

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILES 86/2

975 SCOMM44: HOUSE POWER ALTERNATIVES STUDY COMM. 1979-80 975

TABLE 8A

RESIDENT RETURNS - 1977

AGI Thousands of Dollars	Resident Returns		Residential Fuel Credits		Residential Fuel Conservation Credits	
	Number	%	Dollars	%	Dollars	%
0-5	30,590	15.7%	\$ 80,369	2.9%	\$ 13,840	1.7%
5-10	20,249	10.4%	\$ 185,026	6.6%	\$ 35,284	4.3%
10-15	17,335	8.9%	\$ 246,625	8.8%	\$ 56,396	6.9%
15-25	26,976	13.8%	\$ 539,056	19.3%	\$157,313	19.3%
25-50	39,983	20.5%	\$1,271,202	45.4%	\$439,838	53.9%
50+	8,676	4.4%	\$ 344,823	12.3%	\$ 96,933	11.9%
Total	143,809	73.7%	\$2,667,101	95.3%	\$800,104	98.0%

TABLE 8B

PART-YEAR AND NON-RESIDENT RETURNS
1977

AGI Thousands of Dollars	Part-Year and Non-Resident Returns		Residential Fuel Credits		Residential Fuel Conservation Credits	
	Number	%	Dollars	%	Dollars	%
0-5	19,853	10.2%	\$ 19,213	0.7%	\$ 1,072	0.1%
5-10	11,177	5.7%	\$ 23,670	0.8%	\$ 2,703	0.3%
10-15	6,543	3.3%	\$ 19,666	0.7%	\$ 2,225	0.3%
15-25	7,082	3.6%	\$ 28,116	1.0%	\$ 2,833	0.4%
25-50	5,857	3.0%	\$ 34,028	1.2%	\$ 6,248	0.8%
50+	1,073	0.5%	\$ 6,244	0.2%	\$ 1,013	0.1%
Total	51,585	26.3%	\$130,937	4.7%	\$16,094	2.0%

TABLE 8C

ALL RETURNS - 1977

	All Returns		Residential Fuel Credits		Residential Fuel Conservation Credits	
	Number	%	Dollars	%	Dollars	%
Resident	143,809	73.7%	\$2,667,101	95.3%	\$800,104	98.0%
Other	51,585	26.3%	\$ 130,937	4.7%	\$ 16,094	2.0%
Total	195,394		\$2,798,038		\$816,198	

TABLE 9A

RESIDENT RETURNS - 1978

AGI Thousands of Dollars	Resident Returns		Residential Fuel Credits		Residential Fuel Conservation Credits		Individual Income Tax Credits	
	Number	%	Dollars	%	Dollars	%	Dollars	%
0-5	33,582	18.3%	\$ 120,117	3.9%	\$ 20,664	2.4%	\$ 261,316	1.5%
5-10	20,515	11.2%	\$ 198,191	6.5%	\$ 43,424	5.1%	\$ 1,497,153	8.6%
10-15	17,564	9.5%	\$ 261,918	8.6%	\$ 57,979	6.8%	\$ 1,982,114	11.3%
15-25	25,947	14.1%	\$ 601,140	19.8%	\$155,634	18.1%	\$ 3,687,541	21.1%
25-50	37,260	20.3%	\$1,355,086	44.5%	\$409,109	47.7%	\$ 6,664,510	38.1%
50+	8,483	4.6%	\$ 384,650	12.6%	\$109,006	12.7%	\$ 1,646,278	9.4%
Total	143,351	78.0%	\$2,921,102	95.9%	\$795,816	92.8%	\$15,738,912	90.0%

TABLE 9B

PART-YEAR AND NON-RESIDENT RETURNS
1978

AGI Thousands of Dollars	Part-Year and Non-Resident Returns		Residential Fuel Credits		Residential Fuel Conservation Credits		Individual Income Tax Credits	
	Number	%	Dollars	%	Dollars	%	Dollars	%
0-5	18,088	9.8%	\$ 24,388	0.8%	\$11,235	1.3%	\$ 254,075	1.4%
5-10	9,311	5.1%	\$ 27,485	0.9%	\$15,441	1.8%	\$ 428,898	2.4%
10-15	4,884	2.7%	\$ 20,325	0.7%	\$ 9,460	1.1%	\$ 324,901	1.9%
15-25	4,560	2.5%	\$ 25,318	0.8%	\$13,542	1.6%	\$ 378,608	2.2%
25-50	2,954	1.6%	\$ 22,503	0.7%	\$ 9,872	1.1%	\$ 305,062	1.7%
50+	577	0.3%	\$ 4,486	0.2%	\$ 2,219	0.3%	\$ 63,282	0.4%
Total	40,374	22.0%	\$124,505	4.1%	\$61,769	7.2%	\$1,754,826	10.0%

TABLE 9C

ALL RETURNS - 1978

Type of Return	All Returns		Residential Fuel Credits		Residential Fuel Conservation Credits		Individual Income Tax Credits	
	Number	%	Dollars	%	Dollars	%	Dollars	%
Resident	143,351	78.0%	\$2,921,102	95.9%	\$795,816	92.8%	\$15,738,912	90.0%
Other	40,374	22.0%	\$ 124,505	4.1%	\$ 61,769	7.2%	\$ 1,754,826	10.0%
Total	183,725		\$3,045,607		\$857,585		\$17,493,738	

TABLE 10

RESIDENTIAL FUEL CREDITS

AGI		1977			1978		
Thousands of Dollars		Resident	Part-Year and Non-Resident	All Returns	Resident	Part-Year and Non-Resident	All Returns
Percentage of Returns	0-5	15.5%	18.3%	16.6%	<u>20.5%</u>	25.2%	22.2%
	5-10	41.4%	27.7%	36.5%	<u>50.3%</u>	41.0%	47.4%
	10-15	54.3%	31.3%	48.0%	<u>64.5%</u>	46.3%	60.6%
Receiving a Residential Fuel Credit	15-25	68.6%	34.6%	61.5%	<u>77.8%</u>	49.7%	73.6%
	25-50	84.5%	34.8%	78.1%	<u>89.9%</u>	50.9%	87.0%
	50+	88.3%	29.5%	81.9%	<u>93.1%</u>	43.0%	89.9%
All AGI Categories		57.4%	26.3%	49.2%	<u>62.9%</u>	36.3%	57.0%
Average	0-5	\$16.93	\$ 5.27	\$11.87	<u>\$17.41</u>	\$ 5.36	\$12.62
Residential	5-10	\$22.05	\$ 7.66	\$18.18	<u>\$19.21</u>	\$ 7.20	\$15.96
Fuel Credit	10-15	\$26.20	\$ 9.59	\$23.23	<u>\$23.10</u>	\$ 8.99	\$20.76
Received	15-25	\$29.14	\$11.48	\$27.08	<u>\$29.79</u>	\$11.18	\$27.91
By Returns	25-50	\$37.65	\$16.68	\$36.45	<u>\$40.46</u>	\$14.96	\$39.36
Claiming a Credit	50+	\$45.00	\$19.70	\$43.99	<u>\$48.72</u>	\$18.09	\$47.79
All AGI Categories		\$32.34	\$ 9.63	\$29.12	<u>\$32.41</u>	\$ 8.50	\$29.07
Number of Returns Receiving a Residential Fuel Credit							
		82,478	13,592	96,070	<u>90,125</u>	14,650	104,775
Total Amount of Residential Fuel Credits Received							
		\$2,667,101	\$130,937	\$2,798,038	<u>\$2,921,102</u>	\$124,505	\$3,045,607

TABLE 11
RESIDENTIAL FUEL CONSERVATION CREDITS

AGI		1977			1978		
Thousands of Dollars	Resident	Part-Year and Non- Resident	All Returns	Resident	Part-Year and Non- Resident	All Returns	
Percentage	0-5	0.8%	0.2%	0.6%	1.9%	1.7%	1.8%
of Returns	5-10	2.9%	0.8%	2.2%	5.5%	2.9%	4.7%
Receiving a	10-15	5.0%	0.8%	3.8%	7.9%	3.3%	6.9%
Residential	15-25	8.3%	1.0%	6.8%	11.1%	4.1%	10.1%
Fuel	25-50	13.9%	1.5%	12.3%	16.9%	4.6%	16.0%
Conservation	50+	13.1%	1.0%	11.8%	16.9%	5.0%	16.2%
Credits							
All AGI Categories	7.4%	0.7%	5.6%	9.6%	2.7%	8.1%	
Average	0-5	\$56.95	\$21.88	\$51.07	\$32.39	\$36.60	\$33.76
Residential	5-10	\$59.70	\$30.37	\$55.86	\$38.16	\$56.35	\$41.69
Fuel	10-15	\$65.12	\$44.50	\$64.00	\$41.59	\$59.50	\$43.42
Conservation	15-25	\$70.20	\$38.28	\$69.18	\$53.82	\$73.20	\$54.98
Credit	25-50	\$79.01	\$71.82	\$78.90	\$64.97	\$72.59	\$65.13
Received	50+	\$85.03	\$92.09	\$85.10	\$75.86	\$76.52	\$75.87
By Returns							
Claiming a Credit							
All AGI Categories	\$75.09	\$44.71	\$74.10	\$57.68	\$56.67	\$57.61	
Number of Returns							
Receiving a							
Residential Fuel							
Conservation							
Credit	10,655	360	11,015	13,796	1,090	14,886	
Total Amount of Residential Fuel Conservation Credits Received	\$800,104	\$16,094	\$816,198	\$795,816	\$61,769	\$857,585	

TABLE 12
INDIVIDUAL INCOME TAX CREDIT

	AGI	1978		
	Thousands of Dollars	Residents	Part-Year and Non- Residents	All Returns
Percentage of Returns Receiving an Individual Income Tax Credit	0-5	25.12%	50.96%	34.17%
	5-10	87.28%	79.31%	84.79%
	10-15	96.27%	84.23%	93.65%
	15-25	98.40%	85.48%	96.47%
	25-50	99.64%	83.72%	98.47%
	50+	99.67%	77.12%	98.23%
	All AGI Categories	79.78%	68.19%	77.23%
Average Individual Income By Returns Claiming a Credit	0-5	\$ 30.97	\$ 27.56	\$ 29.19
	5-10	\$ 83.62	\$ 58.08	\$ 76.16
	10-15	\$117.22	\$ 78.97	\$109.74
	15-25	\$144.43	\$ 97.13	\$138.16
	25-50	\$179.51	\$123.36	\$176.00
	50+	\$194.71	\$142.21	\$192.09
	All AGI Categories	\$137.62	\$ 63.74	\$123.28
Number of Returns Receiving an Individual Income Tax Credit		114,365	27,533	141,898
Total Amount of Individual Income Tax Credits Received		\$15,738,912	\$1,754,826	\$17,493,738

TABLE 13

DISTRIBUTION OF CREDITS - 1977

Type of Returns	AGI Thousands of Dollars	Number of Returns	Number of Returns with Fuel Credits	Amount of Fuel Credits	Number of Returns with Conservation Credits	Amount of Conservation Credits
Resident Returns	0-5	30,590	4,748	\$ 80,369	243	\$ 13,840
	5-10	20,249	8,391	\$ 185,026	591	\$ 35,284
	10-15	17,335	9,414	\$ 246,625	866	\$ 56,396
	15-25	26,976	18,496	\$ 539,056	2,248	\$157,813
	25-50	39,983	33,766	\$1,271,202	5,567	\$439,838
	50+	<u>8,676</u>	<u>7,663</u>	<u>\$ 344,823</u>	<u>1,140</u>	<u>\$ 96,933</u>
	Total	143,809	82,478	\$2,667,101	10,655	\$800,104
Part-Year and Non- Resident Returns	0-5	19,853	3,643	\$ 19,213	49	\$ 1,072
	5-10	11,177	3,091	\$ 23,670	89	\$ 2,703
	10-15	6,543	2,051	\$ 19,666	50	\$ 2,225
	15-25	7,082	2,450	\$ 28,116	74	\$ 2,833
	25-50	5,857	2,040	\$ 34,028	87	\$ 6,248
	50+	<u>1,073</u>	<u>317</u>	<u>\$ 6,244</u>	<u>11</u>	<u>\$ 1,013</u>
	Total	51,585	13,592	\$ 130,937	360	\$ 16,094
All Returns	0-5	50,443	8,391	\$ 99,582	292	\$ 14,912
	5-10	31,426	11,482	\$ 208,696	680	\$ 37,987
	10-15	23,878	11,465	\$ 266,291	916	\$ 58,621
	15-25	34,058	20,946	\$ 567,172	2,322	\$160,646
	25-50	45,840	35,806	\$1,305,230	5,654	\$446,086
	50+	<u>9,749</u>	<u>7,980</u>	<u>\$ 351,067</u>	<u>1,151</u>	<u>\$ 97,946</u>
	Total	195,394	96,070	\$2,798,038	11,015	\$816,198

TABLE 14

DISTRIBUTION OF CREDITS - 1978

Type of Returns	AGI Thousands of Dollars	Number of Returns	Number of Returns with Fuel Credits	Amount of Fuel Credits	Number of Returns with Conservation Credits	Amount of Conservation Credits	Number of Returns with Income Credits	Amount of Income Credit
Resident Returns	0-5	33,582	6,900	\$ 120,117	638	\$ 20,664	8,437	\$ 261,316
	5-10	20,515	10,317	\$ 198,191	1,138	\$ 43,424	17,905	\$ 1,497,153
	10-15	17,564	11,336	\$ 261,918	1,394	\$ 57,979	16,909	\$ 1,982,114
	15-25	25,947	20,182	\$ 601,140	2,892	\$155,634	25,532	\$ 3,687,541
	25-50	37,260	33,495	\$1,355,086	6,297	\$409,109	37,127	\$ 6,664,510
	50+	8,483	7,895	\$ 384,650	1,437	\$109,006	8,455	\$ 1,646,278
	Total	143,351	90,125	\$2,921,102	13,796	\$795,816	114,365	\$15,738,912
Part-Year and Non- Resident Returns	0-5	18,088	4,551	\$ 24,388	307	\$ 11,235	9,218	\$ 254,075
	5-10	9,311	3,820	\$ 27,485	274	\$ 15,441	7,385	\$ 428,898
	10-15	4,884	2,262	\$ 20,325	159	\$ 9,460	4,114	\$ 324,901
	15-25	4,560	2,265	\$ 25,318	185	\$ 13,542	3,898	\$ 378,608
	25-50	2,954	1,504	\$ 22,503	136	\$ 9,872	2,473	\$ 305,062
	50+	577	248	\$ 4,486	29	\$ 2,219	445	\$ 63,282
	Total	40,374	14,650	\$ 124,505	1,090	\$ 61,769	27,533	\$ 1,754,826
All Returns	0-5	51,670	11,451	\$ 144,505	945	\$ 31,899	17,655	\$ 515,391
	5-10	29,826	14,137	\$ 225,676	1,412	\$ 58,865	25,290	\$ 1,926,051
	10-15	22,448	13,598	\$ 282,243	1,553	\$ 67,439	21,023	\$ 2,307,015
	15-25	30,507	22,447	\$ 626,458	3,077	\$169,176	29,430	\$ 4,066,149
	25-50	40,214	34,999	\$1,377,589	6,433	\$418,981	39,600	\$ 6,969,572
	50+	9,060	8,143	\$ 389,136	1,466	\$111,225	8,900	\$ 1,709,560
	Total	183,725	104,775	\$3,045,607	14,886	\$857,585	141,898	\$17,493,738

innovations

Rhode Island's Energy Conservation Corporation

Introduction: In 1977, a Rhode Island program was implemented that anticipated the effects of the then-pending National Energy Conservation Policy Act. The Rhode Island Citizens Energy Conservation Corporation (RICECC) was established as a nonprofit organization by the cooperative efforts of the state and major private corporations to help all Rhode Island property owners (not just low-income families) reduce the amounts of energy their homes consume.

To produce a more palatable acronym, the corporation later was referred to as "Rhode Islanders Saving Energy" (RISE).

RISE achieves its objective by providing: (1) free home energy audits with detailed costs of the improvements necessary to reduce energy use; (2) selection of approved contractors to perform the work authorized by the homeowner; (3) supervision and inspection of contractors' work, and (4) reduced financing rates on loans from local lending institutions. Other services, such as advice on oil burner maintenance, wood stove heating and solar energy availability and suitability may soon be included in RISE activities. Similar services for commercial buildings eventually may be provided, pending the promulgation of federal standards regarding energy efficiency in such structures.

Several provisions of the 1978 National Energy Conservation Policy Act should make this Rhode Island program of particular interest to governors, state energy offices, public utility commissions and utility companies.

Federal Legislation: Under the National Energy Conservation Policy Act, each governor must submit a plan to the Department of Energy that will describe how the regulated utility companies in his state will provide information to their customers regarding energy conservation and solar energy measures the customers could adopt, along with the costs of such measures and an estimate of how much energy each measure will save. The utility companies must have procedures for delivering this information to their

customers by January 1, 1980.

The utilities must also have available by that same date procedures which will provide for inspection of individual residential structures, at the owner's request, to ascertain the appropriate energy conservation steps that could be employed, their costs and anticipated energy savings. The utility must also offer to arrange to have the conservation devices installed and assist the homeowner in obtaining a loan to finance the selected work. Nonregulated utilities and home heating supplies must comply with these standards in order to have an approved energy conservation program.

Of relevance to homeowners is another part of the administration's energy legislation package—the Energy Tax Act. Under this law, a nonrefundable credit is allowed for a maximum of 15 percent of the first \$2,000 invested in certain conservation equipment and materials, including storm doors and win-



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dows, automatic furnace ignition systems, insulation, caulking and weather-stripping. A similar credit is provided for 30 percent of the first \$2,000 and 20 percent of the next \$8,000 (to a maximum credit of \$2,200) for residential investments in solar, wind, or other renewable energy sources for home heating or cooking or for domestic hot water.

Background

Since 1975 there has been such movement among states toward the adoption of energy conservation. Part of this activity was spurred by federal legislation, such as the 1975 Energy Policy and Conservation Act which encouraged the states to adopt thermal efficiency and insulation standards. In further recognition of the value of the value of home insulation for reducing fuel usage, at least two federal programs were established to help low-income persons weatherize their homes. The promotion of carpools, solar tax incentives and right-turn-on-red measures offered less promise and smaller returns than the potential of proper building insulation, especially in the colder climates of the northeast.

In the spring of 1977 Governor J. Joseph Garrahy convened the first meeting of a group of Rhode Island corporate leaders to advise him on energy matters, particularly conservation. The governor's energy office supplied staff services for the committee.

From the options available for its consideration, the committee chose to concentrate first on the problem of residential insulation. This decision was based partly on the knowledge that the housing stock in Rhode Island consists predominately of older single-family structures. Over 90 percent are more than 40 years old and are apparently inadequately insulated or weather-sealed.

The committee suggested a private corporation provide home energy audits and insulation services. Financial support to establish the corporation was soon forthcoming as four of the state's major banks, a department store, and other Rhode Island companies pledged to underwrite a \$110,000 loan from one of the banks as the basic capital for RICECC. (To date only about \$75,000 of that amount has been drawn for RICECC's use.) At the outset, a consulting firm was retained to design the operation and structure of the corporation and the corporation began to screen insulation contractors for participation in the program.

In January 1978, the first audits were performed and by April several homeowners had opted for improvements recommended by the auditors. But the corporation was in trouble. In its haste to show results, it tried to make unmanageable leaps in too many directions at once. Staffing was inappropriate and relations with the banking and contracting communities were strained. In April, the consulting firm hired a new manager.

The manager's first step was to personally review the work done up to that time by the contractors and then to rectify the errors that had been committed in many of these jobs. And the task of building RICECC credibility was begun. The new RICECC manager offered training sessions for each contractor who wanted to participate in the program as a way to ensure standard and proper work among the contractors. Insulation and other materials manufacturers helped provide training on the proper use of their products.

Meanwhile, audits continued and work was performed where requested with RICECC supervision and inspection of completed jobs. More homeowner interest in the program was elicited through public appearances by the manager of RICECC and employees of the governor's energy office before local civic groups and with public service announcements on television and radio and messages included with utility bills. In time, a record of performance had been established that could be used to show lending institutions the viability and effectiveness of the program. Several lenders were by then offering reduced interest loans for homeowners employing the RICECC service and contractors.

RICECC—Its Structure and Operations

In the summer of 1978, RICECC was advised that its acronym was awkward and unpronounceable. So, it adopted the new acronym RISE (for Rhode Islanders Saving Energy) as the title for its operating program, although the corporation is officially chartered as RICECC. The telephone is answered "RISE," and most promotional material refers to RISE, not RICECC.

RISE currently operates with a nine-member staff—a manager, a contract supervisor, a contract inspector, an administrative assistant, a clerk-typist and four residential energy auditors. The office operations cost about \$17,000 a month. Funds are obtained from the contributions of utility companies and from a profit margin on all jobs performed.

Depending on the viewpoint of the observer, RISE is a consumer protection organization, a guarantor of work for insulation contractors, or a significant deliverer of energy conservation information and services in the state. In working toward its goal of saving energy, RISE fits all these descriptions.

Customer Service

The RISE services are activated when a homeowner requests an energy audit. At that point, one of the corporation's four auditors examines the house for various types of heat loss. (Audits are often done in evenings or on weekends for the convenience of the homeowner.) Using a standard eight-page form, the auditor takes about an hour to compile a com-

plete description of the house along with specific areas of potential heat loss due to infiltration or conduction through floors, ceilings, walls and windows. Back in the office, the auditor calculates the heating Btu's that could be saved through application of appropriate materials and prepares a list of recommendations for the homeowner.

The recommendations are rank-ordered with the most cost-beneficial appearing first. When the recommendations are presented to the homeowner, actual cost for the suggested measures are included along with approximate payback periods (time over which energy cost savings equal cash outlay for improvements). The homeowner is also given information on the federal tax credit the installation of certain materials may offer. In addition, the auditor can provide some instructions for the homeowner interested in do-it-yourself improvements for heat retention.

If the homeowner is interested in having the recommended work done by professionals, the rest of the RISE package is activated. The auditor can provide a list of banks in the state who have agreed to offer lower interest loans for participants in the RISE program. A 24-hour processing of loan applications for RISE customers enables the homeowner to make the decision to proceed with the work by contacting the RISE office. RISE, in turn, assigns the job to the next contractor on its rotational list, who has a franchise to deal in the materials selected by the homeowners. The contractor can refuse the job, but then must wait until the others on the list have been given offers before he will get another chance.

If the contractor accepts the offer, he does so at the price offered by RISE with materials specified by RISE contract supervisors. Upon completion of the work, RISE sends out an inspector (not an auditor) who uses a thermal scanner to ensure the proper installation of the right materials. If an error has been made or some procedure omitted, the contractor is called back to satisfactorily complete the work. The contractor is not paid until the inspection indicates a correct performance. RISE, in turn, collects from the homeowner the total contract cost which includes the amount paid to the contractor plus a 25 percent margin that helps allay RISE's overhead. The average contract costs the homeowner about \$1,300. The price is still very competitive with prices for comparable work done without RISE supervision because RISE pays the contractors at a wholesale rate. RISE also guarantees the work of its contractors and its customers are eligible for the lower bank rates.

Contractor Relations

There also have been occasions where homeowners have been dissatisfied with work done by contractors that was not completed through RISE, but the homeowners sought advice and help from RISE.

It is a yardstick of RISE's current credibility that in many such cases contractors, even those not participating in the program, are willing to remedy work that has been judged faulty.

None of this is to say that RISE has browbeaten contractors into compliance. Rather, a working relationship has been established out of mutual respect and mutual benefit. Nine of the 14 contractors presently on the contractor rotation list rely exclusively on RISE for their jobs. The contractors and their crews have received special training from RISE that has enabled them to do their work better. Indeed, some contractors use only certain of their workers on RISE jobs, knowing the rigorous supervision and inspection to which that work is subject.

RISE also has helped improve the image of insulation contractors who previously may have been characterized as fast-talking salesmen with limited knowledge and minimal skills. Now, their work is guaranteed by a publicly sponsored corporation. There are even instances where a contractor will call in RISE as an arbiter when a non-RISE customer has refused to pay the contractor for work that is unacceptable to the homeowner for some reason.

The contractors also benefit from RISE's promotion of the corporation's activities. RISE's steady growth and heightened public image are expected to keep the demand for weatherization work fairly constant, even through traditionally slack warm weather months, thus possibly preventing seasonal layoffs of insulation workers. It is interesting to note, too, that prior to RISE, the average weatherization job for contractors cost only about one fourth of RISE's current per-job average.

Energy Savings

At the end of calendar year 1978, more than 2,500 free home energy audits had been performed by RISE. In approximately 25 percent of these homes, RISE contracted to perform at least some of the recommended improvements. Based on responses to limited telephone follow-up, another 35 percent of the homeowners performed the work themselves or made their own contract arrangements.

Most of the home heating in Rhode Island is done by oil furnaces. Through RISE, oil users can obtain the advice of an oil burner expert regarding the size, condition and operation of oil burners. Originally, \$20 was charged for this service, but as part of a state demonstration project, the service is now free for the homeowner. So far, RISE does not provide repair contractors for oil burners, but it is attempting to establish a program for these contract services similar to the program for weatherization.

Other coming additions to RISE include solar and wood stove components. Under the solar program, auditors will explore the attitudes of home-

owners toward the use of solar energy and give advice as to the feasibility and technology available for solar use in domestic hot water production. A delivery mechanism employing local solar product suppliers and installers has just been launched. The wood stove program involves advising homeowners on the safe and efficient installation and use of wood stoves as home heating devices.

The State Role

The RISE manager contends continued state participation in the program is critical to its success. Although it was the governor who called together the group that proposed the formation of the corporation, and that group was partially staffed by members of the governor's energy office (GEO), the state has continued to remain removed from the daily operations of RISE, but the state's relatively low-keyed assistance is considered extremely important to the viability of the corporation.

The two most vital contributions the state provides are public acceptance and liaison with other government agencies. Despite RISE's connection with the business community and its own now-respected status, state approval gave it a higher credibility among its potential customers in the development stages. Even today, promotional brochures contain a letter of official endorsement from the state's energy conservation director. (At this writing, plans were being made for the governor to give additional public acclaim to the program as a result of the favorable impression he drew of RISE when his house was recently audited and insulated.)

Signing letters of praise is not the only way in which the director of energy conservation assists the program. He and his office have written a proposal to the federal Department of Energy that is expected to bring funds to the state for financing the solar component of RISE. The GEO also serves as a liaison between RISE and state agencies, such as the building code commissioner who sets insulation standards for new buildings, or the community affairs agency which administers a weatherization program for low-income households. Some office support, such as use of copying machines, is provided by the GEO as well.

The GEO has another role with respect to RISE—a role that is harder to define, but that might be termed "watchdog." Because of the public trust that has accrued to the program and the reliance state government has placed on RISE as educator and unbiased provider of energy construction services, the state feels a responsibility to guard against the misuse of this trust.

The Private Sector Role

Even though the original idea of RISE came from



Insulation contracting is an important element of the Rhode Island energy conservation program.

influential members of the Rhode Island business community, similar support was not as easily come by from other segments of the private sector. Insulation contractors, for instance, were at first skeptical of the concept and wary of the competition or control the new corporation posed. However, these contractors not only accept RISE's presence now, but rely on its advice and contracts.

In the case of the banking community, a different pattern of doubt/acceptance developed. Four major banks were among the initial backers of the loan to start RISE. Bank financing of RISE weatherization contracts is now available at 10-11½ percent (instead of the usual 15-18 percent) from banks that are satisfied of a reduced risk because of the guaranteed standards of contract performance. The RISE auditors give the homeowners they visit a list of the participating banks and these banks have procedures for expediting applications from these customers.

The state's private utility companies also support the program. A spokesman for the state's largest electric utility said that despite the company's mild skepticism at the outset of the program, the utility, for the first time ever, stuffed its billing envelopes with brochures for an outside organization—RISE. This same utility previously had its own home energy audit program and offered advice from its experience to the fledgling corporation. The state's 10 energy utilities now voluntarily contribute a total of \$5,000 per month to the operational funds of RISE. While voluntary, this contribution should not be seen as entirely altruistic since the utilities recognize that RISE is delivering a consumer-oriented energy conservation program that would be required of the utilities in the near future under the National Energy Act.

Transferring the Innovation

Rhode Island's city-state size affords it a certain advantage in the implementation of a program such as RISE. A person can drive from Providence to any other location in the state in less than an hour. In the case of RISE, this means that all the auditors can work in the same capital city office and save the costs of administering satellite offices. It also means that insulation contractors are equally capable of serving the whole state and the cooperating banks have branches throughout the state.

In a larger state, the logistics of screening contractors and obtaining banking community support might require more patience than was necessary in Rhode Island. But the people involved in running RISE are convinced that the program could work equally well in a larger state with the same government and private sector cooperation as a basis. The program does not have to be implemented through a private corporation to be successful, but that arrangement seems to reduce personnel and other governmental administration problems.

More important factors are the need for the program management to have a thorough understanding of the technical and market aspects of weatherization and a well-trained staff of auditors. In a large state it

might be more practical to begin the program in a single market area and then expand to other areas as funding and expertise permit. Utility companies should be considered as sources of seed money for a home energy conservation program in light of requirements in the National Energy Act. In Rhode Island, the utilities seem certain that their financial burden for RISE is much less than they would incur if they constructed and funded their own programs.

Conclusion

In the delivery of state government services, Rhode Island's Citizens Energy Conservation Corporation shows such functions need not result in new in-statehouse bureaus or regulations. Through cooperation with the private business sector, Rhode Island's program indicates state government adaptability and effectiveness. There is little research indicating what other state services might be similarly resolved through such cooperative ventures, but it does indicate possibilities exist, particularly where the desirable product or service is readily available from private enterprise, but is necessary to state service delivery. The state government's role as a broker provides a realistic, reliable and efficient means of both serving individual citizens and meeting overall public service goals—in this case energy conservation.

INNOVATIONS REPORTS

- Railroad Rehabilitation: A Program to Upgrade Selected Branch Lines in Iowa, January 1976, 23 pp. (BPF, \$3)*
- * *Health Cost Containment: The Connecticut, Maryland, and New Jersey Responses, March 1976, 44 pp. (BPX, \$3)*
 - * *State Energy Management: The California Energy Resources Conservation and Development Commission, May 1976, 32 pp. (RM 580, \$3)*
- Periodic Reappraisal of Real Property: The Utah Approach, July 1976, 35 pp. (RM 581, \$3)*
- Investing State Funds: The Wisconsin Investment Board, August 1976, 31 pp. RM 583, \$3)*
- * *Retirement System Consolidation: The South Dakota Experience, December 1976, 46 pp. (RM 588, \$3)*
- Centralizing State Information Services: Kentucky's Approach, November 1976, 6 pp. (BYL, \$2)*
- * *The Bond Bank Innovation: Maine's Experience, February 1977, 60 pp. (RM 604, \$3)*
 - * *Random Moment Sampling: Georgia's Indirect Cost Allocation Experiment, February 1977, 8 pp. (BAA, \$2)*
- A State-Supported Local Corrections System: The Minnesota Experience, February 1977, 29 pp. (RM 603, \$3)*
- Managing Natural Resource Data: Minnesota Land Management Information System, May 1977, 48 pp. (RM 616, \$3)*
- The Management Audit: A New Experiment in State Regulation of Utilities, July 1977, 6 pp. (BCP 77, \$2)*
- Developing Primary Health Care for Rural Areas in North Carolina, June 1977, 40 pp. (RM 620, \$3)*
- Merging Producer and Consumer Interests: Domestic Agricultural Marketing in New York and Pennsylvania, September 1977, 29 pp. (RM 623, \$3)*
- Health Cost Containment Revisited, July 1977, 8 pp. (BDC 77, \$2)*
- Systematic Use of Volunteers: A Florida Case Study, November 1977, 8 pp. (BEP 77, \$2)*
- Incentives and Performance: Minnesota's Management Plan, April 1978, 12 pp. (BHO 78, \$2)*
- Health Manpower Licensing: California's Demonstration Projects, April 1978, 24 pp. (RM 631, \$3)*
- Assessing Management Potential in State Government, April 1978 (RM 634, \$2)*
- Georgia's Residential Restitution Centers, May 1978 (RM 636, \$3)*
- Untangling the Permit Web: Washington's Environmental Coordination Procedures Act, June 1978, 45 pp. (RM 627, \$3)*
- Restoring Municipal Credit: The New Jersey Qualified Bond Program, June 1978, 10 pp. (RM 643, \$2)*
- Bail Bond Reform in Kentucky and Oregon, August 1978, 31 pp. (RM 645, \$3)*
- Permanent Part-Time Employment: A Staffing Option for State Government, August 1978, 10 pp. (RM 648, \$2)*
- New Mexico's Centralized Risk Management, May 1979 (BOV:79, \$3)*
- Vermont's New Signs of the Times, June 1979 (RM 666, \$2)*
- Financing Family Farms in Minnesota, May 1979, 6 pp. (RM 662, \$2)*

*Published version is out of print, but photocopied versions are available.

ENERGY CONSERVATION

Technological breakthrough

THE recent start-up of the world's first MHD (magneto-hydrodynamic) power plant, in the vicinity of Moscow, promises to rank as a landmark in the history of energy conservation. The wasteful use of fuels which is inherent in electricity generation is perhaps the most important single factor making for an exaggerated overall growth of energy demand, the more so because electricity consumption tends to rise even faster than the direct consumption of fuels. The concept of MHD technology is designed to reduce this waste.

So far, power stations have all been based on steam turbines. They utilise their fuel input, in most cases, to the extent of barely 30 per cent, while even the most advanced types of turbine generators will never be able to achieve efficiencies significantly in excess of 40 per cent. A typical MHD power plant, however, dispenses with the generator equipment and utilises the fuel more thoroughly by converting it into very-high-temperature gases which are then passed through a magnetic field to generate electricity.

The Moscow plant, consisting of an MHD generator as a topping unit coupled with a steam plant bottoming unit, actually operates at an efficiency rate as high as about 50 per cent. Beyond that, it is hoped that further technical progress, with the use of greater heat, will eventually make it possible to reach efficiencies up to around 60 per cent—equal to twice what is now the normal standard.

US-Soviet collaboration

Remarkably, the new technological breakthrough is the outcome of close international collaboration, chiefly between the Americans and the Russians. The Moscow plant has been built with the direct co-operation of experts from leading US firms such as General Electric, Westinghouse, Avco and others, under an agreement with the US Energy Research and Development Agency. Work on this and other relevant facilities in the USSR has been paralleled by similar work in the USA itself, and there has also been a great deal of work on MHD projects elsewhere, notably in Japan where highly efficient super-

conducting magnets have been developed. A paper describing the varied efforts in this field has recently been submitted by an international team to the World Energy Conference*, and a fuller report will shortly be published in Paris.

The Moscow plant still serves primarily for experimentation, though its power output is fed into the general grid. The plant can operate either on natural gas or on fuel oil and is said to achieve a remarkably high degree of cleanliness in its exhaust gases provided that attention is given to the removal of nitrogen oxide concentrations. Furthermore, plans for the construction in the USSR of a 500 MW commercial plant are now at an advanced stage and it is hoped that this will start operating in the mid-1980s. The point has been stressed that the MHD principle will be especially well suited for electricity generation on a very large scale.

Low-grade fuel acceptable

Research and development in the USA is largely concentrated on coal-fired MHD facilities, some of which have already been put to extensive tests, and the projected Russian 500 MW plant is also expected to run on solid fuels. MHD power systems will probably offer the important advantage of being suitable for fuelling with low-grade, high-sulphur coals; and it may thus become possible to by-pass the coal gasification or liquefaction process with a concomitant improvement in net plant efficiency and economy. Among other important current US projects is the construction at Montana of a large specialised component development and integration facility, for completion by 1979.

The economic as distinct from the technical efficiencies of the prospective commercial MHD plants have until recently been subject to wildly differing estimates. The situation has now, however, been largely clarified thanks to independent research by teams from the General Electric and Westinghouse groups, working on the basis of identical specifications laid down by the US National Aeronautics and Space Administration.

The two teams arrived at ranges of cost estimates per unit of power output from first-generation commercial MHD plants which—in the case of Westinghouse—are, on average, 23 per cent higher and—in the case of General Electric—31 per cent higher than comparable cost range data from advanced steam turbine plants. Capital costs for MHD power plants were estimated by the two teams to be 50 per cent and 61½ per cent respectively above those of advanced conventional plants, but their running costs are far more favourable in view of the substantially lower fuel requirements.

* *Magneto-hydrodynamic power generation, an international status report.* By A E Sheindlin, Institute of High Temperatures, Moscow; W D Jackson, US Energy Research and Development Administration; W S Brzozowski, Institute for Nuclear Research, Warsaw; L H Th Rietjens, Eindhoven University of Technology.

Subscription rates

In spite of the continued rise in production costs, we have managed to keep our subscription rates unaltered over the past two years. Regretfully, however, an increase in these rates is now unavoidable. The following new rates, including postage, will apply with effect from 1st January 1978; they take into account alterations both in postal and currency exchange rates.

- £25 Surface mail within the UK.
- US\$ 50 Surface mail to all other destinations.
- US\$ 55 Airmail to Europe.
- US\$ 60 Airmail to all other destinations.

We also publish a special Press edition, printed on one side of the paper only, which some subscribers find useful for cutting and filing items from the journal for reference purposes. Also with effect from 1st January 1978, this edition will cost £37.50 within the UK and US\$ 80 for delivery to all other destinations.

The two estimates are sufficiently close to serve as an adequate provisional guide. Initial extra costs of 23-31 per cent may not be regarded as excessive, considering that there is scope for further reductions both in capital costs and fuel requirements as a result of technological improvements. Moreover, the savings of fuel are bound to become economically even more attractive with the expected continued rise in average fuel prices. The consensus of informed opinion seems to be that the MHD plants of the 1980s will be at least competitive with conventional plants.

The paper submitted to the World Energy Con-

ference by experts from different countries stresses that MHD electrical power generation "has now joined the ranks of technologies for which engineering feasibility has been established", and that planning emphasis should therefore be shifted "from exploratory work and scientific approaches to an engineering oriented programme directed towards specific component and development problems". The paper makes it clear, at the same time, that considerable further progress may well be achieved as a result of fundamental studies devoted to the development of even more advanced types of MHD technology. —B.A.R.

This announcement appears as a matter of record only.

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*The undersigned served as financial advisor
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October 6, 1977

SWEDEN

The case for reduced consumption

AS might be expected for the most prosperous country in Europe, Sweden's energy consumption *per capita* is also one of the highest – in 1973 at 6 110 kg of coal equivalent it was exceeded in Europe only by Belgium with 6 253 kg, according to UN figures. But hydro-electricity, Sweden's only appreciable indigenous energy resource, meets about 15 per cent of overall energy demand. Most of the balance – including up to an estimated 15 million metric tons of crude oil this year – must be imported, and the 8.2 million Swedes are increasingly concerned at the long-term effect of energy imports on their national wealth.

This year imports of crude oil and products are budgeted to amount to about Kr 13 745 million, or nearly 18 per cent of total estimated value of imports. While Swedish industry and trade continue to flourish high energy imports may be acceptable, but lower overall economic growth and a shift in the pattern of energy consumption are being discussed as means to a more moderate rate of energy use.

Nuclear electricity was seen by the government as the best alternative to imported oil, and there were plans to build 19 nuclear plants by 1985 and up to 24 by 1990, giving a combined capacity of nearly 24 000 MW. However, planners had not taken into account strong public feeling on nuclear energy and energy consumption. Many people are opposed to nuclear power stations on safety grounds and a survey showed that three-quarters of respondents would prefer lower living standards to increased energy use.

Lower energy use

The nuclear energy debate still goes on, but the government has recognised the importance of curbing total energy consumption. This is planned to rise at no more than 2 per cent annually to 1985, compared with an estimated 3.4 per cent annual rise if no special measures are taken. After 1990 it is hoped that energy use can be held constant. It has recently been suggested that Sweden could maintain its standard of living on two-thirds of current energy consumption, but some of the measures necessary to achieve this – less-advanced technology, longer-lasting products, more emphasis on public transport, etc – may not yet be acceptable.

Sweden now has five completed nuclear power plants, although the first (a small unit at Ägesta) has now become uneconomic. There are two boiling water reactors of 440 MW and 580 MW capacity at Oskarshamn and a third of 760 MW at Ringhals, and the most recent is a pressurised water reactor of 820 MW, also at Ringhals. A further six plants are either under construction or have been granted construction per-

mits; there will be two additional pressurised water reactors of 910 MW capacity each at Ringhals, two 580 MW reactors at Barsebeck and two of 900 MW at Forsmark.

The government's commitment to nuclear power was underlined when it was decided to develop Swedish nuclear technology, rather than to rely entirely on foreign expertise. A group of Swedish companies and Westinghouse won orders for the Ringhals 2, 3 and 4 plants, while the half state-owned Åsea-Atom will build seven reactors.

However, beyond the eleven power stations either existing, under construction or sanctioned at present and an additional two reactors planned for existing stations, Sweden's nuclear programme remains to be decided. If no further plants are to be built, nuclear capacity in 1985 will total nearly 8 000 MW (on a par with effective hydro-electricity capacity at present) and will meet 12 per cent of primary energy demand. Oil's share could then reduce to 60 per cent of energy demand from about 70 per cent at present – a worthwhile saving, but not the complete answer to the high cost of energy imports.

Sweden's two 50 per cent state-owned exploration companies – Oljeprospektering AB (responsible for domestic operations) and Petroswede AB (responsible for exploration overseas) – have for several years invested considerably in drilling work in the hope of securing direct access to oil reserves, but have met with little success. Minor fields have been discovered around the island of Gotland by Oljeprospektering and four wells on the island have been in production at very low rates for over a year, while Petroswede has been involved in exploration, particularly in Egypt, Tunisia and Spain.

It is natural that the Swedes should look to hydro-electricity – along with forestry and iron ore, one of the country's most important indigenous resources – as an alternative to dependence on imported oil. A high rainfall, with most of the rain as well as snow falling at high altitudes, together with numerous lakes have allowed hydro-electricity generation to be developed at relatively low cost. The result is that at present

some 76 per cent of internal electricity production is hydro-generated.

With most major rivers suitable for hydro-electricity generation already utilised and with environmental reasons for not building dams and generators on many of those that are not, it appears that Sweden's scope for increasing its reliance on hydro-electricity is limited. In 1974 206 220 terajoules* of hydro-electric energy were generated from the 1 000 or so existing plants, compared with the 219 600 TJ which, according to the government, should be available in a year of normal rainfall when new facilities now sanctioned become operational. With a theoretical overall potential for the generation of 720 000 TJ of hydro-electricity annually, it is officially estimated that about 342 000 TJ (including current and sanctioned capacity) could be utilised if new plants were installed at all sites where it would be economic to do so. Hydro-electric energy availability could then increase by 56 per cent or some 122 400 TJ, but this estimate assumes that rivers such as the Vindel, Pite, Kalix and Torne-Muonio (which in the past have been excluded from hydro-electric plans on environmental grounds) would be harnessed.

The government has accordingly decided to limit the expansion of hydro-electricity generation to 18 000 TJ bringing the planned total up to 237 600 TJ. However, as an experiment six small hydro-electric generators will be installed this summer and tested for a year. If successful, it has been suggested that 300 of these remotely-controlled units could be installed.

With no indigenous natural gas or coal, Sweden's consumption of oil *per capita* is the highest in the world. In addition to importing 10 049 000 metric tons of crude oil in 1974 the major part of the country's refined product needs was also imported, the total of main refined products imports amounting to 17 272 000 tons compared with an aggregate consumption of 23 384 000 tons. The 8.3 million tons/year Scanraff refinery, brought on stream a year ago and increasing Sweden's refining capacity to 20.6 million tons/year, will boost crude oil imports by up to 30 per cent this year. According to official estimates, the corresponding fall in refined product imports will be about 12 per cent from 1975-76 but total refinery production is likely to rise by 17 per cent.

Although the country's substantial imports of refined products have in the past been a cause for concern, they could be less so in the future. With refineries in western Europe generally operating at low throughputs – a situation which was recently predicted to last for several years – there could well be advantages in still having to import a certain proportion of the refined products requirement. Production from the four large-scale refineries (Scanraff with 8.3 million tons/year, BP 5.5 million tons/year, Shell 5 million tons/year and Nynäs with some 1.8 million tons/year), together with imports of certain products, may prove to be the most effective way of meeting the country's

refined product needs.

This consideration, together with the recent growth in Norway's refining capacity, may lead to the postponement or cancellation of the proposed 7 million tons/year Statsraff refinery at Lysekil, for which investment decisions were due to be taken this year. It has been suggested that Norway's Mongstad refinery, of which the current capacity is 4 million tons/year, should be expanded and that Sweden should be given long-term contracts for the delivery of refined products, as an alternative to the planned Lysekil refinery.

Norway's influence is also being considered in the petrochemicals sector now that investment plans for the coming decade are discussed. Sweden's projected second ethylene cracker – a 500 000 tons/year unit to be built at Stenungsund on the west coast by Stenungsunds Kemiska – is also in doubt because of Norway's now-building petrochemical complex at Bamble, Telemark, which includes a cracker. The fear that Scandinavian countries could develop excess capacity for petrochemicals production, while being disadvantaged as petrochemicals exporters, are justified. Accordingly, the Swedish and Norwegian industry ministers have agreed to co-ordinate their respective plans, and a joint committee on immediate matters is due to report later this year.

—M.Q.

FORTHCOMING CONFERENCES AND EXHIBITIONS

Health and Safety in the Oil Industry (C). The Grand Hotel, Eastbourne, England, 28th September-1st October. Enquiries: Lynda Boothby, Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR, England. Telephone: 01-636 1004. Telex: 264380.

World Offshore Exhibition and Conference. Olympia, London, England, 4th to 7th October. Enquiries: Dermot B Graham, Fairs and Exhibitions Ltd, 21 Park Square East, Regents Park, London NW1 4LH, England. Telephone: 01-935 8200. Telex: 21879.

Gastech 76 International Conference and Exhibition. Hilton Hotel, New York, 5th-8th October. Enquiries: The Gastech Organisation, 2 Station Road, Rickmansworth, Herts WD3 1QP, England.

Preisbildung in der Energiewirtschaft (C). University of Cologne, West Germany, 13th-14th October. Enquiries: Professor Dr Hans K Schneider, Energiewirtschaftliches Institut, University of Cologne, West Germany.

Design and Construction of Offshore Structures (C). Institution of Civil Engineers, London, England, 27th-28th October. Enquiries: Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA, England.

Longer Term Energy Modelling (C). University of Guildford, Surrey, England, 5th November. Enquiries: Mrs C Steels, Department of Economics, University of Guildford GU2 5XH, England. Telephone: 0483 71281. Telex: 85331.

Offshore International Exhibition and Conference. National Exhibition Centre, Birmingham, England, 7th-10th December. Enquiries: Industrial and Trade Fairs Ltd, Radcliffe House, Blenheim Court, Solihull, West Midlands, B91 2BG, England. Telephone: 021-705 6707. Telex: 337073.

* 1 terajoule = 277.778 megawatt hours

The scope for economy

A highly original new research study, concentrating on conditions in the United Kingdom but broadly applicable to other countries as well, confirms once again that there is great scope for fuel saving even on the assumption that governments are content with moderate energy conservation policies which would not drastically affect the lifestyles of their people.

The authors' general conclusion from their own detailed statistical analysis is that a relatively rapid growth in the country's gross national product, by an average of 3-4 per cent annually, would be compatible with annual increases in energy consumption of only about 1½ per cent, which would raise total consumption from 342 million tonnes coal equivalent in 1976 to not more than about 500 million tonnes in the year 2000. Alternatively, if the general economic growth during the period should remain below 2 per cent, the authors think that fuel demand would probably rise at a minimal rate, possibly remaining well below 400 million tonnes coal equivalent in the last year of the century.

The new study*, made under the auspices of Sussex University, is based on a consideration of the probable course of fuel and electricity requirements in the various sectors of the national economy. It thus differs from those numerous statistical exercises which assume, initially, a fairly constant relationship between energy growth and general economic growth though they may make minor adjustments to take account of special circumstances in individual economic sectors. The present authors emphasise that energy demand in a dynamic society is bound to be affected by changes in the composition just as much as in the size of the national product.

The main statistical findings of the study are summarised in Table I which shows the "maximum" and "minimum" amounts of energy (calculated in billion therms) that may be required in the year 2000, on any reasonable set of assumptions, by the main sectors of the national economy. The probable contribution of the various types of fuels is even more difficult to assess beforehand but Table II indicates a hypothetical split-up of energy resources, on the further assumption that the energy demand will be covered as far as possible by indigenous resources such as North Sea oil and gas, local coal, and nuclear power.

The authors themselves describe their general outlook as "fairly conventional". They consider a reasonably rapid growth to be in the national interest;

TABLE I
UK ENERGY CONSUMPTION BY ECONOMIC SECTORS
Billion therms

	1976 Actual	2000 Minimum	2000 Maximum
Domestic	14.5	14.2	16.2
Manufacturing	17.5	19.6	28.2
Iron and steel	5.3	3.7	8.4
Transport	12.7	17.2	19.9
Public/commercial	6.5	5.3	7.7
Agriculture	0.7	0.7	1.0
Total Net a)	57.3	60.8	81.4
Total Gross b)	85.0c)	83.8	143.1

a) Sum total of the sectoral figures which indicate their requirements of fuels and electricity.

b) Also including uses by fuel and electricity industries, distribution losses and non-energy uses of oil.

c) Approximate figure.

they favour energy conservation policies but recognise that governments are inevitably hampered by political and social as well as purely economic constraints; and they take no account, in their statistical calculations, of the potentialities of district heating, industrial combined heat and power stations, or the use of solar, tidal, wave and other types of energy. They also assume, somewhat pessimistically, that there will be no progress in the overall efficiency of the electricity supply industry during the remainder of this century. By and large they would presumably agree that less "conventional" attitudes could lead to sharper reductions in energy demand than they anticipate.

Domestic heating, lighting, cooking, etc, accounts at present for as much as one-quarter of Britain's energy demand+ though this sector of the economy is obviously not directly affected by the growth of the gross national product. The number of households by the year 2000 will probably be about 10 per cent higher than in 1976; and the study maintains that energy consumption in the domestic sector might,

+ In terms of net energy supplies, ie excluding certain losses, notably in the generation of electricity. For details, see footnotes to Table I:

TABLE II
UK ENERGY CONSUMPTION BY FUELS a)
Million tonnes coal equivalent

	1976 Actual	2000 Minimum	2000 Maximum
Coal	120.1	83.2	162.3
Oil	149.4	124.2	224.1
Natural Gas	57.9	88.2	88.2
Nuclear and Hydro	14.6	39.7	102.2
	342.0	335.3	576.8b)

a) Gross consumption (see Table I, footnote b). The fuel distribution in 2000 is hypothetical, as explained in the text.

b) It is assumed that, by fairly rigorous policies, the maximum could be kept down to 500 or less.

*Estimating UK Energy Demand for the Year 2000: A Sectoral Approach. By J H Cheshire and A J Surrey. SPRU Occasional Paper series No 5. Sciences Policy Research Unit University of Sussex. Mantell Building, Falmer, Brighton, Sussex BN1 9RF, United Kingdom.

over these years, also rise by up to about one-tenth but that there is the chance of an actual standstill or even a slight reduction. There is certainly no reason to think that people in future will want to be much warmer, to use much more hot water, or to cook much more food; ownership levels of high-load electrical appliances, with the possible exception of freezers and dishwashers, are already approaching saturation point; and there is, at the same time, considerable scope for the wider use of more efficient heating installations and, above all, for improved insulation.

A recent survey shows that only 36 per cent of dwellings in the UK have some sort of loft insulation, that only 0.2 per cent have cavity wall insulation, and that the amount of useful energy required for space heating could be roughly halved if all dwellings were insulated to really high standards. There will, indeed, be some automatic improvement in insulation standards over the next two decades as obsolescent houses are replaced by modern dwellings; but there would also be a good case for improving the insulation standards of existing houses, if necessary with government assistance in the form of tax relief or low-interest loans. Persistent high unemployment could perhaps persuade governments of the advantage of a joint job-creation scheme linked to improved domestic insulation.

Turning to the important field of the manufacturing industries other than iron and steel, the study assumes a "maximum" annual production growth of 4 per cent and a "minimum" of 1 per cent over the 24-year period, roughly in line with the anticipated growth ranges for the national economy as a whole. Energy trends in the various manufacturing industries differ, but previous experiences, both during the "low-cost" period up to 1973 and during the "high-cost" period afterwards, show that there are in most industries continuous sharp reductions in energy requirements per unit of output, thanks to technical improvements, economies in scale, "waste" recovery, etc. Interestingly, the outstanding exception appears to have been in the engineering industries where higher labour productivity has been achieved by greater mechanisation, requiring more capital and more energy per employee.

Taking these previous experiences into account, and assuming that rising real energy prices will discourage an accelerated growth of the most energy-intensive industries, the authors postulate that, as a rule, a 1.0 per cent increase in industrial output will be accompanied by an increase in net energy requirement of only about 0.5 per cent. It would appear, on this basis, that net energy consumption in manufacturing industries during 1976-2000 will rise by a minimum of 12 per cent and a maximum of about 60 per cent, though *gross* requirements will rise somewhat faster because a higher proportion of the energy will probably be required in the shape of electricity. The study also makes the point that energy requirements would probably rise at a more rapid rate if

energy prices in the UK were held below world price levels, if the availability of North Sea oil and gas led to a big expansion of the production of basic chemicals, or if there were a further shift in the composition of imports from raw materials to semi-finished goods, owing to the gradual industrialisation of Third World countries.

The iron and steel industries are treated separately, partly because of their great significance for one particular type of fuel — coking coal — and partly because of uncertainties raised by the possible replacement of iron and steel by other materials (aluminium, cement, plastics) and the possible establishment of iron and steel industries in other countries at the expense of the UK industry. There has been a long history of gradual improvements in the energy efficiency of iron and steel industries which will no doubt continue, but output projections for UK steelmaking capacity by the turn of the century vary from a minimum of 20 million tonnes/year (significantly less than at present) to as much as 40 million. The industry's net energy requirements could, therefore, either rise by up to 60 per cent or decline by up to 30 per cent over the period under consideration.

Still more motor cars

The study is perhaps unduly pessimistic about the prospects for energy conservation in the transport sector, where it foresees an increase in fuel requirements — almost exclusively liquid fuels — by somewhere between 35 and 57 per cent. The dominant factor in the recent past has, of course, been the expansion of road transport, notably private road vehicles, with the average number of cars for every 100 inhabitants going from 11 in 1960 to 25 in 1976. The present ratio is very similar to elsewhere in Western Europe, but the study assumes that it will rise by the year 2000 to at least 34 and possibly as much as 42.5 per 100. It also assumes significant further growth in freight traffic and, still more, in air traffic.

Car ownership in the British Isles is certainly not yet approaching saturation point but — given the different geographical, sociological and economic conditions — it may well be doubted whether it will ever reach the high present car density of the USA (45 per 100 people). The suggested "maximum" ratio for 2000 therefore appears unrealistic. The study recognises that "anti-motor" policies are inevitably unpopular though it recommends fiscal measures to foster greater fuel economy.

Be that as it may, the figures so far quoted indicate that the anticipated increase in fuel consumption as a whole is substantially lower than the assumed increase in the vehicle population. Experience shows that, as families acquire a second or third car, the *average* mileage for each single car tends to decline; and — unless the real price of motor fuel is allowed to fall — there is reason to anticipate significant fuel

economies, perhaps by 40 or even 50 per cent, as a result of incremental technical improvements over the next two decades or so. A further reduction in motor transport could also result from government policies fostering public transport, and from developments in electronics and telecommunications, etc.

The study is curiously vague in its comments on commercial consumers and public services whose energy requirements in the year 2000 "will be in the

range between 20 per cent above and 20 per cent below the 1976 level". The authors themselves seem to consider it improbable that the share of the "service" sector will continue to grow in relation to the economy as a whole, and they point out that many commercial buildings are "over-lit", while improved heating control systems in public buildings (according to one case study) could reduce energy requirements by as much as 30-50 per cent. ■

Widespread profit gains in third quarter

Mixed financial results from the five major internationals and a positive improvement in performance by most leading independents were features of US oil company operations in the third quarter of 1978. For 18 companies tabulated, the average advance since July-September 1977 was only some 4 per cent, but for the 13 leading independents profits were 15% higher. For the nine months January-September the changes were less marked, amounting to 3% overall and 7% for the independents.

Third-quarter changes reported by the five majors ranged from a gain of 12% by SoCal to declines of 14% and 15% by Texaco and Exxon; but both the latter attributed the setback to foreign currency translation losses. Exxon, while conceding that the strengthening of most major foreign currencies temporarily boosted its foreign operating earnings in terms of dollars, indicated a net loss of \$178 million due to the effect on its foreign currency financial obligations of the general weakening of the dollar. Current accounting requirements oblige it to report such foreign exchange effects, though these "balance sheet" items are highly volatile and could distort the true income position. Exxon stated that earnings from operations as such were 9.5% up in the third quarter, at \$807m. Texaco similarly reported foreign currency translation losses (\$52m) which were greater than its overall decline in earnings (\$35m); but for Gulf, Mobil and SoCal they were a relatively insignificant item, amounting to a combined figure of some \$30m.

Operating results in the third quarter were mostly good for the "big five", though both Exxon and Gulf reported declines

at home, while SoCal and Texaco noted reduced profits abroad. There were clear signs of a strong recovery downstream, marked by higher prices for gasoline in the USA and natural gas in Europe. Taking the first nine months as a whole, three groups — Exxon, SoCal and Mobil — increased their profits in most sectors, to show gains of 4, 2 and 13% respectively. But Texaco's profits slumped by 23% due largely to increased costs in the context of gross crude production down by 9% in the USA and 15% in foreign areas. And Gulf, despite a good third quarter, reported nine-month earnings 7% down on a continued decline in worldwide refining and marketing profits, a further deterioration in chemicals, and a widening loss on nuclear involvement through its 50% stake in General Atomic.

Among the 13 other companies listed, all but four showed solid gains in both periods. Apart from their virtual immunity from foreign currency factors, most of these domestically oriented companies had higher profits upstream on increased output and improved prices for crude oil and natural gas, as well as better earnings downstream due largely to strong demand for gasoline — which reached an all-time peak of 8 million b/d in August. Shell Oil and Standard of Indiana both underlined this as a potent factor in their higher profits. The latter's worldwide earnings were once again greater than those of any company listed bar Exxon.

The most spectacular gains were scored by Sohio, whose profits multiplied on the rising flow of North Slope crude, despite some oil refining and marketing problems and poor results for chemicals and coal. Arco's big stake in the Alaska pipeline was likewise a major factor in profits up by 14% in the third quarter and 10% for the nine months. Getty's third quarter boost of 44% reflected increased foreign crude production (primarily from the UK North Sea) as well as higher prices for domestic oil and gas. Conoco's 31% increase was attributed to improvements in all business areas, including coal and chemicals.

Special factors accounted for the significantly lower third-quarter profits of three companies. Amerada Hess, down 10%, was plagued by lower realisations on residual fuel sales. Occidental announced a 51% decline due largely to financial arrangements for a proposed legal settlement costing \$11m; for the nine months, it showed a net loss of \$16.6m compared with a year-earlier net profit of \$92.5m, owing largely to write-downs of its European refining operations (see *Petroleum Economist* September 1978, page 374). Phillips Petroleum, with extensive foreign operations, was one of the few citing foreign currency translation effects as a major factor, amounting to a loss of \$17.4m in the third quarter — sufficient to account for its 12% decline in earnings.

In general, however, this group of companies had a good third quarter with average gains of 15%, following a first half when profits were less than 4% up. According to the *Wall Street Journal*, analysts believe that many will report improved results for the fourth quarter and the full year as well. ■

US OIL COMPANIES: NET EARNINGS
Million dollars

	July-September		%	January-September		%
	1977	1978	change	1977	1978	change
Exxon	635.0	540.0	-15	1 855.0	1 920.0	+4
Gulf	195.0	208.0	+7	577.0	538.0	-7
Mobil	239.0	259.0	+8	702.0	795.0	+13
SoCal	236.0r	264.0	+12	734.0r	748.0	+2
Texaco	247.9	212.8	-14	728.4	558.6	-23
Total, majors	1 552.9	1 483.8	-4	4 596.4	4 559.6	-1
Amerada Hess	33.9	30.6	-10	156.7	97.7	-38
Atlantic Richfield	193.9	220.5	+14	530.4	581.8	+10
Cities Service	40.2	52.6	+31	155.9	148.3	-5
Continental Oil	81.0r	105.8	+31	298.7r	296.1	-1
Getty Oil	66.4	95.8	+44	223.9	225.7	+1
Marathon Oil	49.6	50.5	+2	139.9	151.3	+8
Occidental Petroleum	39.2	19.3	-51	92.5	(-16.6)	-
Phillips Petroleum	123.2	107.8	-12	369.8	411.1	+11
Shell Oil	209.0	249.0	+19	763.0	621.0	-10
Standard (Indiana)	273.3	286.5	+5	794.9	921.7	+16
Standard (Ohio)	36.5	125.7	+244	110.9	285.7	+158
Sun Oil	94.9	97.1	+2	269.1	270.9	+1
Union Oil	95.5	92.6	-3	253.2	258.5	+2
Total, others	1 336.6	1 533.8	+15	3 958.9	4 253.2	+7
Grand total	2 889.5	3 017.6	+4	8 555.3	8 812.8	+3

r) Restated

strategies or goals of a program in progress. The engineering societies also have an advantage over permanent organizations in that they are not responsible for maintaining the employment level or "sales" of such a permanent organization; hence they can recommend program termination when a program is no longer useful.

Engineering societies have responded to requests for help in assembling forums for planning and review; the American Society of Mechanical Engineers, for example, is producing excellent results in developing a plan for R & D in tribology, and the Society of Automotive Engineers is proceeding effectively to plan R & D for road vehicle aerodynamics and tire and suspension rolling losses. Further, effective applied research in any of the technical disciplines requires a community with "critical mass." Planning and review by the engineering societies, as well as interagency coordination, help to assemble such a community, although the effort to make it most effective in furthering applied research should probably be supported by providing support in larger blocks, in one place, over relatively long periods of time.

Conclusions

The critically important role of applied research has been identified in a number of specific past, present, and future activities related to fuel conservation. The importance of applied research generally tends to go unrecognized as compared with basic research and product development processes, not only in fuel conservation activities but in virtually every area of technology implementation. There are well-defined roles for both government and industry in the effective utilization of applied research, and the engineering societies offer a potentially effective existing framework for government and industry to implement these roles.

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U.S. Energy Demand: Some Low Energy Futures

Demand and Conservation Panel of the Committee
on Nuclear and Alternative Energy Systems

This article presents several plausible energy demand scenarios for the United States through the year 2010, each one derived from analytic efforts conducted by the Demand and Conservation Panel (1) of the National Research Council's Committee on Nuclear and Alternative Energy Systems (CONAES). While the CONAES study (2) covers a range of plausible energy futures—from continued rapid growth in demand to actual reductions in demand—we focus here on futures in which demands are lower, in order to provide insight into how energy

demand growth can be reduced, and on the consequences of low energy growth. As a further effort to explore low energy growth, we assume future economic growth to be smaller than it has been in the past or than many think it likely to be in the future. This analysis is not intended to show that low demand futures are the most likely or the most desirable; instead, it is meant to illustrate the opportunities for lower energy demand growth and the public policies required to realize these opportunities.

Low energy futures could result from

constraints on supplies that appear as higher prices, import restraints, rationing, taxes, or other public policies (for instance, in response to limitations on oil and gas imports, SO_x and CO₂ production, and nuclear power). They could also result from a national decision to use energy resources more efficiently or from shifts in social priorities (such as less pollution of air and water). Adjustments to these changed conditions, whether in developing new energy supplies, expanding old ones, devising a more efficient utilization system, or changing the mix of goods and services demanded, will require decades of effort. To devise and implement a reasonable

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plan of action we must gain a better understanding of future supplies of energy (and their cost) and at the same time project plausible levels of demand for energy, identifying factors that can influence the future course of demand (energy price, population and income growth, status of technology, and so forth).

Summary. The basic features of the U.S. energy supply and utilization system change so slowly that an understanding of the dynamics of major change requires projections that extend several decades. Over such a time most energy-consuming capital stock is replaced, life-styles change, and technology evolves. This study of plausible low energy futures leans heavily on detailed engineering analysis of demand by sector, combined with econometric techniques where appropriate. The results indicate that, given time for the system to respond to prices, regulations, and incentives, U.S. energy demand is very elastic. Consequently, a major slowdown in demand growth can be achieved simultaneously with significant economic growth by substituting technological sophistication for energy consumption.

The scenarios presented here suggest that there is much more flexibility toward reducing energy demand than has been assumed in the past. Indeed, it appears that very similar conditions of habitat, transportation, and other amenities could be provided in the year 2010 with primary energy consumption ranging from 60 to 135×10^{15} Btu's (quads). This wide range of plausible future energy demands results from the technically possible responses to various price and policy possibilities.

Background

For many decades before the 1970's, the price of a unit of energy was a small and steadily decreasing part of almost everyone's budget. Major discoveries of oil and gas, combined with rapidly advancing technology, led to falling energy prices and promoted enormous growth in consumption. Not only did we find ever-increasing uses for energy, but because the relative price was falling there was correspondingly less incentive to be concerned about efficiency of utilization; instead, expansion of production (especially of electricity) was attractive because each new generating unit was more efficient and helped lower the average cost of production. Despite falling energy prices and the consequent lack of concern for conservation, efficiency of energy utilization improved steadily. For example, industry's energy consumption per unit of output fell at a rate of 1 to 1.5 percent per year from 1950 to 1970 (3). Indeed, in the past half-century, U.S. energy consumption per capita rose by 50 percent while the productivity of that energy—the ratio of gross national product

(GNP) to energy consumed—rose by 70 percent. Part of this improvement came about through conversion from coal to oil and gas (conversion of railroads from coal-fired steam to diesel) but much is attributable to other factors such as new processes and advances in materials (solid state electronics, improved insulation)

that made possible more efficient energy conversion and utilization.

Between 1946 and 1973 amenities such as large automobiles, air conditioning, frost-free refrigerators, and home freezers changed from luxuries to necessities and found ready markets. The future, according to many observers, was filled with prospects of ever-cheaper energy that would provide for our many wants, enable resource production from low-grade ores, and turn deserts green with desalted water. Electricity so cheap that it would hardly pay to meter it was even conjectured. Such times of technological Nirvana now seem far more than 15 years in the past.

Several separate events occurred over the past decade that have profoundly influenced both our energy systems and our perception about the future.

- As low-cost domestic oil resources were consumed, the nation began, in the late 1960's, to depend on imported oil, which was then cheap. The hidden costs (vulnerability to cutoffs and discontinuities in price) of that dependence appeared with the oil embargo of 1973.

- Low-cost nuclear power emerged more slowly and turned out to be more costly than anticipated. Costs of other new energy forms (such as synthetic fuels from coal) also escalated rapidly.

- There was increased awareness in the 1960's of external costs of energy production, such as pollution and health and safety costs. External costs contributed to energy price increases in the 1970's as some of them were internalized. Some coal users switched to oil and natural gas, pushing up demand for those rapidly depleting energy forms.

The long-term trend of declining real energy price (that is, corrected for infla-

tion) was reversed in the early 1970's, when major price increases were traumatically introduced by the Organization of the Petroleum Exporting Countries (OPEC) (fall 1973) and other fuel prices subsequently moved upward (Fig. 1). The trend toward higher prices is not likely to be reversed soon. At issue, therefore, is the extent to which society can respond to these higher prices not by sacrifice but through conservation—substitution of activities and increased efficiency of use.

What Is Energy Conservation?

Few concepts are subject to as many different interpretations as energy conservation (4, 5). In recent years, most people have associated conservation almost exclusively with curtailment, as unanticipated interruptions in supplies of oil and natural gas have forced Americans to cut back on energy use. In this article we do not view conservation as curtailment. Instead, conservation includes technological and procedural changes that allow us to reduce demand for energy (or specific scarce fuels) without corresponding reductions in the goods and services we enjoy. That is, conservation is a means of enhancing the energy user's perceived welfare; it leaves society materially better off than it would be otherwise and therefore is an act of enlightened self-interest; it implies that benefits of conservation actions exceed costs. These changes can be accomplished by substituting capital (insulation) or ingenuity (new microprocessor controls on heating systems) for the brute force use of energy to accomplish a particular task. Our definition allows for changes in the market basket of goods and services making up the GNP, as consumers shift to less energy-intensive goods and services to meet their needs (shifting to less energy-intensive modes of travel, buying more durable or repairable goods).

In the United States today the need for economic efficiency alone demands that energy be conserved. Energy is being wasted in buildings and industrial processes because they were designed in an era when today's energy scarcities and price levels were not foreseen; the energy component of operating costs was then too small to warrant much attention. Today we find it cost-effective to upgrade much energy-consuming equipment and to build more energy-efficient vehicles, industrial equipment, and buildings for the future. In the past, government policies led to energy prices far

below replacement cost—the price level that would occur under perfect market conditions. As these policies are changed, higher levels of energy conservation will become economic.

Many advocates argue for more energy conservation than even "perfect" market signals would call for. The most commonly cited reason is that we should reduce oil imports to minimize our vulnerability to embargoes and our balance-of-payments deficits. Some of the other reasons have to do with timing; President Carter maintains that energy conservation can give us time to reevaluate our commitment to the plutonium breeder reactor and possibly achieve a significant reduction in the risks of nuclear proliferation. Holdren (6) and Lovins (7) suggest that too much energy too soon may create greater hazards than too little too late and recommend energy conservation policies. Conservation would provide the nation with the flexibility to pick and choose among long-term energy options as the uncertainties surrounding nuclear waste management, the technology of solar cells, and the climatic effects of fossil fuel combustion are clarified. Kissinger (8) points to the possibility that oil exporting nations may accumulate balance-of-payments surpluses large enough to precipitate financial crises and economic chaos in the industrial democracies of the world. Other reasons for conserving energy are based on ethical considerations such as the fact that the United States has only 5 percent of the world's population, yet consumes more than one-third of the world's energy, and the belief held by environmentalists that major external costs remain in the energy system and that much of our finite energy resources should be saved for future generations.

The Demand Study

In this study the Demand and Conservation Panel examined some plausible paths that energy demand might take in the future (through 2010) in response to price and other factors. It was undertaken in support of a more comprehensive CONAES study of the future of energy supply and demand (2, 9). Panel members were chosen to provide a diversity of points of view and disciplinary skills. Additional resources and expertise were brought into the study by several resource groups, which were formed by the Panel to examine specific issues (1).

At the outset, the Panel encountered considerable conventional wisdom about energy use that has found extensive, if tacit, acceptance in various segments of American society. The following are some examples of what are now known to be misconceptions about energy use.

- Energy and the production of goods and services are intimately and inextricably linked; energy is a relatively fixed factor in GNP.

- Energy consumption and jobs are inextricably tied together; more energy consumption means more jobs, and vice versa.

- Higher illumination levels generally help productivity; low illumination is injurious to the eyes.

- Reducing the growth of energy consumption implies replacement of machines (bulldozers) with manual labor (men and women wielding picks and shovels).

- Turning down the thermostat at night is counterproductive; the energy used in heating up the house in the morning more than offsets any savings.

This kind of folklore indicated a need

to develop a more quantitative technical and economic understanding of the dynamics of energy consumption. The Panel decided to map out a broad range of plausible future levels of consumption (10). Since consumption is influenced by many factors, certain things were assumed, such as population growth rate at Census Bureau series II, and others were allowed to vary, notably the price of energy, the economic growth rate, and public policies.

Economic growth was assumed to vary linearly in time, with total (real) GNP doubling by 2010. In a variant analysis GNP was allowed to triple by 2010. The latter case corresponds to an average real GNP growth of 3 percent per year between 1975 and 2010 with higher than average growth in the near term (for example, 4 percent) and lower growth in the long term, reflecting lower population growth. In this article we report results based on the assumption of a 2 percent average growth rate, again with higher than average growth in the near term. It should be emphasized that even in these low-demand futures we assume a doubling of real income over the next 35 years.

For most scenarios, price was used as the primary driving force behind the different outcomes. There were three pricing assumptions, corresponding approximately to prices four times, double, and equivalent to 1975 prices (see Table 1). A very low growth variant, assuming significant changes in life-style, was also studied.

Prices serve many functions in a market economy. They reflect the relative scarcity of resources and serve as signals to producers and consumers in allocating the supply of and demand for energy resources. Prices assumed for the scenarios were allowed to reflect external costs as they affect occupational and public health as well as environmental quality, and the degree to which these costs become internalized in the costs of energy products.

Public policies can serve these functions as well. First, they can and do affect price. Environmental regulations internalize costs, tax policy affects pricing patterns, and regulatory agencies (such as state utility commissions) sometimes set prices. For example, in response to external costs, regulation has set minimum standards on car safety, air pollution, pesticides, strip-mining, and mine safety. Second, conservation education can shift the mix of goods and services demanded as well as their energy efficiency. Third, tax subsidies can and have promoted production. Therefore

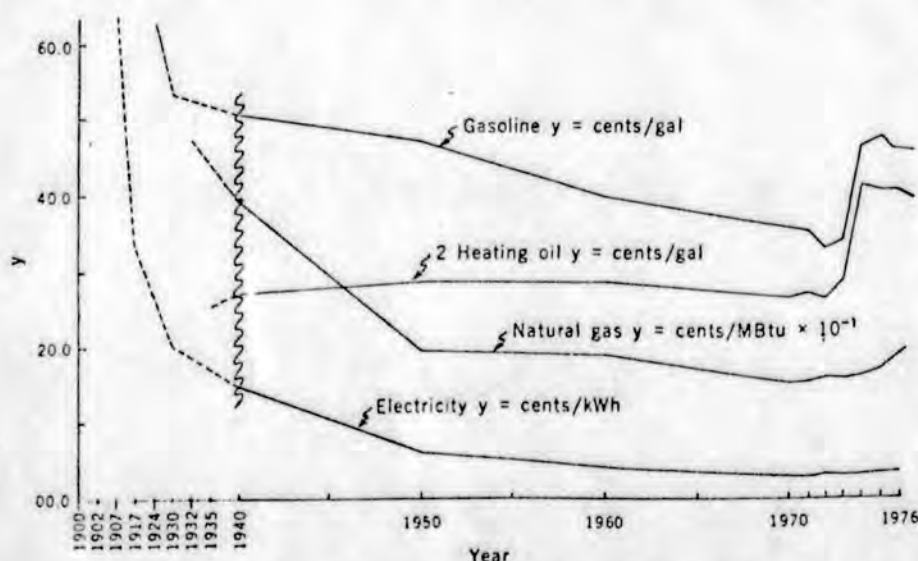


Fig. 1. History of residential energy prices (1976 dollars).

public policies can be alternatives or surrogates for price changes, seeking to reflect social value and cost and guide producers and consumers in decisions concerning production and consumption.

In analyzing the dynamics of demand over such an extended period of time it was decided to invoke several different techniques.

1) *Near future (the next decade).* Since energy consumption patterns in this period will strongly reflect the characteristics of existing capital stock, the most appropriate approach was felt to be econometric analysis. In applying this technique, recent trends in energy consumption were analyzed and used to project demand as influenced by both price and nonprice factors. Statistical techniques were used to determine the past quantitative relationships of energy use to energy prices, conservation efforts, incomes, GNP, population, and other demographic and economic factors. Energy demand in the future was defined by the interaction of these observed historical relationships tempered by the assumptions of future economic and demographic variables. Although this technique can be used to examine historical variations in energy use in relation to geographic variations in energy prices and income to obtain near-term insights, it has limited validity for application to the distant future. It cannot logically be applied to periods with major differences in economic structure or energy prices. The contribution of econometrics to the work of the Panel was that it indicated whether the short-term response to assumed prices and incomes in each scenario leads energy demand to follow a path in the near future that is consistent with the Panel's energy projections into the next century.

2) *Longer-term future (to 2010).* Energy consumption characteristics of various amenities (such as transportation and habitat) can change markedly over periods comparable to the average lifetime of energy-consuming capital equipment (cars, air conditioners, and houses). Social conditions and attitudes can also change greatly over a 35-year span. Therefore, even though our analysis will undoubtedly turn out to be somewhat off the mark, it is important because actions taken today will significantly affect the conditions that exist in 2010. A detailed engineering approach was taken to analyze plausible energy trends in each consuming sector over the long term. Energy consumption was partitioned into three sectors—residential and commercial buildings and appliances, industry, and transportation—

Table 1. Detailed price schedules for key fuel types were determined for each scenario. Average consumer prices for distillate oil, natural gas, utility coal, and electricity in 2010 are given in 1975 dollars per million Btu's. Prices are assumed to change slowly and continuously between 1975 and 2010.

Scenario	Consumer price (\$/MBtu)			
	Distillate oil	Natural gas	Utility coal	Electricity
Actual	1975			
	2.81	1.29	0.81	7.91
I and II	2010			
	13.49	14.84	3.24	26.37
III	6.74	7.42	1.62	15.82
IV	2.81	3.09	0.81	7.91

which were examined independently. The results of the independent sectoral demand analyses were integrated, using energy input-output analysis to make them consistent with a specified market basket of goods and services making up the GNP in each scenario.

For the scenarios presented here, the real GNP growth rate was assumed to slowly decline from 3 percent in the late 1970's to about 1 percent in 2010, corresponding to a linear increase and a doubling of real GNP over the 35-year period. The reduced GNP growth rates in the latter years stem from expected reductions in the rate of growth of population and the labor force. The assumption that GNP will rise while the labor force is leveling off implies a positive rate of growth in productivity, but does not specify the sectors in which it occurs. The scenarios

may be taken to reflect various assumptions about relative price changes in energy and nonenergy sectors, or price may be considered simply a surrogate for a variety of government policy options.

All scenarios implicitly account for the development and market penetration of new technologies and products. This is accomplished by specifying the market basket of consumer goods and services consistent with a fixed GNP. Any new product within this limit would have to displace another; only the differential energy requirement would be relevant.

Caveats. Neils Bohr pointed out that "it is very difficult to make an accurate prediction, especially about the future." We feel that for such subjects as energy demand it is even very difficult to make an accurate projection. Thus, we present our major disclaimers about the study.

- It is assumed that the future unfolds smoothly. Energy prices are a primary driving force behind the analyses, and it is assumed that they are known to energy users or that appropriate regulations compensate for the lack of perfect information. If there is extreme uncertainty about energy prices, and reason to believe that they may drop significantly, many persons will choose not to make major capital investments in conserving technologies.

- For most of the outcomes studied it is assumed that personal tastes will not change very much from those of today. Roughly the same (albeit twice as large) market basket of goods is to be provided to consumers in 2010 as today. Changes

Table 2. Energy demand scenarios.

Scenario	Energy price ratio, 2010/1975*	Energy conservation policy	Energy in 2010 (quads)					
			Buildings	Industry	Transport	Total	Losses†	Primary consumption‡
I	4	Very aggressive, deliberately arrived at reduced demand requiring some life-style changes	6	26	10	42	16	58
II	4	Aggressive; aimed at maximum efficiency plus minor life-style changes	10	28	14	52	22	74
III	2	Slowly incorporates more measures to increase efficiency	13	33	20	66	28	94
IV	1	Unchanged from present policies	20	39	26	85	51	136
1975			16	21	17	54	17	71

*Overall average; assumptions by specific fuel type were made reflecting parity and supply; price increases were assumed to occur linearly over time. The price was assumed to be either that actually charged at the final point of demand or the shadow price reflecting a policy. †Losses include those due to extraction, refining, conversion, transmission, and distribution. Electricity is converted at 10,500 Btu/kWh, coal is converted to synthetic liquids and gases at 68 percent efficiency. ‡These totals include only marketed energy. Active solar systems provide additional energy to the buildings and industrial sectors in each scenario. Total energy consumption values are 63, 77, 96, and 137 quads in scenarios I, II, III, and IV, respectively.

Table 3. Total primary energy consumption in 2010 by fuel type. Each set of numbers represents only one of a wide variety of energy resources that could be used to meet energy demands. Because energy resources are largely interchangeable over the long run, the actual mix in 2010 can be influenced by changes in price, technology, and policy.

Fuel type	Total primary energy consumption (quads)				1975
	Scenario				
	I	II	III	IV	
Liquid fuels*	24	29	38	50	30
Gaseous fuel†	8	9	11	26	17
Coal (direct use)‡	10	11	13	10	4
Electric inputs§	17	26	32	50	26
Total purchased fuels	58	74	94	136	71
Active solar¶	5	3	2	1	Negligible
Totals	63	77	96	137	71

*Liquid fuels include petroleum, shale oil, and synthetic liquids derived from coal. †Gaseous fuels include natural gas and gasified coal. ‡Figures do not include coal used for liquid and gaseous fuels (necessary in most of the scenarios) or for electricity production. §Includes coal, nuclear, hydro, geothermal, and oil (for peak demand only). ¶Because of rounding off, totals may not equal the sums for fuel sectors. ¶Estimated use of active solar units in buildings and industry.

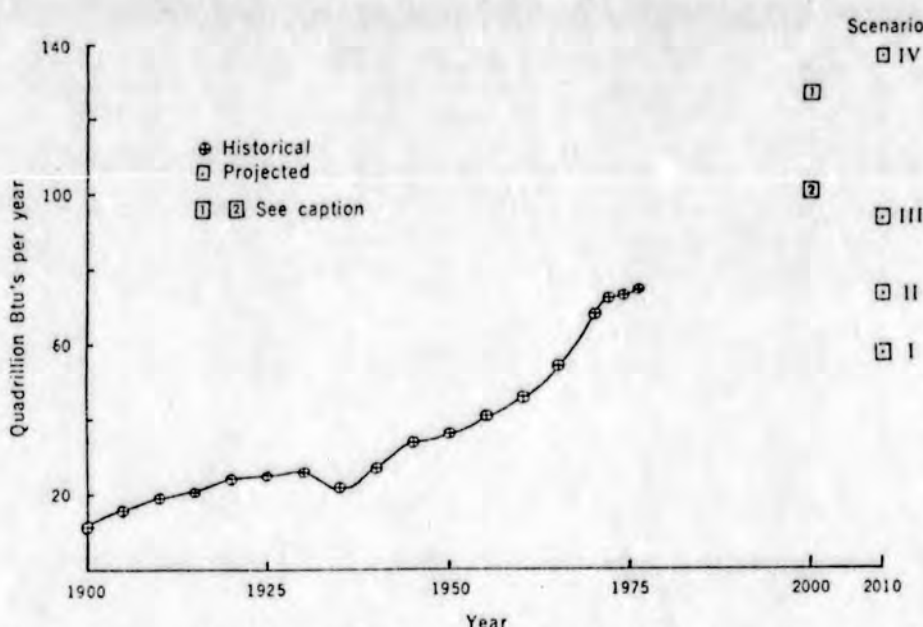


Fig. 2. Summary of total U.S. energy demand scenarios. Some information was obtained on values for 1990, but the detailed evaluations were focused on 2010. Other results shown for comparison are [1] the Energy Policy Project (EPP) (16) "tech fix" case and the Institute for Energy Analysis (IEA) (18) "high" case, and [2] the EPP "zero energy growth" case and the IEA "low" case.

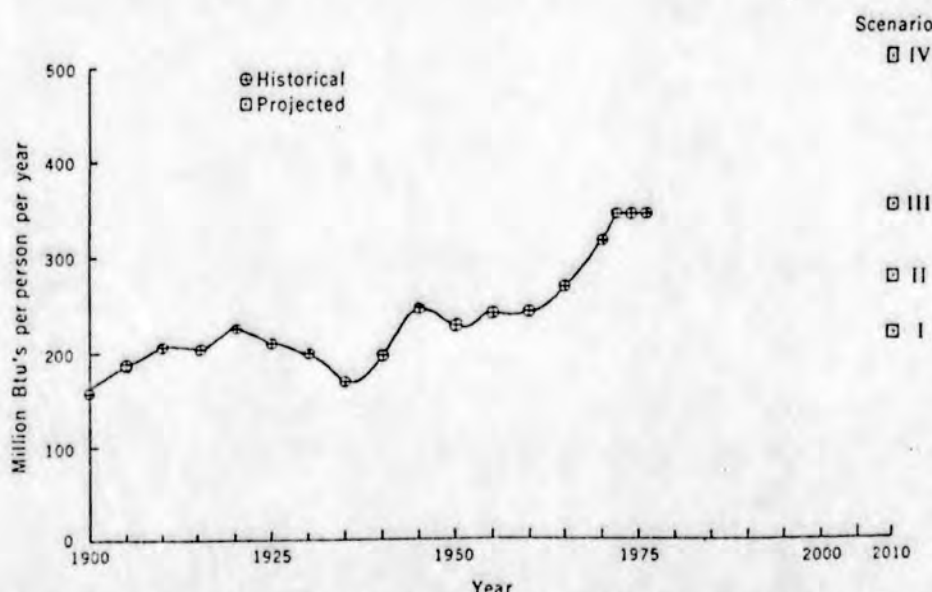


Fig. 3. Per capita energy demand history and projections. Population growth rate was assumed to be that given by Census Bureau series II.

in values could modify this assumption drastically.

• Because the use of energy in the United States is so inefficient, energy consumed in providing an amenity can be reduced by changes in efficiency over a relatively wide range (11, 12). That is, an increase in the real price of energy can make it economically very attractive to use less energy to provide a particular amenity. Recent history shows that the effect of price can just as easily be produced by regulation, standards, incentives, and disincentives; it can also be produced by supply uncertainty, especially in the industrial sector.

• Long-term economic growth is exceedingly difficult to predict because it depends on vagaries of population growth, politics, social attitudes, labor productivity, technological innovation, and resource availability. Therefore any long-term GNP or, for that matter, population assumption is subject to challenge.

• Almost all of our past experience with energy (the basis for econometrically derived price elasticities) has been in an era of falling real energy prices. The lag times associated with price elasticities may not be applicable under conditions of rising real prices.

• Energy consumption models that are primarily based on engineering can only be approximate; this is partly because assumptions must be made about economically rational market behavior. For example, people may choose to buy a slightly cheaper, low-efficiency refrigerator and pay higher operating costs.

• New kinds of unusually energy-intensive consumer goods are not assumed explicitly but neither are new kinds of energy-saving technologies. Either or both could change demand patterns significantly in a decade.

• Energy prices are assumed to reach parity—that is, price is assumed to reflect the quality of energy—by the middle 1980's. (This means that coal will continue to be priced lower than oil or gas on a Btu basis.)

Results of the Analyses

Results are presented here for four demand growth scenarios. Each is believed to represent an internally consistent picture of the U.S. economic system in the year 2010. No scenario is presumed to be more probable than the others. They represent a broad range of plausible alternative futures, within the focus of this article on lower-demand futures.

The characteristics of the scenarios are summarized in Table 2. The sce-

narios highlight the strikingly wide range of energy efficiencies that appear to be technically and economically feasible for a particular level of economic activity. The energy demand paths are illustrated in Fig. 2. The demand levels in 2010 were obtained by using input-output synthesis of the separate sectoral analyses. Trends and projections in terms of per capita energy demand are shown in Fig. 3 and the energy GNP ratio in Fig. 4.

Plausible energy supply mixes corresponding to the scenarios are summarized in Table 3. However, it must be remembered that over a period of decades the mix of fuels (as well as aggregate demand) can change considerably. A discussion of the amount of electricity that could be used is given later in this article. The energy supply mixes shown in Table 3 are quite conventional: resource conservation significantly reduces the imperative for crash programs to develop new technologies and provides the flexibility to eliminate one or more technologies for environmental or safety reasons.

In scenario I we examine a set of fairly extreme changes by considering the combined implications of substantially higher energy prices, significant life-style accommodations, and reduction of energy consumption by equipment to approximately 60 percent of the per capita level today. Some shift of the population to warmer climates and collocation of industry and residences is assumed. For the intermediate scenarios (II and III), we assume substantially higher energy prices and corresponding major market accommodations to obtain amenities less expensively. The results for scenario II indicate the extent to which a society that chooses a high efficiency of utilization, through technical sophistication and innovation of its social institutions, can avoid substantially modifying the nominal market basket of goods and services. The results obtained for scenarios III and IV reflect a future much like today, where efficiency improvements in familiar energy-consuming devices permit production of goods and services with corresponding changes in life-styles. It should be noted, however, that even though the assumed efficiency improvements are cost-effective in terms of assumed energy prices, they are not likely to be achieved in the absence of supportive policies.

Econometric results. Long-run price elasticities were found to be comparable to those reported in other recent studies (13). The greatest response observed was the long-run price elasticity of -1.7 (industrial use of natural gas), while the

smallest was the elasticity of -0.4 for gasoline use with respect to gasoline price. Historic price responses provide a basis for examining how near-future growth in energy demand may vary with energy price.

Differentiation of conservation, price, and income influences in reducing energy demand in 1974 showed that after the increase in energy prices and the decline in personal incomes throughout the country were taken into account, energy use fell below what would be expected from this price- and recession-induced decline. This nonprice-induced conservation effect accounted for further re-

ductions in use of 6 percent (residential-commercial electricity) to 13 percent (industrial use of coal). It probably reflected lower speed limits, increased energy awareness, and simple improvements in energy management. It is impossible to know whether this nonprice effect will continue in the future; however, it apparently existed in a weaker form in 1975, and essentially disappeared in 1976. One such projection (for scenario III) is reproduced in Fig. 5. It shows the near-future econometric forecast associated with twofold growth in real energy prices from 1975 to 2010.

Opportunities for improved efficiency

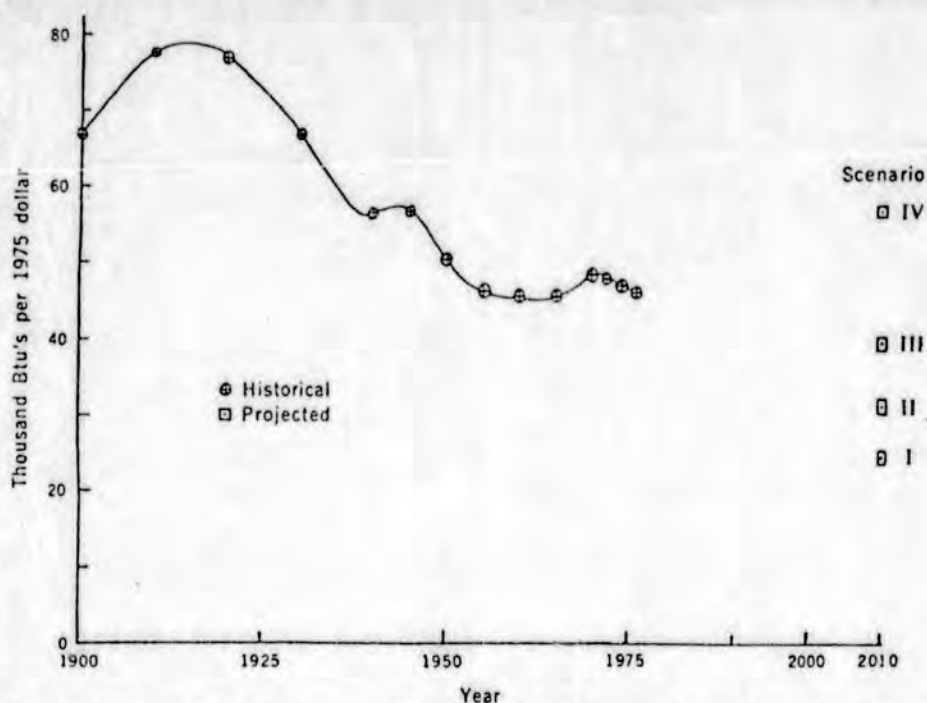


Fig. 4. Time dependence of the energy/GNP ratio. Many factors such as market basket choices and the price of energy can affect this ratio. Long-term trends in the ratio reflect changes in technology as they affect the energy intensity of new capital stock.

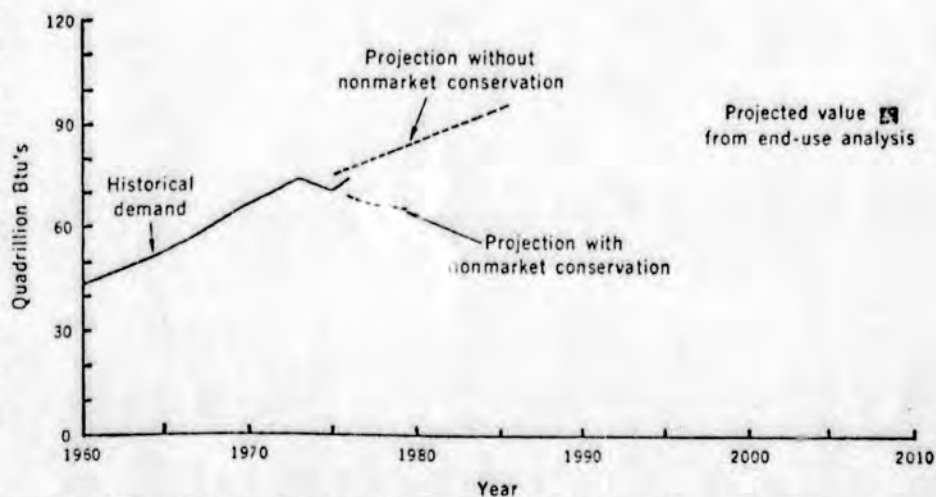


Fig. 5. Energy demand projection for the next 10 years. This example, corresponding to scenario III, indicates the range of total U.S. energy demand that could occur. The upper dashed line corresponds to demand driven by price factors, the lower one to demand influenced by price factors as well as nonmarket factors, including heightened awareness and regulations similar to those existing in 1974 and 1975. The demand value in 2010 obtained through detailed end-use analysis is consistent with extension of the range of econometrically derived demand.

of use. Analyses of the engineering potential for higher efficiency show that major opportunities exist in all sectors of demand and that the economic incentive to shift to higher efficiency is a strong function of the price of energy. Figures 6, 7, and 8 illustrate this point (10, 14, 15). Although the most impressive opportunities for higher efficiency of use occur with new capital goods, there are also many good ways to improve the efficiency of the existing system (operation of buildings, industrial processes).

Highlights of the Scenarios

Scenario IV. With the exception of the price of natural gas (which more than doubles by 2010), energy prices remain constant in this scenario over the entire period, possibly because of breakthroughs in the supply sector or public policies that provide subsidies to energy price. Higher gas prices might result from either deregulation of wellhead prices, regulation at increased price lev-

els, or the introduction of synthetic gas produced from coal.

Despite the lack of higher energy prices, the incentive to increase efficiency of use is greater than it was before 1972, because in those years real energy prices were falling. Furthermore, energy prices are higher today than they were when most existing capital investments were made. Therefore there are additional incentives to increase efficiency even without further improvements in the technology of energy utilization. As a consequence, the efficiency of energy use improves modestly over the period. Representative changes are given in Table 4.

In the buildings sector, the lagged effect of postembargo energy prices and public policy actions already under way result in efficiency improvements in new stocks through 1980. Because of continued increases in gas prices, small improvements in most gas appliances occur beyond 1980. The better performance in new products and buildings is felt throughout the period to 2010 as older

stocks are replaced. However, improvements occur very slowly; for example, electric space heating continues to be dominated by resistance heaters. In the industrial sector the historic trend to lower energy consumption per unit output continues but at a slower pace, resulting in an overall drop of 18 percent by 2010.

In transportation, per capita energy consumption grows modestly, but technological advances result in small improvements in efficiency. Current policies [such as miles per gallon (MPG) standards for automobiles] continue. No significant shifts occur in freight modes, but the percent of consumer transportation expenditures in air travel increases as automobile travel begins to be saturated (ownership, minutes traveled per day, and so on). Transportation energy intensiveness drops in all sectors. Mass transit travel (per capita) nearly doubles.

Scenario III. In this scenario real energy prices steadily climb, ending in 2010 at twice the 1975 levels. These increases are mostly due to higher production costs as cheap supplies of fossil fuels are exhausted. There are substantial efficiency increases in the buildings, including improvements in thermal integrity of structures and increased efficiency of appliances (see Table 5). Overall building energy use decreases at an average annual rate of 0.6 percent, compared to growth of 3 percent per year from 1950 to 1975. The major reason for the decrease in growth rate is the reduction in space heating requirements. Because of differences in assumed energy prices, the relative market share of electricity increases from 21 to 51 percent, while the natural gas share declines from 53 to 21 percent. Electric heat pumps become more efficient and find widespread use. Solar energy becomes increasingly important toward the end of the period for air conditioning, space heating, and water heating. The energy efficiency ratio of new air conditioners in 2010 is close to 10 Btu's per watt-hour (compared with 6 Btu/W-hour in 1975). Because of the increase in energy prices, there are increased expenditures for energy in buildings. However, the percentage of personal income spent for household fuel increases only moderately, from 3.1 in 1975 to 4.3 in 2010. There is a corresponding increase of 3 percent in capital expenditures for buildings and appliances during the period. The technologies to produce the higher efficiencies in this scenario are either currently on the market or are achievable by well-known means. Figures 6 and 7 indicate the kinds of improvements that

Table 4. Energy efficiencies in 2010, according to scenario IV.

Buildings and appliances		Industry		Transportation	
Type	Intensity*	Type	Intensity†	Type	Intensity‡
Thermal integrity (heating)		Agriculture	0.95	Automobile	20 mpg
Residential	0.76	Aluminum	0.79	Light trucks and vans	16 mpg
Commercial	0.7	Cement	0.75	Air passenger	0.5
Government and education	0.5	Chemicals	0.84§	Truck freight	0.9
Space conditioning		Construction	0.73	Air freight	0.6
Air conditioning	0.94	Food	0.86	Rail freight	1.0
Electric heating	0.9	Glass	0.82		
Gas and oil heating	0.8	Iron and steel	0.83		
Refrigeration and freezing	0.92	Paper	0.76		
Lighting	0.70	Other industry	0.85		

*Energy intensity of new construction and products in 2010 compared with 1975. †Average energy per unit production in 2010 compared with 1975. ‡When figures are not given in designated units they refer to energy intensity in 2010 compared with 1975 (including changes in load factor). §Excluding feedstock.

Table 5. Energy efficiencies in 2010, according to scenario III.

Buildings and appliances		Industry		Transportation	
Type	Intensity*	Type	Intensity†	Type	Intensity‡
Thermal integrity (heating)		Agriculture	0.85	Automobile	27 mpg
Residential	0.63	Aluminum	0.63	Light trucks and vans	21 mpg
Commercial	0.6	Cement	0.63	Air passenger	0.45
Government and education	0.45	Chemicals	0.78§	Truck freight	0.8
Space conditioning		Construction	0.65	Air freight	0.6
Air conditioning	0.75	Food	0.76	Rail freight	0.97
Electric heating	0.63	Glass	0.76		
Gas and oil heating	0.75	Iron and steel	0.76		
Refrigeration and freezing	0.68	Paper	0.71		
Lighting	0.70	Other industry	0.75		

*Energy intensity of new construction and products in 2010 compared with 1975. †Average energy per unit production in 2010 compared with 1975. ‡When figures are not given in designated units they refer to energy intensity in 2010 compared with 1975 (including changes in load factor). §Excluding feedstock.

might be expected in the energy efficiencies of structures and appliances. Similar improvements are likely for other kinds of appliances and buildings.

In the industrial sector the steadily increasing price of energy results in slower production growth in the energy-intensive aluminum and chemicals industries than in industries producing less energy-intensive substitutes. The overall weighted average energy consumed per unit output in 2010 is 26 percent lower than in 1975. Some shifts have occurred between producing sectors (less steel, more aluminum and fiber glass), reflecting changed demands by manufacturers and the construction industry. Industrial cogeneration becomes widely practiced.

In the transportation sector, per capita energy consumption in 2010 remains about the same as in 1975 despite slightly expanded passenger and freight movement. The average energy intensity of automobiles (Btu's per vehicle mile) drops to half of the 1975 value, reflecting large gains in automobile performance (Fig. 8). Airline travel grows at an average 2 percent per year. Mass transit use in 2010 (passenger miles per capita) is 3.5 times that in 1975. Although water freight stays relatively constant, rail freight expands (in ton-miles per capita) by about 30 percent and truck freight by

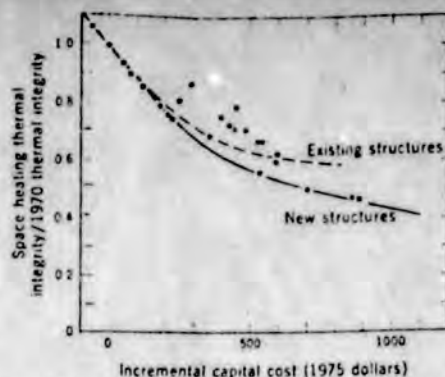


Fig. 7. Energy intensiveness of new and existing residential dwellings as a function of investment in construction (or retrofit). Energy intensiveness falls rapidly for small increases. There are more cost-effective opportunities for new structures because insulation investments cut the required size (and therefore cost) of heating and cooling systems (15).

40 percent, and air freight expands three-fold.

Scenario II. In this case consumption in 2010 is about the same as today, after going through a peak around 1990. Energy prices increase substantially for all energy forms over the 35-year period from 1975 to 2010. Real energy prices are assumed to essentially quadruple by 2010. Public policies provide incentives, taxes, standards and regulations, vigorous research and development (R & D), and public education to help accelerate the United States toward high efficiency of energy utilization.

Because of the higher prices, there are substantial improvements in new appliances, and buildings are carefully designed and constructed for efficient energy use (Table 6). More energy improvements are made in existing buildings than in scenarios III and IV. As a result, overall energy use in buildings declines from 16 quads in 1975 to 11 quads in 2010. Although energy consumption is reduced somewhat, the very high energy prices result in substantial increases in expenditures for fuel. However, increases in income over the period reduce the relative impacts so that residential fuel expenditures increase only from 3.1 to 4.9 percent of personal income. Thermostats are set back and room temperatures are kept lower in winter (68°F) and higher in summer (75°F). Some new appliance technologies are introduced in this scenario. For example, high-efficiency electric and gas heat pumps may be developed and widely adopted with thermal storage (the annual cycle energy system, where heat is stored in water). Decentralized uses of solar energy for space heating, air conditioning, and water heating make a substantial contribution near the end of the period (25 percent of new

air conditioners, 50 percent of new space heaters, and 70 percent of new water heaters in 2010). Improved retrofit measures and construction practices are an important aspect of the scenario. Retrofit measures include extensive insulation of previously uninsulated exterior walls. Passive solar house construction, consisting of heavily insulated structures with a large area of windows facing south, become popular after 1990. Typical house construction would include double 2 by 4 inch exterior walls with a full 8 inches of insulation and 12 inches of insulation in ceilings. Some underground or earth-covered construction would further reduce the energy consumption.

Industry responds to the price trends and tight government regulations and makes large investments in both retrofit and new process development, resulting in an overall decrease in energy consumed per unit output that reaches a value 34 percent lower in 2010 than in 1975. However, the cost of conversion to new, more efficient processes still does not warrant a significantly accelerated write-off of existing plants purely for energy reasons. To achieve this improved efficiency current air pollution standards are not tightened. Throwaway packaging de-

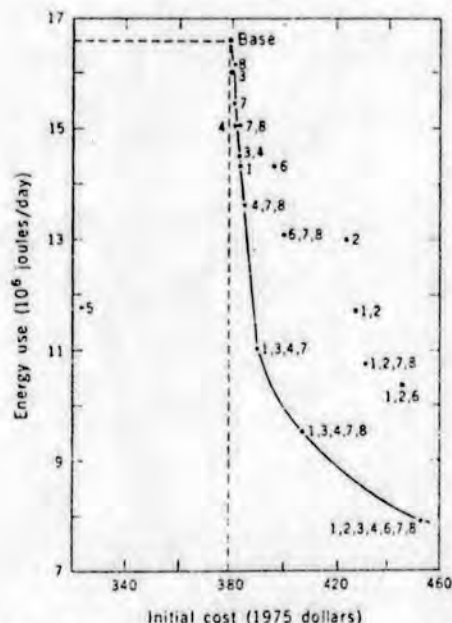


Fig. 6. Energy intensiveness of a typical household refrigerator-freezer combination, plotted against purchase price. The energy intensiveness falls rapidly for relatively small increments in first cost (14). Modifications corresponding to the numbered points were: 1, increase insulation thickness; 2, improve insulation thermal conductivity; 3, remove fan from cooled area; 4, add antisweat heater switch; 5, eliminate frost-free and forced air systems; 6, improve compressor efficiency; 7, increase condenser surface area; and 8, increase evaporator surface area.

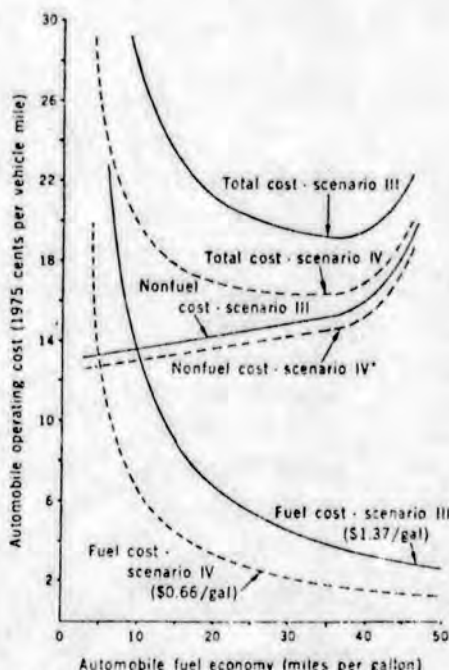


Fig. 8. Total cost of private automobiles plotted against mileage performance achievable by 1985. To provide approximately the same interior space, safety features, and so on, a more energy-efficient car is more expensive, but the added cost is not great for mileages less than 35 to 40 miles per gallon. Balanced against operating costs, the total cost of ownership and operation is remarkably insensitive to mileage. Note that nonfuel cost includes such items as depreciation, maintenance, garaging, parking and tolls, insurance, taxes and fees, and interest lost.

Table 6. Energy Intensities in 2010

Buildings and appliances		Industry		Transportation	
Type	Intensity*	Type	Intensity†	Type	Intensity‡
Thermal integrity (heating)		Agriculture	0.85	Automobile	37 mpg
Residential	0.63	Aluminum	0.55	Light trucks and vans	30 mpg
Commercial	0.42	Cement	0.60	Air passenger	0.42
Government and education	0.35	Chemicals	0.74§	Truck freight	0.6
Space conditioning		Construction	0.58	Air freight	0.6
Air conditioning	0.66	Food	0.66	Rail freight	0.91
Electric heating	0.52	Glass	0.69		
Gas and oil heating	0.72	Iron and steel	0.72		
Refrigeration and freezing	0.58	Paper	0.64		
Lighting	0.60	Other industry	0.57		

*Energy intensity of new construction and products in 2010 compared with 1975. †Average energy per unit production in 2010 compared with 1975. ‡When figures are not given in designated units they refer to energy-intensity in 2010 compared with 1976 (including changes in load factor). §Excluding feedstock.

clines. Production of chemical foams and fiber glass for expanded thermal insulation increases; production of materials for strong but lightweight automobiles is expanded. Industrial cogeneration and power plant waste heat utilization become commonplace.

The most efficient automobiles, using new technologies such as the Brayton and Stirling engines, are introduced beginning in the late 1980's. Federal MPG standards set under the Energy Policy and Conservation Act of 1975 (Public Law 94-163) are reached and new standards are set, taking full advantage of the technological potential to increase mileage. People spend about 30 percent more time in cars, on the average, than in 1975. Air passenger miles per capita increase to a level about 60 percent greater than today's, while telecommunications technology improves substantially. Increased demand results in two generations of aircraft by 2010, which provide one-third more seat-miles per gallon. Airplane load factors increase from 55 to 75 percent as a result of government policy. Some modal switching from truck to rail occurs, and improvements in truck fuel efficiency and load factors yield substantial energy savings. Despite expanded per capita use (miles traveled, tons carried) the energy consumed in this sector in 2010 falls by 18 percent. Per capita use of mass transit expands nearly fivefold.

Scenario I. This scenario received less detailed attention than the others; it was derived by making incremental changes in the assumptions for scenario II concerning additional energy-conserving policy actions. As is the case for any level of energy use, many possible configurations of technology and life-style are compatible with an energy use of 59 quads at twice today's GNP. Here we describe only one set of changes relative

to scenario II. We emphasize that such a scenario could not occur without aggressive, coordinated long-term policy actions in the areas of land use, transportation, and electric utility regulation. A more restricted set of policies limited to energy use (efficiency standards, energy taxes) probably could not achieve such a large reduction in energy use by 2010.

Energy use in buildings is reduced through improved building materials and construction techniques, including expanded use of passive solar design, and extensive use of such techniques as annual cycle energy systems, as well as active solar units. Continued migration to "sun belt" states occurs, along with acceleration of trends toward multifamily units. These measures combine to reduce end use for space conditioning and water heating to a level about one-third less than obtained in scenario II. Additional savings (about 1 quad) accrue from using steam from cogeneration in commercial and apartment buildings. An additional 0.3 quad of electricity is saved through further increases in the efficiency of appliances.

Substantial shifts occur in industrial production, favoring less energy-intensive goods. Major investments are made in new process technology and in new, highly efficient plants with cascaded use of heat. Since maximum practicable cogeneration (of electricity and industrial heat) was assumed in scenario II, no major additional improvements are assumed here.

The average time spent in automobiles (currently about 53 minutes per person per day) is reduced by 2010 to the 1963 average (43 minutes), in part because of better organized living patterns. This results in a savings of 1 quad of gasoline. In scenario II no improvement in the efficiency of military fuel use was assumed. In scenario I we assumed a 50 percent

proved efficiency, saving 1 quad.

No changes are made in the air transport sector beyond those in effect for scenario II. Energy use for freight transportation is reduced by one-third (2.0 quads) by shifts toward a more service-oriented economy and by strong policies promoting shifts from truck to rail transport.

The mix of goods and services constituting the GNP in all other scenarios showed only income effects, such as saturation of food purchases and increases in purchases of durable goods. If present trends continue toward higher prices for all resources (including energy) relative to labor, it may be expected that goods will be made more durable and will be maintained longer. Under such conditions the consumer market basket would shift away from goods toward services (including repair and maintenance).

Scenario I calls for significant changes in energy-consuming technology, and almost all activities become quite energy-efficient. The net result of these changes, in terms of primary fuel use, is a primary energy demand of 59 quads per year, corresponding to 60 percent of today's per capita energy. Scenario I may signal an approach to the level where energy and GNP become tightly coupled even in the longer term because presently anticipated technological improvements are fully utilized in scenario I.

Discussion of Results

Demand for electricity. The demand for energy as electricity has grown substantially faster than the demand for total energy (7.1 percent per year in the decade 1960 to 1970, compared to 4.2 percent per year for all energy). Analyses based on a broad range of assumptions suggest that the demand for electricity will grow substantially more slowly in the future. Ranges of average electricity demand growth are given in Table 7. These ranges are rather broad because of the ease with which electricity can be interchanged with other energy forms in new construction. Thus, an electric heat pump and a gas heating system are almost directly interchangeable. Similarly, for many industrial heat applications and ground-based transportation either electricity or gaseous or liquid fuels can be used. Only in a few applications does electricity appear to serve uniquely (lighting, specialized industrial applications, computers).

For the maximum electricity use analyses virtually all electric heating of build-

ings was assumed. In the industrial sector, the maximum (purchased) electricity scenario describes a situation where there is almost no self-generation of electricity, and where many processes are electrified. At the same time, the transportation sector was still assumed to operate primarily on liquid fuels. Major advances in electric energy storage (such as high-efficiency batteries) could change this situation significantly, however, and lead to even greater demands for electric energy than those included in the analyses given here. In the minimum electricity analyses, gas and oil provide virtually all heating needs, and electricity use is restricted to electric drive and other critical processes. Since the figures pertain only to electricity purchased from utilities, they understate the actual extent to which the industrial sector relies on internally generated electricity.

Economic effects. The scenarios imply a large potential for long-term change in the ratio of energy use to GNP. As long as the transition to energy-efficient capital stocks occurs smoothly and over a significantly long period of time, there is no reason to expect major adverse effects on the GNP. There appear to be no major differences in labor requirements between scenarios I and IV. Since only 16 percent of the labor force is employed in the sectors responsible for 70 percent of industrial energy consumption, the potential for appreciable impacts in that area is small. Labor in construction and maintenance of buildings, appliances, and automobiles could increase, offsetting reduced employment in energy-producing sectors.

Essentially all capital goods require energy (power plants, industrial equipment, buildings). Today about 25 percent of new capital available in the private sector goes for energy supply and conversion facilities (16). This is expected to increase in the future as more capital-intensive energy supply technologies are introduced (solar electric systems, synthetic fuel, nuclear plants). We assume for the purpose of analysis that this would increase to 30 percent in 2010 for scenario IV (energy prices about the same as today's). We will now consider the differences between this "nominal" case and scenario II.

In scenario II energy consumption is about 40 percent lower than in scenario IV, so we assume that the capital needed for energy supply facilities is likewise reduced by 40 percent to only 18 percent of total capital. This leaves 82 percent of new private capital available for energy-consuming stocks, representing about a 12 percent increase over the nominal 70

Table 7. Role of purchased (utility) electricity (2010) in terms of energy

Sector	Scenario II*		Scenario III		Scenario IV		1975 (actual)
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Buildings, quads	10	22	13	25	17	43	12
Industry, quads	8	17	9	20	11	23	8
Transportation, quads†	1	4		4		4	
Total, quads	18	43	22	49	28	70	20
Primary energy, quads		74		94		136	71
Electricity, percent of primary energy‡	25	56	24	49	23	52	28
Average annual electricity growth, percent§	0.2	2.6	0.7	3.2	2.2	4.0	

*Electricity demand growth for scenario I was not estimated here. †A major shift to electricity for ground transportation is not assumed here. However, if about half of transportation were shifted to electricity by 2010 the additional electrical demand, beginning in 1990, would be ~5 GW/year. ‡These numbers represent upper and lower bounds, based on corresponding policies. The likely consumption in each scenario, barring such policies, is given in Table 2. §Over the period 1975 to 2010.

percent level. Each of the sectoral analyses indicated that the incremental capital cost of achieving scenario II efficiency levels is less than 10 percent of total non-energy capital investment. Therefore, the capital not used for energy production could match or exceed the additional capital needed to improve energy efficiency of energy-consuming equipment.

To check sensitivity to assumptions about GNP growth, the Panel considered another scenario in which conditions were assumed identical to those in scenario III except that the GNP is 40 percent higher in 2010 (nearly tripling instead of doubling the 1975 levels). Energy use increases by only 35 percent. This might be interpreted as implying an income elasticity of about 0.90, which is not inconsistent with the results of Herendeen and Tanaka (17) for the U.S. economic system in the early 1960's. This less than proportional increase in energy use is due entirely to shifts in the market basket of goods and services.

Conclusions

The purpose of this article has been to report on plausible energy futures corresponding to the low range of possible energy supplies. The Panel concluded that whatever driving forces might be involved, it will be technically feasible in 2010 to use roughly a total amount of energy as low as that used today and still provide a higher level of amenities, even with total population increasing 35 percent. It should be noted, however, that even under such low-energy scenarios there would still be enormous requirements for developing new energy supplies to replace depleted resources. The results of the analysis can be discussed in terms of responses to some frequently raised questions about the U.S. energy system.

Is a lower-energy future a bleak one for the United States? Probably the most important single finding of the study is that our national well-being can improve while energy growth is constrained to varying degrees. For this to occur requires higher energy prices, more regulation, or both. However, in every sector of the economy major increases in energy efficiency can be made by using presently available technology, and even greater improvements can be made with technology now under development. The large discrepancies between present energy efficiencies and those that are thermodynamically obtainable, together with economic analysis, show that improvements in efficiency of 1 percent per year or more are sustainable over a number of decades in the United States. If slower population growth trends continue, present amenity levels could be maintained and might be slowly expanded (at about half of past economic growth rates) without major increases in energy use.

Is a low-energy future a low-technology future? Probably just the reverse is true. A low-energy future offers strong incentives for technological innovation. In many recent inventions information has been substituted for energy. Modern computers and communication equipment perform better than past units but use only a small fraction of the energy. The techniques used to bring about energy reductions reported in this study in almost every case rely on the use of advanced technology.

If energy demand growth was so rapid in the past, how can it be so slow in the future without major effects? The most significant reasons for rapid energy growth since World War II have been the following.

- Steadily declining energy prices relative to the prices of other goods and services.
- Expanding consumer population.

- Introduction and rapid market penetration of energy-intensive consumer products that provide basic amenities (such as individualized transportation, comfortable habitat, and household conveniences).

- Increasing cost of labor, which increased the substitution of capital and energy for labor.

- Major increases in disposable income, enabling rapid expansion of consumer buying power.

None of these factors is likely to continue at its historic pace. Many past projections of energy futures simply did not take into account inevitable changes in these trends. Where they are taken into account, future demand growth is projected to be slower even without active conservation policies. In all the scenarios discussed in this article we assumed virtually complete saturation of the use of air conditioning and other major appliances by 2010, but did not explicitly account for new "phantom" appliances as energy-intensive as air conditioning. But neither did we count such new technologies as increasing energy efficiency. Considering that real energy prices will probably increase in the future, the latter type of technological development is more likely than the former.

The long-term substitutability of labor and capital for energy indicates that goods and services can continue to be provided in the future with less energy input. However, to do this requires other human and material resources. Therefore, unemployment in power plant construction is compensated by greater employment in constructing more energy-efficient commercial buildings and residences; lower requirements for steel in automobile construction are offset by an increased demand for aluminum and fiber glass; and control system designing for nuclear power plants is replaced by control system designing for space conditioning in commercial buildings. As long as these changes occur slowly, their impacts are minimized. It is essential to have time for adjustment.

What constrains our progress toward more efficient energy utilization? We have pointed out that existing products and technological know-how, if fully utilized, will permit major improvements in energy efficiency with little change in life-style. We can also be confident that improved technologies can be developed through R & D investments in this relatively unexplored field. Because there are already many technical opportunities for improved energy efficiency, we must conclude that the most important near-

term constraints or impediments are not technological ones. They may be categorized as follows.

1) Price signals: energy consumers tend to weigh their conservation investment decisions against current average energy prices, whereas energy producers (such as utilities) weigh investment decisions against long-run incremental prices. Since energy prices at the margin are now usually considerably higher than average prices, producer and consumer investment decisions are not made on equivalent bases. Thus investments are biased toward increasing supply rather than moderating demand. This situation would be largely eliminated if prices were adjusted (as through an energy surcharge tax) to approximate long-run incremental costs.

2) Time: given time, changes that would be highly traumatic if made quickly can be relatively easy. Unfortunately, Americans have a tendency to want to do things instantly. (As Adlai Stevenson said, "We Americans seem never to see the handwriting on the wall . . . until our back is up against it.") Retrofitting is important and economical, but since the greatest technical opportunities to save energy can be achieved in new capital stock, it is clear that attendant efficiencies can be achieved only as that stock is replaced. The time needed for such stock turnover ranges from about a decade (air conditioners, automobiles) to a half-century (industrial processes). Time is also required to introduce new ways of designing and building energy-consuming items.

3) Standards and regulations: public policies that were developed when energy was cheap and plentiful frequently have the effect of constraining energy-conserving actions. These policies include natural gas price controls, freight transportation regulations, building codes, procurement procedures, and tax policy. Most of these are federal policies but there are also many state and local ones. Progress in energy efficiency that is rapid enough to meet national needs will require policies that directly influence energy-consuming activities.

If relative energy prices stay at about their present level, what is the likely future of demand? If we utilize available technology and make wise economic decisions (minimum total cost), future energy demand growth will be considerably slower than most past projections have indicated. Even a small increase in real energy prices provides a significant opportunity for cost saving through higher efficiency of energy use. Depending on the details of future events, U.S. energy

consumption could actually peak within the next 20 years even though well-being continues to improve. But it seems more likely that demand growth will simply slow down. Much depends on public policies (especially those that affect investment), population growth, labor cost, consumer choices, and economic growth. Of this, however, we are certain: many of the principal factors that drove the high energy demand growth in the past are no longer with us.

References and Notes

1. The members of the CONAES Demand and Conservation Panel are listed in the author note. Its chairman is J. Gibbons. The Panel's Resource Groups and their chairmen are: Buildings, R. Carlsmith; Industry, M. Whiting; Transportation, E. Goodson; Integration, E. Bullard; and Economics, D. Chapman. Extensive technical assistance was provided by R. Barnes, E. Berndt, L. Colquitt, K. Friedman, E. Hirst, K. Johnson, T. Mount, D. Pilati, and T. Tyrrell. In addition in each Resource Group a number of experts from universities, business, and government contributed to the study. Although the Panel reached a consensus about the main points brought out in this study, there were individual differences of opinion about some details. These were small enough that no dissenting or minority opinions were recorded.
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18. C. Whittle et al., *Economic and Environmental Implications of a U.S. Nuclear Moratorium, 1985-2000* (Institute for Energy Analysis Report ORAU/IEA 76-4, Oak Ridge Associated Universities, Oak Ridge, Tenn., 1976).
19. The CONAES study has been conducted under the auspices of the National Research Council and supported in part by the Department of Energy.



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FACT SHEET

ENERGY LOAN PROGRAM

AUTHORITY:

PUBLIC LAW 95-315 APPROVED ON JULY 4, 1978, AUTHORIZED THE ESTABLISHMENT OF A SMALL BUSINESS ENERGY LOAN PROGRAM BY AMENDING THE SMALL BUSINESS ACT TO ADD A SECTION 7(1).

ELIGIBILITY:

LOANS UNDER THIS PROGRAM ARE INTENDED TO PROVIDE A MEANS FOR SMALL BUSINESS CONCERNS TO ENTER (STARTUP), CONTINUE, OR EXPAND IN DEVELOPING, MANUFACTURING, SELLING, INSTALLING OR SERVICING OF SPECIFIC ENERGY MEASURES. ENTERPRISES INSTALLING OR UNDERTAKING ENERGY CONSERVATION MEASURES FOR THEIR OWN ACCOUNT ARE NOT ELIGIBLE UNDER THIS PROGRAM. ONLY THE FOLLOWING ENERGY MEASURES ARE ELIGIBLE FOR FINANCIAL ASSISTANCE UNDER THESE PROGRAMS:

- (1.) SOLAR THERMAL ENERGY EQUIPMENT WHICH IS EITHER OF THE ACTIVE TYPE BASED UPON MECHANICALLY FORCED ENERGY TRANSFER, OR OF THE PASSIVE TYPE BASED ON CONVECTIVE, CONDUCTIVE, OR RADIANT ENERGY TRANSFER OR SOME COMBINATION OF THESE TYPES.
- (2.) PHOTOVOLTAIC CELLS AND RELATED EQUIPMENT.
- (3.) A PRODUCT OR SERVICE THE PRIMARY PURPOSE OF WHICH IS CONSERVATION OF ENERGY THROUGH DEVICES OR TECHNIQUES WHICH CAN BE DEMONSTRATED TO INCREASE THE ENERGY EFFICIENCY OF EXISTING EQUIPMENT, METHODS OF OPERATION, OR SYSTEMS WHICH USE FOSSIL FUELS, AND WHICH IS ON THE ENERGY CONSERVATION MEASURES LIST OF THE SECRETARY OF ENERGY.
- (4.) EQUIPMENT THE PRIMARY PURPOSE OF WHICH IS PRODUCTION OF ENERGY FROM WOOD, BIOLOGICAL WASTE, GRAIN, OR OTHER BIOMASS SOURCE OF ENERGY. THIS REFERS TO ENERGY DEVELOPED BY THE BURNING OF COMBUSTIBLE BIOLOGICAL MATERIALS AND/OR THE CONVERSION TO SOLID, LIQUID OR GASEOUS FUELS. THE BURNING OF WOOD AND OTHER FORMS OF BIOMASS IS THE OLDEST FORM OF BIOMASS USE.

USE OF PROCEEDS

PROCEEDS OF SMALL BUSINESS ENERGY LOANS MAY BE USED TO PURCHASE VACANT LAND IMMEDIATELY NECESSARY FOR THE CONSTRUCTION OF A PLANT OR TO ACQUIRE BUILDINGS, MACHINERY, EQUIPMENT, FURNITURE, FIXTURES, FACILITIES, SUPPLIES, OR MATERIALS FOR AN ELIGIBLE LOAN MEASURE.

AMOUNT, TERMS AND INTEREST RATES

THE STATUTORY CEILING ON SMALL ENERGY DIRECT LOANS IS \$350,000. LOANS MADE UNDER THE LOAN GUARANTY PROGRAM MAY EXCEED \$500,000 IF THE AMOUNT OF PARTICIPATION OR THE AMOUNT GUARANTEED BY SBA DOES NOT EXCEED THE LESSER OF \$500,000 OR 90% OF THE TOTAL LOAN. TERMS MAY BE UP TO 15 YEARS. INTEREST RATES WILL BE THE SAME AS SBA'S BUSINESS LOAN PROGRAM.

HOW TO APPLY

INTERESTED APPLICANTS MUST FIRST SEEK FINANCING FROM QUALIFIED LENDERS ON A DIRECT BASIS OR UNDER THE SBA GUARANTY PROGRAM. SHOULD THE BANK DECLINE THE REQUEST, ONLY THEN CAN APPLICANTS APPLY FOR DIRECT SBA FINANCING

lion last year, according to Energy Dept. data. The value of petroleum exports including condensates rose 9.7% to £2.17-billion on an f.o.b. basis. Oil import costs fell 12% to £4.49-billion: £3.53-billion, down 13.8%, for crude oil, and £958-million, down 4.3%, for products.

Crude oil production climbed 40% in 1978 to 53.4-million tons, with exports taking roughly 44%. Refined product output rose 3.3% to 89.2-million tons. The largest increases were for lighter products, notably jet fuel.

UNITED KINGDOM—Testing of two processes for converting coal to oil products and petrochemical feedstocks will advance to the pilot-plant stage. Design and feasibility studies have been started for the pilot plants, each to process 25 tons of coal daily. The National Coal Board has already successfully tested both processes at the laboratory level. One dissolves coal in coal-derived solvent to make gasoline, diesel fuel and kerosene. The other employs high-pressure hot coal gas to make benzene, toluene, xylene and chemical feedstocks. The plants are part of an eight-year oil and gas from coal pilot project expected to cost £43-million.

UNITED STATES—Dependence on imported sources of energy fell last year and the overall growth in energy needs slowed down further to only 1.8% from 2.5% in 1977 and 5.3% in 1976, the Energy Dept. reports. Total energy demand reached the equivalent of 36.7-million b/d of crude oil. Energy imports, at the equivalent of 8.74-million b/d, covered 23.8%, down from 26.1% in 1977 but up from 22.6% in 1976. Crude oil imports fell 7.4% as new Alaskan supplies became available,

and products imports fell 8.6% on stock drawdowns.

UNITED STATES—The cost of modifying existing tankers to meet new U.S. safety standards for entering U.S. ports will add \$50- to \$85-million a year through 1985 to the oil import bill, the government estimates. It's expected the added cost will be reflected in higher freight rates.

Depending on a ship's size and whether an owner opts for segregated ballast tanks, crude oil washing or dedicated ballast tanks, it will cost up to \$2-million to outfit a product carrier and \$500,000 to \$2-million for a crude oil carrier. It's assumed some 589-655 foreign-flag crude carriers, 138-156 foreign-flag product carriers and 90 U.S.-flag ships will be affected by the new U.S. standards, which are slightly stricter than recently adopted international guidelines (PIW Oct. 9, p.8). The effect of these standards on newbuilding costs is not estimated.

UNITED STATES—President Carter is expected to announce in a major energy address this week his delayed decision on the crude oil price control issue, as well as measures to cut oil demand under the 20-nation International Energy Agency commitment (PIW March 12, p.3 & 4).

Mandatory controls on domestic crude prices expire May 31. The President then will have the authority to decide whether to continue them, phase them out or lift them entirely before Sept. 30, 1981, when all oil price controls are due to end. Surging world oil prices and tight supply, together with the Carter commitment to an anti-inflation program, have complicated an already difficult political dilemma over the decision. Any proposal to loosen the controls would likely be tied to some form of tax to prevent producing companies from reaping "windfall profits." A new tax would require Congressional action. There's no current plan in the Administration for a "plowback" provision to return part of such tax to the oil industry to spur more energy investment, but it could be a political tradeoff.

VENEZUELA—Crude oil production this year has continued to average a high 2.3-million b/d through early March, up some 36% from year earlier and 100,000 b/d over the annual average target that the new government says it intends to retain. Crude

production jumped to a 2.3-million average in fourth-quarter 1978 at the onset of the Iranian export shutdown, but the 1978 average of 2.17-million was still below the annual target.

The high current level represents 95% of maximum 2.43-million b/d installed capacity and is stirring political debate. The Oil Ministry says capacity should be raised to 2.8-million for a better cushion and greater flexibility in meeting unusual demand.

New Publications

Jan. 1979 edition of "International Crude Oil & Product Prices, a Biannual Review & Analysis of Price Trends in World Markets," by Energy Economics Research in cooperation with Middle East Economic Survey, 127 pp. From Middle East Petroleum & Economic Publications, P.O. Box 4940, Nicosia, Cyprus. Annual air-mail subscription (two reports) \$280.

"Energy Options & Conservation, Proceedings of the Fourth International Conference" (in Oct. 1977). Published by the International Research Center for Energy & Economic Development, 216 Economics Bldg., University of Colorado, Boulder, Colorado 80309, 300 pp, \$14.50.

In New Posts

Ralph E. Bailey becomes chairman and chief executive of Continental Oil Co. April 1, succeeding retiring Howard W. Blauvelt who remains a director and executive committee member.

Len Dickinson, formerly with Easco, has joined Stevinson Hardy International, London.

South Korea has named former Foreign Minister Kim Dong-Jo president of its new Korea Oil Development Corp.

Clarification

Mobil's worldwide third-party crude oil sales volume was roughly 230,000 b/d last year. It's less this year including 9% allocation cuts.

The 330,000 b/d reported for Mobil in PIW March 19, p.1 includes 100,000 b/d that isn't strictly third-party, since it involves tie-in deals and/or joint ventures where Mobil supplies crude and offtakes products. For example, Mobil explains, it supplies a joint Spanish lube venture in the Canary Islands, offtaking products. And in Japan it supplies crude to Fuji Kōsan, taking the white products for Mobil Sekiyu.

PIW Index

January and February issues of "Petroleum/Energy Business News Index" are now available, providing an index to PETROLEUM INTELLIGENCE WEEKLY issues of Jan. 1 through Feb. 26. For copies of this monthly publication and annual subscription details, contact: The American Petroleum Institute, Central Abstracting & Indexing Service, 275 Madison Av., New York, N.Y. 10016. Telephone: (212) 685-6254.

Susan Thompson

All-Electric Homes May Be Cheaper

By AL CAMPBELL
For The Times

PALMER — More in self defense than for business promotion, the Matanuska Electric Association has prepared a study indicating that all-electric homes, once relatively expensive, now may be cheaper to heat than dwellings with oil-fired furnaces.

Even with a recently-granted 29 percent rate increase for electric consumers in the Matanuska-Susitna area, utility officials believe heating oil prices have outstripped power bills to the point where electrically heated homes could be making a comeback.

At least one major bulk oil dealer in the Valley agrees with the utility's conclusions. But Benjamin Cottle of Cottle Fuels said oil men feel their prices may level out, while electric rates will continue to rise past the point where electric heat is cheaper than oil.

"Yes, quite honestly MEA (heating) is cheaper," said Cottle. "For a long time oil was cheaper, but now we are stuck with these higher prices."

Cottle, who is also an elected director of Matanuska Electric, predicted that new electrical hookups will force the utility to extend itself to the point where power prices will have to be raised to pay for the construction work.

A utility spokesman said the electrical cooperative does not see that situation "in the foreseeable future."

The study compares a typical, 1,300 square-foot home in the Mat-Su area. It is based on the present kilowatt-hour rate but compares oil-heat costs at the rate of 71.9 cents per gallon, and most dealers in the area are now charging more than 80 cents per gallon for No. 2 furnace oil.

Thus the savings would be even greater for all-electric homes, given the higher oil prices — and they are predicted to top \$1 a gallon in Alaska this winter.

Matanuska Electric figures show

annual costs to the owner of the 1,300-foot home to be \$2,136.56 for an oil-fired home and only \$1,716.62 for all-electric. The study includes cost of purchase and installation of the heating system in a new home, as well as the monthly energy bill for heat.

Most of the savings would be in a new home, where the cost of an oil furnace is considerably higher than electric systems.

But Valley homebuilders say higher oil prices are making it more attractive for some home owners to scrap their oil system and pay for new installation of electrical heating.

Noel Woods, president of the Ma-

tanuska Homebuilders' Association, said several people have indicated to him they are planning to switch, and there is "certainly no big demand for oil" in new homes under construction.

Builders have always preferred to install electric heat if they could get a similar price for the homes without oil heat. Oil furnaces require valuable floor space and costly duct work, as well as outdoor excavation for storage tanks, all of which comes off the contractor's profit.

Still, Matanuska Electric is not promoting new or converted use of all-electric homes. In response to requests by the Energy Department, Rural Electrification Agency and

other federal authorities, electric utilities nationwide are playing down consumption in favor of conservation of all energy systems.

The days of "live better electrically" and other media campaigns are over, as the nation rejects any sales pitch designed to promote energy consumption.

Matanuska Electric officials here say they prepared the study only to answer complaints from householders whose electric bills have jumped drastically with recent rate increases. Says a utility official "we can show them we can still be cheaper than oil. And many of them are surprised that they have to agree with us."

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A Hard-Headed Look at the Energy Debate

By WILLIAM TUCKER

One of the gravest problems in the energy debate in the United States has been the widening gap between the people who think in American society and the people who come up with new ideas.

For all its disdain for practicalities and its nouveau-elite snobbery, the environmental movement, it must be admitted, has been very good at latching onto original approaches to the problems of society. It was the environmental movement, after all, which was seriously considering the

business School's six-year-long energy project. "Energy Future" is a truly magnificent book which may be the most important contribution yet to the debate.

The authors, headed by Roger Stobaugh, president of the Academy of International Business and a Cabinet-level consultant, are, surprisingly, all hard-headed professors and graduate students at the Harvard Business School. The exception is Daniel Yergin, a political science lecturer at the Kennedy School of Government at Harvard, who has written a book about the origins of the Cold War. Lest anyone think that the issues have been weighted in favor of the counterculture, however, it must be noted that the section on nuclear energy is written by I.C. Bupp, a Harvard Business School lecturer who has been an ardent supporter of nuclear power, yet is still willing to admit some of its obvious limitations.

The premise of this book is simple—we have indeed reached the era of limits. Although there is ample evidence that getting rid of price controls will stimulate some new production of fossil fuels (and the authors are absolutely in favor of the "gradual" elimination of all market restrictions on energy products), they recognize that we have nonetheless reached an era of *natural* limits on energy production, and that expanding the conventional sources of oil and gas will not be able to meet projected demands of our society at anything resembling current prices. So too, the coal and nuclear options have their inherent limits.

The two areas that show the greatest promise for a return on investment in increasing national energy "production" at the margin are, the authors assert, conservation and solar energy. "Conservation," they insist, does not mean austerity, but improved efficiency—clamping down on all the ways that we waste energy right now. Solar energy includes a wide variety of "renewable" sources, with the most promising areas of development in small hydroelectric plants, solar heating devices and photovoltaic electricity generated in decentralized patterns.

What is most delightful about this book is its thorough, hard-headed understanding of the economic and marketing problems involved in developing these two new energy "sources." Stripping the ideas of romantic pastoralism and utopian rhetoric, the authors squarely face their largest impediment—that these two energy strategies will involve millions of small, isolated decisions made by individual homeowners, minor public officials, and low-level factory workers—precisely the people who are the most poorly informed and least motivated to do something about the energy problem.

Dispelling myths about any widespread impulses toward "self-sufficiency," the au-

thors explain why industry has led the way in improving energy efficiency (Dow Chemical has reduced energy consumption an unbelievable 40% since 1973) while homeowners and consumers have lagged far behind, and why it will be absolutely necessary that the full efforts of American industry be enlisted in any attempt to make these two techniques work. They cite the section of the 1978 National Energy Act in which Congress actually *prohibited* the utility companies from helping to retrofit buildings for greater heating conservation as a "major blunder" which they say will "cost the nation many hundreds of millions of barrels of oil equivalent a year."

There is so much more excellent material in this book that I hesitate to drop any more tidbits for fear of giving the impression that its essence can be conveyed in a short review. It should be read by anyone seriously concerned with the energy debate, which must now include almost everyone with a sense of responsibility in American society. What is most attractive is the book's readability—a trim 240 pages of well-directed argument with a mass of footnotes in the back for further references. The promise that "Energy Future" offers is that neither side—the environmental fanatics or the full-speed-ahead, supply-oriented enthusiasts—will see only their own reflection, but will recognize the reasonable points the other side is making. It could mark a watershed in the decade-old energy debate.

Mr. Tucker is a contributing editor of Harper's magazine.

The Bookshelf

"Energy Future"

Edited by Robert Stobaugh and Daniel Yergin. Random House. 353 pages. \$12.95.

limits of fossil fuels and other resources as early as the 1950s (even though, by the time the crunch hit, a good portion of the movement had jumped on the "consumer" bandwagon and was ready to blame it all on the oil companies). Conservation and solar energy, two of the most recent contributions of environmentalism, are also ideas which, at bottom, have an enormous amount of merit.

The trouble has been that, because environmentalists come up with these ideas first, they are able to tangle them up in their own personal quirks and fantasies so that they become rather unappealing to the broad range of people in society. In order to listen to Barry Commoner talk about the possibilities of photovoltaic electricity, for example, we must also put up with his lectures on "sunshine socialism," and hear about how solar energy will usher in the overthrow of capitalism which Commoner has undoubtedly dreamed about since his boyhood days in Brooklyn. Amory Lovins, another environmental genius, gives us not only a fairly brilliant analysis on the possibilities of energy conservation, but also a pastoral fantasy of a world divided up into isolated, independent neighborhoods, all watering their own organic gardens and tending to the neighborhood windmill. This is, of course, the inevitable result of Commoner's desire to play a permanent adversary role in American culture, or the mining disdain for the world of practicality which oozes out of every page of Lovins's writings.

"Energy Future" is a book that does a heroic job in bridging this gap between the thinkers and the doers, between environmental elitists and the hard-pressed world of responsible people who must deal every day with the demands of consumers, special-interest groups and unrelenting market forces. The result of the Harvard Busi-

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ELECTRIC POWER CONSUMPTION FOR THE RAILBELT:
A PROJECTION OF REQUIREMENTS

by

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Institute of Social and Economic Research

Anchorage * Fairbanks * Juneau

prepared jointly for

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

June 1980

ELECTRIC POWER CONSUMPTION FOR THE RAILBELT:
A PROJECTION OF REQUIREMENTS

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TECHNICAL APPENDICES

I. INTRODUCTION

This report presents the results and documentation of the first systematic attempt to project future electric power requirements for the Alaskan railbelt using a technique which explicitly takes into account uses of electricity.

The study, undertaken jointly for the House Power Alternatives Study Committee of the Alaska Legislature and the Alaska Power Authority, had two purposes. The first was to develop a model of electricity use which would enable the legislature, administration, and others to analyze the impact of policy measures to alter electricity consumption patterns. The second was to forecast future electric power requirements for the railbelt as input to a study of the feasibility of developing the hydroelectric resources of the Susitna River.

The model which was developed as part of the study, an end-use model, is patterned after similar models developed and utilized by the federal government, various state government agencies, and electric utilities. It is a departure from traditional methods of electricity requirements forecasting (based largely upon trend analysis), which is widely recognized as being a necessary and worthwhile improvement. This is because the end-use model bases forecasts on estimates of the electricity requirements for specific uses.

This approach has the additional advantage over traditional electricity forecasting methods of explicitly presenting the assumptions made by the forecaster about the relationships between important variables. For example, the average household size is an important determinant of electricity consumption in the residential sector. Most analysts project that average household size will decline over the next twenty years. The end-use modeling technique requires that this factor be explicitly considered.

A major difficulty with a forecasting model of this type is the lack of data with which to construct and validate the model. Information is necessary on the appliances in the residential and commercial sector, the building stock and its characteristics, the machinery used in industrial processes, and the uses to which fuels which are alternatives (and competing) to electricity are put. Such data is difficult, if not impossible, to obtain, so estimates and indirect methods of obtaining information must often be utilized. Consequently, this model is a "first draft" and, as such, subject to improvement and refinement as more information becomes available. The level of effort expended on this model has been much less than more highly developed and sophisticated end-use models such as those used by the New England Power Pool, California Energy Commission, and Federal Energy Administration.

We expect more information to become available on a regular basis in the future as the general level of interest in and concern for energy consumption increases. This information will come both from work done in Alaska and in other states because the experience of other regions is often applicable to the Alaskan situation. Information from other areas will probably be in the form of better data on appliance electricity use, appliance lifetime, components of commercial electricity consumption, and consumer behavioral responses to changing energy prices and government regulations, incentives, standards, and controls designed to alter electricity consumption patterns.

Within Alaska, better and more current information will become available as a result of a variety of efforts. These would include,

1. Under provisions of the Public Utilities Regulatory Policies Act (PURPA), the large railbelt utilities are required to undertake various end-use studies.
2. Railbelt utilities have, in the past, and will, in the future, conduct end-use studies for their own planning purposes.

3. The 1980 censuses of population and housing will provide information on the geographic distribution of population, trends in household size, the characteristics of the housing stock, and the ownership rates for various appliances.
4. Efforts by local governments through surveys and analyses of existing records (tax records, building permits, etc.) to develop better information bases on the demographic and economic characteristics of their communities.
5. Energy audit programs presently in the initial stages at all levels of government which can provide information about not only where electricity is used but also the impact on consumption of conservation measures.

Information from these secondary sources can improve the modeling and projections. There was no primary data collection effort undertaken as part of this study. The reasons that no primary data were collected in the process of original model development were two. First, the cost of data collection through surveys is expensive. Second, and more important, without a definite understanding of what information was necessary for modeling and what information was available from secondary sources, any primary data collection would be premature and inefficient.

Now that the initial model development has been completed, it is possible to identify those areas where the model could be improved by primary data collection either through surveys or analysis of individual utility account records in conjunction with other primary data sources. The commercial-industrial component of electrical requirements is not well-specified in the model and would benefit most from additional primary data in the form of information on the proportions of electricity in different uses in the various categories of the commercial sector (retail, office, education, etc.) and the amount of electricity consumed in these different uses on an appliance or square foot basis. Unfortunately, because of the heterogeneity of the commercial sector, it is difficult to obtain a complete detailed picture of electricity use in this sector even through survey methods.

Another reason why the model may be expected to change over time, in addition to the fact that better data will be integrated into the parameters, is that conditions in electricity markets are currently in flux and the dynamics of change are presently not fully understood. Consumer behavior is difficult to forecast whenever behavior patterns differ from those of the past, as is presently the case. An example would be in consumer preferences for space heating in the presence of high prices for all fuels as well as relative fuel price uncertainty. To what extent will consumers utilize dual heating systems (wood and electricity, for example) or district (room-by-room) heating systems rather than single, centralized heating which has become the standard in recent years? Only time will provide us with the answers after we have had the opportunity to actually observe consumer behavior in these new situations.

In spite of these model shortcomings (which really are shortcomings of any forecasting technique because we have utilized all the available data), the methodology is a valid one. Every effort has been made to minimize the potential error which may arise because of misallocation of electricity consumption to a particular use. Differences of opinion regarding the parameters used in forecasting future use will obviously always be present. This model makes all those parameters explicit so that discussions about the projections can be structured around the numerical values chosen for these parameters.

The end-use model, in conjunction with an econometric model of the Alaskan economy, has been used to do thirty-year projections of electricity requirements. In a sense, it is presumptuous to think it is possible to forecast for thirty years into the future with any degree of confidence. The last thirty years have produced trends nationally that were unanticipated but had a profound effect on patterns of energy consumption such as suburbanization. Within the state, events such as the discovery of oil at Prudhoe Bay, which shaped the economy through the decade of the

1970s, were unpredictable. Similar, unanticipated factors (although the probability of another petroleum discovery on the magnitude of Prudhoe Bay is slight) will surely be important in the future. On the other hand, there are many things which we can anticipate with some assurance and, because we must try to plan the efficient future utilization of resources, we must attempt to define the future limits of electricity consumption.

In addition to the normal degree of uncertainty in projecting future events, two factors make projecting Alaskan electricity requirements particularly fraught with uncertainty. First, the small, absolute size of the economy and its dependence upon natural resources and government make the economy volatile and projections of future levels of activity subject to larger variability. Second, the ever changing conditions in national and Alaskan energy markets make it difficult to identify long-term trends in prices, fuel availabilities, federal and state policies, and consumer behavior. The projections should be interpreted with this variability and uncertainty in mind.

Specifically, any forecasting method which depends upon the past will necessarily be wrong to the extent it cannot anticipate change. We do try to take some changes into account but do not presume the ability to anticipate technological change which may be significant as a factor either increasing or decreasing electricity consumption from central station utilities.

The electricity end-use model has been constructed to maximize its potential applicability. It is not presently computerized, but the documentation in the technical appendixes is complete and structured in such a way that conversion to the computer would be a simple task. We recommend this be undertaken to facilitate future use of the model for forecasting and policy analysis as well as updating and validation. As used in this study, the model provides results for three electric power markets

for five-year intervals. It can be modified to handle both other regions and shorter or longer time intervals.

In conclusion, we are forecasting electricity requirements at a time when changes are constantly occurring which can have substantial effects on the outcome. We feel the approach of this study is the most appropriate under the circumstances, recognizing at the same time that it can and, hopefully, will be improved in the future.

II. ECONOMIC GROWTH IN ALASKA AND ITS RAILBELT REGION

Introduction

The demand for electric energy is importantly affected by the level of population and economic activity in the region. This chapter describes the population and economic activity in Alaska and its Railbelt region. The railbelt currently contains the majority of the state's population and employment; it includes the Anchorage, Kenai, Seward, Matanuska-Susitna, Fairbanks, Southeast Fairbanks, and Valdez Census Divisions. This chapter discusses both the historical level and the probable future growth of population and economic activity. The projections of the future are the basis of the electricity demand projections.

The analyses of historical economic activity and demographic change provide a point of reference for discussing potential future growth. Examining past activity provides information not only on what happened but also on how things happened, which allows us to develop an understanding of the process of growth in Alaska. An understanding of how this process worked in the past allows us to assess the potential for future changes. We would not expect the future process of growth to differ qualitatively from the past.

Economic Growth

Alaska has a frontier economy. Alaska, like all frontier economies, can be characterized by its small size, relatively recent development, and isolation from major markets and production centers. Examining these characteristics helps both to explain past growth and to define the potential for future economic growth. The small size of Alaska means there are only limited local markets, which limit the local production of goods and services. The recent development of the economy means there are areas with only limited infrastructure and services.

Recent development and small size result in the need to import labor to staff major development projects; this migration requirement necessitates high wages to attract labor. Finally, the isolation from markets and producers means that transportation cost is an important component of the cost of living and producing in Alaska.

These characteristics have two general results for the Alaska economy. First, Alaska, like all frontier regions, is a high-cost region. The cost of living and producing goods and services is relatively higher in Alaska than in competitive regions. Secondly, resource development for export to other regions is the major source of growth for the economy. Because of the cost structure described above, only bonanza resource finds will be developed; the high cost of development means resource finds which would be developed in other areas will be overlooked in Alaska.

Economic growth in frontier regions is then driven by two forces. First, the development of resources is driven by changes in world market price and technology which may reduce production costs in the region. Secondly, growth generated by resource development leads to expansion of local markets. This will increase the production in the region of locally consumed goods and services and reduce the relative cost differentials, possibly encouraging future growth. Each of these causes of growth has been important in the past and will continue to be important in the future.

HISTORICAL ECONOMIC GROWTH IN ALASKA

The importance of natural resource development to the growth of the Alaska economy can be seen by examining the historical growth of the economy. European settlement of the region as a Russian colony was a means of exploiting Alaska's resources, primarily furs. During the American colonial period, major growth occurred with the development of the gold fields in Northwest Alaska in the late nineteenth century. The final major pre-statehood cause of growth was the expansion of the

federal government presence in the state. This was primarily a result of the military expansion during World War II, the Korean War, and the Cold War. This expansion was a result of Alaska's strategic location, a type of natural resource (Kresge, et al, 1977).

Since statehood, economic growth has been dominated by the development of the state's petroleum resources and growth of state government. Two major petroleum developments have been responsible for growth during this period, the Kenai Peninsula-Cook Inlet and Prudhoe Bay. The Kenai fields were developed in the late 1960s, reaching peak production in 1970; employment increased both in Kenai and as headquarters employment in Anchorage. Employment associated with this development declined after peak output was reached in 1970. Development of the Prudhoe Bay fields had two major phases, field development and construction of the trans-Alaska pipeline to carry the oil to a port in Valdez. The construction project had major employment effects, adding 15,000 workers to the work force in 1976; however, field development and production will have more long-run effects.

A second major source of growth has been the expansion of state government. State government expenditures affect the economy by increasing employment in state government and through expenditures, such as for the Capital Improvements Program, in other sectors of the economy. State government expenditures have been a particularly important source of growth since 1970. The lease bonus received by the state in 1969 from the sale of the Prudhoe Bay lease held to a rapid expansion of state expenditures (Scott, 1978). The lease sale bonus and future revenues from petroleum production are a unique source of revenues since they are exogenous to the state economy. Because of this, the level of revenues and state expenditures does not depend on the level of economic activity in the state, but determines it.

Table II.1. describes the growth in employment in Alaska since 1960. Employment increased at an average annual rate of 4.1 percent per year during this period; this is about twice as fast as the growth of the U.S. economy during the period. We can distinguish three separate periods of growth between 1960 and 1979 by their relation to the development of Prudhoe Bay. The most rapid period of growth occurred between 1970 and 1976; employment grew at an annual average rate of growth of 8.1 percent per year. Prudhoe Bay influenced most of the growth in this period.

TABLE II.1. ALASKA EMPLOYMENT GROWTH BY SECTOR

(Average Annual Percent Change)

	<u>1960-1970</u>	<u>1970-1976</u>	<u>1976-1979</u>	<u>1960-1979</u>
Basic Sector ^a	.7	4.6	- 7.0	.7
Support Sector ^b	6.1	12.3	2.9	7.5
State and Local Government	10.1	9.4	4.9	9.0
Total Nonagricultural Wage and Salary (plus military)	3.3	8.1	.4	4.1

^aIncludes mining, construction, manufacturing, and federal civilian and military employment. (Nonagricultural wage and salary does not include agricultural or fisheries employment.)

^bIncludes transportation, communications, utilities, trade, finance, and services employment.

SOURCES: Alaska Department of Commerce and Economic Development, The Alaska Economy Year-End Performance Report, 1978; and Alaska Department of Labor, Alaska Economic Trends, March/April 1980.

State government expansion as a result of the Prudhoe Bay lease sales, the development of the fields, and the employment expansion associated with construction of the Trans-Alaska Pipeline Service (TAPS) occurred during this period. The rate of growth of employment between 1970 and 1976 was more than twice the rate prior to 1970. The period after 1976 reflected the downturn in the economy after the completion of TAPS; average employment growth fell to less than one percent per year during this period. The adjustment after 1976 reflected most importantly the reduction in construction workers connected with the pipeline construction.

Economic growth affects more than total employment; the structure of the economy also changed, as reflected in Table II.1. In all periods, growth in both the support sector and state and local government is more rapid than total employment. This reflects a change in the structure of the economy, which is a result of three factors. The first factor is the increased importance of state government in the economy. Prior to 1970, the state's increased role resulted from a transfer of functions from the federal government to the new state. Since 1970, state government growth was primarily a response to available revenues. The second factor is the maturing of the economy. As an economy grows, it produces locally more of the goods and services it consumes. This structural change results in a nonproportional growth in the support sector. Finally, the composition of the basic sector has changed through time, so that employment numbers do not reflect its impact on the economy. The primary change is the reduction in military employment throughout the period. Because of this, the increase in the civilian basic sector was greater than reflected by Table II.1.

Two economic effects of the structural change which occurred in the past have been the reduced seasonality of employment and a narrowing of the cost of living differential between Alaska and the remainder of the United States. Alaska's dependence on natural resource production and severe winters historically resulted in seasonal increases in unemployment. As the economy matured, this seasonality has been reduced. As measured

by the ratio of fourth-to-third quarter employment, seasonality decreased by about 14 percent between 1950 and 1976; this index was .75 in 1950 and .87 in 1976 (Huskey and Nebesky, 1979). The other major effect of structural change was a narrowing of price differentials. Prior to 1975, the Anchorage consumer price index increased at a yearly rate that was less than the national rate, which meant that the price differential between Alaska and the rest of the United States decreased. The expansion of the local support sector and the economy's size were primarily responsible for this. With the TAPS boom, this price trend was reversed because of bottlenecks which resulted from rapid increases in demand and resulting increases in prices.

RAILBELT ECONOMIC GROWTH

In this study, we are primarily interested in growth in the Railbelt region, the region which would be served by the Susitna Hydroelectric project. The Railbelt region contains the majority of the population and economic activity in the state; most of the recent economic growth has occurred in this region. The Railbelt region contains three separate subregions which are unique, separate economies. The regions are:

- Anchorage. This region contains the Anchorage, Matanuska-Susitna, Kenai, and Seward Census Divisions. Anchorage serves as the administrative, distributive, and transportation center for the state and so reflects growth in other regions of the state. Matanuska-Susitna is a major agricultural region of the state; recent growth has resulted from a suburban connection with Anchorage. Kenai and Seward have experienced growth as a result of both fisheries--the historically important natural resource industry, and petroleum--the currently important natural resource industry.
- Fairbanks. The region contains the Fairbanks and Southeast Fairbanks Census Divisions. Fairbanks is the regional center for most of interior Alaska. It is also an important government

center, operating not only as a regional center but as the site of the University of Alaska's first campus and important military bases. Fairbanks' most recent major expansion occurred in connection with the development of Prudhoe Bay and construction of TAPS for which it served as a construction center.

- Valdez. The Valdez region contains the Valdez Census Division. This region recently experienced rapid growth as the terminus of the trans-Alaska pipeline and site of the oil terminal for Prudhoe Bay oil. Future growth should result from the location of the pipeline terminus in the area.

The remainder of the state consists of three major regions. Southern Alaska from Southeastern to the Aleutians contains the major fishing areas of the state. This region also contains the state capital at Juneau. In contrast to southern Alaska and the railbelt is village Alaska which includes most of western and northern Alaska. These include small Native villages whose pattern was established by subsistence patterns and larger regional centers which serve as governmental and distribution centers. The final regions are resource zones such as Prudhoe Bay. These zones are not necessarily developed or associated with any existing population center. These include Brooks Range minerals zones, Outer Continental Shelf zones, and major agriculture zones. Development of these areas will determine the future economic growth of the state.

Historical growth, as measured by employment, has been evenly distributed between the Railbelt region and the remainder of the state. Table II.2. shows that over the period 1965 to 1978, the railbelt has grown slightly faster, growing at an annual average rate of 4.8 percent per year, compared to 4.1 percent for the rest of the state. The railbelt grew most rapidly during the Prudhoe Bay period (1970-1976); employment in the railbelt grew at an annual average rate of 8.9 percent per year, compared to 6.3 percent for the rest of the state. During this

TABLE II.2. REGIONAL EMPLOYMENT GROWTH^a

(Average Annual Percent Change)

	<u>1965-1970</u>	<u>1970-1976</u>	<u>1976-1978</u>	<u>1965-1978</u>
State	3.7	8.1	- .9	4.6
Railbelt	3.3	8.9	- 3.3	4.8
Anchorage	3.8	8.2	2.4	5.6
Fairbanks	2.2	7.7	-11.3	2.4
Valdez	2.6	45.2	-49.0	8.1
Rest of State	4.3	6.3	- 2.6	4.1

^aIncludes nonagricultural wage and salary employment plus military. Data limit end dates.

SOURCES: 1965-1974, Alaska Department of Labor.
 1975-1978, Alaska Department of Commerce and Economic Development, Numbers: Basic Economic Statistic of Alaska Census Divisions, 1979.

period, the majority of the TAPS construction project occurred in this region. The two regional centers, Anchorage and Fairbanks, also reflected growth in the rest of the state. The location of TAPS employment also accounted for the more rapid decline in employment in the railbelt after 1976. Because of its slightly more rapid growth, the Railbelt region increases its share of state employment from 68.5 percent in 1965 to 70.3 percent in 1978.

The most rapidly growing subregion of the railbelt was Anchorage, which grew at an annual average rate of 5.6 percent during the period. Anchorage did not suffer a decline in employment between 1976 and 1978. The growth in Anchorage employment was not direct construction employment but support and government employment, so it did not suffer the immediate employment decline with completion of construction. Employment between

1976 and 1978 was buoyed by anticipations of future major projects and spending of wealth accumulated during the pipeline period. Both Fairbanks and Valdez were more directly affected by pipeline construction, growing very rapidly during construction and falling equally rapidly after pipeline construction was completed. In each region, a familiar Alaska employment pattern occurred, and employment did not fall back to pre-peak levels after the peak was reached.

FUTURE ECONOMIC GROWTH

The future growth of the state economy will follow a pattern similar to past growth. The characteristics of the economy we have described will continue to affect growth. The importance of the federal government presence in Alaska, both civilian and military, will continue. Although this provides a stable base for economic growth, it is not likely to be an important source of growth. Growth will most importantly result from development of Alaska's natural resources, expansion of state government, and expansion of the scale of the economy. State government expansion will result in increases in government employment, construction employment through the capital improvements program, and expansion of industry through the state loan program. Expansion of natural resource production beyond the bonanza finds depends on the location of reserves relative to transportation and developed areas; areas without easy access to infrastructure will be costly to develop. Expansion of natural resource industry beyond production will continue to be limited by small local markets and high production costs. Finally, as the size of the economy expands, we would expect a continued nonproportional expansion of the support sector as thresholds are reached in various industries.

Although historical analysis can provide some indication of the future growth of the economy, one thing should be evident: there is a large potential variability for the future course of economic activity in the state. The future development of natural resources depends importantly on world market prices. There is also uncertainty about the size and marketability of resource reserves in the state. The future

level of state government activity is also uncertain. Because of the petroleum revenues from Prudhoe Bay, the state is in a position of having revenues which exceed expenditures. Expenditures are constrained only in the long run by revenues. In addition to the amount the state spends, the way the state spends its money will affect state growth. These areas of variability make any projection of future state economic activity probabilistic.

We chose to combine two approaches for forecasting future Alaska economic growth. For the period prior to 2000, we used the MAP econometric model of the Alaska economy (see Appendix B) to project future economic activity. This approach allowed us to create scenarios describing the possible future growth of exogenous events such as natural resource developments and levels of state government expenditures. Use of the model also provides consistency across alternate projections. Beyond 2000, when much less is known of possible exogenous events, we chose to forecast the growth of major economic variables by making assumptions about their rates of growth.

Nine separate state economic projections were made for this study (see Appendix C). These projections were the result of the combination of three separate economic scenarios and three state government expenditure scenarios. These projections were designed to capture the possible future range of economic activity. The three economic scenarios reflect probable low, moderate, and high levels of resource development and exogenous industry growth. Three alternate state government expenditure growth paths were assumed representing state expenditures as a declining, constant, and rising proportion of personal income. Each state expenditure assumption is possible since none exhausts the state's fund balance by 2000.

Of these nine, three were chosen to be used in the electricity demand projections. It was assumed that the three economic scenarios, in combination with a state expenditure assumption which assumed state

expenditures would remain a constant proportion of personal income, would describe the most probable range of alternative futures. These scenarios are described below.

High Economic Growth

The high economic scenario assumes major resource development in the state. In addition to continued petroleum production at Prudhoe and in the Upper Cook Inlet, reserves in the National Petroleum Reserve and eleven OCS lease sales areas are assumed to be developed. Other mining is also assumed to grow with Beluga coal development and U.S. Borax developed. In-state processing of petroleum resources is assumed to increase with a major petrochemical development in Valdez, a petrochemical development using state's royalty gas in Fairbanks, and the Pacific LNG project. The Northwest gasline is also assumed to be built. Agriculture, fisheries, and forestry are all assumed to expand with maximum government support; major agricultural development occurs, and the foreign bottomfish effort is assumed to be replaced by the Alaska industry over the period. In addition to the state government spending assumed, the state capital is assumed to be moved to Willow during the projection period. (See Appendix C for specific scenario description.)

Table II.3. describes the projected growth in employment in the high scenario. In this scenario, the Railbelt region grows at the same rate as the state; both grow at a rate of 3.7 percent per year between 1980 and 2010. The region grows slightly slower between 1980 and 1990 and more rapidly between 1990 and 2000. This is mainly a result of massive OCS development which occurs during the 1980s outside the region. Examining the growth rates over decades ignores the rapid growth in the early 1980s associated with major construction projects which occur in the region.

By 2010, the region contains approximately 67 percent of the state employment; total employment in the railbelt equals 393,738 by 2010.¹ Growth is slightly faster in Fairbanks and Valdez than in Anchorage.

TABLE II.3. HIGH SCENARIO EMPLOYMENT GROWTH

(Average Annual Percent Change)

	<u>1980-1990</u>	<u>1990-2000</u>	<u>2000-2010^c</u>	<u>1980-2010</u>
State ^a	4.6	3.2	3.3	3.7
Railbelt Region ^b	4.2	3.4	3.3	3.7

^aTotal employment includes self-employed.

^bRegional projections are for nonagricultural wage and salary employment plus military. This excludes self-employed and was the basis for electricity demand projections.

^cPost-2000 growth assumed to be 33 percent per year, which is the approximate growth rate of the 1990-2000 period.

Anchorage's share of railbelt employment falls from 76.3 percent to 74.2 percent between 1980 and 2000. Fairbanks and Valdez increase their share from 22.1 to 23.1 and 1.6 to 2.7, respectively. These changes in shares result from growth in resource development and government employment outside the region.

Moderate Economic Growth

The moderate economic scenario also assumes important future resource development although the extent and timing differ from the assumed growth in the high scenario. As in the high scenario, petroleum development continues at Prudhoe and Upper Cook Inlet; however, the extent of further development is limited. Only six OCS lease sales areas are developed and development in the National Petroleum Reserve does not occur until the end of the projection period. Development of Beluga coal is the only nonpetroleum mining which occurs. The state's in-state processing of petroleum resources is more limited, a fuels refinery is built in Valdez

and the Pacific LNG project is built. The Northwest gasline is also assumed to be built. Agriculture is given a low priority and development is limited. Only half the foreign bottomfish effort within the 200-mile limit is assumed to be replaced by Alaska fishermen over the period.

Table II.4. describes employment growth in the state and Railbelt region over the projection period. The Railbelt region grows slightly slower than the state over the period, growing at an average of 2.5 percent per year, compared to 2.6 percent for the state. As in the high case, the state grows slightly faster until 1990, and the region grows slightly faster after 1990. This is also a result of OCS development in the 1980s and the decade growth rates masking the large economic growth associated with large construction projects during the 1980s.

TABLE II.4. MODERATE SCENARIO EMPLOYMENT GROWTH
(Average Annual Percent Change)

	<u>1980-1990</u>	<u>1990-2000</u>	<u>2000-2010^c</u>	<u>1980-2010</u>
State ^a	2.9	2.8	2.0	2.6
Railbelt Region ^b	2.6	3.0	2.0	2.5

^aTotal employment includes self-employed.

^bRegional projections are for nonagricultural wage and salary employment plus military. This excludes self-employed and was the basis for electricity demand projections.

^cPost-2000 growth assumed to be 2 percent per year.

By 2010, the Railbelt region contains 66 percent of the total state employment; total employment in the railbelt is 281,986 in 2010. The subregional growth is similar to the high case with Anchorage growing at a rate slightly slower than the remainder of the region. The Anchorage share of railbelt employment falls slightly from 76.3 to 74.8 percent over the period. Fairbanks and Valdez increase their shares of railbelt employment from 22.1 to 22.9 percent and 1.6 to 2.3 percent, respectively.

Low Economic Growth

The major source of growth in the low scenario is government spending. Only limited resource development takes place in this scenario. Petroleum production at Prudhoe Bay and in Upper Cook Inlet are assumed to continue and the Northwest gasline is built, but no other resource project is assumed to be developed. Agriculture is assumed to disappear from the state by the end of the period, while no bottomfish industry is assumed to be created.

Growth in both the state and Railbelt region are projected to be much lower in this scenario, averaging 1.9 percent per year and 1.8 percent per year, respectively. The Railbelt region is assumed to grow slightly slower than the state. By 2010, the Railbelt region has 68 percent of total state employment; by 2010, total employment in the railbelt is 231,559. As in the other scenarios, the Anchorage region grows slightly less rapidly than the other two railbelt subregions. By 2010, Anchorage accounts for about one percent less of the Railbelt region employment than in 1980. (See Table II.5.)

TABLE II.5. LOW SCENARIO EMPLOYMENT GROWTH

(Average Annual Percent Change)

	<u>1980-1990</u>	<u>1990-2000</u>	<u>2000-2010^c</u>	<u>1980-2010</u>
State ^a	1.9	2.7	1.0	1.9
Railbelt Region ^b	1.6	2.9	1.0	1.8

^aTotal employment includes self-employed.

^bRegional projections are for nonagricultural wage and salary employment plus military. This excludes self-employed and was the basis for electricity demand projections.

^cPost-2000 growth assumed to be one percent per year.

Population Growth

Change in the population of Alaska will follow the growth of employment. The change in the region's population is a result of natural increase (the excess of births over deaths) and migration. In a rapidly growing region with a small population base, like Alaska, migration is the most important component of population change. Migration occurs primarily as a response to economic opportunities which include both relative employment opportunities and higher incomes. The relatively large increases in employment associated with major projects such as TAPS mean that the national increase in the region's labor force will not meet the employment requirements of the economy and migration will be needed to meet the labor requirements.

The growth in population may diverge from the growth in employment; recent experience shows that population did not increase as fast as employment. This is primarily a result of two factors, increasing labor force participation and change in the number of unemployed. Labor force

participation rates measure the proportion of the population in the economy which wishes to be employed. Increases in this rate result from many factors. The increased participation of women in the labor force is a national trend. A change in the age distribution of the population which puts a greater proportion in the working ages will also increase participation rates. The region's labor force participation rates will also change if the migrants have different rates than the existing population. Finally, increased employment opportunities may bring a larger proportion of the population into the labor force. High incomes and employment opportunities in Alaska have this effect, especially when projects are located in rural areas with a high proportion of population which does not participate because of the lack of jobs. High levels of unemployment prior to a growth period may result in many of the jobs being taken by the unemployed with no need for migrants or population growth. As the economy expands, the yearly expansion of the Alaska labor force will provide labor for a large proportion of jobs created and migration will become less important as a force of population change.

HISTORICAL POPULATION GROWTH²

Table II.6. describes the historical growth of the state and the Railbelt region since 1960. Over the entire period, the railbelt grew slightly more rapidly than the state as a whole. Between 1960 and 1978, Alaska grew at an annual average rate of 3.3 percent, while the railbelt grew at 3.8 percent. Over the period, the railbelt increased its population share from 63 percent in 1960 to 70 percent in 1978.

The Railbelt region led the state in growth in each growth period, 1960-70 and 1970-76, as well as in the period of contraction, 1976-78. During 1960-70 and 1970-76, the railbelt grew at 3.6 and 5.8 percent per year, while the state as a whole grew at 3.0 percent and 5.0 percent, respectively. During each of these periods, the major causes of growth were located within the region--the Kenai oil fields and TAPS construction. Because of the location of major portions of the TAPS project in the region, it also suffered a more rapid population decline than the

TABLE II.6. HISTORICAL POPULATION GROWTH

(Average Annual Percent Change)

	<u>1960-1970</u>	<u>1970-1976</u>	<u>1976-1978</u>	<u>1960-1978</u>
State	3.0	5.0	- .7	3.3
Railbelt Region	3.6	5.8	- .8	3.8
Anchorage	4.5	6.1	.1	4.5
Valdez	1.3	16.5	-14.1	4.2
Fairbanks	1.5	3.7	-2.4	1.8
Rest of State	1.9	3.4	- .4	2.2

SOURCE: Alaska Department of Commerce and Economic Development, Division of Economic Enterprise, Basic Economic Statistics of Alaska Census Divisions, November 1979.

state as a whole, with population declining at an annual average rate of .8 percent per year, compared to .7 percent for the state as a whole.

Within the railbelt, Anchorage grew most rapidly, expanding at an annual average rate of 4.5 percent per year. The Anchorage expansion was a result of its service-support function and the location of families of project employees. Valdez also experienced rapid growth over the period, expanding only slightly slower than Anchorage at a rate of 4.2 percent per year.

One population characteristic which is especially important for projecting future energy demand is the number of households in the population. Changes in the average size of households can result in the numbers of households changing more rapidly than population. Changes in the social patterns, age structure and employment opportunities have resulted in rapid changes in the average household size in both

the United States and Alaska. Table II.7. compares the average household size in 1970 and 1976 in both Alaska and the United States. The changes in the United States were reflected in Alaska; within this period, average household size dropped by about the same amount. The average household size in Alaska was 11.5 percent greater than in the United States in 1970; in 1976, it was 12.8 percent greater.

TABLE II.7. AVERAGE HOUSEHOLD SIZE

	<u>1970</u>	<u>1976</u>
United States	3.14	2.89
Alaska	3.50	3.26

SOURCES: U.S. Department of Commerce, Statistical Abstract of the United States, 1978, and Demographic, Social, and Economic Profile of States: Spring 1976, 1979.

PROJECTED FUTURE POPULATION GROWTH

Table II.8. describes the projected growth of population under all three scenarios previously described. The expansion of both the railbelt and state population is similar to the projected growth of employment. There are two major differences between employment and population projections. First, growth of population is assumed to be less rapid than employment over the entire period. Between 1980 and 2010, state population grows .3 percent slower than state employment in the high scenario, .2 percent slower in the moderate scenario, and .2 percent slower in the low scenario. This pattern is repeated in the Railbelt region. This reflects the historical pattern of increasing labor force participation which results from increases in working-age population and participation

TABLE II.8. PROJECTED GROWTH OF POPULATION

(Average Annual Percent Change)

	<u>1980-1990</u>	<u>1990-2000</u>	<u>2000-2010^a</u>	<u>1980-2000</u>
<u>High Scenario</u>				
State	3.8	3.1	3.3	3.4
Railbelt	3.8	3.1	3.3	3.4
<u>Moderate Scenario</u>				
State	2.7	2.5	2.0	2.4
Railbelt	2.7	2.5	2.0	2.4
<u>Low Scenario</u>				
State	2.0	2.2	1.0	1.7
Railbelt	2.0	2.2	1.0	1.7

^aGrowth in this period at same rate as employment growth.

by women in urban areas and greater employment opportunities in rural areas. The second difference from the pattern of employment growth concerns the variability of growth between periods. In all scenarios, population in the Railbelt region grows at approximately the same rate as in the state; while the employment growth in the railbelt varies around the state growth rate. This reflects another historical pattern, the separation of place of employment and place of residence. With development in remote, unsettled areas of the state, many families of workers in these areas settled in the metropolitan regions of the state--Anchorage, Fairbanks, and Kenai. This pattern of settlement will most likely change as more activity occurs in other regions of the state.

Overall growth of population of the Railbelt region ranges from an annual average of 3.4 percent in the high scenario to 1.7 percent in the low. Railbelt population by 2010 reaches 773,804 in the high scenario, 576,037 in the moderate, and 476,007 in the low. Within the region, the distribution of population remains relatively stable throughout. The Valdez region expands its share of regional population to reflect its projected rapid growth in the moderate and high scenarios.

We assume in these projections that the average household size will decline following the projected national pattern. Table II.9. illustrates the effect of this assumption; the number of households is projected to increase more rapidly than population, resulting in the reduction in the average number of people per household. At both the state and regional levels, average population per dwelling unit is assumed to fall over the period, decreasing from 3.2 to approximately 3.7 at the state level in all scenarios and 3.04 to approximately 2.6 in the Railbelt region for all scenarios.³ By 2010, the number of households in the Railbelt region is 294,115 in the high scenario, 216,020 in the moderate, and 180,235 in the low scenario.

TABLE II.9. PROJECTED POPULATION PER HOUSEHOLD

	<u>1980</u>	<u>2010</u>
<u>High Scenario</u>		
State	3.17	2.66
Railbelt	3.04	2.58
<u>Moderate Scenario</u>		
State	3.17	2.69
Railbelt	3.04	2.59
<u>Low Scenario</u>		
State	3.17	2.71
Railbelt	3.04	2.56

Conclusions

The economic and population growth projected in the three scenarios presented in this section is similar to past growth. The determinants of growth are primarily resource development and state spending. These scenarios differ slightly from past growth because it is not as centered in the Railbelt region as past growth. There are two important reasons for this. First, state expenditures play a much greater role in future projected growth. This increased employment is spread more evenly out of the region, concentrating in the capital but also serving other regions. Secondly, more resource development projects occur out of the region. The major future sources of petroleum and such important resources as bottomfish development will occur out of the Railbelt region.

CHAPTER II ENDNOTES

1. Nonagricultural wage and salary plus military employment.
2. The populations described in this section are, except for 1960 and 1970 census figures, only estimates. This may explain some of the difference between growth of population and employment.
3. Regional differences reflect distribution of the population across subregions; each subregion had a different assumed starting value of population per household.

III. ELECTRICITY USE IN THE RAILBELT

Historical Patterns of Electricity Consumption

Between 1920 and 1970, net production of electrical energy in the United States by utilities grew at an average annual rate of 7.6 percent. The growth rate in the 1960s was only slightly below that long-term trend at 7.3 percent. In the 1970s, growth rates have been considerably lower. Table III.1. shows that between 1970 and 1978 the rate has been 4.6 percent, with growth in the years before 1973 twice that of later years (1973 was the watershed year of recession and oil embargo). Electricity consumption has grown historically at a faster rate than total energy consumption and, thus, has accounted for an increasing share of final energy demand.

TABLE III.1. HISTORICAL U.S. GROWTH RATES OF UTILITY
NET PRODUCTION OF ELECTRICITY

<u>Period</u>	<u>Average Annual Growth Rate (%)</u>
1920-1930	8.7
1930-1940	4.5
1940-1950	8.8
1950-1960	8.7
1960-1970	7.3
1920-1970	7.6
1970-1978	4.6
1970-1973	6.7
1973-1978	3.5

SOURCE: U.S. Department of Commerce, Statistical Abstract, various years.

Nationally, industry is the largest user of electricity, most of it supplied by utilities, followed by the residential sector, and finally by the commercial sector. Table III.2. shows that industry has historically been the largest user of electricity but that in recent years combined residential and commercial consumption has surpassed that of the industrial sector.

TABLE III.2. PERCENT DISTRIBUTION OF U.S. ELECTRIC ENERGY USE

<u>Year</u>	<u>Residential</u>	<u>Commercial</u>	<u>Industrial</u>	<u>Other</u>
1920	5	11	54	30
1930	9	12	53	26
1940	13	12	51	24
1950	18	13	49	20
1960	23	14	49	14
1970	28	18	42	12

SOURCE: U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970, 1975.

In the Alaska railbelt, historical growth in electricity sales has been more rapid than the national average. Table III.3. shows the level of utility sales in Anchorage and Fairbanks for selected years since 1940. Although above the national growth rates throughout, there is a pattern of deceleration of growth as the economy has developed and matured.

In the greater Anchorage area (encompassing the Census Divisions of Anchorage, Kenai-Cook Inlet, Matanuska-Susitna, and Seward [see map on Figure III.A.]), this growth has been relatively evenly divided between the residential sector and the commercial-industrial-government sector

TABLE III.3. ELECTRIC UTILITY SALES IN THE
ANCHORAGE AND FAIRBANKS AREAS

<u>Year</u>	<u>Sales (10³ MWh)</u>	<u>Year</u>	<u>Sales (10³ MWh)</u>
1940	10	1965	467
1951	78	1966	523
1952	101	1967	*
1953	134	1968	660
1954	148	1969	757
1955	166	1970	897
1956	190	1971	1,048
1957	204	1972	1,168
1958	220	1973	1,300
1959	243	1974	1,408
1960	320	1975	1,683
1961	353	1976	1,886
1962	387	1977	2,050
1963	431	1978	2,179
1964	472	1979	*
		1980 (est)	2,353

Average Annual Growth Rate (%)

1940-1950	20.5
1950-1960	15.3
1960-1970	12.9
1970-1980	10.1

Note: Data from different sources not totally compatible.

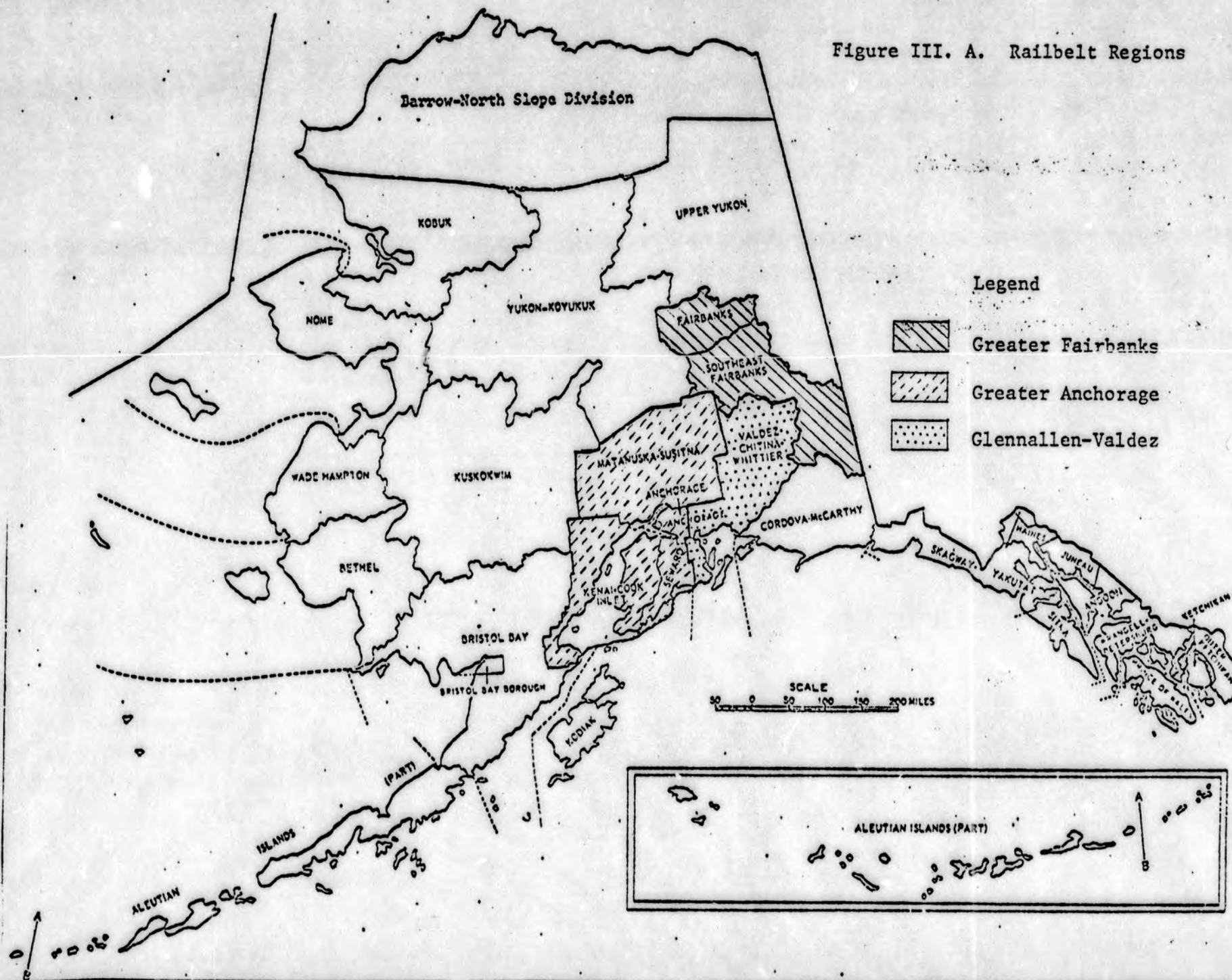
SOURCES: 1940 - U.S. Department of Interior, Susitna River Basin: A Report on the Potential Development of Water Resources in the Susitna River Basin of Alaska, 1952.

1951-59 - Bureau of Reclamation, Devil's Canyon Project: Alaska Feasibility Report, 1960.

1965-78 - Sales to Final Consumer from Federal Energy Regulatory Commission, Power System Statement.

1960-64 - Utility System Requirements from U.S. Department of Interior, Devil's Canyon Status Report, 1974.

Figure III. A. Railbelt Regions



with the latter being slightly larger. In the greater Fairbanks area (Fairbanks and Southeast Fairbanks Census Divisions), the commercial-industrial-government load has been substantially larger than the residential load except in the mid-1970s.

The high rate of growth of electricity sales in the railbelt is the result of both more rapid growth in the number of customers and in consumption per customer. Table III.4. compares the number of customers and annual growth in the number of customers over a recent period in the railbelt with the United States. Growth in the railbelt has exceeded

TABLE III.4. NUMBER OF ELECTRIC UTILITY CUSTOMERS

	Greater Anchorage (10 ³)	Greater Fairbanks (10 ³)	United States Average (10 ⁶)
<u>Residential</u>			
1965	27.0	8.2	57.6
1978	77.0	17.5	77.8
Average Annual Growth Rate (%)	8.4	6.0	2.3
<u>Commercial</u>			
1965	4.0	1.3	7.4
1978	10.2	2.9	9.1
Average Annual Growth Rate (%)	7.5	6.4	1.6

SOURCES: Federal Energy Regulatory Commission, Power System Statements of Alaska Utilities, U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970, and U.S. Department of Interior, Susitna River Basin: A Report on the Potential Development of Water Resources in the Susitna River Basin of Alaska, 1952.

the national average for two reasons. First, the railbelt population growth rate between 1950 and 1980 has been much larger than the national rate over the same period. Second, the proportion of households served by electric utilities was lower for Alaska than for the United States over much of the historical period so that some growth in the number of customers served occurred independent of population growth.

Table III.5. compares average annual consumption in the residential sector in greater Anchorage, greater Fairbanks, and the United States. Overall, the greater Anchorage area growth rate per customer has been about equal to the U.S. average, but the growth has been concentrated in the 1970s. In Fairbanks, the overall growth rate has exceeded the national average with all the growth occurring between 1965 and 1975. The same general pattern can be observed in the commercial-industrial-government sector.

Nationally, in the household or residential sector, the growth in electricity consumption has greatly exceeded that of energy in general. Although the overall annual growth rate for energy consumption in the residential sector (net of transportation) was 3.4 percent between 1950 and 1975 (household formation was 2 percent), the growth rate for electricity consumption was 7.2 percent annually so that between 1950 and 1975 electricity's share of residential consumption grew from 18 percent to 43 percent.¹ A considerable portion of this increased electricity share can be attributed to a substantial increase in electric space heating which accounted for less than 1 percent of households in 1950 but had risen to 12 percent by 1974.² Substantial increases in the proportion of households using electricity for hot water and cooking as well as growth in the percentage of homes having air conditioning also helped contribute to rapid growth in electricity's share of the residential sector.

TABLE III.5. AVERAGE ANNUAL RESIDENTIAL ELECTRIC
USE PER CUSTOMER
(MWh)

	<u>Greater Anchorage</u>	<u>Greater Fairbanks</u>	<u>U.S. Average</u>
1950	2.4	-	1.8
1965	6.4	4.8	4.9
1966	6.9	5.7	5.3
1967	6.9	-	5.6
1968	6.8	6.6	6.1
1969	7.0	7.7	6.6
1970	7.5	8.4	7.1
1971	8.5	9.5	7.4
1972	8.8	10.5	7.7
1973	9.2	11.2	8.1
1974	9.0	11.6	7.9
1975	10.1	13.7	8.2
1976	10.8	12.6	8.4
1977	10.4	11.5	8.7
1978	10.9	10.2	8.8

SOURCES: Federal Energy Regulatory Commission, Power System Statements of Alaska Utilities, U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970, and U.S. Department of Interior, Susitna River Basin: A Report on the Potential Development of Water Resources in the Susitna River Basin of Alaska, 1952.

The most important uses of electricity in the residential sector nationally are for space heating, water heating, refrigeration, cooking, air conditioning, and lighting.

In the Alaskan railbelt, electric space heating in 1978 was used by about 17 percent of the housing units, which contributed to both a larger proportion of total residential energy requirements supplied by electricity than nationally and also a larger portion of electricity use allocated to space heating. Table III.6. shows that the large proportion of housing units heating with electricity and the large unit requirements because of the number of heating degree days (as well as a lack of any substantial air conditioning load) result in a much larger proportion of railbelt residential electricity use for space heating than found nationally. Refrigerators, water heaters, lights, and cooking are next in order of importance.

In the commercial sector nationally, the same general growth patterns of electricity use emerge as in the residential sector. Between 1950 and 1975, annual growth of total energy use (net of transportation) was 4.4 percent; while that of electricity was 6.9 percent, so that its share of the total increased from 34 to 61 percent during the period.³ The majority of commercial consumption of energy (and electricity) is in retail-wholesale trade, education, finance and other office, and health-related activities. In contrast to the residential sector, space heating and water heating are relatively unimportant. Table III.7. shows the proportions of electricity in various uses in the commercial sector in 1975.

Historically, lighting, cooling, and electromechanical uses of electricity have increased relative to space heating and water heating.⁴ Substantial variation in end-use patterns for electricity exists among different types of consumers. Among the four primary commercial consumers, educational facilities use considerably less, and hospitals considerably more, than average amounts of energy for cooling, space

TABLE III.6.
1978 RAILBELT RESIDENTIAL ELECTRICITY CONSUMPTION
Part I: Appliances

		<u>GREATER ANCHORAGE AREA</u>			<u>GREATER FAIRBANKS AREA</u>			<u>GLENNALLEN-VALDEZ AREA</u>		
<u>Households Served</u>		65,250			15,250			1,340		
<u>Appliance</u>	<u>Unit Consump. (kWh/yr.)</u>	<u>Appliance Saturation Rate (%)</u>	<u>Electric Mode Split (%)</u>	<u>Total Elec. Consump. (MWh)</u>	<u>Appliance Saturation Rate (%)</u>	<u>Electric Mode Split (%)</u>	<u>Total Elec. Consump. (MWh)</u>	<u>Appliance Saturation Rate (%)</u>	<u>Electric Mode Split (%)</u>	<u>Total Elec. Consump. (MWh)</u>
Water Heater	3,475	99	34	76,319	97	43	22,103	91	40	1,695
Range	1,200	100	64	50,111	100	81	14,823	100	40	643
Elec. Dryer	1,000	71	90	41,693	66	98	9,863	48	75	483
Refrigerator	1,250	100	100	81,561	100	100	19,063	100	100	1,675
Freezer	1,350	46	100	40,519	42	100	8,647	43	100	778
37 Dishwasher	230	47	100	7,053	36	100	1,263	11	100	34
(Water)	700	--	16	7,308	--	15	1,601	--	4	38
Clothes Washer	70	77	100	3,517	74	100	790	65	100	61
(Water)	1,050	--	26	17,813	--	31	4,964	--	24	338
Television	400	148	100	38,627	149	100	9,089	80	100	429
Air Condition.	400	0	100	0	1	100	61	0	100	0
<u>Total Major Appliances</u>				364,521			92,267			6,174
Lights	1,000	100	100	65,250	100	100	15,250 ^a	100	100	1,340 ^b
Small Appl.	1,010	100	100	65,902	100	100	22,358 ^a	100	100	1,786 ^b
<u>Total Appliances</u>				495,673			129,875			9,300
Consumption/Household Served (kWh)				7,597			8,516			6,940

^a1,466 kWh per household

^b1,333 kWh per household

TABLE III.6. (continued)
1978 RAILBELT RESIDENTIAL ELECTRICITY CONSUMPTION
Part II: Space Heating and Totals

Housing Units Served	GREATER ANCHORAGE AREA				GREATER FAIRBANKS AREA				GLENNALLEN-VALDEZ AREA			
	71,873				17,500				1,500			
Housing Type	Unit Consump. (kWh)	Elec. Housing Heating Mode Mode Split Split (%) (%)		Total Elec. Consump. (MWh)	Unit Consump. (kWh)	Elec. Housing Heating Mode Mode Split Split (%) (%)		Total Elec. Consump. (MWh)	Unit Consump. (kWh)	Elec. Housing Heating Mode Mode Split Split (%) (%)		Total Elec. Consump. (MWh)
Single Family	32,000	52	18.8	224,714	45,900	52	7.3	30,491	31,700	31	2	295
Duplex	21,200	8.3	18.4	23,203	30,400	7.3	7.2	2,796	20,900	13	0	0
Multifamily	15,000	26.7	19.9	57,396	20,200	27.7	10	9,792	13,900	13	0	0
Mobile Home	23,900	13	18.4	40,478	35,100	13	7.3	5,829	24,200	43	0	0
Total Space Heat				345,791				48,908				295
Consumption/Housing Units Served (kWh)		4,811				2,795				197		

SUMMARY

Total Residential Consumption (MWh)	841,464	178,783	9,595
Appliance Consumption (MWh)	495,673	129,875	9,300
Space Heat Consumption (MWh)	345,791	48,908	295
Consumption/ Household (kWh)	12,896	11,724	6,397

TABLE III.7. NATIONAL PROPORTIONS OF ELECTRICITY
IN VARIOUS USES IN THE COMMERCIAL
SECTOR, 1975

Lighting	41
Cooling	36
Other (primarily electromechanical uses)	15
Space heating	7
Water heating	1

SOURCE: Jerry Jackson and William Johnson, "Commercial Energy Use: A Disaggregation by Fuel, Building Type, and End Use," Oak Ridge National Laboratory, 1978, Table 5.

heating, and electromechanical uses; while hospitals use considerable amounts for water heating, and educational facilities use considerably smaller amounts for lighting.⁵

It is difficult to compare Alaskan railbelt commercial electricity use with these national patterns because of the lack of data on Alaskan consumption. Air conditioning is present but to a much smaller degree, and a portion of this demand is met by natural gas. Electric space heat is probably not more important in Alaska than nationally in spite of the higher incidence of electric space heat in the residential sector. This is because a larger proportion of the commercial load is in areas accessible to natural gas.

In this study, both the government and industrial sectors are combined with the commercial sector because of inconsistency of reporting of the government sector (included in commercial by some utilities) and the small size of the industrial sectors, as well as the fact that

some utilities combine the commercial and industrial sectors for reporting purposes. Because of the presence of industrial users in the Alaskan data, one might expect a larger proportion of electricity attributable to electromechanical and other industrial uses. However, it is clear that industrial use of electricity is a much smaller proportion of Alaskan railbelt needs than national needs. This is evident first from the fact that 46 percent of Alaskan railbelt utility sales are residential compared to 28 percent nationally (1970 national data from Table III.2.). Second, Table III.8. shows that manufacturing activity in the railbelt, as reflected by employment, is relatively limited.

Considerations in Projecting Future Electricity Requirements

Several factors are generally recognized as important in the determination of the amount of energy consumed in various uses and the portion of that energy requirement satisfied with electricity.

PRICE

The price of energy relative to other commodities is important in the determination of how much energy is consumed. The price of electricity relative to other energy prices is an important determinant of how much of that energy consumption is in the form of electricity. Historically, both nationally and in Alaska, the real price of electricity (adjusted for changes in the cost of living) has declined. This has been true even during the 1970s when prices in general and energy prices in particular have moved rapidly upward. As it becomes cheaper, people tend to use more.

The movement of electricity prices in the future and the impact of these price movements on electricity consumption are difficult to forecast. Considerable sophisticated statistical analysis has been done nationally in an attempt to determine the exact relationship between

TABLE III.8.
RAILBELT POPULATION AND WAGE AND SALARY
EMPLOYMENT IN 1978

GREATER ANCHORAGE AREA

	<u>Anchorage</u>	<u>Matanuska- Susitna</u>	<u>Kenai- Cook Inlet</u>	<u>Seward</u>	<u>Total</u>
Resident Population	179,000	14,200	19,600	2,900	215,700
Employment Total	88,040	3,090	6,565	1,327	99,022
Mining	1,874	*	805	*	2,740 ^a
Construction	6,431	235	485	12	7,163
Manufacturing	1,683	*	989	*	3,103 ^a
Transportation-Communication- Utilities	7,924	307	574	*	8,865 ^a
Wholesale Trade	4,197	51	240	*	4,498 ^a
Retail Trade	12,668	588	950	201	14,407
Finance-Insurance-Real Estate	5,018	128	197	16	5,359
Services	15,526	363	853	164	16,906
Miscellaneous and Farm Workers	459	129	58	*	666 ^a
State and Local Government	11,265	1,125	1,324	241	13,955
Federal Civilian	5,140	94	87	72	5,393
Military and Related Federal	15,854	8	3	101	15,966

* Information withheld to protect confidentiality.

^a Author's estimate.

SOURCE: Alaska Department of Commerce and Economic Development, Division of Economic Enterprise,
"Numbers: Basic Economic Statistics of Alaska Census Divisions," November 1979.

TABLE III.8. (continued)
RAILBELT POPULATION AND WAGE AND SALARY
EMPLOYMENT IN 1978 (Continued)

	GREATER FAIRBANKS AREA			GLENNALLEN-VALDEZ AREA
	<u>Fairbanks</u>	<u>Southeast Fairbanks</u>	<u>Total</u>	
Resident Population	54,100	5,300	59,400	5,900
Employment Total	27,061	1,719	28,780	2,043
Mining	54	0	54	10 ^a
Construction	1,960	*	1,968 ^a	89
Manufacturing	564	*	571 ^a	10 ^a
Transportation-Communication- Utilities	2,765	24	2,789	362
Wholesale Trade	798	*	805 ^a	23
Retail Trade	3,274	86	3,360	236
Finance-Insurance-Real Estate	1,004	*	1,012 ^a	56
Services	3,939	157	4,096 ^a	409
Miscellaneous and Farm Workers	86	*	93 ^a	10 ^a
State and Local Government	4,814	281	5,095	790
Federal Civilian	984	45	1,029	48
Military and Related Federal	6,819	1,089	7,908	0

* Information withheld to protect confidentiality.

^a Author's estimate.

SOURCE: Alaska Department of Commerce and Economic Development, Division of Economic Enterprise,
"Numbers: Basic Economic Statistics of Alaska Census Divisions," November 1979.

price and consumption. The studies generally conclude, as common sense would suggest, that higher electricity prices in the future will result in lower rates of growth of electricity consumption than in the past.

Because of a lack of Alaskan data, the inappropriateness of using national estimates of the price-consumption relationship, and the difficulties involved in trying to predict energy prices over the next thirty years, we do not specify a price-consumption relationship. We assume that electricity prices will continue to rise as they have since the mid-1970s and that growth in consumption per customer will generally follow the pattern since that time. That is, the nominal price of electricity will continue to rise, but the real price of electricity may not increase significantly. This is in contrast to the past when the real price of electricity consistently fell.

We assume that the electricity price relative to other fuels will not change in such a way as to significantly shift the proportion of appliances fueled by electricity. This is particularly important for space heating which is the largest single user of electricity per customer.

INCOME

Historically, as household and aggregate incomes have increased, electricity consumption has also grown. This consumption growth is manifest in the residential sector in both a larger stock of electrical appliances and a larger unit consumption of electricity within appliances. In the commercial-industrial sector, the same factors can be observed and, in addition, an increase in the number of commercial consumers. Higher aggregate income means more business activity in trades and services and, consequently, more utility customers.

We assume that real incomes per capita will continue the general pattern of growth of the past. During the years of oil pipeline construction in Alaska, real incomes grew much more rapidly than the national

average; but in the post-pipeline era, the level of Alaskan personal income per capita is moving back toward its previous relationship to national trends. This implies more and larger appliances and larger living units in the future.

FUEL AVAILABILITY

In most of the Greater Anchorage area, consumers have a choice among electricity, natural gas, fuel oil, and other fuels for their needs. In Greater Fairbanks and Glennallen-Valdez, natural gas is not available. Changes in fuel availabilities in the future could significantly affect electricity consumption patterns. We assume that there will be no significant change in the availability of different fuels in the future or in the geographic distribution of economic activity and housing units within regions which would significantly alter the fuel-use opportunities available to consumers.

CONSERVATION

Some conservation measures will affect the use of electricity independent of price effects. Federal, state, and local government regulations and incentives can be directed at conservation. Estimating the impact of such conservation measures on consumption is difficult because each policy generally involves technical, institutional, and consumer behavior considerations which, because conservation programs are relatively new, are not well understood. We assume that substantial federal conservation programs are mandated and implemented during the next five years. (Some may be administered by state and local governments.) The effects of these programs will be less than the idealized engineering analyses would indicate, and the impacts will be observed to occur over a period of years because of institutional constraints and the time required for old, less efficient appliances to wear out and to be replaced by more energy-efficient counterparts. The implementation and impact of the automobile fuel efficiency standards is an example of the type of program assumed for electricity conservation.