

ALASKA LEGISLATURE COMMITTEE FILES 1983-1984

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MARKETS & INVESTMENTS

# A fiasco that may rock municipal bonds

When a delegation of top Washington State officials traveled to New York City recently to drum up interest in a bond sale, institutional money managers turned out in force. Despite the unusually large crowd, the obligatory call for questions following the briefing was greeted with silence. "Finally, someone asked about 'Whoops,'" recalls one attendee, "and all hell broke loose."

Washington Public Power Supply System, better (if unaffectionately) known as Whoops, is giving Wall Street a severe case of the jitters. WPPSS, which is the nation's largest single issuer of tax-exempt debt, is perilously close to defaulting on \$2.25 billion of the \$8.3 billion in bonds it has sold to finance a massive nuclear construction program. "The worst is beginning to come true," sighs a municipal bond portfolio manager for a big mutual fund.

A WPPSS default would be the biggest in municipal bond market history, and analysts say it could prove more disruptive than previous financial collapses. Unlike the typical tax-exempt issue, WPPSS bonds are in the hands of investors throughout the country. And in contrast to New York City and Cleveland—both of which had delayed repayment of short-term debt—WPPSS is on the verge of defaulting on long-term bonds. "It is an unparalleled situation," says Howard Sitzer, municipal research director for Thomson McKinnon Securities Inc.

Bad timing. WPPSS's predicament, moreover, is entering the crisis stage just as the health of the municipal bond market is becoming more crucial than ever. Sales of long-term tax-exempt bonds, which have hovered at \$45 billion since 1977, shot up to \$76 billion in 1982. Another record is expected this year as states and cities rush to finance long-delayed building projects.

"Any problem with Whoops will have an effect on the whole muni market," says a senior executive at a top brokerage house. "I really shouldn't say any more about it," he adds. "Just say we are very concerned." Investment bankers are particularly loath to discuss Wall Street's role in the WPPSS debacle. At the urging of four Northwestern congressmen, the Securities & Exchange Commission recently began looking into alle-

gations of fraud in the underwriting and sale of WPPSS bonds. And John D. Dingell (D-Mich.), chairman of the House Energy & Commerce Committee, is considering holding hearings.

The syndicates put together to underwrite WPPSS bonds were headed by some of the premier names in public finance—Merrill Lynch, Goldman Sachs, Salomon Bros., Smith Barney, Blyth Eastman, and Paine Webber. Virtually every brokerage house of any consequence participated in these huge offerings. "Every-

WPPSS received payments from only two utilities—totaling \$9,435 of the \$19 million it had coming. Five other utilities set aside funds in escrow accounts.

WPPSS needs the funds to make monthly payments to Chemical Bank, the bond fund trustee, which in turn makes semi-annual distributions to investors. Unless WPPSS begins collecting by March, it will not have enough money to cover the \$93.9 million payment due bondholders on July 1. Chemical holds \$102 million in reserves, but tapping them might trigger a technical default.

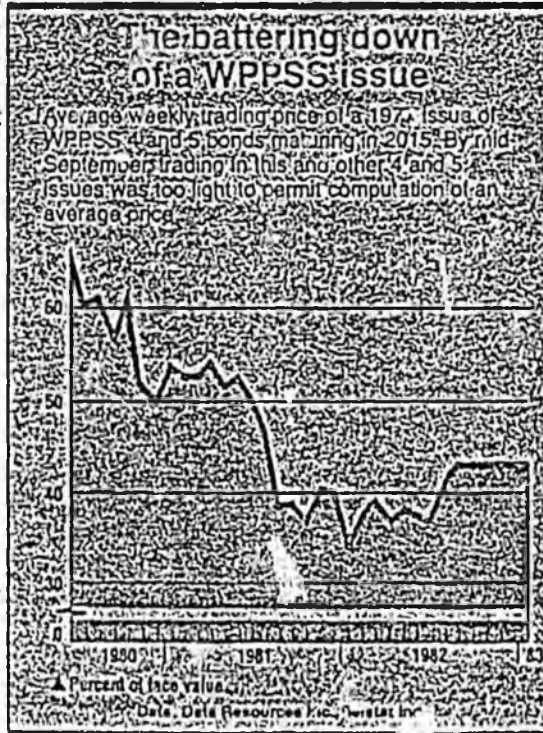
"We're stretching." Moreover, by the end of March, WPPSS expects to exhaust the funds set aside to pay up to \$490 million due contractors on the ill-fated plants. It might be able to buy more time by selling off assets and delaying payments to contractors. "We're stretching," says James Perko, WPPSS's treasurer.

The participants, most of which are small public utilities, are under intense pressure from angry ratepayers. Crowds have marched on, and in some cases occupied, headquarters of public utility districts. Although many major participants are willing and able to fulfill their WPPSS contracts, they are unlikely to begin paying unless their legal obligation to do so is clarified in court. (Otherwise, they could be sued by ratepayers—and in Washington, public utility officials are personally liable.)

In fact, the 11 participants from Oregon are barred from paying by a state court ruling that found they exceeded their authority by enter-

ing into contracts with WPPSS in the first place. That decision is being appealed. Similar challenges are before courts in Idaho and Wyoming. In Washington, home to 17% of the participants, a suit to force utilities to pay WPPSS will not go to trial until April at the earliest. A half dozen other WPPSS cases—including one not expected to reach a federal court until summer—are pending.

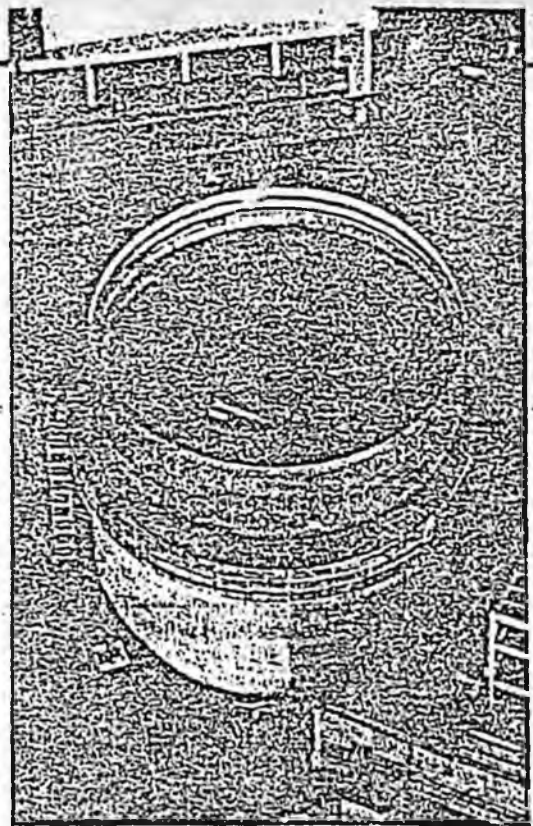
No sympathy. Northwestern political and business leaders have tried in vain to jawbone recalcitrant utilities into paying. Attempts to seek a solution outside the region have proved similarly ineffective. California utilities have demonstrated little interest in buying WPPSS plants or any future output, and neither the Rea-



body sold Whoops bonds," says one analyst. To the dismay of investors, a long series of setbacks has depressed many WPPSS bond issues (chart).

Upward revisions. WPPSS was forced to abandon two partially constructed nuclear plants a year ago; estimates had soared after Robert Ferguson took charge as WPPSS managing director and ordered a recalculation of costs. On Jan. 25, the 88 Pacific Northwest utilities that joined in this project were required to begin paying off the \$4.8 billion in interest due over 30 years on the \$2.25 billion in bonds sold to finance the plants.

Although each participant signed a contract obligating it to pay its share even if the plants were never completed,



Director Ferguson and one of the two nuclear power plants (right) WPPSS decided to leave unfinished after getting new cost estimates.

gan Administration nor Congress is sympathetic to pleas for federal help.

Last fall, Shearson/American Express Inc., a major institutional owner of WPPSS debt, was unable to muster even token support on Capitol Hill for a bailout plan. "The federal government is waiting to receive guidance from the states to see what, if anything, they want done," says Lawrence S. Hobart, deputy executive director of the American Public Power Assn.

Efforts to reach an out-of-court compromise have gotten nowhere. "A lot of people would like to see all the parties sit down together and work something out," says Robert Greening, director of the Public Power Council, a utility trade group that counts many participants as members. "But as long as the lawyers are advising everyone not to give an inch, it won't happen. A lot of people are becoming fatalistic."

Thinking the unthinkable. Default, once unthinkable, increasingly is being viewed in the Northwest as a legitimate political option. Two recent studies contended that the impact of default on Washington's economy would not be as catastrophic as had earlier been predicted. Washington Governor John Spellman in mid-January commissioned an independent study of the effect on the state.

Although many observers cling to the hope that default can somehow be averted, some veteran WPPSS analysts already

have concluded that it is virtually inevitable. "Under the most streamlined circumstances imaginable, there is the potential for an interruption in payment of interest, conceivably for two years or greater," says Eileen Titmuss, an analyst for Drexel Burnham Lambert Inc. Adds Jeffrey Whitehorn, an analyst for Dreyfus Corp.: "There is no way bondholders are going to come out whole." If WPPSS is forced into receivership or bankruptcy, creditors might be able to get at funds—including bond reserves—meant for the three other plants it is building. WPPSS still needs to raise \$1.1 billion to complete two of these plants (work on the third has been halted). "It is not clear that the Supply System will be able to return to the bond market for additional financing this spring as planned unless the legal uncertainties surrounding the impact of a default have been resolved.

The \$6.2 billion in bonds WPPSS has sold to finance these plants are backed by the Bonneville Power Administration (BPA), a federal agency that markets the output of U.S. government-owned dams in the Northwest. But the BPA, too, is under mounting financial strain. Standard & Poor's Corp. recently downgraded the bonds for the three plants to AA.

A default also is likely to trigger an investor backlash against other Pacific Northwest tax-exempt issuers—even those not directly involved in WPPSS.

"The precedent is really bad," says Edward Hosinger, municipal research director for Oppenheimer & Co. "I don't think a portfolio manager can risk owning a general obligation bond within these states."

The old story. Investors also may demand an additional risk premium to buy the securities offered by the nation's other 31 major regional public-power agencies, many of which employ "take or pay" contracts of the sort that WPPSS relied on. As a result, they may have to pay more for the \$24 billion that John Nuveen & Co. estimates they will need to raise by 1990. One lesson of the WPPSS debacle, Titmuss says, is that "a project financing is only as good as the economics which underlie it."

But some analysts foresee an even stronger investor reaction. Although individuals now account for as much as 75% of all municipal bond purchases, "they are relatively unknowledgeable about munis," Sitzer argues. "If you had a Supply System default, people are going to be reluctant to buy more."

"It will affect people's assessment of the safety of all similar investments or even of all dissimilar investments," says Sterling Munro, former chief administrator of the BPA and Nuveen's national director of public power. "It is the old story—once the cat has been burned, it won't sit on the hot stove again, and it won't sit on a cold stove, either."

(J)



# Alaska State Legislature

Senator Vic Fischer • Pouch V • Juneau, Alaska 99811 • (907) 465-4954

January 20, 1983

Eric Yould, Executive Director  
Alaska Power Authority  
344 W. 5th Avenue.  
Anchorage, Alaska 99501

RECEIVED  
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ALASKA POWER AUTHORITY

Dear Eric:

As you know, developments in recent months have significantly altered the outlook for future oil and gas prices and for energy demand. It now appears that some of the assumptions made by Acres and Battelle in their evaluations of the proposed Susitna project and alternatives are inaccurate. For example, it now appears that supplies of Cook Inlet natural gas will be available as fuel for the southcentral part of the state, and that they may be considerably less expensive than previously anticipated. (The intertie will make gas-fired electricity available to the interior as well.)

I have heard, though, that your understanding of the \$2.32/mcf contracts recently signed by Enstar is that they do not differ significantly for the \$3.00/mcf assumed in the Acres study, because the Acres price includes some additional costs that must also be added to the \$2.32 to compare them on an equal basis. I would very much appreciate it if you could provide me with a written explanation of this, as I believe it's critical to an understanding of the impact of the Enstar contracts.

Perhaps more important than the initial price, however, is the expected price escalation. Acres, I noted, in their medium forecast, assumes a real price escalation to \$4.80/mcf by the year 2000. Since the Enstar contracts are tied to changes in the price of locally-produced fuel oil and, since at least some experts in the field expect those prices to drop, it seems very possible that the escalation rate assumed by Acres is too high.

I understand further that people within the industry expect the Enstar contracts to act as a ceiling, and that future contracts are expected to be equal to or lower than the Enstar prices.

Given these developments, I would very much like to know how the up-dated Susitna-related work will reflect them. It seems to me that new net benefits calculations comparing Susitna to the base thermal case and to alternatives is called for. It would be most helpful to the legislature if such calculations could include a sensitivity analysis or, at the very least, a careful explanation of how changes in oil and gas prices will affect the net benefits.

I understand that Acres has in the past insisted on valuing the thermal alternatives at their "opportunity costs," or the prices they could bring on the export market if they could be sold. Although there

may be some value in providing such a comparison, it seems to me obvious that we have at work some local market conditions that must be considered when deciding on the relative costs and merits of competing sources of energy. In fact, the market value of Cook Inlet gas is not the price it might bring in Japan if Japan wanted to buy it, but the price that the producers are willing to sell it for. It would be fiscally irresponsible to develop an energy project that would cost more than an available alternative; I would not want to face the prospect of building Susitna and then having the utilities opt to purchase Cook Inlet gas instead. Even disregarding such as extreme event, an accurate net benefits calculation is critical to determining how much state funding will need to be appropriated to Susitna so that its initial costs are lower than the thermal alternative, assuring that there will, in fact, be a market for the power. I would therefore very much appreciate it if Acres, or the APA, would, in addition to its "net-back" approach, provide a net benefits calculation based on actual costs available in Alaska.

Because of changing economic conditions, I have previously stressed to you what I felt was a need for updated load forecasts. I understand that Battelle was to do some revised forecasts, but that the contract has been both altered and delayed. I again stress the importance of this information to future decisions regarding Susitna. Further, I hope that new forecasts will include information on the effect of pricing on demand and some analysis of the energy demand "bubble" experienced by Anchorage in the last year.

I understand that the APA is apparently still expecting to submit a FERC license application for Susitna in February. It seems to me that there's a great deal of new information (including environmental field data for the 1982 season) that needs to be integrated into the application. Will a license application submitted in February take into account the recent pricing and demand developments and include this year's data and update? If it does not, how will the information later be incorporated?

I thank you for your attention to these matters and look forward to your early response.

Best regards,



Senator Vic Fischer

cc: Governor Bill Sheffield  
Dick Lyon, Commissioner, DCED  
Chuck Conway, APA Board Member  
Robert Weeden, APA Board Member  
John Schaeffer, APA Board Member  
Peter McDowell, Director, CMB

# ALASKA POWER AUTHORITY

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(907) 276-0001

February 10, 1983

The Honorable Vic Fischer  
Senator  
Alaska State Legislature  
Pouch V  
Juneau, Alaska 99811

Dear Senator Fischer:

Thank you for your thoughtful inquiry into matters affecting the economic feasibility of the Susitna Hydroelectric Project.

In being associated with the project, I have noted that various people frame the arguments for or against Susitna in very different ways. Some concentrate on the environmental issues; others focus on the alternative uses for state funds. Some emphasize the risks inherent in building Susitna; others concentrate on the risks of relying on the alternatives and not building Susitna. Some base their judgement on the economic analysis, while others prefer to take a long term view of the project's potential contribution.

It is my personal opinion, and one which I have passed on to Governor Sheffield, that the issue is whether or not, at this juncture in the State's history, the State has sufficient discretionary funds to develop a secure renewable energy resource, at some risk regarding project cost, to satisfy power needs of about 70 percent of the State's population for more than 100 years.

Philosophy aside, there is no doubt that the economic analysis (with all its limitations) is a useful indicator that should contribute to a well reasoned decision. I will try to respond to each of your points.

The feasibility study, for purposes of the economic analysis, assumed unlimited supplies of Cook Inlet gas. I believe this to be a potentially dangerous assumption, but it nonetheless underlies the cost comparison. Mr. Dale Teel, of Enstar, continues to advise, in the strongest terms, that Cook Inlet gas supplies should not be depended upon for power generation beyond the mid 1990's. You may want to speak with him to gain insight into his view of the future.

With respect to Cook Inlet gas prices, the recent Enstar contracts provide an extremely valuable data point in the forecast of gas value. Previously contracted supplies will be exhausted by the time Watana could come on line in 1993. Therefore, the pertinent price for evaluating Susitna is the marginal value of new supplies. I have no reason to

Senator Vic Fischer  
February 10, 1983  
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believe that the recent Enstar contracts are other than accurate indicators of the present day marginal price of Cook Inlet gas. The Alaska Power Authority's review of the contracts and our discussions with Mr. Teel lead us to the conclusion that the 1993 price of Cook Inlet gas delivered to Anchorage Municipal Light & Power (ML&P), in 1982 dollars and excluding any escalation between now and 1993, is about \$3.00. This figure is arrived at by adding the severance tax (0.06/MCF), the delivery system fixed charges (0.30/MCF) and the demand charge (0.35/MCF) to the base price of \$2.32/MCF. The estimates of severance tax and delivery system cost were provided by Mr. Teel. He was also the source of the forecast as to when the demand charge would go into effect (1990).

If an electric utility manages to negotiate an equally attractive contract and is able to burn the gas closer to the field than can ML&P, at least a portion of the delivery costs could be eliminated. Of course, that would mean increased electrical transmission facilities.

The Susitna Feasibility Report uses a 1993 cost of Cook Inlet gas (1982 dollars) of \$3.03/MMBTU. Thus, the indicated cost based on the Enstar contracts would be virtually identical to the feasibility study estimate, as long as there is no real escalation in the gas prices between now and 1993. If there is real escalation over the next decade, Acres' estimate would prove too low; if there is de-escalation, the opposite would be true.

With this fairly close agreement on initial year prices between forecasted values and costs recently contracted, I agree with you that the expected price escalation is probably more important than the initial price. Acres assumed several escalation rates. In the low case, the price was assumed constant at \$3.00/MMBTU throughout the study period (i.e., no escalation). The high case escalation rate was set at five percent to the year 2000, two percent for the next decade and zero thereafter. The resulting set of long-term system costs are presented in the Feasibility Report.

I am not privy to industry expectations that the Enstar contracts will serve as a ceiling for future price agreements. Please transmit any such information so that we can take it into account in our planning.

At my insistence, the Feasibility Report has been prepared to reflect and highlight the uncertainties and risks associated with both proceeding and not proceeding with the Susitna Project. Pages 46-49 of the March 1982, Summary Report offer a vivid presentation of the sensitivity of the economic evaluation to assumptions different than those that were assumed as the base case. Section 18, Volume 1 of the Feasibility Report provides more detail.

Your letter goes on to ask for economic (net benefits) and financial (yearly cost of thermal power) calculations based on actual costs

available in Alaska. With respect to the latter, the actual generation cost (fuel, O&M and new capital investment) facing the utilities when Watana goes into operation is a very critical number in formulating the finance plan. The estimate is very dependent on inflation over the next decade and is also sensitive to the rate of demand growth. The first year alternative cost facing the utilities is one of several items that must receive periodic review.

You suggest that the market value of a fuel is not a function of the price it could bring in the Far East, but rather the price the Alaskan producers are willing to sell it for. Why would the producers want to sell the fuel locally at a price less than could be received from exporting? As long as the net-back procedure is performed properly and cost estimates are reasonably accurate, the procedure should yield good fuel price forecasts. If there is no interested overseas buyer, then the estimated market price should reflect that situation. If the forecast of world demand and markets proves incorrect and an export opportunity turns out not to exist, then the Alaskan production cost would become the controlling price.

To summarize, the net-back export price is the appropriate yardstick, but it is admittedly difficult to estimate world market conditions a decade and more into the future. The lowest price at which Alaskan fuels could possibly be valued is the local cost of production. I will include a sensitivity test where production based fuel costs are used for those fuel types where there is presently no established markets.

Battelle's RED model for Railbelt load forecasting has now been transferred to the State, under the custodianship of the Division of Energy and Power Development. Rather than hire Battelle to exercise the model for a forecast update, the project team will be using it directly. By so doing, we will be able to provide the necessary coordination of the forecasting and project evaluation to satisfy Federal Energy Regulatory Commission (FERC) requirements and can eliminate an extra player. The updated forecasts, like those prepared by Battelle, will show the sensitivity of demand to varied prices. They will also incorporate actual 1982 demand in the historical base.

You are correct that the Susitna license application will be submitted to FERC this month. It will have had the benefit of FERC and agency review and will be more thorough as a consequence. It will incorporate much of the results of the 1982 field season and will be accompanied by Alaska Department of Fish and Game's (ADF&G) 1982 data report. It will represent the largest amount of environmental information ever assembled for a FERC license application.

The "need for power" sections of the application will present the same analytical tools for load forecasting and project evaluation that are contained in the Feasibility Report. The application will also

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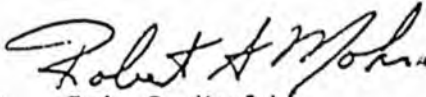
include the sensitivity testing methodology of the Feasibility Report and the full range of sensitivity test results. As the license processing proceeds, the Power Authority will be transmitting periodically updated load forecasts, fuel price assumptions and revenue projections. The FERC staff can be expected to critically review these and develop their own independently.

The FERC staff will initially concentrate on understanding and evaluating the analytical tools; only then will FERC turn to the actual evaluation of the project itself. By that time, the update presently in progress should be complete. FERC is well aware of the changing outlook for Alaskan revenues and is sensitive to their impact on demand.

As you consider the merits of the Susitna Project, it might be helpful to keep in mind that only the second phase, Devil Canyon, is predicated on load growth. The Watana phase is being planned to displace thermal generation and can be utilized from its first day of operation. Of course, the finance plan must result in competitive power costs to support this approach.

I hope I have adequately responded to your questions.

Sincerely,

  
for Eric P. Yould  
Executive Director

Attachment: Vic Fischer's letter dated January 20, 1983

cc: Governor Bill Sheffield  
Richard Lyon  
Charles Conway  
Robert Weeden  
John Schaeffer  
Peter McDowell  
Ray LaRusso  
Henry Chen  
Jane Drennan

POLICY ANALYSIS PAPER 82-14

Potential for Industrial Development  
in the Railbelt Region of Alaska Based  
on the Availability and Cost of  
Electric Power

December 1982

Prepared by: SRI International  
333 Ravenwood Ave  
Menlo Park, CA 94025

# SRI International



POTENTIAL FOR INDUSTRIAL DEVELOPMENT IN THE  
RAILBELT REGION OF ALASKA BASED ON THE  
AVAILABILITY AND COST OF ELECTRIC POWER

Prepared for:

State of Alaska  
Office of the Governor  
Division of Policy Development  
and Planning  
Juneau, AK 99811

Submitted by:

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December 1982

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## EXECUTIVE SUMMARY

The potential of new Alaskan hydroelectric and tidal power projects to provide large amounts of electrical power suggests that such hydroelectric capacity might serve as a magnet for industrial development and would help expand Alaska's economy. To assist the Office of the Governor in evaluating the potential for industrial development in Alaska based on inexpensive power, SRI International has reviewed available information on the proposed hydroelectric and tidal power projects and examined the issues related to an Alaskan location for a group of identified electrically intensive industries.

In addition to addressing particular industrial segments, SRI has examined other nonindustrial uses for low-cost electrical energy. These include electrification of the Alaskan Railroad, the possibility of an intertie to electrical grids in the lower 48 states, and expansion of electric space heating.

To determine the scope and timing of the proposed facilities, SRI used several studies on electric power development in the Railbelt region of Alaska. These include:

- Preliminary Assessment of Cook Inlet Tidal Power (Acres American/Governor's Office).
- Susitna Feasibility Study (Acres American/Alaska Power Authority) (Final Draft).
- Railbelt Electric Power Alternatives Study (Battelle Northwest Laboratories/Governor's Office) (Comment Draft).
- Energy Intensive Industry for Alaska (Battelle Northwest Laboratories/Division of Energy and Power Development).
- Various feasibility, engineering, and design studies on the Railbelt region by the Alaska Power Authority.
- Economic Development in Alaska--A Sectoral Analysis (Arthur D. Little/Alaska Department of Revenue).

In reviewing these studies of the Susitna hydroelectric and Cook Inlet tidal power projects, SRI collected data by project and in total for the following factors:

- (a) Project location, likely completion date, power output, and other relevant system characteristics.
- (b) Estimated project cost range.
- (c) Forecast of service area demand.
- (d) Estimated electric power price based on a, b, and c above.
- (e) Nonutilized or surplus power availability through 2010, including a definition of "surplus" power and analysis of the impact of load growth on surplus power availability over time.
- (f) Surplus or nonutilized power price ranges, including four cases: 100% market financing, 50% market financing and 50% state grants, 100% state loans with the rate of return equal to the inflation rate, and 100% state grants. The effect of potential wholesale and retail rate structures on surplus power price ranges was considered.

In addition, to place the hydroelectric and tidal power projects in perspective, SRI tabulated information about hydroelectric and other electric power developments worldwide that affect Alaska's competitive position compared to alternative industrial locations.

After reviewing the reports listed above, SRI concludes that for many of the proposed financing methods and demand scenarios, the projected capacities and price of power of electricity from the Susitna and Eagle Bay projects will not be major incentives for electrically intensive industries to locate in the Railbelt region.

Energy projects are usually phased to balance supply with expected demand. Significant quantities of nonutilized power are unlikely to be available as an inducement for industry to locate in Alaska unless the state chooses to adopt a construction schedule and plant mix that result in excess capacity.

More importantly, even though the annual operating costs of these projects may be low relative to alternative power sources, the high carrying costs associated with the initial construction of these projects, financed at prevailing interest rates, will offset such savings. As a result, unless the state is able to obtain low interest rates or provide the majority of capital costs at no or very low interest rates, the cost of excess power, even if available, will not be sufficiently low to attract industry.

Table 1 summarizes the pertinent data of the reviewed reports and to indicate the likely completion dates. The actual completion dates will depend on the demand for electric power and the potential for financing the projects.

Table 1

## CHARACTERISTICS OF HYDROELECTRIC AND TIDAL POWER PROJECTS

Project Location	Earliest Completion Date, Medium Demand Forecast	Installed Capacity (MW)	Energy (GWh)	Capital Costs (billion 1982 \$)	Projected Electricity Cost (mills/kWh)	Forecasts for Nonutilized Energy, 2000-2010 (GWh)	
						Medium Demand	Low Demand
<b>Hydroelectric</b>							
Susitna--Watana	1993	680					
Subtotal				\$3.647		0	0
Susitna--Devil Canyon	2002	600		\$1.470		0	900-1,300
Total		1,280	6,790	\$5.117	58		
<b>Tidal</b>							
Eagle Bay	2010	1,440	4,000	\$3.825 <sup>2</sup>	48	4,000	4,000
Directly usable power			1,600		121		
Available power for retiming			2,400		79		

<sup>1</sup>Actual costs will include any additional interest to finance each project.

<sup>2</sup>Does not include any costs for retiming or storage.

To identify potential industries that might be attracted to Alaska by the long-term availability of inexpensive electrical energy, SRI compared U.S. Department of Commerce data on the value of purchased electrical energy with the value of shipped product for over 960 4-digit Standard Industrial Classification (SIC) code industries.

The screening process identified nine industries that might benefit from inexpensive power. Four are in Category I, for which electricity costs exceed 10% of product value. Two are in Category II, for which electricity costs are between 5% and 10% of product value; these were combined with three in Category III, for which total energy costs are greater than 10% of product value and electricity may be substituted for thermal energy sources.

In addition to the Category I, II, and III industries retained for further screening, four other potential large-scale electrical energy uses were considered as specified in the statement of work. The list of industries and "other industrial applications" evaluated are listed in Table 2.

Of the nine potential candidate industries and four additional application areas considered, only residential space heating and processing of certain primary metals are likely to take advantage of the low-cost power in the Railbelt region. Expanded space heating usage has the best potential to utilize any excess power produced in the Railbelt. Investment in an aluminum plant appears to be likely only if the construction costs of the hydroelectric projects are subsidized by the state, and then it is questionable that there will be sufficient excess power available to serve a single "world-class" plant. Although the tidal project might provide sufficient power, the power from this project will not be low cost. Other metal processing plants are likely to be considered only if feedstocks are found in Alaska. The construction of an intertie with the Lower 48 does not appear to be cost-effective without state grants to finance the power projects, but there is no rationale for Alaska to subsidize power delivered to other states.

SRI's findings are predicated on 10% interest rates, continued high Alaskan labor costs, and little real increase in petroleum prices during the next 25 years.

The major findings of the study are:

- The cost of power from the Susitna project will not be competitive without a very substantial state subsidy, in the form of either grants or subsidized interest rate (until the capital cost obligation is paid off in 2010).
- The Cook Inlet project will not produce power at competitive rates because of the intermittent nature of tidal power.

Table 2

INDUSTRIES AND OTHER INDUSTRIAL APPLICATIONS EVALUATED  
AS POTENTIAL LARGE USERS OF RAILBELT ELECTRICAL POWER

Category I

- The Aluminum Industry (SIC 3334, Primary Production Aluminum)
- The Chlor-Alkali Industry (SIC 2812, Alkalies and Chlorine)
- Industrial Gases (SIC 2813, Industrial Gases)
- Ferroalloy and Miscellaneous Metal Alloy Production (SIC 3313, Electrometallurgical Products)

Categories II and III

- Pulp and Paper Industry (SIC 2661, Building Paper and Building Board Mills; 2611, Pulpmills; and 2621, Papermills, Excluding Building Paper)
- Cement Industry (SIC 3241, Hydraulic Cement)
- Chemical Industry (2719, Industrial Inorganic Chemicals, NEC)
- Primary Metals Industry (SIC 3339, Primary Smelting and Refining of Nonferrous Metals, NEC; SIC 3333, Primary Zinc)
- The Fertilizer Industry (SIC 2873, Ammonia Production, Nitrogenous Fertilizers; 2874, Phosphate Fertilizers)

Other Applications

- Agglomerations of Small Industrial Facilities
- Residential Space Heat
- Electrification of Alaskan Railroad Intertie with the Lower 48
- Intertie with the Lower 48.

- There is not likely to be excess power available from Susitna alone unless the Alaskan economy stagnates or declines.
- There is unlikely to be sufficient excess power to serve a single world-class aluminum plant.
- Other than aluminum, electrically intensive industries are unlikely to derive sufficient cost savings from subsidized power to consider an Alaskan site on the basis of low-cost electricity alone.
- The availability of low-cost power might improve the economics of processing materials, provided the major feedstocks are native to Alaska.
- Without a tiered rate structure to discourage use for residential space heating, subsidized power is likely to increase electric space heating use sufficiently to absorb any excess power from the Susitna project.
- The relatively high state corporate income tax is a barrier to industrial development in the state.
- Although the SRI study is predicated on stable energy prices through 2002, the findings of the study are not greatly affected by an increase in fuel prices of 50%, since transportation costs will escalate commensurately.

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## I PROPOSED RAILBELT HYDROELECTRIC AND TIDAL POWER PROJECTS

The potential of new Alaskan hydroelectric and tidal power projects to provide large amounts of electrical power suggests that such hydroelectric capacity might serve as a magnet for industrial development and would help expand Alaska's economy. To assist the Office of the Governor in evaluating the potential for industrial development in Alaska based on inexpensive power, SRI International has reviewed available information on the proposed hydroelectric and tidal power projects and examined the issues related to an Alaskan location for a group of identified electrically intensive industries.

In addition to addressing particular industrial segments, SRI has examined other nonindustrial uses for low-cost electrical energy. These include electrification of the Alaskan Railroad, the possibility of an intertie to electrical grids in the lower 48 states, and expansion of electric space heating.

To determine the scope and timing of the proposed facilities, SRI used several studies on electric power development in the Railbelt region of Alaska. These include:

- Preliminary Assessment of Cook Inlet Tidal Power (Acres American/Governor's Office)
- Susitna Feasibility Study (Acres American/Alaska Power Authority) (Final Draft)
- Railbelt Electric Power Alternatives Study (Battelle Northwest Laboratories/Governor's Office) (Comment Draft)
- Energy Intensive Industry for Alaska (Battelle Northwest Laboratories/Division of Energy and Power Development)
- Various feasibility, engineering, and design studies on the Railbelt region by the Alaska Power Authority
- Economic Development in Alaska--A Sectoral Analysis (Arthur D. Little/Alaska Department of Revenue).

In reviewing these studies of the Susitna hydroelectric and Cook Inlet tidal power projects, SRI collected data by project and in total for the following factors:

- (a) Project location, likely completion date, power output, and other relevant system characteristics.
- (b) Estimated project cost range.
- (c) Forecast of service area demand.
- (d) Estimated electric power price based on a, b, and c above.
- (e) Nonutilized or surplus power availability through 2010, including a definition of "surplus" power and analysis of the impact of load growth on surplus power availability over time.
- (f) Surplus or nonutilized power price ranges, including four cases: 100% market financing, 50% market financing and 50% state grants, 100% state loans with the rate of return equal to the inflation rate, and 100% state grants. The effect of potential wholesale and retail rate structures on surplus power price ranges was considered.

In addition, to place the hydroelectric and tidal power projects in perspective, SRI tabulated information about hydroelectric and other electric power developments worldwide that affect Alaska's competitive position compared to alternative industrial locations.

The economics of the proposed hydroelectric and tidal power plants are highly dependent on future oil prices and lower interest rates. Increasing oil prices will provide more state revenue, enabling the Legislature to consider grants or low-interest loans. More importantly, increased oil prices are more likely to force electric energy costs higher and induce electric-energy-intensive industries to build new facilities in regions with low-cost electric power. Industry is also more likely to finance the construction of new plants if interest rates are low.

After reviewing the reports listed above, SRI concludes that for many of the proposed financing methods and demand scenarios, the projected capacities and price of power of electricity from the Susitna and Eagle Bay projects will not be major incentives for electrically intensive industries to locate in the Railbelt region.

Energy projects are usually phased to balance supply with expected demand. Significant quantities of nonutilized power are unlikely to be available as an inducement for industry to locate in Alaska unless the state chooses to adopt a construction schedule and plant mix that result in excess capacity.

More importantly, even though the annual operating costs of these projects may be low relative to alternative power sources, the high carrying costs associated with the initial construction of these projects, financed at prevailing interest rates, will offset such savings. As a result, unless the state is able to obtain low interest rates or provide the majority of capital costs at no or very low interest rates, the cost of excess power, even if available, will not be sufficiently low to attract industry.

SRI International prepared Table I-1 to summarize the pertinent data of the reviewed reports and to indicate the likely completion dates. The actual completion dates will depend on the demand for electric power and the potential for financing the projects.

### Susitna Hydroelectric Development

#### Project Location

The Susitna basin development plan recommended by Acres American, Inc., indicates that the proposed 1,280 MW Watana-Devil Canyon dam project is the optimum plan from an economic, environmental, and social point of view. The proposed plan develops approximately 91% of the total basin potential.

The Susitna River system is the sixth largest in Alaska. The main stream of the Susitna River originates about 90 miles south of Fairbanks, where melting glaciers contribute much of its summer flow. For more than 30 years, the vast hydroelectric potential of this river has been recognized and studied. Strategically located in the heart of the south central Railbelt, the Susitna could be harnessed to produce more than twice as much electrical energy per year as is now being consumed in the Railbelt. Figure I-1 illustrates the location of the proposed Watana and Devil Canyon dams.

The main Watana dam is projected to be an earth/rockfill structure constructed primarily with locally excavated materials. The maximum height of the dam above the foundation will be approximately 880 feet, and the crest elevation will be 2,225 feet. The overall volume of the dam is estimated at approximately 63 million cubic yards.

The main Devil Canyon dam is currently proposed as a thin concrete arch structure with an overall height of 650 feet and developed crest length of 1,230 feet. The crest width will be 20 feet, and the base width at the crown cantilever will be 90 feet. The geometry of the arch corresponds to a two-center configuration compatible with the asymmetric transverse profile of the valley. The development at Devil Canyon will be located at the upper end of the canyon at its narrowest point.

Table I-1

## CHARACTERISTICS OF HYDROELECTRIC AND TIDAL POWER PROJECTS

Project Location	Earliest Completion Date, Medium Demand Forecast	Installed Capacity (MW)	Energy (GWh)	Capital Costs (billion 1982 \$)	Projected Electricity Cost (mills/kWh)	Forecasts for Nonutilized Energy, 2000-2010 (GWh)	
						Medium Demand	Low Demand
<b>Hydroelectric</b>							
Susitna--Watana	1993	680					
Subtotal				\$3.647		0	0
Susitna--Devil Canyon	2002	600		\$1.470		0	900-1,300
Total		1,280	6,790	\$5.117	58		
<b>Tidal</b>							
Eagle Bay	2010	1,440	4,000	\$3.825 <sup>2</sup>	48	4,000	4,000
Directly usable power			1,500		121		
Available power for retiming			2,400		79		

<sup>1</sup>Actual costs will include any additional interest to finance each project.

<sup>2</sup>Does not include any costs for retiming or storage.



### Completion Dates

The Watana rockfill dam is expected to take approximately 11 years to complete from the start of the access road to the testing and commissioning of all generating units. The earliest date that power production from the Watana dam could start is January 1993, based on construction of the access road beginning in early 1985 as soon as the Federal Energy Regulatory Commission (FERC) license is received. The Devil Canyon thin arch dam will take approximately 9 years and will be completed by 2000 at the earliest.

### Power Output

The selected Susitna Basin development plan involves the construction of the Watana dam with a 680-MW powerhouse scheduled to commence operation by 1993, the earliest that a project of this magnitude can be brought on line. The final stage involves the construction of the Devil Canyon dam with an installed capacity of 600 MW.

Should the load growth rate increase more slowly than the current medium growth forecast, then Alaska would have to consider postponing both the capacity expansion proposed at Watana and the construction of the Devil Canyon dam to the year 2002 or later. If Watana were delayed to the late 1990s, Devil Canyon would be delayed to 2010. This slippage corresponds to the low load forecast with an increased level of load management and conservation. For actual load growth rates higher than the medium load forecasts, construction of the Devil Canyon dam could be advanced to 1998.

Although this development plan is economical for a wide range of possible future energy growth rates, the actual scheduling for various stages should be continuously reassessed. In addition, dam heights and installed capacities should be considered representative at this stage of project planning.

### Project Cost Estimates

The total projected capital cost (1982 dollars) for the selected Susitna hydroelectric development project is \$5.117 billion, with Watana costing \$3.647 billion and Devil Canyon an additional \$1.470 billion. The annual operating costs are projected to be \$10 million for Watana and \$5.42 million for Devil Canyon--a total of \$15.42 million per year. Other forecast financial parameters are shown in Table I-2.

### Cook Inlet Tidal Power Development

Tidal power was selected for consideration in Railbelt electric energy plans because the substantial Cook Inlet tidal resource is among the largest in the world and because of the renewable character of this energy resource.

Tidal power plants typically consist of a tidal barrier extending across a bay or inlet that has substantial tidal fluctuations. The barrier contains sluice gates to admit water on the incoming tide and turbine-generator units through which the outgoing tide passes to generate power. Tidal power is intermittent, requiring a power system with an equivalent amount of installed capacity capable of cycling its output. Hydroelectric plants and/or energy storage facilities (pumped hydro, compressed air, storage batteries) could be used to regulate the power output of the tidal facility.

#### Project Location

The Acres American study, "Preliminary Assessment of Cook Inlet Tidal Power" (September 1981), evaluated three tidal power plant alternatives, identifying Eagle Bay in Knik Arm northeast of Anchorage as the most economically attractive site based on preliminary results of its technical evaluation. SRI analyzed the price and availability of power only at the Eagle Bay site because of its compatibility with Railbelt load projections and avoidance of some environmental problems common to sites farther down the Knik Arm in Cook Inlet. The other two sites, Rainbow and Point Mackenzie-Point Woronzof, are not included in the SRI comparative analysis.

#### Completion Date

The overall tidal project at Eagle Bay is estimated to require 10 years to complete once the FERC license application is received. A license probably would not be awarded by FERC before late 1989 at the earliest. The process could be accelerated by performing the detailed design and engineering specifications (with a model of the test turbines) during the federal license process. Although construction could begin as early as 2000, the State of Alaska is unlikely to undertake the tidal project until the Susitna project is nearing completion. The phasing of economic cycles, in combination with the financial drain of the large capital outlays required by both tidal and hydroelectric projects, precludes them from being constructed concurrently. In light of the periodic nature of tidal energy output, the hydroelectric projects at Susitna built before the development of the Cook Inlet tidal basin could assist in leveling the output of a tidal generation facility by idling Susitna generators during tidal plant output periods. Alternatively, thermal power plants could be disengaged while the tidal power plant was generating. However, even with Susitna on line, not all tidal power would be used. With the Devil Canyon dam being completed by 2000 at the earliest, the Eagle Bay project would be ready to start up by 2010.

Table I-2

FORECASTS OF SUSITNA FINANCIAL PARAMETERS

	<u>Watana</u>	<u>Devil Canyon</u>	<u>Total</u>
Project completion date	1995	2002	
Costs (1982 \$)			
Capital costs (billion \$)	\$ 3.647	\$ 1.470	\$ 5.117
Operating costs (million \$/year)	\$10.0	\$ 5.42	\$15.42
Provision for capital renewals* (million \$/year)	\$10.94	\$ 4.41	\$15.35
Operating working capital	15% of operating costs plus 10% of revenue		
Reserve and contingency fund	100% of operating costs plus 100% of provision for capital renewals		
Real rate of increase in operating costs			
1981 to 1987	1.7% per annum		
1986 to 1992	1.0% per annum		
1993 on	2.0% per annum		

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\*0.3% of capital costs.

### Power Output

The planned Eagle Bay tidal plant could have an installed capacity of 1,440 MW and could produce about 4,000 GWh annually when the project is in full operation. In the Railbelt system, the value of the installed capacity of a tidal power plant operating strictly on tidal cycles cannot be fully realized. The periodic nature of the tidal plant's generation cycle and the very substantial output of energy in comparison to the Railbelt demand provides a unique problem in fitting the supply to match the pattern of demand.

Previous tidal power studies estimated that, in theory, the energy output from a tidal plant must be less than 10% of the total system requirements for it to be directly absorbed without "retiming" of energy. The 4,000 GWh produced at Eagle Bay would be as much as 90% of total system energy needs in the Railbelt projected by Battelle for the year 2010. SRI is not aware of any major industrial users of electricity that could utilize the intermittent power. Some type of retiming or energy storage is necessary if the full tidal power plant output is to be absorbed effectively.

If the energy usable in the system is defined as that portion of the tidal power plant production that meets system demand, the usable portion varies from about 30% of the total energy produced in summer months, to about 35% in the spring and fall months, to more than 50% in the winter months. Overall, about 1,600 GWh, or 40% of the Eagle Bay plant total of 4,000 GWh, can be classified as directly usable in the system.

Because of the magnitude of the directly unusable energy--about 2,400 GWh--three options should be considered to increase utilization of the tidal power: (1) installation of an energy storage system designed to balance the tidal fluctuations, (2) providing a balancing power supply source, or (3) attracting an industrial base to take advantage of unretimed tidal output. The penalty for not using the full output of tidal power is major. The cost of the usable energy goes up by a factor of 2.5 at Eagle Bay if the unretimed and directly unusable energy is not utilized.

### Project Cost Estimates

Cost estimates for the tidal project of Eagle Bay are taken from the study prepared by Acres American. The Eagle Bay project is expected to have a capital cost of \$3.825 billion (1982 dollars), which does not reflect the additional costs for retiming or any other costs associated with integration of the intermittent phased output pulses of tidal power.

## II RAILBELT FORECASTS OF ANNUAL PEAK LOAD AND ELECTRIC ENERGY REQUIREMENTS

### Historical Electricity Demand Profiles

Between 1940 and 1978, electricity sales in the Railbelt grew at an average annual rate of 15.2%, roughly twice the national average. However, the gap between national and Alaskan energy consumption has been narrowing due to the maturing of the Alaskan economy. Growth in the Railbelt has exceeded the national average for two reasons: the population growth in the Railbelt has been higher than the national rate, and the proportion of Alaskan households served by electric utilities was initially lower than the U.S. average so that some growth in the number of customers occurred independently of population growth.

The 1980 annual energy requirement of the Railbelt utility system was estimated to be 2,790 GWh and the peak demand 515 MW. Near-term future demands can be satisfied by the existing generating system, the committed expansion at Bradley Lake (hydroelectric), and the combined-cycle (gas-fired) plant at Anchorage. These facilities are expected to meet the demand until 1993, provided an Anchorage-Fairbanks intertie of adequate capacity is constructed.

### Demand Forecasting

The feasibility of a major hydroelectric project depends partly on the extent to which the available capacity and energy are consistent with the needs of the market to be served by the time the project comes on line. Therefore, load forecasts are a most important factor in selecting the type and timing of generation units.

The Battelle Northwest study, "Railbelt Electric Power Alternatives Study" (February 1982), produced forecasts of annual electric energy and peak electric demand requirements for the Railbelt region and its three principal load centers: the Anchorage-Cook Inlet area, the Fairbanks-Tanana Valley area, and the Glennallen-Valdez area. These forecasts are designed as internally consistent estimates of power needs that take into account the following effects on the Railbelt region:

- Future economic and population growth.
- Future changes in the age, size, and energy-use characteristics of households.
- Future growth in commercial building stock.
- Future price and availability of fuel oil, natural gas, and wood.
- Cost of power from specific combinations of conservation and electrical generation that could be used to meet power demands.

- Public policy actions directly affecting energy demand or the cost of power.
- Possible new major uses of electric power, such as industrial use in manufacturing.

Because groups of these factors may interact in complex ways to produce a range of possible (but not equally plausible) forecasts, computer models of the interaction process were developed to determine how these factors individually and jointly affect demand estimates. The models, together with certain key assumptions concerning Alaska's economy, Alaskan public policy, and world prices for fossil fuels, produced contingent forecasts of electricity demand at 5-year intervals beginning from 1980. The demand forecasts were used as the basis for power plant planning in the Battelle study.

The forecasting process consisted of two steps: (1) combining sets of consistent economic and policy assumptions (scenarios) with economic models from the University of Alaska Institute of Social and Economic Research (ISER) to produce forecasts of future economic activity, population, and households in the Railbelt region and its three load centers; and (2) combining these forecasts with data on current end uses of electricity in the residential sector, data on the size of the Railbelt commercial building stock, data on the cost and performance of conservation, assumptions concerning the future prices of electricity and other fuels, and future new uses of electricity to produce demand forecasts.

Specifically, three basic scenarios for private economic activity and state spending were combined to give three overall economic scenarios: (1) high private economic activity and high state spending (high economic growth case); (2) medium private economic activity and medium state spending (medium economic growth case); and (3) low private economic growth and low state spending (low economic growth case). Increased industrialization and unsustainable state spending were investigated by Battelle but are not included in the three major-growth scenarios. The Battelle forecasting model, the Railbelt Electric Demand (RED) model, is based on the linkage between economic growth scenarios and electricity consumption.

Peak demand and annual energy forecasts for the low, medium, and high economic growth cases, as developed by Battelle, are presented in Table II-1.\* The medium growth scenario is established in the Battelle

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\*Note that the forecasts used by Acres American, Inc., in the Susitna hydroelectric project were initial projections derived from December 1981 computer runs of the various scenarios. The final forecasts produced in February 1982 by Battelle are approximately 20% lower. The result is that the Acres American low growth case corresponds to the latest Battelle medium growth forecast.

study as the base-case. The projected annual growth rate in base-case demand for electric energy is approximately 3.0% between 1980 and 2010, for an increase in per capita use of approximately 0.9% per year. Demand in the low economic growth case increases at 2.2% per year. Demand in the high economic growth case shows an average increase of 4.3% per year. The corresponding Railbelt system peak load (expressed in megawatts) corresponds basically to growth rates in annual energy demand.

Table II-1

PEAK DEMAND AND ANNUAL ENERGY REQUIREMENTS FOR THE LOW, MEDIUM, AND HIGH ECONOMIC GROWTH CASES\*

Year	Low Economic Growth		Medium Economic Growth		High Economic Growth	
	Peak (MW)	Energy (Gwh)	Peak (MW)	Energy (Gwh)	Peak (MW)	Energy (Gwh)
1980	520	2,550	520	2,550	520	2,550
1985	620	3,030	640	3,140	670	3,240
1990	800	3,850	880	4,260	1,060	5,414
1995	840	4,060	990	4,880	1,180	6,060
2000	820	3,990	1,020	5,030	1,230	6,380
2005	870	4,280	1,090	5,420	1,440	7,430
2010	1,000	4,940	1,260	6,260	1,760	9,010

\*The peak demand and annual energy requirements in this table do not assume a subsidy of the electric rate. The demand for electricity would increase if rates were subsidized.

### III ELECTRIC POWER PRICE RANGES

#### Susitna Project

Electricity cost estimates depend directly on the ability to correctly forecast electricity demand. If electricity consumption drops by one-third, the cost per kilowatt-hour more than doubles. As the unit price of power increases (decreases), consumption rates tend to decrease (increase). This elasticity of demand for electric power has proven to be a major factor in the economic health of domestic utilities. Clearly, to assure an economical match between electricity production and consumption, the timing of a major project like Susitna and the cost of power are extremely critical. The issue of full utilization of Susitna capacity is complicated by the present system of decentralized independent utilities which can be expected to bargain for rates no higher than the cost of energy from the best thermal option available to them.

Unless Susitna is completely financed by the state, residual bond financing will be required, at interest rates determined by complex political and economic forces. Acres American developed a financing plan based on interest rates of 10% to 12% to arrive at estimates of project financing characteristics. Analysis of this plan indicates that the costs of supporting the Susitna project on a 100% market-financed basis are higher than its projected revenues during the early years of the project. The cost of 100% market financing would result in electric rates which vary over time but are 9 to 15 times the level that would result from 100% state grants. These multiples result from high debt-servicing costs associated with the 100% market-financed scenario.

Table XII-1 illustrates overall power costs, and the fraction of those costs attributable to operational costs and debt servicing for the four basic scenarios under consideration for the year 1995 (2 years after Watana's earliest power production), 2003 (2 years after Devil Canyon's earliest power production), and 2010 (at which point Susitna power costs should be relatively level). Price ranges were taken directly from published Acres American financial data, except for the 100% state loan scenario. The power price for this scenario was calculated from yearly plant expenses in the absence of capital cost debt servicing as determined by the 100% state grant case, and from debt-servicing data used in the 100% market-financed case.

With 100% state grants and a total capital cost of \$5.1 billion (in 1982 dollars), the price for hydroelectric power of \$.01 per kWh would be very competitive worldwide. This plan represents the simplest financing option.

Table III-1

ELECTRIC POWER PRICE RANGES  
(Mill/kWh, Constant 1982 Dollars)

Scenario	Amount of Power Cost Attributable to Debt Servicing			Annual Operational Expense*			Total Cost		
	1995	2003	2010	1995	2003	2010	1995	2003	2010
	100% state grant	N/A	N/A	N/A	8.24	8.84	8.35	8.24	8.84
100% state loan	78.47	49.05	26.72	8.24	8.84	8.35	86.71	57.89	35.07
50% market financing 50% state grant	47.14	51.06	25.11	8.24	8.84	8.35	55.38	59.90	33.46
100% market financing	112.10	70.07	38.17	8.24	8.84	8.35	120.34	78.91	46.52

\*Assumed constant for all scenarios; see Table II-1.

Source: Acres American Susitna Feasibility Study

If Susitna is built with 100% state grants, the implication is that only the relatively small annual costs necessary for successful operation would be charged as the cost of output. The energy developed by Susitna would thus be supplied to utilities at a fraction of the cost of power from alternative sources. It has been assumed that no financing or marketing problems will exist for this case. The major problem may be arriving at an equitable allocation of the low-cost power among the consuming utilities whose normal demand may well exceed the supply of heavily subsidized power. The 100% state grants case would result in rates of about \$.01/kWh (in 1982 dollars), which are comparable to but slightly lower than the \$.0125 industrial rates for Le Grande Complex in Canada.\*

Another possible scenario is for the state to provide 100% of the capital costs in the form of a state loan to be repaid at an interest rate based on inflation. Assuming repayment at an average interest rate of 7%, this scenario would result in a rate of \$.09/kWh in 1995, which decreases to \$.035/kWh by 2010 (in 1982 dollars). If the state provides about half (\$2.3 billion) of the capital costs as a grant, with the remaining portion being market financed, the electric rate would vary from \$.05/kWh in 1995 to \$.06 in 2003 and then decrease to \$.033/kWh by 2010, somewhat higher than the current industrial rates in the Pacific Northwest. This rate is fractionally lower than the state loan case, reflecting the effect of the \$2.3 billion grant. If the Susitna hydroelectric project is 100% market financed, then the rates would be \$.12/kWh in 1995, decreasing to \$.08/kWh in 2003 and \$.046/kWh by 2010.

#### Cook Inlet Tidal Project

As illustrated in Table III-2, estimated production costs of an unretimed tidal power facility (\$.048/kWh) would be competitive with principal alternative sources of power, such as coal-fired power plants, but this cost can be realized only if all the available power could be used effectively by a specialized industry established to absorb the predictable but cyclic output of the plant. Alternatively, if it is assumed that only the portion of the power output that could be absorbed by the Railbelt power systems could be classified as usable, the cost of this energy (\$.121/kWh) would be extremely high relative to other power-producing options because only a fraction of the raw energy production could be used. An additional alternative would be to construct a re-timing facility, such as a pumped storage facility. Because of the increased capital costs and power losses inherent in this option, busbar power costs (\$.079/kWh) would still be substantially greater than for nontidal generating alternatives.

If the power production capability of the proposed 1,440-MW Eagle Bay plant were halved, using 30 instead of 60 turbines, the energy costs, when the excess energy cannot be used, are still relatively high.

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\*LeGrande Complex rates for small power users vary between \$.026/kWh and \$.045/kWh.

Table III-2

TIDAL GENERATION ENERGY COSTS AT ~~1971~~ 1971  
 (\$/kWh)

<u>Installed Capacity (MW)</u>	<u>Production Cost of Unretimed Energy</u>	<u>Excess Energy Not Used</u>	<u>Excess Energy Retimed</u>
1,440	.048	.121	.079
720	.058	.087	.076

\*Assumes a 3% real rate of return on the capital invested.

Source: Preliminary Assessment of Cook Inlet Tidal Power, Phase I Report, Acres American, Incorporated, September 1971.

#### IV AVAILABILITY OF NONUTILIZED POWER THROUGH 2010

Nonutilized power can be the result of seasonal variations, insufficient demand in the short term (3 to 5 years), or long-term low energy demand. The actual demand for electricity in the Railbelt varies seasonally. The capacity of new generation facilities is designed to meet peak loads, even if some surplus capacity results during certain time periods. Little can be done with short-term excess capacity when the normal demand growth will consume it within a few years. Only long-term surpluses of a generation system like the Susitna hydroelectric or the Eagle Bay tidal project would have the potential for attracting electrically intensive industry. These industries require reliable energy sources at low cost for periods exceeding 10 to 15 years.

According to Table I-1, in their final configuration the proposed Susitna hydro projects at Watana and Devil Canyon are expected to produce 6,790 GWh of energy annually. Under the Battelle-derived medium demand electric energy forecast, all of this energy will be consumed through normal load growth and displacements of existing generation facilities. Nonutilized power would only become available if the low growth forecast occurs. Should the low growth scenario prevail, approximately 1,200 to 1,800 GWh of nonutilized power, when Devil Canyon comes on line in 2002, could then be consumed annually by electrically intensive industries.

The mere availability of inexpensive electrical energy is not sufficient to ensure that the managers of electrically intensive industries will elect to locate new facilities in Alaska. Companies are reluctant to invest the required capital in a new plant to take advantage of inexpensive electric energy if large quantities of electricity cannot be guaranteed beyond 10 to 15 years. For example, the Acres American report states that even under their medium demand scenario some Susitna energy output (about 350 GWh) will not be used during the summer in 2010 (medium demand, summer). This seasonal energy output could be available to industry in the summer months. However, since most manufacturing processes require year-round operation, this power would not be attractive to most industries and cannot really be classified as a "surplus." In addition, the projected cost of the power from the unsubsidized facility is high when compared to other large hydroelectric power facilities like Le Grande Complex in Canada. If the state provides 100% of the capital for the project and does not expect any return on capital, then the cost of electricity will be very low, but this lower rate is likely to increase domestic demand significantly, resulting in little power availability for industry.

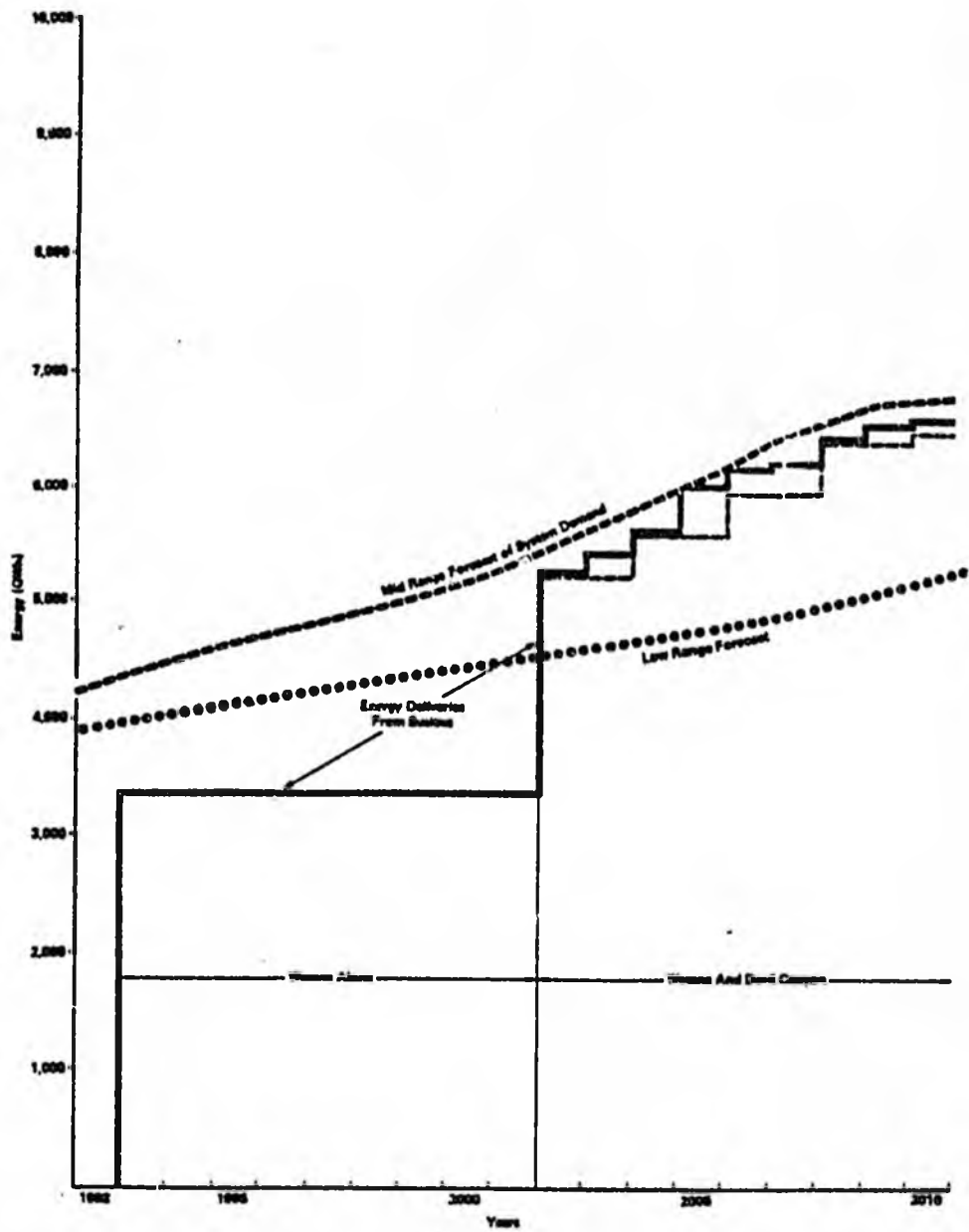
If the proposed Eagle Bay tidal power facility is approved, construction is expected to begin after 2000, when the Susitna project is about ready to go on line. This schedule would most effectively use Alaskan labor supply and is not likely to overtax the Alaskan economy. The required 10 years of construction would bring the tidal-generated power on line in 2010 or 2012. Even for the medium demand forecast, very little if any Eagle Bay output is expected to be required in 2010-2012. All of the output of this facility could be available, therefore, for additional industrial consumption. Because the generation of tidal power is intermittent, the energy produced will be in excess of the demand at certain periods, resulting in power that is not directly usable by the power grid without a large energy storage facility for retiming. The additional costs for retiming would make the project uneconomical. If only the directly usable power is included in the overall project, the cost for Eagle Bay power is estimated at \$0.12/kWh.

Optimum economic use of the Watana and Devil Canyon hydroelectric plants requires that they be operated as close as possible to full capacity. Large users of electric power could be offered blocks of power at a reduced rate to encourage full utilization of the capacity of the dam with maximum payback on the high capital costs and fixed operation and maintenance.

#### Potential for Nonutilized Electric Power

By comparing the forecast of system demand for the Railbelt with the energy deliveries from Susitna and Eagle Bay, the projected quantity of nonutilized electric power can be derived. The medium forecast of system demand and capacity is used as the base case in most of the studies that were compared. This comparison is shown in Figure IV-1 for both the medium and low case scenarios used by Acres. The wholesale energy cost from the hydroelectric and tidal plants is assumed to be less than the cost of the best thermal option and also less than the avoided operating costs of electricity supplied by existing equipment so that existing facilities are displaced. These assumptions would result in Railbelt utilities purchasing the majority of their power requirements from the hydroelectric and tidal projects. If the wholesale energy cost from the hydroelectric and tidal plants is not competitive with the cost of the thermal options, then there is little justification to undertake the large water projects. If the wholesale price is substantially less than the thermal alternatives because of financing subsidies, then the quantity of nonutilized power (excess capacity) would decrease as a higher "normal" demand consumes the lower-cost energy.

Figure IV-1 compares energy demand projections from Acres and projected deliveries from the Susitna hydroelectric projects. When Watana comes on line in 1993, the total energy output would not exceed the expected demand. No surplus is expected to be available for large-scale industrial usage, at least until Devil Canyon comes on line in



SOURCE: Acris American Incorporated, *Susitna Hydroelectric Project, Task 11: Economic, Marketing and Financial Evaluation*, prepared for Alaska Power Authority (March 1982)

FIGURE IV-1 ENERGY DEMAND AND DELIVERIES FROM SUSITNA

2000-2002. Under the medium growth forecast, little if any nonutilized power would be available. However, the low range forecast projects that 1,200 to 1,800 GWh of energy would be available annually for at least 10 years.

If the Eagle Bay tidal power plant comes on line in 2010, then the complete output of the project would be available for industrial use in the near term, although only 1,600 kWh would be directly usable.

The State of Alaska and the Corps of Engineers are considering two additional hydroelectric projects, Chackachamna and Bradley Lake. Chackachamna would be completed no earlier than 1995; its installed capacity of 330 MW would produce 1,500 GWh of energy annually. The 90-MW Bradley Lake project, which could be completed in 1988, would produce 350 GWh of energy annually. This plant has a 90-MW base load and 135-MW peak load capacity. By 1995 these plants would make an additional 1,850 GWh available for industrial use.

#### Fiscal Crisis Scenario

The various scenarios that have been discussed assume that any non-utilized or excess power capacity above normal reserve margins is the general result of a conscious decision to build such capacity for attracting industry and that massive excess capacity will not occur unintentionally. One additional scenario that SRI was asked to address concerns a worst-case fiscal crisis situation in which dams are constructed and even the low growth economic projection fails to materialize. This scenario is similar to the situation in which the utilities that make up the Washington Public Power Supply System found themselves when building what turned out to be excess nuclear capacity. They were forced to terminate at least two plants of five under construction, one of which was more than 24% complete. Under the fiscal crisis scenario, the state would have approximately 3,800 GWh available to attract industry.

In all financing scenarios except the 100% state grant, the ability or nonability to repay financing debt has serious consequences. In cases with fixed capital costs and falling demand, management is likely to increase power prices to maintain revenue. In any event, this scenario would result in an increase in the range of power available for industrial development if capacity is built before the Alaskan economy enters stagnation or downturn.

#### Summary of Potential for Surplus Energy

Table IV-1 summarizes the potential for surplus energy that might develop in the Railbelt. The data in the table indicate that if all the contemplated projects are built and if the Railbelt region experiences a low growth rate (2.2% per year), up to 5,350 GWh of annual output could be available by 2010 to attract electrically intensive industries. Even if the Cook Inlet and Chackachamna facilities are not built, 2,000 GWh of annual output could be available by 2000 if Devil Canyon is built and the "fiscal crisis" scenario develops.

Table IV-1

SUMMARY OF POTENTIAL SURPLUS ENERGY\*

	<u>2000</u>	<u>2010</u>
Watana/Devil Canyon <sup>1</sup>	1,300 GWh	
Watana/Devil Canyon and Cook Inlet Tidal <sup>1</sup>	1,300 GWh	5,300 GWh
Watana alone <sup>2</sup>	2,500 GWh	
Watana/Devil Canyon <sup>2</sup>	3,800 GWh	

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\*Without consideration of project financing.

<sup>1</sup>Assumes Acres low demand case.

<sup>2</sup>Assumes Battelle "Fiscal Crisis" case.

## V WORLDWIDE POWER PROJECTS COMPETITIVE WITH ALASKA'S HYDROELECTRIC DEVELOPMENT

Roughly half of the world's hydropower potential (approximately 1,200 GW) is in developing countries. Only 10% of the potential projects have been developed. Tables V-1 and V-2 show the status of worldwide hydroelectric development. Given the large increases in oil prices, many previously uneconomical hydroelectric sites have become more attractive. Developing countries are funding hydropower surveys and feasibility studies to explore these possibilities, but because of the long lead time for such projects and high financing cost, very few large projects will be completed during the present decade. Nevertheless, about 100 GW of hydroelectric capacity are expected to be completed over the next decade in some 60 developing countries. At fuel oil prices of \$20-\$25 per barrel, hydropower costing \$2,500 to \$3,000 per kilowatt of installed capacity can be competitive with oil-fueled steam units or large diesels. At this investment cost, assuming financing at 10%, hydroelectricity would cost about \$0.07/kWh. Several sites, particularly in Canada and Brazil, have projected rates of about \$.015/kWh. With power costs of \$.0125/kWh for large industrial users, Le Grande Complex in Quebec will be a competitor of the Railbelt for electrically intensive industries. Moreover, significant amounts of power are expected to be available for industrial use from this facility.

Industry is a major user of commercial energy in the developing world. In countries for which data are available, the industrial sector accounts for one-fifth to two-thirds of total commercial energy consumption, with an average at around 35%.

Those developing countries with relatively high levels of energy consumption are also major producers of the more energy-intensive industrial products, such as steel (Brazil, India, Republic of Korea, Mexico, Romania, Turkey, Yugoslavia), cement (Brazil, India, Republic of Korea, Romania, Turkey), ammonia (India, Indonesia, Republic of Korea, Mexico, Romania), aluminum (Brazil, India, Yugoslavia), pulp and paper (Brazil, Republic of Korea, Mexico, Romania), fertilizers (India, Brazil, Romania, Turkey), and chemicals (Brazil, India, Portugal, Romania). These countries are potential competitors of Alaska as industrial sites.

Table V-1

HYDROELECTRIC DEVELOPMENT STATUS  
(MW)

<u>Country</u>	<u>Installed Capacity</u>	<u>Under Construction</u>	<u>Planned</u>	<u>Other Probable</u>
Australia (1981)	6,113	-	2,350	9,765
Argentina (1979)	3,900	3,872	33,717	8,340
Brazil (1979)	23,842	26,163	14,096	100,000
Chile (1979)	1,480	950	6,595	6,781
Venezuela (1979)	3,000	2,620	13,565	-
India (1979)	9,908	6,820	1,978	42,000
Indonesia (1979)	450	-	2,500	31,000
Nepal (1979)	37	90	80,000	-
Colombia (1979)	3,120	1,150	23,350	23,600
Iceland (1979)	3,069	-	-	28,000
Honduras (1979)	69	600	-	3,000
Nigeria (1979)	600	1,145	1,200	8,000
Guatemala (1977)	121	600	1,635	4,000
Thailand (1977)	910	185	19,602	-
New Zealand (1978)	3,766	-	-	-

Table V-2

INTERNATIONAL DEVELOPMENT STATUS OF HYDROELECTRIC POWER  
SITES--INSTALLED OR INSTALLABLE CAPACITY  
(MW)

<u>Country</u>	<u>Operating</u>	<u>Under Construction</u>	<u>Planned</u>	<u>Other Probable</u>	<u>Total</u>
World	402,294	122,137	247,105	457,850	1,229,386
Canada	40,810	17,522	4,050	37,397	99,779
U.S.	68,933	8,200	2,013	103,477	182,623
<u>Asia and Pacific</u>					
Australia	5,695	1,660	2,350	-	9,705
New Zealand	3,617	868	1,320	5,000	10,805
Nepal	36	-	-	-	36
Philippines	725	2,085	-	4,778	7,588
Sri Lanka	335	-	-	-	335
Thailand	910	185	19,602	-	20,697
India	9,353	6,820	1,978	-	18,151
Indonesia	976	-	2,500	28,500	31,976
Malaysia	350	348	838	1,150	2,686
<u>Latin America</u>					
Argentina	1,945	5,872	33,717	8,340	49,874
Brazil	19,038	26,163	14,096	44,734	104,031
Chile	1,474	950	6,595	6,781	15,800
Colombia	2,801	1,150	23,350	23,600	50,901
Guatemala	121	20	1,635	4,881	6,657
Honduras	69	-	-	-	69
Paraguay	265	-	-	-	265
Peru	1,412	488	-	37,140	39,040
Uruguay	236	1,245	20	42,520	1,926
Venezuela	2,353	2,620	13,565	0	18,538
<u>Africa</u>					
Angola	368	80	300	9,000	9,748
Ghana	792	-	140	527	1,459
Madagascar	40	-	-	-	40
Mozambique	937	3,700	2,500	5,000	12,137
Nigeria	420	440	3,930	-	4,790
Zaire	1,159	289	-	32,000	33,448
Zambia	1,669	-	-	-	1,669

Source: Yearbook of World Energy Statistics, United Nations (1979).

## VI INDUSTRIAL LOCATION DECISIONS

### General

Business location decisions depend on a variety of site-specific factors, the objectives of the particular company involved, and the changing business environment and health of the relevant industry. Justification for specific facilities is an outgrowth of specific corporate strategies. The compelling reasons behind the search for new sites include:

- Expansion of existing production capacity
- New product manufacturing
- Cost reduction of production and distribution
- Expansion of market area
- Replacement of obsolete facilities.

Table VI-1 lists typical site selection criteria. Five broad categories--labor costs, transportation costs, utility costs, construction and other occupancy costs, and tax costs--represent about 90% of the total geographically variable cost factors associated with a typical plant location study. Usually treated as recurring expenses, these costs are therefore annualized; their totals represent a major input into locational decisions by most companies.

Usually a number of noncost, or subjective, factors are investigated during the course of a facility location project. The list may be as short as a half-dozen or as long as 100 or more. However, most company lists include at least labor issues (unionism, attitudes, availability), electric power and natural gas availability and dependability, physical site suitability, community attitude toward business development, and living conditions.

The specific measures used by an industry to determine each location's degree of compliance with the general location criteria consist of two types of screens: (1) thresholds or minimum requirements that must be met by any location to be considered suitable for a plant, such as those relating to environmental regulations or availability of required utilities, transportation facilities, and land and buildings; and (2) relative measures that provide a basis for comparing locations that meet all minimum requirements, such as those relating to production factors and quality of life issues.

Once the list of alternative locations is narrowed, specific cost analyses of total facility costs attributed to labor, transportation, amortization, utilities, taxes, and other costs are often conducted.

Table VI-1

GENERAL SITE SELECTION CRITERIA

Financial Considerations

- Overall cost of living
- Cost of transportation for feedstock and parts to plant and for product to marketplace
- Cost of direct and indirect labor
- Utility costs
- Salary levels
- Taxes on industry
- Availability of industrial development assistance
- Availability of capital
- Overall operating costs
- Employee relocation costs
- Cost of land and buildings
- Construction costs, including expense of added time for permit approval

Locational Considerations

- Availability and reliability of utilities
- Proximity to transportation, including airports, rail lines, trucking, shipping, and mass transit
- Proximity to like industries
- Proximity to materials, vendors, and services
- Start-up training and facilities
- Stability of regulatory and political climate
- Labor union presence
- Environmental sensitivities
- Recruitment potential and labor availability
- Legal status of land ownership

Quality of Life Considerations

- Quality of public schools
- Availability and cost of housing; potential neighbors
- Cultural activities
- Presence of major university--4-year, 2-year, vocational
- Recreational activities
- Climate
- Community attitudes
- Alternative employment potential
- Proximity to resource centers for professional development

Compromises are almost always necessary in locating a new facility. For example, a company may have extensive requirements for electricity that would cause it to select a second-best site. Many site selections result from arbitrary corporate decisions that contradict purely economic analyses. This situation most often occurs when economic variations between competing sites show few significant differences and personal preferences by corporate management become the deciding factor. A list of the site selection factors considered by industry in analyzing energy issues is presented in Table VI-2.

#### Electrically Intensive Industries\*

The cost of electric power, like the cost of any input to production, will affect Alaska's attractiveness as a location for new production facilities, but low-cost electricity by itself is insufficient to attract industry. For example, although a typical aluminum plant incurs electrical energy costs from 14% to 18% of product value, the extra construction costs (1.6 times U.S. average) and other additional expenditures associated with an Alaskan location may outweigh the benefit of reduced electricity costs.

#### Plant Location Factors

New forces are emerging that are shifting the weight of the relative measures for comparing locations. Cost factors are changing significantly, making future cost projections difficult. Figure VI-1 shows that transportation, electric power, and occupancy costs have increased much more dramatically during the past 10 years than the cost of labor or local property taxes.

Changes in transportation costs during the past 10 years have been closely linked to escalating fuel costs. As transportation costs increase, the importance of strategic markets and raw material availability increases for new plant sites.

Electric power costs have escalated rapidly during the past 10 years and can be expected to continue to increase over the next 10 years. Electricity rates for large industrial users rose by 18% between 1980 and 1981 alone, and recent increases in the Northwest have dramatically shifted the economics of existing plants.

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\*Derived from A. R. Tussing in "Introduction to Electric Power Supply Planning," Tussing and Associates, May 1980.

Table VI-2

SITE LOCATION FACTORS RELATING TO  
ELECTRIC ENERGY AND UTILITIES

Power Source

- Thermal--coal, natural gas, propane, fuel oil, lignite
- Hydroelectric
- Other--nuclear, geothermal, solar

Electric Power Supply

- Company or public agency serving area
- Interconnection with other systems
- Capacity--present and planned
- Recent record of shortages or interruptions
  - Average number of interruptions per year
  - Maximum duration
- Vulnerability to natural disasters
- Location of nearest electric substations and whether interlocking
- Voltage, phase, and cycle available
- Size of connection at proposed site
- Two-way feed
- Rates based on demand for services
  - Lighting
  - Machine operation
  - Air conditioning
  - Welding
  - Furnaces
- Cost of extending service
- Typical residential rates
- Off-peak possibilities
- Fuel adjustment provisions

Potential for On-Site Independent Energy Source

- Gas well
- Coal mine
- Nuclear reactor
- Cogeneration
- Waste burning

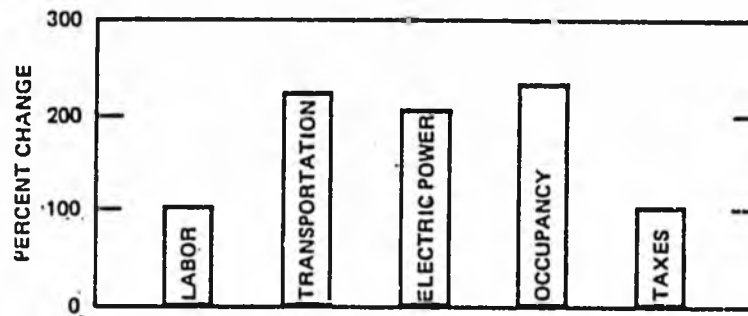


FIGURE VI-1 PERCENT CHANGE IN KEY COST FACTORS, 1970-1980

As competition among the states for new facilities increases, more and more states are seeking to improve their business climates to attract new industries. Although median tax rates have increased from about 2% to 4% of total investment during the past 10 years, more states are granting full or partial exemption to various classes of property to lure new facilities. Similarly, state levies on corporate income have remained relatively stable. Only two states have increased corporate income taxes during the past 5 years.

Occupancy costs have risen faster than any other costs during the 1970s. Both of the key elements that make up this cost, construction costs and interest rates, have doubled during the past 10 years. A \$2 million building in 1970 cost \$4,444,000 in 1980. A typical revenue bond interest rate in 1970 of 7% nearly doubled to 13% by 1980. The annual cost to amortize a 25-year loan jumped more than 250% between 1970 and 1980.

A review of site location studies written during the early 1970s reveals a concern with unionism, natural gas availability, proximity to interstate highways, and proximity to various support services. By 1980, additional factors such as state and community attitude toward industry, environmental concerns, living conditions, airline and truck service, and electric power availability and reliability are equally important.

Companies are becoming more concerned, in making their siting decisions, about living conditions, community attitudes, and political stability. In addition to forecasting geographically variable costs, corporations will become more adept at evaluating noncost or subjective factors. These concerns could become significant when comparing an Alaskan site to a site in a developing country with competing low-cost hydroelectric power. The relative political stability offered by Alaska represents a real asset when compared to the political uncertainty in many developing countries, although this asset may be offset by the economic uncertainty resulting from the expected decline in oil revenues in the 1990s.

During the next 10 years, additional issues such as water availability are expected to increase in importance. The availability of grants, subsidies, and inducements will also be a major locational criterion. The aggressive worldwide competition for new industry, exemplified by Japanese aluminum smelters in Brazil and by U.S. microelectronics industry in Scotland, are becoming increasingly important as U.S. manufacturers look in both developed and developing countries for sites which lower their production costs.

## VII CHARACTERISTICS, RESOURCES, AND LIMITATIONS OF THE RAILBELT REGION

Characteristics of the Railbelt region critical to industry-specific location decisions are:

- Labor costs and supply
- Taxation
- Construction costs
- Transportation cost and infrastructure
- Land status
- Climate
- Environmental considerations and land use plans
- Basic services and secondary industry
- Natural resources
- Existing industry
- Geographical location and proximity to markets

Alaska's principal economic attractions are its potential supply of undeveloped raw materials and fuel and its power availability. These attractive features must be weighed against those factors of the Alaskan economy which will prevent certain types of development in the state for the foreseeable future.

### Labor Costs and Supply

As indicated in Table VII-1, the Railbelt has only limited supplies of labor in the construction, mining, and manufacturing (industrial) sectors. Any major developments in those sectors would require a significant labor influx. The most recent, accurate data concerning labor supplies in the Railbelt region are the employment figures for the third quarter of 1980. The data in Table VII-1 represent the averages for that year and are given by sector and by subregion (census division).

Table VII-1

## NUMBER OF EMPLOYEES BY SECTOR IN THE RAILBELT

Sector	Anchorage	Kenai	Mat-Su	Subtotal South Central	Fairbanks/ SE Fairbanks	Cordova/ Valdez	Total Railbelt	Percent Total
Government	20,356	1,169	1,281	22,806	7,460	1,100	31,366	26%
Services	17,182	1,023	511	18,716	4,554	686	23,956	20
Retail trade	13,324	1,048	792	15,164	3,662	332	19,158	16
Transportation, communication, utilities	8,318	671	306	9,295	2,882	608	12,785	11
Construction	7,190	902	267	8,359	2,374	360	11,093	9
Finance, insurance, real estate	4,900	203	115	5,218	698	123	6,039	5
Manufacturing	2,532	2,022	27	4,581	502	532	5,615	5
Wholesale trade	4,230	272	53	4,555	679	51	5,285	4
Oil & gas extraction	2,671	793	--	3,464	6	--	3,470	3
Other mining	244	--	53	297	74	152	523	--
Other	804	82	36	922	103	--	1,025	1
<b>Total</b>	<b>81,751</b>	<b>8,185</b>	<b>3,441</b>	<b>93,337</b>	<b>22,994</b>	<b>3,944</b>	<b>120,315</b>	<b>100%</b>
Percent Total	68%	7%	3%	78%	19%	3%	100%	

Source: U.S. Bureau of Labor Statistics

Alaskan wage rates for industrial occupations tend to be substantially above U.S. averages. For example, in 1982 the average construction worker's weekly wage in Anchorage was approximately 1.52 times the average of 27 other U.S. metropolitan areas (Table VII-2). Other industries such as services and manufacturing are somewhat closer to national averages. Hourly manufacturing wage rates in Alaska in 1980 were about 1.17 times higher than those for the U.S. as a whole and are expected to remain at least 1.3 times higher in most sectors throughout the study horizon of 1982-2010. In the specific industry analyses, which are contained in Section IX, labor data for the individual industries are used where available.

Not only are prevailing wage rates in Alaska relatively high, but Alaska does not have a large pool of highly skilled workers. Many of the recent unemployed are construction workers. Workers with specific skills in the oil industry and other specialized skills are generally recruited outside of the state.

In general, extractive and primary processing operations are less labor intensive than final product manufacture. In addition, the increased use of automation and robotics in manufacturing will decrease the importance of labor in this sector. Nevertheless, labor costs, especially for construction, will remain an inhibiting factor to any industry that does not gain an offsetting economic advantage from an Alaskan location (e.g., lower material or energy costs).

### Taxation

Recent changes in Alaskan taxation policies have made the state more attractive to both individuals and corporations, although corporate income taxes remain high.

Most states levy corporate income and/or corporate franchise taxes as significant sources of state revenues. For 1982, the income tax rate for large corporations was significantly reduced in Alaska, to 9.4% from the previous maximum rate of 11%. This reduction makes Alaska more competitive with states such as California (9.6%), but the rate remains high relative to many Sunbelt states which have either no corporate income tax (Nevada, Texas) or rates in the 5% to 6% range (Alabama, Florida, Georgia, South Carolina, North Carolina, etc.). Alaska is also high relative to Pacific Northwest states. Washington has a business occupation tax of 1%, and Oregon has a 7.5% corporate tax rate.<sup>2</sup>

The retroactive repeal of personal income tax, in combination with the absence of a general sales tax, is a significant attraction to individuals and may eventually have a positive impact on Alaskan labor rates.

Table VII-2

HOURLY AVERAGE WAGE RATES IN CONSTRUCTION  
FOR ANCHORAGE AND 27 U.S. METROPOLITAN AREAS  
(\$ 1982/hr)

Albuquerque	15.10	Indianapolis	17.78
Anchorage	27.28	Kansas City	18.13
Atlanta	13.89	Miami	15.74
Baltimore	15.49	Minneapolis	17.52
Birmingham	13.41	New Haven	17.70
Boston	18.31	New York	19.33
Buffalo	18.39	Philadelphia	17.33
Chicago	19.25	Phoenix	19.28
Cincinnati	19.05	Pittsburgh	17.88
Cleveland	19.24	Portland, OR	20.51
Dallas	16.21	St. Louis	17.63
Denver	16.19	San Diego	22.30
Detroit	19.71	San Francisco	22.96
Houston	17.73	Seattle	21.06

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Source: Engineering News-Record, September 23, 1982.

### Construction Costs

Location adjustment factors computed to account for added construction costs in Alaska typically range from 1.5 to 2.0. Location adjustment factors increase as site locations move inland and northward. They are also dependent on the extent to which prefabrication can be performed in the lower 48 states.

Many estimates of Alaskan construction escalation factors were based on pipeline construction experience and reflect the high rates of inflation which occurred during that period. There is evidence that the Alaskan labor rate differential is moderating. Cost of living indexes for various Alaskan areas are not growing as rapidly as some other U.S. regions.<sup>3</sup> Nevertheless, 1982 hourly construction labor rates in Anchorage are approximately 1.52 times those of 27 other U.S. metropolitan areas (see Table VII-2).

Material costs also contribute to high construction costs in Alaska because of the necessity to import many materials. Some materials, such as sand and gravel, may be at or below national average prices because of their availability in Alaska. However, cement prices are approximately 2 times higher in Anchorage than in Seattle due to transportation charges. A general materials cost factor of 1.7 was assumed by SRI and is reasonable for the Railbelt region during the time frame of the study. Labor costs generally constitute about 1/3 of direct construction costs, with materials and project management costs accounting for the remainder. An overall construction factor of 1.5 can be derived for the Railbelt region based on current rates.

This factor is consistent with recent estimates obtained by SRI for specific plant construction cost factors in the Railbelt region. The engineering firm C. F. Braun recently quoted 1.5 as the construction offset factor, and Chevron (a component of Standard Oil of California) suggested 1.6 as a construction factor for a hypothetical ammonia/urea plant constructed in the Railbelt. Wherever possible, construction cost factors for specific plants have been used in the SRI study. These location factors would probably decrease over time, assuming that Alaska economic development continues.

### Transportation Costs and Infrastructure

The Railbelt region has the only comprehensive transportation system in the state. All of the urban centers are connected by air, rail, and highway links and have good access to ocean shipping. Specialized oil ports exist in Valdez and Cook Inlet. A coal terminal is planned for Seward, and grain terminals are being planned for Seward and Valdez. A

specialized coal terminal is also contemplated for the Beluga coal fields.\* Specific areas set aside for energy, industrial, and port development activities include the Port of Anchorage, Point MacKenzie (Mat-Su Borough), and the Port of Seward.

Transportation costs are high both within Alaska and between Alaska and its markets and suppliers. Because the state's transportation infrastructure is limited, low-cost intrastate transportation is scarce. Many areas can only be reached by air, or by sea in ice-free months. The costs of transportation to areas outside of the Railbelt are high because of their remoteness and because of the small quantities shipped and lack of backhaul. The cost of shipping equipment to or product from a mine or plant off the established transportation routes places the additional burden of road construction on any prospective developer.

Until additions to this infrastructure are made, most development will be limited to the coastal and immediate Railbelt areas. Only projects with immense economic potential will be able to finance their own transportation facilities (e.g., the oil/gas pipelines, coal facilities) and these projects will occur only as dictated by world market and national policy considerations. Beyond the Anchorage/Fairbanks corridor, little infrastructure is available to serve industries and their employees. Any mining or manufacturing activities outside of the Anchorage/Fairbanks corridor will have to provide housing and other population-serving infrastructure--either temporary camps or permanent new towns--for workers.

Because of the lack of a major inland waterway transportation infrastructure, locations in Alaska near coastal areas can be expected to be favored for process plants. Pulp, chemicals, and primary metals are all industries that typically require waterborne transport access.

Industries whose transportation costs are low relative to the value of product have more flexibility in location decisions than those with comparatively high transportation costs. Industries that produce high-value, low-weight products may choose locations that minimize power, labor, or other costs.

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\*The transportation network is described in detail in ISER, Alaska's Unique Transportation System (June 1980), and Booz, Allen, Strategic Marketing Plan for Port of Anchorage, Chapters II and III and Appendix B (February 1981).

In summary, transportation costs will remain a major factor in Alaska's future economic development because of the costs involved in transporting natural resources and feedstocks to processing facilities and the costs of transporting goods to international markets.

### Land Status

A great deal of important land in the Railbelt is still under federal ownership, a fact that will limit certain resource extraction and industrial activities. Much of the Anchorage coastline, for example, is owned by the Alaska Railroad (a federal entity) and the Department of Defense. The Fairbanks area also has large military reservations and other federal holdings.

Land status is currently in flux because of the slow pace of selection by, and conveyance to, the state and native corporations. Site-specific information about particular land areas is available from federal, state, and local authorities for areas under their respective jurisdictions and from private holders, including native corporations.

Although land availability is a negative factor for firms seeking to exploit mineral resources, most land that might be desired for industrial development in the Railbelt region could be leased for the economic life of the facility, which should be a satisfactory arrangement to most firms.

### Climate

Not only is the Railbelt region's climate severe, but Fairbanks often has extensive ice smog created by air inversions trapping sediments and particles from burning fuels in the river valleys of the area, and active volcanoes are located in the Cook Inlet region. Permafrost is a unique subsurface characteristic of the Arctic that poses special problems for construction.

Alaska's climate limits most construction and extraction activities to the summer months and curtails transportation to northern parts of the state in winter. The limitations imposed by the weather raise the overall cost of doing business in the state (e.g., creating a need for substantial summer overtime hours and premiums in construction or for costly air freight transport in the winter). Weather conditions in the Railbelt region are a severe inhibitor to the location of manufacturing industries in Alaska, not only because of construction and operating cost considerations but also because it restricts freedom of movement for personnel and material during much of the winter.

### Environmental Considerations and Land Use Plans

Uncertainty over the state's future environmental policies, especially for pristine wilderness areas, may inhibit new industry. An example of such uncertainty is the state's mineral tax policy. The question of whether royalties and severance taxes (similar to those on oil and gas) should be imposed on hardrock minerals and the rates of such taxes remain unsolved. In addition, opinions on what the state should seek to gain through industrial development are contradictory and unresolved.

The Anchorage and Matanuska-Susitna boroughs (Mat-Su) have standards for energy facility siting. Anchorage has a formal coastal management plan. Mat-Su, Kenai/Cook Inlet, and Valdez have written plans which are currently being reviewed and are in the approval process. All permit--and encourage--industrial location in designated areas. The state also has a natural resources plan for its lands. Most intermediate product manufacturers and bulk material producers require large sites to accommodate plants and facilities. The effect of land use plans must be considered on a project-by-project basis once the initial threshold requirements have been met.

### Basic Services and Secondary Industry

Local representation of major infrastructure (e.g., insurance firms, repair services, banking) and secondary industry firms (e.g., emergency resupply for mechanical or electrical failure) can be an important factor in plant location decisions. The perceived lack of secondary support facilities is likely to be a major inhibiting factor for the location of new industries in Alaska.

Many aspects of developed industrial infrastructure, such as specialized industrial supplies and services, apart from petroleum extractors and transportation services, do not currently exist in Alaska. Repair services, machine shops, parts depots, and other complementary firms will have to be established concurrently with industrial development, or such supplies and services will have to be imported at high cost.

### Natural Resources

The major natural resources of the Railbelt include coal, minerals, and metal ores (although no bauxite reserves for aluminum production), oil and natural gas, fish and shellfish, forests (soft and hardwood), nonfuel minerals; and water (for hydroelectric generation and for consumption). Historically, economic development in any region has usually begun with some type of resource extraction. Mineral resources that have not yet been extensively developed can

become the basis for primary processing industries, including mining and smelting. Timber and fishing resources have supported most of Alaska's manufacturing activity to date, and it is likely that manufacturing based on these resources can be expanded.

A special category of natural resources includes hydrocarbons, which can serve as raw materials as well as fuels for manufacturing processes. Industries such as food processing, pulp and paper, petrochemicals, primary and fabricated metals, and electrometallurgical processes require stable and/or low-cost supplies of oil, gas, or coal as process fuels or as feedstocks as well as the appropriate materials, minerals, and metals for processing. The potential of Alaskan oil and gas as industrial feedstocks is widely recognized and proposals for in-state processing of royalty oil have been considered. If oil and natural gas (including LNG) become more expensive and scarce, the availability of petroleum feedstocks will become an increasingly attractive factor.

While oil and particularly natural gas have traditionally been used as industrial process fuels, this use will become less widespread as costs continue to increase and regulatory actions encourage use of other fuels (primarily coal). In this regard, Alaska also has vast quantities of low-sulfur steam coal available for industrial use. The ready availability of water in the south central region could be particularly important for those industries that require significant amounts of process water (e.g., food products, particularly beverages, pulp and paper, chemicals), particularly in view of the shortfalls in water availability predicted for many regions of the U.S.

The presence of important natural resources is not sufficient to guarantee development. For example, extensive high-grade strategic metals and minerals are present in the Brooks Range, but development of the transportation infrastructure for extraction is economically prohibitive.

#### Existing Industry

Government is the major employer in the Railbelt (see Table VII-1), and most of the employment in the region is associated with services. Although relatively small, the petroleum industry has the character of a true basic industry in that the Railbelt includes the people and facilities for administration (primarily in Anchorage), transportation (primarily in Valdez and Kenai), and processing (North Pole refinery near Fairbanks and Tesoro and Chevron Oil refineries, Phillips LNG plant, and Union Chemicals nitrogen fertilizer plant, all located at Nikiski, Kenai), as well as exploration and development.

Employment statistics for the petroleum industry are aggregated by reporting agencies to avoid disclosure of individual business reporting units. The labor force in the petroleum sectors is estimated, however, to include about 3,650 to 4,900 persons.

Petroleum production capacities are as follows:

	<u>Capacity (barrels/day)</u>
<b>Kenai</b>	
Tesoro oil refinery	48,000
Chevron oil refinery	22,000
<b>Fairbanks</b>	
Mapco North Pole refinery	47,000

Another major plant is the Union chemical fertilizer plant, which produces 1 million tons of liquid ammonia per year and 800,000 tons of urea per year. The Phillips LNG plant produces 140 million cubic feet of LNG per year for the Japanese market.

Other than those associated with the petroleum industry, there are few industry groupings already in Alaska to naturally attract similar firms or suppliers.

#### Geographical Location and Proximity to Markets

Alaska's remoteness and the requirement to use U.S. registered ships for U.S.-bound goods results in high shipping costs between Alaska and the rest of the United States. The state's vastness also increases the likelihood of future developments being remote from the state's population centers or from the principal resource base. If a primary processing facility is located near a mine to minimize ore handling and shipping, for example, provisions will have to be made to provide housing and related facilities for workers. Alternatively, a firm performing processing near the population centers will have to transport bulk ores from the mine. Similarly, the distance from Anchorage, the commercial center, to the many outlying towns and villages will make it very difficult for even an Anchorage-based producer to supply the in-state market at reasonable prices. In addition, Alaska's remoteness from the Lower 48 may discourage small or medium-sized firms from even considering Alaska as a potential site.

Alaska's local market is quite small (approximately 400,000 people) and is further limited by the difficulties of distributing products to the more remote areas. Furthermore, unlike other states with relatively small markets, no neighboring states can absorb excess production of local market-oriented goods. The most basic local market industries do exist in Alaska--bakeries and newspapers, for example--but the population is too small to support other consumer-product

makers. The need to ship excess production at possibly high cost will inhibit development of locally oriented consumer or industrial suppliers until local demand is sufficiently sustained to support such industries.

Service industries, which are the fastest growing segment of the U.S. economy, locate near the population centers or companies they serve. Intermediate product industries, such as concrete producers, metal forgers, commercial printers, and glass container makers, tend to locate near industrial or commercial purchasers of their products. In many of these industries, industrial development must occur sequentially. For example, a plastics manufacturer may logically locate near a petrochemical complex as long as product transportation costs to the marketplace are relatively low. The sequencing or downstream integration of production facilities depends on upstream materials being available.

Alaska's geographic location on the Pacific Ocean is tantalizing. As the international procurement of materials and the international manufacturing of products increase, Alaska's location may be more beneficial than previously assumed. The ports in the south central region of the Railbelt are closer to Japan and Korea than the Lower 48 ports; unfortunately, this factor is currently largely offset by higher construction, labor, and operating costs in the Railbelt region.

#### Summary

The major advantages of developing an Alaskan industrial site are the state's vast supplies of natural resources and its fuel and feedstocks for extraction and initial processing industries. As natural resources and fuel or power shortages develop, Alaska will become an increasingly attractive site. Alaska is also favorable in comparison to many developing countries, which have the potential for political instability.

Deterrents to an industry's siting its facilities in Alaska arise from the state's economic environment, as well as industry-specific resource development constraints. Inhibiting factors are generally those that raise the costs of operating in Alaska, making Alaska-produced goods less competitive in U.S. and world markets, or that contribute to an adverse business climate (e.g., highly publicized environmental lawsuits and Teamsters Union activities have had a detrimental effect on corporations contemplating expansion into Alaska).

The principal inhibitors to development in Alaska are:

- High labor costs (1.3 to 1.5 times U.S. average) and lack of skilled labor.
- Lack of transportation and other infrastructure.

- High construction costs (1.5 times U.S. average is typical).
- Remoteness from major markets (transportation costs--highly dependent on product and destination).
- Limited local market.
- Institutional and regulatory issues:
  - Uncertain land status
  - Environmental constraints
  - Federal government influence.
- Climate.
- Relatively high corporate taxes.

The relative importance of inhibiting factors to economic development and industry-specific location decisions varies, depending on the proposed industrial facility, the economic health of the industry, and world market trends. Most of the Railbelt characteristics that presently inhibit industrial development increase the operating costs for industry. The advantages of an Alaskan location, such as proximity to specific resources and Pacific markets, are insufficient to offset these additional operating costs for most industries. The special case of electrically intensive industries will be examined in the next section.

## VIII IDENTIFICATION OF POTENTIAL LARGE USERS OF RAILBELT ELECTRICAL POWER

To identify potential industries that might be attracted to Alaska by the long-term availability of inexpensive electrical energy, SRI compared U.S. Department of Commerce data on the value of purchased electrical energy with the value of shipped product for over 960 4-digit Standard Industrial Classification (SIC) code industries. The four SIC industries for which electrical energy costs exceed 10% of the value of the shipped product are listed in Table VIII-1. Firms in these Category I industries are considered the most likely to consider an Alaskan site for new plant facilities if long term, low cost electrical power becomes available in the Railbelt region.

Additional industries considered as secondary candidates are listed in Table VIII-2. For these Category II industries, electrical power costs range between 5% and 10% of the value of shipped product. The lure of inexpensive energy will generally be less important for firms participating in the industries listed in Table VIII-2 than those in Category I.

Finally, the value of total (not just electrical) energy used was compared with the value of shipped product for all 4-digit SIC code industries to identify energy-intensive industries that might consider substituting inexpensive electrical energy for other forms of energy. These Category III industries identified during this process are listed in Table VIII-3, which does not include industries already listed in Table VIII-1 and Table VIII-2. Firms participating in Category III industries are considered to be less likely candidates for a Railbelt location than firms from the industries listed in Table VIII-1 and Table VIII-2, because of the largely unexplored issues associated with energy substitution.

Based on this initial screening, all four Category I industries were further evaluated to determine the potential additional costs of a Railbelt location for new plants in these industries. Of the Category II industries, manufactured ice, hydraulic cement, iron foundries, and reclaimed rubber were not considered likely candidates because of the obvious tradeoff between low product value and high transportation costs associated with these industries. An analysis of the transportation costs for cement is included in the study for comparison purposes and is considered to be representative of these low-value products. Malleable iron foundries and reclaimed rubber both depend on close proximity to associated industries (e.g., heavy machinery, automobile) and are unlikely to consider any locations which lack these supporting industries.

Table VIII-1

**CATEGORY 1: ELECTRICALLY INTENSIVE INDUSTRIES**  
 (Electrical Energy Costs as Percentage of Product Value, 1980)

<u>SIC Code</u>	<u>Description</u>		
2812	<p><u>ALKALIES AND CHLORINE (18.8)</u></p> <p>Establishments primarily engaged in manufacturing alkalies and chlorine.</p> <table border="0"> <tr> <td style="vertical-align: top;">           Alkalies            Carbonates, potassium and sodium            Caustic potash            Caustic soda            Chlorine, compressed or liquefied            Potassium carbonate         </td> <td style="vertical-align: top;">           Potassium hydroxide            Sal soda            Soda ash            Sodium bicarbonate            Sodium carbonate (soda ash)            Sodium hydroxide (caustic soda)         </td> </tr> </table>	Alkalies Carbonates, potassium and sodium Caustic potash Caustic soda Chlorine, compressed or liquefied Potassium carbonate	Potassium hydroxide Sal soda Soda ash Sodium bicarbonate Sodium carbonate (soda ash) Sodium hydroxide (caustic soda)
Alkalies Carbonates, potassium and sodium Caustic potash Caustic soda Chlorine, compressed or liquefied Potassium carbonate	Potassium hydroxide Sal soda Soda ash Sodium bicarbonate Sodium carbonate (soda ash) Sodium hydroxide (caustic soda)		
2813	<p><u>INDUSTRIAL GASES (23.3)</u></p> <p>Establishments primarily engaged in manufacturing gases for sale in compressed, liquid, and solid forms. Establishments primarily engaged in manufacturing fluorine and sulfur dioxide are classified in Industry 2819, household ammonia in Industry 2842, and other ammonia in Industry 2873, and chlorine in Industry 2812. Distributors of industrial gases and establishments primarily engaged in shipping liquid oxygen are classified in trade. Ammonia and chlorine production are considered separately. Fluorine, sulfur dioxide, and liquid oxygen are expected to have production economics similar to the gases listed in SIC 2813.</p> <table border="0"> <tr> <td style="vertical-align: top;">           Acetylene            Argon            Carbon dioxide            Dry ice (solid carbon dioxide)            Gases, industrial: compressed,                liquefied, or solid--in form         </td> <td style="vertical-align: top;">           Helium            Hydrogen            Neon            Nitrogen            Nitrous oxide            Oxygen, compressed and                liquefied         </td> </tr> </table>	Acetylene Argon Carbon dioxide Dry ice (solid carbon dioxide) Gases, industrial: compressed, liquefied, or solid--in form	Helium Hydrogen Neon Nitrogen Nitrous oxide Oxygen, compressed and liquefied
Acetylene Argon Carbon dioxide Dry ice (solid carbon dioxide) Gases, industrial: compressed, liquefied, or solid--in form	Helium Hydrogen Neon Nitrogen Nitrous oxide Oxygen, compressed and liquefied		

Table VIII-1 (Concluded)

<u>SIC Code</u>	<u>Description</u>
3313	<u>ELECTROMETALLURGICAL PRODUCTS (14.1)</u>  Establishments primarily engaged in manufacturing ferro and nonferrous additive alloys by electrometallurgical or metallothermic processes, including high-percentage ferroalloys and high-percentage nonferrous additive alloys.  Additive alloys, except copper: not produced in blast furnaces Electrometallurgical products, except aluminum, magnesium, and copper Ferroalloys, not made in blast furnaces Ferrochromium Ferromanganese, not produced in blast furnaces Ferromolybdenum Ferrophosphorus Ferro-silicon, not produced in blast furnaces  Ferrotitanium Ferrotungsten Ferrovanadium High-percentage ferroalloys, not produced in blast furnaces Manganese metal, not produced in blast furnaces Molybdenum silicon, not produced in blast furnaces Nonferrous additive alloys, high percentage: except copper Steel, electrometallurgical
3334	<u>PRIMARY PRODUCTION OF ALUMINUM (15.4)</u>  Establishments primarily engaged in producing aluminum from alumina, and in refining aluminum by any process. Establishments primarily engaged in rolling, drawing, or extruding aluminum are classified in Industries 3353, 3354, and 3355 and are not classified as electrically intensive.  Aluminum ingots and primary production shapes, from bauxite or alumina Extrusion ingot, aluminum: primary  Pigs, aluminum Slabs, aluminum: primary

Source: U.S. Commerce Department Data

Table VIII-2

CATEGORY II: ELECTRICALLY INTENSIVE INDUSTRIES  
(Electrical Energy Costs as Percentage of Product Value, 1980)

<u>SIC Code</u>	<u>Description</u>
2097	<p><u>MANUFACTURED ICE (8.0)</u></p> <p>Establishments primarily engaged in manufacturing ice for sale. Ice plants operated by public utility companies are included in this industry when separate reports are available. (Establishments primarily engaged in manufacturing dry ice are classified in Industry 2813 and have not been analyzed.)</p> <p>Block ice Can ice Ice cubes</p> <p>Ice, manufactured or artificial: except dry ice Ice plants, operated by public utilities</p>
2661	<p><u>BUILDING PAPER AND BUILDING BOARD MILLS (5.6)</u></p> <p>Establishments primarily engaged in manufacturing building paper and building board from wood pulp and other fibrous materials. Pulp mills combined with building paper and building board mills, and not separately reported, are also included in this industry; where separately reported, they are classified in Industry 2611.</p> <p>Asbestos paper and asbestos-filled paper, miscellaneous Asphalt board and sheathing, miscellaneous Asphalt paper: laminated--miscellaneous Board, building: composition, cellular fiber, and hard pressed--miscellaneous Board, building; except gypsum--miscellaneous Building board, miscellaneous Building paper: sheathing, insulation, saturating, and dry felts--miscellaneous Construction paper, miscellaneous Dry felts, miscellaneous Felts, building: unsaturated--miscellaneous Fiber board, wood or other vegetable pulp: miscellaneous Insulating siding, paper or board, miscellaneous</p> <p>Insulation board, cellular fiber or hard pressed (without gypsum): miscellaneous Kraft sheathing paper, miscellaneous Lath, fiber: miscellaneous Paper, building: miscellaneous Paperboard, building (containing no gypsum): miscellaneous Roofing board and felt stuck, unsaturated: miscellaneous Roofing, wood fiber: miscellaneous Saturated felts, miscellaneous Tar paper, building and roofing: miscellaneous Wall tile, fiber board: miscellaneous Wallboard, except gypsum: cellular fiber or hard pressed--miscellaneous</p>

Table VIII-2 (Continued)

SIC Code	Description		
2819	<u>INDUSTRIAL INORGANIC CHEMICALS,</u> <u>SEC (8.7)</u>		
	Establishments primarily engaged in manufacturing industrial inorganic chemicals, not elsewhere classified. Important products of this industry include inorganic salts of sodium (excluding refined sodium chloride), potassium, aluminum, calcium, chromium, magnesium, mercury, nickel, silver, tin; inorganic compounds such as alums, calcium carbide, hydrogen peroxide, sodium silicate, ammonia compounds (except fertilizers), rare earth metal salts and elemental bromine, fluorine, iodine, phosphorus, and alkali metals (sodium, potassium, lithium, etc.). Establishments primarily engaged in mining, milling, or otherwise preparing natural potassium, sodium, or boron compounds (other than common salt) are classified in Industry 1374, which is not electrically intensive. Establishments primarily engaged in manufacturing household bleaches are classified in Industry 2842, which is not electrically intensive; phosphoric acid in Industry 2874; and nitric acid, anhydrous ammonia, and other nitrogenous fertilizer materials in Industry 2873 are discussed separately.		
	<table border="0"> <tr> <td data-bbox="766 924 1094 1475">           Activated carbon and charcoal            Alkali metals            Alumina            Aluminum chloride            Aluminum compounds            Aluminum hydroxide (alumina trihydrate)            Aluminum oxide            Aluminum sulfate            Alumina            Ammonia alum            Ammonium chloride, hydroxide, and molybdate            Ammonium compounds, except for fertilizer            Ammonium perchlorate            Ammonium thiosulfate            Barium compounds            Bauxite, refined            Beryllium oxide            Bleaching powder            Borax (sodium tetraborate)            Boric acid         </td> <td data-bbox="1196 924 1561 1475">           Bromine, elemental            Cesium metal            Calcium carbide, chloride, and hypochlorite            Calcium compounds, inorganic            Calcium metal            Calomel            Carbide            Catalysts, chemical            Cerium salts            Charcoal, activated            Chlorosulfonic acid            Chromates and dichromates            Chromic acid            Chromium compounds, inorganic            Chromium salts            Cobalt chloride            Cobalt 60 (radioactive)            Cobalt sulfate            Copper chloride            Copper iodide and oxide            Copper sulfate            Cyanides         </td> </tr> </table>	Activated carbon and charcoal Alkali metals Alumina Aluminum chloride Aluminum compounds Aluminum hydroxide (alumina trihydrate) Aluminum oxide Aluminum sulfate Alumina Ammonia alum Ammonium chloride, hydroxide, and molybdate Ammonium compounds, except for fertilizer Ammonium perchlorate Ammonium thiosulfate Barium compounds Bauxite, refined Beryllium oxide Bleaching powder Borax (sodium tetraborate) Boric acid	Bromine, elemental Cesium metal Calcium carbide, chloride, and hypochlorite Calcium compounds, inorganic Calcium metal Calomel Carbide Catalysts, chemical Cerium salts Charcoal, activated Chlorosulfonic acid Chromates and dichromates Chromic acid Chromium compounds, inorganic Chromium salts Cobalt chloride Cobalt 60 (radioactive) Cobalt sulfate Copper chloride Copper iodide and oxide Copper sulfate Cyanides
Activated carbon and charcoal Alkali metals Alumina Aluminum chloride Aluminum compounds Aluminum hydroxide (alumina trihydrate) Aluminum oxide Aluminum sulfate Alumina Ammonia alum Ammonium chloride, hydroxide, and molybdate Ammonium compounds, except for fertilizer Ammonium perchlorate Ammonium thiosulfate Barium compounds Bauxite, refined Beryllium oxide Bleaching powder Borax (sodium tetraborate) Boric acid	Bromine, elemental Cesium metal Calcium carbide, chloride, and hypochlorite Calcium compounds, inorganic Calcium metal Calomel Carbide Catalysts, chemical Cerium salts Charcoal, activated Chlorosulfonic acid Chromates and dichromates Chromic acid Chromium compounds, inorganic Chromium salts Cobalt chloride Cobalt 60 (radioactive) Cobalt sulfate Copper chloride Copper iodide and oxide Copper sulfate Cyanides		

Table VIII-1 (Continued)

2819

INDUSTRIAL INORGANIC CHEMICALS,  
NEC (8.7) (Continued)

Boron compounds, not produced at mines	Desiccants, activated: silica gel
Borosilicate	Dichromates
Brine	Ferric chloride
Fissionable material production	Ferrocyanides
Fluorine, elemental	Potassium iodide
Fuel propellants, solid: inorganic	Potassium metal
Fuels, high energy: inorganic	Potassium nitrate and sulfate
Glauber's salt	Potassium permanganate
Heavy water	Propellants for missiles, solid: inorganic
High purity grade chemicals, inorganic: refined from technical grades	Radium chloride
Hydrated alumina silicate powder	Radium luminous compounds
Hydrochloric acid	Rare earth metal salts
Hydrocyanic acid	Reagent grade chemicals, inorganic; refined from technical grades
Hydrofluoric acid	Rubidium metal
Hydrogen peroxide	Salt cake (sodium sulfate)
Hydrogen sulfide	Salts of rare earth metals
Hydrosulfites	Scandium
Hypophosphites	Silica, amorphous
Indium chloride	Silica gel
Inorganic acids, except nitric or phosphoric	Silicofluorides
Iodides	Silver bromide, chloride, and nitrate
Iodine, elemental	Silver compounds, inorganic
Iodine, resublimed	Soda ash
Iron sulphate	Sodium aluminate
Isotopes, radioactive	Sodium aluminum sulfate
Laboratory chemicals, inorganic	Sodium antimoniate
Lead oxides, other than pigments	Sodium bichromate and chromate
Lead silicate	Sodium borates
Lime bleaching compounds	Sodium borohydride
Lithium compounds	Sodium bromide, not produced at mines
Lithium metal	Sodium chlorate
Luminous compounds, radium	Sodium compounds, inorganic
Magnesium carbonate	Sodium cyanide
Magnesium chloride	Sodium hydrosulfite
Magnesium compounds, inorganic	Sodium, metallic
Manganese dioxide powder, synthetic	Sodium molybdate
Mercury chlorides (calomel, corrosiva, sublimate), except U.S.P.	Sodium perborate
Mercury compounds, inorganic	Sodium peroxide
Mercury oxides	Sodium phosphate
Mercury, redistilled	Sodium polyphosphate
Metals, liquid	Sodium silicate
	Sodium silicofluoride

Table VIII-2 (Continued)

2819

INDUSTRIAL INORGANIC CHEMICALS,  
NEC (8.7) (Concluded)

Mixed acid	Sodium stannate
Muriate of potash, not produced at mines	Sodium sulfate--bulk or tablets
Nickel ammonium sulfate	Sodium tetraborate, not produced at mines
Nickel carbonate	Sodium thiosulfate
Nickel compounds, inorganic	Sodium tungstate
Nickel sulfate	Sodium uranate
Nuclear cores, inorganic	Stannic and stannous chloride
Nuclear fuel reactor cores, inorganic	Strontium carbonate, precipitated, and oxide
Nuclear fuel scrap reprocessing	Strontium nitrate
Oleum (fuming sulfuric acid)	Sublimate, corrosive
Oxidation catalyst made from porcelain	Sulfate of potash and potash magnesia, not produced in mines
Perchloric acid	Sulfides and sulfites
Peroxides, inorganic	Sulfocyanides
Phosphates, except defluorinated and ammoniated	Sulfur chloride
Phosphorus and phosphorus oxychloride	Sulfur dioxide
Potash alum	Sulfur hexafluoride gas
Potassium aluminum sulfate	Sulfur, recovered or refined, including from sour natural gas
Potassium bichromate and chromate	Sulfuric acid
Potassium bromide	Tanning agents, synthetic inorganic
Potassium chlorate	Thiocyanates, inorganic
Potassium chloride and cyanide	Tin chloride
Potassium compounds, inorganic: except potassium hydroxide and carbonate	Tin salts
Potassium cyanide	Uranium slug, radioactive
Potassium hypochlorate	Water glass
	Zinc chloride

Table VIII-2 (Continued)

SIC Code	Description
3031	<u>RECLAIMED RUBBER (6.9)</u>  Establishments primarily engaged in reclaiming rubber from scrap rubber tires, tubes, and miscellaneous waste rubber articles by processes which result in devulcanized, depolymerized, or regenerated replasticized products containing added ingredients. These products are sold for use as a raw material in the manufacture of rubber goods with or without admixture with crude rubber or synthetic rubber. Establishments primarily engaged in the assembly and wholesale sale of scrap rubber are classified in trade industries.  Reclaimed rubber (reworked by manufacturing processes)
3241	<u>CEMENT, HYDRAULIC (7.4)</u>  Establishments primarily engaged in manufacturing hydraulic cement, including portland, natural, masonry, and pozzolan cements.  Cement, hydraulic: portland, natural masonry, pozzolan
3122	<u>MALLEABLE IRON FOUNDRIES (5.6)</u>  Establishments primarily engaged in manufacturing malleable iron castings.  Castings, malleable iron                      Pearlitic castings, malleable Foundries, malleable iron                      iron

Table VIII-2 (Concluded)

SIC Code	Description		
3339	<u>PRIMARY SMELTING AND REFINING OF NONFERROUS METALS, NEC (5.4)</u>		
	Establishments primarily engaged in smelting and refining nonferrous metals, not elsewhere classified. Establishments primarily engaged in rolling, drawing, and extruding these nonferrous primary metals are classified in Industry 3356, which is not electrically intensive, and the production of bullion at the site of the mine is classified in the mining industries.		
	<table border="0"> <tr> <td data-bbox="853 640 1225 1186">           Antimony refining, primary            Beryllium metal            Bismuth refining, primary            Cadmium refining, primary            Chromium refining, primary            Cobalt refining, primary            Columbium refining, primary            Germanium refining, primary            Gold refining, primary            Ingots, magnesium            Iridium refining, primary            Magnesium refining, primary            Nickel refining, primary            Nonferrous refining, primary:                except copper, lead, zinc, and                aluminum            Pigs, magnesium            Platinum-group metals refining,                primary            Precious metal refining, primary            Primary refining of nonferrous                metal: except copper, lead,                zinc, aluminum         </td> <td data-bbox="1284 640 1651 1256">           Primary smelting of nonferrous                metal: except copper, lead,                zinc, aluminum            Refining of nonferrous metal,                primary: except copper, lead,                zinc, aluminum            Rhenium refining, primary            Selenium refining, primary            Silicon, epitaxial (silicon                alloy)            Silicon, pure            Silicon refining, primary                (over 99% pure)            Silver refining, primary            Slabs, magnesium: primary            Smelting of nonferrous metal,                primary: except copper, lead,                zinc, aluminum            Tantalum refining            Tellurium refining, primary            Tin base alloys, primary            Tin refining, primary            Titanium metal, sponge and                granules            Zirconium metal, sponge and                granules         </td> </tr> </table>	Antimony refining, primary Beryllium metal Bismuth refining, primary Cadmium refining, primary Chromium refining, primary Cobalt refining, primary Columbium refining, primary Germanium refining, primary Gold refining, primary Ingots, magnesium Iridium refining, primary Magnesium refining, primary Nickel refining, primary Nonferrous refining, primary: except copper, lead, zinc, and aluminum Pigs, magnesium Platinum-group metals refining, primary Precious metal refining, primary Primary refining of nonferrous metal: except copper, lead, zinc, aluminum	Primary smelting of nonferrous metal: except copper, lead, zinc, aluminum Refining of nonferrous metal, primary: except copper, lead, zinc, aluminum Rhenium refining, primary Selenium refining, primary Silicon, epitaxial (silicon alloy) Silicon, pure Silicon refining, primary (over 99% pure) Silver refining, primary Slabs, magnesium: primary Smelting of nonferrous metal, primary: except copper, lead, zinc, aluminum Tantalum refining Tellurium refining, primary Tin base alloys, primary Tin refining, primary Titanium metal, sponge and granules Zirconium metal, sponge and granules
Antimony refining, primary Beryllium metal Bismuth refining, primary Cadmium refining, primary Chromium refining, primary Cobalt refining, primary Columbium refining, primary Germanium refining, primary Gold refining, primary Ingots, magnesium Iridium refining, primary Magnesium refining, primary Nickel refining, primary Nonferrous refining, primary: except copper, lead, zinc, and aluminum Pigs, magnesium Platinum-group metals refining, primary Precious metal refining, primary Primary refining of nonferrous metal: except copper, lead, zinc, aluminum	Primary smelting of nonferrous metal: except copper, lead, zinc, aluminum Refining of nonferrous metal, primary: except copper, lead, zinc, aluminum Rhenium refining, primary Selenium refining, primary Silicon, epitaxial (silicon alloy) Silicon, pure Silicon refining, primary (over 99% pure) Silver refining, primary Slabs, magnesium: primary Smelting of nonferrous metal, primary: except copper, lead, zinc, aluminum Tantalum refining Tellurium refining, primary Tin base alloys, primary Tin refining, primary Titanium metal, sponge and granules Zirconium metal, sponge and granules		

Source: Commerce Department Data

Table VIII-3

CATEGORY III: ENERGY-INTENSIVE INDUSTRIES  
 (Total Energy Costs as Percentage of Product Value, 1980)

<u>SIC Code</u>	<u>Description</u>	<u>Energy Costs As Percent of Product Value</u>
2046	Wet Corn Milling	8.7
2063	Beet Sugar	8.3
2083	Malt	6.7
2261	Finishing Plants, Cotton	7.4
2492	Particleboard	6.8
2611	Pulpmills	10.1
2621	Papermills, Excl. Building Paper	10.3
2631	Paperboard Mills	14.4
2816	Inorganic Pigments	8.8
2822	Synthetic Rubber	5.1
2823	Cellulosic Manmade Fibers	8.0
2824	Organic Fibers, Noncellulosic	5.2
2861	Gum and Wood Chemicals	7.1
2865	Cyclic Crudes & Intermediates	6.9
2869	Industrial Organic Chemicals, NEC	7.1
2873	Nitrogenous Fertilizers	18.2
2874	Phosphatic Fertilizers	6.0
2895	Carbon Black	10.7

Table VIII-3 (Continued)

<u>SIC Code</u>	<u>Description</u>	<u>Energy Costs As Percent of Product Value</u>
2951	Paving Mixtures and Blocks	6.4
3211	Flat Glass	9.8
3221	Glass Containers	10.3
3229	Pressed and Blown Glass	8.1
3251	Brick & Structural Clay Tile	20.1
3253	Ceramic Wall & Floor Tile	6.2
3255	Clay Refractories	8.0
3259	Structural Clay Products	17.3
3261	Vitreous Plumbing Fixtures	5.5
3263	Fine Earthenware Food Utensils	6.8
3269	Pottery Products, etc.	6.3
3274	Lime	31.3
3275	Gypsum Products	9.3
3295	Minerals, Ground or Treated	7.7
3296	Mineral Wool	9.1
3297	Nonclay Refractories	6.1
3312	Blast Furnaces & Steel Mills	9.7
3321	Gray Iron Foundries	7.5

Table VIII-3 (Concluded)

<u>SIC Code</u>	<u>Description</u>	<u>Energy Costs As Percent of Product Value</u>
3325	Steel Foundries, NEC	5.4
3333	Primary Zinc	10.3
3398	Metal Heat Treating	6.9
3624	Carbon & Graphite Products	6.6

The three remaining industries in Category II are building paper and building board mills; industrial inorganic chemicals, not elsewhere classified; primary smelting and refining of nonferrous metals, not elsewhere classified. These industries were considered further as potential candidates because of possible Alaskan feedstocks.

Industries identified in the Category III screening that are associated with food processing (e.g., wet corn milling, beet sugar, malt); textile finishing (e.g., cotton finishing plants, man-made fibers); or heavy, low-value materials (e.g., paving mixtures, lime, glass containers, brick and structural clay tile and clay products) are unlikely candidates because of the remoteness of an Alaskan location from both feedstocks and markets for these commodities. Carbon black production is energy intensive only because petroleum-based feedstocks are used in the manufacturing process and is therefore precluded from further consideration. Although ammonia production is energy intensive for the same reason, electrically driven compressors can be substituted for gas-fired turbines in the production process. Furthermore, the major feedstock for ammonia production, natural gas, is available in Alaska. For these two reasons, ammonia production was selected for limited consideration. The construction of new processing facilities of most primary metals (e.g., copper, steel) is unlikely in the Railbelt region primarily because these industries are dependent on nearby feedstocks and are likely to remain depressed in the U.S. economy in the foreseeable future. In addition, the consequences of energy conservation (e.g., automobile downsizing) have caused the heavy manufacturing industries that are supplied by the primary metal industries to permanently reduce their requirements for feedstock. Although selected primary metals (e.g., zinc) might benefit from the combination of Alaskan feedstocks and low-cost electrical energy for thermal processes, most of these industries are unlikely candidates for expansion throughout the remainder of this century. The only industries in Category III that were retained for further consideration were ammonia production, nonferrous metals, and paperboard mills.

In addition to the Category I, II, and III industries retained for further screening, four other potential large-scale electrical energy uses were considered as specified in the statement of work. The list of industries and "other industrial applications" evaluated in Section IX are listed in Table VIII-4.

Table VIII-4

INDUSTRIES AND OTHER INDUSTRIAL APPLICATIONS EVALUATED  
AS POTENTIAL LARGE USERS OF RAILBELT ELECTRICAL POWER

Category I

- The Aluminum Industry (SIC 3334, Primary Production Aluminum)
- The Chlor-Alkali Industry (SIC 2812, Alkalies and Chlorine)
- Industrial Gases (SIC 2813, Industrial Gases)
- Ferroalloy and Miscellaneous Metal Alloy Production (SIC 3313, Electrometallurgical Products)

Categories II and III

- Pulp and Paper Industry (SIC 2661, Building Paper and Building Board Mills; 2611, Pulpmills; and 2621, Papermills, Excluding Building Paper)
- Cement Industry (SIC 3241, Hydraulic Cement)
- Chemical Industry (2719, Industrial Inorganic Chemicals, NEC)
- Primary Metals Industry (SIC 3339, Primary Smelting and Refining of Nonferrous Metals, NEC; SIC 3333, Primary Zinc)
- The Fertilizer Industry (SIC 2873, Ammonia Production, Nitrogenous Fertilizers; 2874, Phosphate Fertilizers)

Other Applications

- Agglomerations of Small Industrial Facilities
- Residential Space Heat
- Electrification of Alaskan Railroad Intertie with the Lower 48
- Intertie with the Lower 48.

## IX EVALUATION OF POTENTIAL LARGE USERS OF RAILBELT ELECTRICAL ENERGY

To evaluate the real potential of the candidate users of electrical energy, the likely characteristics of representative process plants in the selected industries must be considered. Because of the increasing importance of energy costs in recent years, much of the research and development in the candidate industries is devoted toward reducing process energy costs. The effect of these efforts should be to increase the likelihood of the construction of new process facilities in the candidate industries, but to reduce the importance of a regional location based on low cost electrical energy. The industry averages used to select candidate industries undoubtedly overestimate the importance of the costs of electrical energy for new facilities because they include marginal facilities that might be replaced by more efficient plants during a period of economic expansion. In the specific industry analyses which follow, the most recent available data on plant efficiency were used to evaluate the attractiveness of low-cost electrical energy. In each case the reduced costs of an Alaskan location attributable to inexpensive power must be balanced against the increased costs associated with an Alaskan location.

A range of electric energy rates, including a most probable competing energy rate (where possible), was assumed when comparing energy savings with additional transportation, construction (e.g., capital) and labor expenses associated with a Railbelt location. Because of industry infrastructures and market locations, the competitiveness of given electrical energy prices to attract new industry varies with the industry. Aluminum smelters are typically sited in lower-cost energy locations than chlor-alkali plants, which are more dependent on local resources. Since the availability of the low-cost electric power is highly dependent on the demand scenario associated with Alaskan population growth and petroleum-derived state revenues, SRI assumed for the purposes of the study that sufficient capacity would be available for at least one "world-class" plant in each category (e.g., 2,700 GWh annually for an aluminum smelter).

In addition to energy requirements, a major consideration for prospective Alaskan industries is the cost of transporting raw materials to Alaska and the resultant products to user markets. Materials and products which are subject to mass handling techniques and bulk shipment are preferable because lower handling costs associated with such materials reduce the overall cost of transportation. Transportation costs were considered for a "typical" facility to determine the additional expense

of this factor associated with an Alaskan location. Related to transportation costs is the important consideration of the ability of the candidate industries to utilize indigenous Alaskan raw materials.

Primary industries with relatively simple input requirements may be most easily sited initially. As will be described in the industrial analyses which follow, however, synergistic relationships can form as an industrial base develops and industries are able to utilize locally produced materials. As an example, caustic soda from chlor-alkali production is an important input to alumina production, or facilities producing bulk commodities such as caustic soda might provide a partial return cargo for Alaska-bound alumina carriers serving aluminum smelters in the state.

Other important factors are the relatively high costs for labor and construction in the state, the degree of labor intensiveness of candidate industries, the relative proximity of markets, and the overall projected demand for candidate industry products.

#### The Aluminum Industry

Of the industries which have been examined, aluminum has, at .154, the third highest ratio of purchased electrical energy costs to value of shipped product. In spite of the high energy costs associated with aluminum production, the metal increasingly contributes to energy efficiency in other products, particularly in the transportation sector. As a result, projections for aluminum demand indicate annual growth of 4-6%<sup>4,5</sup> over the next decade. As the aluminum industry continues to expand, areas offering low-cost electricity will be considered as locations for new plants.

Currently, the industry is dominated by six multinational corporations which collectively account for over 66% of the world's bauxite/alumina production and 54% of aluminum metal production.<sup>6</sup> As shown in Table IX-1 and Table IX-2, these corporations are:

- The Aluminum Company of America (Alcoa, U.S.A.)
- Pechiney Ugine Kuhlmann (France)
- Swiss Aluminum (Alusuisse, Switzerland)
- Aluminum Company of Canada (Alcan, Canada)
- Reynolds Metals Company (U.S.A.)
- Kaiser Aluminum and Chemical Corporation (U.S.A.).

Table IX-1

INVESTORS IN THE ALUMINUM INDUSTRY: ALUMINA REFINERIES, 1979  
(Thousands of Tons; Percentage)

	Capacity in Developed Countries	Capacity in Developing Countries	Thousands of Tons	Total Capacity	
				As Percentage of Market Eco- nomy Countries' Capacity	As Percentage of World Capacity
<u>Six Major Transnational Corporations</u>					
Alcan	2,208	1,344	3,552	12.2	10.3
Alcoa	4,135	1,966	6,101	20.9	17.8
Alusuisse	1,265	36	1,301	4.5	3.8
Kaiser	2,645	471	3,116	10.7	9.1
Pecliney	2,169	130	2,299	7.9	6.7
Reynolds	2,318	430	2,749	9.4	8.0
Total	14,740	4,377	19,118	65.6	55.7
<u>Other TNCs with Private Investors in Developed Market Economy Countries</u>					
	5,772	738	6,510	22.3	18.9
<u>Governments of Developed Market Economy Countries</u>					
	1,569	18	1,587	5.4	4.6
<u>Governments of Centrally Planned Countries</u>					
	5,208	-	5,208	-	15.2
<u>Governments of Developing Countries</u>					
	-	1,590	1,590	5.5	4.6
<u>Private Investors in Developing Countries</u>					
	-	355	355	1.2	1.0
<u>World Total</u>	27,289	7,078	34,368	100.0	100.0

Source: United Nations Centre on Transnational Corporations, as published in Transnational Corporations in the Bauxite/Aluminum Industry, United Nations, 1981, p. 37.

Table IX-2

INVESTORS IN THE ALUMINUM INDUSTRY: ALUMINUM SMELTERS, 1979  
(Thousands of Tons; Percentage)

	Capacity in Developed Countries	Capacity in Developing Countries	Thousands of Tons	Total Capacity	
				As Percentage of Market Eco- nomy Countries' Capacity	As Percentage of World Capacity
<u>Six Major Transnational Corporations</u>					
Alcan	1,355	154	1,509	11.2	8.6
Alcoa	1,673	131	1,804	13.4	10.3
Alusuisse	649	-	649	4.8	3.7
Kaiser	884	227	2,222	8.2	6.3
Pachiney	973	71	1,044	7.7	6.0
Reynolds	1,043	82	1,125	8.3	6.4
Total	6,577	665	7,242	53.6	41.3
<u>Other TNCs and Private Investors</u>					
Europe	686	13	699	5.1	4.0
United States and Canada	1,218	32	1,251	9.3	7.1
Other	1,652	26	1,678	12.4	9.6
Total	3,556	71	3,628	26.8	20.7
<u>Governments of Developed Market Economy Countries</u>					
	1,569	-	1,569	11.6	9.0
<u>Governments of Developed Centrally Planned Economies</u>					
	3	-	3,732	-	21.2
<u>Developing Country Governments</u>					
	-	979	979	5.2	5.6
<u>Developing Country Private Investors</u>					
	-	378	378	2.8	2.2
<u>Market Economy Countries, Total</u>					
	11,703	1,821	13,522	100	
<u>World, Total</u>					
	15,434	2,093	17,528		100

Source: United Nations Centre on Transnational Corporations, as published in Transnational Corporations in the Bauxite/Aluminum Industry, United Nations, 1981, p. 37.