interest and Rents	10.2	5.1	5.3	0.9	0.9	1.7
Real Nonfarm Proprietors Income	1.2	7.3	3.3	1.9	1.5	2.2
Real Transfer Income	13.5	1.5	3.7	1.7	1.8	2.0
Real Other Labor Income	10.8	9.6	8.9	3.0	3.2	4.3
Real Per Capita Income	3.9	-0.1	1.9	0.7	1.5	1.3

Table A.3
ARELM-MACRO Endogenous State-Level Variables
Historical and Projected for the High World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
Population	2.9	2.9	1.8	1.3	1.3	1.5
Real Personal Income	6.9	3.4	3.7	2.1	2.9	2.9
Unemployment Rate	0.8	4.6	0.0	0.4	1.7	1.6
Employment	6.3	3.0	2.7	1.7	2.2	2.3
Mining Employment	13.1	1.1	2.2	-0.6	0.7	0.8
Mining Wages	2.6	3.5	3.2	3.0	2.6	2.8
Construction Employment	5.8	0.0	0.9	1.0	1.7	1.4
Construction Wages	1.4	3.1	1.4	1.0	1.3	1.4
Manufacturing Employment	4.2	-2.1	3.5	2.2	2.3	2.4
Manufacturing Wages	-0.1	2.4	2.9	2.8	2.6	2.7
Trans/Comm/Util Employment	5.6	3.7	3.8	2.4	2.8	3.0
Trans/Comm/Util Wages	1.8	-0.3	0.7	0.4	0.4	0.4
Wholesale/Retail Trade Employment	8.1	4.1	3.3	2.2	2.2	2.5
Wholesale/Retail Trade Wages	-0.4	-1.2	-1.2	-1.4	-3.2	-2.4
FIR-Services Employment	9.4	4.4	2.9	2.2	2.5	2.6
FIR-Services Wages	1.4	-0.9	1.1	0.8	-0.6	-0.2
Government Employment	4.1	3.1	2.0	1.1	1.9	1.9
Government Wages	1.8	1.3	1.2	1.4	2.6	2.2
Real Dividends, Interest and Rents	10.2	5.1	5.3	0.9	0.9	1.7
Real Nonfarm Proprietors Income	1.2	7.3	3.3	1.9	1.5	2.2
Real Transfer Income	13.5	1.5	3.7	1.7	1.8	2.0
Real Other Labor Income	10.8	9.6	8.9	3.0	3.2	4.3
Real Per Capita Income	3.9	0.2	1.8	0.7	1.5	1.4

Table A.4
ARELM-MACRO Endogenous Railbelt Variables
Historical and Projected for the Mid World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
ANCHORAGE						
Population	3.8	3.4	2.0	1.5	1.4	1.6
Real Per Capita Income	3.7	0.2	1.7	0.7	1.4	1.3
Commercial Employment	9.2	4.3	3.3	2.1	2.5	2.7
Industrial Employment	9.2	2.6	2.8	1.8	2.3	2.3
FAIRBANKS						
Population	2.0	2.1	1.3	1.0	1.0	1.1
Real Per Capita Income	3.7	0.2	2.0	0.8	1.7	1.5
Commercial Employment	6.4	-0.8	2.3	1.3	2.2	1.9
Industrial Employment	5.9	1.0	2.2	1.5	2.4	2.1
PENINSULA						
Population	5.8	4.0	2.3	1.7	1.6	1.9
Real Per Capita Income	2.9	0.1	1.5	0.6	1.2	1.1
Commercial Employment	10.6	4.2	2.9	1.4	2.8	2.7
Industrial Employment	15.5	2.4	1.5	1.2	1.7	1.7
RAILBELT						
Population	3.6	3.2	1.9	1.4	1.4	1.6
Real Per Capita Income	3.6	0.1	1.7	0.7	1.4	1.3
Commercial Employment	8.7	3.5	3.1	2.0	2.5	2.6
Industrial Employment	9.1	2.4	2.6	1.7	2.3	2.2

Table A.5
ARELM-MACRO Endogenous Railbelt Variables
Historical and Projected for the Low World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
ANCHORAGE						
Population	3.8	3.3	2.0	1.5	1.4	1.6
Real Per Capita Income	3.7	-0.1	1.7	0.7	1.4	1.2
Commercial Employment	9.2	4.0	3.3	2.2	2.5	2.7
Industrial Employment	9.2	2.1	2.7	1.8	2.3	2.3
FAIRBANKS						
Population	2.0	2.1	1.3	1.0	1.0	1.1
Real Per Capita Income	3.7	-0.2	2.0	0.8	1.7	1.5
Commercial Employment	6.4	-1.9	2.2	1.2	2.2	1.3
Industrial Employment	5.9	-0.1	1.8	1.5	2.4	2.0
PENINSULA						
Population	5.8	3.8	2.3	1.7	1.6	1.9
Real Per Capita Income	2.9	-0.1	1.5	0.6	1.2	1.1
Commercial Employment	10.6	3.6	2.9	1.5	2.8	2.7
Industrial Employment	15.5	1.9	1.1	1.1	1.6	1.6
RAILBELT						
Population	3.6	3.1	1.9	1.4	1.4	1.6
Real Per Capita Income	3.6	-0.2	1.8	0.7	1.4	1.3
Commercial Employment	8.7	3.0	3.1	2.0	2.5	2.6
Industrial Employment	9.1	1.8	2.4	1.7	2.3	2.2

Table A.6
ARELM-MACRO Endogenous Railbelt Variables
Historical and Projected for the High World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
ANCHORAGE						
Population	3.8	3.4	2.1	1.5	1.4	1.7
Real Per Capita Income	3.7	0.5	1.8	0.7	1.4	1.3
Commercial Employment	9.2	4.6	3.3	2.2	2.5	2.8
Industrial Employment	9.2	3.1	2.8	1.8	2.3	2.4
FAIRBANKS						
Population	2.0	2.2	1.4	1.0	1.0	1.2
Real Per Capita Income	3.7	0.5	2.1	0.9	1.7	1.5
Commercial Employment	6.4	0.2	2.5	1.3	2.2	2.0
Industrial Employment	5.9	2.1	2.5	1.6	2.4	2.3
PENINSULA						
Population	5.8	4.1	2.4	1.7	1.6	1.9
Real Per Capita Income	2.9	0.4	1.6	0.7	1.2	1.2
Commercial Employment	10.6	4.7	3.1	1.5	2.8	2.8
Industrial Employment	15.5	2.8	1.8	1.3	1.7	1.8
RAILBELT						
Population	3.6	3.3	2.0	1.4	1.4	1.6
Real Per Capita Income	3.6	0.4	1.8	0.8	1.4	1.3
Commercial Employment	8.7	3.9	3.2	2.0	2.5	2.6
Industrial Employment	9.1	2.9	2.7	1.7	2.3	2.3

Table A.7
ARELM-LOAD Endogenous Anchorage Variables
Historical and Projected for the Mid World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	10.5	7.2	4.1	2.3	2.1	2.7
Real Avg. Price	-2.4	-1.5	-0.1	0.5	0.5	0.2
Customers	6.7	6.1	3.7	2.8	2.5	3.0
COMMERCIAL						
Sales	10.7	5.5	4.0	2.1	1.0	1.8
Real Avg. Price	-2.8	-1.5	-0.2	0.4	0.5	0.2
Customers	5.9	4.0	3.3	2.5	1.8	2.3
INDUSTRIAL						
Sales	11.8	8.3	5.6	3.5	2.0	3.2
Real Avg. Price	-2.7	-2.1	0.0	0.5	0.5	0.3
Customers	10.3	8.5	7.2	5.8	4.8	5.5
TOTAL						
Sales	10.3	6.7	4.3	2.4	1.7	2.5
Real Avg. Price	-2.6	-1.6	-0.1	0.4	0.5	0.3
Customers	6.7	5.9	3.7	2.8	2.5	2.9
OPERATING COSTS						
Real Avg. Cost	-3.5	-2.2	0.0	0.6	0.6	0.3

Table A.8
AREL M-LOAD Endogenous Anchorage Variables
Historical and Projected for the Low World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	10.5	7.9	4.6	2.5	2.2	2.9
Real Avg. Price	-2.4	-3.4	-0.2	0.4	0.4	0.0
Customers	6.7	5.9	3.7	2.8	2.5	3.0
COMMERCIAL						
Sales	10.7	6.2	4.5	2.3	1.1	2.0
Real Avg. Price	-2.8	-3.1	-0.3	0.3	0.5	0.1
Customers	5.9	3.9	3.3	2.5	1.8	2.3
INDUSTRIAL						
Sales	11.8	8.3	5.6	3.5	2.0	3.2
Real Avg. Price	-2.7	-4.9	0.0	0.5	0.5	0.0
Customers	10.3	8.5	7.2	5.8	4.8	5.5
TOTAL						
Sales	10.3	7.3	4.7	2.6	1.8	2.7
Real Avg. Price	-2.6	-3.5	-0.2	0.3	0.5	0.1
Customers	6.7	5.7	3.7	2.8	2.5	2.9
OPERATING COSTS						
Real Avg. Cost	-3.5	-5.0	0.0	0.5	0.5	0.0

Table A.9
ARELM-LOAD Endogenous Anchorage Variables
Historical and Projected for the High World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	10.5	6.5	3.8	2.2	2.0	2.6
Real Avg. Price	-2.4	-0.1	0.0	0.5	0.5	0.4
Customers	6.7	6.1	3.9	2.8	2.5	3.0
COMMERCIAL						
Sales	10.7	5.1	3.7	2.0	1.0	1.7
Real Avg. Price	-2.8	-0.3	-0.1	0.4	0.5	0.4
Customers	5.9	4.1	3.4	2.5	1.8	2.3
INDUSTRIAL						
Sales	11.3	8.3	5.6	3.5	2.0	3.1
Real Avg. Price	-2.7	0.0	0.0	0.6	0.5	0.5
Customers	10.3	8.5	7.2	5.8	4.8	5.5
TOTAL						
Sales	10.3	6.2	4.1	2.4	1.7	2.4
Real Avg. Price	-2.6	-0.1	-0.1	0.5	0.5	0.4
Customers	6.7	5.9	3.8	2.8	2.5	2.9
OPERATING COSTS						
Real Avg. Cost	-3.5	0.0	0.0	0.6	0.5	0.5

Table A.10
ARELM-LOAD Endogenous Fairbanks Variables
Historical and Projected for the Mid World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	9.5	4.7	3.1	1.6	1.5	1.9
Real Avg. Price	-1.8	-2.3	-0.1	0.6	0.7	0.3
Customers	5.7	4.0	2.6	2.0	1.9	2.2
COMMERCIAL						
Sales	8.2	12.4	7.0	3.2	1.0	2.8
Real Avg. Price	-2.7	-3.6	-0.9	0.2	0.6	0.0
Customers	5.0	4.7	3.1	2.1	1.5	2.0
INDUSTRIAL						
Sales	13.3	5.6	3.9	2.5	1.9	2.5
Real Avg. Price	-0.2	-3.5	0.0	0.9	0.9	0.5
Customers	10.3	7.8	7.1	5.8	4.7	5.4
TOTAL						
Sales	10.0	7.3	4.6	2.4	1.4	2.4
Real Avg. Price	-1.9	-3.2	-0.5	0.5	0.8	0.3
Customers	5.6	4.1	2.7	2.1	1.9	2.2
OPERATING COSTS						
Real Avg. Cost	-1.6	-3.6	0.0	0.9	0.9	0.5

Table A.11
ARELM-LOAD Endogenous Fairbanks Variables
Historical and Projected for the Low World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	9.5	6.2	3.9	1.8	1.6	2.2
Real Avg. Price	-1.8	-5.4	-0.3	0.5	0.6	0.0
Customers	5.7	4.0	2.6	2.0	2.0	2.2
COMMERCIAL						
Sales	8.2	13.5	7.9	3.5	1.0	3.1
Real Avg. Price	-2.7	-6.2	-1.2	0.0	0.6	-0.2
Customers	5.0	4.5	2.9	2.0	1.5	2.0
INDUSTRIAL						
Sales	13.3	5.6	3.7	2.4	1.9	2.5
Real Avg. Price	-0.2	-7.9	0.0	0.8	0.9	0.1
Customers	10.3	7.8	7.1	5.8	4.7	5.4
TOTAL						
Sales	10.0	8.2	5.2	2.6	1.5	2.6
Real Avg. Price	-1.9	-6.4	-0.6	0.4	0.6	-0.1
Customers	5.6	4.1	2.7	2.1	1.9	2.2
OPERATING COSTS						
Real Avg. Cost	-1.6	-8.1	0.0	0.8	0.9	0.1

Table A.12
ARELM-LOAD Endogenous Fairbanks Variables
Historical and Projected for the High World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	9.5	3.8	2.6	1.5	1.5	1.8
Real Avg. Price	-1.8	0.1	0.0	0.7	0.8	0.5
Customers	5.7	4.1	2.7	2.0	1.9	2.2
COMMERCIAL						
Sales	8.2	11.6	6.4	3.0	0.9	2.6
Real Avg. Price	-2.7	-1.6	-0.7	0.3	0.6	0.2
Customers	5.0	4.9	3.4	2.2	1.6	2.1
INDUSTRIAL						
Sales	13.3	5.7	4.0	2.6	1.9	2.6
Real Avg. Price	-0.2	0.0	0.0	1.0	1.0	0.7
Customers	10.3	7.8	7.1	5.8	4.7	5.4
TOTAL						
Sales	10.0	6.6	4.3	2.4	1.4	2.3
Real Avg. Price	-1.9	-0.6	-0.4	0.6	0.8	0.5
Customers	5.6	4.3	2.9	2.1	1.9	2.2
OPERATING COSTS						
Real Avg. Cost	-1.6	0.0	0.0	1.0	0.9	0.7

Table A.13
ARELM-LOAD Endogenous Peninsula Variables
Historical and Projected for the Mid World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	17.5	10.4	4.7	2.7	2.3	3.2
Real Avg. Price	-5.8	-1.7	-0.1	0.4	0.4	0.1
Customers	10.5	7.0	4.2	3.1	2.8	3.3
COMMERCIAL						
Sales	12.4	2.1	1.2	0.7	0.8	0.9
Real Avg. Price	-4.8	-2.3	-0.6	0.0	0.4	0.0
Customers	7.6	-3.8	-1.2	0.1	1.5	0.6
INDUSTRIAL						
Sales	13.3	9.5	5.7	3.2	1.6	2.9
Real Avg. Price	-0.2	-1.5	0.0	0.4	0.4	0.2
Customers	7.6	5.7	6.9	5.8	4.8	5.3
TOTAL						
Sales	15.7	8.9	4.8	2.7	1.9	2.8
Real Avg. Price	-5.0	-1.9	-0.4	0.2	0.4	0.1
Customers	9.9	5.8	3.7	2.9	2.8	3.1
OPERATING COSTS						
Real Avg. Cost	-5.1	-1.5	0.0	0.4	0.4	0.2

Table A.14
ARELM-LOAD Endogenous Peninsula Variables
Historical and Projected for the Low World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	17.5	10.8	5.1	2.7	2.3	3.3
Real Avg. Price	-5.8	-3.0	-0.2	0.3	0.4	0.0
Customers	10.5	6.7	4.2	3.1	2.8	3.3
COMMERCIAL						
Sales	12.4	2.5	1.5	0.8	0.8	1.0
Real Avg. Price	-4.8	-3.4	-0.7	0.0	0.4	-0.1
Customers	7.6	-3.9	-1.3	0.1	1.5	0.6
INDUSTRIAL						
Sales	13.3	9.5	5.6	3.0	1.6	2.8
Real Avg. Price	-0.2	-3.4	0.0	0.3	0.4	0.0
Customers	7.6	5.7	6.9	5.8	4.8	5.3
TOTAL						
Sales	15.7	9.1	4.9	2.7	1.9	2.9
Real Avg. Price	-5.0	-3.4	-0.4	0.2	0.4	0.0
Customers	9.9	5.5	3.7	2.9	2.8	3.1
OPERATING COSTS						
Real Avg. Cost	-5.1	-3.5	0.0	0.3	0.4	0.0

Table A.15
ARELM-LOAD Endogenous Peninsula Variables
Historical and Projected for the High World Oil Price Scenario
1965-2022
Average Annual Growth Rates

(In Percentages)

Sector/Variable	1965-1982	1982-1985	1985-1990	1990-1995	1995-2022	1982-2022
RESIDENTIAL						
Sales	17.5	10.1	4.6	2.6	2.3	3.2
Real Avg. Price	-5.8	-0.7	-0.1	0.4	0.4	0.2
Customers	10.5	7.2	4.3	3.1	2.8	3.3
COMMERCIAL						
Sales	12.4	1.8	1.0	0.7	0.8	0.9
Real Avg. Price	-4.8	-1.4	-0.5	0.1	0.4	0.1
Customers	7.6	-3.7	-1.1	0.2	1.5	0.6
INDUSTRIAL						
Sales	13.3	9.5	5.9	3.3	1.6	2.9
Real Avg. Price	-0.2	0.0	0.0	0.4	0.4	0.3
Customers	7.6	5.7	6.9	5.8	4.8	5.3
TOTAL						
Sales	15.7	8.7	4.8	2.8	1.9	2.8
Real Avg. Price	-5.0	-0.8	-0.3	0.2	0.4	0.2
Customers	9.9	5.9	3.9	3.0	2.8	3.2
OPERATING COSTS						
Real Avg. Cost	-5.1	0.0	0.0	0.4	0.4	0.3

APPENDIX B

HISTORICAL DATA SOURCES

Table B.1
Data Sources for ARELM-MACRO

Variables	Sources
Population, Personal Income, Per Capita Income, Dividends, Interest and Rents, Transfer Payments, Other Labor Income, for Alaska, Anchorage, Matanuska/Susitna, Fairbanks, Kenai Peninsula and Seward	U.S. Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income, 1969-1982 and unpublished data received from BEA on computer printouts, 1958-1968.
Population, Personal Income, Per Capita Income, Dividends, Interest and Rents, Transfer Payments, Other Labor Income, Unemployment Rate, and real GNP in the U.S.	Data Resources, Inc., "History Tables," 1957-82, U.S. Long-Term Review, Winter 1983-1984, (1983).
Alaska Unemployment Rate	U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the U.S. (annual), 1958-1984.
Employment and Average Monthly Wages in Alaska, Total and By Sector: Mining, Construction, Manufacturing, Transportation, Communication and Other Public Utilities, Wholesale and Retail Trade, Finance, Insurance, Real Estate, Services and Government	Alaska Department of Labor, Statistical Quarterly, First Quarter (annual), 1969-1982 and unpublished data for 1956-1968.
U.S. Consumer Price Index	U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, Bulletin No. 2175 (1983), p.328
Alaska Price Index	Institute of Social and Economic Research, University of Alaska, Susitna Hydroelectric Project, Man-in-the-Arctic Program (MAP) Technical Documentation Report, Alaska Power Authority, July 1983.

Table B.1 (Continued)

Variables	Sources
Alaska Oil Production	Reported to the Alaska Oil Conservation Commission.
U.S Employment and Wages in Mining and Manufacturing	U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the U.S. (annual), 1958-1984.
U.S. Refiners' Acquistion Price of Crude Oil - Composite of Domestic and Foreign	Data Resources, Inc., "History Tables," 1957-82, U.S. Long-Term Review, Winter 1983-1984 (1983).
Employment, Total and in Mining, Manufacturing and Construction, for Anchorage, Matanuska/Susitna, Fairbanks, Kenai Peninsula and Seward	U.S. Department of Commerce, Bureau of the Census, County Business Patterns - Alaska (annual), 1965-1982.

Table B.2
Data Sorces for ARELM-LOAD

Variables	Sources
Operating Statistics - Sales, Revenues, and Customers by Sector, and Operating Costs for the Cooperatives (Chugach, Golden Valley, Homer and Matanuska).	U.S. Department of Agriculture, Rural Electrification Administration, Statistics of Rural Electric Borrowers, Bulletin 1-1 (annual), 1965-1982.
Operating Statistics - Sales, Revenues, and Customers by Sector, and Operating Costs for the Municipals (Anchorage, Fairbanks and Seward)	U.S. Department of Energy, Energy Information Administration, Statistics of Publicly-Owned Electric Utilities in the U.S. (annual), 1965-1982; U.S. Department of Energy, Alaska Power Administration, Alaska Electric Power Statistics (annual), 1976-1983.
Number of Miles of Distribution and Transmission Lines	Electrical World (annual), 1965-1983.
Per Capita Income and Population for Anchorage, Fairbanks, and Peninsula	U.S. Department of Commerce, Bureau of Economic Analysis, Local Area Personal Income, 1969-1982 and unpublished data received from BEA on computer printouts, 1965-1968.
Heating Degree Days for Fairbanks, Anchorage, Talkeetna, Seward and Homer	U.S. National Oceanic and Atmospheric Administration, Comparative Climatic Data (annual), 1965-1982.
Household Size for Anchorage, Peninsula and Fairbanks	Calculated for census years using data from the U.S. Department of Commerce, Bureau of the Census, County and City Data Book (1977 and 1983) and 1960 Census of Housing. Estimates for non-census years were based upon relative growths in population and the number of residential electricity customers.

Table B.2 (Continued)

Variables	Sources
Price of Natural Gas in the Residential Sector	American Gas Association, Gas Facts (annual), 1965-1982.
Employment, Total and in Mining, Manufacturing and Construction, for Anchorage, Matanuska/Susitna, Fairbanks, Kenai Peninsula and Seward	U.S Department of Commerce, Bureau of the Census, County Business Patterns - Alaska (annual), 1965-1982.
U.S. Gross National Product and the U.S. Refiners' Acquisition Price of Crude Oil - Composite of Domestic and Foreign	Data Resources, Inc., "History Tables," 1957-82, U.S. Long-Term Review, Winter 1983-1984 (1983).

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