

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILES 86/2
976 SCOMM44: HOUSE POWER ALTERNATIVES STUDY COMM. 1979-80 976

TECHNOLOGICAL CHANGE

Over a thirty-year period of time, substantial technological change can be expected to occur in the use of electricity as a result of price and other incentives. Some change may result in increased electricity consumption as electricity substitutes for other types of energy. The electric car is an example of a new and possibly very substantial use of electricity which could be energy conserving. Other changes could significantly reduce utility supplied electricity consumption. Cogeneration and solar voltaics are examples of this phenomenon.

We do not speculate on the possible impact of these developments on utility electricity sales. Although it is important to consider such developments, they should be analyzed in separate studies which directly involve engineers and other technicians familiar with the prospects and problems of such emerging technologies.

Projection Methodology

Utility-supplied electric power requirements are projected on the basis of an end-use model driven by projections of households, the composition of the housing stock, and employment. A simplified diagram of the end-use model is shown as Figure III.B.

The model is divided into five submodels, each of which uses a different formulation to forecast a portion of total consumption. The submodels are as follows:

1. Residential appliances
2. Residential space heating
3. Commercial-industrial-government
4. Street lighting
5. Second homes

This division was chosen because different variables determine consumption for each of these uses and because further subdivisions, where appropriate

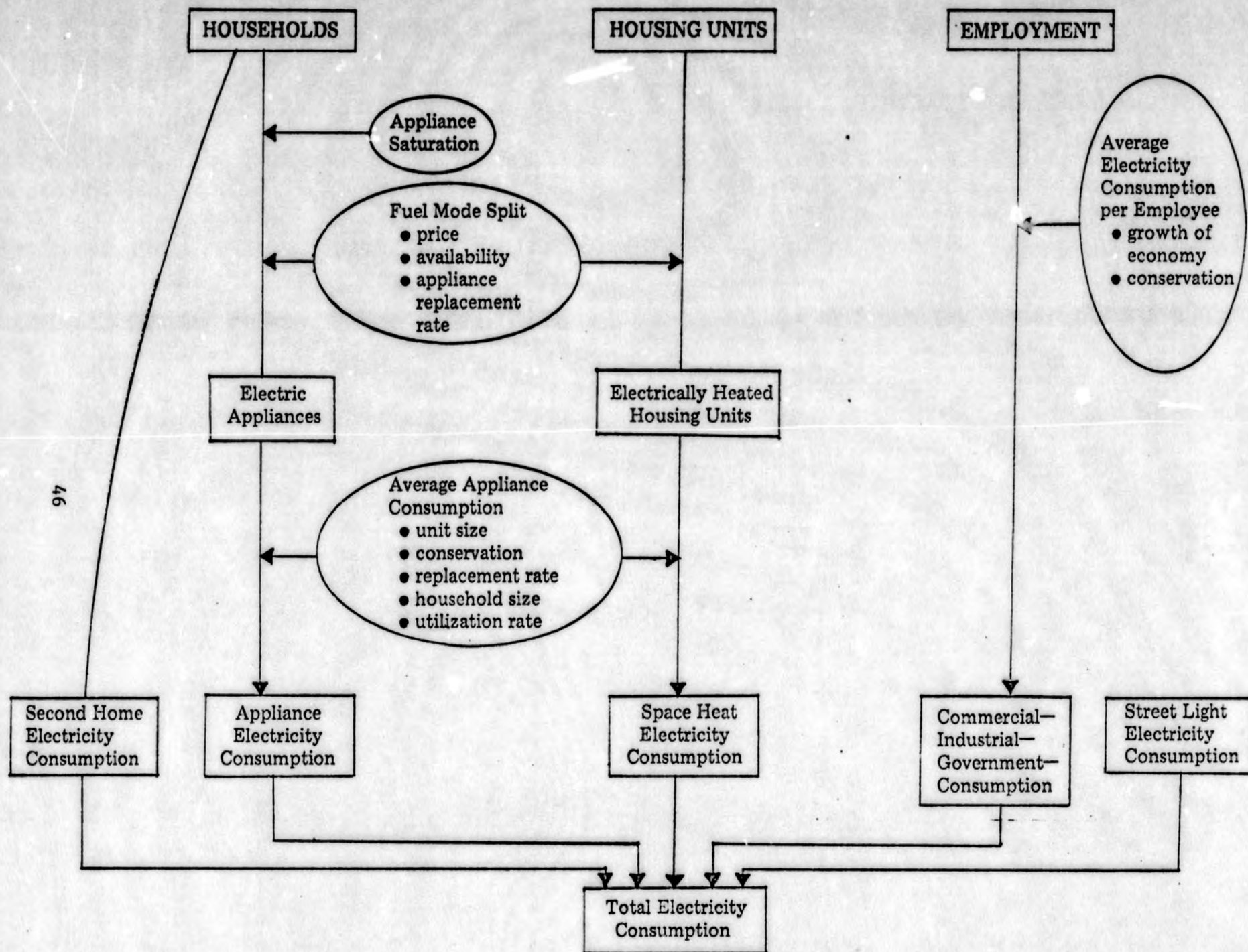


FIGURE III.B.

Figure III. B. Diagram of Utility-Supplied Electricity Requirements Model

(the commercial-industrial-government sector), were not possible because of the way the utilities report sales.

The residential appliance model forecasts requirements for nine separate appliances plus lighting and unspecified small appliances.

The appliances are as follows:

1. Water heater
2. Range
3. Clothes dryer
4. Refrigerator
5. Freezer
6. Dishwasher
7. Clothes washer
8. Television
9. Air conditioner
10. Lighting
11. Small appliances

These appliances are separately identified because over time we would not expect growth of electricity consumption in the different appliances to respond identically to changes in economic projection variables.

The model first calculates the number of households who own and operate each appliance. This is the product of households, the saturation rate, and, for those appliances that may be fueled by gas or oil, the electric mode split. Average annual consumption per appliance is separately calculated as the weighted average annual consumption of appliances of each vintage, or age group. Newer appliances tend to be larger, but in the future they will also be more energy efficient. Thus, it is important to keep track of the vintage, or age, of appliances as well as how long they last before wearing out.

The residential space heating model forecasts requirements for four different housing types based upon the assumption that the space heating requirements and characteristics of each is different. These divisions are as follows:

1. Single family
2. Duplex
3. Multifamily
4. Mobile home

The number of housing units determines the potential electric space heating load. (Each household corresponds to or resides within a housing unit, but because of vacancies, there will normally be more housing units than households.) We assume all housing units must be heated even if unoccupied as long as they are available for a household. As in the case of appliances, only a portion of all heating systems will use electricity--the electric mode split. The model also estimates the average consumption per unit. The product of the number of units and average consumption is total residential space heating consumption. In addition to different housing types using different amounts of energy for space heating, newer units use more fuel because they are larger; but in the future, they will be more efficient. Also, older units may be retrofit to be more efficient. Thus, the average unit consumption will vary with the age of the unit.

The commercial-industrial-government model is much simpler because of a lack of data. Nonagricultural wage and salary employment serves as a proxy for establishments. New establishments are equivalent to increases in employment. New establishments, since most of the electricity consumption is determined at the time of construction, consume electricity at different rates than existing establishments whose consumption remains constant.

These three model components account for about 99 percent of utility sales. The remainder is miscellaneous, composed of street lighting and second or vacation homes. For simplicity, street lighting is a small, fixed percentage of sales in other categories. Consumption by second homes is based on a very rough estimate of the number of households with second homes.

The parameters used in the model are derived from analyses of a large number of sources, both within and outside the state. None are based upon econometrics or other sophisticated techniques because of data limitations. Because of the severe data limitations and the novelty of this approach within Alaska, a large degree of judgment is involved in choosing parameter values. They are all explicit and explained in the appendixes.

An important part of model development is model validation, that is testing the model before it is used to gauge how well it forecasts. Two partial tests of the model were done. The first was a "backcast" to see how well the model, calibrated on 1978, could predict consumption in 1970 and 1960. The model predicted too high. The problem was traced to a probable underestimation of the growth rate of average appliance consumption for which adjustments were subsequently made.

A second test would be to predict 1979 consumption since preliminary 1979 figures began to become available after the model was constructed. The model projects an 8 percent growth between 1978 and 1980, including a shift to a normal winter in 1980 from an abnormally warm one in 1978 (which would account for about one-quarter of the projected growth). Actual growth between 1978 and 1979 was 3 percent; so that if growth between 1979 and 1980 were also 3 percent, independent of weather-related factors, the model will have predicted well for an initial two-year period. It appears as though there was a slight underestimate of growth in residential space heating demand in the outlying areas of the Greater Anchorage region for 1979, but this may correct itself in 1980. Although it is some consolation that the model appears reasonable in the short run, its validity in the long run is more important. Further analysis of the model structure and methods used to determine the parameters is the only way to assure that the model is appropriate for long-run analysis.

Electric Power Requirements Projections

One set of assumptions about electricity consumption behavior was applied to three sets of economic projections. The economic projections are minimum, maximum, and most likely economic growth cases. All economic cases are assumed to be identical with respect to relative energy price, per capita income, energy availability, and conservation measures. The major assumptions about electricity consumption in the projections are as follows:

- The electricity market is presently in relative equilibrium except for space heating use of electricity in Fairbanks where a significant shift away from electric space heat is underway.
- This relative equilibrium (in terms of the price of electricity relative to other fuels) is projected to remain in effect throughout the period of the projections such that no major shift toward or away from electricity use in favor of alternative fuels occurs.
- This assumption is consistent with a long-run projection of decontrol of energy prices and movement of relative fuel prices towards equivalency as market forces play a larger role in price determination.
- The price of energy relative to other goods and services will continue to rise. The reduction in electricity consumption resulting from this price rise will be more than offset by the effect of rising real incomes acting to increase electricity consumption.
- Federal policies designed to conserve energy will be effective in the area of electric appliance efficiency standards but will have a smaller impact on electricity consumption through the building stock through incentives for retrofitting and the application of new building standards. These programs will go into effect during the 1980s.
- No state conservation policies specifically directed at the use of electricity are implemented.

- No significant state policies designed to alter the price or availability of alternative fuels to consumers or utilities are implemented.
- No new technologies are assumed such as solar voltaics for electricity generation or electric cars.
- Additional growth in population will be centered in utility service areas.
- Assumptions specific to residential appliance electricity consumption include the following:
 1. Growth in major appliance saturation rates generally follows a continuation of national trends.
 2. As appliances wear out, their replacements are generally larger and contain more features requiring more energy. (This assumption is independent of the appliance efficiency standards assumption.)
 3. For some large appliances, the reduction in average household size reduces average electricity requirements.
 4. Changes in consumption rates resulting from changes in the size and other characteristics of the appliance stock occur over a period of time according to the rate at which appliances wear out and are replaced.
 5. Residential electricity consumption not attributable to the appliances specified in the end-use model or to lighting is projected to increase 5 percent annually per household. This assumption reflects both the relationship of appliance purchase and utilization with real income and the development of new electrical appliances not currently available.
- Assumptions specific to residential electric space heating requirements are as follows:
 1. A slight trend toward single-family homes comprising a larger portion of the housing stock.
 2. The average size of new housing units continues to grow in a reflection of a national trend.
 3. No significant shift in the geographic distribution of the housing stock occurs to areas where electricity is the least expensive fuel. At the same time, the

service areas of existing natural gas utilities or the introduction of new gas utilities into regions not now served does not occur.

4. The introduction of alternatives to central space heating which would involve the use of electricity in conjunction with other fuels such as fuel oil, wood, or coal does not result in a significant increase in the space heating load.
 5. No significant utilization of electric heat pumps occurs.
- Assumptions specific to commercial-industrial-government utility-supplied electricity consumption include:
 1. Growth in electricity requirements in excess of residential requirements will occur both because employment is projected to increase more rapidly than population and because, without specific conservation measures enacted by standards and regulations, less conservation of electricity will occur in this sector than in the residential sector.
 2. The distribution of end uses of electricity within this sector will not shift markedly over the projection period.
 - Miscellaneous utility sales, composed of street lighting and second home use, will grow at rates consistent with overall utility sales and remain an insignificant portion of the total.
 - Military net energy requirements are assumed constant in spite of mandated conservation efforts.
 - Self-supplied industrial net energy requirements are composed of those projects identified and included in the economic scenarios. They do not include possible projects attracted to Alaska by the prospect of inexpensive electricity.

The projections of utility sales as well as military and self-supplied industrial net generation are presented in Table III.9. and detailed projections by consumer category in Table III.10. for the most likely case and in Table III.11. for the high and low cases.

TABLE III.9. PROJECTED ELECTRIC UTILITY SALES AND MILITARY
PLUS SELF-SUPPLIED INDUSTRIAL NET GENERATION
(10³ MWh)

Year	Utility Sales				Total Utility Sales	Military Net Generation	Self-Supplied Industry Net Generation
	Anchorage	Fairbanks	Anchorage+ Fairbanks	Glennallen- Valdez			
1978	1,747	427	2,174	38	2,212	334	414
1980	1,907	446	2,353	37	2,390	334	414
1985							
L	2,249	619	2,868	53	2,921		414
M	2,438	669	3,107	64	3,171	334	571
H	2,676	769	3,445	116	3,561		847
M-E	2,438	669	3,107	64	3,171		571
1990							
L	2,510	666	3,176	60	3,236		414
M	2,782	742	3,524	75	3,599	334	571
H	3,249	914	4,163	119	4,282		981
M-E	2,782	742	3,524	75	3,599		571
1995							
L	3,097	813	3,910	66	3,976		414
M	3,564	949	4,513	88	4,601	334	571
H	4,438	1,227	5,665	124	5,789		981
M-E	3,564	949	4,513	104	4,617		571
2000							
L	3,981	1,040	5,021	80	5,101		414
M	4,451	1,177	5,628	102	5,730	334	571
H	5,519	1,537	7,056	136	7,192		981
M-E	4,973	1,416	6,389	136	6,525		571
2005							
L	4,375	1,154	5,529	88	5,617		414
M	5,226	1,397	6,623	119	6,742	334	571
H	7,013	1,988	9,001	176	9,177		981
M-E	6,220	1,834	8,054	165	8,219		571
2010							
L	4,807	1,277	6,084	95	6,179		414
M	6,141	1,671	7,812	140	7,952	334	571
H	8,927	2,586	11,513	223	11,736		981
M-E	7,624	2,318	9,942	200	10,142		571

L = Minimum economic growth
M = Likely economic growth
H = Maximum economic growth

M-E = Likely economic growth with shift to
electric space heat and appliances
in residential sector

TABLE III.10.
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER ANCHORAGE
MEDIUM

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	365	131	346	841	884	22	1,747
1980	382	144	395	921	966	20	1,907
1985	464	203	508	1,175	1,238	25	2,438
1990	523	255	578	1,356	1,397	29	2,782
1995	627	334	717	1,678	1,849	37	3,564
2000	753	427	906	2,086	2,319	46	4,451
2005	858	509	1,045	2,412	2,760	54	5,226
2010	975	604	1,198	2,777	3,301	63	6,141
<u>Annual Growth Rate</u>							
1980-1990	3.2	5.9	3.9	3.9	3.8	3.8	3.9
1990-2000	3.7	5.3	4.6	4.4	5.2	4.7	4.8
2000-2010	2.6	3.5	2.8	2.9	3.6	3.2	3.3
1980-2010	3.2	4.9	3.8	3.8	4.2	3.9	4.0

Components may not sum to totals due to rounding error.

TABLE III.10. (continued)
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER FAIRBANKS
MEDIUM

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	92	38	49	179	243	5	427
1980	95	41	51	187	255	4	446
1985	123	60	48	231	431	7	669
1990	142	78	44	264	470	8	742
1995	175	105	37	317	622	10	949
2000	211	137	25	373	792	12	1,177
2005	242	166	17	425	958	14	1,397
2010	278	200	15	493	1,161	17	1,671
<u>Annual Growth Rate</u>							
1980-1990	4.1	6.6	(1.5)	3.5	6.3	7.2	5.2
1990-2000	4.0	5.8	(5.5)	3.5	5.4	4.1	4.7
2000-2010	2.8	3.9	(5.0)	2.8	3.9	3.5	3.6
1980-2010	3.6	5.4	(4.0)	3.3	5.2	4.9	4.5

Components may not sum to totals due to rounding error.

TABLE III.10. (continued)
 PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
 (10³MWh)
 GLENNALLEN - VALDEZ
 MEDIUM

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	6	3	0	10	29	0	38
1980	6	3	0	9	27	1	37
1985	9	5	0	14	49	1	64
1990	10	7	1	18	56	1	75
1995	13	9	1	23	64	1	88
2000	15	12	1	28	73	1	102
2005	18	14	1	33	85	1	119
2010	21	17	2	40	99	1	140
<u>Annual Growth Rate</u>							
1980-1990	5.2	8.8	-	7.2	7.6	-	7.3
1990-2000	4.1	5.5	-	4.5	2.7	-	3.1
2000-2010	3.4	3.5	7.2	3.6	3.1	-	3.2
1980-2010	4.3	6.0	-	5.1	4.4	-	4.5

Components may not sum to totals due to rounding error.

TABLE III.11.
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER ANCHORAGE
LOW

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	365	131	346	841	884	22	1,747
1980	382	144	395	921	966	20	1,907
1985	444	193	476	1,113	1,113	23	2,249
1990	489	238	539	1,266	1,218	26	2,510
1995	564	301	643	1,508	1,557	32	3,097
2000	679	385	816	1,880	2,060	41	3,981
2005	736	437	900	2,073	2,257	45	4,375
2010	795	494	982	2,271	2,487	49	4,807
<u>Annual Growth Rate</u>							
1980-1990	2.5	5.2	3.2	3.2	2.4	2.7	2.8
1990-2000	3.3	4.9	4.2	4.0	5.4	4.7	4.7
2000-2010	1.6	2.5	1.9	1.9	1.9	1.8	1.9
1980-2010	2.5	4.2	3.1	3.1	3.2	3.0	3.1

Components may not sum to totals due to rounding error.

TABLE III.11. (continued)
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER FAIRBANKS
LOW

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	92	38	49	179	243	5	427
1980	95	41	51	187	255	4	446
1985	118	58	48	224	389	6	619
1990	135	73	44	251	408	7	666
1995	159	95	36	290	515	8	813
2000	194	125	24	343	686	11	1,040
2005	211	144	16	371	771	12	1,154
2010	230	165	12	407	857	13	1,277
<u>Annual Growth Rate</u>							
1980-1990	3.6	5.9	(1.5)	3.0	4.8	5.8	4.1
1990-2000	3.7	5.5	(5.9)	3.2	5.3	4.6	4.6
2000-2010	1.7	2.8	(6.7)	1.7	2.3	3.2	2.1
1980-2010	3.0	4.8	(4.7)	2.6	4.1	4.0	3.6

Components may not sum to totals due to rounding error.

TABLE III.11. (continued)
 PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
 (10³MWh)
 GLENNALLEN - VALDEZ
 LOW

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	6	3	0	10	29	0	38
1980	6	3	0	9	27	1	37
1985	8	5	0	13	39	1	53
1990	9	6	0	15	44	1	60
1995	10	7	1	18	47	1	66
2000	12	9	1	22	57	1	80
2005	14	11	1	26	61	1	88
2010	15	12	1	28	66	1	95
<u>Annual Growth Rate</u>							
1980-1990	4.1	7.2	-	5.2	5.0	-	5.0
1990-2000	2.9	4.1	-	3.9	2.6	-	2.9
2000-2010	2.3	2.9	-	2.4	1.5	-	1.7
1980-2010	3.1	4.7	-	3.9	3.0	-	3.2

Components may not sum to totals due to rounding error.

TABLE III.11. (continued)
 PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
 (10³MWh)
 GREATER ANCHORAGE
 HIGH

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	365	131	346	841	884	22	1,747
1980	382	144	395	921	966	20	1,907
1985	485	211	520	1,216	1,432	28	2,676
1990	574	282	640	1,496	1,719	34	3,249
1995	728	390	842	1,960	2,432	46	4,438
2000	886	509	1,076	2,471	2,991	57	5,519
2005	1,065	646	1,327	3,038	3,903	72	7,013
2010	1,302	817	1,623	3,742	5,094	91	8,927
<u>Annual Growth Rate</u>							
1980-1990	4.2	7.0	4.9	5.0	5.9	5.5	5.5
1990-2000	4.4	6.1	5.3	5.2	5.7	5.3	5.4
2000-2010	3.9	4.9	4.2	4.2	5.5	4.8	4.9
1980-2010	4.2	6.0	4.8	4.8	5.7	5.2	5.3

Components may not sum to totals due to rounding error.

TABLE III.11. (continued)
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER FAIRBANKS
HIGH

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	92	38	49	179	243	5	427
1980	95	41	51	187	255	4	446
1985	134	66	48	248	513	8	769
1990	162	89	45	296	609	9	914
1995	208	125	38	371	843	13	1,227
2000	257	167	27	451	1,070	16	1,537
2005	315	215	21	551	1,417	20	1,988
2010	387	278	21	686	1,874	26	2,586
<u>Annual Growth Rate</u>							
1980-1990	5.5	8.1	(1.2)	4.7	9.1	6.1	7.4
1990-2000	4.7	6.5	(5.0)	4.3	5.8	5.9	5.3
2000-2010	4.2	5.2	(2.5)	4.3	5.8	5.0	5.3
1980-2010	4.8	6.6	(2.9)	4.4	6.9	5.7	6.0

Components may not sum to totals due to rounding error.

TABLE III.11. (continued)
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GLENNALLEN - VALDEZ
HIGH

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	6	3	0	10	29	0	38
1980	6	3	0	9	27	1	37
1985	11	6	1	18	97	1	116
1990	13	9	1	23	95	1	119
1995	16	11	1	28	95	1	124
2000	18	14	1	33	102	1	136
2005	23	18	2	43	131	2	176
2010	28	23	2	53	168	2	223
<u>Annual Growth Rate</u>							
1980-1990	8.0	11.6	-	9.8	13.2	-	12.4
1990-2000	3.3	4.5	-	3.7	.1	-	1.3
2000-2010	4.5	5.1	7.2	4.9	7.4	7.2	5.1
1980-2010	5.3	7.0	-	6.1	7.1	2.3	6.2

Components may not sum to totals due to rounding error.

The projected rates of growth of consumption are considerably below historical growth rates and all previous projections. In the most likely case, the average annual rate of growth over the thirty-year period is 4.1 percent with somewhat more rapid growth in the 1990s and somewhat less rapid growth after 2000.

The reasons for projecting slower growth in the future are three:

1. The long-run rate of economic growth of the state will moderate. In the most likely case, the growth of population in the railbelt over the next thirty years is projected at 2.4 percent annually. The statewide population growth rate during the twenty years since statehood has been about 3 percent annually.
2. Conservation measures and other factors will moderate the rate of increase in electricity consumption per customer.
3. Electric utilities will saturate their market areas.

Table III.12. shows the performance of previous electric power requirements studies in predicting the 1980 net energy sales of railbelt utilities. Of nine studies done, six significantly overestimated the growth rate between the time the study was conducted and 1980. Only those studies done before 1970 underestimated the actual growth rate, and all were closer to the actual growth rates than those done since 1970. This suggests that the projections done during the 1970s may have been upwardly biased because of the influence of the overall rapid growth of the economy during the mid-1970s.

The lower projected growth rates of consumption in this report are consistent with recent projections done nationally and in other states. A recent article in the New York Times noted:

Last year electricity consumption rose only 2.8 percent in this country, down sharply from the 7 percent annual rate of growth that the industry routinely experienced until the early 1970s. So far this year, consumption has actually dropped, by 1.4 percent.

TABLE III.12. PERFORMANCE OF PAST PROJECTIONS OF
RAILBELT ELECTRIC POWER REQUIREMENTS

HITTING 1980 ON TARGET^a

Study Number ^b	Year of Publication	Net Energy (10 ³ MWh)		Annual Growth Rate of Net Energy Between Forecast Year & 1980		Percent Error in Forecast of Growth Rate to 1980 (%)
		Year of Forecast	Forecast for 1980	Implicit in Forecast	Actual	
I.1	1952	101	1,600	10.4	12.4	- 16
I.2	1960	320	2,391	10.6	11.1	- 6
I.3	1969	833	2,355	9.9	11.0	- 10
I.4	1974	1,549	3,450	14.3	9.2	+ 55
I.5	1974	1,549	3,543	14.8	9.2	+ 62
I.6	1975	1,851	3,240	11.9	7.3	+ 63
I.7	1976	2,093	2,985	9.3	5.9	+ 58
I.8	1978	2,397	3,000	11.9	4.8	+148
I.9	1979	2,469	3,155	27.8	6.5	+328

^a Assuming 1980 Net Energy consisting of 2,390 of sales plus 10 percent losses.

^b See Appendix I.

^c Net Energy figures calculated from sales plus 10 percent for losses.

One reason is that the mild winter sharply reduced the needs of those who heat their homes with electricity.

"I think what we've seen in the last year is probably the precursor to the 1980s--much, much lower growth rates" said Roger W. Sant, Director of the Carnegie-Mellon Institute of Research. "I suppose 3 percent growth is now the conventional wisdom, but my guess is that it will still be quite a bit lower than that."

The Edison Electric Institute, the trade association for the nation's investor-owned utilities, is now updating its long-term forecast, last published five years ago. William McCollam, Jr., President of the institute, said in an interview that the study analyzes growth rates, over the next 20 years, ranging from 2 percent to more than 5 percent a year.

"But the most important conclusion in our study," he said, "is that factors of choice are far more important than factors of chance. He added, "If the nation doesn't go to what we call the preferred scenario--in the order of magnitude of 4-to-4.5 percent a year--then we are not going to have the healthy economic growth that we ought to."⁶

This article indicates substantial disagreement among experts about what the new long-term trend in the electricity growth rate may be. It is clear, however, that everyone expects the rate to be lower than historically.

California is a state which has done considerable analysis of its energy situation. The state government estimate of electricity sales growth between 1978 and 2000 is 2 percent annually. In contrast, the combined estimate by the large utilities is 3.4 percent. Between 1973 and 1978, the average annual growth rate was 1.2 percent.⁷ (This covers the years of the Great Recession and consequently may be downward biased.)

Drawing parallels between Alaskan experience and that of other states or the nation as a whole can be misleading because of different circumstances. Comparisons do suggest, however, that if Alaskan electric power

requirements are to grow faster than in other states or the nation, such growth must be attributable to one of several factors:

1. More rapid economic growth
2. Increase in electric space heating
3. Less implementation of conservation measures

Consumption per customer has always exceeded the national average, and its growth is unlikely to be a contributing factor to higher overall growth in electricity requirements.

Detailed sensitivity analysis of the projection results has not been done at this time. It is clear from the projections using the three economic scenarios and the implied slow growth rate of electricity consumption per capita that the projections are more sensitive to the assumptions about economic growth than to those of consumption per capita.

The only case where this is not true would be if there were a significant shift in space heating and residential appliances toward the electric mode. The impact of this could be almost as substantial as that of a shift from the most likely to the maximum economic growth scenario. Such a case is presented for illustrative purposes in Table III.13. Here all of the economic assumptions are the same as the most likely case, and the only changes in the electricity use assumptions involve a greater preference for electricity in the residential sector after 1990. The specific assumptions are as follows:

- In the period after 1990 for Glennallen-Valdez and after 1995 for the remainder of the railbelt, the price of electricity falls relative to that of alternative fuels because of a shift in generation capacity towards coal plants, hydroelectric facilities, or other types of facilities which have costs independent of the prices of natural gas and fuel oil. It is

TABLE III.13.
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER FAIRBANKS
MEDIUM - ELECTRIC SPACE HEAT

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	92	38	49	179	243	5	427
1980	95	41	51	187	255	4	446
1985	123	60	48	231	431	7	669
1990	142	78	44	264	470	8	742
1995	175	105	37	317	622	10	949
2000	238	137	235	610	792	14	1,416
2005	292	166	399	857	958	19	1,834
2010	345	200	589	1,134	1,161	23	2,318
<u>Annual Growth Rate</u>							
1980-1990	4.1	6.6	(1.5)	3.5	6.3	7.2	5.2
1990-2000	5.3	5.8	18.2	8.7	5.4	5.8	6.7
2000-2010	3.8	3.9	9.6	6.4	3.9	5.1	5.1
1980-2010	4.4	5.4	8.5	6.2	5.2	6.0	5.7

Components may not sum to totals due to rounding error.

TABLE III.13. (continued)
PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
(10³MWh)
GREATER ANCHORAGE
MEDIUM - ELECTRIC SPACE HEAT

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	365	131	346	841	884	22	1,747
1980	382	144	395	921	966	20	1,907
1985	464	203	508	1,175	1,238	25	2,438
1990	523	255	578	1,356	1,397	29	2,782
1995	627	334	717	1,678	1,849	37	3,564
2000	919	427	1,257	2,603	2,319	51	4,973
2005	1,166	509	1,722	3,397	2,760	63	6,220
2010	1,391	604	2,250	4,245	3,301	78	7,624
<u>Annual Growth Rate</u>							
1980-1990	3.2	5.9	3.9	3.9	3.8	3.8	3.9
1990-2000	5.8	5.3	8.1	6.7	5.2	5.8	6.0
2000-2010	4.2	3.5	6.0	5.0	3.6	4.3	4.4
1980-2010	4.4	4.9	6.0	5.2	4.2	4.6	4.7

Components may not sum to totals due to rounding error.

TABLE III.13. (continued)
 PROJECTED ELECTRIC UTILITY SALES TO FINAL CONSUMERS
 (10³MWh)
 GLENNALLEN - VALDEZ
 MEDIUM - ELECTRIC SPACE HEAT

<u>Year</u>	<u>Residential</u>			<u>Total Residential</u>	<u>Commercial Industrial Government</u>	<u>Misc.</u>	<u>Total</u>
	<u>Large Appliance</u>	<u>Small Appliance</u>	<u>Space Heat</u>				
1978 (actual)	6	3	0	10	29	0	38
1980	6	3	0	9	27	1	37
1985	9	5	0	14	49	1	64
1990	10	7	1	18	56	1	75
1995	16	9	14	39	64	1	104
2000	22	12	28	62	73	1	136
2005	26	14	38	78	85	2	165
2010	31	17	51	99	99	2	200
<u>Annual Growth Rate</u>							
1980-1990	5.2	8.8	-	7.2	7.6	-	7.3
1990-2000	8.2	5.5	39.6	13.2	2.7	-	6.1
2000-2010	3.5	3.5	6.2	4.8	3.1	7.2	3.9
1980-2010	5.6	6.0	-	8.3	4.4	2.3	5.8

Components may not sum to totals due to rounding error.

assumed that prices of natural gas and fuel oil rise sufficiently high to make electric power relatively more attractive in the residential sector.

- Replacement appliances in subsequent years are largely electric.
- New additions to the housing stock in subsequent years are primarily electrically space heated, but electric space heat retrofitting does not occur.

CHAPTER III ENDNOTES

1. Eric Hirst and Jerry Jackson, "Historical Patterns of Residential and Commercial Energy Uses," Energy, Vol. 2, 1977, pp. 131-140. In this discussion, electricity use is in terms of primary energy; that is, it includes generation and transmission losses.
2. Ibid.
3. Ibid.
4. Jerry Jackson and William S. Johnson, "Commercial Energy Use: A Disaggregation by Fuel, Building Type and End Use," Oak Ridge National Laboratory, 1978, p. 11.
5. Ibid., p. 13.
6. Anthony J. Parisi, "Electricity Use No Longer Soaring, Nation Expected to Benefit in 80's," New York Times, April 6, 1980, p. 1.
7. California Energy Commission, California Energy Demand 1978-2000, A Preliminary Assessment, August 1979, pp. 1-4.

TECHNICAL APPENDICES

MJ Comment copy

ELECTRIC POWER CONSUMPTION FOR THE RAILBELT:

A PROJECTION OF REQUIREMENTS

EXECUTIVE SUMMARY

by

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Lee Huskey

Institute of Social and Economic Research

Anchorage * Fairbanks * Juneau

prepared jointly for

State of Alaska
House Power Alternatives Study Committee
and
Alaska Power Authority

May 16, 1980

ELECTRIC POWER REQUIREMENTS FOR THE RAILBELT

Executive Summary

Results of the Analysis

The electric power requirements of the Alaskan railbelt will continue to grow over the next thirty years as the economy expands and personal income grows. Based upon the analysis of a large number of economic, demographic, and electricity consumption factors, the most likely growth rates for the most important state economic variables and railbelt electric utility sales over the next thirty years are as follows:

TABLE A. PROJECTED ALASKAN GROWTH RATES

(Average Annual Percent)

<u>Time Interval</u>	<u>Statewide Population Growth</u>	<u>Statewide Employment Growth</u>	<u>Railbelt Electric Utility Sales Growth</u>
HISTORICAL			
1965 - 1970	2.7	5.6	13.9
1970 - 1975	6.0	12.1	13.5
1975 - 1980	.8	.5	7.0
PROJECTED			
1980 - 1985	3.7	4.6	5.8
1985 - 1990	1.7	1.4	2.6
1990 - 1995	2.7	3.2	5.0
1995 - 2000	2.3	2.5	4.5
2000 - 2005	2.0	2.0	3.3
2005 - 2010	2.0	2.0	3.4

*Much
higher than
projected
national
rates*

2
Detailed utility sales projections for this most likely case are presented in Table B as well as projections for three other cases analyzed. These are a minimum (L) and maximum (H) economic growth case and a most likely (M) economic growth case with a price-induced shift toward electricity (ME) consumption in the residential sector for space heating and appliances. Differences between the minimum, likely, and maximum economic growth projection cases are the result of differences in consumption which result from differences in the rate of economic growth. (Differences between the likely economic growth case and the likely economic growth case with a price-induced shift toward electricity consumption in the residential sector are the result of differences in electricity use patterns but not rates of economic growth.)

Several salient features of these projections may be summarized as follows:

- Future growth of electric utility sales will be slower than historical growth rates.
- Because of projected high rates of economic growth, these projected growth rates of consumption equal or exceed recent national electricity consumption growth projections.
- These projections are considerably below those of the Alaska Power Administration done for the Corps of Engineers in 1979. This is the result of lower population growth rate estimates, lower electricity consumption per customer estimates, the advantage of hindsight in the analysis of economic and electric power consumption growth in recent years, and other factors.

TABLE B. PROJECTED ELECTRIC UTILITY SALES AND MILITARY
PLUS SELF-SUPPLIED INDUSTRIAL NET GENERATION
(10³ MWh)

Year	Utility Sales				Total Utility Sales	Military Net Generation	Self-Supplied Industry Net Generation
	Anchorage	Fairbanks	Anchorage+ Fairbanks	Glennallen- Valdez			
1978	1,747	427	2,174	38	2,212	334	414
1980	1,907	446	2,353	37	2,390	334	414
1985							
L	2,249	619	2,868	53	2,921		414
M	2,438	669	3,107	64	3,171	334	571
H	2,676	769	3,445	116	3,561		847
M-E	2,438	669	3,107	64	3,171		571
1990							
L	2,510	666	3,176	60	3,236		414
M	2,782	742	3,524	75	3,599	334	571
H	3,249	914	4,163	119	4,282		981
M-E	2,782	742	3,524	75	3,599		571
1995							
L	3,097	813	3,910	66	3,976		414
M	3,564	949	4,513	88	4,601	334	571
H	4,438	1,227	5,665	124	5,789		981
M-E	3,564	949	4,513	104	4,617		571
2000							
L	3,981	1,040	5,021	80	5,101		414
M	4,451	1,177	5,628	102	5,730	334	571
H	5,519	1,537	7,056	136	7,192		981
M-E	4,973	1,416	6,389	136	6,525		571
2005							
L	4,375	1,154	5,529	88	5,617		414
M	5,226	1,397	6,623	119	6,742	334	571
H	7,013	1,988	9,001	176	9,177		981
M-E	6,220	1,834	8,054	165	8,219		571
2010							
L	4,807	1,277	6,084	95	6,179		414
M	6,141	1,671	7,812	140	7,952	334	571
H	8,927	2,586	11,513	223	11,736		981
M-E	7,624	2,318	9,942	200	10,142		571

L = Minimum economic growth
M = Likely economic growth

H = Maximum economic growth
M-E = Likely economic growth with shift to electric space heat and appliances in residential sector

- Utility sales growth in the 1980s is projected to be a reflection of growth in the 1970s, except at lower levels. That is, rapid economic growth in the early part of the decade will result in rapid growth of sales. Slower growth in the second part of the decade will retard sales growth.
- Utility sales growth is projected to be about as rapid in the 1990s as in the 1980s for three reasons in spite of a projection of slightly slower population growth in the decade of the 1990s.

These are the following:

1. The implementation of conservation measures by the Federal government in the 1980s. This has two effects. The first is a permanent reduction in consumption growth, while the second is a temporary reduction in the growth rate of consumption as existing consumers shift to more conservative modes. This second "transition" effect occurs largely in the 1980s and, without the introduction of additional conservation measures, has terminated sometime in the 1990s.¹
 2. A continuation of the downward trend in average household size. Thus, a given population growth rate implies a somewhat faster household growth rate.
 3. A continuation of relatively stable growth of consumption in the commercial-industrial-government sector and of consumption of smaller, unspecified appliances in the residential sector.
- The range of variation among the projections is a reflection of uncertainty surrounding both future levels of economic activity in the Alaskan railbelt and future conditions in energy markets.

¹This notion can be illustrated by reference to the impact of mandatory fuel standards on total automobile consumption of gasoline. During the transition phase when older, less efficient autos are being replaced by newer, more efficient ones, the average rate of consumption per auto will probably be falling. When the total stock of autos is energy efficient, the average rate of consumption per auto will no longer be falling and may again begin to rise as the average car is driven more miles.

Total electricity requirements appear to be somewhat more sensitive to economic conditions than conditions in energy markets.

These projections of electricity requirements, as well as those done by others in recent years, have been difficult to construct because of the large number of factors which have affected consumption rates in the last decade, particularly in Alaska. During such a period, when the structure of the energy market has been undergoing significant change, it is necessary to identify the specific factors affecting electricity consumption and estimate their quantitative effects in order to make informed projections. In spite of the fact that there has been a significant and identifiable shift in energy consumption rates since 1973, analysts have yet to sort out the long-range implications of these shifts and to identify a new long-run trend in electricity consumption (comparable to the 7 percent annual rate of growth experienced throughout the first six decades of this century). The more important factors making this task difficult appear to be the following:

1. National and regional business cycles affect consumption rates. In Alaska, the cycle generated by the construction of the oil pipeline is only now coming to an end.
2. Abnormally warm winter weather such as experienced in the Anchorage area during the winters of 1976-77, 1977-78, and 1978-79 can significantly reduce consumption figures for a year and make it difficult to interpret a change in trend.
3. Voluntary conservation measures may reduce consumption. There is no evidence that this is a significant factor in Alaskan railbelt electricity consumption.

4.

Price-induced conservation measures may reduce consumption. This appears to have been a factor in the reduction of the growth rate of electricity consumption in the Fairbanks area.

→ real costs
did not rise

5. Changing electricity use patterns could account for some of the reduction in growth rates. As the average household obtains a full set of major appliances, continued growth would occur through appliance upgrading and the purchase of additional small appliances using smaller amounts of electricity. Likewise, the shift from room-by-room space heating to centralized space heating created a one-time surge in energy consumption.

6. Changing geographic distribution of households to areas which utilize more or less electricity. In the Anchorage electricity service area, a rapid growth in households in outlying regions where natural gas is not available has caused an increase in electricity use for space heating.

These factors and others will continue to make it difficult for some years to identify long-term trends in electricity consumption growth rates. The present projections are predicated on the following interpretation of recent electricity use patterns:

1. A one-time surge of growth in electricity consumption accompanied the expansionary phase of the regional business cycle generated by pipeline construction.

2. The warm winters in Anchorage over the last three years have had the effect of reducing the growth of consumption in Anchorage, but not the growth rate.

3.

Price-induced conservation of electricity has not been significant in Anchorage and has resulted in a shift away from electric space heating in Fairbanks.

4.

Electricity consumption growth patterns are beginning to change as large electrical appliance saturation rates approach their upper limits.

Methods

The analysis is divided into three components. The economic analysis uses an econometric model (the MAP [Man-in-the-Arctic Program] model) to project future levels of economic activity in the state and the railbelt. The model calculates the total level of employment and other economic variables on the basis of estimates of both basic sector activity (petroleum and other mining, Federal government, agriculture-forestry-fisheries, tourism, components of construction) and state government economic activity and the corresponding response of the support sectors to that activity level.

The demographic analysis uses a series of models to estimate the population which will be required to support the economic activity level generated by the economic analysis. The demographic variables generated in addition to the age-sex distribution are the number of households, average household size, labor force participation rate, and the housing types chosen by households. This work involved the development of several new analytic tools.

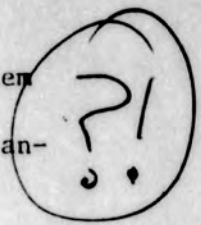
The electricity use analysis determines, on the basis of economic and demographic variables, the electricity consumed in various uses within the railbelt. The end use model covers electricity sales by utilities (excludes military and self-supplied industrial sales) and treats each region of the railbelt and end use separately. Thus, projections of the growth of each use can be determined individually (and

policy analysis of measures to alter consumption patterns can utilize the model). The end use model represents the idea that electricity consumption is determined by the electric appliances used by the consumer. It is, therefore, important to identify electrical appliances and their uses in order to understand aggregate electricity consumption.

Major Economic Assumptions

- P
- The high probability of a number of large construction projects occurring in the 1980s which will positively impact the Alaskan economy makes it relatively easy to project a narrow range for the level of economic activity in the 1980s. (Much of that activity will occur in the first half of the decade.)
 - In the subsequent decades, it becomes more difficult to identify specific projects or types of projects which may generate continued economic growth. Thus, the range of economic projection widens.
 - The specific magnitude of the impact of state government spending activity on the Alaskan economy is difficult to predict. Growing revenues from petroleum development will allow for the expansion of spending levels through the 1980s and into the 1990s. Since more than 90 percent of state revenues are derived from petroleum production and transportation, state revenue sources will begin to decline when the value of petroleum production on state lands begins to decline. [This may result in a significant "fiscal crunch" in the decade of the 1990s or the subsequent decade. The reduction of money flowing into the economy could have a significant negative "multiplier effect" on the level of aggregate economic

activity. The likely economic scenario assumes that the problem of a "fiscal crunch" can be avoided through adequate fiscal planning and controlled growth of state government employment.



- The support sector of the economy continues to expand in response to basic sector growth, but the relative cost of doing business in Alaska remains high so that trade and services, rather than local manufacturing, continues to be the main component of the support sector.

Major Demographic Assumptions

- The major determinant of the population will be the availability of jobs within the economy.
- In periods of rapid growth in the availability of jobs, a large number will, of necessity, be filled by net in-migrants to the state.
- The employment rate of the population will continue to increase, in a reflection of national trends and continuing integration of the Native community into the market economy.
- The average household size will continue to decline in a reflection of the national trend.

Major Electricity Use Assumptions

The electricity use assumptions apply to all the projections presented, with the exception of the most likely case with a price-induced shift toward electricity for space heating and appliances.

- The electricity market is presently in relative equilibrium except for space heating use of electricity in Fairbanks where a significant shift away from electric space heat is underway.
- This relative equilibrium (in terms of the price of electricity relative to other fuels) is projected to remain in effect throughout the period of the projections such that no major shift toward or away from electricity use in favor of alternative fuels occurs.
- This assumption is consistent with a long-run projection of decontrol of energy prices and movement of relative fuel prices towards equivalency as market forces play a larger role in price determination.
- The price of energy relative to other goods and services will continue to rise. The reduction in electricity consumption resulting from this price rise will be more than offset by the effect of rising real incomes acting to increase electricity consumption.
- Federal policies designed to conserve energy will be effective in the area of electric appliance efficiency standards but will have a smaller impact on electricity consumption through the building stock through incentives for retrofitting and the application of new building standards. These programs will go into effect during the 1980s.
- No state conservation policies specifically directed at the use of electricity are implemented.
- No significant state policies designed to alter the price or availability of alternative fuels to consumers or utilities are implemented.

• No new technologies are assumed such as solar voltaics for electricity generation or electric cars.

*different from
Seifert
res.*

• Assumptions specific to residential appliance electricity consumption include the following:

1. Growth in major appliance saturation rates generally follow a continuation of national trends.

2. As appliances wear out, their replacements are generally larger and contain more features requiring more energy. (This assumption is independent of the appliance efficiency standards assumption.)

*not a trend
towards efficiency*

3. For some large appliances, the reduction in average household size reduces average electricity requirements.

4. Changes in consumption rates resulting from changes in the size and other characteristics of the appliance stock occur over a period of time according to the rate at which appliances wear out and are replaced.

? 5. Residential electricity consumption not attributable to the ten appliances specified in the end use model or to lighting is projected to increase 5 percent annually per household. This assumption reflects both the correlation of appliance purchase and utilization with real income and the development of new electrical appliances not currently available.

• Assumptions specific to residential electric space heating requirements are as follows:

1. A slight trend toward single-family homes comprising a larger portion of the housing stock is projected.

2. The average size of new housing units continues to grow in a reflection of a national trend.

? 3. No significant shift in the geographic distribution of the housing stock occurs to areas where electricity is the least expensive fuel. At the same time, the service areas of existing natural gas utilities or the introduction of new gas utilities into regions not now served does not occur.

4. The introduction of alternatives to central space heating which would involve the use of electricity in conjunction with other fuels such as fuel oil, wood, or coal does not result in a significant increase in the space heating load.

5. No significant utilization of electric heat pumps occurs.

- Assumptions specific to commercial-industrial-government utility supplied electricity consumption include:

1. Growth in electricity requirements in excess of residential requirements will occur both because employment is projected to increase more rapidly than population and because, without specific conservation measures enacted by standards and regulations, less conservation of electricity will occur in this sector than in the residential sector.

2. The distribution of end uses of electricity within this sector will not shift markedly over the projection period.

- Miscellaneous utility sales, composed of street light and second home use, will grow at rates consistent with overall utility sales and remain an insignificant portion of the total.
- Military net energy requirements are assumed constant in spite of mandated conservation efforts.
- Self-supplied industrial net energy requirements are composed of those projects identified and included in the economic scenarios. They do not include possible projects attracted to Alaska by the prospect of inexpensive electricity.

Assumptions of the Most Likely Case with
a Price-Induced Shift Toward Electricity
for Space Heating and Appliances

This case is presented for illustrative purposes only. In order to proceed on the assumption that this is the most likely growth pattern for future electricity sales, it is necessary to do a complete analysis of the cost of electricity generated by these alternatives which are not currently producing electricity in the railbelt. This analysis was beyond the scope of the present study. However, it is possible using the model developed in this study to analyze electricity requirements under the assumption of inexpensive electricity. It is from this perspective that this case should be interpreted.

- 17
- In the period after 1990 for Glennallen-Valdez and after 1995 for the remainder of the railbelt, the price of electricity falls relative to that of alternative fuels because of a shift in generation capacity towards coal plants, hydroelectric facilities, or other types of facilities which have costs independent of the prices of natural gas and fuel oil. It is assumed that prices of natural gas and fuel oil rise sufficiently high to make electric power relatively more attractive in the residential sector.
 - Replacement appliances in subsequent years are largely electric.
 - New additions to the housing stock in subsequent years are largely electric, but electric space heat retrofitting does not occur.

Concluding Comments

This study has built a detailed model of electricity end use and in conjunction with economic and demographic projections has projected future electric power requirements for the railbelt. The model has been specifically designed to be flexible in terms of its regional and temporal capabilities. It is presently somewhat more sophisticated than the data utilized in it. As new data becomes available as a result of other energy-related research, it can easily be integrated into this model.

It is difficult to project most variables over a thirty-year period. The 1980 Alaskan economy and electricity consumption patterns are very different from what most analysts would have predicted in 1950. The present study strives to minimize the possible range of error in projection by specifying explicitly and in all practicable detail the qualitative interrelationships affecting electricity consumption in future years.

Acres 3/20

ISER demand forecasts

3% growth rate considered key

① Acres needs info to 2010; will be extrapolated, by ISER ★

② Discontinuity 1980 - 1990 - rapid growth in early 80's, passing by 1985

★ space heating requirements, will have specific impacts, on ~~an~~ electric demand.

★ Formalize formulation of alternatives:

small - medium hydro + financing

natural gas - export or use

coal - developed for power or export

alternative energy
conservation

+ electricity vs. space heating alternatives

Scott G - instead price parameters

Call Nancy Blunck

Not with me!
Should be able to get one, but I'm not sure how many will be left after. Do you have a required extra copy of your distribution? 2/80 Power Plan I can have? will check.

Process

① for leg - ~~series~~
series of demand curves

② for APA - selection of a 3 most likely
scenarios for running of (GE) Areas

model
then feedback / inputs need to be checked
for consistency

load factor relationship

but ^{poor} data exists on load management
+ it all needs to collated

check w/
Scott -
self-supplied
industrial

Work to be done:

- ① Recalibrate end use model values, based on inventory
(assumptions modified, etc.)
- ② How will parameters of end use change during projection period?
mode split changes in relation to energy prices
consistency, dynamics of housing stock
(housing demand determines supply) — income stream?
- ③ Dynamics of Housing
 - 1) distribution of housing by type
 - 2) significant changes in mode split
 - 3) age of housing stock
- ④ Methodology of Comm / Ind. -
Wanted to link to floor space / employment
but bad data on floor space
so may have to link employment + electricity
assumes certain patterns of space heat / lighting / process
eg cleaners, bulky
- ⑤ econometrics - documentation
- ⑥ development of energy scenarios
- ⑦ Glenallen / Valder

2 sources of change since 3/79 ^{APA} report
 model structure, new data
 input scenarios

Q - Why is current model different from previous?
 - ie, current runs much lower than 3/79
 report
 needs to be documented by ISER

End Use Model -

(Theoretical relationships, equations have been developed

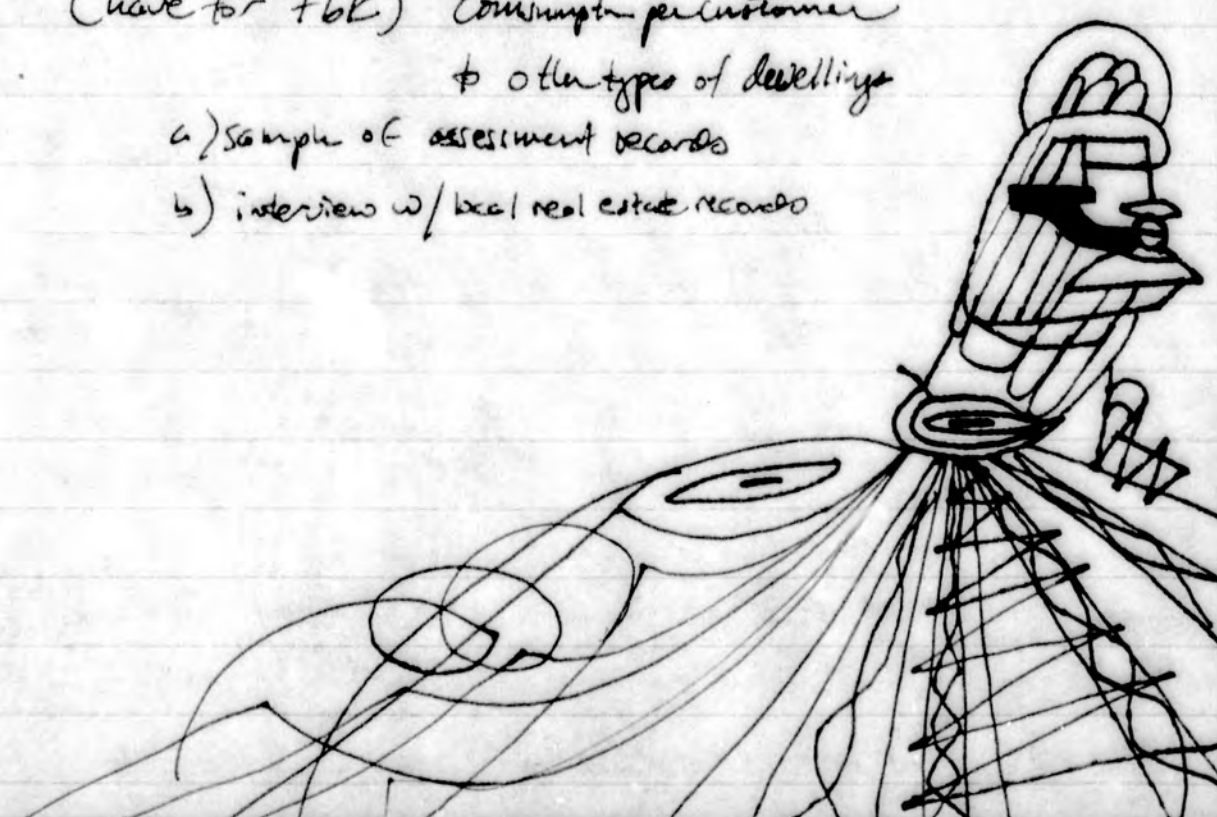
Need - ① Analysis of utility records - esp. HEA, MEA

② est. of avg. floor space for Auch.

(have for Fbk) consumption per customer
 & other types of dwellings

a) sample of assessment records

b) interview w/ local real estate records





SUSITNA HYDROELECTRIC PROJECT

March 14, 1980
P5700.13.00

Alaska State Legislature
House of Representatives
Pouch V
State Capitol
Juneau, Alaska 99811

Attn: Mr. M. Wittow
c/o Malone

Dear Mark,

A meeting has been called at our offices to discuss the energy use forecasting work being carried out by the University of Alaska's Institute of Social and Economic Research (ISER). Concerns have been expressed by various parties over the defensibility of some parts of their work.

You are invited to attend this meeting, which is scheduled to begin at approximately 9:00 a.m. on Thursday March 20, 1980. Due to the complexity of the content of this meeting, I cannot be sure that we will be able to complete our work on Thursday. Therefore, I would advise you to be available on Friday the 21st, in the event that we must extend our discussions.

I am enclosing a tentative agenda and a list of the anticipated participants for your use. Also enclosed is a map which should make it easier to find our offices.

Very truly yours,

James K. Landman
Coordinator--Power Systems Studies

JKL/jkl

ACRES AMERICAN INCORPORATED

Consulting Engineers
2207 Spenard Road
Anchorage, Alaska 99503

Telephone 907 276-4888 Telex 91-6423 ACRES BUF

Other Offices: Columbia, MD; Pittsburgh, PA; Raleigh, NC; Washington, DC; Buffalo, NY

1. Purpose of Meeting: This meeting has been called to discuss the availability of data used in the ISER econometric model, the "MAP" model. ISER, as well as Acres' consultants and subcontractors have noted that there is not a great abundance of data on Alaskan energy end uses. This shortcoming, its effect on the validity of the MAP model output, and steps which can be taken to lessen these effects will be discussed. At Woodward-Clyde's request, time has been set aside to discuss the scenarios used as input, as a bit of concern has been raised over this matter.

2. Agenda:

- A. ISER Progress Report (Issued on March 14, 1980)
 - 1. Content and limitations
 - 2. Work remaining
 - 3. Schedule

-  B. Input Scenarios Used for MAP Model
 - 1. Development of scenarios
 - 2. Limitations of scenarios
 - 3. Implications of limitations
 - 4. Ways of overcoming limitations

- C. End-Use Model
 - 1. Description of model
 - 2. Description of data used by model
 - a. sources
 - b. extent or degree of detail
 - c. validity
 - 3. Limitations of data
 - 4. Implications of limitations
 - 5. Ways of overcoming limitations
 - a. what needs to be done?
 - b. additional data that needs to be gathered
 - 1. how should it be gathered
 - c. how will new data improve the model
 - d. time requirements

- D. Other Business

3. Anticipated Attendees:

- ✓ A. Institute of Social and Economic Research
 - ✓ -O. Scott Goldsmith--Principal Investigator
 - T. Lee Husky
- ✓ B. Acres American, Inc.
 - Chuck Debelius--Project Manager
 - Jim GILL--Resident Manager, Anchorage
 - ✓ -Jim Landman--Coordinator Power Systems Studies
- ✓ C. Acres Consulting Services, Ltd.
 - ✓ -Peter Sandor--Economist
- ✓ D. Woodward-Clyde Consultants, Inc.
 - ✓ -Perry Sioshansi--Economist

- ✓ E. Alaska Power Authority
 - Robert A. Mohn--Manager of Engineering
- ✓ F. Alaska House of Representatives
 - Power Alternatives Study Committee
 - Mark Wittow--Coordinator
- ~~G.~~ Energy Probe
 - Chris Conway
- ~~H.~~ University of Alaska, Anchorage
 - Dr. Bradford Tuck--Economist
- I. Alaska Department of Commerce and Economic Development
 - Division of Energy and Power Development
 - Clarissa Quinlan--Director
 - *Greg Ehlum*



UNIVERSITY OF ALASKA
Institute of Social and Economic Research
707 "A" St., Suite 206
Anchorage, Alaska 99501
Phone (907) 278-4621

March 14, 1980

Mark Wittow
Study Coordinator
House Power Alternatives Study
c/o Representative Malone
Pouch V
Juneau, Alaska 99811

Dear Mark,

Enclosed is a copy of the progress report on the Institute's study of electric power requirements for the railbelt area of Alaska. In the interest of getting the report into the hands of other parties involved in the study, I have sent copies directly to Energy Probe, Alaska Power Authority, Acres American, and Woodward Clyde.

I regret that this progress report has been delayed and is in such rough form. The primary reason that it is late has been the problem of inadequate data. This has had two consequences. First, much more time was required than originally intended in collecting what data could be obtained. Second, I felt it was necessary to document all data sources and methodological procedures as early and as clearly as possible. The purpose of this is to have a solid basis for improvement of the data base and methodology during the second phase of the study and to provide the other interested parties with as much information as possible concerning our data sources and approach.

To summarize the progress to date, a ten-component model has been developed which can be utilized to project demand for electricity and other fuels on a regional basis. The model specifies particular energy end uses and is sensitive to a large number of factors which might reasonably be expected to change in the future either as the result of market forces or direct government policy. Thus, the model is capable of analyzing the impacts of government policies affecting energy consumption patterns.

The starting point for model development and the first portion of this report is an energy end-use inventory of the railbelt area. A substantial effort has gone into the development of this inventory which, unfortunately, has only been partially successful in terms of accurately

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Mark Wittow
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specifying end-use patterns on a detailed basis. It is anticipated that additional effort can be directed toward the task of continuing to refine the inventory. The Institute has, in this task, concentrated on the Anchorage portion of the railbelt and the progress report contains a summary of only that work. Use is being made of the end-use data collected by the Federation for Community Self-Reliance for the Fairbanks area. Data for the Glennallen-Valdez area has been collected but not developed into an inventory at this time.

The individual projection model components are in various stages of completion. Each is described in detail in section 2 of this progress report. For each model component, I have attempted to identify the most important items which affect the electricity requirements projections and the future work that is contemplated in further refining the model component.

It is not possible at this time to rank the items identified as being important in the determination of electricity requirements because sensitivity analyses have not been done and probably will not be done in a completely systematic way. It is possible, however, to point to some factors which appear to be quite important but which are often overlooked. I will just mention two and refer you to the individual model component descriptions for others.

The number of households is a basic determinant of residential energy consumption. Demographic trends indicate a decline in the average household size historically, and national projections presume a continuation of that trend. The result is that population alone is not an adequate indicator of residential energy demand. A modest growth in population may be consistent with a substantial growth in energy consumption if the number of households is growing rapidly.

The demand for energy and for energy provided by particular fuels is, in Alaska probably more than anywhere else in the nation, a direct result of state policy decisions. The state owns substantial energy resources; it has sufficient monetary resources to provide for the delivery of virtually any fuel to any region of the state; and the development of Alaska's energy resources and the distribution of those resources to the citizens of the state are very important political concerns. Because of these three facts, state policies will--consciously or unconsciously--affect the availability and relative prices of various fuels. Regulatory authority provides another means for affecting energy requirements levels.

For example, the state could probably assure an adequate supply of natural gas for the Southern railbelt for the foreseeable future by swapping some of its Prudhoe Bay royalty gas for Cook Inlet reserves,

UNIVERSITY OF ALASKA

Mark Wittow
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which it would then sell to the Anchorage utilities. (Obviously, I am not advocating such a policy but merely presenting it as an example.) The result of such a policy would be that natural gas would continue to be used for space heating in Southcentral Alaska and perhaps for electricity generation also, and the demand for electricity would grow relatively slowly.

This suggests that the real use of the end-use model will be in indicating to state analysts the range of possibilities which the state itself can affect. Alaska, as a state, need not sit back and wait for its energy future to develop. Rather, it seems to have the potential for creating it and, in all likelihood, it will create it.

The third portion of the report is a description of the use of the end-use projection model. The result is not a projection. It is a "dry run" of the model to see whether it works, where it is weak, and where further work is required before actual projections can be done. The "dry run" shows how the model works and how the model results will be presented in the final report. It is our intention to present a series of projections in the final report to the legislature demonstrating the range of variation in future demand projections as well as the range of impact of government policies.

Several areas where further work will be necessary have been identified and others will, no doubt, be suggested by those reviewing this progress report. Particular areas already identified as needing more refinement are:

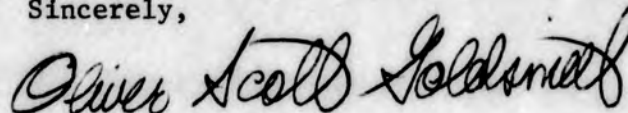
1. The end-use inventories
 - a. Space heat mode split
 - b. Average space heat energy consumption
 - c. commercial-industrial floor space
 - d. commercial-industrial average energy consumption
2. Development of energy price and availability scenarios
3. Projection of appliance mode split model parameters
4. Projection of appliance utilization and saturation rates.

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With the completion of this progress report, work turns to the refinement of the model components and preparation of a set of demand projections.

Sincerely,



Oliver Scott Goldsmith
Assistant Professor
of Economics

OSG/ds

Enclosures

P.S. I have just received a copy of a letter from the Alaska Power Authority to Representatives Malone and Rogers concerning "slippage" in the ISER work under our contract with your office. I can understand the concern of the Power Authority over a possible delay. The letter seems to imply that there is a potential problem and that ISER is to blame. I feel I should respond briefly.

First, ISER fully intends to produce the complete, final report by the May 15 deadline as specified in our contract.

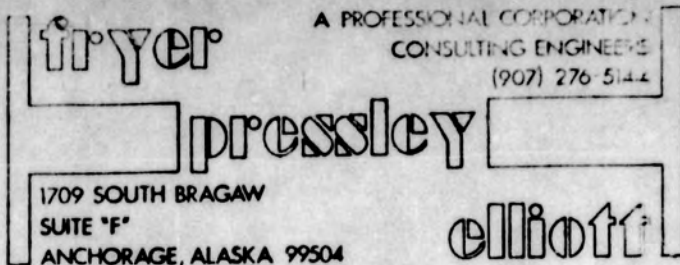
Second, the letter implies that Subtask 1.02 cannot begin until our draft report is complete. (Subtask 1.02 is the Development of Peak Load Forecasts.) This is not the case, since work on that task by Woodward-Clyde Consultants has already begun, according to Jim Landman of Acres American. In addition, to the best of my knowledge, Woodward-Clyde did not have a contract on March 3, 1980, the date when Subtask 1.02 was to begin.

Third, there is a data availability problem, as I have long maintained; but to characterize it as a data collection problem may be misleading. If data does not exist, there is no way that I know of to collect it. ISER has attempted to collect all the data available within the time and budget constraints of the study. A reevaluation of the data available in light of the study requirements may result in a decision to provide additional funding to the data collection effort, but it may also result in a change in the perceptions of the study users concerning what is "required."

P.P.S. The extra copy is for Energy Probe if they arrive in Juneau before receiving their copy which I sent to Toronto. Scott

SCOMM

#44:19



Mark

APR 17 RECD

April 11, 1980

Mr. Vic Fischer
Alaska Center for Policy Studies
221 East 7th, #204
Anchorage, Alaska 99501

RE: Final Report on Alternate Energy Resources.
Alaska's Railbelt

Dear Vic:

Transmitted herewith is our final draft of the subject report. Please add Rich Seifert's Solar Report, previously transmitted as an appendix to our report. Looking forward to your comments.

Sincerely,

FRYER : PRESSLEY : ELLIOTT

Mark Fryer

Copies to: Jim Babb
Brian Rogers
Mark Wittow
Rich Seifert
Eric Meyers
Scott Goldsmith

ALTERNATIVE ENERGY RESOURCES OF ALASKA'S RAILBELT

Prepared for
Alaska Center for Policy Studies

as part of a study for
House Power Alternatives Study Committee

BY:
FRYER : PRESSLEY : ELLIOTT, INC.
1709 South Bragaw
Anchorage, Alaska 99504

April, 1980

OUTLINE OF ALTERNATE ENERGY SOURCE

1.0 SUMMARY

2.0 INTRODUCTION

3.0 METHODOLOGIES

- 3.1 Micro-Hydro
- 3.2 Wood Resources
- 3.3 Solar Potentials

4.0 THERMODYNAMIC MACHINES

- 4.1 Electric Power Plant Fuels
- 4.2 Waste Heat

5.0 OTHER TECHNOLOGIES

6.0 CONCLUSIONS

7.0 RECOMMENDATIONS

- 7.1 Engineering Data
- 7.2 Waste Heat Studies
- 7.3 Technology Availability

APPENDIXES

- 1. Calculations
- 2. Solar Study

ACKNOWLEDGEMENTS

Fryer : Pressley : Elliott, Inc., was assisted in the preparation of this work with substantive contributions from Skip Roy and Bruce Melzer concerning wind power, Will Theuer concerning wood resources and Richard Seifert of the University of Alaska concerning solar resources. Roy Barkwell of Fryer : Pressley : Elliott, Inc., was responsible for a good share of documents research and micro-hydro potential analysis.

1.0 SUMMARY:

The magnitude of the annual energy consumption for use in space heating and electric power production for the Railbelt Region of Alaska is about 53 trillion BTU's per year.¹ If the range of values expressed in Table 1 is acceptable, the maximum practical exploitation of alternative energy resources could conceivably provide up to perhaps 10% of current energy use, or perhaps 5 trillion BTUs per year. Further, if steps as significant in scope as those suggested for exploitation of alternative energy were taken in the area of energy conservation and, as a result, energy use were decreased (on a per capita basis) by say 17%, then alternative energy resources could serve as much as 12% of the Railbelt Region's electric and thermal energy requirements.

Table 1 lists "reasonable levels" of alternative energy use expressed as a percent of the total raw energy potential currently consumed in the Railbelt Region for electric power generation and for space heating. Fuels used in transportation and industrial processes are neglected in the analysis. The values shown in the table are meant more as an aid to ranking the potential use of the various alternatives, than as an accurate quantification of the resources potential.

The term "reasonable level" is subjective, and is based on engineering judgment rather than laws of physical science or explicit economic equations (see 3.0 methodologies).

Table 1 indicates that the most promising alternative resources are solid waste used as electric generation plant fuel, fuel wood for residential heating, and waste heat recovery from electric generation plants.

In order to achieve these levels of alternative energy utilization, some environmental effects would be realized. For example:

° Wood Resource:

From this resource, to obtain 10% of the 1980 home heating fuel requirements 3,000 acres of virgin forest land would be logged for firewood each year.²

° Micro-Hydro Resource:

To provide the equivalent of 1 1/2% of electric generation fuel, the precipitation from about 134 square miles located in the center of the railbelt would be collected. To accommodate continuous, year round generation, some of this water would be impounded. Such storage will extend over perhaps 22 square miles of new and existing lakes. If 25% of this lake surface is newly created to accommodate the development of micro-hydro, 3,520 acres of land will be flooded by such development.²

¹At the time this paper was written "End Use" analysis portions of this project were not complete. The value given in the text is therefore an estimate made by the authors. See appendix of calculations.

²See appendix of calculations.

TABLE 1. Summary of Alternative Energy Potential

<u>Resource</u>	<u>Potential Fraction of 1980 Energy Consumption</u>		<u>Rank</u>
	<u>Thermal</u>	<u>Electric</u>	
° Solid waste combustion as a co-generation fuel.	Included in Waste Heat	6% to 7%	1
° Wood Resources	3% to 4%	--	2
° Waste heat recovery from electric generation plants	1 1/2% to 2%	--	3
° Solar Energy (year 2000) (includes Passive Solar)	0.3% to 1 3/4%*	Photovoltaic ?	4
° Micro-Hydro (end use)	--	1 1/2%	5

* Upper limit includes possible contribution of passive solar design techniques which could be incorporated in future building construction.

2.0 INTRODUCTION:

The information contained herein has been compiled specifically for use by the Alaska Center for Policy Studies as background information for a broader study. This work is not at all intended to be comprehensive; it is intended rather, to place the alternative energy resources that are accessible within Alaska's Railbelt, into perspective with both current technologies and the physical environment of the region.

In order to discuss alternative energy, and related technologies, it is necessary to first define some terms. In this area many popularly used terms are frequently misused; for the purposes of this work, we wish to narrowly define the terminology.

Alternative Energy refers to an energy source or energy technology that is not expected to significantly use non-renewable energy resources. An energy resource that is renewable, or an energy technology that deals with such renewable energy resources.

Micro-Hydro means a hydroelectric facility capable of producing 500 kilowatts or less at peak output.

Solar Energy means that energy contained in the rays of sun used for space heat or photovoltaic conversion to electric energy. (Note: Specifically omitted from this definition are hydro, wind, biomass, etc.)

The objective of this paper is to place some alternative energy resources and technologies into the technical and economic perspectives of the late twentieth century, and into the physical environment of the Railbelt Region of Alaska.

The scope of our work has been limited to a "survey" that specifically excludes transportation, communication and developmental technologies such as fusion, orbital solar power stations, and ocean thermal, etc.

ALTERNATIVES SURVEYED

During the course of this work, six alternative energy resources were examined:

- | | |
|---------------|--------------|
| ° Micro-Hydro | ° Solar |
| ° Wind | ° Waste Heat |
| ° Solid Waste | ° Wood |

The surveys undertaken are qualitative and geographic; however, no distinction as to land ownership, covenant or legal restriction has been made. Obviously, land disposition and ownership have significant impact on resource availability. Thus, the abundance of such resources as wood and micro-hydro are necessarily overestimated.

3.0 METHODOLOGIES:

3.1 Micro-Hydro:

Micro-hydro feasibility is dependent upon a number of factors. Most prominent however are the quantity of water available and the head, or vertical distance, the water may fall.

For example, a lake of elevation 150 feet and located near the sea, containing 5 million cubic feet of water will possess a potential energy of 46.8 billion foot-pounds. Were that lake to be drained over the period of a year, the potential work available would be a continuous 2.7 horsepower or about 2 kilowatts (Note: Machine efficiencies, and friction, etc., neglected).

If that lake is the low point of a 10 square mile basin that experiences an average rainfall of 20 inches per year, about 15 cubic feet of water each second will leave the lake making a potential for work of a continuous 250 horsepower or 187 kilowatts of electricity.¹

As the imaginary lake is moved further and further away from the site of the power plant, the longer the pipe required to carry water from the lake to the power plant. The lengthening of the pipeline has two effects:

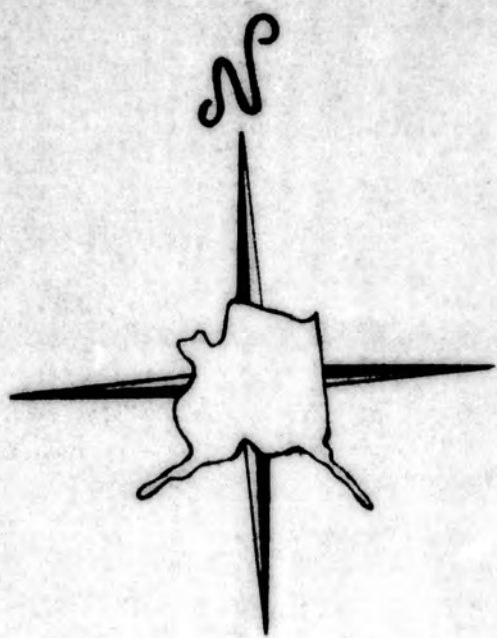
- a. The cost of the project is increased because of the longer pipeline and required right of way on which to lay pipe, and
- b. More inefficiencies will characterize the system because of frictional losses as the water flows through the pipe.

The relationship between horizontal distance and elevation change is defined as the "slope." The slope of the terrain plays an important part in assessing the feasibility of micro-hydro potential. Rainfall also influences the energy potential; obviously, if the rainfall is cut in half, the theoretical potential will also be halved.

The method used herein to survey the potential for micro-hydro was to construct a slope map of the railbelt, overlay a precipitation map for the region and combine the two parameters to obtain a "potential index."

This potential index neglects such effects as seasonal flow variations which are very important in the feasibility of micro-hydro potential. Such factors are, however, site specific and cannot be quantitative in this overview paper. Furthermore, the annual freezing index (a parameter used to estimate depth of frost penetration and thickness of lake ice, etc.) affects the annual variation in flow of streams. We have neglected this factor as well, since the relationship between the variation in the flow of small streams and the freezing index is poorly known and is also site specific.

¹See appendix of calculations.



INDICATES LIMITS
OF AREAS STUDIED

FAIRBANKS

TAHANA RIVER

TAHANA

McKINLEY
PARK

GLACIERS

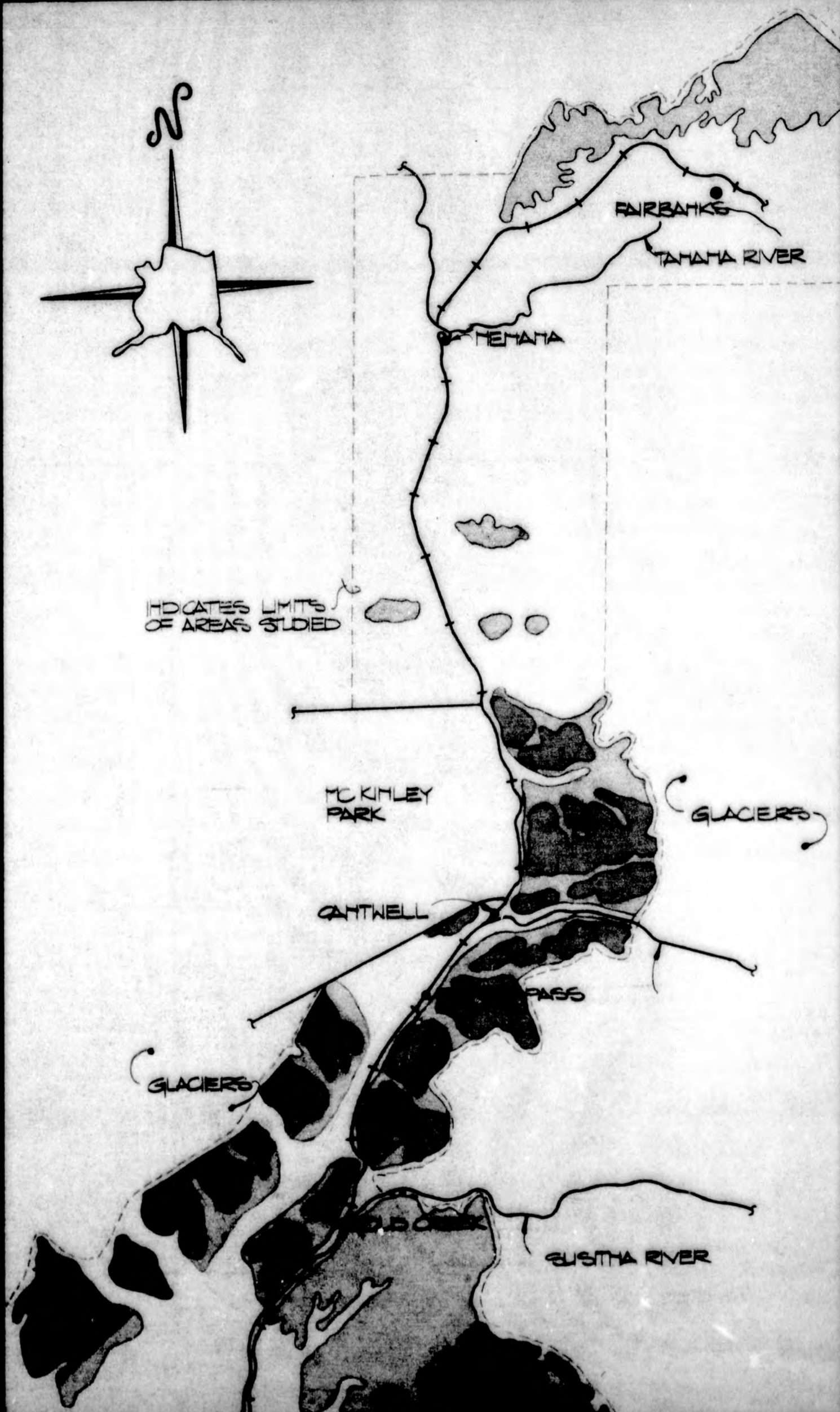
CANTWELL

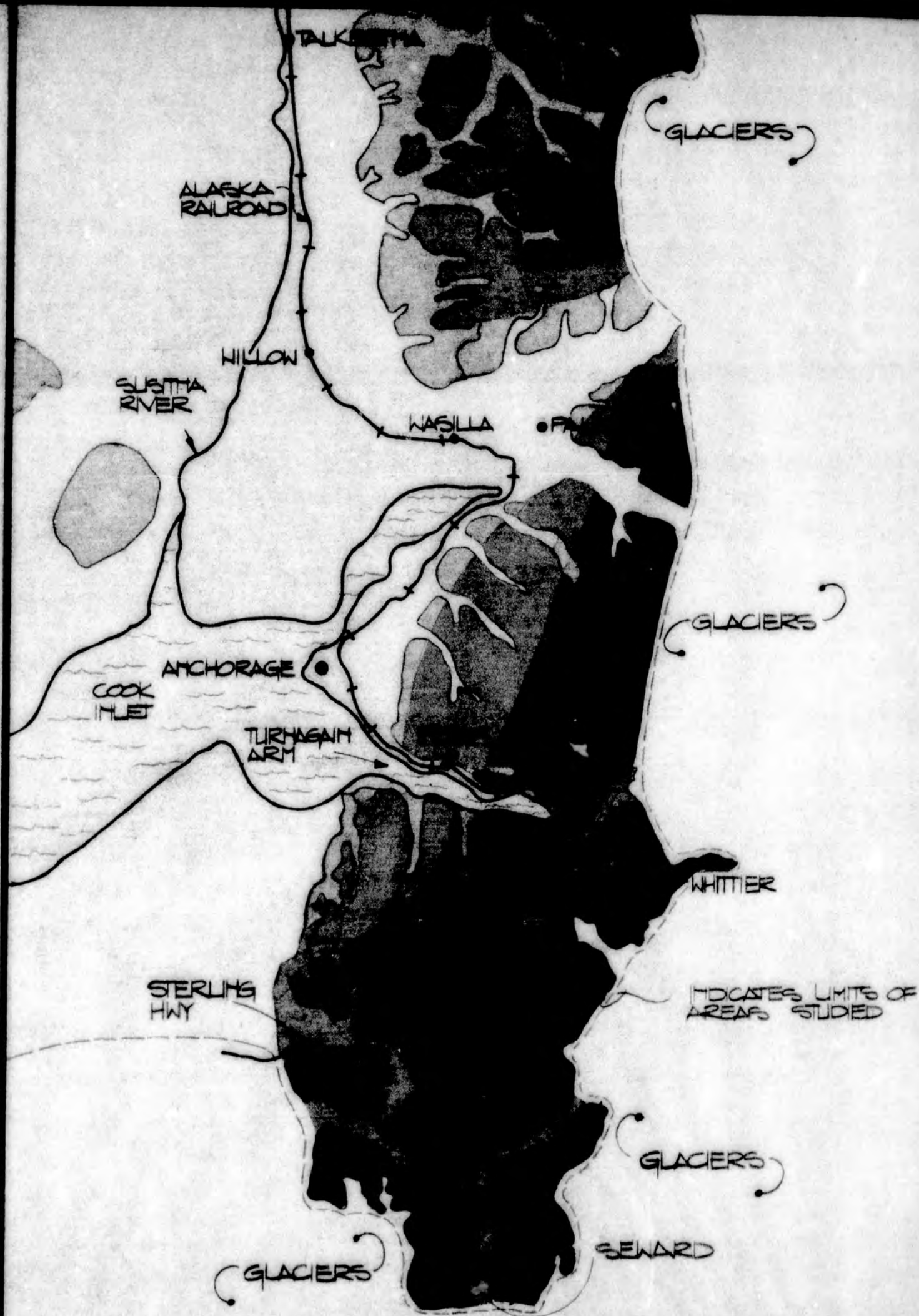
PASS

GLACIERS

OLD CREEK

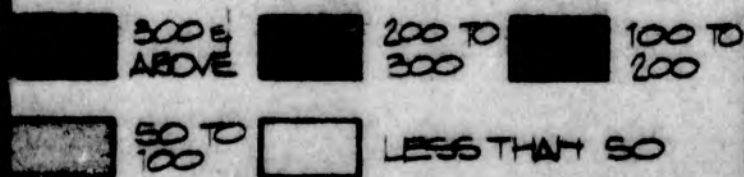
SUSTHA RIVER





MICRO-HYDROPOWER POTENTIAL

SCALE 1:1,000,000 STATUTE MILES



MARK FRYER & ASSOC.
CONSULTING ENGINEERS
ANCHORAGE, ALASKA
2/80 R.B.

A micro-hydro potential map has been constructed by plotting and contouring the potential index data derived by overlaying a slope map of the Railbelt Region with a precipitation map. This potential map compares well with run-off maps constructed by the U.S. Geological Survey.

The potential map could be used to estimate approximate potential of a micro-hydro site. The potential index is derived such that for every 100 square miles of watershed area, the index approximates the continuous kilowatt production potentially available from that area. A reasonable length of penstock is assumed and a potential head of 50 vertical feet used as a basis of calculations.

For potential indexes below 50, it is assumed that penstock length would be too great for gravity head dependent micro-hydro schemes. It is assumed that hydro power for these smaller potential ranges would be developed from stream velocity head only.

For the purposes of estimating micro-hydro potential, the authors have assumed that the development of 50 micro-hydro projects averaging 50 kilowatts of continuous output each is probably an upper limit to the exploitation of this technology. This assumption is made presuming that the current economic and land disposition environment is static. The assumed development would require between 10 million and 20 million 1980 dollars for capital investment.

Should economic and social conditions cause hydroelectric projects to become more attractive than they are today, emphasis should move away from micro-hydro to larger hydro projects because of their obvious cost and environmental advantages, thus limiting the expansion of the use of micro-hydro technology.

Considering the above noted assumptions, it is the judgment of the authors that an aggregate of perhaps 2.5 megawatts of installed micro-hydro is a reasonable upper limit to the expanded use of this technology.

3.2 Wood Resources (Fuel Use):

Under contract arrangements with Fryer : Pressley : Elliott, Inc., Will Theuer undertook a survey of wood as a fuel resource. The following is a resume of that survey.

Landsat satellite imagery in black and white as well as multi-spectral color reconstituted imagery were analyzed in order to estimate the extent of the fuel wood resource. Seven land categories were developed for the purpose of the analysis as follows:

1. Non Forest Land
2. Urban Areas
3. Water
4. Commercial Forests
(defined as containing 2,000 cubic feet
of wood or more per acre)

5. Fuel Wood Type 1
(Land containing up to 1000 cubic feet of wood per acre)
6. Fuel Wood Type 2
(Land containing 1000 to 2000 cubic feet of wood per acre)
7. Sparsely Covered Ground
(Containing about 500 cubic feet per acre)

As in the hydro work, political boundaries were disregarded.

Table 2 summarizes the fuel wood potentials. In total, at this time, the energy equivalent of about 180 million barrels of oil is determined to be contained within an area approximately 30 miles wide from Seward to Fairbanks. The amount of this energy obtainable on a sustained annual basis would be the subject of an extensive study. However, as a general observation the actual productivity is invariably different from potential productivity. It is theoretically attractive to use a scheme based on assumed potential of land; however, actual productivity will be largely determined by current vegetation and management methods. Forestry in this regard is unlike agriculture, where productive potential is quickly realized.

Mr. Theuer as well as others point out that progressive management of this resource could, over the study period substantially increase the yield of our timber stands. For example, thinning some stands to acquire fuel wood could, if managed properly, result in the promotion of commercial stands of timber at a later date.

The potential for the use of wood as a heating fuel was determined through the consideration of several assumptions as follows:

1. Extensive use of fuel wood will meet price competition with coal.
2. The equipment required to burn wood efficiently is not substantively different than coal burning equipment.
3. The inconvenience of wood burning as opposed to other sources of thermal energy will limit the use of wood fuels to the residential sector.
4. The aesthetics of wood burning, as well as the low cash cost to the individual of the harvest (and to a degree the personal pleasure the individual may experience during wood harvest) will act to promote the use of wood as a fuel.
5. Most multi-family dwelling units are not equipped to burn wood with convenience, thus limiting the use of wood to single family dwellings.

Therefore, even though the fuel wood resource is extensive, economic lifestyle and convenience will limit the use of this resource to the roll of a secondary fuel source for single family dwelling units.

Table 2: Estimate of Fuel Wood Potential Located In Alaska's Railbelt

STUDY AREA	FUEL WOOD LANDS (MILLIONS OF ACRES)			ESTIMATED RESERVE (MILLIONS CUBIC FT.)	THERMAL POTENTIAL 10 ¹² BTU	EQUIVALENT/ BARRELS OF OIL (MILLIONS)
	Fuel Wood Type 1	Fuel Wood Type 2	Fuel Wood Total			
Fairbanks	0.54	0.26	0.80	415	111	19.1
Nenana	1.57	0.55	2.12	1,600	430	73.5
Talkeetna	0.50	0.47	0.97	950	256	44.1
Cook Inlet	0.52	0.52	1.04	1,000	279	47.6
Seward	0.04	--	0.04	210	5.56	0.9
TOTALS	3.17	1.80	4.97	4,175	1081.6	185.2

NOTE: Fuel wood type one contains up to 1000 cubic feet per acre.
 Fuel wood type two contains between 1000 and 2000 cubic feet of wood per acre.

4.0 THERMODYNAMIC MACHINES:

The second law of Thermodynamics (credited to Rudolf Clausius, a 17th century German physicist) is the law that stops most "Perpetual Motion" machines from being workable. In practice the second law of thermodynamics requires coal, oil and gas fired, electric generation plants to reject heat to the environment. Large coal fired power plants reject heat into rivers or use cooling towers. Smaller power plants usually reject heat directly to the air (small diesel plants for example).

Modern electric generation plants (such as supply the Railbelt's electric needs) range in efficiency between 20% and 30%. That is to say that for every unit of chemical energy delivered to the electric generation plant, only 0.2 to 0.3 units of electric energy leave the plant, the remaining energy is rejected in the form of "waste heat". Since the efficiency of conversion of chemical energy to electric energy characterized by the electric power generation plant is frequently much poorer than the conversion efficiency of chemical energy to thermal energy of the residential furnace or water boiler, electric heat is not typically energy conservative. The residential natural gas or oil fired burner typically operates between 60% and 80% efficient, while electric heat is probably less than 20% fuel efficient.

When power plants are designed to recover and use waste heat for process energy requirements or for space heat, the plant so designed is termed a co-generation plant. Such plants are now in use at Fairbanks and on some Alaska Military bases.

It is obvious that two features of the thermodynamic, electric generation process can be addressed as a topic of alternate energy discussion. First, the fuel used to fire the plant could be a fuel derived from renewable resources and second, the heat wasted from the thermodynamic process could be used as a part of the heating energy required of the region.

4.1 Electric Power Plant Fuels:

The capital cost of electric power generation plants is governed to a large degree, by the character of the raw fuel it relies on for its basic energy supply. On the one end of the spectrum, natural gas and high quality fuel oils can be burned directly. Gas turbines are probably the cheapest electric generator prime mover for commercial sizes of electric generation plants.

As the quality of the primary fuel is reduced, steam is generated to drive the turbine, which in turn drives the electric generator. The steam is produced by boilers which are designed to convert the chemical energy of the primary fuel to thermal energy. The equipment required to store, process and convey the primary fuel is more or less elaborate depending again on the quality and consistency of the primary fuel.

Further, the need for environmental plant features, bag houses, flue gas scrubbing, etc., and the cost of those features is dependent upon the quality of the primary fuel. Thus the processing and burning equipment required for solid waste fuel costs more than that required of wood burning, which costs more than coal burning equipment, which in turn costs more than heavy oil burning equipment, which costs more than light oil burning equipment, which costs more than natural gas burning equipment.

For use in electric generation plants, coal is a superior fuel to wood or solid waste (the two most obvious alternative chemical fuels). The environmental impacts of large scale harvest of wood fuels are in some ways, probably comparable to open pit coal mining. This statement is based on the assumption that a thousand acres of forest land would yield about the same energy as mining a single acre of coal.¹

Furthermore, coal, though nonrenewable is an abundant resource of Alaska. However, once coal became a readily exportable resource, natural price pressures could conceivably rise to a level that would make wood a valuable electric generation fuel. Until that time, however, wood used as an electric generation fuel will be limited to areas of the state that harvest lumber and pulp wood and incidentally create quantities of slash or sawdust, and perhaps rural areas where wood is a readily available local resource. This waste wood has a negative value, since it must be disposed of in an environmentally acceptable way; a way that generally creates costs to the timber or mill operations. In these cases electric generation from mill wastes appears to be potentially feasible.

Similarly, solid waste materials so profusely generated by urban communities, have a negative value. Since landfills require expensive real estate, and acceptable disposal thereon generates additional costs, use of solid waste as a fuel for electric generation becomes interesting.

The solid waste materials currently generated by the Greater Anchorage Area contain enough chemical energy to fire a 20 megawatt power plant. The economics of using this fuel rather than coal have been examined and found to be marginal; however, new technology, or a marked increase in coal prices could make such an option attractive.

¹See appendix of calculations.

The economical use of solid waste as a fuel for electric generation plants is dependent upon the scale of operation. Currently, maintenance intensive equipment is used to condition the waste materials into a fuel. Further, the burner equipment required must be suited to the fuel (fluidized bed burners for example), and conditioning of the gases that result from the combustion process is required for obvious environmental requirements. All of these elements of the process demand full time operators to attend to the facility. The labor costs of such attendance are only warranted when basic economics of scale are met. Coal generation plants of traditional design are subjected to most of the same sort of economic limitation as have been described for solid waste fired plants. Thus, solid waste fuel becomes an option to coal.

4.2 Waste Heat

Over the period of a year the average railbelt resident consumes about 5000 kilowatt-hours (17 million BTU's) of electric energy and about 69 million BTU's of space heating energy. In order to produce the electric energy, the electric utility consumes nearly 85 million BTU's of fuel. The difference between the 17 million BTU's and the 85 million BTU's (68 million BTU's) is typically lost as: a) "Second law" heat (50 million BTU's), b) stack and plant losses (17 million BTU's) and c) electric transmission losses (1.7 million BTU's). The 50 million BTU's of "second law" heat is of high enough quality (temperature) to be used for ordinary space heating or process heat.

It is obvious that the waste heat could go a long way in the supply of space heating energy requirements of the residents if, somehow, it could be made available for such use.

Modern waste heat space heating systems use hot water, pumped from a co-generation plant to the building spaces. Since such systems require large insulated water pipes to supply heat to various buildings, the beneficial use of this energy resource becomes more and more expensive the further from the generation plant the point of use becomes. Studies produced by the new Capital Site Planning Commission suggest that the ratio thermal load to distance for the economical service with district hot water space heat, is about 30 million BTU's per foot of distance from power plant to heat consuming space. Thus, to transmit waste heat from a power plant to a point of use five miles away, for example, the annual thermal load would have to be about 800 billion BTU's or the equivalent of the thermal consumption required of a 12,000 population community.

In the recent past, power generation plants have been located away from densely populated areas because of the noise and pollutants produced by such plants. Thus, adding waste heat recovery features to existing power plants is often difficult to justify from a cost view; the transmission of waste heat becomes too costly.

For the purposes of this work, the Fairbanks Municipal Utilities downtown power generation facility, the University of Alaska's co-generation plant located in Fairbanks and a new, solid waste fired plant designed to consume the solid waste co-generated by the City of Anchorage were surveyed as being potential sources of waste heat.

Other plants in Anchorage and at Healy, Alaska may show promise upon indepth study, however the limited resources of this survey precluded analysis of any but the obvious schemes.

The estimated "second law" heat available from the options briefly examined during this work amounted to an additional 0.5 trillion BTUs annually that could be collected and used for space heat.

In the case of Fairbanks, the bulk of this conserved energy could be used to heat spaces currently electrically heated. Thus, the savings would be marked by affecting the peaking generation problems Fairbanks has suffered in the past.

5.0 OTHER TECHNOLOGIES

Geothermal energy, tidal power and wind power are energy resources properly termed "alternative." We are unable to find substantial application for any of these resources except by application of unproven technology such as "hot rock" geothermal or the very large tidal project proposed for Knik Arm. Some estuaries along the Cook Inlet could be used for smaller tidal power projects; however, it is the opinion of the authors that such projects would prove financially unfeasible, if not environmentally unacceptable.

At the outset of this project, it was assumed that some wind power potential would be identified. However, examination of 19 weather stations indicate but marginal potential for only two locations (Gulkana and Homer) one of which actually falls outside of the study area.

6.0 CONCLUSIONS:

Perhaps ten percent of the energy budget accounted to residential, institutional and commercial buildings, located within the study area, could be provided through alternative energy sources examined during the course of the work reported upon herein. Of the resources surveyed, use of solid waste fuel, wood fuel, and waste heat rejected from electric generation plants, appear to hold the greatest promise.

Solid waste fuel and waste heat recovery potentials are primarily located in the Anchorage and Fairbanks areas and lend themselves well to large demonstration type projects.

The competition of coal as a fuel for electric power generation will limit the use of wood to residential heating, primarily supplemental to electric, oil and gas fired systems. Most single family residences, however, could be fitted with efficient wood fuel heating equipment; thus this potential seems an attractive alternative.

A potential savings of up to 30% of the heating fuels could theoretically be achieved with passive, solar design; provided that the home was not located on a shady site (i.e. northern slope or heavily "treed" location). Such benefits are only practically achieved (on a large scale) with new construction. Assuming 30% of new construction were designed to exploit this resource, by the year 2000, the annual savings realized through application of this technology is probably on the order of 10^{12} BTU's per year, (equivalent of 170,000 barrels of oil) or about 1% of the year 2000 energy requirements of the residential, institutional, and commercial building energy needs of the Railbelt. Active solar could also contribute to domestic water heating.

Benefits from micro-hydro are somewhat small. Not that the resource is itself small but, rather, energy from micro-hydro must be used close to the point of generation. The demand for such power in areas removed from densely populated areas is small compared to the demands of the whole. Large capital costs considerations together with regulatory costs and competition from electric utilities also discourage the exploitation of this resource. By the year 2000, if 50 micro-hydro sites were developed to deliver an aggregate of 2.5 megawatts of continuous output, perhaps, 0.3×10^{12} BTU's annually of electric generation fuel could be saved. This amount of fuel is about one percent of the residential commercial and institutional electrical energy budget.

Benefits from tidal, electrical, wind power, and geothermal are negligible.

7.0 RECOMMENDATIONS:

It is recommended, that the state set up a program that could:

1. Streamline the permit acquisition process for small and micro-hydro site development.
2. Arrange for the management of the railbelt wood resources so as to encourage harvest of fuel wood at locations near to densely populated areas. Such management may require the development of access roads as well as the selection of suitable lands and management of the harvest itself.
3. Develop a program that would assist the layman in the technical aspects of solar design, micro-hydro feasibility analysis and energy products selection.
4. Encourage municipal and borough governments in the assessing of feasibility of solid waste fuel potentials and waste heat capture and distribution schemes.

NOTE: Significant opportunities exist for large scale energy conservation demonstrations at both Anchorage and Fairbanks International Airports -

- ° The airport at Fairbanks is electrically heated to avoid air pollution.

The facility was designed during a time of cheap energy, thus not only the heating, ventilation and air conditioning systems but the building envelope as well could be upgraded for conservation purposes. District heat concepts with heat pump and heat storage could significantly reduce non-renewable energy consumption.

- ° Another project that could yield benefits is the upgrade of the district heating system currently serving the core area of Fairbanks. Not only would this project result in substantial economic savings to the people of that community, it could potentially reduce the fuel oil consumption of that community by perhaps a million gallons of oil per year.
- ° The electric and thermal energy loads required of the Anchorage International Airport are of such a character that a solid waste fired co-generation plant with waste heat and heat pump features could reduce the need to consume non-renewable fuels to zero.

The projects cited above will demonstrate payback periods for capital investment attractive to the institutional owners, while demonstrating alternative energy technology and reducing our dependence upon oil and natural gas fuels.

- ° The requirements of these projects suggest a comprehensive solution which would include the University of Alaska's co-generation plant as well as the Municipal Utilities facilities located near downtown Fairbanks.
- ° The non-renewable resource aggregate savings of these projects suggested above are perhaps 0.5×10^{12} BTU's per year (on the order of 1% of the total energy consumed by the residential, commercial and institutional buildings of the Railbelt area).

RECOMMENDED WORK TO BE DONE

7.1 Engineering Data:

There does not now exist adequate engineering data on the environment of the Railbelt. The following information should be collected on a regular basis at every proposed project or population growth site along the Railbelt:

1. Population
2. Wind profiles in three components: direction, height and velocity
3. Stream gauging and hydrology, periodically throughout the year
4. Temperature
5. Precipitation
6. Solar measurements periodically throughout the year. (Both diffuse and incident normal)
7. EPA base line air quality
8. EPA base line water quality

In order to accomplish this accumulation of information a scientific group consisting of the following expertise should be formed:

- ° Solar Specialist
- ° Hydrologist
- ° Environmental Engineer
- ° Weather Specialist
- ° Data Collection Coordinator

These specialists should select specific sites and design standard data collection stations.

Other probable groups to involve in project planning:

- ° University of Alaska
 - Institute of Water Resource
 - Arctic Environmental Information and Data Center
 - Geophysical Institute

- ° State of Alaska
 - Division of Energy & Power Development
 - Department of Environmental Conservation
 - Department of Transportation
 - Alaska Power Authority
 - Department of Natural Resources
 - Department of Environmental Conservation
- ° Federal Government
 - U. S. Geological Survey
 - U. S. Department of Environmental Quality
- ° Private Consultants
- ° Other Interests
 - Local Governments
 - Local Utilities
 - Local business interests, such as Usibelli Coal Co.
 - Native Corporations

The idea suggested here is that the groups cited would develop a comprehensive project plan and budget and select individuals to represent the specific technologies required of the project. One group would be named project coordinator. That group would be charged with the responsibility of carrying out the data collection, analyzing the data and making the results of analysis available to the public.

This project should be thought of as a long-term commitment of the State; a commitment to the development of alternate energy resources as well as collecting information required of resource development in general.

7.2 Waste Heat Studies:

A comprehensive study of waste heat utilization and district heat transmission and distribution should be undertaken for the Railbelt Region of Alaska. Such an effort should result in the documentation of feasibility and recommended capital projects. Further, the study should address the local political realities of current utilities management and make appropriate recommendations.

7.3 Technology Availability:

The technologies dealing with both solar and micro-hydro are difficult for the lay citizen to grasp. Because of the small scale of projects that exploit these technologies, the cost of professional expertise may, in many cases, be prohibitive. Thus, the appropriate technology could be made available through some sort of "energy extension service."

This concept is not at all new. The Federal Government now promotes such a program. The State, however, could augment Federal efforts and cooperate with various Federal programs and the State University to deliver the required technology to the individual citizen.

Should such a program be developed, the administrator that heads it must be an experienced engineer. The problems to be dealt with, though superficially informational, are founded in applied engineering science, not political policy, nor developmental science. Hydro projects frequently require impoundment of water for the storage of potential hydro energy. The untimely release of that stored energy can obviously devastate property and populace located down stream of the impoundment site. The risk of poor professional consulting to builders of hydro projects, large or small, is a risk to human life.

In addition to assisting the citizen to design and construct solar or hydro energy facilities, the "energy extension" should "approve" or "endorse" various products available to the public. These products include:

- Solar panels
- Wood burning stoves
- Hydro turbines and wheels
- Electric generators
- Solid state control accessories
- Storage systems
- Thermal insulations
- Thermally resistive building products such as windows, doors, weatherstripping, etc.

Some products that purport to save energy for the home owner are of marginal value. The lay citizen has little or no basis for selection among the profusion of products now on the market. Experts in the field could help the citizen to sort through the various products and recommend a variety for the consumer's choice, a variety that is well-conceived, of recognized quality, and most importantly, fits the application for which it is intended.

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RAILBELT ALTERNATE ENERGY SURVEY
Appendix of Miscellaneous Calculations

1. Population

- 1980 = 285,000 (Assumed)
- Growth = 3% (Assumed)
- 2000 = 515,000

2. Built Space

- Residential = $\frac{350 \text{ sq. ft.}}{\text{capita}}$ (Assumed)
- Non-Residential = $\frac{150 \text{ sq. ft.}}{\text{capita}}$ (Assumed)

	1980	Δ	2000
Residential sq. ft.	99,750,000	80,500,000	180,250,000
Units	95,000	76,667	171,667
Non-Residential sq. ft.	42,750,000	34,500,000	77,250,000

3. Energy Use (Assumed)

	Unit Consumption (sq. ft./yr.)	
	Thermal	Electrical
Residential	120,000 BTU	5.5 KWH
Non-Residential	185,000 BTU	20.0 KWH