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SUSITNA HYDROELECTRIC PROJECT

TERMINATION REPORT

TASK 1: POWER STUDIES

SEPTEMBER, 1980

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES
TERMINATION REPORT

SEPTEMBER, 1980

ACRES AMERICAN INCORPORATED
1000 Liberty Bank Building
Main at Court
Buffalo, New York 14202
Telephone (716) 853-7525

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1 - INTRODUCTION

1.1 - Background

The Plan of Study (POS) for the Susitna Hydroelectric Project, which was prepared and revised by Acres American Inc., was issued by the Alaska Power Authority for public review and comment in February, 1980. The scope of power alternatives studies to be undertaken in this POS under Task 1 - Power Studies, was originally developed to satisfy the anticipated requirements of a FERC license application for the Susitna Hydroelectric Project, should the project be proven feasible. As a result of concerns expressed by various individuals and agencies, the Alaska State Legislature resolved in June, 1980 that the "Power Market and Alternative Supply Studies be deleted from the Acres contract for Susitna Feasibility Studies". Orders were issued to Acres by the Power Authority on June 13 and 30, 1980 terminating work on Subtasks 1.03 through 1.06 and 11.03 of the original POS.

This report presents the results of work undertaken by Acres American Incorporated (Acres) and its subcontractors, Woodward-Clyde Consultants (WCC), and Terrestrial Environmental Specialists (TES), within the Susitna Plan of Study prior to this termination order.

1.2 - Report Content

Section 2 of this report is a summary of the events leading to the issue of the termination order, the results of Task 1 activities prior to termination and the activities remaining to be completed. Section 3 deals with the originally proposed POS for Task 1 and presents a status report on on-going Subtasks 1.01 and 1.02, which were not terminated. Section 4 of the report presents the results of work completed under Subtasks 1.03 and 1.07 prior to termination, including additional work undertaken at the request of the Power Authority in an attempt to respond to public comment on the scope of alternatives studies.

In Section 5, a description is presented of termination activities undertaken at the request of the Power Authority under a new Subtask 1.08, including planning of expanded alternatives studies in response to public comment, subsequent to the State legislation.

A series of Appendices, A through S, are attached to document the various reports and letters which deal with relevant Task 1 activities prior to termination.

2 - SUMMARY

2.1 - Scope of Original Task 1 Studies

The overall objectives of Task 1 - Power Studies as stated in the February 1980 POS were:

> "To determine the need for power in the Alaska Railbelt Region, to develop forecasts for electric load growth in the area, to consider viable alternatives for meeting such load growth, to develop and rank a series of feasible, optimum expansion scenarios and finally to determine the enviromental impacts of the selected optimum scenarios".

To accomplish this objective the study had been divided into six Subtasks:

Subtask 1.01 - Review of the ISER Work Plan and Methodologies
Subtask 1.02 - Forecasting Peak Load Demand
Subtask 1.03 - Identification of Alternatives
Subtask 1.04 - Selection of Viable Expansion Sequences
Subtask 1.05 - Expansion Sequence Impact Assessments
Subtask 1.06 - Power Alternatives Study Report

Work on Subtask 1.01 is essentially complete. A complete report will be drafted by mid-September 1980.

Work on Subtask 1.02 is well underway with initial results anticipated by late September 1980. A subtask 1.02 completion report will be prepared in October 1980.

Work on Subtask 1.03 through 1.07 has been terminated by Acres as instructed by APA on June 13, 1980.

2.2 - Status of Terminated Activities

A summary of the events that precipitated the termination of Subtask 1.03 through 1.06 and Subtask 11.03 activities is presented in Section 4.1. Work was terminated as a result of an Act passed by the Alaska Legislature in June 1980. Table 4.1 lists chronologically all events of significance that occurred in the period from January 1, 1980 through June, 1980 prior to termination of work.

In response to a public meeting held in mid-April and a draft report issued by Arlon R. Tussing et al on April 15, 1980 entitled "Susitna Hydropower: A review of the Issues" for the Alaska State Legislature, the Scope of Subtasks 1.03 through 1.06, were being significantly revised during May and early June. A new Subtask 1.07 - Power Study Review Panel, was also added at that time. The revisions to the POS, the work completed prior to revision, and the project activities occurring during the revision process, are discussed in Subtasks 4.2 through 4.6 of this report. The most significant revisions were made to Subtasks 1.03, 1.04 and 1.05 and are discussed in Sections 4.3, 4.4, and 4.5 of this report respectively.

The revised scope for Task 1 is presented in Appendix C, and the detailed plan of study is presented in Appendix I.

2.3 - Termination Activities - Subtask 1.08

As of June 6, following the passage of the Act "Relating to power projects of the Alaska Power Authority and the Susitna River Hydroelectric Project" by the Alaska State Legislature, work on Subtasks 1.03 through 1.07 and 11.03 was terminated at the direction of the Alaska Power Authority. Section 5.1 describes the scope of termination activity. Section 5.2 discusses the relationship between Task 1 - Power Studies and Task 6 - Design Development, and the need to implement Task 6 by those activities that prior to termination of Task 1, would have been completed in Task 1 and input to Task 6. Principal areas of overlap were an analysis of generating sources, cost analysis, scale and scheduling of Susitna development, and generating planning analysis.

The costs for termination of Task 1 activity are discussed in Section 5.3.

3 - SCOPE OF ORIGINAL TASK 1 STUDIES

3.1 - Task Objectives

The original objectives of Task 1 - Power Studies as stated in the February 1980 POS were:

> "To determine the need for power in the Alaska Railbelt Region, to develop forecasts for electric load growth in the area, to consider viable alternatives for meeting such load growth, to develop and rank a series of feasible, optimum expansion scenarios and finally to determine the enviromental impacts of the selected optimum scenarios".

The primary purpose of the Task 1 Studies was essentially the establishment and documentation of appropriate load forecasts for the Alaska Railbelt area and the development of optimum system expansion sequence scenarios to meet this forecast.

This portion of the study was to have been undertaken in essentially three parts. The initial phase was to have included evaluation of the various project energy consumption scenarios developed by independent study teams. From these forecasts, the Acres team would develop kilowatt load forecasts appropriate for the low, medium, and high growth rate scenarios. The second portion of Task 1 would have dealt with the development of optimum mixes and sequences of feasible alternative sources for meeting future power demands. These mixes were to have been developed with and without the Susitna Project, which at this stage was assumed for study purposes to be that developed by the Corps of Engineers. The third section of the study would have dealt with the preliminary comparative environmental and socioeconomic impacts of the developed optimum mixes on the Railbelt Region.

To accomplish these objectives, the Task had been subdivided into six Subtasks:

Subtask 1.01 - Review of the ISER Work Plan and Methodologies
Subtask 1.02 - Forecasting Peak Load Demand
Subtask 1.03 - Identification of Alternatives
Subtask 1.04 - Selection of Viable Expansion Sequences
Subtask 1.05 - Expansion Sequence Impact Assessments
Subtask 1.06 - Power Alternatives Study Report

If these studies had indicated that the Susitna Project was not the optimum development for the Alaska Power Authority then it had been intended that the ongoing studies would have been halted pending discussions with Alaska Power Authority to determine the future course of action most appropriate. On the other hand, had Task 1 studies confirmed the earlier studies undertaken by the Corps of Engineers and others that the Susitna Project, with dams at Watana and Devil Canyon is the appropriate means of meeting future load growth in the Railbelt area, the study would have continued as planned.

The specific objectives of each Subtask were as follows:

(a) Subtask 1.01 - Review of the ISER Work Plan and Methodologies

Critically review the work plan and the methodologies developed by the University of Alaska's Institute of Social and Economic Research (ISER) for forecasting energy demands.

Review and comment upon those written documents prepared by ISER as a part of its study and other relevant documents prepared by various authorities.

Reach a thorough understanding of the assumptions used by ISER in its work.

Exchange information with ISER regarding data needed by the Acres team in its subsequent work.

Ensure adequate data output by ISER through coordination efforts.

(b) Subtask 1.02 - Forecasting Peak Load Demand

Derive scenarios describing a reasonable range of load (kW) and load duration curve forecasts for the system through the year 2010. Prepare data in a form adequate for incorporation in the power system model to be developed in Subtask 1.04.

(c) Subtask 1.03 - Identification of Power Alternatives

Identify and select for evaluation purposes alternative power sources appropriate for inclusion in future Alaska Railbelt Region load-growth scenarios.

(d) Subtask 1.04 - Selection of Viable Expansion Sequences

Determine the total system costs of selected future Railbelt Region expansion sequences, both with and without incorporation of the Susitna Hydroelectric Project, and rank the preferred generation expansion scenarios.

(e) Subtask 1.05 - Expansion Sequence Impact Assessments

Compare, from an environmental standpoint, the consequences of developing the selected alternative expansion scenarios in the Alaska Railbelt Region, including historical, socioeconomic and other factors.

(f) Subtask 1.06 - Power Alternatives Study Report

Prepare power alternatives study report for Susitna Hydroelectric Project.

3.2 - Status of Subtask 1.01

A substantial portion of work in this subtask has been sub-contracted to Woodward Clyde Consultants (WWC). The Closeout Report on Acres' and WCC's work is the subject of a separate document. The initial ISER work plan was issued November 14, 1979. This has since been the subject of numerous meetings and reviews by various individuals and agencies, including Acres and WCC, and the issue of draft and final reports by ISER. This final report was issued May 23, 1980.

In ISER's words, "The electric power requirements of the Alaskan Railbelt will continue to grow over the next thirty years as the economy expands and personal income grows. Based upon the analysis of a large number of economic, demographic, and electricity consumption factors, the most likely growth rates for the most important state economic variables and railbelt electric utility sales over the next thirty years are" .... shown in Table 3.1.

Electrical energy sales for the Railbelt Region were projected to grow from a 1980 value of 3,101 GWh to minimum, most likely and maximum economic growth scenario values of 4,807, 6,141 and 8,927 GWh respectively by 2010. These values are substantially less than the 1978 forecasts produced by the Alaska Power Administration.

Credible load forecasts are required for the continuing Susitna studies, for purposes of planning the expansion of generating capacity in the Railbelt Region, both with and without the proposed Susitna development. The Acres' Closeout Report will therefore seek to establish appropriate low, and high load forecasts which will take into account the various authoritative critiques made of the ISER forecast by individuals, agencies and others. and an immediate forecast for use with a reasonalbe degree of confidence in ongoing Susitna Planning Studies.

The Subtask 1.01 Closeout Report is scheduled to be issued to the Power Authority in draft form late September, 1980.

3.3 - Status of Subtask 1.02

A substantial portion of work on this Subtask has also been sub-contracted to WCC. The Closeout Report on Acres' and WCC's work will also be the subject of a separate document presently scheduled to be issued in late September, 1980. Work is currently underway on establishing relationships between peak loads and load durations with energy sales forecasts based on Alaskan experience and characteristics of such relationships elsewhere in the U.S.

TABLE 3.1: PROJECTED ALASKAN AVERAGE ANNUAL GROWTH RATES (ISER)

Time Interval	Statewide Population Growth (%)	Statewide Employment Growth (%)	Railbelt Electric Utility Sales Growth (%)
HISTORICAL			
1965 - 1970	2.7	5.6	13.9
1970 - 1975	6.0	12.1	13.5
1975 - 1980	0.8	0.5	7.0
PROJECTED			
1980 - 1985	3.7	4.6	5.8
1985 - 1990	1.7	1.4	2.6
1990 - 1995	2.7	3.2	5.0
1995 - 2000	2.3	2.5	4.5
2000 - 2005	2.0	2.0	3.3
2005 - 2010	2.0	2.0	3.4

4 - STATUS OF TERMINATED ACTIVITIES

4.1 - Summary of Events

Table 4.1 lists chronologically all events of significance which took place in the period from January 1, 1980, the scheduled commencement of Acres work on the Susitna POS, to termination of work on Subtasks 1.03 through 1.07 in June 1980.

Several of these events led to proposals for revisions to the POS in regard to Tasks 1 and 11 in particular. These events and the consequences of them are summarized as follows:

(a) Public meetings and workshop sessions held in Alaska between April and July 1980

A series of community meetings were organized by APA to present the POS for the Susitna Hydroelectric Project and other power alternatives. The schedule of these meetings was as follows:

Fairbanks, 7 p.m., Monday, April 14
Travelers Inn Gold Room, 813 Noble

Talkeetna, 7 p.m., Tuesday, April 15
Talkeetna Elementary School

Wasilla, 7 p.m., Wednesday, April 16
Wasilla High School

Anchorage, 7 p.m., Thursday, April 17
Bartlett High School Yellow Cafeteria

The records of these meetings are the subject of a separate report issued by the Power Authority.

During these sessions it became apparent that it would be desirable to increase the level of effort devoted to studying alternative generating facilities to Susitna and also to alternative developments within the Susitna basin. By expanding the scope associated with these aspects it would be possible to address the concerns expressed by a large group of people that the Scope of Work as outlined in the February 1980 POS unduly favored the Susitna Project. This increased level of detail was considered necessary to upgrade the degree of accuracy associated with all possible alternatives to the currently proposed U.S. Corps of Engineers scheme, thereby facilitating more accurate comparisons of costs and environmental and other intangible aspects.

(b) Report to the Alaska State Legislature on Electric Power Supply Planning issued in May 1980, by Arlon R. Tussing and Associates, Inc.

This report, which was first issued in draft form April 15, 1980, reemphasized the aspects discussed above and gave further impetus to increasing the level of detail associated with studying alternatives to development of the Susitna Basin. APA instructed Acres on April 23, 1980 (Appendix Q) to proceed to develop expansions to the studies in Tasks 1, 6 and 11 in order to address the concerns discussed above.

Summary responses to specific issues raised by the Arlon R. Tussing Report were sent to APA on April 24 and May 2, 1980. These reviews are included in this report as Appendix B together with attachments of comments by WCC. A revised scope of Task 1 - Power Studies, post-Tussing, was prepared and sent to APA for review and comment on May 7, 1980 and is attached as Appendix C and discussed further under Section 4.2 below.

(c) The Alaska State Legislature Act "Relating to power projects of the Alaska Power Authority and the Susitna River hydroelectric project"

This was passed by the Alaska Legislature in June 1980 and as of June 6 effectively debarred Acres from participating any further with the alternatives studies outlined in Task 1 and the risk studies associated with the alternatives to Susitna under Task 11.

(d) Meetings Between APA, Acres, WCC, and Representatives of the Office of the Governor, June 10 and 11, 1980

These meetings were held to discuss the current status of Task 1 studies and to review the various options available for proceeding with the Susitna studies under various interpretations of the Alaska State Legislation. A summary of these meetings is presented in Appendix P.

As a result of the above developments and of subsequent decisions made by the Office of the Governor on interpretation of the State legislation, APA instructed Acres June 13, 1980 and June 30, 1980 to make the following revisions to the POS:

TASK 1: Complete work on Subtasks 1.01 and 1.02 as originally proposed in the February 1980 POS and terminate all work on Subtasks 1.03 to 1.07. Prepare a completion report which includes discussion of a plan for forecast improvement.

TASK 6: Revise the work plan to incorporate more detailed study of alternative Susitna Basin developments and to allow Acres to proceed with planning the Susitna Basin development, as part of the Railbelt system, complying as closely as possible with the February POS study schedule. The revised work plan should include preparation of appropriate inputs to the "Preliminary Reports" to be submitted by APA to the State Legislature by March 30, 1981, and April 30, 1982, recommending whether work should continue on the Susitna Project.

TASK 11: Revise the scope of work by eliminating the risk studies associated with the "assessment of power alternatives" (Subtask 11.03).

On August 4 a draft Revision 1 to the POS responding to these requirements was submitted to APA for comment and approval. This document will be issued as a formal revision to the POS in due course.

4.2 - Post-Tussing Revisions to POS

In the development of scope of Power Alternatives Studies undertaken prior to termination, the content of the Power Alternatives Report originally scheduled to be issued in November, 1980, had undergone a series of reviews.

An outline of the Interim Report on Task 1 proposed by Acres was presented to APA for discussion on April 15, 1980. Also discussed in this meeting was a methodology for a global evaluation of alternative power generation plants for the Railbelt. The outline and the methodology were presented in response to APA recommendations on alternative power sources and parameters to be considered in the Power Studies as stated in a letter dated March 19, 1980 (Appendix Q). The outline of the Interim Report was modified to incorporate changes agreed to during this meeting. A copy of the final outline is attached as Appendix A.

As stated in Section 4.1 above, in response to the May 1980 Tussing Report and other public comment during the period April-June 1980, proposed revisions to the scope of Task 1 studies were developed and forwarded to the Power Authority May 7, 1980, for review and approval (Appendix C). These revisions involved significant expansion of scope of all subtasks and the addition of Subtask 1.07 - Power Study Review Panel. Pending formal approval of this expanded scope, work continued on Subtasks 1.01 through 1.05 until the action of the State Legislature terminating Acres' involvement in power alternatives studies June 6, 1980.

The proposed expanded scope for Task 1 is summarized as follows:

(a) Perform additional engineering studies under Subtask 1.03 to better formulate non-Susitna alternatives, including conservation and load management.

(b) Identify several of the most promising expansion scenarios for more detailed evaluation rather than a single recommended plan.

(c) Conduct detailed feasibility studies on each of the several most promising expansion sequences, to include marketing, financing, cost scheduling, and risk analyses.

(d) Formulate a plan for improving the data base for future energy and load forecasting and execute the plan.

(e) Based on the improved data base, perform another forecast of energy demand, peak load and load duration curves.

(f) Incorporate marketing, financing, risk analysis, cost and scheduling into selection of the optimum Susitna Basin development (Task 6).

(g) Using the results of (e) and (f), perform a second iteration of power studies using a generation planning model (perhaps OGP-5).

(h) Establish a multidisciplinary panel to review assumptions and the various analyses.

(i) Reiterate using the results of (g) to assess risk in the face of unlikely but possible load growth scenarios.

(j) Identify an additional decision point in early 1982 when the feasibility studies will be complete and when a single development plan will be identified for preparation of license application.

4.3 - Status of Subtask 1.03

(a) Pre-Tussing Activities

Subtask 1.03 - Identification of Alternatives, was originally scheduled in the February POS to commence late May 1980 and be completed August 31. Subsequent rescheduling of Project Activities April 17, 1980 led to March 24 - July 7, 1980 latest start-completion dates for Subtask 1.03. Substantial portions of work on Subtask 1.03 under the original POS had been subcontracted to WCC and TES. WCC were to develop all data relevant to "non-hydro" alternatives, and TES the environmental data relevant to hydro and tidal alternatives. Public comment relayed to Acres through the Power Authority led to a requirement to rescope Subtask 1.03 in terms of the number and types of alternatives to be considered as part of future Railbelt region generation expansion scenarios. Work on rescoping and relevant discussions between Acres, WCC, and the Power Authority were actually started March 31, 1980.

Discussions between Acres and WCC resulted in a preliminary scope agreement reached during a meeting on April 18, 1980 in San Francisco. Under this agreement, WCC would proceed with Subtask 1.03, "non-hydro" alternatives with a preliminary scope of work detailed as follows:

(i) Global evaluation of alternatives utilizing the criteria presented in the Interim Report Outline (Appendix A), and to include the following:

- energy resource availability in Alaska
- technical and commercial use availability
- expected fuel dependency
- site availability
- preliminary safety and environmental concerns
- global cost estimates in mills/kWh
- corresponding ranking

(ii) Preparation by WCC and submission to Acres for consideration and approval of an analytical approach incorporating proposed decision analysis techniques to be used in making the global evaluation of alternatives.

(iii) Evaluations to be made by WCC of:

- Fossil Fuel Alternatives:
  - coal-fired steam cycle
  - oil-fired steam cycle
  - natural gas-fired steam cycle
  - oil-fired combined cycle
  - natural gas-fired combined cycle
  - oil-fired combustion turbines
  - natural gas-fired combustion turbines
- Nuclear Alternatives:
  - converter reactors (LWR, HWR)
  - breeder reactors
  - fusion
- Other Generation Alternatives and Alternative Fuels:
  - municipal solid waste
  - wood-fired steam cycle
  - biomass gasification applications
  - biomass-fired steam cycle
  - solar thermal steam cycle
  - solar photovoltaic
  - solar satellite

The evaluation of hydro, tidal, geothermal and wind-powered alternatives together with decentralized systems possibly also involving cogeneration, peat-fired steam cycle, and small-scale hydro alternatives would be undertaken by Acres and TES. Consideration of conservation and load management as non-structural alternatives would also be Acres' responsibility.

(b) Post-Tussing Activities

Following the issue of the draft and final Arlon Tussing Reports April 15 and May 9, further reviews of scope of Subtask 1.03 studies were undertaken to expand the methodology for selection and screening of alternatives in response to Tussing's comments.

Following further discussions on the expanded scope of Subtask 1.03, responsibility for evaluation of biomass-fired steam cycle and solar satellite alternatives was also transferred to Acres. The criteria for initial screening of alternatives were also modified as shown in Table 4.2.

Work on data collection for various power generation alternatives was initiated to a significant extent prior to termination of Subtask 1.03. Work on some alternatives was more advanced than on others. Specifically, a preliminary draft of the proposed report on Wind Power is attached as Appendix M. An inventory of hydroelectric sites in the Railbelt Region is presented in Appendix N. A list of technical reports reviewed at a preliminary level, and a brief summary and indication of the possible use of the information contained in each of these reports as input to Task 1, are also attached in Appendix O.

4.4 - Status of Subtask 1.04

The original POS schedule for Subtask 1.04 activities was to have commenced July 1 and be completed by October 6. Subsequent rescheduling of all POS activities April 17, 1980, resulted in early and late schedule start dates for this activity of April 7 and December 22, 1980, respectively with corresponding completion 15 weeks later.

Although some planning activity for this Subtask was initiated April 7, no significant work output was accomplished prior to the Tussing Report. Following the issue of that report, however, activity was initiated by Acres and WCC on developing a proposed modified approach to be used in the selection of alternatives and generation expansion sequences.

(a) Proposed Revised Approach by Acres

The revised approach to selection and ranking of alternatives under Subtask 1.04 proposed by Acres is presented in Appendix I. A key aspect of this approach is the involvement in all decision processes of a Review Panel of experts representing an appropriate cross-section of Alaskan opinion and knowledge. The actual decision process would be accomplished by the technique of the Delphi Method discussed in Appendix K.

The actual analysis of alternative generation expansion scenarios would be undertaken essentially as proposed in the original POS using the OGP5 computer model. It is stressed that although this model does have some in-built optimization capability, its use was intended to be principally that of a mathematical tool to investigate the sensitivity of various expansion scenarios to changes in basic parameters such as load forecasts, costs, interest rates, fuel costs and availability, environmental restrictions, etc. By this means it had been planned that a free and exhaustive interchange of information between the Review Panel and the study group would have resulted in a credible consensus on the generation expansion scenarios to be evaluated and selected.

(b) Proposed Modified Approach by WCC

The WCC proposal for use of a decision analysis approach to evaluation of alternative options for meeting Railbelt electric power requirements was submitted to Acres May 19, 1980 (Appendix J).

The overall objective of the activities proposed by WCC were stated to be:

- To evaluate the options available for meeting future Railbelt electric power requirements in a realistic manner which recognizes:
  - The sequential nature of the decisions that will be made in the future regarding methods for meeting electric power requirements, and
  - The risks and uncertainties that will exist as each of these sequential decisions is made.

The proposed scope of the work specifically excluded any analysis of the advisability of proceeding with Susitna feasibility studies. Nevertheless, the staged approach proposed was intended to provide timely information to support upcoming decisions regarding the advisability of proceeding with feasibility studies for the Susitna Project.

This proposal was based on a fundamental premise that a logical and defensible procedure for analyzing the options available for meeting the Railbelt's need for power must explicitly address the uncertainties in the situation and the sequential nature of the decisions that are made.

In addition to uncertainties and the sequential aspect of the problem, two other factors were considered central to a defensible analysis of the options for meeting Railbelt power needs:

- A variety of different concerns must be addressed in evaluating the desirability of each option, and

- A variety of groups within Alaska have legitimate reasons for having some input into the analysis.

The approach proposed by WCC would explicitly address multiple evaluation concerns, including financial aspects, public health and safety, environmental effects, socioeconomics and institutional factors. It would also provide a well-defined mechanism for incorporating the views of persons outside the Alaska Power Authority and the Acres team into the analysis. Uncertainties would be analyzed using probability theory. In situations where sufficient data existed, these probabilities would be determined from this data, while in other situations expert professional judgment would be used to establish the probabilities. Because of the lack of data in Alaska, it was expected that these "judgmental" probabilities would be particularly useful for Susitna planning.

The multiple evaluation concerns would be analyzed within a decision analysis framework using multiattribute utility functions, for which the underlying theory is well established. These functions would allow the multiple concerns to be addressed in a quantitative manner that allowed explicit consideration of the tradeoffs among the concerns. In this manner, probabilities and utilities would be combined to evaluate and rank various available alternatives. Experience had shown that the proposed approach could be effective in providing a fruitful mechanism for communications in situations where there are disagreements among interested parties over both the facts and the relative importance of various evaluation concerns.

(c) Acres' Critique of WCC Approach

The specific environmental and socioeconomic aspects of the WCC proposed approach are addressed in Section 4.5 of this report. Although the WCC proposal is considered acceptable in principal, Acres' review concluded that some aspects could lead to significant difficulties and potential delays in meeting the objectives of the Susitna POS. A separate critique by Dr. Chris Chapman of Acres International Management Services, is presented in Appendix L. Specific comments related to Activities II and III of the WCC proposal are as follows:

(i) Activity II: Consideration of Alternatives

The approach proposed by WCC for consideration of alternatives essentially follows the revised Task 1 guidelines proposed by Acres. Activity II is aimed at single alternatives and is intended to result in a Report on Alternatives available to the proposed Review Panel and the public. This report would include a summary showing the alternatives, their evaluation measures (cost, resource availability, technical feasibility, health and safety concerns, environmental and socioeconomic effects, institutional factors) and the corresponding ranges generally as proposed in the revised Task 1. However, the treatment of uncertainties is considered to be somewhat artificial.

It is obvious that there is potentially a considerable amount of uncertainty about the levels of the evaluation measures for the alternatives. The proposal to assign judgmental probabilities to the range limits is, however, considered unconvincing. In the inevitable environment of a weak data base, no probability distribution can be defined based on available records. The logical procedure is to account for the uncertainities by generating alternative levels for evaluation measures which, as alternate inputs to the generation planning model (i.e. OGP5), will generate new scenarios for sensitivity analyses. The proposed panel of experts--used in a structured interaction within the Delphi procedure--is considered to be a superior mechanism for providing credible alternate ranges and producing the basis for sensitivity analyses.

(ii) Activity III: Preliminary Evaluation of Sequential Decision Options

The purpose of this activity is to analyze the information generated by previous activities to arrive at a preferred strategy for electrical development in the Railbelt. The first step--the identification of the scenarios (sequential decision options)--will use the generation planning computer analysis (i.e. OGP5) as the basis for construction of the scenarios. The procedure is identical to that proposed in the revised Task 1 scope.

The next step proposed is the preparation of data to evaluate and compare the expansion scenarios. The approach proposed is similar to that in the revised Task 1 scope--the use of experts to articulate issues/concerns related to various scenarios. The use of the Delphi method as discussed in the revised Task 1 scope to summarize issues, to decompose them into objectives to be reached by various scenarios and to establish attributes (and corresponding ranges) which would represent the objectives is considered to be more suitable than the procedure proposed by WCC. Within the Delphi method, appropriate questionnaires can be constructed and consensus can be reached in many important issues.

The last step in Activity III is aimed at the evaluation of the scenarios and at identifying the preferred option. The approach proposed, the use of the techniques from multiattribute utility theory, is in fact, the only important departure from the revised Task 1 scope proposed by Acres.

The procedure uses mathematical algorithms extensively, which will inevitably suffer from the lack of an adequate data base within the Railbelt. Individual utility functions (per attribute) varying from 0 to 1 are developed, usually as an exponential fit to three points. While the limits of 0 and 1 correspond to the range limits per attribute, the intermediary point is generally defined through interviews with experts and is intended to represent their general risk-attitude toward the particular attribute (e.g. risk averse, less risk averse or risk neutral). The expectations from these interviews are obviously unrealistic, especially considering that with the exception of costs, the majority of the attributes are environmental in nature, difficult to scale and practically impossible to quantify in tradeoffs.

The individual utility functions are used to provide attribute values to characterize scenarios. The individual attribute values are aggregated into a general preference structure represented by the multiattribute utility function. The function is calibrated, based on value judgements and preferences of individuals. When the individual attributes are aggregated (the simplest mathematical algorithm representing this function is a product of all the individual utility functions), it results in a single numerical indicator which is then used to rank the scenarios. Again, despite the mathematical algorithms used, the aim to represent all the intangible impacts corresponding to a development scenario in a highly environmentally sensitive area by a single number oversimplifies the issue. Such an exercise may prove interesting and useful in showing that efforts were spent to explore every possible type of analysis. However, in Acres' judgement a quantitative (cost) and qualitative matrix of impacts corresponding to the scenarios constructed through generation planning should be the principal approach. These matrices will represent the basis for the panel sessions to be conducted under the Delphi method, in order to progressively narrow the preferences and to define the preferred scenarios. Within the total scope of work under Task 1, the application of the multiattribute utility theory, with its extensively mathematical approach might be used as a second method in parallel for purposes of verification.

4.5 - Status of Subtask 1.05

Work on Subtask 1.05 - Expansion Sequence Impact Assessments was scheduled in the original POS to commence July 21, 1980 and be complete by November 10, 1980. Rescheduling of all POS activities April 17 resulted in early and late start dates of April 28 and June 16 respectively with a 16-week duration. The major portion of work on predominantly non-hydro generation expansion sequences had been subcontracted to WCC and that on predominantly hydro sequences has been subcontracted to TES. Prior to termination only preliminary planning activities were undertaken by these subcontractors on Subtask 1.05.

Acres' proposed approach to expanded environmental assessments to alternatives and alternative generation expansion scenarios following the Tussing Report, is presented in Appendix I, and that of WCC in Appendix J. Details of environmental criteria to be used in these expanded studies are presented in Table 4.3. It had not been proposed that TES would be involved in these studies.

The Acres' approach in the evaluation of alternative scenarios did not attempt to rigidly quantify the impacts in terms of expert judgement. Rather the Acres' approach, as discussed under Section 4.4, would be to solicit the input of a screening panel and the general public to reach a concensus that the decisions being made are in agreement with the views of the State of Alaska. Using the Delphi approach, the potential difficulties of face-to-face interaction among members of the panel would be largely eliminated. To this end:

- the selection of panel members would be as non-biased as possible;
- representation of key groups would be provided;
- nontechnical, as well as technical representation would be emphasized;
- the development of questions would be as unbiased as possible, if necessary by means of separate outside review;
- selection of the evaluation measures would be made in cooperation with the panel and the general public.

The basis for environmental evaluation of alternative scenarios would be as follows:

- establish evaluation criteria (panel review)
- obtain information on alternatives
- evaluate alternatives by screening (panel review)
- develop selected scenarios (input from panel)
- evaluate and rank scenarios (panel review)

Although considerable effort would be directed toward the collection of defensible estimates for the evaluation measures, it must be realized that there are numerous data gaps which cannot be easily overcome. The WCC proposal to quantify uncertainties through the use of standard judgemental probability encoding techniques is itself subject to severe limitations. For example, the proposed conversion scale for transmission line mile equivalents is as follows:

Raw Mileage	Mile Equivalent	Level of Impact
1	2	Urban route traversing populated areas; route traversing BLM or Indian-owned lands; or aesthetics intrusion on primary highways
1	10	Route traversing state or national parks; wildlife refuges; historical monument sites or habitats containing unusual or unique communities or supporting endangered species

This can be interpreted to mean that 50 miles of transmission line traversing BLM land is equivalent to 10 miles of line traversing a national park or areas supporting endangered species. It is not realistic to use this quantitative scale (or any other similar scale) to "explicitly express how well a development scenario achieves a particular objective".

The problem becomes even more complicated when these quantitative scales are used to compare essentially unrelated impacts, e.g. transmission line mile equivalents to impact on fisheries to socioeconomic effects.

4.6 - Subtasks 1.06 and 11.03

No work was initiated on these Subtasks in the period prior to termination.

TABLE 4.1: LIST OF SIGNIFICANT EVENTS

Event	Date (1980)	Reference
(1) - Original Plan of Study	February 4	"Susitna Hydroelectric Project, Plan of Study," Section A.5.2 - Task 1: Power Studies, pages 5-3 through 5-24
(2) - Meeting of Alaskan Economists in Anchorage, ISER offices	February 15	Records of meeting by Institute of Social and Economic Research, University of Alaska (ISER)
(3) - Issue of ISER's Progress Report	March 14	"Electric Power Requirements for the Railbelt", ISER
(4) - Letter from APA offering views and indicating expectations for the alternatives study and report	March 19	Appendix Q
(5) - Meeting at Acres Anchorage office (ISER, Acres and WCC) to discuss ISER Progress Report and future work	March 20	Appendix F
(6) - Public Meetings in Anchorage, Fairbanks, Talkeetna and Wasilla - APA Presentation of Plan of Study, February 1980	April 14-17	"Energy for the Future - A Community Meeting on the Susitna Hydroelectric Project and Other Power Alternatives", APA records
(7) - Presentation of Interim Report outline on Task 1 - Power Studies to APA	April 15	Appendix A
(8) - Meetings of Acres with ISER in Anchorage, and WCC in San Francisco	April 14-18	Fact-finding meetings
(9) - Reviews of ISER Progress Report by Acres and WCC	March, April	Appendix G

TABLE 4.1: LIST OF SIGNIFICANT EVENTS (Cont'd)

Event	Date (1980)	Reference
(10) - Draft Report by Arlon Tussing	April 15	"Susitna Hydropower: A Review of the Issues" prepared for the Alaska State Legislature by Arlon R. Tussing, Lois S. Kramer, Barbara F. Morse
(11) - APA Request for Additional Work	April 23	Appendix Q
(12) - Acres Recommendations for Changes to Power Alternatives Study	April 24	Appendix B
(13) - Review of Arlon Tussing Report	May 2	Appendix B
(14) - Revised Scope of Task 1 (Post-Tussing)	May 7	Appendix C
(15) - Final Report by Arlon Tussing	May 9	"Introduction to Electric Power Supply Planning with Special Attention to Alaska's Railbelt Region and the proposed Susitna River Hydro-electric Project", prepared for the Alaska State Legislature by Arlon R. Tussing and Associates, Inc.
(16) - Final Report by ISER	May 23	"Electric Power Consumption for the Railbelt: A Projection of Requirements," ISER
(17) - Reviews of Final ISER Report by Acres and WCC	June	Appendix G
(18) - Revised Detailed Plan of Study for Task 1	June	Appendix I

TABLE 4.1: LIST OF SIGNIFICANT EVENTS (Cont'd)

Event	Date (1980)	Reference
(19) - Utility and Public Workshops in Anchorage	June 10, 11	APA Records of Meetings
(20) - APA - Acres Meetings with WCC and the Governor's Office Representatives	June 10, 11	Appendix P
(21) - Termination of Work Orders from APA to Acres	June 13, 30	Appendix D

TABLE 4.2: SCREENING CRITERIA FOR ALTERNATIVES

Criteria	Elements	Types of Attribute
Economic	- Capital Cost	$
	- Cost/kWh	$
Technical	- Installed capacity	MW
	- Plant factor	#
	- Resource availability	Quantity
	- Transmission facilities	$
	- Access	$
Environmental*		
Physical	- Water	Descriptive
	- Land	Descriptive
	- Atmosphere	Descriptive
Ecological	- Fisheries	Descriptive
	- Wildlife	Descriptive
	- Vegetation	Descriptive
Social	- Land use	Descriptive
	- Quality of life	Descriptive
Institutional	- Licensing	Descriptive
	- Schedule	Descriptive
	- Finance	Descriptive

*For detailed environmental criteria, see Table 4.3

TABLE 4.3: DETAILS OF ENVIRONMENTAL CRITERIA

	Environment Type	Effects
Physical/Chemical effects (direct effects)	Water - groundwater - surface water - coastal water	- deterioration of water quality - change in flow rate - alteration of waterway - change in water table, water availability - change in ice conditions
	Land - topography - soils - natural cover	- geomorphic processes induced (erosion, sedimentation) - removal of natural cover - alteration of topography - deterioration of soils - alteration of geologically important areas - solid waste disposal
	Atmospheric	- air quality change (emissions) - long-term atmospheric effects (e.g. green house effect)
	Meteorological	- change in local temperature - energy loss from environment which effects local climate (e.g. large solar may cause loss of heat to earth)
	Geological	- alteration of geologically important area - alteration of chain of natural events (e.g. prevention of natural scouring of river valley by periodic floods) - induced seismicity
	Noise	- disturbance of human/natural population
	Consumption of natural resources	- water, forests, natural energy
Ecological Effects	Fisheries	- loss of natural passageways - loss of spawning grounds - destruction of population - alteration of natural food chains - loss of endangered and important species or other unique species

TABLE 4.3: DETAILS OF ENVIRONMENTAL CRITERIA

	Environment Type	Effects
Ecological Effects (Cont'd)	Vegetation	- removal of natural cover - alteration of food chain - introduction of incompatible species
Social Effects	Land Use land quality land planning	- loss/alteration of land use - wilderness, scenic - recreational opportunities - forestry - archaeological and historic - traditional livelihoods (hunting, fishing, trapping) - urban - (residential, commercial, industrial) - mining - agriculture - ownership
	Quality of Life	- loss/alteration/improvement of Q.O.L. factors
	- community	- disturbance/creation of community
	- opportunities	- create/destroy
	- economics	- effects of temporary economic stimulation - change in property values
	- infrastructure	- overburden existing public facilities - change in property values
	- demography	- short-term/long-term creation of job market

5 - TERMINATION ACTIVITIES - SUBTASK 1.08

As of June 6, following the previously discussed changes in State legislation, the Power Authority directed Acres to terminate work on Subtasks 1.03 through 1.07 and 11.03 and to complete Subtasks 1.01 and 1.02, as originally proposed in the February 1980 POS. Acres were also requested to make formal recommendations to the Power Authority on the interfacing requirements with the independent consultant to be appointed to undertake Power Alternatives studies following termination of Acres' involvement in these studies. These requirements were such that Susitna Task 6 - Design Development, and Task 11 - Marketing and Financing Studies, could be continued without delay to the scheduled submission by APA of the required "Preliminary Reports" to the Alaska State Legislature in March 1981 and April 1982. The Power Authority also directed Acres to prepare this termination report for the terminated Task 1 and Task 11 activities. Subtask 1.08 was therefore created to undertake this work.

5.1 - Scope of Work

The scope of work to be undertaken under Subtask 1.08 is presented in Revision 1 to the POS dated September, 1980. The objective of this work is to "perform all activities necessary to terminate Subtasks 1.03 to 1.07 and 11.03, and prepare a Task 1 Termination Report".

This subtask was introduced to incorporate all Task 1 work performed at the request of APA, other than on Subtasks 1.01 and 1.02, following the termination of work on Subtasks 1.03 to 1.07 and 11.03, June 6, 1980. This work includes:

- preparation and presentation to representatives of the Governor's Office of proposals for options available for continuation of objective power alternatives studies;

- assessment of impacts of State Legislature actions on Tasks 6 and 11 studies;

- determination of the interfacing requirements between the independent power alternatives studies and Acres' Task 6 and 11 studies;

- preparation of this Task 1 Termination Report;

- documentation of associated administrative costs, including preparation of the final termination cost statement.

5.2 - Continuation of Acres' Susitna POS

The scope of work for Tasks 1 and 11 in the original February 1980 POS was such that a number of key inputs to Tasks 6 and 11 of that POS would be possible. These are, most notably:

(a) Forecasts of a range of likely growth rates for energy and peak demand through the year 2010 and the shapes of the corresponding load duration and daily load curves (Subtasks 1.01 and 1.02).

(b) Estimated costs, planning characteristics and scheduling of a range of the most likely mixes of generation sources which would be installed in the Railbelt region to meet the capability and reserve requirements of the system through the year 2010 (Subtasks 1.03 through 1.07).

(c) An assessment of risks associated with the planned expansion of the Railbelt system (Subtask 11.03).

These inputs are necessary to allow studies to proceed to determine the optimum capacity, energy output, characteristics, scheduling and cost of the proposed Susitna River Basin development.

Presentations were made to representatives of the Office of the Governor June 10 and 11, 1980, of four options available for continuation of Susitna studies and the proposed independent alternatives study. Each of these options, which are presented in detail in Appendix P, would have varying levels of impact on the ongoing Susitna studies. As a result of these presentations, a precise interpretation of the legislation was possible and appropriate work termination orders were issued by APA June 13 and 30.

Subtask 1.01 and 1.02 activities were substantially complete at the time of the termination order. It was therefore most logical that this work should be continued to completion and hence would not delay the ongoing Susitna studies. The results of this work will thus also be available in a timely manner to the consultant selected to perform independent alternatives studies. The scope of work under item (b) above necessary for uninterrupted continuation of Susitna studies, is somewhat less exhaustive than that appropriate to the development of a comprehensive, preferred plan for Railbelt region development, such as that currently contemplated in the independent alternatives study. It was therefore appropriate that the scope of Susitna Task 6 studies be expanded to accommodate the requirements of Susitna Project planning, as proposed in Revision 1 to the POS.

The assessment of risks of alternatives is also a key element in the development of a credible financing and marketing plan for the proposed Susitna Project. The proposed expanded Task 6 Studies will also seek to examine the risks and uncertainties associated with planned expansion of the Railbelt region electric power generation system, both with and without the proposed Susitna development.

5.3 - Termination Cost Statement

(a) Original POS Budget

Table 5.1, reproduced from the February 1980 POS, provides a summary of estimated costs for Task 1 as it was originally conceived. At the time it was prepared, the major roles to be played by Acres were in the analysis of hydroelecric power alternatives outside of the Susitna River Basin (Subtask 1.03), generation planning to produce viable expansion sequences (Subtask 1.04), final report preparation (Subtask 1.06), and, of course, management of all subtasks. TES would have provided envionmental analysis for hydroelectric portions of selected expansion sequences (Subtasks 1.03 and 1.05 respectively). The bulk of the work had been allocated to WCC in terms of reviewing the ISER work (Subtask 1.01), load forecasting (Subtask 1.02), analysis of non-hydroelectric alternatives (Subtask 1.03), and environmental impact assessments (Subtask 1.05).

Because early and continuing public involvement placed great emphasis on the study of power alternatives, APA requested that Acres provide a full time representative in the Anchorage Project Office to facilitate communications in this area as well as to increase the level of effort to be applied to Task 1. Assignment of Mr. James Landman to fulfill the requested role resulted in a budgetary increase $95,900 for labor, additional disbursements, and his relocation cost. This latter value does not appear in Table 5.1.

(b) Costs Expended Prior to Termination

By the time that termination action had been taken on June 6, 1980, for various Task 1 activities, funds expended were $145,478. Table 5.2 provides a summary of expenses by subtask for Task 1 as well as an indication that no funds had yet been committed for Subtask 11.03. (It should be noted that although Subtask 11.03 was a part of Task 11, Financing and Marketing Studies, it bore directly upon Task 1 work for it provided for a risk analysis of alternatives to the Susitna Hydroelectric Project).

Table 5.2 indicates that $31,741 had been expended for Subtask 1.03 by June 6, 1980. A portion of this total had been devoted to expanded activities undertaken after May 7, 1980, when proposed revisions to the POS were submitted to APA (see paragraph 4.2).

(c) Cost Summary for Amended Task 1

Table 5.3 provides a summary of cost changes to Task 1 resulting from partial termination action. As may be seen from the tabulation, the total cost for Task 1 was reduced to $233,884, a net savings of $229,460 from the "original budget." (See d below for a brief discussion of the relationship between the POS cost estimates and the "original budget" developed for cost control purposes). Subtasks 1.01 and 1.02 reflect totals in excess of those carried in the "original budget" because of some work which had been done in connection with scope revisions submitted on May 7, 1980, as well as the fact that the ISER report was completed late and monitoring requirements were in excess of those originally planned.

(d) Conversion from POS Estimates to Original Budget

After publication of the POS in February 1980, cost estimates contained therein were converted to a new format to facilitate cost control. This new format is referred to as "original budget" in Table 5.3. Some of the principal features associated with this conversion include:

- A new Task 00 was formed to provide for explicit accounting for management and overall project activities.

- Fees which had originally been contained within the total Acres manhour costs in the POS were redistributed to provide for proper accounting by Task in accordance with the Acres-APA Agreement.

- A number of changes approved by APA (such as the addition of a power study specialist as noted in paragraph (a) were incorporated into the "original budget".

The format of information contained in Table 5.2 is consistent with that of the "original budget". Details providing a reconciliation of the original POS estimates and the "original budget" were provided to APA by letter dated June 12, 1980.

Table 5.3 provides costs for Subtask 1.08 in the amounts of $7,000 for a termination report and $19,177 for preparation for termination. In addition to those costs, it is anticipated that certain administrative, travel, and relocation costs will be incurred in connection with the termination action. A termination claim will be submitted to APA by December 31, 1980, in accordance with the terms of the Acres-APA Agreement.

SUSITNA HYDROELECTRIC PROJECT - ALASKA POWER AUTHORITY

Addendum to POS
December 18, 1879

TABLE 5.1 - ORIGINAL POS BUDGETS

Consultant	Subtask -	1.01	1.02	1.03	1.04	1.05	1.06	Manhours	Costs
ACRES	Manours	50	70	540	740	70	280	1,750	
	Manhour Cost	$ 1,700	$ 2,500	$19,000	$26,000	$ 2,500	$10,000		$ 61,700
	Disbursements	1,300	1,300	3,000	4,000	500	2,000		12,300
	Subtotal	$ 3,000	$ 4,000	$22,000	$30,000	$ 3,000	$12,000		$ 74,000
WCC	Manhours	350	450	790		1,200		2,790	
	Manhour Costs	$22,200	$28,700	$49,300		$77,000			$177,200
	Disbursements	10,000	15,000	15,000		13,000			53,000
	Subtotal	$32,200	$43,700	$64,300		$90,000			$230,000
TES	Manhours			320		1,430		1,750	
	Manhour Cost			$ 8,900		$40,400			$ 49,300
	Disbursements			1,100		4,600			5,700
	Subtotal			$10,000		$45,000			$ 55,000
	TOTAL MANHOURS	400	520	1,650	740	2,700	280	6,290	
	TOTAL COSTS	$35,200	$47,700	$96,300	$30,000	$138,000	$12,000		$359,200

* Including Alaska Office Expense

TABLE 5.2 - SUMMARY OF EXPENSES BY SUBTASK FOR TASK 1 AND SUBTASK 11.03 THROUGH JUNE 6, 1980

	1.01	1.02	1.03	1.04	1.05	Not Broken down by Subtask	Total Task 1	11.03
1. Acres American Inc.								
Project Cost of Services								
Invoiced	10,772	9,431	7,755	87			28,045	
June 1-6, 1980	996	1,488	4,621	-			7,075	
Subtotal	11,738	10,919	12,376	87			35,120	
Overhead @ 75%	8,804	8,189	8,282	65			36,340	
Subtotal	20,542	19,108	21,658	152			26,340	
Disbursements								
Invoiced						9,772	9,772	
Accumulated, Not Invoiced						3,917	3,917	
Estimated Additional (A)						4,000	4,000	
Subtotal						17,689	17,689	
Handling Fee 2%						1,602	1,602	
Fixed Fee						2,328 (B)	2,328	
TOTAL	20,542	19,108	21,658	152		21,619	83,079	
2. WCC								
Invoiced	18,453	13,915	-				32,368	
Paid But Not Invoiced	7,795	1,564	779		305		10,443	
In Circulation	560	1,312	9,038				10,910	
Estimated Additional (A)						3,000	3,000	
Fixed Fee						3,910	3,910	
TOTAL	26,808	16,791	9,817		305	6,910	60,631	
3. TES								
Invoiced			210		42		252	
Paid But Not Included			-					
In Circulation			56				56	
Estimated Additional (A)						500	500	
Fixed Fee (C)						960	960	
TOTAL			266		42	1,460	1,768	
4. GRAND TOTAL	47,350	35,899	31,741	152	347	29,989	145,478	

5. NOTES: (A) Accounts for costs incurred but not yet billed by suppliers
(B) Fixed fee allocation in Task 1 through end June
(C) Fixed fee allocation through end May

TABLE 5.3 - COST CHANGES RESULTING FROM TERMINATION OF TASK 1 (EXCLUSIVE OF TERMINATION CLAIM)

	Original Task 1 Budget[1]	Budget Subtask 1.01[3]	Budget Subtask 1.02[3]	Expended thru June 1.03-1.06	Subtask 1.08 Termination Report	Subtask 1.08 Prep for Termination	Total Task 1 Manpower Budgets	Disbursements thru June 6	Disbursements to complete 1.02	Task Wide Costs	Total Task 1 Budget	Net Change from Original[1]
Acres												
Manhours	3,350				190	510						
Project Cost of Service	55,268	11,738	14,000	12,463	3,771	10,729	52,701				52,701	(2,567)
Overhead	41,453	8,804	10,500	9,347	2,828	8,048	39,527				39,527	(1,926)
Handling Fee	6,397							728	728	2,276	2,276	(4,121)
Disbursements												
900 Misc	3,000								200			
901 Travel	9,600				200	200			200			
902 Telephone/Telex/etc.	4,200				100	100			200			
903 Reproductions	4,100				100	100						
915 Publications	4,500											
916 Photography	900											
921 Computer	6,000											
Subtotal Disbursement	32,300				400	400		17,689	600	19,089	19,089	(13,211)
Fee on Services	11,586									11,048	11,048[4]	(538)
TOTAL ACRES	147,004											(23,363)
WCC												
Manhours	3,900	600	800									
Manhour Costs	212,600	29,400	40,900									
Disbursements	17,600	2,800	2,800									
TOTAL WCC	230,200	32,200	43,700	17,032			92,932				92,932	(137,268)
TES												
Manhours	1,750											
Manhour Costs	51,500											
Disbursements	5,830											
TOTAL TES	57,330			1,768			1,768				1,768	(55,562)
SUBTOTAL	434,534				7,000	19,177					219,341	(215,193)
ESCALATION	28,810[2]										14,543	(14,267)
GRAND TOTAL	453,344										233,864	(229,460)

Notes:

(1) Based on POS budget as restructured for monitoring purposes under Acres Cost Report System.

(1) Allocated portion of total contract escalation after removing fee escalation from total contract escalation.

(2) Budget to complete is greater than original budget for these subtasks due to: a) effort expended in May on Tussing changes, b) late completion by ISER on energy forecast and extraordinary monitoring requirements.

(3) Prorated in same ratio as in Column 1 for fee to labor cost.

A - DRAFT OUTLINE OF INTERIM REPORT:
TASK I - POWER STUDIES

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES (First Part)

INTERIM REPORT

B - REVIEWS OF ARLON TUSSING REPORT
BY ACRES AND WCC

LS - Columbia file

April 24, 1980
P5700.11

Mr. Robert Mohn
Director of Engineering
Alaska Power Authority
383 West 4th Avenue
Suite 31
Anchorage, Alaska 99501

Dear Robert:

Susitna Hydroelectric Project
Recommended Changes to Power
Alternatives Study

The purpose of this letter is to provide a rapid response to recommendations contained in the Arlon Tussing Report which we received April 21. On the basis of that report and the obvious public concern about the Power Alternatives Studies, we are recommending certain changes be made to the scope of the work. These changes are summarized herein: subject to your agreement in principle with our proposal, we will be pleased to forward more detailed work plans within the next week. We believe that these changes will respond to the very valid concerns raised by Mr. Tussing and others, and result in a high quality product. We would welcome any further comments you may wish to make.

Before discussing our specific proposals, we believe it to be important to note that:

(1) The GO-NO-GO decision points in the POS relate to continuation of study efforts for Susitna and not construction of the project. We are now recommending two such decision points, one in early 1981 much as originally proposed, a second in the spring of 1982. The first decision was and is still intended to provide the Authority with some assurance that continuation of Susitna Project studies are likely to be worthwhile. The second decision will provide the more detailed comparison of all viable alternatives suggested by Tussing such that a decision can be made on whether to proceed with licensing of the project.

(2) When the Plan of Study was prepared originally, we set out to describe a program for the study of alternatives which is, in our view, sufficient to satisfy the pertinent requirements for license application to the Federal Energy Regulatory Commission (FERC). In the interest of minimizing costs, we included no more effort than this sufficiency requirement.

ACRES AMERICAN INCORPORATED
Consulting Engineers
The Liberty Bank Building, Main at Court
Buffalo, New York 14202

Telephone 716-853-7525 Telex 91-6423 ACRES BUF

Basis for Recommended Scope Changes

Having attended all of the recent public meetings, I am keenly aware that there is a strong interest in the alternative study effort. It is evident that whatever decision is made about future generating capacity in the Railbelt, it must be based upon unusually exhaustive studies which clearly support it. In addition, you were kind enough to provide us a list of questions which should be addressed by us prior to the time that the Governor makes the first GO-NO-GO decision early in 1981. Some of these questions also highlight the need for a strong alternatives study. We, therefore, conclude that it is in the best interests of the State and, in particular, of the Alaska Power Authority, to increase the level of effort expended on power alternatives studies to a point well above the minimum necessary for successful license application.

In the event that funding can be made available for the purpose, I recommend that the Scope of Work covered by our agreement of December 19, 1979, be changed to accommodate the broader objective of providing convincing evidence to the public that any recommended future expansion sequence for generating capacity is the best possible selection, regardless of whether or not the Susitna Hydroelectric Project is contained within it. Satisfaction of this latter objective will more than meet the test of FERC scrutiny if Susitna appears to be an appropriate development.

I believe the recommendations contained within Arlon Tussing's report are basically sound, and I have prepared a number of attachments for your consideration describing how we would implement them if additional funding were made available. The tabulation at Attachment 1 begins with tasks and subtasks as currently detailed in the Plan of Study and distributes recommended funds in a manner which we believe best meets the broader objectives described above. To the extent that new subtasks appear appropriate, they are designated by descriptive titles. Remarks are provided so that you will have some understanding of our rationale in the construction of this table. Attachments 2 and 3 are a set of flow charts which display the manner in which information is developed and processed throughout the course of the work.

Summary of Scope Changes

Our proposed approach is as follows:

(1) We propose to significantly increase the work involved in dealing with the identification and description of power alternatives. This proposed increase accounts for a number of issues raised by Mr. Tussing and others:

(a) Whereas we had anticipated eliminating a sizeable number of alternatives at the initial screening stage because of questions of technical availability (including availability of reliable systems), obvious high costs, and severe environmental consequences, it now appears that many more alternatives should survive the first screen. In short, there are more alternatives to be studied in greater detail.

(b) More detail is appropriate for site specific aspects of certain alternatives so that more refined data can be generated regarding costs, risks, schedules, and financing.

(c) To ensure most effective public input as well as professional review, we now propose to insert a number of new screening points (as may be seen from the flow diagram), which may lead to further iterations. These in turn may be expected to yield additions of alternatives not previously addressed as well as modifications to site locations, plant sizes, assumed availability dates, and the like. Sufficient funds must be provided if these reiterations are to be accomplished.

(d) We propose to increase our description and analysis of conservation and load management. (It is worth noting, by the way, that the POS did address time of day pricing and demand controls in Subtask 1.03, despite Mr. Tussing's assertion to the contrary).

(2) Whereas we had originally planned to identify the single most promising (and therefore recommended) expansion sequence by the end of Task 1, we now propose to present a number of alternative sequences for public review. Our own recommendation to you in the final report for Task 1 will be made only after the public scrutiny process is complete.

(3) We have from time to time in the past several months expressed some apprehension as to the quality of the data base for ISER's work. Gaps do exist, and I believe we can gain from continuation of the ISER work well beyond submission of their initial report. Thus, we propose that the sum of $100,000 be appropriated for continuing support of ISER's forecasting effort. There are related data base deficiencies insofar as load forecasting is concerned. These, too, we propose to address by increasing the level of effort now allocated to Subtask 1.02. We hope to involve ISER in the development of load forecast and load duration curves, particularly as these items will be affected by load management strategies.

(4) While details as to marketing, financing, cost, risks, and schedules are clearly appropriate in a final Susitna development selection, such information will not be available at the time of the first GO-NO-GO decision. Stated simply, such details cannot be produced with precision until the alternative Susitna developments are themselves clearly defined. We propose to modify the nature of the first GO-NO-GO decision. By the end of the first year of study, we will have developed expansion sequences with and without Susitna as well as for a decentralized alternative set. (It is important to note that "with Susitna" implies a development of the Corps of Engineers scheme, possibly with an envelope defined around its parameters to express the likely range in which other Susitna alternatives might lie. The Corps plan does have defined costs and a schedule, though we must update this information to the present). These sequences as well as other preliminary data on costs and impacts will be the subject of an interim report and will be presented at a public meeting early in 1981. If Susitna is not selected by the Optimum Generation Program even when it is a part of the input set, strong evidence will exist to suggest that the decision should be "NO GO" and that further study work on Susitna should be stopped, probably in favor of more detailed study of whichever alternative set (or sets) appears best for railbelt needs. If, on the other hand, clear economic advantage can be seen in the "with Susitna" sequence, it is likely that further study can be justified. The second GO-NO-GO decision point would occur about a year later. At that time, detailed studies will have been made of possible alternatives within the Susitna Basin and each of the various expansion sequences will have been studied for financial and marketing aspects, environmental impacts, risk analyses, and cost and schedule refinements. A sensitivity analysis will also have been conducted and reiterations, where appropriate,

Mr. Robert Mohn
Alaska Power Authority

will have been made. This second decision point would be a decision to proceed with license application and to do Phase II work or, alternatively, to stop further work on the project -- again, perhaps, with an indication that any favored alternative set should be pursued.

(5) As noted above, reiterations after detailed marketing, financing, cost and schedule, risk, and environmental studies may be necessary. Certainly the demand itself could change as a function of the way in which generating capacity comes on line to satisfy it. Peak loads and load duration curves may also be modified. In addition, of course, ongoing ISER studies (see Item 3 above) may have yielded new demand and load data. Our proposal accounts for a number of reiteration decisions as shown on the flow charts at Attachments 2 and 3. However, it is important to note that the cost estimates and schedules are based on no more than one reiteration in each case.

(6) We agree with the recommendation to establish a multidisciplinary panel and a new subtask has been created to identify it and its objectives explicitly. We are prepared to recommend the composition of this panel, but we believe that the actual selection of its members should be made by APA.

(7) One important part of the sensitivity analysis to be conducted in the latter phase of the study will be an examination of "what if" questions of the type Mr. Tussing poses in his recommendation Number 7.

(8) While the Tussing report does not include specific recommendations regarding environmental studies of alternatives, we are convinced that increases in level of effort devoted to such matters as technical aspects, financing, and the like should be balanced by corresponding increases in environmental assessments and analysis. We propose a substantial increase in environmental effort devoted to alternative studies.

(9) The total order of magnitude of study work suggested in Attachment 1 amounts to an increase of approximately $1.1 million for efforts by the ACRES team and $100,000 for additional ISER work. These values are subject to refinement because they were of necessity generated rapidly. We will be pleased to develop detailed work plans, manhour allocations, and disbursement estimates in the event that you favorably consider this proposal.

Mr. Robert Mohn
Alaska Power Authority

April 24, 1980
- 6

Schedule and Personnel Requirements

We have done an initial analysis of the schedule required to undertake the proposed work and we believe that it can be accomplished in time to accommodate the two decision points I described above. Much will depend, of course, on the extent to which reiterations may be required as well as on the earliest possible availability of ISER's initial report (now scheduled for May 15). I suggest that we work together closely to monitor these items. In any case, a precise date for the next set of public meetings should not be selected until the latter part of 1980.

Should the Legislature decide to provide funds for this expanded scope of work, we are prepared to increase the commitment of certain key project personnel (e.g. A. Vircol) as well as to supplement the current study team with individuals within our organization experienced in the study of alternative energy concepts. We will furnish resumes for these persons when the detailed work plan is submitted.

I have not at this time attempted to counter various assertions contained wtihin the body of the Tussing report, though I do not agree with some of them. We will be pleased to provide detailed response in the near future if you desire.

I look forward to your comments on this proposal. Should you find it appropriate, a meeting can be arranged in the very near future to discuss its content.

Sincerely,

John D. Lawrence
Project Manager

CAD/JDL/rw
Attach.

ATTACHMENT 1

SUMMARY OF CHANGES RECOMMENDED TO INCREASE LEVEL OF EFFORT FOR ALTERNATIVE POWER STUDIES ($ x 1000)

Subtask	Original POS Value	Changes Associated With Recommendation Number[4] 1	2	3	4	5	6	8	Other Recommended Changes	New Value	Remarks
ISER Work	$ 60[1]							+100		$160	Provides funds for major updates, especi: after census data is in
1.01 - Review ISER	35.2							+ 50		85.2	Permits continuing interaction with ISER including the formulation of a place for proving the data base for future energy a. load forecasting
1.02 - Forecasting Peak Load Demand	47.7	+100								147.7	Provides separate peak load and load durat for each load management strategy at each demand level
1.03 - Identify Alternatives	96.3	+100									Provides detailed analysis of load manager strategy and considers interrelationship w conservation strategy. Develops energy co servation in more detail as an alternative
				+100						296.3	Provides for refined site-specific data to assess energy resource availability, techn and commercial use availability, expected dependency, preliminary safety, health and environmental concerns, costs per unit of electricity supplied, schedules and input risk analyses.
1.04 - OGP Analyses and Expansion Sequence	30.0						+ 70			100.0	Significant increases due to: (1) More alternatives to be evaluated in-depth and screened through OGP Progr (2) Decentralized scenario added (3) Imposition of three load management strategies on each demand level (4) Reiterate when necessary using additi OGP analyses and Delphi method whe appropriate.
1.05 - Impact Assessments	138.0								+150.0	288.0	Balances more detail on study of other fa (cost, risk, site specificity, finance, et. Has to be expanded to additional scenarios (Decentralized scenario, three load manager strategies).

ATTACHMENT 1 (Cont'd)

SUMMARY OF CHANGES RECOMMENDED TO INCREASE LEVEL OF EFFORT FOR ALTERNATIVE POWER STUDIES ($ x 1000)

Subtask	Original POS Value	Changes Associated With Recommendation Number[(4)] 1	2	3	4	5	6	8	Other Recommended Changes	New Value	Remarks
1.06 - Report	12		+ 25				+ 50			87.0	$50k for interim report and updates. $25k t account for reporting on broader scope, mor alternatives, etc.
6.01 - 6.08 (Susitna alts)	354.6		+200							554.6	Develop more details on cost and schedule fo all Susitna alternatives (not just "selected scheme)
11.01, .02 - Project Overview and Internal Reports	$ 191.1 (2)							+ 50 (3)		$241.1	Although Task 11 is still under discussion with APA, changes noted here are based on effect of Tussing recs on plan as currently in POS
11.03 - Alternative Risk Analysis	17.5			+ 50 (3)						67.5	Major increase in number of expansion sequences to be considered requires corresponding increase in risk analysis
11.04 - Susitna Risk Analysis	24.5		+ 50 (3)							74.5	Risk analysis would now be done on all Susitr alternatives (not just one)
11.12 - Preliminary Marketing and Financial Studies	(New)				+ 75					75	Marketing and Financing studies were to be made only for Susitna and only if selected. More detail is now sought earlier per Mr. Tussing's comment
1.07 - Power Study Panel	(New)					+ 75				75	Adds subjective probability factors permittir increase in information available at review points. Adds objectivity factor to eliminate potential bias
TOTALS	1006.9	200	275	150	75	75	120	200	150	2251.9	

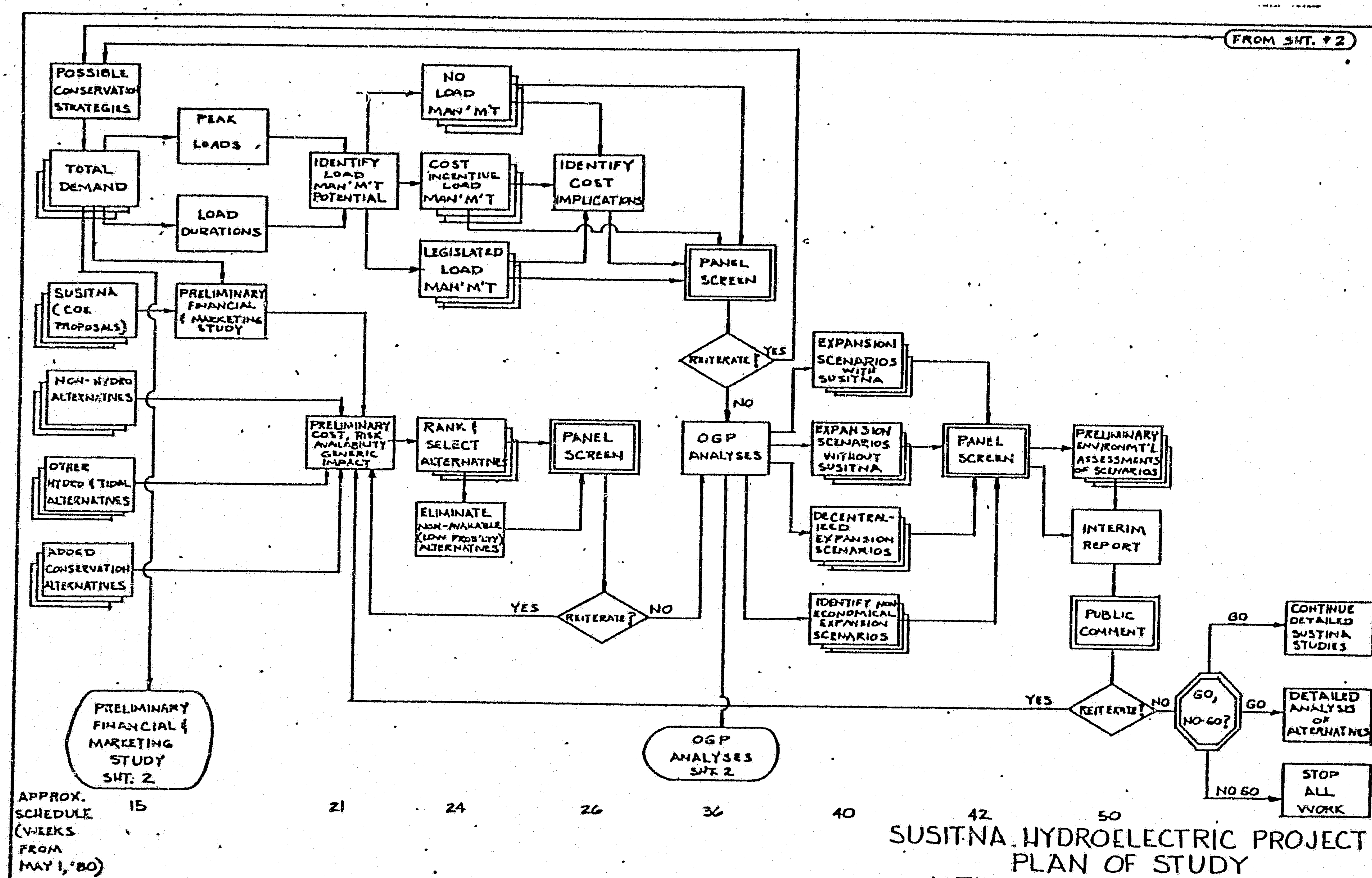
(1) The ISER work is funded in part by APA ($30) and in part by the Legislature ($30)

(2) Although this is the POS value for subtasks 11.01 and 11.02, the work involved is only partially in support of power studies.

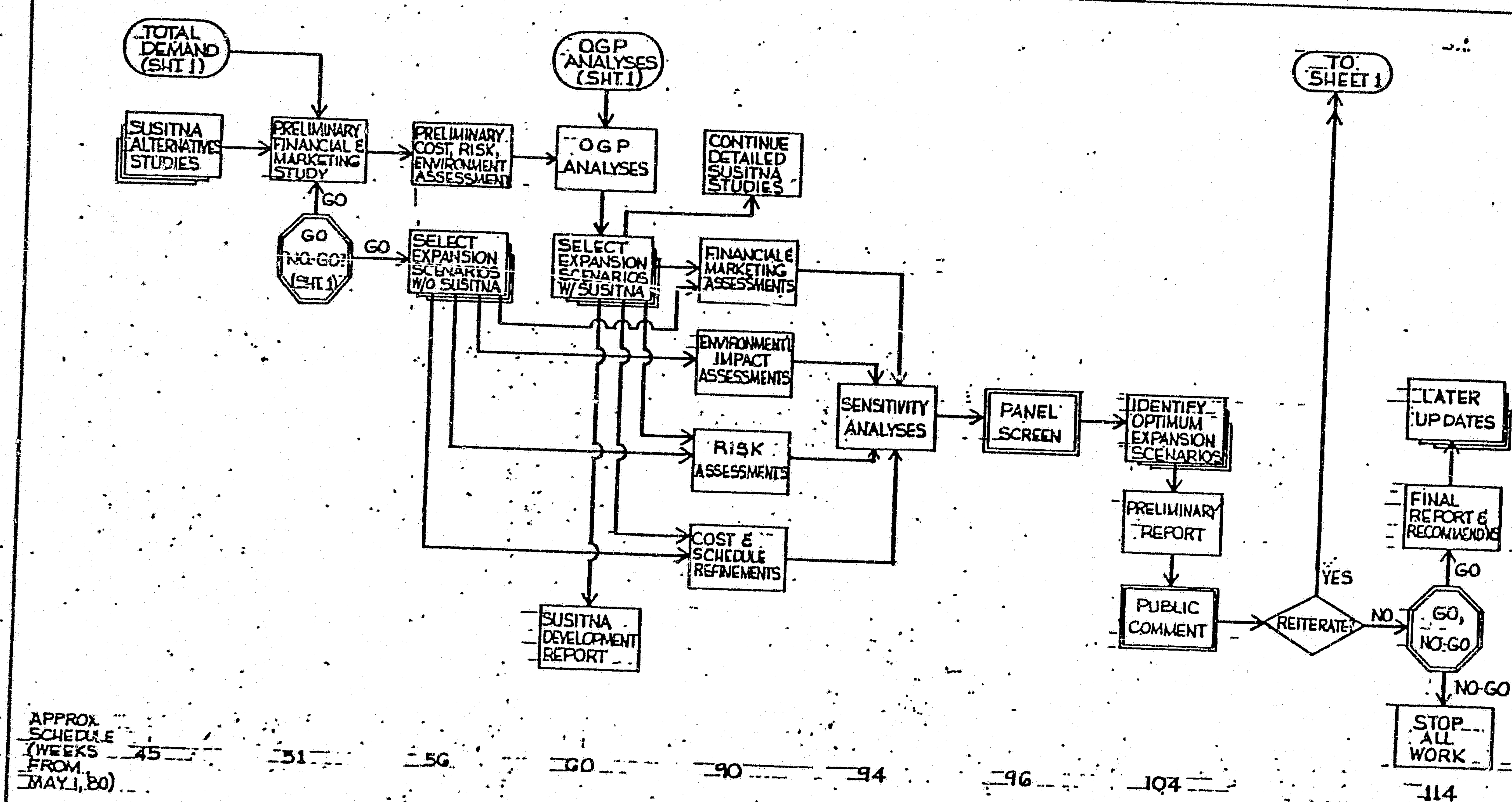
(3) These values may not require full additional funding by the Legislature if pending proposed Task 11 changes are accepted by APA.

(4) Numbers above each column are keyed to numbered recommendations on pp 22-23 of the Tussing report.

00328



SUSITNA HYDROELECTRIC PROJECT
PLAN OF STUDY
ALTERNATIVES STUDY SHT. #1
APRIL 23, '80



(1) INCLUDES DECENTRALIZED SCENARIOS

SUSITNA HYDROELECTRIC PROJECT
PLAN OF STUDY

ALTERNATIVES STUDIES, SHEET 2
APRIL 23, '80

May 2, 1980
P5700.11
T.133

Mr. Eric P. Yould
Executive Director
Alaska Power Authority
333 West 4th Avenue, Suite 31
Anchorage, Alaska 99501

Attention: Mr. Robert A. Mohn

Dear Robert:

Susitna Hydroelectric Project
Review of Arlon Tussing Report

I am pleased to attach a summary response to specific issues raised by the Arlon Tussing Report. We are continuing to develop our proposals for detailed amendments to the POS on the basis of our letter dated April 24.

Please call if you have any questions.

Sincerely,

John D. Lawrence
Project Manager

JDL/jmh
Attachment

ACRES AMERICAN INCORPORATED

SUSITNA HYDROELECTRIC PROJECT P5700.14.01

REVIEW OF REPORT BY ARLON R. TUSSING ET ALIA
DATED 15 APRIL 1980

1 - INTRODUCTION

The report entitled "Susitna Hydropower: A Review of the Issues" was issued as a "Review Draft" by Arlon R. Tussing, Lois S. Kramer and Barbara F. Morse on 15 April 1980. This report, referred to in this document simply as the "Tussing Report" contains a critical review of the Alaska Power Authority/Acres American Incorporated Plan of Study (POS) for the Susitna Hydroelectric Project dated February 1980. The purpose of this document is to present the considered response of Acres American Incorporated to several of the key issued raised in the Tussing Report.

In this response we initially summarize in Section 2 the purpose of the POS and discuss its intended philosophy. In Section 3 we discuss some of the specific issues raised in the Tussing Report. It is proposed that amendments be made to the POS to reflect some of the points made in the Tussing Report: further documentation will be forthcoming to support such changes as they become available.

2 - PURPOSE OF POS

The Susitna Plan of Study is a dynamic document which has been and will continue to be modified and expanded as the concerns and needs of various agencies and the general public become known. There are obviously a number of courses of action which the Power Authority might take over the next 10 years or so to meet the future electric power needs of the Railbelt Region. As presently conceived, the Susitna POS embodies but one of these courses of action. The scope of work will:

- establish the criteria by which the technical, economic, financial and environmental feasibility of the Susitna Project should be measured;

- assess whether Susitna or some other alternative future Railbelt generation expansion plan satisfies such criteria; and finally,

- if such criteria are satisfied, pursue the FERC licensing of the Project.

In other words, the study will establish whether the Susitna development is appropriate and if so, how best to proceed with that development.

The POS has since its inception undergone a continuing process of evolution in satisfying the overall objectives (as presented in Section A1). At the same time, provision has been made for tapping the input of those concerned through reviews, public meetings and the action list. As a result, the scope and direction of the Susitna study may be changed at any time or the study even terminated, should the evidence indicate that some other course of action should be pursued instead.

2.1 - The Evolving Study Process

A prime example of the process of evolution of the POS is expansion of environmental studies which has already taken place. This was as a result of concerns expressed by the State and Federal environmental agencies involved. A number of other concerns have also been taken into consideration (Section A4). The Tussing Report evinces probably the most detailed assessment yet made of the POS, and is welcomed as a positive contribution to the development of an acceptable course of action.

It is regrettable that Tussing has made his report carry comments which are entirely out of place or which appear to be carrying a bias message emanating from those in opposition to the project. By and large, the "Review and Issues" is well prepared, thoughtful, and well written. Continued input by Tussing and his associates to the House Committee of the Alaska Legislature would no doubt be a useful contribution to the project. As our work on the basis of the POS proceeds, the scope for criticism will surely diminish.

A significant flaw in the Tussing Report, however, is perhaps its preoccupation with making explicit judgements before all the evidence is in, i.e, before the study is done., Many of Tussing's comments may well be valid, but until studied, cannot be verified. With few exceptions, to do more requires that the work actually be done first. It should be understood that the study as presently planned, a 30 month, $30 million exercise, can only be fully described by the actual products of the study, which are the numerous reports and documents which will be prepared during the course of the work. The POS is an attempt to summarize what will be done, how, when, by whom, and at what cost.

2.2 - The Go-No-Go Decision Points

A major misunderstanding of the Tussing Report also appears to relate to Go-No-Go decision points. In the original POS there were essentially three such decision points. During the proposed 30-month study period, each of these decision points relate to "continue-to-study" or "not-continue", rather than "build the project". We wholeheartedly agree with Tussing that a Project as large as Susitna requires extensive study and cost expenditures to fully determine whether it is the appropriate course of action. In Acres' judgement, a 30-month period and a $30 million expenditure is necessary for a final decision to be made which adequately considers all issues involved. Nevertheless, it would clearly not be cost effective to defer an obvious No-Go decision until the end of the 30-month period. The Power Authority has not only fiscal responsibility, but also cannot delay its power generation expansion planning activities for that long. The first Go-No-Go decision in early 1981 will consequently be made on the basis of an initial comparison of alternatives essentially based on available information and considerable well-informed judgement.

There appears to be no difficulty in establishing that, with the constraints imposed on data collection, load forecasting, alternative energy studies, etc., it will be difficult enough to make the decision whether or not to proceed with the study within one year; it would be entirely impractical and imprudent to take the much more profound decision regarding whether or not to build at that time, unless some overwhelming factor(s) intervene (either for or against).

As a result of Tussing's comments, we agree that advancing and expanding the scope of some activities will aid in making this decision. Nevertheless, the decision process will also involve significant public and state legislative participation. We are certain that the Susitna studies will not be allowed to continue without a convincing demonstration that Susitna is likely to competitive with its alternatives.

2.3 - Modification to Power Alternative Studies

The recommendations by Tussing in regard to increase in the level of effort in the Power Study area, if adopted, cannot help but improve the quality of information before APA and the Alaska legislature at the time of the decision to proceed with study or not. It is not for Acres to judge whether the additional funding required be made as this is a matter of budgeting priorities for the state government. In accepting the scope of work and schedule under the revised POS for Task 1 Acres and its subcontractors undertook a challenging task which could, however, be achieved if inputs from other sources were available to the extent required and on schedule. In all probability, more than the planned input effort could have been required and provided.

While still pursuing a course which limits as far as possible outlays in the first year of study, Acres would certainly now recommend adoption of many of the Tussing proposals. To contradict them after they have been made in a somewhat challenging manner would be imprudent, as any perceived shortcomings in future output from the Acres study could be attributed to an overly stringent cost approach at this vitally important stage of a major project. In fairness to the position adopted by Tussing, it should be noted that Acres was becoming increasingly aware of some limitations being imposed by the revised POS on the level of effort that would be necessary to treat all concerns being more recently expressed by APA and the public.

The second of the three Go-No-Go decision points referred to above, as originally conceived, related to the optimum development in the Susitna basin. This was essentially a "fine-tuning" of Susitna project design to ensure that more realistic costs and schedules for the development were considered in the comparison. As a result of the Tussing Report, we recommend this work be advanced such that the two decision points will now coincide. The third (now second) decision point will occur in early 1982 after all design, environmental, alternatives, financial, marketing, economic, scheduling and risk assessments are made and will involve deciding whether or not to proceed with licensing of the project. Again any recommendation will be subjected to the closest state and public scrutiny before it is implemented.

3 - ISSUES RAISED IN THE TUSSING REPORT

The Tussing Report presents a useful overview of the planned Susitna hydroelectric project in relation to likely future developments and economic trends in Alaska's Railbelt Region. in this regard, however, the Report is biased towards a general scenario which sees preferential pricing of natural gas continuing into the next century and a resource-depletion-led-slow-down in the mid 1990's. This bias strongly influences the arguments presented in relation to the marketability of Susitna power and energy. While there is some support for the cautionary attitude regarding competitiveness of Beluga coal and other alternatives, the situation regarding these must certainly be taken at the time as "not proven."

In fact, this level of relative competitiveness with Susitna hydroelectric power production will be only partially established one year from now when the decision is taken whether or not to proceed with the study (let alone the project).

3.1 - Marketing and Financing Studies

The "Marketing and Financing" issue calls for a more potent challenge of Tussing's assertions. The content of Task 11 as proposed in the POS does not appear to be properly understood.

The Tussing report suggests with emphasis that "Susitna's viability will not be based on either its economic or financial feasibility." This is incorrect. Task 11 requires incisive studies and reports on:

"Possible Economic Limits to Project"
"Overrun Possibilities"
"Security of Project Capital and Structure"
"Evaluation of Alternative Markets for Susitna Output"
"Evaluation of Alternative Options for Meeting Railbelt Power Needs"

From these reports and other pertinent study work on economic impact, a vitally important element of the Project Overview would be developed. Admittedly, with the deferment to all work in Task 11, its output would not be available, as originally planned, for the Power Study phase. Acres, however, did not overlook the need for properly conducted analyses of marketing, financing and risk assessment. Apparently, however, we have not clearly enough stated the true significance of the output of Task 11. Furthermore, proposals to eliminate the input from Salomon Bros., suggesting that the all important financing issues can be dealt with in the normal course of events rather than with intensive professional study, can now be seen as a possibly retrograde step. The downgrading and deferment of Task 11 have in no small measure contributed to the apparent shortcomings of the POS highlighted by Tussing.

An immediate start at Week 1, as planned in the original POS, would have brought into being a draft Project Overview by about this time and "available for comment" by September 1980. The general thrust and tenor of this initial overview would have been very similar to that embedded in the Tussing paper (avoiding, however, the bias which appears to have been introduced, probably reflecting the overly strong reaction being stimulated by Chugach). The Project Overview would be well suited for the audience being addressed by Tussing; it would also be written in simple, easily understood text; it would take as objective a view as possible and aim at establishing without any doubt that both negative and positive aspects of Susitna and alternatives were being properly balanced.

3.2 - <u>Project Financing</u>

One particular point in Tussing's report deserves particular attention. This relates to Project Financing--and particularly to Construction Financing. It is fully realized that one of the problems to be faced with a capital intensive development such as a hydropower plant is that the cost of service <u>with</u> the project in the system is likely to exceed the cost of service <u>without</u> the project in the system for the first several years (probably 8-10). Particular attention will be necessary to find ways and means of alleviating the burden on Alaskan consumers in this century of costs of service which will benefit the next generation. This is a very major issue which will require review of a number of options and it should not be readily assumed that past practices will prevail.

In two places in the report, Tussing refers to the burden imposed on consumers by the Construction Financing burden (AFUDC). It suggests that the consumer will pay in advance for electricity they may not receive for 10 years or, in Tussing's words, "if ever." Capitalization of AFUDC is yet another issue that will be exhaustively studied and treated in the marketing and financing tasks. It is quite improper to assert at this stage that "Non-recourse financing would require all-events contracts (<u>compelling</u> consumers to pay for Susitna whether or not they ever got Susitna Power and no matter how much it turned out to cost) prior to construction." The statement is correct if the words in parenthesis are omitted; but the inference with the words left in is, to say the least, provocative and misleading. The authors may claim that under Alaska PUC rules this has occurred in the past on other arrangements between wholesaler and utility delivering to consumers, but it is a gross assumption that is is the approach for Susitna.

To: J. Lawrence
From: G. Warnock

May 1, 1980

Alaska Power Authority
Susitna Hydroelectric Project
Tussing Report - "Review of Issues"

(1) The review draft of the Tussing report issued on April 15, 1980, presents a useful overview of the planned Susitna hydroelectric project in relation to likely future developments and economic trends in Alaska's Railbelt region. It is biased towards a general scenario which sees preferential pricing of natural gas continuing into the next century and a resource depletion led slow down in the mid 1990's. This bias strongly influences the arguments presented in relation to the marketability of Susitna power and energy. While there is some support for the cautionary attitude regarding competitiveness of Beluga coal and other alternatives, the situation regarding these must certainly be taken at the time as "not proven."

In fact, this level of relative competitiveness with Susitna hydroelectric power production will be only partially established one year from now when the decision is taken whether or not to proceed with the study (let alone the project).

The major difference of approach advocated by Tussing to that in Acres/APA POS is in the level of knowledge and information available at certain milestone points and in the type of decision then to be taken. APA sees the go/no go as being whether or not to proceed with the study and preparation of license application. Tussing sees this being the decision whether or not to build Susitna. There appears to be no difficulty in establishing that, with the constraints imposed on data collection, load forecasting, alternative energy studies, etc., it will be difficult enough to make the decision whether or not to proceed with the study within one year; it would be entirely impractical and imprudent to take the much more profound decision regarding whether or not to build at that time, unless some overwhelming factor(s) intervene (either for or against).

The recommendations by Tussing in regard to increase in the level of effort in the Power Study area, if adopted, cannot help but improve the quality of information before APA and the Alaska Legislature at the time of the decision to proceed with study or not. It is not for AAI to judge whether the additional funding required be made as this is a matter of budgeting priorities for the state government. In accepting the scope of work and schedule under the revised POS for Task 1, AAI and its subcontractors undertook a challenging task which could, however, be achieved if inputs from other sources probability, more than the planned input effort could have been required and provided.

While still pursuing a course which limits as far as possible outlays in the first year of study, Acres would certainly now recommend adoption of many of the Tussing proposals. To contradict them after they have been made in a somewhat challenging manner would be imprudent, as any perceived shortcomings in future output from the AAI study could be attributed to an overly strigent cost approach at this vitally important state of a major project. In fairness to the position adopted by Tussing, it should be noted that Acres was becoming increasingly aware of some limitations being imposed by the revised POS on the level of effort that would be necessary to treat all concerns being most recently expressed by APA and the public.

(2) The "Marketing and Financing" issue calls for a more potent challenge of Tussing's assertions. The content of Task 11 as proposed in the POS does not appear to be properly understood.

The Tussing report suggests with emphasis that "Susitna's viability will not be based on either its economic or financial feasibility." This is incorrect. Task 11 requires incisive studies and reports on:

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An immediate start at Week 1, as planned in the original POS, would have brought into being a draft Project Overview by about this time and "available for comment" by September 1980. The general thrust and tenor of this inital overview would have been very similar to that embedded in the Tussing paper (avoiding, however, the bias which appears to have been introduced, probably reflecting the overly strong reaction being stimulated by Chugach). The Project Overview would be well suited for the audience bing addressed by Tussing; it would also be written in simple, easily understood text; it would take as objective a view as possible and aim at establishing without any doubt that both negative and positive aspects of Susitna and alternatives were being properly balanced.

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(4) It is regrettable that Tussing has made his report carry comments which are entirely out of place or which appear to be carrying a biased message emanating from those in opposition to the project. By and large, the "Review of the Issues" is well prepared, thoughtful, and well written. Continued input by Tussing and his associates to the House Committee of the Alaska Legislature would no doubt be a useful contribution to the project. As our work on the basis of the POS proceeds, the scope for criticism will surely diminish.

TO: J. Lawrence

FROM: Peter Sandor

Review of A. R. Tussing's Paper:

"Introduction to Electric Supply Planning

Dr. Tussing, as far as I know, used to be in charge of ISER before going on his own. This might have influenced his attitude to what he perceives to be an ISER-APA-Acres team. I was not asked to reflect on his criticism regarding Acres' plan (Chapter IV), therefore I will review only on his capacity oriented remarks (Chapter II), and specifically his work covering demand forecasting and facilities planning.

In summary, Tussing goes out of his way putting forward a "no growth" scenario. If there are public hearings, the fallacies of his approach can be brought out in cross-examination of expert witnesses. Here are my first thoughts on his work.

Tussing's monograph represents a most intelligent display of the minimalist, "no growth" attitude displayed by an influential section of the American academic establishment. The risks of underplanning and of shortages are underplayed as compared to the dangers of overexpansion.

It is interesting to observe Tussing's remark that forecasts in Alaska during low growth periods have tended to underestimate actual power demand. His subsequent evaluation indicates to me that he is following the same path.

Under the title "Economic Boom in the 1980's" Tussing concludes that Alaska's economic outlook is dominated by government spending. I would conclude (as discussed in Appendix A) that this implies higher growth than ISER's "low" projection. He follows up with the statement that this will lead to a "Decline in the 1990's". I have failed to find his quantitative proof? Tussing overlooks the impact of those major resource based developments for which funds are firmly committed.

Talking about "Electricity consumption per capita", attention is drawn to the fact that air conditioning cannot be expected to grow in Alaska. True. But air conditioning growth was not assumed by any forecasters for Alaska and ISER's work still indicates electricity consumption growth per household. Other appliances (water heaters, clothes washers/driers, etc) are to be considered.

Tussing makes a statement, that "residential and commercial structures already committed to oil or gas (have) little or no opportunity to provide (a new power source) for heating". This

.../2

statement is uncorroborated and is contradicted by both theoretical calculations and practical experience. It is possible to convert oil and gas heaters to electricity.

The evaluation of energy intensive industries has a strong downward bias. A new aluminum reduction plant will seek a combination of cheap, reliable power and of a year round harbour. An Alaskan location (with Susitna power hypothetically available) qualifies as well as Kitimat in northern British Columbia. Tussing refers to a construction cost factor in Alaska of 1.6. I would suspect, that this is an overestimate. The hardware of an aluminum smelter (e.g. transformers, rectifiers, control equipment, etc) has to be manufactured in the industrial heartland of America and transported to the site, wherever the smelter is to be built. The construction cost difference (if any) has to be written off in cheaper power costs over the lifetime of the plant. It is necessary to use a reasonable escalation of world oil prices in current dollar terms against the fixed costs per kWh of a hydroelectric plant to come up with a valid answer. One does not require a major difference in the first years in order to get a result favouring hydro. Tussing's simplistic approach can be misleading.

I have very little knowledge of Uranium enrichment needs, but I would venture to say that the statement "the U.S. market for new light-water reactors has virtually disappeared" is not valid for the 1980-2010 period. It probably is only part of the "Jane Fonda syndrome".

The remarks regarding pumping and compressor stations are somewhat pessimistic. If these pipelines have to cost their own fuel (crude oil and natural gas) at $40/bbl equivalent or more, they may well opt for full time electricity priced at full cost, not for self-fuelling combined with off peak power.

Tussing's comments regarding the "Federal restrictions on use of natural gas" are very important. The availability and price of gas for electrical power generation are the determining variables of modal choice. The statement "Since the law (the Plant and Industrial Fuels Act, PIFUA) was enacted in 1978 however, the national outlook for natural gas supply has improved radically" is misleading. Natural gas can replace crude oil based fuels in both home heating and industrial applications. Transformation of heavy fuels (e.g. Bunker C) into motor fuel is making quick progress since 1978. The market for American natural gas in the "Lower 48" will be increasing on the long run as part of the self-sufficiency strategy of the U.S. government. It is not at all likely tha PIFUA would be stopped or significantly mollified. As far as natural gas liquids are concerned, their true market value (shadow price) will escalate with OPEC prices and thus they cannot be used as cheap fuel alternatives for power generation.

.../3

It is hard to imagine that Congress will allow an expensive and fuel wasting loophole to PIFUA by sanctioning the production of methanol from Alaskan natural gas and its use in local power generation. This option would require large amounts of investment and a waste of BTU's. It would deprive the "Lower 48" from Alaskan natural gas while increasing electricity costs in Alaska itself.

Tussing takes a rather facile approach to the problem of reserve generating capacity and systems reliability. It may well be possible to lower the generating reserves by more interties, better maintenance, load management, etc. On the other hand in the harsh climate of Alaska the same blackout will have a much more severe impact on life and property than in the more forgiving environment of California or New York. By utilizing existing natural gas burning power plants at higher rates it is feasible to save investment but this approach still uses more of the scarce resource, compared to moving into hydro or even coal.

TELEX FROM WOODWARD-CLYDE CONSULTANTS

To: Alex Vircol
Acres American Incorporated

From: Craig Kirkwood

Office: San Francisco, CA

Date: 5/2/80

Subject: Tussing's Report "Susitna Hydropower: A Review of the Issues"

This memorandum is in response to your telephone request of April 30 that we comment on the Tussing report. You specifically asked for comments on the sections of Chapter 17 related to electric energy demand forecasting. In addition, we will make some general observations about issues raised in the report.

General Comments

The general thrust of Tussing's comments is that

- o The scope of concerns addressed in the Task 1 Power Studies is much too narrow,
- o The resources proposed to carry out Task 1 are much too small, and
- o The Task 1 activities are insufficiently integrated.

Woodward-Clyde has expressed the first two views on a number of occasions, and we are pleased that another source is finally expressing this opinion also. Our recent discussions with you have addressed the third point above, but the politics of the situation seem to dictate that it will continue to be a problem.

We agree with may of Tussing's specific comments about shortcomings in presently proposed Task 1 activities. In particular, we believe a careful decision analysis of the need-for-power and alternatives for meeting this need would be useful. However, the large technical modeling effort Tussing seems to propose will not be useful in the absence of a logical and well-structured general approach for analyzing these questions.

We will now comment on several of the section in Chapter 11 of Tussing's report, and, in the process, expand on the comments above. In what follows, the section headings are those used by Tussing.

Information for Decision Making

Tussing's comments regarding the effects of contingencies and risks are significant. We have raised similar concerns on a number of occasions, and to date neither ISER nor Acres has addressed this issue. I will summarize my past comments here. In general, they agree with the remarks made by Tussing on pp. 61-66 of his report.

It appears likely that plausible forecasts of the need for power made using any forecasting method, regardless of how sophisticated, will have a large amount of uncertainty. In particular, possible low estimates will probably suggest that no major new generation facility is necessary, while high estimates will suggest that even the Susitna Project will be insufficient to meet the projected demand.

Because of these variations, no single demand forecast will be completely defensible basis for an evaluation of alternatives. For this reason we believe analysis of uncertainties should be explicitly incorporated into the Power Studies at all stages.

Tussing notes that it will be necessary to do this using expert judgments. We agree with this, but would add the further comment that such judgments must be carefully elicited if they are to be defensible and useful.

ISER's Demand Scenarios

The comments above regarding uncertainties apply here also. However, I would add to Tussing's comments my own observation that ISER does not seem to have developed any systematic procedure for developing scenarios, let alone quantifying uncertainties about which scenario will come true.

Forecasts of Peak Loads and Load Duration Curves

Tussing's comments are correct; however, they are not completely relevant. Woodward-Clyde has agreed to forecast peak loads and load duration curves based on scaling historical data to account for changes in total electric energy demand. This approach has been extensively used in the past, but is subject to the errors Tussing points out.

Tussing seems to feel that more sophisticated methods will provide more accurate forecasts. I think this is a naive view. Nobody has had great luck in forecasting anything related to future energy demand over a long period of time. I question whether any approach currently available will provide better forecasts than those obtained using historical data with judicious hand corrections for load management effects.

However, more sophisticated modeling approaches would enable use to assure that consistent assumptions are being made in the various parts of the demand forecasting activities. This consistency has certain advantages, particularly in presenting the results of the analysis to an audience that is not technically sophisticated.

As a final note regarding Woodward-Clyde's budget, I note that there has never been any thought that we would address load management effects in Task 1.07 in other than a very crude manner. If these are to be addressed in a detailed manner, then our current budget is clearly very inadequate.

Peak Responsibility Pricing and Load Management

The comments Tussing makes in this section are a continuation of those in the last section, and my comments above apply here, also.

Selection of New Generating Facilities

Although Tussing's language is somewhat extreme here, he does have a point. It seems misleading to use a fancy model like OGP-5 when most of the required input data will have large uncertainties.

There is another concern I have about using OGP-5 not raised by Tussing. Basically OGP-5 selects generation alternatives to achieve optimal financial results. However, as I noted in my April 24 letter, finances are only one of several areas of concern in evaluating alternatives. If OGP-5 plays a major role in the evaluation, it is not clear how these other concerns will be adequately addressed.

Summary of Recommendations

I will now comment on each of Tussing's recommendations in turn.

1. Total and peak loads, and load duration curves, must be derived by one study team, in a single effort, and must take into account th potential impact of peak-responsibility pricing and load management on the need for peak generating capacity. A credible effort of this sort would require at least $250,000 and one year.

I strongly support the recommendation for a single integrated analysis effort. However, I believe Tussing does not go far enough--it would be highly desirable to have a single integrated effort addressing both the need for power and the alternative strategies for meeting this need.

This would be desirable because some of the alternatives might significantly affect both the total energy demand and the shape of that demand (i.e., the load duration curve). Hence, it is important that the energy demand forecasting procedures be developed in a manner that effectively supports the evaluation of these alternatives. This requires an integration of the demand forecasting and alternatives evaluation into a single analysis activity.

2. Preliminary cost, risk, and scheduling analyses for alternative Susitna scenarios should be available as inputs to the decision of generating strategy. These preliminary analyses would cost at least $300,000, and require one year.

A systematic decision analysis should address these issues, as well as others such as public health and safety, environmental factors, socioeconomic factors, institutional considerations and technological feasibility.

3. Cost, risk, and scheduling analyses for the most promising alternatives to Susitna according to the current studies should be as thorough and reliable as those for Susitna itself. At least $150,000 and six months would be necessary.

If Tussing really means what he says here, then the budget for this should be substantially larger than what is proposed under recommendation 2 since more alternatives must be studied here.

When, and if, an Environmental Report is written for the Susitna Project considerable detailed information will be needed on the various alternatives that were considered. It isn't clear that this much detail is needed now.

4. Preliminary marketing and financial analyses are necessary as inputs to the demand, cost and risk, and, scheduling studies, and to any practical decision regarding Susitna. The cost of these studies would probably be about $75,000 over six months.

No comment.

5. A multidisciplinary panel of contractor, subcontractor, agency and outside experts should examine and reexamine the major assumptions used in the demand, cost, risk, scheduling, marketing and financing studies. The views of these experts should be translated into probability distributions and systematically incorporated into the assumptions by means of Delphi or comparable methods. This process would cost on the order of $75,000, and run concurrently with the other studies mentioned here.

Although I think the specific mechanism that Tussing proposes has problems, the basic thrust of the recommendation is correct. It is highly desirable that the views of a variety of knowledgeable people be incorporated into the analysis.

6. The program used to rank expansion strategies for Railbelt electrical generating capacity should take account of all of the information generated in the power studies, and its results should be expressed in terms of probabilities. Operating a state-of-the-art power planning model with the information described here would cost at least $100,000.

I do not believe any current power planning model has the capabilities listed. One could be developed based on decision analysis principals.

7. The results of the decision model should be "run backward" through the process that led to those results. That is, those strategies the model identifies as having the greatest expected not benefit, or having the greatest benefit in the most likely scenario, should be analyzed under other plausible assumptions in order to compare (say) the consequences of not building Susitna if it turned out to be "needed" with the consequences of building the facility if its power turned out to be unmarketable. The cost of this process are incorporated in the previous figures, which total (at minimum) $950,000.

Good analysis practice requires that sensitivity studies of the type proposed here be done.

C - SUSITNA HYDROELECTRIC PROJECT: REVISED
SCOPE, TASK 1 - POWER STUDIES

ACRES

May 7, 1980
P5700.11
F.1-C

Mr. Robert Mohn
Alaska Power Authority
333 West 4th Avenue
Suite 31
Anchorage, Alaska 99501

Dear Robert:

Susitna Hydroelectric Project
Revised Scope, Task 1 - Power Studies

We are forwarding herewith for your review and comment our proposed revised scope for Task 1 - Power Studies. This revised scope reflects those changes arising out of comments by Tussing and others, essentially as proposed in our letter and attachments of April 24.

We are currently engaged in discussions with our sub-contractors, Woodward-Clyde Consultants and TES, to determine the extent and cost of their participation in the expanded scope of work. Consequently, we are not forwarding at this time a detailed breakdown of man-hours and cost. Also, please note that the detailed scope of the "second part" of Task 1 may well be modified when the results of the "first part" become known. Furthermore, we have refrained at this time from describing in detail our proposed approach to the planning of the following two items:

(a) derivation of peak loads and load duration curves based on ISER's energy forecasts

(b) the method to be adopted to translate the inputs of review panels into usable assumptions on a probabilistic basis, as recommended by Tussing.

These two items are also the subject of our current discussions with our sub-contractors. We will advise you of our conclusions as soon as possible.

The necessary rescheduling and preparation of detailed scopes of work for changed portions of Tasks 6 and 11 will also be forwarded as soon as possible. With regard to Task 11 in particular, it is important to know whether you agree with the proposal presented to you by Gavin Warnock on April 17. Your early response on this latter point will permit us to prepare new Task 11 scope combining Gavin's ideas with those of Arlon Tussing.

Sincerely,

John D. Lawrence
Project Manager

JDL/ls

ACRES AMERICAN INCORPORATED
Consulting Engineers
Suite 329, The Clark Building
Columbia, Maryland 21044

Telephone 301-992-5300 Washington Line 301-596-5595

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

TASK 1 - POWER STUDIES

The objective of this task is to provide convincing evidence to the public and to local authorities and agencies (a) that the future electric energy and peak demand needs in the Railbelt, if any, have been properly evaluated, and given that expansion is necessary, (b) that any recommended generation expansion sequence designed to cover these needs in the Railbelt is the best possible solution. Should it be convincingly demonstrated that an appropriate development of the Susitna Hydroelectric Project should be included in the recommended expansion scenario. The Task 1 total output will also provide enough support for a decision to be made whether to proceed with the licensing of the project. The analyses and studies completed within this task will more than meet the FERC licensing requirements.

In order to meet the above objectives of Task 1, other tasks of the Plan of Study will proceed in parallel, providing direct or indirect input into the various Task 1 studies. These will essentially involve the field investigations performed under Task 2 - Surveys and Site Facilities, Task 3 - Hydrology, Task 4 - Seismic Studies, Task 5 - Geotechnical Exploration as well as activities representing direct input into the power studies such as Susitna alternatives design development (Subtasks 6.01 - 6.08), environmental impact assessment of Susitna and alternative scenarios (Subtasks 7.03, 7.04 and parts of Subtasks 7.05 and 7.07), preliminary financial and marketing analysis (Subtasks 11.01 - 11.02, 11.12) and risk analyses (Subtasks 11.03, 11.04).

The completion of the above activities implies a significant effort to be spent before a final decision is made. However, Task 1 has the built-in capability of producing interim evidence whether the Susitna Project represents an appropriate development. Should the Task 1 studies demonstrate that Susitna is not the appropriate development, the ongoing studies would be halted pending discussions with the Alaska Power Authority to determine the future course of action most appropriate. On the other hand, should Task 1 studies confirm earlier studies undertaken by the Corps of Engineers and others that the Susitna Project with dams at Watana and Devil Canyon is among the appropriate means of meeting future load growth in the Railbelt area, the study will continue as planned.

To facilitate the decision process mentioned above, two Go-No-Go decision points related directly to the continuation of study efforts are included in Task 1. The first is in early 1981 and is intended to provide the Authority with some assurance that continuation of Susitna Project studies is justified. To assist in this decision making process, a Task 1 Interim Report on Power Studies will be completed early in 1981.

If the decision made at that time is to proceed with Susitna studies, a second year of Task 1 studies will be completed. It will lead to a second Go-No-Go decision point in the spring of 1982 and will provide detailed comparison of all viable alternatives such that a decision can be made whether to proceed with licensing of the project. At this time, the whole sequence of findings, analyses and studies completed under Task 1 activity will be presented to the Authority in a Final Report on Power Studies.

It should be noted that in parallel with the above activities, efforts under Task 11 will result in Project Overview Reports and updates thereof which will be designed to provide the financial and marketing community with appropriate information for accomplishment of the objectives of Task 11.

The scopes of work to be completed under the two parts of Task 1 are described in the following pages. Within each part, a series of subtasks have been identified. Subtasks representing the same generic activity bear the same identification number under both parts, although it is obvious that a subtask listed under the second part of Task 1 represents a more detailed analysis. Attachment 1 presents two flow charts displaying the manner in which information is developed and processed throughout the course of the work.

TASK 1 - FIRST PART

POWER STUDIES, 1980/81

(i) Objectives

To determine the need for power in the Alaska Railbelt Region, to develop forecasts for electric load growth in the area through the year 2010, to consider viable alternatives for meeting such load growth, to develop a series of feasible expansion scenarios (including a preliminary environmental assessment) to be presented for public review and to support the first Go-No-Go decision process related to the continuation of study efforts for the Susitna Hydroelectric Project.

(ii) Output

The primary output of Task 1 (First Part) will be an Interim Report presenting viable expansion sequences for power development in the Alaska Railbelt Region, with and without the Susitna Hydroelectric Project as well as a small-scale decentralized expansion scenario, without or in combination with Susitna. The study results and recommendations made by the Acres team will at key points in the progress of the work be subjected to a screening process by a Review Panel of experts experienced and knowledgeable of conditions in the Railbelt Regions. The Interim Report will be presented for public review early in 1981. The resulting comments will possibly lead to iterations of the study process in order to reflect public concerns. The final version of the Interim Report will include Acres recommendations after the public participation process and will be submitted to the Alaska Power Authority for review and approval in May 1981. The Interim Report content will provide technical support for the first Go-No-Go decision process by the Authority as to whether continuation of Susitna Hydroelectric Project Studies is likely to be worthwhile.

(iii) List of Subtasks

Subtask 1.01 - Review of the ISER Work Plan and Methodologies
Subtask 1.02 - Electric Peak Load Demand Forecast
Subtask 1.03 - Identification of Power Alternatives
Subtask 1.04 - Optimum Generation Analyses and Selection of Expansion Sequences
Subtask 1.05 - Expansion Sequence Impact Assessments
Subtask 1.06 - Power Alternatives Study - Interim Report
Subtask 1.07 - Power Study Review Panels

(iv) Scope Statement

The primary purpose of Task 1 as discussed in Sections (i) and (ii) above is the establishment and documentation of appropriate load forecasts for the Alaska Railbelt area and the development of viable system expansion sequence scenarios to meet these forecasts. Initially, various projected energy consumption scenarios will be evaluated by independent study teams. From these forecasts, the Acres team will develop kilowatt load forecasts appropriate for the low, medium, and high growth rate scenarios. Simultaneously, mixes and sequences of feasible alternative sources for meeting future power demands, with and without the Susitna Hydroelectric Project (which at this stage will be assumed for study purposes to be that developed by the Corps of Engineers), will be developed. A small-scale decentralized expansion scenario will be also identified. Finally, the study will deal with the preliminary environmental impacts assessments of the developed expansion scenarios of the Railbelt Region.

Subtask 1.01 - Review of the ISER Work Plan and Methodologies

(a) Objective

Critically review the work plan and the methodologies developed by the University of Alaska's Institute of Social and Economic Research (ISER) for forecasting energy demands.

Review and comment upon those written documents prepared by ISER as a part of its study. These documents will include, but will not be limited to, those documents listed under Section (b) of this Subtask.

Reach a thorough understanding of the assumptions used by ISER in its work. Review the conservation strategies considered in ISER's scenarios. Comment upon the extent of the conservation measures considered and suggest additional measures to be accounted for in ISER's study. List other conservation measures to be developed separately as an alternative to Susitna under Subtask 1.03.

Exchange information with ISER regarding data needed by the Acres team in its subsequent work. Formulate a plan for improving the data base for future energy and load forecasting.

Ensure adequate data output by ISER through coordination efforts.

(b) Approach

ISER is under contract with the Power Authority and the State of Alaska Legislative Affairs Agency to develop projections of the possible future energy consumption trends for the Railbelt Region. As part of this work, ISER is responsible for developing the methodologies used for the projection; for the collection of data used in its models; and for producing projections detailing the energy consumption trends for six categories of consumers in three distinctly different areas of the Railbelt. The six categories of consumers for which individual growth projections will be made are:

- Residential
- Commercial
- Non self-supplied industrial
- Self-supplied industrial
- Potential industrial
- Users who cannot be supplied by the urban power grids

The three geographical areas which will be studied individually are:

- The Anchorage-Cook Inlet area which forms the southwestern section of the Railbelt Region. This area will include the Kenai Peninsula.

- The Fairbanks-Tanana Valley area lying to the north.

- The Glenallen-Valdez area which is the southeastern area under study.

These three study regions are relatively distinct areas of load concentration.

The approach taken by ISER, as broadly described in its contract with the Alaska Legislative Affairs Agency, and as further defined in its "Detailed Work Plan" dated November 14, 1979, consists of four major areas of effort:

(1) A review of available econometric forecasting methods and models. The most apparently suitable model will be selected for further use in ISER work. A written report will be produced describing the advantages and disadvantages of the methods which were studied.

(2) A review of the available electrical energy consumption forecasting methods. The most apparently suitable method will be selected for further use in ISER work. A written report will document the advantages and disadvantages of the methods which were studied.

(3) Data needed for implementation of the forecasts of 1 and 2 above will be collected and analyzed to determine its limitations and potential uses. A written report will describe the data collection and the uses to which it will be put in future work.

(4) Incorporation of all appropriate data into the econometric and electric energy use forecasting models. These models will then be used to predict electrical energy consumption through the year 2010. Inputs to the models will be varied to produce values of energy consumption growth at the most likely level, a highest probable level, and the lowest probable level.

As a general rule, the scenario method implies a consistent description of a system's evolution by fixing, through exogenous assumptions, the evolution of the scenario components: those variables characteristic of the system. The components selected by ISER, as well as the assumptions upon which the decisions to select those components lie, will be critically reviewed. Finally, the electricity use projection methodology developed by ISER and the steps involved in its use; namely model design, regression equation and forecasting, will be examined.

Model designs involves the selection of the independent variables which affect model output and the formulation of the mathematical relations between those variables. Estimation of the form taken by the regression equation involves the use of historical data. Limitations in the data may, in some cases, preclude the use of otherwise relevant variables. Availability of data will be studied and a statistical analysis of the model's accuracy and validity will be undertaken.

A summary report on the review of the ISER model and recommendations for further analysis to be undertaken by ISER will be submitted to the Power Authority by the Acres team. Provision has been made for ISER to undertake such additional analyses and may prove to be necessary. The total electrical energy demand projections finally derived from the IER study will form the basis for electric peak load demand forecast (Subtask 1.02) and the preliminary financial and marketing studies (Subtask 11.12), required by the evaluation of alternatives.

(c) Discussion

It is the responsibility of the Acres team to carefully evaluate the steps undertaken by the ISER in developing its energy consumption projections. Undoubtedly, to successfully accomplish subsequent Task 1 work, it is imperative that the Acres team have a thorough understanding of, and a high degree of confidence, in the work of ISER. This can come only by close cooperation between members of Acres team and those involved in the ISER work.

ISER submitted a detailed work plan to the Alaska Power Authority (APA) dated November 14, 1979. This work plan was reviewed and modifications were suggested to ISER. The energy and econometric modeling methodologies and the development scenarios proposed by ISER will be reviewed for the validity of their assumptions following the study issuance on May 15, 1980.

(d) Schedule

Weeks 1 through 26

Subtask 1.02 - Electric Peak Load Demand Forecast

(a) Objective

Derive scenarios describing a reasonable range of load (kW) and load duration curve forecasts for the system through the year 2010. Prepare data in a form adequate for incorporation in the power system model to be developed in Subtask 1.04.

(b) Approach

Based on projections of energy (kWh) consumption as developed by ISER (see Subtask 1.01), annual power (kW) demands for each of the three defined Railbelt Regions will be forecast through the year 2010. The forecasts will include both peak load levels and the shape of the load demand over time in the form of load duration curves. The Load Management potential will be identified and the impact of Load Management measures will be reflected in two of the scenarios: the cost-incentive load management scenario and the legislated load management scenario. Cost implications of applying these scenarios will be identified. The identification process will take into account not only voluntary measures, but also certain forced measures to include time of day pricing (an economic incentive to use energy consumptive appliances during off-peak hours), demand controls (such as devices to limit the maximum amount of electric energy provided to a particular distribution point) and more efficient use of existing system resources (such as providing interties between generating stations or electrical systems which would otherwise independently deal with different peak load requirements). To ensure that the maximum accuracy of the system model is realized, load duration curves will be developed for both typical weekend and midweek days. These data will be produced separately for each of the three geographic areas of the study region and for each of the six consumer groups within each of those regions.

(c) Discussion

As noted in Subtask 1.01, ISER will prepare projections of future energy consumption in the Railbelt area. ISER will not predict peak power demands (kW) or load duration curves. This information will be developed by the Acres team in a manner which is consistent with the economic, social, political and technical assumptions made by ISER when developing their energy consumption forecasts.

It is intended that the forecasts to be developed by the Acres team satisfy the dual purpose of filling out ISER data into a total picutre of electrical demand for the study period and of providing detailed data input to Subtask 1.04 for direct utilization in the system planning model. This required data will include consideration of load shapes on a monthly basis as well as typical daily load shapes for weekday and weekend occurrences.

Load duration curves describe the percentage of time that a power system operates at any fraction of its full power level. Load duration curves can be developed on an annual, seasonal, monthly or even a daily basis. A load duration curve can be interpreted to yield the average power level for the time period described by the curve. The average-to-peak ratio is known as the load factor of the system.

Several methods can be used to produce peak load (kW) forecasts once energy (kWh) consumption predictions have been made. The basic procedure is to divide the energy consumption (kWh) of a given time period by the product of that period's length (in hours) and its load factor to obtain power (kW).

From the above discussion, it is evident that a crucial point in producing credible load forecasts is the development of the load duration curves. The available methods and the degree to which they will be applied to the system under study will be reviewed to determine their suitability to the problem at hand.

(d) Since the subsequent Task 1 work is dependent upon the efforts of this subtask, it is imperative that the data produced by this subtask is accurate, complete and in a readily usable form. A discussion of the methods used, the assumptins and the resulting scenarios (no load management, cost-incentive load management and legislated load management) will be summarized in a report. A panel of outside experts will screen the report and may make recommendations to enlarge the assumptions field and to iterate the forecasting process including the global electric energy projections done by ISER.

For use in the system modelling work of Subtask 1.04, the following data are finally required:

(1) Month-to-annual peak load ratios for full 12-month period.

(2) For typical weekend and midweek days, hourly-to-monthly load ratios, arranged in descending order, month to month.

(3) Per unit peak load ratios associated with the 0, 20, 40 and 100 percent points on the monthly load duration curve month by month.

(4) Peak power level annual.

(5) The year-to-year variations of the quantities 1-4 above.

To remain consistent with earlier work, data outputs will be broken down along the same geographical and consumer lines as the energy predictions of ISER.

(e) <u>Schedule</u>

Weeks 8 through 42

Subtask 1.03 - Identification of Power Alternatives

(a) Objective

Identify and select for detailed evaluation purposes alternative power sources appropriate for inclusion in future Alaska Railbelt Region load-growth scenarios.

(b) Approach

This subtask will be subdivided into further work packages:

- Non-hydro alternatives
- Hydro and tidal alternatives (including Susitna alternatives)
- Added conservation alternatives

These packages will be undertaken concurrently. Each package will include appropriate analyses to identify which energy sources would be viable alternatives to the Susitna Project. The evaluation will also include an initial review of the March 1978 "Analysis of Future Requirements and Supply Alternatives for the Railbelt Region" published by Battelle Laboratories.

In selecting viable alternatives, they will be initially screened based primarily on technical availability, fuel availability, generic impacts, cost, scheduling an risk analyses. At least the following basic factors will be included in the screening process:

- Anticipated demand (location and amount) that the alternative must supply

- The maximum amount of power that could be supplied to the Alaska Railbelt Region by each alternative

- Technical and commercial use availability of the alternative within the study period

- The cost per unit of electricity supplied by each alternative (mills/kWh)

- Construction and licensing schedule of each alternative

- The non-cost impact of implementing each alternative (preliminary safety, health and environmental hazards and concerns)

The risk analysis of the alternatives will be performed under Task 11 (Subtask 11.03 and 11.04).

The intent will be to examine the widest possible range of alternatives using published data. The viable alternatives will be ranked based on a qualitative-quantitative analyses of the above criteria. A multi-disciplinary panel will examine the major assumptions and findings and panel recommendations may generate iterations in the preliminary assessment of the alternatives. The results of the evaluations undertaken in this subtask will produce the system planning model input data required in Subtask 1.04.

(c) Non-hydro Alternatives

The non-hydro alternatives to be examined include "traditional" energy sources such as coal or gas-fired steam turbines, combustion turbines (including combined cycle design), diesel electric systems and nuclear power plants. Studies undertaken to date for the Railbelt Region suggest that development of the Beluga and Nenana coal fields may be a viable alternative source of large quantities of power. Published data already developed by Woodward-Clyde Consultants on behalf of the Golden Valley Electric Association will be used in the proposed study. "Non-traditional" alternatives will include solar generation, wind, biomass, geothermal, and energy from wood and municipal waste. The Alaska Power Administration is presently pursuing a study of the potential offered by wind generation in the Cook Inlet Region. The results of this study will be utilized in the evaluation of non-hydro alternatives.

(d) Hydro and Tidal Alternatives

The hydro alternatives considered will not only involve a single conventional large hydro project but also will include a group of smaller hydro projects with, for instance, a gas-turbine installation to provide firm capacity backup along with conservation measures which could serve to limit projected growth.

Within the Southcentral Railbelt of Alaska, the Susitna and Copper River drainage basins and other small rivers, including Crescent, Chakachatna, Beluga, Yentna, Skiventna Chulitna, Talkeetna, Bradley (Creek) and Love were identified in the 1976 Alaska Power Survey by the Federal Power Commission as having significant conventional hydropower potentials. This study identified 23 projects, including Devil Canyon, Watana and Vee on the Susitna, with a potential installed capacity for all 23 sites of 8,419 megawatts. There are currently indications that the 70 MW Bradley Lake Project in the Kenai Peninsula may be developed in the foreseeable future. Current studies are also being undertaken by the Alaska Power Administration to identify "small hydro" potential.

The above references, in addition to other earlier work by the Bureau of Reclamation and Corps of Engineers and the most recent national Hydropower Study inventory by the Corps of Engineers, will be used in the overall assessment of available hydro potential in the region. The data contained in the previous studies will be used to develop hydro alternatives which could satisfy projected load demands at least as well as the Susitna Project. Published reports on the potential for development of the tidal power resources of the Cook Inlet Region will be reviewed for consideration of this alternative.

At this stage of the study, the Susitna alternative used will be the Corps of Engineers scheme, updated to 1980 prices. A band of confidence applied to this updated cost will approximate the costs corresponding to the Susitna alternatives which will be evaluated in parallel under Task 6: Design Development. A preliminary financial and marketing analysis performed under Subtask 11.12 for the Susitna alternatives will represent an additional input into the preliminary evaluation of this alternative for the generation expansion analysis.

(e) Added Conservation Alternatives

Conservation measures of various kinds may be regarded as "non-structural" alternatives. To the extent that conservation can produce a reduction in total energy demand, it leads to changes in demand projections. The ISER model will be structured to permit consideration of the effects of conservation on demand projections. Some energy conservation measures will be built-in in the total electric energy demand forecasts derived under Subtask 1.01. Additional energy conservation measures will be identified after the ISER study becomes available and will be evaluated as a "non-structural" alternative.

(f) The analysis of electrical energy production alternatives for the Railbelt Region requires input from Subtask 1.02 as well as the forecasting work performed by ISER as described in Subtask 1.01. These efforts predict the anticipated need for power and energy consumed in the Railbelt Region regardless of its ultimate source.

The load duration curves produced in Subtask 1.02 are of key importance to the alternatives study. Depending upon the general shape of the load duration curves, various alternatives may stand out as particularly attractive to meet the future needs of the Railbelt Region.

Concurrent with the development of load duration curves, an evaluation will be made of the amount of energy that can be supplied by each of the technologies considered. This will involve a preliminary review of the estimated amount of total energy and peak power that are available from each resource in Alaska, including such items as coal and oil reserves, solar, wind and tidal patterns and geothermal as well as other hydroelectric resources. The estimates for developing technologies will also include the availability date for commercial use. Preliminary cost estimates will be developed for each technology (cost/unit energy) based on the many existing studies (for example see "California Electricity Generation Methods Assessment Project", 1976). These cost estimates may vary wtih the amount of energy delivered, reflecting the necessity to use scarcer resources.

A scheduling analysis will be conducted to determine when the technology(s) for the alternative will be available and what lead times are necessary for construction. Finally, an evaluation will be made to identify the generic (non-cost) impacts of each alternative. These impacts are likely to include environmental impacts (air quality, water quality and ecology); public health and safety impacts; socioeconomic impacts (such as a "boom-bust" cycle of population during plant construction); and the licenseability of specific alternatives to the extent that no insurmountable legal or environmental barriers are evident.

Non-cost concerns will be organized into a set of attributes for measuring the overall desirability of each alternative and combined with cost and scheduling concerns to evaluate each alternative. Each attribute will have an associated scale (or measure) to identify the level of achievement of each alternative with respect to attribute.

Scales will be designed to be meaningful to decision makers and to be measurable using existing data as much as possible. If no natural scale (such as dollars for the cost attribute) exists, constructed (judgmental) scales will be used. The results of this analysis can be presented in a matrix showing the level achieved on each attribute for each alternative. The assistance of a Review Panel will be utilized in applying the ranking and selection process and performing any iteration studies which may be necessary.

As a result of these global evaluations of alternatives, all viable technologies (or group of technologies) will be selected for a more detailed and comprehensive analysis to be undertaken in Subtask 1.04.

(g) Schedule

Weeks 1 through 40

Subtask 1.04 - Generation Planning Analyses and Selection of Expansion Sequences

(a) Objective

To perform a detailed cost analysis for the alternatives retained, to determine the total system costs of selected future Railbelt Region expansion sequences, including expansion scenarios with and without the Susitna Hydroelectric Project, a decentralized expansion scenario (without Susitna) and other scenarios.

(b) Approach

The detailed cost analysis of each selected alternative will still be based primarily on published studies. The analysis will include the evaluation - for each alternative - of following technical and economic elements:

- Unit Sizes and Years of Availability/Unit Size
- Plant Capital Cost ($/kW)
- Annual Capital Requirements ($/kW/Yr)
- Operating (non-fuel and Maintenance Costs (Fixed-$/kW/Yr, Variable-Mills/kWh)
- Fuel Heat Contents (Btu/unit) and Prices ($/Unit)
- Heat Rates (Btu/kWh) and Fuel Costs (mills/kWh)
- Differential Fuel Cost Escalation
- Scheduled and Forced Outage Rates
- Economic Lifetime of Equipment

The most straightforward method of evaluating the potential economic benefit of a hydroelectric project in a given system expansion scenario is to compare capital investment and system operating costs on an annual basis, throughout the term of the study, for various scenarios, with and without the benefits of the proposed hydro project.

A number of mathematical models are available to facilitate the vast number of calculations involved in this type of study. In simplified terms, the user of such a model provides the program with data which includes the characteristics of the forecasted loads and the characteristics, availability and costs of generation sources which will be available throughout the period of the study. The model then selects the generation sources available to it to satisfy the projected load in the most economical manner.

To evaluate the economics of a given project, a comparison may be made of total annual costs of the various system scenarios on a year-by-year basis throughout the study period. If the system with the hydro project available is less costly throughout the planning period, the project is obviously attractive (though not necessarily selected, because impacts must also be accounted for). Conversely, if this system is more expensive in all years, then the project is unattractive.

It is possible, indeed likely, that the outcome of an economic evaluation would prove not to be so clear cut. It may be that the system incorporating the hydro plant would be more expensive in some years of the study, and less expensive in others, than the systems without that project. In this situation, it would be necessary to perform comparisons between present worth values of operating cost for systems represented by the two scenarios.

Although such a strategy may provide a valid economic comparison, the results may be inconclusive. This is most likely to occur in the case of a hydro project having a capacity which is relatively small when compared to its connected system. The economic comparisons may produce a relatively small difference in two large numbers. This is not valid, however, for the Susitna Hydroelectric Project which is expected to represent an important generation capacity within the system, for the scenarios including the development.

An external multidisciplinary panel will screen the results of the first set of program runs presented in terms of annual operating costs (and of corresponding present worths) per scenario and will provide feedback for subsequent runs. The final results will be presented in the Interim Report for public review, together with a preliminary environmental assessment (Subtask 1.05) of the scenarios generated by the planning program.

(c) Selection of Model

In the search for a usable generation planning computer model, three characteristics of the model are paramount:

- Flexibility -- does the model allow for a varied combination of alternatives?

- Accessibility -- is the model presently available and can it be used with a minimum of learning time?

- Reliability -- is the model actively maintained by its supplier and has it been used by other utility planners?

A preliminary survey of the market has revealed one model which satisfies all three criteria. Other models may be available, but these are generally developed either by or for specific utilities to solve their particular problems or they are so intricate so as to require special training for their use.

The computer model selected by Acres for this study is the General Electric Optimized Generation Program, Version Five (OGP-V). Several of Acres' staff have become familiar with the use of this program on other studies similar to the Susitna alternatives evaluations. The model is currently being used by Acres for the evaluation of small hydro sites in the eastern U.S. Earlier versions of the model, OGP-III and OGP-IV were used in studies performed for the U.S. Army Corps of Engineers in evaluating alternatives for New England Power Supply scenarios through the year 2000. This study was part of the Environmental Impact Statement for the proposed 944 MW Dickey-Lincoln School Lakes Project in Maine.

(d) OGP-V

The OGP-V program combines three main factors of the generation expansion planning decision process: system reliability evaluation, operations cost estimation, and investment cost estimation. The program begins by evaluation of the power system reliability in the first study year by means of one of two methods -- either a percentage-of-reserves calculation or the computation of the loss of load probability (LOLP).

When the system demand level rises to the point at which either the use-specifed reserve level or the LOLP criteria is violated, the program "installs" new generating capacity. The program will add generation capacity from a use-provided list of available sources. As each possible choice is evaluated, the program carries out a production cost calculation and an investment cost calculation, and eliminates those units or combinations of units whose addition to the system results in higher annual cost than other units or combinations. The program continues in this manner until the least-cost system addition combination is determined for that year. In cases where operating cost inflation is present, or where outage rates vary with time, OGP-V has a look-ahead feature which develops levelized fuel and O&M costs and mature outage rates out to ten years ahead of the "present" time. Once the apparent least-cost additions to the system necessary to satisfy reserve or LOLP criteria have been selected, the optimum system is described.

(e) Discussion

Load forecasting and daily load variation data generated in Subtask 1.02 will be used as input to the computer model together with the following technical and economic planning criteria:

- generation capacity and energy reserve requirements

- addition capacity and energy reserve requirements

- technical and economic elements of various alternatives (as presented under paragraph b)

- economic discount rate

- period of analysis

This data will be established in consultation with Alaska Power Authority, other utilities in the Railbelt Region and other pertinent agencies. The analysis will be carried out at the base rate with sensitivity testing over the possible range for selected alternatives. The sensitivity testing will be based mainly on the external panel recommendations.

One of the benchmarks against which the economics of a power generating facility may be measured is the economics of its alternatives. In many cases, it is possible to identify specific alternatives against which a given project may be directly compared. Most generating projects are intended for a specific operating regime within the power system, such as base-, intermediate-, or peak-load operation. For such sources, it is a relatively straightforward task to evaluate the cost of operating a specific alternative.

Hydroelectric projects, due to their hydrologic characteristics, must be evaluated in a somewhat different manner. A hydro project can be subject to significant seasonal variations in its generation capacity. Factors such as rainfall patterns and springtime snowpack runoff can work to make baseload and peaking benefits available from the same hydroelectric project. Also, although initial studies of the Devil Canyon-Watana installations were based upon fifty percent annual capacity factor (1,394 MW, 6,100,000 MWh/yr), some base-load (greater than 80 percent capacity factor) and some peak-load (less than 10 percent capacity factor) energy can be expected to be available. The way in which such additional capacities become available complicates the evaluation of a hydroelectric project.

Conventional base-load plants such as coal-fired or nuclear steam plants are commonly built to take advantage of the economies of scale available to large plants of this type. Conversely, peaking plants are usually relatively small (less than 100 MW). The base-load energy produced by even a large hydro plant may be available only at such a small capacity as to make comparison with the conventional alternatives meaningless. For example, if the Susitna project, with its 1,394 MW output at 50 percent can produce only 125 MW at capacity factors greater than 80 percent, it is difficult to make comparisons with base-load nuclear or coal plants with capacities on the order of 500 MW or larger. In the same sense, hydrologic conditions may make a great deal of capacity available at a given site for very short periods of time as peaking energy. Such large amounts of surplus energy may make meaningful comparisons between the hydro project and its conventional alternatives (combustion turbines) difficult.

Thus, the Susitna Hydroelectric Project will be evaluated in the light of its effect upon the mix of alternatives in the power system and any possible deferment of capital expenditures for other facilities. To properly take into account the capacity variations of the projects, its operation within a power system will be analyzed on a monthly, or at least a seasonal, basis. More detailed analyses could be performed to define exact operating procedures, but such detail is not justified in a long-term planning study.

(f) Schedule

Weeks 42 through 56

Subtask 1.05 - Expansion Sequence Impact Assessments

(a) Objective

To compare, from an environmental standpoint, the consequences of developing the alternative expansion scenarios selected for public review, including historical, socioeconomic and other factors.

(b) Approach

The approach to review and assessment of expansion scenarios will be to primarily utilize existing data, and available aerial photography of the selected or potential sites whenever and wherever sufficient information is available. However, it may be necessary to gather limited site-specific data for the assessments, since the environmental resources of mayn of the more remote portions of the study corridor have not be inventoried. The key to this approach is the use of staff who have an in-depth knowledge of both fish and wildlife habitat requirements and the short-term and long-term effects of construction and operation of various facilities in Alaska.

The environmental consequences of developing alternative energy sources are dependent upon numerous factors including energy source, production method, site location characteristics, site fish and wildlife characteristics, land-use patterns, and facility construction and operation. A thorough assessment of the impacts of generation expansion scenarios is also dependent upon an understanding of the critical (or limiting) habitat requirements of local fish and wildlife during their life history; such as fish overwintering areas, and nesting and feeding habitats of endangered or threatened fauna.

The significant impact-producing actions will vary with the individual alternative being assessed. At times, the selected site location will be the prime factor, while for other alternatives, the short-term or long-term air quality or water quality perturbations, or wildlife habitat degradation may be the overriding factor. Some of the more significant potential concerns are discussed below.

The environmental evaluation of the selected hydroelectric and tidal power development alternatives (if any) will identify the associated potential impact issues, and their relative magnitudes. Such issues will involve the relative sizes of reservoirs and impacts on water quality and fish and wildlife habitats in particular. The environmental analysis will be performed on the basis of available data, which will be compiled for this purpose. Transmission facilities associated with the hydro alternative sites will be included in this environmental analysis.

With coal-fired power plants, such as those associated with the Beluga and Nenana field, the collection of large quantities of coal through surface mining would create environmental concerns. These concerns are related primarily to large-scale, long-term habitat alterations affecting fish and wildlife. The operation of coal-fired plants would also create problems relating to air quality, cooling water discharges, and run-off from fly ash ponds. However, plants can be designed to successfully mitigate (though not eliminate) these concerns.

New gas or oil-fired power plants require construction of pipelines that at least lead to short-term concerns associated with river crossings, wetlands disturbance, and habitat alterations. On-site facilities can cover large acreages, and operation can create air quality problems related to nitrogen emissions and winter steam plumes.

Wood-produced energy would also cause air quality problems such as those currently found in the Fairbanks area. Such plants would furthermore require clear-cutting of vast acreages of timber. This may not be environmentally wise due to the slow regeneration times required for time timber production and hence would lead to long-term wildlife habitat alterations. Potentially severe impacts to stream habitats and local fish populations may also result.

Field investigations will not be undertaken to confirm the potential magnitude of impacts of the alternatives within this preliminary environmental assessment of scenarios.

The impact assessments for the alternative sequences submitted for public review will be presented in the Interim Report, together with the economic evaluations (Subtask 1.04).

Parameters for computing and evaluating the expansion scenarios are presented in Attachment 2.

(c) <u>Land and Water Use</u>

Land ownership in the vicinity of the alternatives will be identified as federal (including agency jurisdiction), state, borough, private and Native Corporation. Land ownership status may be in transition due to the Alaska-Native Claims Settlement Act and State Selection under the Statehood Act. Land management plans and regulations affecting alternatives will be evaluated. The various federal, state and local agencies, and some Native Corporations will have land classification and management systems governing activities that are allowed on those lands and waters being managed. Stipulations concerning allowable activities could affect the feasibility of alternatives. Land and water use patterns (historical, current and proposed) will be documented in order to evaluate impacts and potential use conflicts posed by alternatives.

Unique features in the vicinity of alternative projects, such as recreation areas and aesthetic/visual resources, also will be identified. The presence of popular recreation areas and unusual aesthetic quality may present impact and feasibility problems, particularly when on public lands.

(d) Socioeconomic Characteristics

Demographic data, historic, current and projected, will be evaluated to estimate the impact created by the influx of construction and operations work forces. Employment characteristics of the work force in the vicinity of alternative projects will also help to evaluate positive and negative impacts created by project implementation. This information would include employment and unemployment by region and skill classification, and wage rates (also regional and skill specific).

Financial characteristics of any borough or municipal governments in alternative project areas will be considered. Tax revenue, mill rates, and tax base data will help estimate potential impacts. Housing characteristics, such as available stock (including rental units) and vacancy rates, will be utilized for impact evaluation. Community infrastructure could be impacted by implementing alternatives to the Susitna project. Current loads on infrastructural systems (i.e., electricity, water, sewage) service areas, and system capacity will therefore be considered.

Transportation systems potentially affected by project alternatives will be identified. Data will include current traffic estimates, capacity, area of service, and intermodal connections.

Sociocultural characteristics could be an issue in several project areas. Life style, ethnic traditions and subsistence use patterns of biological resources will be documented.

(e) Archaeological and Historical Resources

Existing archaeological and historical sites will be inventoried in alternative project areas, as available data allow. The State Historical Preservation Office maintains a statewide file of known sites and will be utilized in this effort.

(f) Schedule

Weeks 56 through 66

Subtask 1.06 - Power Alternatives Study - Interim Report

(a) Objective

Prepare power alternatives study Interim Report for Susitna Hydroelectric Project.

(b) Approach

The power alternatives study Interim Report will present economic evaluations and preliminary environmental impacts assessment for expansion scenarios with and without Susitna, as well as for a decentralized alternative scenario documenting the findings of Subtasks 1.01 through 1.05 and including various external panel reviews and corresponding iterations. The "With Susitna" Scenario implies a development of the Corps of Engineers scheme, possibly with an envelope defined around its parameters, to express the likely range in which other Susitna schemes might lie. The Interim Report will be presented at a public meeting for review early in 1981. Public comments may induce at that time the need for refined analyses starting as far back as the global evaluation of alternatives (Subtask 1.03). The reviewed Interim Report will represent the basic document to be considered in the first GO-NO-GO decision process.

(c) Discussion

If, based on the Interim Report preliminary data on costs and impacts, Susitna is not selected by the Optimum Generation Program even when it is a part of the input set, strong evidence will exist to suggest that the decision should and that further study work on Susitna should be stopped i.e., "NO GO", perhaps in favor of more detailed study of another expansion scenario that appears best for Railbelt needs. If, on the other hand, clear advantages can be seen in the "With Susitna" sequence, it is likely that further study will be undertaken.

(d) Schedule

Weeks 58 through 66

Subtask 1.07 - Power Study Panel

(a) Objective

Examine major assumptions, analyze results and make recommendations related to all major study subtasks: electric energy demand forecast, global evaluation of alternatives, cost, risk and scheduling studies, expansion scenario evaluation and preliminary environmental assessments.

(b) Approach

A multidisciplinary panel will be established and the selection of its members will be made by APA. Panel recommendations may induce iterations at main review points within the study. Major screening points occur at the end of Subtasks 1.02 (electric energy demand and electric peak load demand forecast), 1.03 (ranking and elimination of alternatives based on global evaluations) and 1.04 (expansion scenarios generation by OGP).

(c) Discussion

The present proposal (cost estimates and schedules) is based on no more than one iteration at each review point.

(d) Schedule

Weeks 40 through 58

TASK 1 - SECOND PART

POWER STUDIES, 1980/81

(i) Objectives

To study the financial and marketing aspects, to complete a preliminary environmental impact analysis, to complete a risk analysis, to refine the cost and schedule, and to perform a sensitivity analysis on selected expansion scenarios with and without the Susitna Project (including decentralized development scenarios). Optimum expansion scenarios will be identified and presented for public comment and to support the second GO-NO GO decision process as whether to proceed with license application for the Susitna Hydroelectric Project.

(ii) Output

The output of Task 1 (Second Part) will be the Final Report presenting the analyses and studies completed under this Task, including methodology used, final panel and public reviews, Acres recommendations and the Authority decision.

A preliminary report identifying optimum expansion scenarios will be presented for public review in March 1982. The resulting comments will possibly lead to iterations of the study process. The final report will include Acres response to the review process and will provide the technical support for the second GO-NO GO decision process.

(iii) List of Subtasks

Subtask 1.04 - Generation Planning Analyses and Selection of Optimum Expansion Sequences
Subtask 1.05 - Environmental Impact Assessment
Subtask 1.06 - Power Alternative Study - Final Report
Subtask 1.07 - Power Study Review Panel

(iv) Scope Statement

The main purpose of Task 1 (Second Part) as discussed in Section (ii) above is the selection of viable expansion scenarios with and without the Susitna Project to meet the future electrical needs in the Railbelt area and to identify the optimum ones based on more detailed studies.

The detailed Task 1 studies will use the data generated as part of Subtask 6.01 - 6.08 studies of hydroelectric developments within the Susitna River Basin, including the detailed evaluation of the tunnel alternative, the Devil Canyon site, the Watana/Devil Canyon staged development, the preliminary Watana Dam and Devil Canyon Dam alternatives, the preliminary financial and marketing study (Subtask 11.12), the preliminary environmental assessment of impacts in the socioeconomic, archeological - historical resources and land use areas (parts of Subtasks 7.05, 7.06 and 7.07), and preliminary risk and scheduling analysis (an expansion of Subtask 11.04) will be completed. Based on these more precise data, new runs of the OGP Program (Subtask 1.04) will be completed to generate updated expansion scenarios which include alternative Susitna developments.

The work done under the first part of Task 1 (year 1980/81) will permit the selection of viable expansion scenarios without the Susitna Project (including a decentralized scenario). However, the level of detail relative to the non-Susitna expansion scenarios will also be updated.

Next, a new evaluation of the scenarios will be conducted to rank both groups of expansion sequences - with and without the Susitna Project. These in-depth evaluations will consist of:

- a financial and marketing analysis, to be performed as part of Subtask 11.12;

- an environmental impact assessment, essentially an extension of the Subtask 1.05, covering parallel activities to those included under Task 7 but applied to alternative scenarios;

- risk and scheduling analyses, basically an increase in the scope of work of Subtasks 11.03 and 11.04.

The results of the above evaluations will undergo a sensitivity analysis, and will integrate the multidisciplinary panel recommendations (Subtask 1.07).

Preliminary and Final Reports will be written, revised and updated under Subtask 1.06.

Subtask 1.04 - Generator Planning Analyses and Selection of Optimum Expansion Sequences

(a) Objective

To determine the optimum system expansion scenarios with the Susitna Hydroelectric project to select viable expansion scenarios with and without Susitna for detailed assessment, to identify the optimum expansion scenarios based on the detailed assessment and on sensitivity analysis performed with the results of the above assessments.

(b) Approach

The total system cost of expansion scenarios will be evaluated using more detailed data generated for this phase of Task 1. The General Electric Optimized Generation Program, Version Five (OGP-V) would probably be used for the purpose. At that time, the detailed studies performed under Task 6 (Subtasks 6.01---6.08) will be available; also available will be preliminary financial marketing studies and cost-risk-scheduling analyses performed under Task 11 as well as preliminary environment assessments. All the above parallel studies will be input into the analyses thus representing a key reiteration processes regarding level of detailed analysis to be performed within this study. This detailed analyses will permit a scenario selection process based on actual (1981 level) Susitna Project economic - financial characteristics and environmental impacts.

The entire array of expansion sequences, both with and without the Susitna Project, will be studied in detail as follows:

- an in-depth financial and marketing assessment will be conducted under Task 11

- a detailed environmental impact assessment of the expansion scenarios without Susitna Project will be performed

- a risk and scheduling analysis of all the expansion sequences will be conducted under Task 11

- a sensitivity analysis based on the results of the above studies will conclude the in-depth scenarios assessment, and iterations--where appropriate--will be made.

The multidisciplinary external panel of experts will screen the assessment of expansion scenarios and will present its recommendations. The assessments, the results of sensitivity analysis and the panel recommendations will permit the identification of the optimum expansion scenarios to be presented for public review.

(c) Discussion

Iteration after detailed marketing, financing, cost-schedule, risk and environmental studies may prove necessary as a basis for the sensitivity analysis. The multidisciplinary panel may itself induce iterations resulting from its recommendations. The demand energy itself may change as a function of the way in which generating capacity comes on line to satisfy the demand. Peak loads and load duration curves may also be modified, especially as the industrial-commercial sector takes a particular shape and becomes a significant entity. Ongoing ISER studies may yield new demand and load data. The work to be performed under this subtask may require numerous iteration as the optimum expansion scenarios are identified and submitted for public review.

(d) Schedule

Weeks 51 through 104

Subtask 1.05 - Environmental Impact Assessment

(a) Objective

To assess and compare, from an environmental standpoint, the consequences of developing expansion scenarios to meet future electric demand needs in the Railbelt area.

(b) Approach

An increased level of detail, as compared to the environmental studies performed under the first part of Task 1, to be completed. Specifically, it will be necessary to gather more site specific data for the assessment of the scenarios which include such alternatives as coal-fired plants using the Beluga and Nenana coals, gas or oil-fired power plants using local resources, wood- or peat-fired steam-electric plants or wind-driven turbines installed in clusters.

The socioeconomic analysis will include, in addition to a literature search, a preliminary socioeconomic impact study based on a profile development and intended to identify the significant scenario impacts. Finally, an evaluation of these significant socioeconomic impacts will be performed. The analysis will represent an extension and application of parts of Subtask 7.05 to alternative expansion scenarios.

The cultural resources investigation will identify archeological and historical sites within the proposed development sites included in the alternative expansion scenarios. The site inventory will be based on the existing statewide files and on short reconnaissance trips on field.

To evaluate the land use impacts, the land types covered by various developments included in alternative expansion scenarios will be identified. Their historical, current and proposed use pattern will be investigated in order to evaluate impacts and possible conflicts posed by developing the alternative expansion scenarios. Special features in the areas covered by the developments included in the alternative expansion scenarios, such as recreational areas and aesthetic and visual resources, will also be identified by reconaissance trips on field, as they may represent heavy impacts, especially when on public lands. The analysis will represent an application of parts of Subtask 7.07 to alternative expansion scenarios.

Additional factors to be considered include institutional factors, licensing prospects, public health and safety aspects as well as State and Federal regulations (i.e. Fuel Use Act, Antiquities Act, etc.)

(c) Discussion

The socioeconomic, cultural and land use impact analyses performed under this subtask will represent an extension of the effort in Subtask 1.05, under the first part of Task 1. The impacts identified, inventoried and evaluated for the alternatives making up a scenario will be superimposed in order to represent the total scenario impact.

Additional activities to be completed will consist mainly of site-specific evaluations such as reconnaissance trips to the field and in a further evaluation of the most significant socioeconomic impacts.

(d) Schedule

Weeks 60 through 90

Subtask 1.06 - Power Alternative Study - Final Report

(a) Objective

Prepare power alternatives study Preliminary and Final Report for Susitna Hydroelectric Project.

(b) Approach

The power alternatives study Preliminary Report will present few optimum expansion scenarios identified as a result of detailed studies of all selected expansion scenarios including Susitna Basin alternatives. The selection will be based on financial and marketing aspects, environmental impacts, risk analyses and cost and schedule refinements and a sensitivity analysis. The Preliminary Report will be issued for public review in March 1982. Public comments may induce several iterations, requiring refined analyses starting as far back as the reevaluation of future electric energy demand forecast (Subtasks 1.01 and 1.02).

(c) Discussion

If, based on the Preliminary Report detailed analyses on costs and impacts, the Susitna Project is not included in the optimum expansion scenarios, the decision should obviously be "NO GO" and all work will be stopped. If Susitna is indeed included as a development within one or more of the optimum expansion scenarios identified and the decision is "GO", a Final Report will be issued incorporating all the findings, analyses and studies performed under Task 1. In parallel, detailed studies on the Susitna Hydroelectric Project will continue and the licensing application will proceed.

(d) Schedule

Weeks 100 through 114

Subtask 1.07 - Power Study Review Panel

(a) Objective

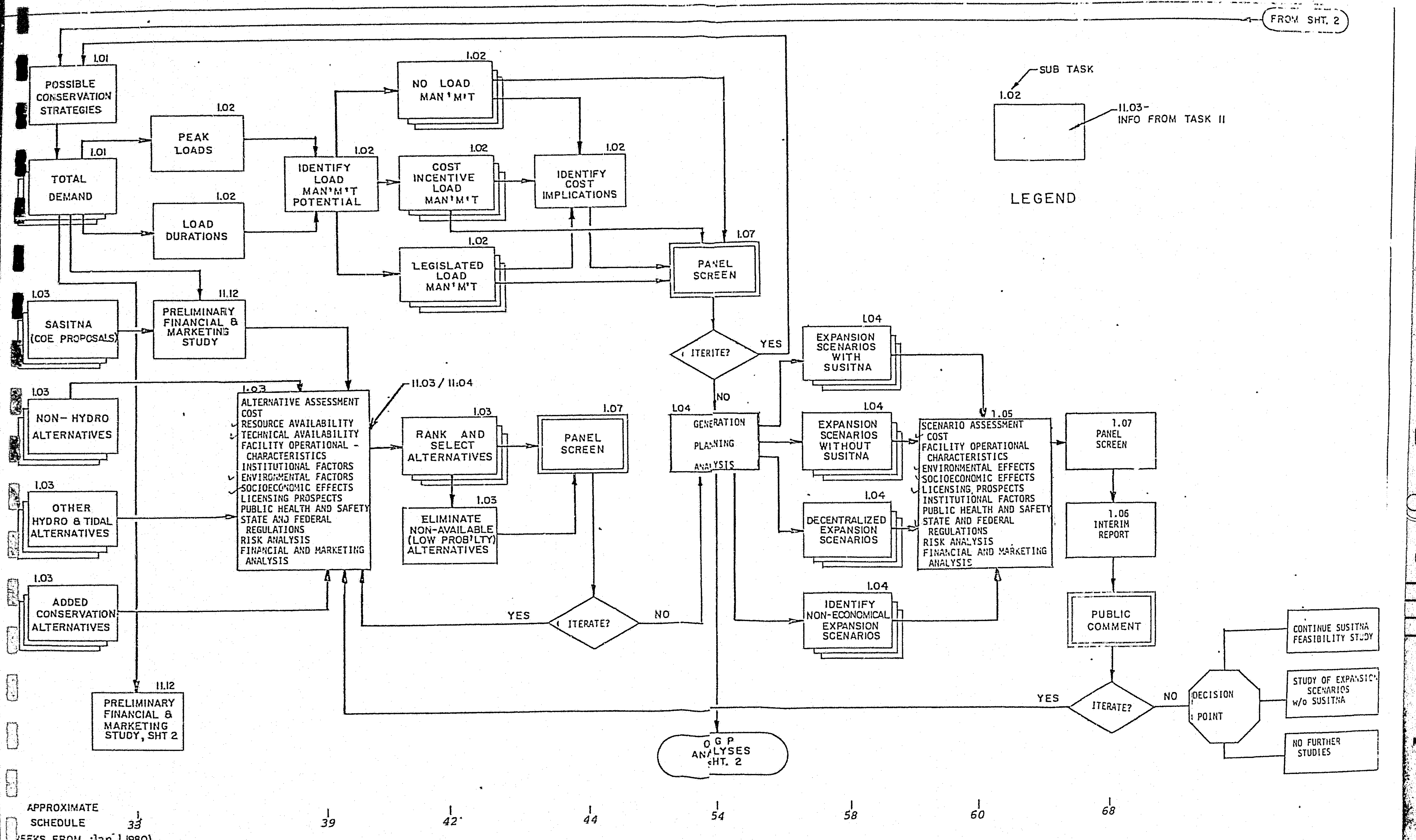
Examine major assumptions, analyse results and make recommendations related to the selection of expansion scenarios (with and without Susitna).

(b) Approach

The multidisciplinary panel established and selected in 1980 by APA will have a major screening role at the end of Subtask 1.05. Panel recommendations related to the detailed study of the expansion sequences for financial and marketing aspects, environmental impacts, risk analyses and cost and schedule refinements may induce iterations which will be handled mainly as additional sensitivity analyses. The panel is expected to produce direct input into the Final Report development.

(c) Schedule

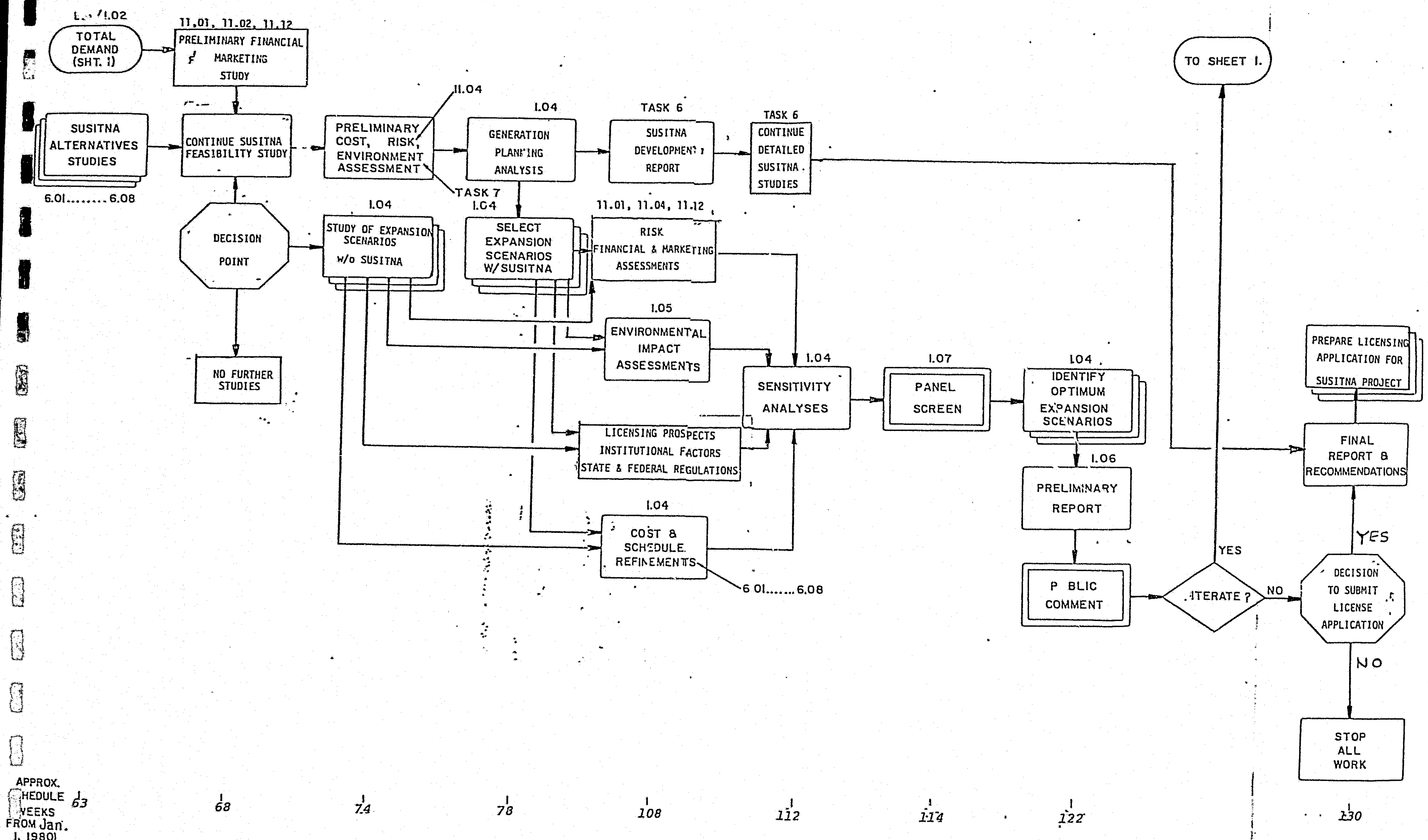
Weeks 90 through 98



SUSITNA HYDROELECTRIC PROJECT- PLAN OF STUDY

TASK I- POWER STUDIES / FIRST PART

ATTATCHMENT 1 SHEET 1 OF 2



(1) INCLUDES DECENTRALIZED SCENARIOS

SUSITNA HYDROELECTRIC PROJECT—PLAN OF STUDY
TASK 1—POWER STUDIES/SECOND PART
ATTACHMENT 1 SHEET 2 OF 2

Attachment 2

PARAMETERS FOR COMPARING AND EVALUATING EXPANSION SEQUENCES

A. COST PARAMETERS

1. Total system costs
2. Costs to consumer (typical household)
3. Cost trend (stable, subject to inflation, cost eventually decreases after amortization,etc.)
4. Ownership/control (municipal, utility, state)
5. Uncertainty and risk regarding cost (reflecting history of cost overruns in constructing the alternatives in this expansion sequence)

B. SAFETY AND HEALTH PARAMETERS

1. Catastrophic failure impacts (probability and costs)
2. Health effects from pollution (probability)
3. Interruption of service (probability)

C. ENVIRONMENTAL PARAMETERS

1. Noise
2. Smell
3. Visual (from populated areas, from air, etc.)
4. Water quality impacts
5. Solid waste impacts
6. Impacts on fish (relative to the size and value of the resource)
7. Impacts on birds (relative to the size and value of the resource)
8. Impacts on wildlife (relative to the size and value of the resource)
9. Impacts on important ecosystems
10. Water consumption (relative to supply)
11. Property damage

D. SOCIOECONOMIC PARAMETERS

1. Extent of generation system diversification
2. Employment impact
   (a) construction (number, type and from where)
   (b) operation
3. Relocations necessary
4. Surplus power
   (a) description
   (b) probable effect on growth, industry relocation, etc.
5. State energy independence
6. Regional settlement patterns

PARAMETERS FOR COMPARING AND EVALUATING EXPANSION SEQUENCES (Cont'd)

E. OTHER PARAMETERS

1. Fossil fuel consumed
2. Efficiency (ratio of energy out to energy in)
3. Natural systems altered
4. Plan flexibility

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

INTERIM REPORT OUTLINE (MAY 1981)

CHAPTER 1 - INTRODUCTION
- 1.1 - Project Description
- 1.2 - Interim Report Content

CHAPTER 2 - SUMMARY
- 2.1 - Electric Energy Demand Forecast
- 2.2 - Electric Peakload Demand Forecast
- 2.3 - Existing Generation Plan
- 2.4 - Preliminary Evaluation of Alternatiaves for Future Generation Plan
- 2.5 - Further Evaluation of Alternatives
- 2.6 - OGP Analyses and Formulation of Expansion Sequences
- 2.7 - Preliminary Environmental Assessements
- 2.8 - Acres Recommendations

CHAPTER 3 - ELECTRIC ENERGY DEMAND FORECAST

- 3.1 - Introduction
- 3.2 - Past and Present Electric Energy Demand
  - 3.2.1 - Anchorage - Cook Inlet Area and Kenai Peninsula
  - 3.2.2 - Fairbanks - Tanana Valley Area
  - 3.2.3 - Glenallen - Valdez Area
- 3.3 - Methodology for Electric Energy Demand forecasting
  - 3.3.1 - Existing (recent) Forecasts and Data Base used
  - 3.3.2 - Review of existing Electrical Energy Demand forecasting methods
  - 3.3.3 - Qualitative and Quantitative Analyses of Data Base for Electric Energy forecasting in Alaska
  - 3.3.4 - Selection of the most suitable method for Electric Energy forecasting in Alaska. Basic Assumptions.
- 3.4 - Future Electric Energy Demand Scenarios
  - 3.4.1 - Impact of Conservation Measures on Electric Energy Demand
    - 3.4.1.1 - Residential (weatherization, house heating efficiency improvement, solar home heating; electric appliances efficiency improvement)
    - 3.4.1.2 - Commercial (improvement of electric energy supply efficiency in existing buildings; more stringent codes for new buildings)
    - 3.4.1.3 - Industrial (cogeneration)
  - 3.4.2 - High Probable Future Demand Scenario
    - 3.4.2.1 - Anchorage - Cook Inlet Area
    - 3.4.2.2 - Fairbanks - Tanana Valley Area
    - 3.4.2.3 - Glenallen - Valdez Area

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

FINAL REPORT OUTLINE (MAY 1982)

CHAPTER 1 - INTRODUCTION
- 1.1 - Project Description
- 1.2 - Report Content

CHAPTER 2 - SUMMARY
- 2.1 - Electric Energy Demand Forecast
- 2.2 - Electric Peakload Demand Forecast
- 2.3 - Existing Generation Plan
- 2.4 - Preliminary Evaluation of Alternatiaves for Future Generation Plan
- 2.5 - Detailed Evaluation of Selected Alternatives
- 2.6 - Susitna Hydroelectric Project Alternatives
- 2.7 - OGP Analyses and Formulation of Expansion Sequences
- 2.8 - Acres Recommendations

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- 3.1 - Introduction
- 3.2 - Past and Present Electric Energy Demand
  - 3.2.1 - Anchorage - Cook Inlet Area and Kenai Peninsula
  - 3.2.2 - Fairbanks - Tanana Valley Area
  - 3.2.3 - Glenallen - Valdez Area
- 3.3 - Methodology for Electric Energy Demand forecasting
  - 3.3.1 - Existing (recent) Forecasts and Data Base used
  - 3.3.2 - Review of existing Electrical Energy Demand forecasting methods
  - 3.3.3 - Qualitative and Quantitative Analyses of Data Base for Electric Energy forecasting in Alaska
  - 3.3.4 - Selection of the most suitable method for Electric Energy forecasting in Alaska. Basic Assumptions.
- 3.4 - Future Electric Energy Demand Scenarios
  - 3.4.1 - Impact of Conservation Measures on Electric Energy Demand
    - 3.4.1.1 - Residential (weatherization, house heating efficiency improvement, solar home heating; electric appliances efficiency improvement)
    - 3.4.1.2 - Commercial (improvement of electric energy supply efficiency in existing buildings; more stringent codes for new buildings)
    - 3.4.1.3 - Industrial (cogeneration)
  - 3.4.2 - High Probable Future Demand Scenario
    - 3.4.2.1 - Anchorage - Cook Inlet Area
    - 3.4.2.2 - Fairbanks - Tanana Valley Area
    - 3.4.2.3 - Glenallen - Valdez Area

D - LETTERS FROM APA TO ACRES DATED
JUNE 13 AND 30, 1980

00328

ALASKA POWER AUTHORITY

WEST 4th AVENUE - SUITE 31 - ANCHORAGE, ALASKA 99501

Phone: (907) 277-7641
(907) 276-2715

June 13, 1980

Mr. David C. Willett
Vice President
Acres American Incorporated
900 Liberty Bank Building
Buffalo, New York 14202

Dear Dave:

In compliance with Articles I and XIII of our Susitna Project agreement dated December 19, 1979, we are hereby notifying you of an anticipated change in project scope and directing that certain work be stopped immediately pending final disposition of the issue.

The Alaska Legislature has directed that the "Power Market and Alternative Supply Studies be deleted from the Acres contract for Susitna Feasibility Studies". This action arose through no fault of Acres but rather as a result of a perception of possible conflict of interest that could potentially bias the results of the alternatives study.

In keeping with the Legislative intent and after consultation and direction from the Office of the Governor, we are directing that the following actions should be taken:

1. Continue and complete subtasks 1.01 and 1.02 as per the existing Plan of Study and subcontract with Woodward Clyde Consultants. The cost of this work shall not exceed $82,900.

The work on these subtasks should include consideration of and recommendations regarding suggestions offered at the utility and public workshops of June 10 and 11, 1980. A partial list of issues raised is included as Attachment 1. Attachment 2 is a set of written comments from Mr. Bob Hufman of Golden Valley Electric Association. Additional written comments from workshop attendees will be forwarded upon receipt. The product of subtasks 1.01 and 1.02 should include a plan for forecast improvement.

2. Stop work on subtask 1.03 until further notice. That further notice is expected within two weeks. If later requested to continue work on subtask 1.03, you will only be directed to develop technical parameters for each alternative; the work shall not include any evaluation or screening of alternatives. In the meantime, please provide a budget

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JWH - pl. discuss with A.V. and me
I will prepare a draft response for Dave's signature
R

allocation for subtask 1.03, based on the expanded post-Tussing scope as presented in your May 7, 1980 letter, that shows costs allotted to development of technical parameters on the one hand and alternative evaluation and screening on the other.

3. Discontinue any planning for and do not initiate the following subtasks: 1.04, 1.05, 1.06, 1.07, 11.03, and 11.12(new).

Upon final direction from the Office of the Governor, we shall prepare a draft contract amendment describing the reduction in scope, the appropriate fee adjustment, the changes in estimated cost, and any change in completion schedule that may result.

Sincerely,

FOR THE EXECUTIVE DIRECTOR

Terry J. McGuire

Terry J. McGuire
Director of Finance

Encl.

RECEIVED JUL 7 1980
CWC LS File

ALASKA POWER AUTHORITY

333 WEST 4th AVENUE - SUITE 31 - ANCHORAGE, ALASKA 99501

Phone: (907) 277-7641
(907) 276-2715

June 30, 1980

Mr. Dave Willett
900 Liberty Bank Bldg.
Buffalo, New York 14202

Dear Dave,

We have now received official word on the Susitna Alternatives Study (attached). Work on subtasks 1.03 through 1.06 and on 11.03 should be halted on a permanent basis. We request the following:

1. Comprehensive and final summary of expenses by subtask for Task 1 and subtask 11.03.

2. Invoice for costs of termination of work underway, if any.

3. Cost estimate for termination report on subtasks 1.03 through 1.06 and 11.03.

4. Information requirements from the now seperated alternatives study needed to maintain our Susitna program schedule.

As directed previously, please complete subtasks 1.01 and 1.02 in accordance with the POS and existing contracts with Woodward Clyde.

Sincerely,

for Robert A. Mohn
Director of Engineering

Attachment

ALASKA POWER AUTHORITY
SUSITNA
FILE P5700
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SEQUENCE NO.
1362

ACTION	INFORM.	DISTRIB.	INITIAL
	XC	DCW	
	XC	JDL	
	XC	C.A.D.	
	XC	JBG	
	1	JWH	
		JPB	
	2	PGH	
XC		BNS	
		SNT	
		DVL	
		MPV	
	4	HRC	
	3	TWG	
	XC	EJC	7/7
XC		NHC	
	5	FILE	

C.A.D. has action on response.

NHC should notify the subcontractors.

S. HAMMOND
GOVERNOR

STATE OF ALASKA
OFFICE OF THE GOVERNOR
JUNEAU

June 24, 1980

Mr. Charles Conway
Chairman, Alaska Power Authority
333 West 4th Avenue, Suite 31
Anchorage, Alaska 99501

Dear Mr. Conway:

This letter is to inform you of the Governor's decisi approve a recommendation made by the Governor's Budget Committee (BRC) concerning implementation and manageme the Railbelt Power Market and Supply Study. The decisi was reached following the frank and open discussion held by all interested parties on Thursday, June 19th in the Governor's Conference Room.

333 WEST 4

The decision is composed of two parts. Regarding the implementation of the study, the BRC decided that ACRES and its subcontractors should be requested to terminate all Task I work immediately. The only exception is Subtask 1.01 and 1.02 work substantially completed by ISER and Woodward-Clyde, including review of ISER's demand forecast and preparation of peak load forecasts.

Regarding management of the Study, the BRC has decided to retain a Project Manager in the Governor's Office to manage the contract and insure coordination among the interested parties.

To provide for the development of the Power Market and Supply Study, the BRC intends to establish a Committee consisting of the Chairman of the Alaska Power Authority and the Directors of the Divisions of Energy and Power Development, Policy Development and Planning, and Budget and Management. The responsibilities of this Committee include:

1. selection of the Project Manager

2. design of the study Request for Proposals (the study must be designed to integrate with the Susitna Plan of Study and avoid delays to that effort)

3. selection among bidders of contractor
4. policy oversight

The BRC has chosen this approach due primarily to the strong mandate given the Governor's Office by the Legislature to address the issues energy policy and administration. This decision is based upon the clear legislative intent to separate this study from the ACRES contract and in no way reflects upon the professional ability or quality of ACRES work. The Governor's Office received several appropriations for energy policy work and also received a letter from the Speaker of the House requesting that energy issues receive special attention by the Governor's Office. Given the pivotal nature of the Railbelt Power Market and Supply Study, it was felt that this study should be managed within the Governor's Office by a Project Manager able to devote full time to this study and coordination among the concerned agencies.

Sincerely,

Jerry Reinwand

Jerry Reinwand
Executive Assistant
to the Governor

E - MINUTES OF MEETINGS ON JANUARY 7, 1980 AND FEBRUARY 20, 1980

Meeting Notes: January 7, 1980, ISER Offices, Anchorage

Attendees:	Scott Goldsmith	ISER
	Jerry Lee Huskey	ISER
	Jim Landman	Acres
	Craig Kirkwood	WCC

These notes were prepared by Craig Kirkwood. Unless otherwise noted, the comments and opinions expressed are those of Scott Goldsmith.

I. The MAP model

- developed over a six year period under NSF support
- has been used for
  - policy analysis (elimination of income tax)
  - econ. impact anal. of large scale projects (gas line)
  - econ. projections (popu. & unemp. in 1990)
- components
  - econ. projections
    - employment, residential
    - exogenous
      - employment in petroleum, commercial
  - demographic
    - sectors
      - military (25,000 uniformed)
      - natives (70-80,000)
      - civilian non-native
    - exogenous
      - military
      - exogenous native growth rates
    - civilian non-native projected based on economic activity (including in-migration)
  - gov't.
    - gov't revenues projected
    - expenditures projected
    - generally assumes available money will be spent

state, local gov't. 30,000 out of 100,000 (employment)

- data base:

  1961-1978

- output:

  on an annual basis

- regional aspects:

  - originally 2 models were built

    - aggregated; 7 sectors (problem - 400,000 people, half in greater Anchorage. Also cumbersome to use)

  - revision underway - will attempt to estimate shares of total state in regions of interest.

II. Other Economic Models of Alaska

- short-run forecasting (2 yrs.) - dept. of com
- short-run forecasting - dept. of labor
- I/O model not appropriate because not much interaction between sectors or manufacturing

III. Possible Alternatives to the Susitna Project

- railbelt has potential for:

  oil, gas, coal, hydro

- coal - probs. are environmental
  no good cost estimates

- gas - primary current Anchorage source; cheap
  - uncertainties on future supply, fed. gov't. regulations (could attempt to get exemptions from these)

- oil - used in Fairbanks (from pipeline)
  - probably expensive for Anchorage

- hydro - 2 small projects supply Anchorage; another being built

- The relative desirability of the alternatives depends on national and international developments, however, coal vs. hydro seems to be the decision for the long-run.

- The choice will depend on the preferred space heating fuel.

IV. The Select Legislative Committee

Brian Rogers, Fairbanks (conservation)
Hugh Malone (cost/effectiveness)

V. Difficulties with Projecting Electric Energy Demand for Alaska

- economy very small, backward
- future size heavily dependent on a few exogenous variables
    - petroleum industry
    - state gov't spending (oil tax money)

VI. ISER Projections:

- preliminary toward end of Feb.
- more final mid-to late-March
- main difficulty (time-consuming) is getting agreement on assumptions

MEETING NOTES: Feb. 20, 1980 11 a.m. - 5:20 p.m., WCC Offices, San Francisco

Attendees: Scott Goldsmith, ISER
Peter Sandor, Acres
Gary Smith, WCC
Perry Sioshansi, WCC
Craig Kirkwood, WCC

The attached notes were prepared by Craig Kirkwood. Unless otherwise noted, the comments and opinions expressed are those of Scott Goldsmith.

AGENDA

February 20, 1980 Meeting--Acres, ISER, WCC

I. Review of the roles of everybody:

-- ISER
-- Acres
-- WCC
-- Others

II. Review of existing models of Alaska economy

III. Review of alternative potential economic and total electricity demand projecting techniques

IV. Review of status of ISER modeling/analysis work, and estimated schedule

V. Review of ISER-directed meeting of 2/15/80

VI. Discussion of ISER modeling/analysis work:

-- general structure of models
-- feedback of energy prices and availability on Railbelt economic development
-- interfuel substitution (including pricing of alternative fuels and escalation rates)

I. Agenda Item I: Review of the roles of everybody.

A. WCC's role (presented by Kirkwood): primarily interested in getting defensible results from ISER as a basis for estimating load duration curves.

B. Sandor's role (presented by Sandor):

-- translator between forecasters and engineers

-- to assure ISER & WCC activities fit into overall Acres Susitna work

C. ISER role:

-- Background--a subcommittee of 2 from the state legislature wanted a check on the Alaska Power Authority's (APA) Susitna work

- they hired many consultants for a short period of time (this work is behind schedule)
- ISER was one of these

-- ISER is projecting energy demand through 2005. Legislature wanted:

- check on APA
- tool for study of conservation-oriented legislation

-- It was decided to have ISER do the forecasting for APA as well.

-- ISER's work is being reviewed by Energy Probe, WCC and Brad Tuck.

D. Other Consultants of Particular Interest:

-- Arlon Tussing may have best overall understanding of energy issues in Alaska of anyone.

-- Greg Erickson doesn't have much formal background in the area, but he has a good understanding of the practical issues.

-- Alaska Center for Policy Studies is an umbrella organization for several engineers and political (conservation) activists --especially the Alaska Public Interest Research Group.

-- These studies are all short term, but other similar studies will probably continue in the future.

-- The Alaska Div. of Energy & Power Development also should have some role in energy generation planning, but it hasn't been too active.

E. Final Comment: The needs of APA and the legislature with regard to ISER's study are somewhat different. In particular, the legislature doesn't need a forecast as much as it needs to realize that by its decisions it can determine what fuels will be used in the future.

II. Lunch--during which the history of the Susitna project was discussed.

III. Agenda Item I continued:

The legislature needs forecasts for only a few benchmark years, while Acres wants much more detail. ISER feels it would be on weak grounds providing this level of detail.

IV. Agenda Item II: Review of existing models of Alaska economy

A. Three econometric models of the state exist:

-- ISER's MAP model

-- Two state agency models (neither is designed for long-range forecasting)

- Department of Commerce
- Department of Revenue

B. There is also an input-output model somewhere (Washington State?)

C. Due to the ongoing structural changes in the Alaska economy the I/O model is not appropriate for use on the Susitna project. Thus, by process of elimination, the MAP model was selected for use.

V. Agenda Item III: Review of alternative potential economic and total electricity demand projecting techniques

A. The growth of Alaska will be driven by resource development. Thus, the selection of an economic and total energy demand projection technique becomes a question of how to best predict this development.

B. There are two broad approaches to doing this:

-- Examine the menu of possible resource development projects and use these as a basis for the projections. The problems with this approach are:

- it is myopic; it is difficult to think of possible projects in the distant future
- it doesn't show the (possibly significant) aggregate affects of many small projects

-- Extrapolation based on historical data. This can capture past interactions in the economy well, but can't explicitly handle structural changes in the economy.

C. ISER would like to combine the best features of each of these approaches; i.e., use a scenario/project approach to handle possible structural changes but include extrapolation to overcome myopia problems. There was no discussion of how this combination would be done.

D. Techniques for projecting total energy demand

-- Extrapolation: The problem with using this in the Railbelt is that the basic structure of electricity use has changed significantly over the past few years (particularly the per cent of households hooked up to electricity and the electric use per hook-up).

-- Econometric: The major problem is the lack of sufficient data to establish the required mathematical relations. In addition, Goldsmith is skeptical of the validity of the approach for this use.

-- End-use: The major problem is similar to that with using a scenario/project approach to economic forecasting--it is myopic. An advantage is that it is straightforward to check the model against current data.

-- Econometric end-use: An econometric model could be used to predict the saturation rates for the end-use model. However, ISER doesn't currently have the required data for the Railbelt.

VI. Agenda Item IV: Review of ISER modeling/analysis work, and estimated schedule.

A. ISER, like the other consultants to the Alaska legislature, is behind schedule. The deliverables due to date (and not delivered) were mostly boilerplate.

-- To attempt to de-fuse possible future criticism of ISER's work by informing interested parties about the work and developing a concensus on the economic development scenarios to be used by ISER.

-- To conduct an experiment to see what information could be obtained from the group by non-traditional means.

B. Meeting was attended by 20 to 25 people (economists and some others):

-- Most of the attending economists work for the state.

-- However, there was still a surprising diversity of views.

C. Meeting had two parts:

-- Discussion of the structure and assumptions for ISER's modeling. There was little response from those present, and most of it was in the form of requests for information rather than critical comments.

-- An attempt to elicit feelings of those present regarding three basic economic variables for the year 2000:

- input variables for ISER models: level of real government spending and employment in resource development activities

- output variable from ISER model: state population

D. Elicitation process:

-- The elicitation was to have been done twice, the first time with little data. The results of this elicitation were presented to the group along with some preliminary MAP model output. There was to be a second elicitation following this presentation; however, most of the attendees views didn't change following the presentation.

-- The purpose of the elicitation was not so much to get specific numbers as to gain insights from the discussion during the process.

VIII. <u>Agenda Item VI</u>: Discussion of ISER modeling/analysis work

A. The MAP model

-- Output: annual outputs in three sectors:

- demographic
- economic
- fiscal

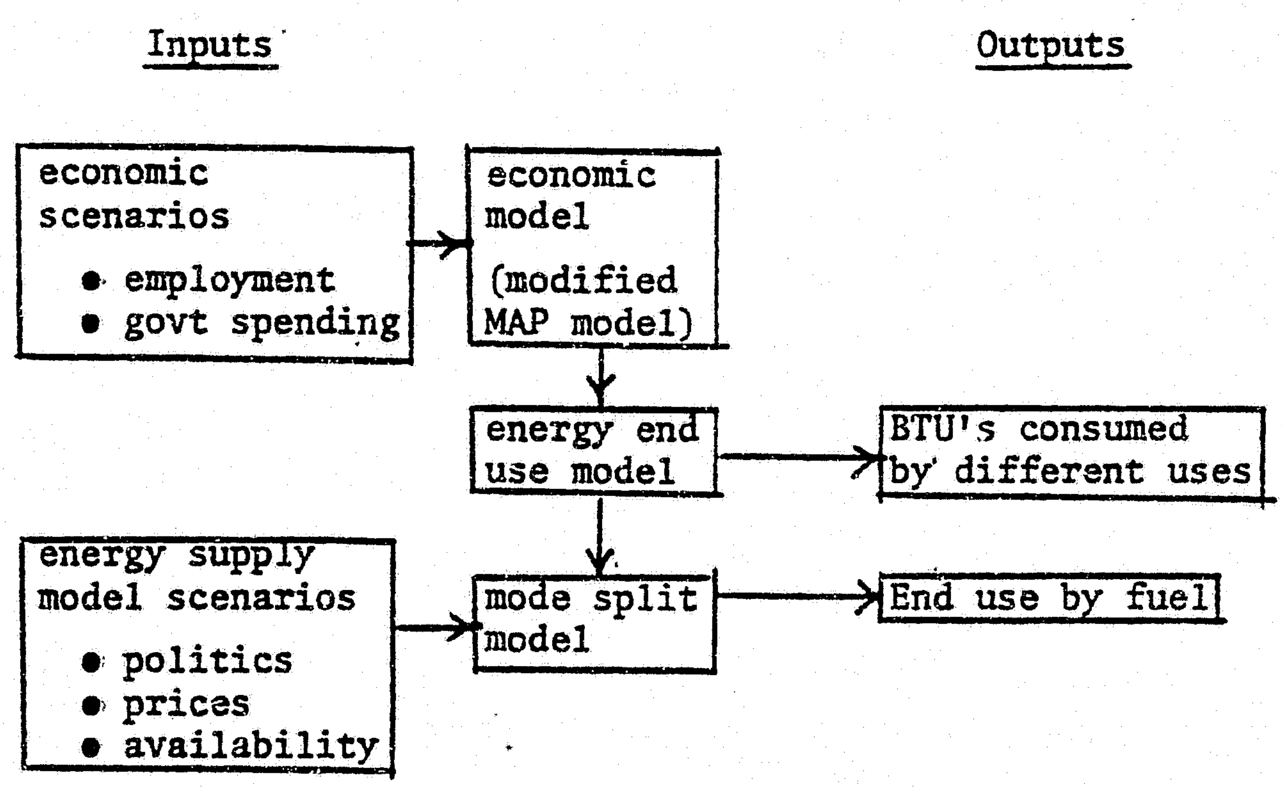
-- The model does no optimization

B. The basic approach to generating energy demand is to do this for <u>benchmark</u> years rather than for every year.

C. Structure of the ISER modeling effort.

-- There seemed to be considerable confusion in everyone's mind about how the various parts of the ISER modeling effort fit together.

-- After some discussion the following was agreed to as representing the structure:



-- There is no feedback in the model from end use to price/availability.

D. At the moment the mode split model is not developed, and the best method to use is not clear.

IX. The meeting adjourned at 5:20 p.m.

F - NOTES ON MEETING ON MARCH 20, 1980

25

MAR 31 1980

ACRES

OFFICE MEMORANDUM

~~COD~~
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TO: J.K. Landman

Date: March 25, 1980

File: ~~P5700.01~~
P5700.14.01

FROM: P.E. Sandor

cc: Dr. P. Sioshansi
(Woodward-Clyde Consultants)

SUBJECT: SUSITNA HYDROELECTRIC PROJECT

ALASKA POWER AUTHORITY		
SUSITNA		
P5700 .14.01		
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XC	~~APA~~	
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May I briefly review the results of our meetings with Dr. Scott Goldsmith on March 20 and 21. I do not propose to repeat the material covered in my memos of February 28th and March 18th, but most remarks still apply. I have some difficulty putting my thoughts into writing, as I have to balance my professional and personal respect for Dr. Goldsmith on the one hand, with my worries about some important aspects about the accuracy of the expected results of his MAP/end-use model. The progress made by Scott and his sole assistant since the February 20th meeting is impressive, still it is difficult to see how ISER will be able to finish the project on time at the required quality. In the body of this letter I will generally describe my thoughts regarding the deviations for ISER's detailed work plan, about the MAP model runs and also cover the progress on the end-use model. An Appendix will list my detailed remarks regarding ISER's draft report of March 14th.

In summary, I am having doubts about the defensibility of the methodology. I am worried by the lack of progress in structural scenario formulation and even more so by the very conservative input to the MAP model runs. Even in the "high" version a radical drop in construction is assumed from 1983 on. No provision is made in the econometric input for <u>any</u> source of energy to meet the demands of Alaska beyond the early eighties. I recommend an increased involvement in the load forecasting project.

1. <u>ISER's Detailed Work Plan</u>

The methodology described in the "Detailed Work Plan" of November 14, 1979 serves as the terms of reference for ISER. The methodology has been significantly simplified under the pressure of time and because of lack of data. This applies mainly to the interfuel substitution section (Task D). The idea of building econometric relationships has been completely abandoned and the estimation of modal choices will be entirely judgmental. This is true for points D7 through D9, which are related to total energy and also for D10 which is describing the estimation of short and long term price elasticities. Task E will also be highly simplified; point E4 is completely missing from the recent plans, as the commercial/industrial sector gets very little attention; process energy demands of future projects are not yet estimated even judgmentally.

It is clear that much more sophistication is not justified. We have to live with the unavailability of historic and inventory type data in Alaska, and also with the lack of statistically established price and income elasticities, and substitution effects. We are faced with immense uncertainty regarding absolute and relative energy cost escalations. On the other hand, we have to realize that critics of ISER (and potential opponents of all power development) may use this significant deviation from approved terms of reference as a reason for rejecting all conclusions and recommendations based on the ISER forecast. These critics may well remind the Government of Alaska that the above mentioned lacunae should have been recognized before the detailed terms of reference were submitted and approved.

As a specific problem, I would like to mention that the simplified methodology omits a quantified forecast of conservation and of improved energy efficiency. This is not very realistic and (if not corrected) it may be the target of attack by some vociferous pressure groups.

2. MAP Model Runs

The updating of the MAP model includes in the data base the years of the "post pipeline blues". The population forecasts including these years in the base come out much lower than previous projections. As Dr. Perry Sioshansi carried out a detailed analysis of this subject, I would only like to remark that in general forecasts carried out at a time of recession or of slow growth are known to underestimate future trends. ISER's conservative approach might be appropriate for the "low" macro-economic scenario, but even for the "moderate" or "most likely" one I would rather select the continuation of decadal growth patterns instead of a slowdown in the energy-richest State of the Union. The "high" scenario should definitely be much bolder. If you look up the MAP scenarios (pages 3.11 through 3.16) none of them includes any "special project" supplying the energy base for the State. As the expanded use of natural gas for electric power production is prohibited by Federal law, electricity will have to be generated by hydroelectric, coal-fired or (less likely) nuclear plants. None

.../3

of these major investment items is listed. The employment associated with any of these projects will have a significant impact on the overall economy of the State. Omitting all of them makes the results of the MAP runs subject of criticism for underestimating manpower demand and economic growth. If the "moderate" and "high" scenarios would be augmented by unspecified energy supply projects, this problem could be rectified without the incestuous inclusion of Susitna itself.

The "high" scenario should, in my opinion, assume some growth in military employment, as such expansion is not at all unlikely to happen.

An area of further clarification is that of State spending. It was not clear if there is an accounting equation in the MAP model controlling the financial balance of the State of Alaska. The equations on page 2.5 do not provide equilibrium. It is my opinion that over a long period of time (1980-2010) there has to be an overall balance. Even for each individual year, the sum of spending on capital and operations plus net saving must equal total current revenue plus investment income, plus net dissavings.

Dr. Goldsmith expressed the opinion that it is not possible to project government decisions regarding such politically sensitive matters. He may well be right. If this is so, I fail to understand how the annual estimates for the government's capital and operating expenses can be quantified. Handling these as endogenous variables does not seem to be entirely logical.

If you turn your attention to the "special projects" employment tables on pages 3.17, 3.18 and 3.19 you will find that the "myopia" of a project-oriented approach is clearly visible even in the "high" scenario. After the crest of presently known construction endeavors passes by 1983, there is no assumption for the trend of development to continue. This approach contradicts the methodology statement which clearly indicates a combination of the two approaches. More importantly, the disappearance of all major projects from the mid-eighties on is unlikely; it gives the econometric model a downward bias. Although scenario selection is clearly ISER's responsibility, I would strongly suggest a much more growth-oriented set of assumptions for both the "moderate" and particularly for the "high" alternative. My suggestion for the inclusion of power projects might have some merit.

As a minor observation, I think the slight ups and downs of the forecasts in the "far down" years give the impression of more

.../4

accuracy than intended. It might be more appropriate to round the figures to the nearest hundred and to show smoother trends.

3. <u>The End-Use Model</u>

It was my observation that ISER still has no clear idea of the scenarios to be selected for either the total Btu (energy demand) or the kW·h oriented (electric power) parts of the end-use model. A clear, consistent and well-designed combination of these with the MAP alternatives is crucial. The overall envelope of cases should show the most likely and the realistic upper and lower values of electricity demand; probabilities should also be assigned to them. This is the main objective of the entire exercise. The cases should also cover some rational alternatives regarding policy choices. The number of runs must be limited not only because of time and cost limitations but mainly to avoid confusing over-information by dozens of outputs.

The above statements look somewhat general, but they implicitly cover such diverse areas as household size, housing type, saturation, intensity of use and efficiency of appliances, conservation efforts, industrial development, electric cars, competitive fuel prices, government policy regarding energy and budgets, etc.

It may well be advisable to outline in advance the structure of the final evaluation cases and assign the appropriate level to the exogenous variables in line with each combined scenario. The subsequent hierarchies of MAP-Energy Demand-Electric Power and even OGP would then follow the same logic. At the time of our recent meeting, ISER had not yet started to make assumptions regarding relative energy prices, price elasticities, conservation/efficiency effects. These numbers will determine the results more than everything else combined. It is the area of scenario formulation where cooperation between ISER on one side and Acres with its associated consultants on the other, would save time, effort and potential friction. At present there is little conscious structure in the choice of levels for exogenous variables in ISER's progress report pointing to "high" or "low" scenarios. The assumptions which may lead to a "low" boundary could well be attacked for not being sufficiently conservation oriented; the omission of process energy demands, of a fast movement towards all-electric homes and offices, no appearance of electric cars, etc., does not seem to cover a "high electric" case. I know very well that scenario formulation is ISER's duty and prerogative, but I also think that Dr. Goldsmith has up to now concentrated on the "moderate" scenario set and may well be willing to incorporate friendly advice from

.../5

Acres and its consultants regarding the upper and lower boundaries of exogenous variables.

. . . . . .

In the light of the above described observations, I believe that the project would benefit from a more active cooperation by Acres in ISER's work. Either the APA and the Legislature should be persuaded to provide funds for this endeavor which was not originally part of our terms of reference, or there is a danger that the results of the ISER forecast will not be sufficient as a reliable base of the OGP work.

Peter

Peter E. Sandor

PES:md

Att.

APPENDIX

DETAILED REMARKS REGARDING ISER'S PROGRESS REPORT

March 14, 1980

Remarks regarding

Part I - South Central Alaska - 1978 Energy End-use Inventory

Page 1.3

The remark at the bottom of the page regarding process electricity is questionable. Process electricity might be a growing consumer of power with the increasing industrialization of Alaska. Process electricity required for major, identifiable projects such as LNG etc. should also be considered.

Page 1.4

I would suggest that aggregate energy should also be expressed in terms of a common unit (e.g. kW·h, Btu or joule).

Page 1.7 and subsequent tables

It might be a good idea to provide an example to explain the use and interpretation of the tables.

Page 1.20

The estimate of 45 percent electric may need better corroboration. This is a very important parameter and may be different under high, moderate or low electric assumptions.

Page 1.29

Saturation rates for freezers should take into account the increasing proportion of apartments in the housing stock because these are unlikely to have freezers.

Part II - Component Description of the Energy Demand Model

Page 2.1

The diagram shown is incomplete, it does not indicate where industrial/commercial demands are calculated. The efficiency model (including conservation and technological impacts) should enter the calculations before the mode split model.

.../2

Page 2.5

The level of government spending should be subject to a financial balance equation.

Page 2.10

Non-native and native household formation rates require careful adjustment to Alaskan conditions and an extrapolation to 1995-2010. As this is a rather important variable dominating the housing market, a strong corroboration of all assumptions is necessary.

Page 2.13

The share model is not yet operational but its results are quite important due to the different supply of nat ral gas to Fairbanks versus Anchorage. The present approach (as to be shown later) is not completely consistent.

Economic activities as described in the last paragraph on this page should be slightly amended. The basic sector should include the direct infrastructure associated with the listed industries. The transportation part of the support sector should not cover the pipelines which are basic.

Page 2.14

The assignment of non-basic sector activities involves assumptions regarding urban hierarchies in Alaska and their change. Although detailed analytical work cannot be carried out, justification of assumptions must be provided. The "historical people per dwelling unit ratios" and the "housing choice component" mentioned on page 2.15 have to be carefully developed and documented, this again will have great impact on energy end-use. It is quite likely that different assumptions will be required for the high, moderate and low scenarios.

Page 2.17

It is my opinion that the methodology is subject to criticism. Utilization rates of many important appliances are not related to real income and on the other hand conversion efficiency and conscious or mandated conservation should outweigh this impact (if any). At least for the low scenario a change in this assumption is recommended.

.../3

Page 2.18

I agree with the statement mentioned under "current status" that the construction of detailed models for saturation and utilization rates is unjustified. On the other hand, judgmental assumptions for change in these rates are necessary. I am somewhat confused by the statement in the "current status" section and the description of "future work". I am convinced that some additional work will be carried out.

Page 2.19

Under "sources of variation" I would like to see the mention of electric cars. The effects of conservation and increased technological efficiency might enter at this point if these are related to total Btu demand rather than mode split. Individual estimates of energy use by major industrial customers and of general industrialization might also be included at this step.

Page 2.22

The housing mode split which is to be carried out "on the basis of local and national trends" is related to the "people per dwelling unit ratio" mentioned on page 2.14; my remarks apply.

Page 2.23

I suggest that the title should be amended to "energy pricing and availability scenario".

The methodology of this work element is extremely important. The judgmental determination of the parameter values of the mode split model (present and future) have at least as much influence on the forecast as all other parameters put together. Even if analytical-modeling work is not carried out, all assumptions must be well documented and a list of sources should be shown. The choise of parameter values must be explained. It is this area where outside criticism is hard to deflect.

Page 2.24

If Woodward-Clyde and Acres would have the chance to review "future work" before the results go into a report, problems and delays might be avoided.

.../4

Page 2.27

The "lower price" mentioned in point 1 should include the depreciation of the appliance. The assumption under point 2 does not seem to be realistic. It is not likely that incremental customers will immediately swing to alternative fuels whenever the price of one falls below the other. The combination of normal and premature replacement rates assumes some weighting on the basis of points 1, 2 and 3. Maybe keeping them separate would have some advantage.

Page 2.28

The tasks described under "future work" are important but I do not know how this amount of research fits into the availability of time. It maybe that the increased availability of natural gas in Fairbanks should be introduced as part of at least one scenario in this section of the model.

Part III - Development of an
Electric Power Requirement Projection

Page 3.2

On Figure 1 the Btu final demands should be adjusted for the effects of conservation and transformation efficiency.

Page 3.5

Process energy should be considered here, as mentioned before.

Page 3.6

Regional allocation indicates a significant drop in Fairbanks and a compensating increase in Kenai-Seward. Dr. Goldsmith did not have an explanation for this shift, it may deserve some analysis.

Page 3.7

Section I is not in line with the house mode split analysis described in the previous task. Energy conservation might be assumed to be better at least for the "low" scenario. Point 3 seems to prejudge the mode split to be carried out in line with the methodology described in page 2.25. The same remark applies to points 4, 7 and 8. The assumption in point 9 that in the

.../5

commercial/industrial/government sector, there will be neither conservation nor improvement in transformation efficiency seems to be pessimistic. The growth of unspecified electricity demand as described in point 10 may serve as a proxy for the process use mentioned above. If this is so, the 2 percent assumption should be rationalized.

Page 3.10

I have described my remarks regarding scenario selection in the body of my memorandum. I think that unspecified but significant projects should be expected to happen after 1985 and that at least in the "moderate" and "high" scenarios appropriate employment levels should be assumed for them. Otherwise there is no provision to provide the energy base for Alaska.

Pages 3.17-18-19

The remarks for the scenarios apply to employment figures. As the third column (transportation) includes the existing pipeline, I question the need to list it under "special projects".

In order to show no more accuracy than intended, the numbers should be rounded to the nearest hundred, minor fluctuations should be smoothed.

PES:md

March 25, 1980

TO: Gavin Warnock

FROM: Peter Sandor

Review of ISER's Report:

Electric Power for the Railbelt: A Projection of Requirements

At your request I have carried out a quick survey of ISER's forecasts, dated May 23, 1980. Let me start the review with a brief description of the main parameters governing the need for the Susitna project, and then continue with remarks regarding the report.

The need for Susitna

If one looks at the "low" utility sales projection of ISER, it shows a growth factor of 2.3 over 1978 by the year 2000. As the generating capacity in the railbelt was very close to 1.0 gigawatt in the base year, a "Susitna-size" addition seems to be well justified by 2000. Going further in the future and/or using any of ISER's faster growth scenarios yields an even more optimistic picture. There are two questions. Firstly, should the incremental electric generation in Alaska be mostly hydraulic or are other options more attractive? Secondly, is ISER's "low" forecast by any chance higher than what is to be reasonably assumed? Let me address the modal choice problems first.

The rationale for choosing natural gas, coal or waterpower for future electrical generation in Alaska will not be an analytical or even economic one. It will have to be mostly political. At present natural gas is sold approximately at one twentieth of its market value to Alaskan power utilities and at similar discounts to residential and other users. By not selling this gas (in the form of LNG) to "Lower 48" customers, the State of Alaska would forego large future revenues. Most people would also assume that Congress will enforce legal restrictions on the use of natural gas in existing and particularly in projected power plants. For these reasons it is hard to imagine a political environment in which more than twice the present volume of gas would be available to utilities below 20 cents per 1000 ft^3?

If the gas is sold at a "shadow price" the cost has to be proportional to OPEC crude prices.

One of the generation alternatives should in my opinion cover the possibility of the gradual phasing out and replacement of existing gas burning power plants under the pressure of escalating gas prices and federal legislation.

The development of Beluga coal for power generation in Alaska competes against the export option of the same commodity. It is most important for Acres to assure that the independent A.E. doing the evaluation of alternatives includes the cost of natural gas at full shadow prices and/or the revenue loss by the State on subsidized sales. The environmental impact of buring coal should also be quantified, including the long distance damage caused by downwind acid rain.

The next question is that of the volume of demand. In the subsequent sections I will review the ISER projections.

The levels of demand covered by ISER

Acres must know if the ISER forecast is methodologically defensible and also realistic. I am pleased to report that most inconsistencies of the previous draft have been resolved. Some parts of the actual methodology are much less sophisticated than originally promised in the workplan, but they are at least acceptable. The still existing inconsistencies all point towards an overly conservative approach.

No provision is made on the investment side for the construction of either a coalmine plus thermal station or of a hydroelectric plant to meet projected power demands. One must somehow provide electricity! Even the "high" government expenditure scenario implies a hoarded government treasure of $48.9 billion by the year 2000. It is extremely likely that this money will be spent or handed directly to the people and thus enter the investment and/or personal income streams of Alaska. This would radically speed up all economic indicators, particularly in the years beyond 1990, which are assumed to have such a low growth rate.

It is very likely that the manufacturing sector would grow significantly faster than projected even in the "high" scenario. Alaska starts from an extremely low manufacturing and services base; with the growth of population and income, all precedents indicate that one should assume the establishment of plants and offices replacing goods and services presently imported from the "Lower 48". This is particularly likely under the preferential tax regime of Alaska.

The above remarks are directed towards some of ISER's seeming inconsistencies. Further points have to be made regarding the downward bias in ISER's judgement. While one would not argue with the "low" scenario, the "most likely" and particularly the "high" one should include at least some new major investment projects starting after 1984. These would show up through the acceleration of employment, population and housing in the power demand. The picture for the late '90's and the 2000-2010 period might radically change if self-sustaining growth is assumed.

Both the LNG plant and the ALPETCO petrochemical plant are assumed to be self-supplied with electricity thus not included in the utility demand. They should be changed for the high electric scenario to network supplied, as the shadow value of oil and gas would exceed the cost of a coalfired or hydroelectric station. Electric cars are explicitly excluded, these are a logical part of a "high" scenario demand. The retrofitting of home heating from gas to electric heat could be faster and more complete than assumed, if the price of the competing fuels is in line with a scenario evaluating the upper bounds of demand.

In general ISER may be overreacting to the upward errors shown by power forecasts prepared in boom periods. History has also shown that projections done during recessions tend to be too low. This may well be the reason of their unrealistically low "most likely" and "high" projections.

APPENDIX

WOODWARD CLYDE'S REVIEW OF ISER DRAFT REPORT

SOME REMARKS BY P.E. SANDOR

May 5, 1980

FIGURE 3.1 (page 10)

In an economy which will be driven to a large extent by Government investments, incentives and directives, there is strong interaction between Basic Private Sector Activity and State Government Activity. This is not only a question of putting a two-way arrow between the boxes on the graph. I believe that scenario formulation should start with a set of assumptions regarding State policies towards both public and private spending. For instance, the future of the Beluga coal fields (for local and/or export consumption) will be decided by Government but it is likely to fall into basic private sector activity. The State decision regarding maximum export of natural gas at world market price or conversely favoring maximum domestic consumption will have a great effect on private sector investments.

SPACE HEATING (page 12)

The modal choice for space heating (and waterheat) is probably the most important assumption besides the question of overall growth. I do not necessarily agree fully with Woodward-Clyde's conclusions. If natural gas is exported and world market prices are applied for it in Alaska to both utilities and private homes, this may make hydroelectric and/or coal generated electricity more (and not less) competitive for space heating. The answer is not absolutely clear and can only be settled after the cost of electricity is computed and then compared with the estimated world market price of natural gas adjusted for transportation cost. This question deserves great care because it swings lot of GW·h and also because it involves both technological calculations and crystal-balling of world markets.

INTRODUCTION OF NATIONAL ECONOMETRIC MODELS (page 13)

This attractive modelling embellishment may well be the first one I would drop in order to keep things simple. Woodward-Clyde's remarks in the final sentence of 2.1 (page 4) are fully applicable.

STRUCTURE OF FORECASTING MODELS (FIGURE 3.3 before page 20)

This lucid representation deserves full credit. Let me suggest some further improvements. In the Commercial/Industrial Stock Model in block II, a separate entry for Government as an industry

.../2

is recommended. Whether we like it or not, Government is a growth industry, particularly in a State with a huge projected cash surplus.

The end use models (# III) should take into consideration the increase in process energy consumption. With the growth and maturation of Alaska's economy, this aspect deserves at least an educated and well documented guess. If, for instance, large-scale development of Beluga coal takes place, this will certainly consume significant amounts of energy, so would any other government encouraged new primary and processing industry.

<u>ENERGY UTILIZATION</u> (page 27)

I completely agree with Woodward Clyde that this part of ISER's model requires thorough revamping and quantification. On the other hand, I believe that "time of day pricing" probably belongs into the sphere of peak estimation rather than energy forecasting. ISER has already enough on its plate, let us leave this out.

A ONE-STEP APPROACH TO FINAL
<u>ENERGY DEMAND ESTIMATION</u> (page 28)

I only partly agree with Woodward-Clyde on this recommendation. Some very important factors (space heat, water heat, electric automobiles) definitely require a two-step approach: first total energy and after that, modal selection shifting over time and in line with other policy and pricing assumptions. I would be willing to trade simplification in other forecasting sectors (e.g. the use of the age of the household head as proxy for income and age on page 32) for a quantified and well-documented two-step calculation of electric space heat.

PES:md

G – REVIEWS OF ISER'S REPORTS BY
KIRKWOOD/SIOSHANSI (WCC)

REVIEW OF ISER DRAFT REPORT

by

Craig W. Kirkwood
F. Perry Sioshansi

April 1980

Woodward-Clyde Consultants
Three Embarcadero Center, Suite 700, San Francisco, CA 94111

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1.0 INTRODUCTION

This document constitutes the written critique of the University of Alaska Institute of Social and Economic Research (ISER) draft report as required by Section 1.1.5 of the Scope of Work for agreement no. P5700.10.21 between Woodward-Clyde Consultants (WCC) and Acres American Incorporated (Acres).

Under Subtask 1.01 of the abovementioned Scope of Work, WCC is to review the methods investigated by ISER for possible use in its forecasting, and to assess the strengths and weaknesses of the methods selected by ISER for its forecasting. This review and assessment is to include consideration of the techniques and methods investigated by ISER for use in:

1) Projecting economic development,

2) Selecting input scenarios for its economic development models,

3) Developing its econometric-end-use mode for forecasting electricity load requirements, and

4) Considering the uncertainties in its forecasts.

In addition, the review is to consider the quantity and accuracy of the data used in the ISER forecasting methods. Furthermore, WCC is to assess the implications for the ISER work of the work done by others in the area of energy and economic development in the Railbelt Region.

These issues are addressed here to the degree possible given the information in ISER's draft report. It should be noted that ISER refers to their draft report as a "progress report." However, it is clear from discussions with them that this report is the draft report called for in Clause I of the contract between the State of Alaska Legislative Affairs Agency and ISER. Hence, it is this report that WCC is to review under its agreement with Acres to critique the ISER draft report.

This review is organized into the following sections:

1) a summary of the general conclusions of our review
2) a detailed review of the draft report
3) a consideration of the implications for the ISER work of the work done by others, and
4) an assessment of the strengths and limitations of the ISER work.

2.0

OVERALL REVIEW CONCLUSIONS

2.1 GENERAL CONCLUSIONS

ISER's basic approach to forecasting total electric energy demand is state-of-the art. Because the approach requires substantial model development effort and an extensive data base, it has generally only been attempted by large utilities or other organizations with substantial resources. Althouth the basic approach that ISER has taken is sound, the specific methodology they have developed to implement the approach has serious technical deficiencies which substantially limit the defensibility of the results obtained. In addition, there are serious weaknesses in the data base that ISER is using to support their modeling work.

Most of the methodological weaknesses could be corrected with several person-months of additional development work by knowledgeable analysts. Some deficiencies in the data base could also be corrected with several additional person-months of data collection. Additional work would also be required to adequately document the methodology and data base.

However, even with this additional work, certain types of data that are important for defensible forecasting using ISER's approach could only be collected by a well-designed data-gathering program over a period of some years. This length of time is necessary to obtain information on variations in electric energy consumption patterns as weather conditions change with the seasons.

With the additional model development, data collection and documentation effort, defensible forecasts could be produced for use in the Susitina Project power studies. However, the sophisticated methods that are being used by ISER will probably not produce forecasts that are, on the whole, necessarily more defensible than what could be obtained using considerably simpler methods. This is because there are substantial uncertainties about some of the major inputs needed by any model that forecasts future Railbelt development. The variations in the forecasts resulting from plausible variations in these uncertain input quantities will probably be greater than errors that may result from using a simplified forecasting model.

2.2 SPECIFIC CONCLUSIONS

Our specific conclusions regarding the work presented in ISER's draft report are summarized in this section. The results of our detailed review of the draft report (which serve as the basis for these conclusions) are presented in Section 3.

We conclude the following:

- ISER's overall approach, utilizing economic and population projections coupled with an end-use model to forecast total electric energy demand, is sound. However, their methodology for implementing this approach has numerous technical and procedural flaws. In addition, there are numerous deficiencies in the way they have implemented this methodology.

- Many of the methodological deficiencies could be reduced with moderate additional effort by knowledgeable analysts. Similarly, substantial improvements in the implementation should be possible with moderate additional work.

- Some deficiencies in the current work are due to lack of some important data and the poor quality of other data. Some improvement in data would be possible with a short-term data collection program. However, major improvements can only be achieved by an ongoing data collection program over a period of years.

- End-use models, by their nature, require an extensive data base. Due to the current lack of quality data, the forecasts made using the ISER end-use model are not necessarily superior to those provided by a simpler analysis approach. Based on our review of other applications of end-use models, we expect that the defensibility of the end-use model results will improve over time as better data become available.

- At present, ISER's end-use model is incomplete and poorly documented. In particular, distinctions between the residential and commercial/industrial sectors are not well addressed. The treatment of the commercial/industrial sector is very weak, and within the residential sector not enough emphasis has been placed on analyzing various types of residential housing and their associated electric demands.

- The documentation in the draft report is generally poor. Many important assumptions are not substantiated while others are not explicitly stated. A systematic documentation of all input assumptions, and the rationale for making them, is highly desirable.

- The draft report does not indicate that any structured approach was used to develop input scenarios regarding possible future developments in the Railbelt. In view of the dynamic political climate and great uncertainties about the future of Alaska, it is essential that input scenarios be carefully selected if the resulting forecasts are to be defensible.

- The draft report indicates an inadequate review of existing literature and data sources regarding modeling and forecasting demand for electricity. Some of ISER's model components could be substantially improved by adopting existing similar models or model components.

Any one of these deficiencies would compromise the defensibility of ISER's forecasts for the purposes of the Susitna Project. In our judgment, the combination of all the above deficiencies means that ISER's current forecasts would not be able to withstand critical review well enough to serve as a defensible basis for assessing the need for the power the Sustina Project would provide.

We have provided specific suggestions for overcoming many of the deficiencies as part of our detailed critique in Section 3. Some of the deficiencies can be overcome without excessive delay or effort. Other deficiencies, particularly data inadequacies, would require more effort and time to improve.

There are some important issues related to the Susitna Project power studies that are not directly addressed by the ISER work. Consideration of these issues goes beyond just a review of ISER's work, so further discussion of them will be deferred until Section 5 where there is an assessment of the strengths and limitations of ISER's work with regard to the Susitna Project power studies.

3.0

DETAILED REVIEW OF DRAFT REPORT

This section contains a detailed review of the ISER draft report. In keeping with the scope of work for our review, this section considers the following:

1) Alternative forecasting methods considered by ISER,
2) The forecasting methodology used,
3) Quantity and accuracy of the data used, and
4) Methods used to consider uncertainties.

Because of serious editorial problems with the ISER draft report, it is often difficult to be certain exactly what was done.

In what follows, page numbers in parentheses refer to pages in the ISER draft report unless otherwise noted. In numerous places we have suggested further work that could be done or additional sources of information that we believe would be useful for ISER's work. Strictly speaking, these suggestions are beyond the immediate scope of our review. Ultimate responsibility for the total electric energy demand forecasting work rests with ISER, of course.

3.1 ALTERNATIVE FORECASTING METHODS CONSIDERED BY ISER

The draft report contains no discussion of alternative forecasting methods considered by ISER before adopting their present methodology.

From our discussions with ISER it appears that they considered various alternative forecasting methods. It would be helpful to discuss what alternative methods were considered and the rationale for selecting the methodology used. ISER's contract with the Alaska Legislative Affairs Agency calls for a report on this topic in mid-January 1980; this has still not been delivered.

Considerable research has been carried out elsewhere in the U.S. on forecasting electric power demand, and ISER appears to be unfamiliar with this literature. There are no references to this work in ISER's draft report. Several references and data sources are suggested in our discussion in the following section.

3.2 FORECASTING METHODOLOGY

The forecasting methodology used by ISER is presented in Part II of their draft report. The methodology consists of eleven components:

- I. Economic Growth Scenarios
- II. MAP Statewide Econometric and Demographic Model
- II.A. Household Formation Model
- III. Regional Allocation Model
- IV. Appliance Saturation and Energy Utilization Model
- V. Final Energy Demand Model
- VI. Housing and Appliance Stock Model
- VII. Energy Availability Scenarios

VIII. Mode Split Model

IX. Energy Efficiency Model

X. Energy Requirements by Fuel Type Model

Each of these is separately discussed below.

3.2.1 Economic Growth Scenarios

This model component is critical as it influences every other aspect of the model. At present, this component is inadequately defined, as well as poorly structured and presented. Although further discussion of economic scenarios is presented in Part III (pp. 3.10-3.16), even with this added discussion, the scenarios are inadequate and poorly documented.

Major problems are that relationships between endogenous and exogenous variables are not well defined and that the sources and relative magnitudes of impacts for given scenarios are not discussed. This is a significant shortcoming since several major exogenous factors are the basic driving forces of the Alaskan economy. These exogenous variables influence three major sectors which, in turn, affect everything else in the economy (see Figure 3.1). To develop credible economic scenarios, one must start with a clear specification of these basic entities and their interrelationships. Particular attention, for example, should be given to state government policies. The role of the federal government must also be considered, particularly as it applies to energy policies.

Major Exogenous Variables

- National/International Economy
- World Market Fuel Prices
- National Energy Policies
- State Government Investment/Expenditures
- Discovery of Major New Fuel Reserves in Alaska

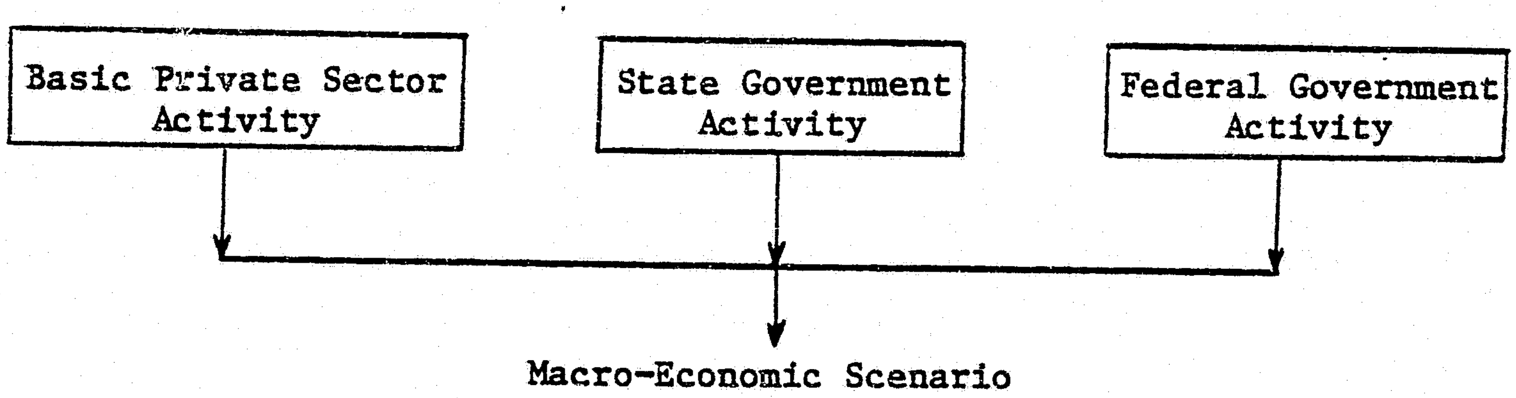

Figure 3.1. MAJOR EXOGENOUS VARIABLES AND ECONOMIC SCENARIOS

The role of the private sector must be defined in the context of state and federal regulations and policies.

A defensible scenario combines reasonable and internally consistent assumptions about these basic sectors. ISER's scenarios are not well documented and presented. For example, their "High Scenario" (pp. 3.14-3.16) results in construction employments (Table 3, p. 3.19) which are not only low but, in fact, incredible for the 1990-2000 period. Part of this problem (which is also present in the "low" and "moderate" scenarios) may be attributed to myopia. ISER only considers projects that are currently being considered and can be expected to be completed by 1990. This implicitly assumes that no additional projects will start in the 1990s. At the very least it seems appropriate to assume a continuing, reasonably healthy level of construction activity under the "high" scenario.

Another shortcoming of ISER's work is the absence of direct or induced state government investment/expenditure (although part of the indirect involvement may be implicit in ISER's "Industry Assumptions" [pp. 3.11-3.16] regarding industries such as agriculture and fisheries). In view of Alaska's large expected budget surplus for the next couple of decades* and of the potential for further exploration, development,

*According to a recent article in the Wall Street Journal, "The extra money will total $53 billion over the next 10 years and a further $44 billion in the succeeding decade" (Wall Street Journal, 1980).

and export of oil and natural gas, particular attention should be devoted to the role of state government. The high scenario, in particular, should consider a sizable and increasing state government surplus which can be used to accelerate economic development and growth.

Furthermore, the effect of state and/or federal regulatory decisions, energy and conservation policies, and politically induced legislations are not considered. Any of these factors could have a significant impact on the Alaskan economy and demand for electricity in the Railbelt.

To illustrate the importance of carefully considering input scenarios, consider the possibility of a trans-Canada natural gas pipeline or an LNG facility on the Kenai Peninsula. Currently, all utilities in the Anchorage area use natural gas, at rates far below the world market price, to generate electricity, and their customers enjoy some of the lowest electricity rates in the nation. As a result, many homes are electrically heated. If the natural gas were to be exported the local utilities might be forced to pay higher prices which would be passed on to their customers. Under these circumstances, electric space heating might no longer remain attractive. The long-term effect of this on future electricity consumption is likely to be sizable. There is currently strong opposition by some of the gas burning utilities to such an eventuality. Hence, it may be politically unpopular to vote for the gas pipeline or LNG plant. On the other hand, federal regulations may make it progressively more difficult to use natural gas for power generation when other alternatives are available. This example illustrates the importance of well thought-out and consistent scenarios.

ISER's "Current Status" (p. 2.5) is clearly not adequate, and their proposed "Future Work" (p. 2.5) does not appear adequate to provide defensible scenarios.

3.2.2 MAP Statewide Econometric and Demographic Model*

The current MAP model appears to be a defensible method for providing overall population, employment, and income level forecasts for Alaska for the Susitna Project. In the long-run, however, MAP should be modified to better accommodate policy type variables and macro-economic scenarios. The link between the national and Alaskan economies should also be strengthened using a national macro-economic model (such as those available from Data Resources, Inc. and Chase Econometrics). Variables other than wage differentials (e.g., low mortgage rates, lower taxes, etc.) may attract people to Alaska in the future and should be considered and appropriately modeled. A particularly useful economic/ demographic model which may be of value to ISER's subsequent work is the model jointly developed by New England Power Pool (NEPOOL) and Battelle Columbus Laboratories (1977).

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*Our comments on the MAP model are based on documentation provided by ISER dated May 31, 1979: "Man-In-The-Arctic-Program," compiled by Oliver Scott Goldsmith, Institute of Social & Economic Research, University of Alaska, Anchorage, Alaska.

3.2.3 Household Formation Model

ISER has linked this model to the MAP model. In our judgment, it would be better to link this model to the Regional Allocation Model. It appears simpler to allocate total population to the Railbelt area first and then forecast household formation rates for the Railbelt. ISER's modeling component diagram does not show this subcomponent and its relationship to the housing and appliance stock model (p. 2.1).

Particular reasons for recommending the above modification are: (1) the Railbelt area comprises Alaska's most developed and populous region and better data (compared to the rest of Alaska) is available for this area, (2) the Railbelt has a relatively low percentage of natives (whose household formation and size patterns are not as well understood), and (3) the modification would simplify the link between the MAP and Regional Allocation Models.

Since similar models have been developed previously and adjustments for Alaska's unique characteristics could have been readily made, we are not sure why ISER developed their own model. The present model is fairly crude and its forecasts depend on several key assumptions that are not adequately documented. ISER's claim that "In reality, the complexity of the household formation decision and the important recent structural changes make any statistical estimates of this relation questionable" (p. 2.9) is only partially true. While there are disagreements between demographers on future rates of household formation, certain qualitative trends are likely to continue and can provide useful forecasting bounds (for example, see Slater 1980; NEPOOL and Battelle 1977; U.S. Department of Commerce, Projections of the Population of the US: 1977-2050, 1976).

Despite these shortcomings the ISER model could provide adequate results which could be tested against more detailed models. This would provide an opportunity to fine tune their model and calibrate its parameters. However, we were not able to verify if the model is appropriately formulated because ISER's intermediate results (such as the average number of people per household, etc.) are not presented in the draft report. We recommend that such information be summarized in their final report and that they compare this information to national trends and trend forecasts. Furthermore, we recommend that ISER perform sensitivity analyses on the key assumptions used and present these results in summary form. Their statement, "The future household formation rates are assumed to follow the pattern of change projected at the national level," (p. 2-10) requires substantiation.

3.2.4 Regional Allocation Model

This model component converts MAP's statewide projections to corresponding projections for the Railbelt area, bypassing the development of a separate regional economic model. This is a reasonable approach because many development and construction activities are likely to take place outside the Railbelt which affect the residential and commercial activities in the Railbelt. This is true because of the central geographical location of the area and the fact that more than three quarters of the state's population lives within its boundaries.

ISER's present approach appears to be based on a continuation of historical trends and past relationships between various regions. While we do not recommend a detailed analysis of regional economics and growth patterns, it is suggested that analysis of historical regional growth trends be complemented by a study of their relative potential for future development and economic activity. For example, some regions of the state may be expected to prosper more than proportionately as a result of new discoveries of natural resources (e.g., oil, natural gas, wood products) and subsequent development of these resources. Such possibilities should be considered in the context of the overall economic scenarios to produce consistent and credible results.

ISER's "Current Status" (p. 2.14) indicates that this model component requires additional work. Their present documentation does not clearly indicate exactly which factors are assumed to determine each region's share of activity (p. 2.13). Better documentation would be necessary to judge the validity of ISER's assumptions. It would be adviseable to perform sensitivity analysis to identify and better define the most influential parameters.

3.2.5 General Comments Regarding Remaining Model Components

Following a review of several other forecasting approaches (in particular NEPOOL and Battelle 1977; Pacific Gas and Electric Co., California Energy Commission, Burbank 1979; Comerford 1979; Thomas 1979; Torrence and Maxwell 1979; Fitzpatrick 1979; National Research Council 1978; and DRI 1976), taking into account Alaska's unique characteristics, data inadequacies, and ISER's time and resource constraints, we conclude that a reasonably sophisticated and defensible electric demand forecasting model of the type ISER is developing should include the following four major components (Figure 3.2):

- Scenarios that provide the primary exogenous inputs of the model (as discussed in Section 3.2.1),
- Economic projections that take various scenarios and other data as input and generate forecasts of population, employment, income, and so on using econometric models,
- End-use models that convert the output of the economic projections into forecasts of electric appliance ownership (purchase/replacement) and utilization taking into account factors such as price of alternative fuels, income of the household, regulations on average efficiency of electric appliances and so on (Note that a direct link between the scenarios and the end-use models is required.), and
- Electricity demand projections that simply sum total electricity consumption across individual consuming units using information generated in the previous two steps.

These components should be linked so their interdependencies are technically correct and logically consistent. ISER's present model components (p. 2.1) do not fully satisfy either qualification. Figure 3.3, a more detailed version of Figure 3.2, shows the subcomponents of a reasonably sophisticated and defensible model and their interdependence. A comparison of this figure and that shown in ISER's report (p. 2.1) suggests how ISER's model components might be rearranged and what new components are necessary. (Some of these subcomponents may already be implicit in ISER's work but not specifically referred to or presented.) The suggested rearrangement should not involve substantial additional work and would result in a better structured and more defensible model.

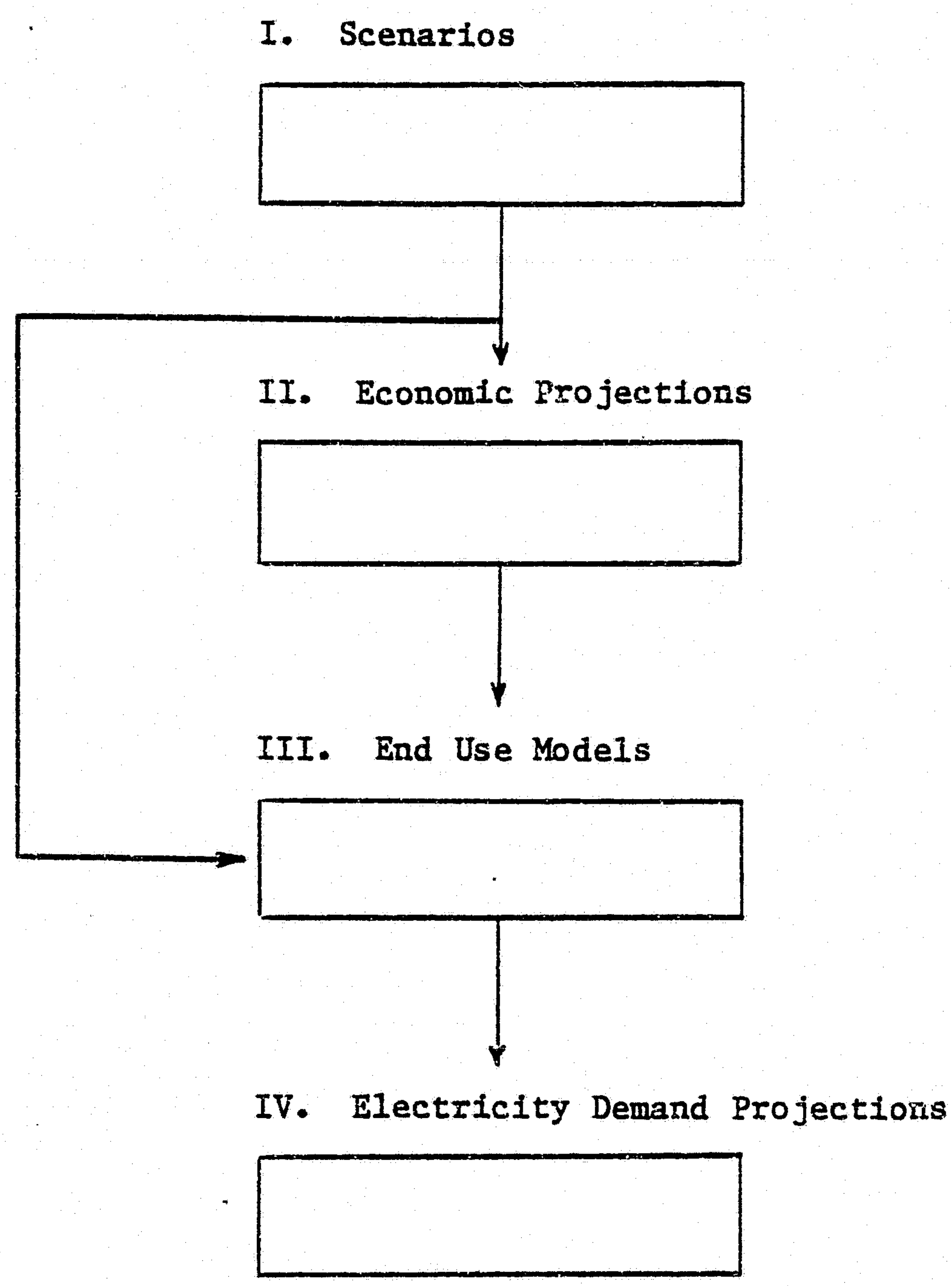

Figure 3.2. MAJOR COMPONENTS OF AN ELECTRIC DEMAND FORECASTING MODEL

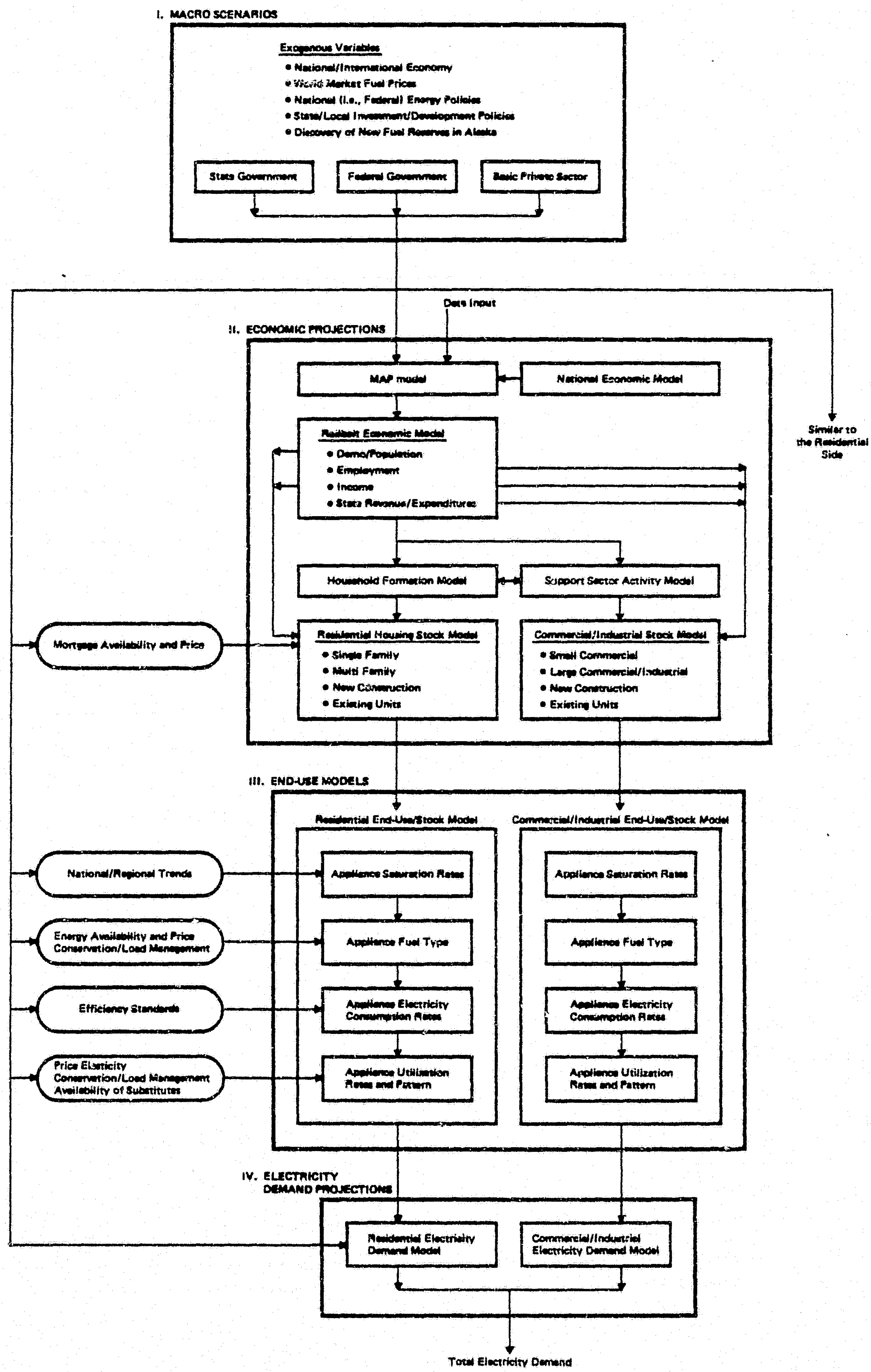

Figure 3.3. DETAILED COMPONENTS OF AN ELECTRIC DEMAND FORECASTING MODEL

3.2.6 Appliance Saturation and Energy Utilization Model

This section of ISER's model is poorly documented. The assumptions/results presented in Part III are difficult to interpret and are generally shown in unconventional units and terms. The assumptions made about future saturation and utilization rates, when presented, are unsubstantiated. Substantial additional work and better documentation and presentation are required on this model component.

It would aid the reader if a summary table were included, showing for residential and commercial customers:

1) Saturation rates for major appliances, both historical and projected (%),

2) Average consumption rates for appliances, both historical and projected (kWh/unit/yr), and

3) Average utilization rates per appliance, both historical and projected (kWh/household/yr).

Since this type of data is available for many lower 48 utilities, (for example, see Table 3.1) a rough check on the validity of the projected rates could be made if this information was presented. The information in this proposed table, coupled with information on numbers of households, would allow a computation of total demand per household, which could also be compared to national data (for example, see Tables 3.2 and 3.3). Much of the desired information is in the report, but one has to sift through several tables and do additional calculations to convert it to the desired format.

Table 3.1. COMPONENTS OF RESIDENTIAL USE PER CUSTOMER+

	Annual Kilowatthours		
	kWh/Unit	1976 Saturation	kWh/Cust.
Frost-free refrigerator	1400	0.678	949
Refrigerator	860	0.493	424
Freezer	1400	0.271	379
Color television	500	1.048	524
B&W television	235	0.924	217
Water heater	4500	0.067	302
Electric range	1200	0.474	569
Clothes washer	103	0.837	86
Electric dryer	993	0.455	452
Dishwasher	363	0.517	188
Air conditioner, window	390	1.020	398
Air conditioner, central	3200	0.115	368
Lighting	1000	1.000	1000
Small appliances	300	1.000	300
Heating plant	560	0.975	546
			6702 kWh*

*6702 kWh/customer compares with an actual 1976 experience of 6689 kWh.

**1.92 kW/customer compares with an actual 1976 experience of 1.90 kW.

+Data abstracted from "Peak Load Forecasting Methodology" by George L. Fitzpatrick, Long Island Lighting Company, Mineola, New York. Presented in EPRI Symposium on Electric Load Forecasting (Fitzpatrick 1979).

Table 3.2. POPULATION, HOUSEHOLDS, AND CUSTOMERS+

Calendar Year	Population*	Population per Household	Households*	Households per Residential Customer	Residential Customers*
1950	5059	3.80	1331	1.37	970
1955	5071	3.70	1371	1.12	1229
1960	5349	3.61	1483	1.05	1418
1965	5630	3.44	1635	1.00	1635
1970	5882	3.23	1819	0.97	1868
1975	6285	3.09	2033	0.92	2203
1980	6630	2.93	2265	0.90	2509
1985	6940	2.72	2550	0.89	2852
1990	7252	2.61	2783	0.89	3143

*1970 TVA region (thousands).

+Table reproduced from "Three Methods of Forecasting Residential Loads" by James Torrence and Lynn C. Maxwell, Tennessee Valley Authority, Chattanooga, Tennessee. Presented in EPRI Symposium on Electric Load Forecasting (Torrence and Maxwell 1979).

Table 3.3. APPLIANCE SATURATIONS AND CONTRIBUTIONS TO ANNUAL AVERAGE RESIDENTIAL USE+

	Calendar Year 1976			Calendar Year 1986			
	Saturation (%)	Average Use of Appliance (kWh)	Contribution to Annual Average Use (kWh)	Saturation (%)	Average Use of Appliance (kWh)	Contribution to Annual Average Use (kWh)	Annual Growth Rate (%) 1976-86
Electric heater	44	9300	4,092	55	8580	4,720	
Range	80	1330	1,064	86	1210	1,040	
Water heater	73	5000	3,650	84	5000	4,200	
Air conditioner	63	2900	1,827	81	2650	2,145	
Refrigerator	99	1220	1,208	100	1560	1,560	
Freezer	47	1075	505	56	1180	665	
Washer	74	100	74	75	100	75	
Dryer	45	1370	616	5	1350	760	
Dishwasher	24	350	84	40	330	130	
Lighting, TV, other			1,797			3,210	
Average use			14,917			18,505	2.2
Average customers (1000s)			2,251.0			2,918	2.6
Energy use (10^6 kWh)			33,577.4			53,998	4.9

+See footnote for Table 3-2.

Several important types of appliances (lighting, TV, refrigerators) are apparently combined together under the heading "non-substitute electric" (p. 3.27). We suggest that all "major" appliances be separately accounted for. The reason for this being that improvements in efficiency standards, price elasticity of demand, and numerous other variables are likely to affect these appliances in different ways, hence the need for separate record keeping. Other small electrical appliances can then be combined under one category. Electric cars should be considered for the period 1990-2010, since they may become commercially available during that time frame (Burbank 1979; EPRI Journal 1979).

There is little documentation presented on per unit comsumption of various appliances, their saturation rates, average useful life, and expected improvements in efficiency. What little data is presented is fragmentary and divided between Parts I and III of the report. Apparently, ISER has not utilized the available information from several generally quoted sources such as:

- Association of Home Appliance Manufacturers (AHAM) - Information on average size, consumption, and replacement of major appliances.
- Federal Energy Administration (FEA) - Information on energy efficiency targets for major appliances.
- Electrical Power Research Institute (EPRI) - Information on electrical load forecasting and modeling. In particular, the following four reports:

  (1) "How Electrical Utilities Forecast: EPRI Symposium Proceedings," EA-1035-SR, March 1979.

(2) "Patterns of Energy Use by Electrical Appliances," Report prepared by Midwest Research Institute (MRI), EA-682, January 1979.

(3) "Analysis of Household Appliance Choice," Report prepared by Charles River Associates, Inc. (CRA), EA-1100, June 1979.

(4) "Electric Load Forecasting: Probing the Issues with Models - Final Report," Report prepared by Stanford University EA-1075, April 1979.

- Edison Electric Institute (EEI) - Various reports.

- Bureau of the Census, Statistical Abstracts of the U.S., Electrical Appliances, various years.

Other useful data sources include:

- FEA Electric Pricing Experiments - Conducted on ten regions of the country and more underway in other areas. Questionnaire surveys were used for each pricing experiment and a complete documentation on all of these data sets should be available shortly. Detailed information on housing type, income, age, number and types of appliances, and utilization rates are included in these data sets.

- "Models for Long Range forecasting of Electric Energy and Demand," models and report jointly developed by the New England Power Pool (NEPOOL) and Battelle Columbus Laboratories, June 30, 1977 (revised and updated version forthcoming).

- Washington Center for Metropolitan Studies (WCMS) - Conducted two national surveys on number and ages of household residents, household income, attitudes toward energy consumption, insulation type used and extensive information on appilance ownership and utilization.

- San Diego Gas and Electric - Conducted extensive customer surveys on a number of household and appliance characteristics and use pattern.

- A.C. Nielsen Co. - Conducted a survey for the State of Illinois which was restricted to single family dwellings.

Failure to consider the various available data sources is a significant deficiency of ISER's present work.

ISER's definition of the saturation rate, defined as "the number of appliances divided by the number of consumers" (p. 2.17) is unconventional. This makes it more difficult to interpret and compare their assumptions/results to other studies. The conventional definition of the saturation rate uses number of households (as opposed to number of consumers) and makes more intuitive sense since many appliances (e.g., black and white TVs) are approaching 100 percent saturation by this definition (U.S. Department of Commerce).

The "logistic curve" (p. 2.17) is not completely defined in the draft report. A simpler approach might be to extract useful information from the EPRI reports (ii) and (iii) mentioned above and to calibrate this model to fit Alaskan data. The above two studies identify several relevant attributes affecting the choice and use patterns of most common appliances and can provide the basis for better end-use modeling as well.

While we agree with ISER's statement that "it does not appear cost-effective to construct detailed models for predicting changes in [saturation and utilization] rates" (p. 2.18), we believe that development of simple, common sense models based on results of similar studies elsewhere (e.g., Thomas 1979) would be desirable.

The following are a number of other specific comments/suggestions which may be useful in ISER's subsequent work on the appliance saturation and energy utilization model. Some of these comments/suggestions are applicable to other model components as well.

- More emphasis should be placed on forecasting per capita and per customer electricity demand and cost. The relationship between cost of electicity and utilization rate (i.e., price elasticity of demand) should be considered.

- If possible, develop relative cost of labor ratios (Alaska vs. national average) for some major commercial/industrial sectors (Burbank 1979). This information would be useful in determining which commercial/industrial sectors may attract workers from the lower 48 states.

- Consider the effect of new energy efficiency standards mandated by Federal Energy Administration (FEA)--now part of DOE (FEA 1977). For example, a 50 percent energy use reduction for certain types of end-use by 1990 may not be unreasonable (Burbank 1979). Higher and lower energy efficiency improvements should be considered in the context of appropriate economic and regulatory scenarios (see Figure 3.3).

- Consider the possibility of different rate structure for electric space heating (as was once the case in the Anchorage area) and declining vs. inverted block rates.

- Consider establishment of time-of-day-pricing in the 1990s and beyond, particularly for large users. Also consider the potential for heat pumps and heat storage systems in the same time frame.

- Consider higher insulation standards in response to:

  (1) higher electricity rates (i.e., voluntary action due to economic inducements),

  (2) regulations, either forced or through incentives.

- Consider the implications of the following two events on demand for electricity:

  (1) price of natural gas (used for power generation) rising to world market price, and/or

(2) a federally imposed ban on use of natural gas for power generation.

3.2.7 Final Energy Demand Model

ISER's current model forecasts total energy demand (in BTUs) followed by a second model component which breaks total energy demand into subcomponents (e.g., electricity, gas, oil). For the purposes of the Susitna Project, this two-step approach is unnecessarily complicated. It would be sufficient to directly forecast electric energy demand. The two-step approach is more involved and produces results which are not of immediate interest in the context of the Susitna Project. Furthermore, to obtain defensible results, the approach requires simultaneous analysis of mode splits (between various fuel types) and supply and demand (one for each fuel type). This, in turn, requires development of a series of internally consistent and plausible scenarios concerning the supply of, and demand for, each fuel type at various prices. To date, ISER has not undertaken this complete of an analysis.

The approach we recommend, given ISER's limited resources, is to concentrate on electricity demand and derive it in a one-step process using an end-use model. The advantage of a well thought-out end-use model is that it can generate electricity demand projections directly taking as input data on number of households and housing units, income, assumptions about relative fuel prices, and several other parameters. Similar studies have been carried out in the lower 48 (e.g., Burbank 1979) and would be relevant to the present study.

The "Sources of Variation" (p. 2.19) listed in ISER's draft report leave out several important variables (e.g., rise in price of energy relative to labor and commodities). ISER's "Methodology" section suggests, "For the commercial-industrial sector, there is no data on average conversion efficiency, so no final demand model exists" (p. 2.19). If this is true, then additional effort in this area is required. This is not mentioned in their "Future Work" section.

Finally, ISER's implicit assumptions suggest that total energy demand is not sensitive to price. This is clearly implied by the figure on p. 2.1 where energy availability and price scenarios and energy efficiency models follow the final energy demand model. This assumes perfect price inelasticity in demand for energy. It is a strong assumption and requires further substantiation.

3.2.8 Housing & Appliance Stock Model

The "Model Description" (p. 2.22) for this model component indicates that ISER has projected future housing stock on the basis of local and national trends. An approach more in keeping with the rest of ISER's forecasting methodology would be to develop a model incorporating demographic information, particularly household formation rates and income/employment data, into a demand for housing function which can then be broken down into single-family and multi-family components taking income, housing supply, and mortgage availability into account. The model need not be complicated, and the required effort need not be substantial. Models of this type have been developed (e.g., NEPOOL and Battelle 1977) and can be readily modified for the present study. Since Alaskan mortgage rates are currently subsidized by the state government and may continue to be influenced by forces other than availability and cost of funds in financial markets, they should be accounted for as part of the state government scenarios.

Single-family units should be separated from multi-family units. Similarly, new homes/businesses should be distinguished from older homes/businesses since their energy consumption rates and patterns generally differ. A flow diagram similar to Figure 3.4 would be helpful.

We do not fully agree with ISER's statement that estimation of housing stock and mode split should be carried out "on the basis of housing demand without significant supply constraints" (p. 2.21). Both housing demand and mode split decisions are sensitive to supply conditions although they tend to be sluggish. A supply crunch, for example, can increase the cost of housing and affect the ratio of single-family to multi-family units. A similar result can also occur if the supply of available funds for housing dries up or government subsidies on mortgage rates are removed.

In the lower 48, housing vacancy rates, particularly for owner-occupied single-family dwellings, are quite low. (The U.S. national average for 1976 was 1.2 percent, U.S. Department of Commerce, Statistical Abstracts 1976). From ISER's discussion of the topic it appears that this is not the case in Alaska. The same apparently applies to second

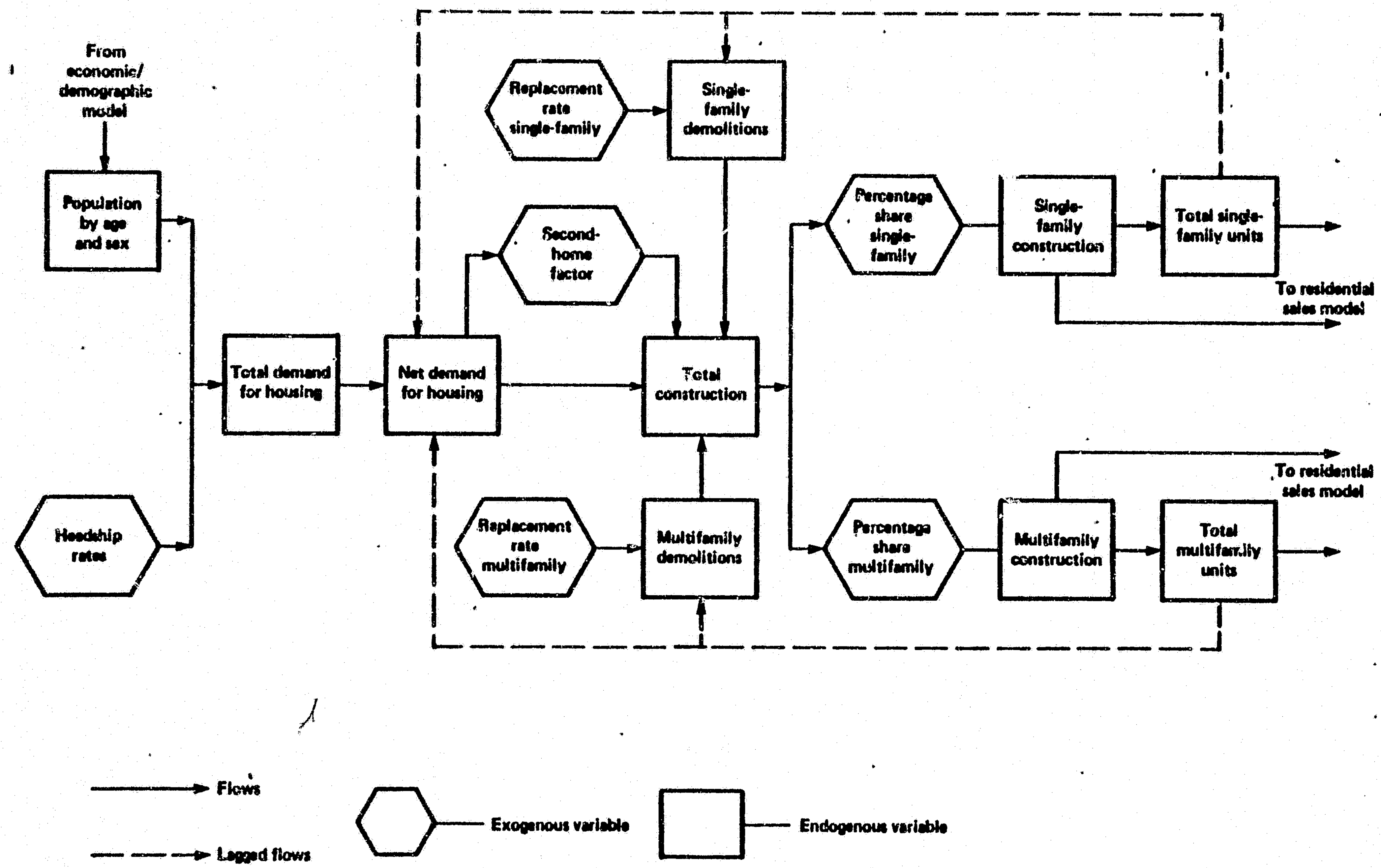

Figure 3.4. Housing Unit Model

Source: See Table 3.2.

homes. If this is the case, better discussion, documentation and modeling of vacancy rates and second homes is required.

. ISER's discussion on "preference" (as opposed to "affordability") for a housing type and "household head age" as explanatory variables (p. 2.22) are not strictly correct. The two most important determinants of housing type are household income and size (U.S. Department of Commerce, Statistical Abstracts). (Age of the household head is sometimes used as a surrogate for income and/or family size.)

ISER proposes to project housing mode split on the basis of local national trends in Part II (p. 2.22). What they have actually done, however, is to take the present mode split percentages and assume that they remain constant over time (see p. 3.7 and pp. 3.21-3.23). In the absence of more documentation and better substantiation, this assumption is clearly unacceptable. Since housing mode split is an important parameter affecting all subsequent work, small variations in this split can lead to significant variations in electricity demand.

3.2.9 Energy Availability Scenarios

This model component, which would more accurately be called "Energy Price and Availability Scenarios," is treated as a separate model component. In our view, energy price and availability are more defensibly treated as outputs of the economic scenarios already discussed. This distinction is important because energy scenarios are a major component of any economic scenario developed and should be consistent with the other scenario assumptions and implications. For this reason, energy price and availability scenarios should be carefully integrated with other endogenous and exogenous variables, such as state and federal government regulations or policies; relative price of alternative fuels in the world market over time; and critical energy related projects such as an LNG plant on Kenai Peninsula or the trans-Canadian gas pipeline.

A defensible scenario considers a consistent sequence of events/decisions over time and makes reasonable assumptions about its implications. According to their draft report (p. 2.24), ISER has not developed such scenarios. This is a critical step in any forecasting model and particularly in energy forecasting. No one can expect to accurately predict the future, and so scenario generation is designed to allow analysis of a number of "what if" questions in order to show the sensitivity of the projections to variations in important parameters. The results obtained allow a study of the implications of given decisions/policies under a variety of assumptions about the future.

It is difficult to evalute ISER's work on this aspect of the problem since very little is presented about it in the draft report. In particular, it is not clear if ISER's energy price and availability scenarios are consistent with the more general macro-economic scenarios affecting the MAP model.

3.2.10 Mode Split Model

According to ISER's stated "Objective" this model component determines "the proportion of consumers owning a particular appliance, type of housing, or type of commercial-industrial space that utilizes a particular fuel type" (p. 2.25). It describes the process by which a consuming unit decides to purchase new, or replace existing, appliances. The single most important "appliance" under consideration is, of course, space heating. Other appliances are not as energy intensive individually, but they become significant collectively. For certain appliances (e.g., lighting) the choice of fuel types is fairly limited, whereas in other cases several alternative fuel types may be available, each with its particular attributes. The question addressed in this model component is which alternative fuel type will be chosen when several are available.

This problem is a typical marketing problem and can be analyzed in two stages. The first stage deals with the question of whether to buy a new appliance and/or replace an existing one (Theil 1967; Charles River Associates 1979). The second stage considers the type of appliance (e.g., size, fuel type, model) chosen once a decision has been reached to purchase a new appliance or replace an old one (McFadden 1974; Theil 1971; Domenich et al. 1976).

ISER's initial approach (p. 2.26), if used in a dynamic context, appears adequate. This approach is, however, considerably simplified before it is considered ready to apply through a number of unrealistic assumptions (p. 2.27) and reduced to the form presented on page 2.28. This simplified approach is crude, and many of its important parameters (e.g., replacement and saturation rates) appear to be judgmentally set (e.g., p. 3.28).

In addition, there is a discrepancy between what is proposed in Part II (pp. 2.25-2.28) and what is actually carried out in Part III (e.g., p. 3.7 and pp. 3.21-3.23). Percentages of residential units on electric space heating, for example, are assumed to remain constant (pp. 3.21-3.23) at their present levels (p. 1.8) over the next thirty years (also see, e.g., pp. 3.27-3.29). It is misleading to present a mode split model in Part II, since it is not actually used.*

As already pointed out, an important component of the mode split model should be its sensitivity to economic and fuel price and availability scenarios. Based on what is presented in Part III, ISER's current approach is inadequate. There is nothing in the draft report to indicate that these deficiencies will be addressed in future work.

In modeling mode splits it is desirable to distinguish purchase/replacements in three appliance markets that are known to differ on their choice of appliances (Burbank 1979):

*Strictly speaking, ISER's report refers to what appear to be input assumptions/results as "electric power requirement worksheet" (pp. 3.20 - 3.38). In the absence of better clarification, we assume that what is presented in these "worksheets" are indeed assumptions that are fed into the model by the modelers.

- the new housing (residential or commercial) market,
- the replacement market, and
- the existing market.

New homes or commercial establishments consider all available alternatives and purchase appliances based on several important parameters such as:

- perceived initial costs,
- perceived operating and maintenance costs,
- perceived availability and cost of fuel, and
- perceived safety and convenience.

New homes and commercial establishments have great flexibility in their choice and take long-run marketability of the home/establishment into account (NEPOOL and Battelle 1977).

The replacement market deals with existing homes or commercial establishments with particular appliances that are wearing out, becoming obsolete, or becoming uneconomical to operate. This market does not have the flexibility of the new market (e.g., lack of duct work may make it difficult/expensive to add central forced air heating systems.

The third market consists of existing houses or commercial establishments without particular appliances which are considering purchase of new appliances. It also includes households/establishments that are considering duplicating appliances (e.g., second TV).

A complete housing stock model would provide information on new and existing housing stocks which could be used to provide input regarding the above markets. At a minimum the new housing market should be distinguished from the other two and treated separately. Similarly, single-family dwellings should be distinguished from multi-family units, and small commercial (e.g., small retail) from large commercial. Their use patterns and available choices are different enough to warrant separate treatment.

3.2.11 Energy Efficiency Model

We recommend including this model as an integral part of the end-use model (Figure 3.3), since the decision to purchase a particular appliance and appliance fuel type is affected by its perceived operating and maintenance costs which are dependent on its fuel conversion efficiency. As currently presented in ISER's work, a person's purchase decison is unaffected by improvements in efficiency standards because the model component which considers this follows the mode split model.

The current model's only function is specification of appliance fuel efficiency (p. 2.30) which is, apparently, judgmentally set. BTU demand for various appliances and efficiencies of electric conversion are, for example, set without any supporting rationale (e.g., pp. 3.27-3.29). Specification of appliance fuel efficiency, should be part of the input scenarios that are fed into the end-use model and should be consistent with FEA's efficiency standard targets (FEA 1977).

3.2.12 Energy Requirements By Fuel Type

No comments.

3.3 QUANTITY AND ACCURACY OF DATA

A defensible forecast requires reasonably complete data in addition to a logical, well-structured, and technically correct model. Our comments in Section 3.2 were directed at ISER's model. In this section, we consider the accuracy and adequacy of the available data.

End-use models are data intensive because many parameters have to be identified and specified over time. Based on our experience and review of other end-use models (e.g., those of the California Energy Commission and Pacific Gas and Electric Company), these models generally take several years of data gathering and calibration before they can provide completely defensible forecasts. For this reason we believe that ISER's end-use model cannot be realistically expected to become fully operational in the short-run. ISER has undertaken an ambitious task in attempting to put together an end-use model for the Railbelt area. Their model should provide more defensible forecasts as additional data are collected and the remaining deficiencies of the model are rectified.

The quantity and quality of Anchorage data could be improved. The data for the Fairbanks area is even less satisfactory. More specifically, the following comments are addressed at data and input assumptions presented in Parts I and III.

- The documentation and discussion of the end-use inventory should be presented separately from the data, which belong in an appendix.
- Factual data should be distinguished from assumed data.

- Factual data should be appropriately referenced. Assumed or estimated data should be substantiated and discussed to the extent possible. Judgmental assumptions should be distinguished from assumptions based on historical trends or similar studies done elsewhere.

- Each data sheet and inventory table should come complete with its footnotes and references.

- It appears that the key on p. 1.7 contains much redundant information (i.e., only three pieces of information are necessary to complete the remaining five blank spaces). If so, a more compact format, with instructions on how to obtain additional information could be presented.

- Many important input assumptions (e.g., percent of year-round housing units [p. 1.15] and electric consumption for space heating [p. 1.14]) are crudely estimated. Substantial additional effort appears necessary to improve these rough estimates.

- In cases where national (as opposed to Alaskan) data is used (e.g., p. 1.18), judgmental adjustments for Alaska, based on the available information, seem appropriate.

- Estimates regarding all-electric homes and electric space heating are crucial. ISER's rough estimates (p. 1.20) should be better substantiated and double checked to the extent possible.

- Appliance unit demands, energy efficiencies and annual consumption rates (pp. 1.30-1.33) should be augmented with more recent and accurate data (e.g., [Fitzpatrick 1979], [Charles River Associates 1979], [Midwest Research Institute 1979], [Edison Electric Institute]) and adjusted for Alaska.

- The flow pattern presented in Figure 1 (p. 3.2) is confusing.

- Assumptions stated on p. 3.7 are unsubstantiated. Each one of them is critical and requires careful consideration, evaluation and sensitivity analysis. As presently stated, they are clearly indefensible.

- The heading for Table 00 (p. 3.9) is incomplete.

- The "Electric Power Requirement Worksheets" (pp. 3.20-3.38) are undocumented and their assumptions are questionable and unsubstantiated. Many of the stated assumptions are dependent on future economic and energy scenarios. It is not clear if and how these scenarios will be integrated into more reasonable input assumptions and if and how sensitivity analysis will be performed.

- The Commercial/industrial sector requires a finer breakdown of the "General" category (p. 3.33) while certain other categories (e.g., Manufacturing and Warehouse) may be combined.

- Fairbanks area data appears non-existent (e.g., pp. 3.36-3.38) or of poor quality (e.g., p. 3.45). Better documentation of assumptions such as housing size and heat requirements (e.g., p. 3.40) is necessary.

3.4 METHODS USED BY ISER TO CONSIDER UNCERTAINTIES

The accuracy of total electric energy demand forecasts produced by ISER's models is affected by three major factors:

1) The degree to which the models accurately capture the true structure of energy use in the Railbelt,

2) The accuracy of data about current conditions in the Railbelt, and

3) The degree to which the assumed input scenarios for future economic development and energy use are accurate.

ISER's draft report, as well as our discussion elsewhere in this critique, shows that there are significant uncertainties about all three of these factors. It is important that these uncertainties be considered in the forecasting work in a systematic and realistic manner if the results are to be defensible. The draft report does not indicate how ISER intends to address these uncertainties. The steps generally used to address them include the following:

1) Sensitivity analyses to identify which structural features and input data most significantly affect the forecasts,

2) Additional modeling work or data collection where the sensitivity analyses indicate it is warranted, and

3) Incorporation of a broad range of viewpoints into the procedure for selecting input scenarios.

ISER has apparently not yet estabished methods for carrying out these steps. Although we foresee no particular difficulties in doing this, our experience indicates that carrying out the steps can be time-consuming.

4.0

IMPLICATIONS OF OTHER WORK

A review of several other electricity demand forecasts for the Railbelt region ([U.S. Department of Energy, Alaska Power Administration 1979], [U.S. Department of the Army, Corp of Engineers 1979], and [Battelle Pacific Northwest 1978]) indicates that past work has used less sophisticated methods than those proposed by ISER. None of these studies make use of end-use models. Generally, the studies are based on crude estimates of per capita energy demand and demand growth rates based on historical trends. The Corps of Engineers Report, for example, uses per capita consumption projections for "comparable regions in the Pacific Northwest, "(U.S. Department of the Army, Corps of Engineers 1979, Appendix, Part I, p. C-32) as the basis for its projections. The population projections used are typically those provided by ISER's previous MAP forecasts with a consideration of "low" and "high" growth scenarios.

Overall, these forecasts have limited defensibility since there is little documentation and specification of their critical parameters and input assumptions. Furthermore, various assumptions are not well integrated (e.g., population scenario, per capita consumption and energy price and availability scenarios are not necessarily consistent with one another). However, the assumptions are clearly stated and can be readily varied to produce alternative forecasts.

The two most recent power market analyses [U.S. Department of Energy, Alaska Power Administration 1979] and [U.S. Department of the Army, Corp of Engineers 1979] are based on ISER's MAP population projections (December 1978 revisions). These population projections, reproduced in Table 4.4 for easy reference, are higher than ISER's current projections (compare Table 8, p. 34 of [U.S. Department of Energy, Alaska Power Administration 1979] to Table O, p. 3.6 of [ISER 1980]). In fact, ISER's previous "low" projections for 1980, 1990, and 2000 exceed their respective present "medium range." Similarly, the previous "low" forecasts of total annual energy demand for 1980, 1990, and 2000, reproduced in Table 4.5 for easy reference, exceed ISER's present "medium range" forecasts (compare Table 10, p. 40 of [U.S. Department of Energy, Alaska Power Administration 1979] to Table OO, p. 3.9 of [ISER 1980]). Most of the discrepancy between these two population forecasts appears to be the result of updating of the MAP model; the previous population forecasts were based on a MAP model calibration using data up to 1973 where the more recent forecasts are apparently based on a recalibration of MAP which includes data up to 1978, including post Arab oil embargo data.

Table 4.4 COMPARISON OF ISER'S POPULATION PROJECTIONS [ISER 1980, TABLE O, P. 3.6] TO THE ALASKA POWER ADMINISTRATION'S POPULATION PROJECTIONS [U.S. DOE, ALASKA POWER ADMINISTRATION 1979, TABLE 8, P. 34] FOR THE RAILBELT AREA

population in thousands, rounded to nearest full thousand

	ISER's "Medium Case Scenario" Projections		APA's Projections			
			Anchorage Area+		Fairbanks Area+	
Year	Anchorage Area*	Fairbanks Area*	"Low"	"High"	"Low"	"High"
1980	208	61	240	270	60	62
1990	286	78	299	407	75	95
2000	371	97	424	651	90	140

*ISER uses Anchorage-Matanuska Susitna and Fairbanks-Southeast Fairbanks, respectively.

+APA uses Anchorage-Cook Inlet and Fairbanks-Tanana Valley, respectively.

Table 4.5. COMPARISON OF ISER'S "DRY RUN" ELECTRIC POWER DEMAND PROJECTIONS [ISER 1980, TABLE 00, P. 3.9] AND THE ALASKA POWER ADMINISTRATION'S PROJECTIONS [U.S. DOE, ALASKA POWER ADMINISTRATION 1979, TABLE 12, P. 46] FOR THE RAILBELT AREA*

Total Annual Electric Demand in GWh, rounded

Year	ISER'S Medium Case Scenario Projections	APA's Projections Low	APA's Projections Medium	APA's Projections High
1980	2,200	3,400	3,700	3,900
1990	3,800	5,200	7,100	11,000
2000	5,700	7,900	12,700	21,000

*Includes the entire Railbelt area.

5.0

STRENGTHS AND LIMITATIONS OF ISER WORK

ISER's work has the ambitious objective of accomplishing the first integrated combination of economic and end-use models for the Railbelt region. This is a major undertaking. It requires a systematic inventory of current end-use devices, their replacement, and utilization rates, efficiency levels and use patterns over time. In addition, future purchase/replacement decisions have to be modeled and integrated with various possible assumptions about relative price and availability of alternative fuels, energy efficiency standards, as well as policies and regulations on conservation.

A well integrated economic/end-use model can be a powerful planning tool for considering the possible implications of proposed actions or policy changes. However, attempts to develop such models by electric utilities and regulatory commissions in the lower 48 states have been carried out with substantially more resources than the work by ISER. Generally, it has taken two or more years of data collection, model specification and calibration to achieve reasonably defensible results.

Our review of ISER's present work indicates that substantial additional work will be required before their model becomes fully integrated and operational. This assessment is based on our conclusions (see Section 2) that serious deficiencies exist in ISER's work to date. (A detailed discussion of these deficiencies is presented in Section 3.) At the present state of development, the model's forecasts are not necessarily more accurate or defensible than forecasts from a less sophisticated approach. This is true because:

- ISER's present model is not complete nor fully integrated,
- The model is based on an incomplete and possibly inaccurate data base, and
- The selection and specification of input scenarios is not adequately addressed.

Additional work would substantially improve the defensibility of ISER's forecasts. However, there are other important issues related to the Susitna Project power studies that are not directly addressed by the ISER work, at least as it is presented in the draft report. These are not, strictly speaking, technical deficiencies in the work but rather limitations on the scope of what ISER is attempting to do. However, they may limit the ultimate usefulness for the Susitna Project of ISER's work.

A variety of studies have been carried out during the last two decades to assess future electricity demand in the Railbelt. Several studies have assessed the desirability of building the Susitna Project. Generally, these studies have concluded that there will be a need for substantial additional electric generating capacity and that the Susitna Project would be a reasonable way to meet this need.

However, the Susitna Project continues to be highly controversial, with both support and opposition by substantial interest groups. There is no reason to believe that another forecasting study, regardless of how complex it is or how carefully it is carried out, will damp the controversy surrounding Susitna.

Fundamentally, the assessment of the need for the Susitna Project is not an issue that can be "resolved" by analysis. In view of the many uncertainties that exist regarding the future of the Railbelt, there is no way to assure that <u>any</u> forecast of future demand for electric energy is accurate. In view of this, the central focus of Susitna Project concerns with regard to the need for power might profitably be shifted from concern for forecasting by itself to the following question: "For what level of future demand is it prudent that the Alaska Power Authority plan in carrying out its responsibilities to the citizens of the Railbelt?"

Addressing this question requires some forecasting work; however, it also requires careful consideration of a variety of other factors. Given the enormous influence that the state government will have on developments over the next few decades, the question requires careful consideration of options open to the government during this period. Perhaps most importantly, it requires careful consideration of the consequences of having over- or under-generation capacity relative to the demand.

This last point warrants further discussion. An analysis of Table 4.5 shows that ISER's projected "medium case" total electric energy demand growth from 1980 to 2000 averages 4.9% per year while the Alaska Power Administration's "low", "medium" and "high" projections average, respectively, 4.3%, 6.4% and 8.8% annual growth over this period. Thus there is a range of 8.8%-4.3%=4.5% in the Alaska Power Administration's projected growth rates.

The differences between ISER's forecast and those of the Alaska Power Administration appear to be due mainly to updated initial conditions and differing estimates of future population growth. In both cases the MAP model was used to do the population estimation. Thus it seems likely that there is roughly the same level of uncertainly associated with ISER's forecasts as with the earlier forecasts by the Alaska Power Administration based on the MAP model. If we assume this then the growth rate might be as low as 4.9-4.5/2=2.7% or as high as 4.9+4.5/2=7.2%.

Using these growth rates, starting form a base of 2200 GWh in 1980, results in the following projections of total electric energy demand in 2010:

- For 2.7%/yr. growth: 4900 GWh
- For 4.9%/yr. growth: 9200 GWh
- For 7.2%/yr. growth: 17,700 GWh

Note that the range of these estimates is 12,800 GWh. The firm annual energy from the Susitna Project is estimated to be 6,100 GWh, so the uncertainty in the projections is as great as two Susitna Projects!

An important issue relative to the power studies for the Susitna Project is which demand figures should be used for planning purposes in view of this uncertainty. For example, if the APA plans on the assumption of 2.7%/yr. growth in demand, and the actual growth is 7.2%/yr. the consequences for the citizens of the Railbelt are likely to be very different than if plans are made for a 7.2%/yr. growth and the actual growth is 2.7%/yr.

Questions of this type are not addressed in the ISER work, except in a very indirect manner. Thus, we believe that even if the technical deficiencies in ISER's work are corrected, it will not address some important needs of the Susitna Project.

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Review of

The University of Alaska Institute of
Social and Economic Research Report

"Electric Power Consumption for the Railbelt:
A Projection of Requirements"

by

Craig W. Kirkwood
F. Perry Sioshansi

July 1980

Woodward-Clyde Consultants
3 Embarcadero Center, Suite 700
San Francisco, CA 94111

INTRODUCTION

This document constitutes the written critique o. the University of Alaska Institute of Social and Economic Research (ISER) final report [S. Goldsmith and L. Huskey, "Electric Power Consumption for the Railbelt: A Projection of Requirements," May and June 1980] as required by Section 1.1.5 of the Scope of Work for agreement no. P5700.10.21 between Woodward-Clyde Consultants (WCC) and Acres American Incorporated (Acres). In accordance with a letter of May 14, 1980 from Acres, this review is brief. Primarily it is an update of WCC's review of the ISER draft report [C. W. Kirkwood and F. P. Sioshansi, "Review of ISER Draft Report", April 1980]. For a complete review of the ISER electric demand forecasting work, this earlier document should be read in conjunction with the current critique.

The conclusions reported here are based on a review of all three parts of the ISER final report: the Executive Summary dated May 16, 1980, the main body dated June 1980 and the Technical Appendices dated May 23, 1980. Additional perspective was gained by WCC attendance at a workshop for Railbelt utility representatives on June 10, 1980 and a public workshop on June 11, 1980. At these workshops Scott Goldsmith of ISER presented the results of the ISER study and answered questions.

REVIEW CONCLUSIONS

ISER's work is the first attempt to construct an econometric/end use electric energy demand forecasting model for the Alaska Railbelt. It is the most comprehensive look at future Railbelt electric energy needs to date. Given the difficulty of obtaining much of the needed data and the limited time available, the ISER work is a major achievement. However, there are significant limitations in the work which restrict its usefulness in a study of alternatives for meeting the Railbelt's future need for electric power.

Most of our conclusions reported earlier regarding the work discussed in ISER's draft report apply to the final report as well. In particular, we conclude the following:

- ISER's overall approach, utilizing economic and population projections coupled with an end-use model to forecast total electric energy demand, is sound.

- The modeling work suffers from a lack of some important data and the poor quality of other data. Substantial improvements in this would require an ongoing data collection program over a period of years.

- It does not appear that a structured approach was used to develop input scenarios regarding possible future development in the Railbelt. In particular, the scenarios appear to represent only the personal professional views of the authors with no systematic attempt to incorporate other points of view.

- Uncertainties associated with the forecasts are treated in a crude manner. Because of this it is difficult to determine the significance of these uncertainties for power system planning.

- Only very limited sensitivity analysis was carried out to study the implications of varying the input assumptions used in the forecasting model.

- For the above reasons, the forecasts made by ISER are not necessarily superior to those provided by a simpler analysis approach.

IMPLICATIONS OF OTHER WORK

The ISER final report contains a summary of other electric demand forecasting studies that have been carried out for the Railbelt. In general, previous studies have forecast greater future demand than the current ISER study.

At the utility and public workshops, Professor Goldsmith commented that he believes other studies done during the last decade were overly influenced by the high rate of development occurring during the oil pipeline construction period. However, he also noted that the scenario approach to forecasting, which is used in the ISER work, may be myopic and, as a result of this, underestimate future growth. He discussed steps taken in the ISER study to counter this tendency. In addition, he noted that previous studies that used the scenario approach have not systematically underestimated the Railbelt growth that has actually occurred to date, although the details of the growth have turned out to be somewhat different than what was forecast.

An important reason for the differences in forecasted energy demand growth between the ISER study and previous studies is the difference in forecasted population growth. The factors influencing future population growth in the Railbelt are subject to many uncertainties. The assumptions about these factors that were made in the ISER study should be given careful consideration since the authors of the study have considerable knowledge and experience regarding Railbelt development. However, as the utility and public workshops made clear, there are other reasonable points of view about these factors that might lead to substantially different forecasts of future electric energy demand.

STRENGTHS AND LIMITATIONS OF ISER WORK

A well-constructed econometric/end-use model can be a powerful tool for studying the possible implications of proposed energy-related actions or policy changes. However, past experience indicates that substantial time and resources must be invested to achieve reasonably defensible results with such a model.

The ISER work to date provides a solid basis for development of an econometric/end-use model. However, we believe that at its current stage of development, the ISER model does not give results that are more defensible than those of previous forecasting studies. The previous studies were, however, limited, one-time efforts while the ISER work could form the basis for an ongoing modeling and data collection effort to develop a sophisticated energy forecasting tool for the Railbelt.

Regardless of what model is used to forecast future electric energy demand, there will be substantial uncertainties about many of the input assumptions made in the model. These will lead to substantial uncertainties in the forecasted electric energy demand. For example, Professor Goldsmith commented in the public workshop that he believed there was approximately a 20 or 25 percent chance the actual future demand would be below the "low" forecast presented in the ISER final report and a similar chance it would be above the "high" forecast.

With this degree of uncertainty, there are reasonably likely levels of future electric demand so low that the Susitna Project could provide more electric energy than would be needed. There are also reasonably likely levels of demand for which substantially more capacity would be needed than could be provided by the Susitna Project.

It appears desirable to analyze the over- and under-capacity risks associated with Susitna Project planning in the presence of these large uncertainties about future demand for electricity. Such an analysis requires that uncertainties be treated explicitly in the demand forecasts. This is not done in the ISER work; this is a major limitation of the work with regard to its usefulness for the Susitna Project.

A second, related limitation is that the input assumptions and scenarios used in the modeling work represent only the judgments of ISER professionals. While these experts are very knowledgeable about potential future Railbelt developments, it appears from the utility and public workshops that there are other knowledgeable individuals who have somewhat different views about the future of the Railbelt. It seems desirable to have these views incorporated into the demand forecasting work. This was not done systematically in the ISER work.

H – PARTIAL LIST OF ISSUES RAISED DURING MEETINGS ON JUNE 10 AND 11, 1980

Partial List of Issues Raised During Energy Requirements Forecast Workshops, June 10 & 11, 1980

1. A sensitivity analysis of the forecasting model needs to be performed in order to determine the sensitive assumptions and the degree of variability in the outcome from changes in the assumptions. One particular question is how sensitive is the forecast to the set of conservation assumptions.

2. Scott Goldsmith stated that the limits of the forecast range represent 20-25% probability of exceedance; in other words, that there is a 40 to 50% chance that the actual energy requirements would fall outside the forecast range. This is a much narrower band than APA had assumed. Is it too narrow? Goldsmith should be asked to clarify the issue.

3. Do subjective probabilities have to be assigned over the forecast range to permit later risk analysis? Can it be done?

4. Consider a legislatively mandated shift away from electrical use, especially space heating.

5. There appears to be a downward bias in the econometric model due to the inability to identify discrete exogenous projects in the period after 1985 and before trending takes over in the year 2000.

6. Should a high level growth case with a mode switch toward electric (i.e., an H-E case) be added? A L-E case would not be useful since the forecast range would not be enlarged.

7. Should supply side information be fed into the forecast at some future date to somewhat define the nature and timing of the gas-electric mode split?

8. The conversion response time in the electric space heat conversion scenario may be underestimated.

Comments by Bob Hufman
General Manager
Golden Valley Electric Association, Inc.
Fairbanks, Alaska

Study forecasts sales only - need to adjust 8 to 10% to compensate for losses. Low figures are accentuated by projecting sales only when compared to previous reports estimating gross generation.

Study assumes alternate energy will be "cheap" energy. Photovoltaic cell installation just on-line costs 3 million for 100 kW = $30,000 per kW.

Study fails to address the probability of increased use due to a stable rate provided by ample hydro capacity.

In Fairbanks, deregulated oil will eventually not be competitive for space heating. Wood will be depleted. Coal will cause additional air quality problems. Natural gas may or may not be available. However, electric heat with a stable rate base will be a top contender when produced from hydro.

The study declares that electric heat retrofitting does not occur. If the price incentive is there it will occur. GVEA can attest to that fact. In addition, many of the systems have hydronic baseboard which are easy inexpensive conversions to electric boilers.

The Cantwell Summit area should be included in the forecast.

The probability of seeing a substantial number of electric cars by 1990 is great. Even though most would hopefully recharge off peak, the total kWhs may be substantial. We may see 10% by 1995-2000.

We expect electric heat conversions to bottom out by 1981. Those left will stay there regardless of price - perhaps 250-350 accounts.

Decline of revenue from petroleum royalties will be compensated for from natural gas royalties and new discoveries.

Would prefer to have Bob Richards from Alaska Pacific Bank do an econometric study.

Military plants would purchase energy from hydro beyond that derived from a steam/electric overall plant balance. Wainwright, Eielson, Clear AFB, Elmendorf, Ft. Richardson.

Heat pumps may be practical in southcentral with hydro.

Who is doing demand forecast?

This has a major bearing on installed capacity.

Utilities are cognizant of the inherent dangers of grossly underestimating demand/energy projection for planning purposes.

It is quite easy for those with zero responsibility to keep the lights on, to use the ultraconservative approach most favored by obstructionists and no-growthers. There may be some economic penalty to overbuilding but most likely the penalty would be wiped clean by inflation within a short period of time. However, the penalty for underbuilding could be a disaster both economic and otherwise.

I - DETAILED WORK PLAN FOR REVISED TASK 1 - POWER STUDIES, POST-TUSSING

DRAFT

Detailed Work Plan For Task 1 - Power Studies

1 - Introduction

The Task 1 work will be divided chronologically into two phases. The first phase, taking place throughout 1980 and carrying on into early 1981. The second phase to be commenced following a "Decision Point" at the end of phase one and continuing to mid 1982. Contained in this document is Acres detailed methodology for completing Task 1 with particular emphasis on the work to be completed by early 1981.

The work to be completed during the first phase is divided into the following subtasks:

1.01 - The determination of the rate at which the demand for electrical energy in the railbelt will grow over the period 1980 to 2010.

1.02 - Using the results of 1.01 develop load demand curves and peak generating capacity requirements taking into consideration various conservate measures.

1.03 - Explore all the alternatives for generating electrical energy that may be used to satisfy the load curves and peak capacity requirements developed in 1.02. Data will be collected for each alternate identified; the alternatives will be screened, ranked, and submitted to a panel for review and comment. (It is recognized that after this Subtask, a large amount of data assembled on the alternatives will necessarily be general in nature, although site-specific information will be gathered where possible within the time constraints of the project).

1.04 - A methodology will be developed and applied to the alternatives that are judged "best" in 1.03 to assemble the individual alternatives into generation expansion scenarious capable of satisfying the load growth out to year 2010.

1.05 The generation expansion scenarios will be assed in greater detail and as site specific as possible by early 1981. These more detailed assessments will be resubmitted to the panel, the public, and APA for review and comment.

1.06 - A Power Alteration Study report will be prepared following the review process and incorporating the comments received. The report, containing recommendations, will be submitted to APA as a decision making tool from which APA can select the most desirable scenarios (3-6).to to study in greater detail duringtthe second phase of Task 1.

The Detailed methodologies to accomplish the six subtasks listed above are desireable in the following sections.

2 - Subtask 1.01 Methodology

The University of Alaska's Institute for Social and Economic Research (ISER) recently completed a contract issued jointly by the Alaska Power Authority and to the Alaskan Legislature's Legislative Affairs Agency to estimate the annual electric energy use in the Railbelt through the year 2005.

Early in the Susitna project, Acres had decided to study loads and alternatives through the year 2010. ISER agreed to revise their work plan and included these extra five years in their study.

The projection work undertaken by ISER was based upon their own data gathering efforts and the use of their econometric computer program, the "MAP" model. ISER produced their first large, definitive energy growht study using these methods in 1976. That work has been the basis of other subsequent energy projections. Their work is generally thought of as one of the more credible energy projection in the Railbelt. This may largely be because they are not associated with any power generation entity and are thus not perceived as having a vested interest in the expansion of generation facilities.

As part of the Subtask 1.01 work, Acres, through their subcontractor Woodward-Clyde, must identify the strengths and weaknesses of ISER's methods so that their end results can be judged as to their suitability for the Susitna study. The work of Acres group is designed to understand as well as possible ISER's methods, data bases, and assumptions used as input. This effort will later allow Acres to know the limitations of ISER's work.

ISER's final report was published in May of 1980 and presumably its findings will not be significantly altered during 1980. Therefore, during the first phase of Task 1 Acres work will be based on the May 1980 ISER report.

As part of the work to be completed in this subtask, Acres will investigate the need for further improvement in ISER's model their input data base and the and the assumptions used to develop their input scenarios.

In a continuing effort to increase the acceptability of the energy projections being used for this study.

Interviews will be held with recognized experts in such fields as energy and economics. These epople will be askéd to assess the uncertainties in the input parameters. The results of these interviews will be used to assemble a set of well defined scenarios.
The interviewing process will be useful to identify the depth and divergence of the disparate opinions unique Alaska. Speakers for special interest groups representing a spectrum of economic and environmental philosphies will be sought out and asked for their judgments on the future growth of the Railbelt area. This will provide a forum by which virtually the entire range of rational viewpoints can be aired.

3 - Subtask 1.02 Methodology

As follow-up work to the analysis of the ISER Final Report Woodward-Clyde must forecast peak power demand (megawatts (MW) for the period 1980-2010.
The missing link between electrical energy forecasts and power demand forecasts is the concept of load duration curves. The derivation of load duration curves used to describe the consuming systems' load characteristics will be an important part of this work.

The major utility companies in the Railbelt (Chagach Electric Association, Anchorage Municipal Power and Light, Golden Valley Electric Association, and Fairbanks Municipal Utilities System) are all required to file records with the Federal Energy Resource Commission concerning the operation of their systems. The data filed by the individual utilities includes the load characteristics of the utility. The utilities file records of hourly data for three separate one week periods annually. The data filed peak summer, winter, and a typical spring week. From these three data sets plus data reflecting month to month variations in energy, load duration curves can be developed by interpolation for each month of the year. The differences between mid-week and weekend daily load patterns will also be obtained by this process. Such information will be relevant to unit dispatch and production costing calculations performed in Subtask 1.04.
Based on the forecasting off the load duration curves and peak power demand WCC will produce the following output produce the following output products:

1. Variations of monthly load expressed as a decimal fraction of the annual peak monthly load.
2. For each month, load duration curves for mid-week and weekend days. These curves will express the loads as decimal fractions of each month's peak load. These daily curves will be developed as a series of 24 hourly values for both weekend and mid-week days.

4. The load duration curves will be in a non-dimensional form. That is, the absissa axes wil be scaled in decimal fraction values from 0.00 to 1.00 to represent "fraction of total time," with a notation made indicating the number of hours represented by the load durarion curve. The ordinate axes will be scaled in decimal fraction values from 0.00 to 1.00 to represent "fraction of peak load". Alternately, axes may be scaled from 0.0 to 100.0, with the axis labels noted as "percent..." rather than "fraction...".

Using the total electrical energy consumption projection developed by ISES and monthly energy consumption levels developed by WCC it is a relatively straightforward matter to develop projected monthly peak power loads. Since the load duration curves are developed in a non-dimensional form, the non-dimensional area under the load duration curve is also a non-dimensional quantity know as a "load-factor". The load factor represents the power level, in terms of a fractional part of the peak, at which a system would have to operate for the entire period under investigation in order to provide a particular amount of energy to the system. In other words:

Energy (kWh) = Peak Power (kW) x Load Factor x Time (h)

Peak Power (kW) = Energy (kWh)/(Load Factor x Time (h))

It is these concepts which will be used to derive the power levels from the monthly energy use projections.

4 - Subtask 1.03 - Methodology

4.1 General

This part of the Task 1 work will develop information to permit the evaluation of a number of alternatives using a set of consistent criteria. Factors used to evaluate the alternatives in this subtask will include:

- cost
- resource availability
- technical availability
- facility operational characteristics and constraints

In addition to the above factors, which can be expressed in tangible terms (X dollars per kilowatt, Y percent plant factor, etc.), alternative evaluations will be incomplete without consideration of less easily quantified factors such as:

- Institutional factors
- environmental effects
- socioeconomic effects
- licensing prospects
- public health and safety
- state and federal regulations
- risk analysis, financial and marketing analysis

Except for an estimation of an alternative's lecenseability, the criteria for evaluating this last set of factors will be more fully developed as a part of Subtask 1.05. Therefore, there will be interaction between Subtask 1.03 and 1.05. Subtask 1.03 shall assemble the available information for each of the alterntives.

The alternatives under consideration for use in the Railbelt can be separated into two generic groups: Those which generate electric energy in response to the system load "on-line" at any given time, and those which act to reduce the energy requirements of the system.

For the purposes of this study, the first of the above groups will be further divided into two groups, one consisting of hydroelectric alternatives (those which produce electric energy by conversion of the kinetic energy in falling water to electrical energy by means of hydraulic turbines and generators) and another of non-hydroelectric alternatives. The hydroelectric alternatives evaluation will take into consideration the exploitation of tidal energy in the Cook Inlet, as well as the development of the more conventional river-and-storage reservoir schemes. The non-hydroelectric alternatives include a larger number and types of alternatives than the hydro work. Presently, the types of alternatives under consideration include:

- coal
- oil
- gas
- nuclear
- biomass
- solar
- wind
- geothermal
- solid waste
- wood

There may be more than one method of utilizing each of these resources but only the generic types are listed above.

As information is gathered characterizing an alternative type or a particular alternative at a specific site, it may become evident that incorporation of such an unacceptable option. It may be possible at that point to eliminate from further consideration any alternati.

4.1.1 - Tangible Evaluation Factors

In order that meaningful comparisons can be made between various alternatives, hydro and non-hydro alike, it is important that estimates of the cost of those alternatives be built on a common base. For the first phase of the Task 1 work, all costs be given in terms of 1980 dollars.

In the case of a number of alternatives results from previous studies are available.. Such studies may have investigated the alternative to the extent of developing detailed cost estimates. If this is the case and the basis of the estimate appears reliable, the adjusment to 1980 cost levels is a fairly straightforward procedure using the latest version of the Handy-Whitman Index.

In those cases where no reliable cost estimates can be found, the lates version of the U. S. Army Corps of Engineers cost/capacity curves of Acres* cost estimation methodologies will be applied to conventional hydro plants. For alternatives, standard cost/capacity data must be used to arrive at a valid 1980 capital cost fo the alternative.plant.

Total capital costs for any alternatives shall be broken down as follows;

1. Land Acquisition and Site Preparation $________
2. Plant Construction
   (Detailed breakdown where possible) $________
3. Transmission Lines
   (Based on length and per unit cost for appropriate line) &________
4. Access Roads $________
   Based length and per unit cost)
5. Other cost elements associated with a particular alternative. &________

Total ________

All of the above costs shall be expressed in terms of 1980 dollars. Enough information must be gathered on alternative plant operating characteristics so that reliable cost of electricity evaluations can be made for any given alternative plant. The factors entering into cost of electricity calculations include:

- plant fixed charge rate ($/kW)
- plant capacity (kW)
- plant annual energy production (kWh)
- plant fuel costs ($kWh)
- plant O and M costs ($/kW and $/kWh)
- plant A and G costs ($/kW and $kWh)

The first factor noted above, the fixed charge rate for a particular plant or unit is itself a function of a number of factors. This fixed charge is the amount which must be charged per kilowatt of plant or machine capacity to raise the revenue necessary to meet the annual requirement for capital. The annual revenue requirement is generally expressed as a percentage of the total capital cost of the plant or unit and is commonly called the "Fixed Charge Rate". The exact figure used for the fixed charge rate varies from facility to facility and among different types of ownership categories.

In addition to the relevant cost data, other operational data is needed by Acres to successfully incorporate an alternative plant into its Subtask 1.04 work. A summary of the data needed for each plant or alternative development is shown below:

NON-HYDRO PLANTS

1. Year of Availability. Due consideration must be given to construction times and to development times for advanced technologies.

2. Maximum Net Power Output (MW). This is power output at the line-side of the unit transformer minus any plant auxiliary load taken from that point.

3. Net Heat Rate (Btu/kWh). Again, taken at the line-side of the unit transformer minus any plant auxiliary load taken from that point.

4. Fuel Cost (cents/MBtu). In the case of some unit types which may be able to use more than one type of fuel or which have multiple fuel

contracts, provisions are made to accept up to three different fuel costs. In the event that multiple fuel costs are developed, a projection of the percent of time that the unit in question uses each particular type of fuel is necessary.

5. Plant Lifetime (years). This value will be used for fixed charge rate calculations as well as 1.04 work.

6. Forced outage Rate (percent).

7. Planned Outage Rate (percent).

8. Minimum Net Power Output (percent).

9. Fuel Consumption at Minimum Output (per unit of full load fuel consumption

10. Fuel Heating Value (Btu per unit of fuel: gallon, ton, pounds, etc.).

HYDRO PLANTS

1. Year of Availability. Same as non-hydro

2. Maximum Net Power Out (MW). Same as non-hydro except that values must be monthly.

3. Minimum Net Power Power Output (MW). Again, monthly values are necessary.

4. Net Energy Output (GWh). Monthly values.

All of the above data is in addition to that which was noted to be necessary for cost of electricity calculations.

4.1.2 - Intangible Evaluation Factors

The approach to review and assessment of intangible factors relative to each alternative will be to primarily utilize existing data, and available aerial photography of the selected or potential source sites whenever and wherever sufficient information is already available.

However, it may be necessary to gather limited site-specific data for the assessment, since the environmental resources of many of the more remote portions of the study corridor have not been inventoried. The key to this approach is the use of staff who have an in-depth knowledge of both fish and wildlife habitat requirements and a short-term and long-term effects of impact-producing actions of construction and operation of various facilities in Alaska.

The environmental consequences of developing alternative energy sources are highly dependent upon numerous factors including energy resource, collection method, site location characteristics, site fish and wildlife characteristics, land-use patterns, and facility construction and operation designs. A thorough assessment of the impacts of optimum generation expansion mixes (Subtask 1.05) is also dependent upon an understanding of the habitat requirements of local fish and wildlife during their life history; a knowledge of limiting habitat factors; and sensitivities such as fish overwintering areas, and nesting and feeding habitats of endangered or threatened fauna.

The significant impact-producing actions will vary with the alternative being assessed. At times, the selected site location will be the prime factor, while for other alternatives, the short-term or long-term air quality or water quality perturbations, or wildlife habitat degradation may be the overriding factor.

The environmental evaluation of the selected hydroelectric and tidal power development alternatives (if any) will identigy the associated potential impact issues, and their relative magnitudes. Such issues will involve the relative sizes of reservoirs and impacts on water quality and fish and wildlife habitats in particular. The environmental analysis will be performed on the basis of available data, which will be compiled for this purpose. Transmission facilities associated with the hydro alternative sites will be included in this environmental analysis.

For this assessment work set of criteria must be developed. A proposed group of evaluating factors is shown below:

Environmental		
Physical	- water	Descriptive
	- land	Descriptive
	- atmosphere	Descriptive
Ecological	- fisheries	Descriptive
	- wildlife	Descriptive
	- vegetation	Descriptive

Social	- land use	Descriptive
	- quality of life	Descriptive
Institutional	- licensing	Descriptive
	- schedule	Descriptive
	- finance & risk analysis	Descriptive
Public health and safety	- environmental aspects	Descriptive
	- catistropic events	Descriptive
	- man induced problems	Descriptive
State and Federal regulations	- fuel use act.	Descriptive
	- anticquities act.	Descriptive
	- withheld/owes	Descriptive

4.2 Detailed Scope of Work for Alternatives Assessment

4.2.1 Hydro and Tidal Alternatives.

The activities listed in table 1 will be completed to prepare data relative to the hydro and tidal alternatives for input to the screening and ranking process. However, before any conceptual work is done standard criteria to size the main components of a scheme must be adopted; for example:

- installed components as a function of mean annual flow
- standard water passage velocities for sizing all major passages
- spillway design flood
- diversion flood
- provision for multi-level outlet
- etc.

The data base used to size the components will consist of:

(a) Mean Annual Runoff

Identify study area; abstract all latest USGS gaged mean annual flow values and plot a 1:250,000 or 1:500,000 scale mapping; superimpose mean annual ppt. mapping, if available; draw a mean annual flow map; abstract mean annual flow for each site.

(b) Regionalized Storage Yield Analysis

For two or three long-term gages representing full range of hydrologic conditions carry out storage/yield simulations; establish storage requirement for specific firm monthly yield; non-dimensionalize by dividing mean annual flow; extrapolate to other sites to calculate required storage capacity; calculate average annual drawdown in volume units; non-dimensionalize as above and extrapolate.

(c) Installed Capacity

Calculate as X times mean annual flow (or firm monthly flow).

(d) Average Annual Energy Calculation

From simulations carried out in point (b) above, calculate usable flow as percent of mean annual; extrapolate percent to other sites, multiply by site mean annual flow and average head to calculate mean annual energy.

(e) Firm Power

Firm yield x firm head x firm flow

Table 1

Description

1 - Review Available Material
- hydro and tidal

2 - Develop Work Plan
- AP Administration inventory report and backup material
- US Corps inventory and current small hydro study
- CH2M Hill reports
- mapping (topographic, population, land status, geologic, etc.)

Product - sheet memo outlining impartial findings and information sources

3 - Regional Hydrology Studies
- As outlined in Section
Product - mean annual runoff map and outling procedures

4 - Evaluate Engineering Attributes for All Selected Sites (assume 50 sites)
i.e. capital costs, average energy costs, etc.
Includes provision for reworking say 20 sites, i.e. changing storage, installed capacity, etc.

5 - Analyze Tidal Power Schemes
Update cost estimates, prepare attribute values (consider involving R. Tanner, N.F.)
Product - memo commenting on schemes, revised cost estimates and attributes

6 - Modify, Refine, Add to etc. Hydro Inventory
(includes provision for doing more detailed work at certain sites

7 - Preparation of Input Required for Generation Planning Program
assume required for short listed 10-15 sites. Methodology as outlined in Section ___.
Product - table containing input data for each site.

Provision for (i.e. only required if alternative hydro carried through into second year).

8 - <u>Conceptual Design of 5 Schemes</u>

(say 3 large 2 small hydro) carry out detailed power and energy calculations as in Section ___. Prepare conceptual layouts. Calculate costs. Include provision for site reconnaissance (200 hrs.).
Product - drawing for each site and memo containing descriptions of site and table listing all attributes.

9 - <u>Modify, Refine, Add to etc. Conceptual Layout Studies</u>

The detailed work plan for large hydroelectric schemes is included in the Task 6 detailed plan of study. For small hydroelectric facilities the following steps will be completed:

- identify potential load centers on a map
- screen US Corps, Alaska Power Administration, etc. inventories, for potential hydro site to each load center
- add these sites to this study inventory (if not on already)
- (for interconnected system) add additional small hydro sites which can be tied into grid to the inventory
- for decentralized load centers for which above approach does <u>not</u> yield any suitable schemes, consult available mapping, identify sites, if any, evaluate costs (by 1980 cost methodology) and add to inventory.

Step 2 of this process is essentially complete at this time. It should also be noted that the data gathered in Step 1 following completion of Subtask 1.01 and 1.02 will also be applicable to large hydroelectric schemes. Because an important aspect of evaluating any scheme(large or small) a consistant method of updating or estimating must be followed. Intially the following steps will be used to estimate costs:

(a) Where cost estimates have been derived from calculations of quantities
- use available cost data and update using inflation indes established from latest Handy-Whitman indices. Take out all indirect costs such as contingencies, engineering, interest during construction, etc.

(b) Where cost estimates are very old and/or have been derived from old cost-capacity curves (e.g. much of AP Administration work)
- use lates standard US Corps (or alternative) cost-capacity curves to calculate new costs.

(c) Wher no cost data is available - as for (b).

(d) Transmission lines - add in transmission line cost estimates based on length and unit cost for appropriate capacity line.

(e) Access roads

- add in access road costs based on length and unit cost.

(f) Cost basis - 1980

(g) Convert above capital costs to annual costs using following parameters:

life = 50 years?

interest rate + 10 percent?

O&M - 2 percent capital cost?

(These assumptions to be reviewed with management before finalization).

As the study progress from 1980 to 1981 the cost estimating procedure will be reviewed to provide as reliable as possible a cost estimate for viable alternative. The detailed environmental data to be collected are shown below.

	Environment Type	Effects
Physical/Chemical effects (direct effects)	Water - groundwater - surface water - coastal waters	- detertoration of water quality - change in flow rate - alteration of waterway - change in water table, water availability - change in ice conditions
	Land - topography - soils - natural cover	- geomorphic processed induced (erosion, sedimentation) - remobal of natural cover - alter topography - deterioration of soils - alternation of geologically important areas - solid waste disposal
	Atmospher	- air quality change (emissions) - long term atmospheric effects (green house effect - example)

	Environment Type	Effects
Physical/Chemical effects (direct effects) cont.	Meteorological	- change in local temp - energy loss from environment which effects local climate (e.g., large solar may cause lose of heat to earth) - long term atmospheric effects - fogging, ice formation, change in natural patterns
	Geological	- alteration of geologically important area - alteration of chain of natural events (e.g., prevention of natural scouring of river valley by periodic floods - induced seismicity
	Noise	- Distub human/natural population
	Consumption of natural resources	- water, forests, natural energy
Ecological Effects	Fisheries	- loss of natural passageways - loss of spawing grounds - destruction of population - alteration of natural food chains - loss of endangered and important species or other unique species
	Vegetation	- removal of natural cover - alteration of food chain - introduction of incompatible species
Social Effects	Land Use land quality land planning	- loss/alteration of land use - wilderness, scenic - recreational opportunities - forestry - archeological and historic - traditional livelihoods (hunting, fishing, trapping) - urban - (residential, commerical, industrial) - mining - agriculture - ownership

	Environment Type	Effects
Social Effects (cont.)	Quality of Life	- loss/alteration/improvement of Q.O.L factors
	- community	- disturbance/creation of community
	- opportunities	- create/destroy
	- economics	- effects of temporary economic stimulation - change in property values
	- infracstructure	- overburden existing public facilities - change in property values
	- demography	- short term/long term creation of job market
	- aesthetics and cultural aspects	- improve/disturb
	- scenic values and resources	- alter

For each alternative scheme being considered an information table will be constructed. This table will include a description of the project, and identification of expected changes and a prediction of the effect with these changes. An example format for an information table is shown in Table . On this table, data gaps will be clearly identified and judgment decisions on impacts noted.

TABLE 2

Alternative ________

Type ________

Capital Cost ________

Cost/RWH ________

Installed Capacity ________

Plant Factor ________

Resource Availability ________ volume, # of years supply

Transmission Required ________ distance, cost, feasibility

Access Required ________ distance, cost, feasibility

Construction Time years

This criterion will be used to reject alternatives if any of the attributes of the alternatives pertain to the criterion list. Otherwise, the alternative will be retained and subjected to further screening. As alternatives are rejected, they will be grouped according to the component of the criteria on which they were rejected (e.g., rejected because of economic, technical, environmental or institutional constraints). Any alternative rejected will be reassessed to determine if the constraint can be mitigated. If mitigation is possible, the technical or economic modifications required for mitigation will be incorporated into the design. This alternative will then be reevaluated and subjected again to the screening process. Screening will continue until reasonably sized pools of alternatives remain. These alternatives will then be considered for inclusion with the expansion scenarios.

4.2.2 - Non hydro alternatives

Not completed at this time.

4.3 - Screening and Ranking Procedure

The screening procedures are to be used to reduce the planning burden by eliminating the alternatives which:

- are non-significant for the decision-making process
- are plainly dominated by other major or minor alternatives
- are out of the system's interest.

The screening procedure described below is based on an interactive multiple criteria screening process. It will be used for setting up reasonably sized pools of alternatives for subsequent ranking procedures and/or the generation planning exercises.

The basic methodology involves establishing evaluation criteria, and then determining these criteria for each site. The screening process is then achieved by setting up appropriate screening criteria which are then used to screen out all sites which do not meet these criteria.

4.3.1 ~~(2)~~ Evaluation Criteria (tentative)

The basic criteria to be used include the following components:

- economic
- technical
- environmental
- institutional

o Each of the above components is divided into several elements, e.g. the economic component may include the following elements, cost of energy ($/kWh), total capital cost ($, etc...).

- o Each element is ascribed an attribute which can be a number (e.g. \$50/Mwh), a numerical range or an alphanumeric description of an effect (e.g. severe, slight, etc.).
- o The attributes can be changed during an interactive screening process to accomplish the following:
  - sensitivity analysis;
  - to force some alternatives to enter or to leave the selected set (see paragraph on screening errors correction);
  - as a result of a "best compromise" option during the planning process.
- o The list of attributes and their values/definitions constitute the basic data base of the screening procedure.
- o The following elements and attributes are proposed (for hydro and tidal):
  - (i) economic
    - total capital cost (\$)
    - the cost of energy produced (\$/MWh)
  - (ii) technical
    - installed capacity (MW)
    - plant factor (i.e. ratio of average output to installed capacity)
  - (iii) environmental
    - effect on fish (significant, minor, negligible, unknown)
    - effect on wildlife (as for fish)
    - socioeconomic impact (?)
  - (iv) institutional
    - probability of approval (high, medium, low)

4.3.2 Screening Criteria

The screening criteria is a list of attributes or logical combination of attributes. Logical operators such as OR or And will be used to link the attributes to give a specific type of screen.

An example of such criteria is as follows:
"capital cost less than \$3,000,000.AND. cost of energy less than \$50/MWh.AND.plant factor greater than 0.5 No significant effects on fish.OR.wildlife, etc..."

This criterion will be used to select alternatives for a specific list if <u>all</u> the attributes of the alternatives pertain to the criterion list. Otherwise, the alternative is rejected.

It is expected that inadequate information will be available for evaluation of some alternatives. Since our screening process will only eliminate those alternatives that are known to be unacceptable, alternatives with insufficient information for proper evaluation are expected to remain at the end of the screening process. If those alternatives are incorporated into an expansion scenario, additional effort will be required to fill in any data gap prior to final scenario evaluation.

A list of proposed evaluation criteria will be sent to the personnel responsible for assessing the various types of generation (i.e., hydro, non-hydro, conservation). Following their review and comment, a final list will be prepared for presentation to the screening panel. The panel will be expected to review, revise and approve the evaluation criteria prior to the implementation.

A computer program will be developed to undertake this screening work.

An Example

The data for this example are taken from a study of Alaska Power Administration (Appendices A and D).* The hydropower plant proposed to be analyzed in Agashok. The eleven attributes correspondent to the outputs and effects are listed below.

Name	Size	Peaking	Costs	Fish	Wild life	Dist ove	Acces	Man-power	relocation	Capital	~~Addit~~ other
0	1	2	3	4	5	6	7	8	9	10	11
Agashashok	A	H	L	S	S	0	D	~~H~~	M	Q	0

see for definition of letters

The selecting criteria will be formulated as:

1	2	3	4	5	6	7	8	9	10	11
L	$\boxed{H}$	$\boxed{L}$	M	M	I	E	$\boxed{M}$	$\boxed{M}$	I	P
$\boxed{A}$		M	N	N	$\boxed{O}$		N	N	$\boxed{O}$	$\boxed{O}$
S										
M			0	0						

* U.S. Department of Energy, Alaska Power Administration: "Hydroelectric Alternatives for the Alaska Railbelt", Juneau,

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Table 1

NED			EQ*		RD*					
Size	Producing	Cost	Fish	Wildlife	Location		Social		Economic	
					Dist	Access	Develop	Settle.	Capital	Other
L = large: installed capacity over 500 MW	H = high plant factor under 50%	L = low under 10 ¢	S = significant effects		I = in the region	D = difficult	S = significant		I = in	P = positive
A = medium: installed capacity 100 - 500 MW	L = low plant factor over 50%	M = medium 10-20 ¢	M = minor effects		O = outside the region	E = easy	M = minor		O = out	N = negative
S = small: installed capacity 30 - 100 MW		H = high greater than 20 ¢	N = negligible effects		F = free		N = negligible		N = none	O = not affecting
M = mini: installed capacity under 30 MW			U = unknown effects							

*) all the attributes must be defined in this stage

Calculations

SUBJECT:

JOB NUMBER

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BY DATE

APP DATE

In other words, we are looking for all alternatives with high peaking capabilities, low or medium costs, minor negligible or unknown environmental effects, not far from Railbelt region, easy to access, minor or negligible effects in terms of socio-economic aspects and indifferent from the regional economic impact.

This criterion will reject the alternative Agashashoke because of its adverse environmental conditions (4 and 5) and difficult access (7). A re-evaluation of additional costs to improve environmental conditions and a re-evaluation of the costs of transmission will raise the unit energy costs to 18¢. In this case, the new attributes of the alternative will be:

0	1	2	3	4	5	6	7	8	9	10	11
Agashashok	A	H	M	M	M	O	E	M	M	O	O

and the alternative will be accepted.

At this stage, some decision makers may consider that an outflow of capital from the region is not a desired effect and modify the criteria as follows:

1	2	3	4	5	6	7	8	9	10	11
L $\boxed{A}$ S M	$\boxed{H}$	L $\boxed{M}$	$\boxed{M}$ N U	$\boxed{M}$ N U	I $\boxed{O}$	$\boxed{E}$	$\boxed{M}$ N	$\boxed{M}$ N	I	P $\boxed{O}$

and the alternative will be rejected again.

4.3.3 ~~(a)~~ Screening Error Corrections

The above screening process only incorporates a representative sample of all the possible attributes of a project. The value of certain attributes may be uncertain and some values can be changed by changing to the nature of the project (i.e. reducing dam height to mitigate environmental impact, etc.).

Two basic types of errors may therefore arise:

Type 1 - acceptance of a bad alternative

Type 2 - rejection of a good alternative.

An error of Type 1 may be corrected by looking at the selection list and performing all the corrections and adjustments manually to reject the alternative accepted.

An error of Type 2 is more difficult to correct. It requires a reassessment of the attributes which resulted in the rejection of certain marginal projects.

4.3.4 ~~(b)~~ Ranking Procedure

The procedure to be adopted involves setting up several screening criteria and listing those to screen out groups of projects of ascending and decending rank.

Screening Criterion 1 (most severe) -- Selected Group 1 -- Rank #1

Screening Criterion 2 (less severe than 1) -- Selected Group 2 then (Group 2 - Group 1) -- Rank #2

4.3.5 ~~(c)~~ Panel Review

Public comment and opinion will be welcomed at any time and will be actively sought at a number of public meetings and workshops scheduled to take place throughout the course of Task 1 (see Task 12). Where appropriate, additional topics suggested by the public will be considered for incorporation into Acres' study. If it is perceived that a particular topic is especially relevant to the production of an adequate study but that the study of the topic is beyond the contracted scope of work, negotiations will be initiated with the client to modigy the terms of the contract to provide for such study.

Similarly, Acres will solicit the opinion and comment of review panels made up of members selected by the client for their knowledge of Alaskan economic and energy needs and potentials. These panels will meet at strategic times in the study schedule to review Acres' activities and progress. By virture of the stature of their members, the recommendations of these panels will be taken very seriously by Acres and will be incorporated into our work where at all possible. As with comments from the general public, however, if changes are needed to the basic study scope of work, negotiations will be initiated with the client to modify the contract.

Acres will, of course, incorporate the thoughts of its own internal experts and those of its subcontractors.

The amount of data gathered and analyzed during the course of Task 1 work is of little value if it is not somehow disseminated for the client to act upon and for public information. Such distribution will be accomplished by two methods: formal written reports and i-formal public meetings and workshops (see Task 12).

Formal reports to the client will be produced at the end of each phase of the Task 1 work. Presentations will be made to the review panels to enable them to perform their evaluation duties. Much of the material produced for these purposes will be of a highly detailed and technical nature. At the public meetings and workshops, the information will necessarily be presented more informally and at a less sophisticated level. It is anticipated, however, that the client will make our detailed reports available for public use.

5 - Subtask 1.04 - Generation Planning Analysis

The work in this subtask will be intended to pull together the data gathered as a part of the Subtask 1.03 work so that a number of coherent power generation scenarios may develop.

The most straightforward method of evaluating the potential economic benefit of a hydroelectric project in a given system expansion scenario is to compare capital investment and system operating costs on an annual basis, throughout the term of the study, for two scenarios: one without the benefit of the proposed hydro project; the other with it.

A number of mathematical models are available to facilitate the vast number of calculations involved in this type of study. In simplified terms, the user of such a model provides the program with data which includes the characteristics of the forecasted loads and the characteristics, availability and costs of generation sources which will be available throughout the period of the study. The model then selects the generation sources available to it to satisfy the projected load in the most economical manner.

To evaluate the economics of a given project, a comparison may be made of total annual costs of the two system scenarios on a year-by-year basis throughout the study period. If the system with the hydro project available is less costly throughout the planning period, the project is obviously attractive (though not necessarily selected, because impacts must also be accounted for). Conversely, if this system is more expensive in all years, then the project is unattractive.

It is possible, indeed likely, that the outcome of an economic evaluation would prove not to be so clear cut. It may be that the system incorporating the hydro plant would be more expensive in some years of the study, and less expensive in others, than the system without that project. In this situation, it would be necessary to perform comparisons between present worth values of operating cost for systems represented by the two scenarios.

Although such a strategy may provide a valid economic comparison, the results may be inconclusive. This is most likely to occur in the case of a hydro project having capacity which is relatively small when compared to its connected system. The economic comparisons may produced a relatively small difference in two large numbers. This is not valid, however for ~~t~~ the Susitna Hydroelectric Project which is expected to represent an important generation capacity within the system, for the scenarios including the development.

An external multidisiplinary panel will screen the results of the first set of program runs presented in terms of annual operating costs (and of corresponding present worths) per scenario and will provide feedback for subsequent runs. The final results will be presented in the Interim Report for public review, together with a preliminary environmental assessments (Subtask 1.05) of the scenarios generated by the planning program.

In the search for a usable generation planning computer model, three characteristics of the model are paramount:

- Flexibility — does the model allow for a varied combination of alternatives?

- Accessibility — is the model presently available and can it be used with a minimum of learning time?

- Reliability — is the model actively maintained by its supplier and has it been used by other utility planners?

A preliminary survey of the market has revealed one model which satisfies all three criteria. Other models may be available, but these are generally developed either by or for specific utilities to solve their particular problems or they are so intricate so as to require special training for their use.

The computer model selected by Acres for this study is the General Electric Optimized Generation Program, Version Five (OGP-V). Several of Acres' staff have become familiar with the use of this program on other studies similar to the Susitna alternatives evaluations.

The OGP-V program combines three main factors of the generation expansion planning decision process: system reliability evaluation, operations cost estimation, and investment cost estimation. The program begins by evaluation of the power system reliability in the first study year by means of one of two methods — either a percentage-of-reserves calculation or the computation of the loss of load probability (LOLP).

When the system demand level rises to the point at which either the user-specified reserve level or the LOLP criteria is violated, the program "installs" new generating capacity. The program will add generation capacity from a user-provided list of available sources. As each possible choice is evaluated, the program carries out a production cost calculation and an investment cost calculation, and eliminates those units or combinations of units whose addition to the system results in higher annual cost than other units or combinations. The program continues in this manner until the least-cost system addition combination is determined for that year. In cases where operating cost inflation is present, or where outage rates vary with time, CGP-V has a look-ahead feature which develops levelized fuel and O&M costs and mature outage rates out to ten years ahead of the "present" time. Once the apparent least-cost additions to the system necessary to satisfy reserve or LOLP criteria have been selected, the optimum system is described.

Load forecasting and daily load variation data generated in Subtask 1.02 will be used as input to the computer model together with the following technical and economic planning criteria:

- generation capacity and energy reserve requirements

- addition of new units/retirements of older units

- economic discount rate

- period of analysis

This data will be established in consultation with Alaska Power Authority, other utilities in the Railbelt Region and other pertinent agencies. The analysis will be carried out at the base rate with sensitivity testing over the possible range for selected alternatives. The sensitivity testing will be based mainly on the external panel recommendations.

One of the benchmarks against which the economics of a power generating facility may be measured is the economics of its alternatives. In many cases, it is possible to identify specific alternatives against which a given project may be directly compared. Most generating projects are intended for a specific operating regime within the power system, such as base-, intermediate-, or peak-load operation. For such sources, it is a relatively straightforward task to evaluate the cost of operating a specific alternative.

Hydroelectric projects, due to their hydrologic characteristics, must be evaluated in a somewhat different manner. A hydro project can be subject to significant seasonal variations in its generation capacity. Factors such as rainfall patterns and springtime snowpack runoff can work to make baseload and peaking benefits avaiable from the same hydroelectric project. Also, although initial studies of the Devil Canyon-Watana installations were based upon fifty percent annual capacity factor (1,394 MW, 6,100,000 MWh/yr), some base-load (greater than 80 percent capacity factor) and some peak-load (less than 10 percent capacity factor) energy can be expected to be available. The way in which such additional capacities become available complicates the evaluation of a hydroelectric project.

Conventional base-load plants such as coal-fired or nuclear steam plants are commonly built to take advantage of the economies of scale available to large plants of this type. Conversely, peaking plants are usually relatively small (less than 100 MW). The bas-load energy produced by even a larger hydro plant may be available only at such a small capacity as to make comparison with the conventional alternatives meaningless. For example, if the Susitna project, with its 1,394 MW output at 50 percent can produce only 125MW at capacity factors greater than 80 percent, it is difficult to make comparisons with base-load nuclear or coal plants with capacities on the order of 500 MW or larger.

In the same sense, hydrologic conditions may make a great deal of capacity available at a given site for very short periods of time as peaking energy. Such large amounts of surplus energy may make meaningful comparisons between the hydro project and its convention alternatives (combustion turbines) difficult.

Thus, the Susitna Hydroelectric Project will be evaluated in the light of its effect upon the mix of alternatives in the power system and any possible deferment of capital expenditures for other facilities. To properlv take into account the capacity variations of the projects, its operation within a power system will be analyzed on a monthly, or at least a seasonal, basis. More detailed analyses could be performed to define exact operating procedures, but such detail is not justified in a long-term planning study.

Scenarios used as input will be chosen for their apparent technical, environmental, and economic merits.

Guidance from Acres' environmental engineers will be sought for the formulation of the scenarios.

6 - Subtask 1.05 - Expansion Scenario Impace Assessments

This subtask is an interactive work package having inputs to Subtask 1.03, 1.04, and 1.07. The basic purpose of Subtask 1.05 is to compare from an environmental standpoint, the consequences of developing the selected alternative expansion scenarios in the Alaska Railbelt Region, including historical, socioeconomic and other factors.

The approach to review and assessment alternatives will be to primarily utilize existing data, and available aerial photography of the selected or potential source sites whenever and wherever sufficient information is already available. However, it may be necessary to gather limited site-specific data for the assessment, since the environmental resources of many of the more remote portions of the study corridor have not been inventoried. The key to this approach is the use of staff who have an in-depth knowledge of both fish and wildlife habitat requirements and a short-term and long-term effects of impact-producing actions of construction and operation of various facilities in Alaska.

The environmental consequences of developing alternative energy sources are highly dependent upon numerous factors including energy resource, collection method, site location characteristics, site fish and wildlife characteristics, land-use patterns, and facility construction and operation designs. A thorough assessment of the impacts of optimum generation expansion mixes is also dependent upon an understanding of the habitat requirements of local fish and wildlife during their life histroy; a knowledge of limiting habitat factors; and sensitivities such as fish overwintering areas, and nesting and feeding habits of endangered or threatened fauna.

The significant impact-producing actions will vary with the alternative being assessed. At times, the selected site location will be the prime factor, while for other alternatives, the short-term or long-term air quality or water quality perturbations, or wildlife habitat degradation may be the overriding factor. Some of the more significant potential concerns are discussed below.

The environmental evaluation of the selected hydroelectric and tidal power development alternatives (if any) will identify the associated potential impact issues, and their relative magnitudes. Such issues will involve the relative sizes of reservoirs and impacts on water quality and fish and wildlife habitats in particular. The environmental analysis will be performed on the basis of available data, which will be compiled for this purpose. Transmission facilities associated with the hydro alternative sites will be included in this environmental analysis.

For this assessment work set of criteria must be developed. The data provided to the review panel at the end of this subtask will describe the economic, social, and environmental impacts of all alternatives scenarios examined. Such information will permit the client to decide if additional expenditures for the study of the Susitna project are justified, or if pursuit of alternative scenarios may be wiser.

7 - <u>SUBTASK 1.06 Interim Report</u>

The power alternatives study Interim Report will present economic evaluations and preliminary environmental impacts assessment for expansion scenarios with and without Susitna, as well as for a decentralized alternative scenario documenting the findings of Subtasks 1.01 through 1.05 and including various external panel reviews and corresponding iterations. The "With Susitna" Scenario implies a development of the Corps of Engineers scheme, possible with an envelope defined around its parameters, to express the likely range in which other Susitna schemes might lie. The Interim Report will be presented at a public meeting for review early in 1981. Public comments may induce at that time the need for refined analyses starting as far back as the global evaluation of alternatives (Subtask 1.03). The reviewed Interim Report will represent the basic document to be considered in the first GO-NO-GO decision process.

8 - SUBTASK 1.07 - Panel Screen

The panel will examine major assumptions, analyze results and make recommendations related to the selection of expansion scenarios (with and without Susitna) and to their detailed evaluation, and provide input into the sensitivity analysis.

The multidisciplinary panel established and selected in 1980 by APA will have a major screening point at the end of Subtasks 1.03 and 1.05. Panel recommendations related to the detailed study of the expansion sequences for financial and marketing aspects, environmental impacts, risk analyses and cost and schedule refinements may induce reiterations which will be handled mainly as additional sensitivity analyses. The panel is expectecd to produce direct input into the Preliminary Report.

J - WOODWARD-CLYDE PROPOSED MODIFIED APPROACH FOR EVALUATING ALTERNATIVE OPTIONS FOR MEETING RAILBELT ELECTRIC POWER REQUIREMENTS

A PROPOSED MODIFIED APPROACH FOR EVALUATING
ALTERNATIVE OPTIONS FOR MEETING
RAILBELT ELECTRIC POWER REQUIREMENTS
(TASK 1, SUSITNA HYDROELECTRIC PROJECT)

Submitted to

Acres American Incorporated
Suite 329, The Clark Building
Columbia, Maryland 21044

by

Woodward-Clyde Consultants
3 Embarcadero Center, Suite 700
San Francisco, California 94111

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1.0
OBJECTIVES AND OVERVIEW

The overall objective of the activities proposed here is:

- To evaluate the options available for meeting future Railbelt electric power requirements in a realistic manner which recognizes:
  - The sequential nature of the decisions that will be made in the future regarding methods for meeting electric power requirements, and
  - The risks and uncertainties that will exist as each of these sequential decisions is made.

It is not within the scope of the work proposed here to directly analyze the advisability of proceeding with Susitna feasibliity studies. However, the staged approach proposed should provide timely information to support upcoming decisions regarding the advisability of proceeding with feasibility studies for the Susitna Project.

Our basic framework for thinking about this objective is shown in schematic form in Figure 1.1. In this figure the square boxes indicate points at which decisions are made by the Alaska Power Authority, the various Railbelt utilities, and the Alaska state government which will impact the capacity of the Railbelt for meeting future power requirements.

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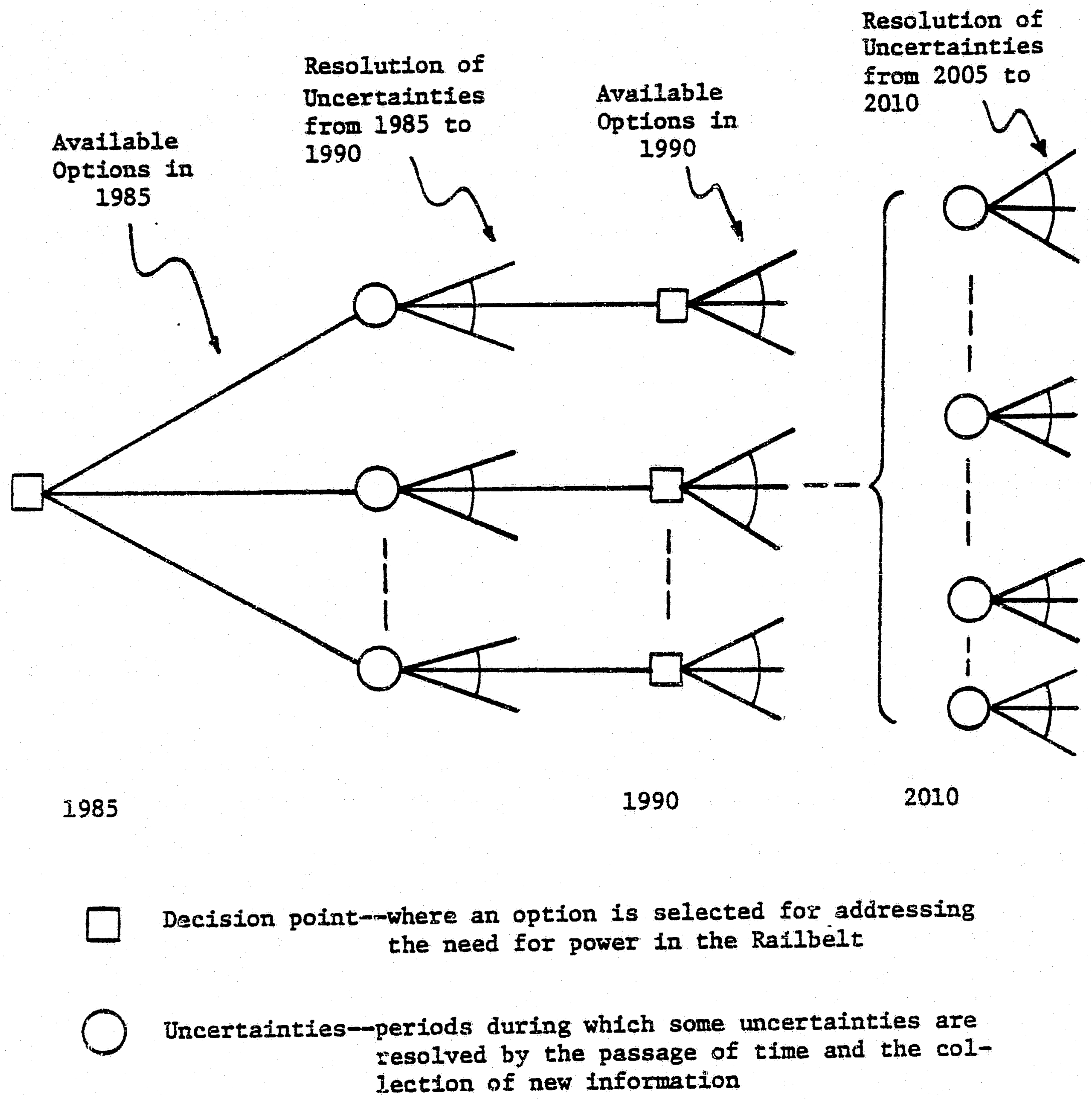


Figure 1.1. The Sequential Nature of Alternative Options for Meeting Railbelt Electric Power Requirements

The several lines radiating from each box indicate that a variety of options is available at each decision point. (The dashed lines at various points in Figure 1.1 indicate that parts of the complete figure have been left out to keep the presentation simple.) At any decision point a large variety of options exists, consisting of various combinations of generating facilities, conservation measures and load management. In Figure 1.1 we indicate that such decisions are made every five years until the end of the Susitna Project planning horizon in 2010. Of course, in reality such decisions are made at irregular intervals; however, the tree structure in the figure illustrates the sequential nature of these decisions.

The circles in Figure 1.1 illustrate periods between each decision point when various uncertainties will be resolved by the passage of time. Thus, for example, when a decision is made in 1985 concerning an option for meeting electric power requirements, the actual demand for power over the period from 1985 to 1990 is uncertain. However, by the time the next decision point shown in the figure is reached in 1990, the uncertainty about demand over the period 1985-1990 will have been resolved. Of course, there will still be uncertainty about the demand for power beyond 1990.

The fans emanating from each uncertainty circle illustrate that there is a variety of possible ways the uncertainty may be resolved. It is a frustrating, but important, part of Railbelt power planning that many uncertainties will not be resolved until after important decisions have been made.

We believe that a logical and defensible procedure for analyzing the options available for meeting the Railbelt's need for power must explicitly address the uncertainties in the situation and the sequential nature of the decisions that are made. Failure to address uncertainties would mean that the possibly significant consequences of having over-or-under capacity could not be considered. Failure to consider the sequential nature of the decisions might lead to drawing unwarranted conclusions about the significance of some decisions. For example, if the sequential nature of the decisions is ignored, then an analysis of the consequences of deciding not to build the Susitna Project in 1985 might indicate that there is a significant probability of a shortfall in generating capacity by 2010. Figure 1.1 shows, however, that if a decision is made not to build in 1985, this decision can be reversed at a later time. A few years will have been lost, but the Susitna option will not have been ruled out for all time.

In addition to uncertainties and the sequential aspect of the problem, two other factors are central to a defensible analysis of the options for meeting Railbelt power needs:

- A variety of different concerns must be addressed in evaluating the desirability of each option, and

- A variety of groups within Alaska have legitimate reasons for having some input into the analysis.

Our proposed approach explicitly addresses the multiple evaluation concerns, including financial aspects, public health and safety, environmental effects, socioeconomics and institutional factors. It also provides a well-defined mechanism for incorporating the views of persons outside the Alaska Power Authority and the Acres team into the analysis.

Our proposed approach is discussed in the next section. It is based on a logical, defensible and time-tested approach utilizing multiobjective decision analysis. With a decision analysis approach all of the concerns discussed above can be addressed within a single unified framework. The sequential nature of the problem is captured using a "decision tree" along the lines shown in Figure 1.1. Uncertainties are analyzed using probability theory. In situations where sufficient data exists, these probabilities can be determined from this data, while in other situations expert professional judgment can be used to establish the probabilities.

Because of the lack of data in Alaska we expect that these "judgmental" probabilities will be particularly useful for Susitna planning. Woodward-Clyde has extensive experience obtaining such probabilities.

The multiple evaluation concerns are analyzed within a decision analysis framework using multiattribute utility functions. These functions allow the multiple concerns to be addressed in a quantitative manner that allows explicit consideration of the tradeoffs among the concerns. The theory underlying utility functions is well established, and Woodward-Clyde has extensive experience using utility functions in a wide variety of engineering planning problems.

Decision analysis provides a logical and defensible procedure for combining probabilities and utilities to evaluate and rank various available alternatives. Extensive applications experience over more than two decades has shown that the approach is particularly useful in complex decision problems like those of interest in the Susitna Project. We have found that the approach is particularly effective in providing a fruitful mechanism for communications in situations where there are disagreements among interested parties over both the facts and the relative importance of various evaluation concerns.

2.0
OVERALL APPROACH

Our proposed overall approach for evaluating alternative options for meeting Railbelt electric power requirements is briefly sketched in Figure 2.1. It consists of four major Activities, the first two of which proceed simultaneously. The figure shows that major activities are completed at weeks 26, 50 and 104 after the start of the analysis effort. These weeks correspond with times when major decisions will be made by the Alaska Power Authority regarding whether to proceed with the Susitna Project or not. Because of the structure and schedule shown in Figure 2.1, useful information should be available from the studies to support each of these decisions.

The central activity in our proposed approach is III, Preliminary Evaluation of Sequential Decision Options. During this activity an analysis will be carried out which addresses all of the complexities discussed in Section 1 above. Important information for this analysis will be provided by Activities I and II, where the demand and supply sides, respectively, of the need for power question will be addressed. In Activity IV an update of the analysis in Activity III will be carried out. This update will primarily consist of more detailed information

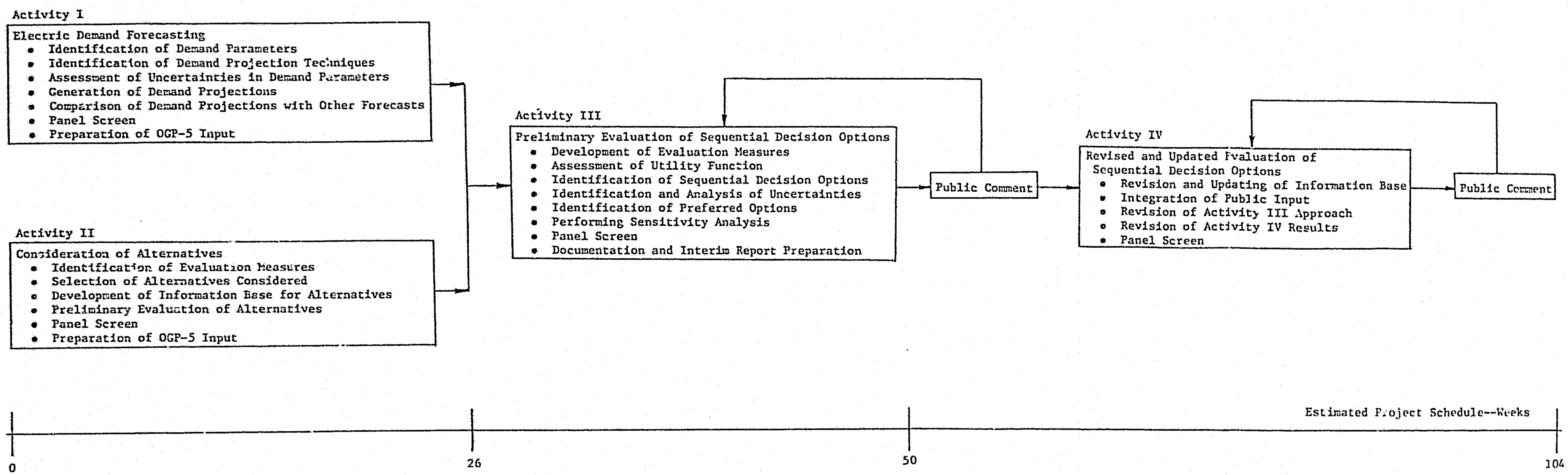


Figure 2.1. Schedule of Activities for Evaluation of Sequential Decision Options--Susitna Hydroelectric Project.

about the exact nature of the Susitna hydro alternatives which will become available through the analysis and testing activities currently being undertaken by Acres and its subcontractors.

Our approach to Activity III will simultaneously address the sequential nature of generation expansion decisions and the uncertainties which make these decisions difficult. The approach will have three elements:

1) A set of alternatives which are available to address the need for power at each decision point,

2) A description of uncertainties which are present at each decision point but which will be reduced by the time the next decision point is reached, and

3) An evaluation function which can be used to assess the desireability of sequences of decisions over time.

Using this approach, Railbelt electric power development will be analyzed as a series of decision stages. At each stage a decison is made to follow one of a set of alternative courses of actions. The information available to make each decision includes knowledge about decisions made at previous stages and the values of certain relevant parameters (such as current fuel costs and demand). Uncertainties will remain about such things as future fuel costs and demand. In addition, the types of alternatives available at each stage will depend on decisions made at previous stages. For example, if a decision to continue feasibility studies for Susitna is made at one stage, the next stage might include the alternatives "Begin construction of Susitna Project", "Delay start of construction at least until next decision point," and "Drop further consideration of Susitna and order 500 MW of gas turbine capacity". On the other hand, if feasibility studies are stopped at one decision stage it may not be possible to "begin construction of Susitna Project" at the next decision stage.

The decision stages and associated uncertainties will be organized into a "decision tree" like the one sketched briefly in Figure 1.1. Each "path" from left to right through the tree represents a sequence of decisions and resolutions of uncertainty which is a particular scenario for future electrical development in the Railbelt.

We propose to develop an evaluation function which will be used to identify the preferred decision at each stage. If this function is to provide a defensible basis for the identification of preferred decisions, it must include consideration of all the multiple concerns of importance for a complete evaluation. These include cost, public health and safety, environmental impacts and other factors. These concerns will be addressed by developing a "multiattribute utility function" which quantifies tradeoffs between the multiple and often competing concerns mentioned above. Woodward-Clyde has used such utility functions with great success in a variety of past projects.

This approach, involving a decision tree and a multiattribute utility function, addresses the central issues of the electric power capacity planning problem in a defensible manner. However, to keep the analysis tractable some approximations will need to be made. The two major types of approximations will relate to the number of decision stages analyzed and the variety of alternatives analyzed at each stage.

The decision tree shown in Figure 1.1 shows decisions being made every five years. In reality, of course, decisions concerning generation alternatives, conservation or load management can be made at any time. It is not feasible to construct or analyze a tree which includes this complexity, and thus it will be necessary to approximate the true situation by assuming that decisions are made at some interval, such as the five years shown in Figure 1.1.

In addition, it is not feasible to analyze all the myriad of generation, conservation and load management alternatives available at each decision point. We believe, however, that based on the preliminary analysis carried out in Activities I and II (which is discussed below), as well as the OGP-5 analysis Acres will be carrying out as part of Activity III, the principal alternatives available can be identified and analyzed. We expect that there will be five to ten such alternatives at each decision point.

Because of the approximations discussed above, some caution will be necessary when drawing conclusions from the analysis about which options are best for addressing the Railbelt's future need for power. However, we believe that the only realistic alternatives to the type of analysis we propose will have to make other assumptions that are considerably more unrealistic than those we propose. In particular, more "conventional" approaches to capacity expansion planning often assume that future demand is known with certainty. This is clearly not true, particularly in Alaska with its mineral resource based boom-bust type of economy, and assuming that future demand is known for certain can lead to widely inaccurate conclusions about the relative desirability of various options for addressing power demand. This inaccuracy is likely to be particularly severe when comparing large capital-intensive options (such as hydro) with smaller alternatives (such as gas turbines). This is because such differing alternatives may provide significantly different flexibility for meeting unforeseen changes in demand. The situation in the Railbelt will require that such alternatives be compared.

Even with the approximations discussed earlier, the decision tree analysis will be fairly complex, and it will be necessary to utilize computer methods to construct and analyze it.

Much of the input required for the analysis in Activity III will be provided by Activities I and II. As shown in Figure 2.1, these activities will precede Activity III chronologically. This assures that useful and timely information will be available to the Alaska Power Authority when it makes its first decision whether or not to proceed with Susitna feasibility studies. In addition, this sequential approach will allow a review of the results of Activities I and II by interested agencies, groups and individuals before the analysis in Activity III is carried out.

Activity I will consider one of the most critical factors bearing on the power planning question, namely the future demand for power. The analysis proposed for Activity I will explicitly recognize and characterize the uncertainties that are inherent in any forecast of future energy demand. Briefly, this will be done as follows: the parameters will be identified which are crucial to determining the level of electrical demand in the Railbelt (e.g., commercial growth, demographic trends, etc.). Next, an appropriate model will be identified or developed which can take specific levels of the crucial parameters and translate them into a specific electric energy demand level. Third, interviews will be held with appropriate experts in Alaska and elsewhere to assess the range of uncertainty in the crucial parameters in a quantitative and structured manner. These uncertainties will then be structured into a set of well defined scenarios with associated probability values. The model will then be used to obtain a probability distribution over demand.

Models for forecasting future energy demand range from simple back-of-the-envelope calculations to sophisticated econometric-end use models of the type under development by the California Energy Commission. The existing data base for many important characteristics of the Railbelt is very weak. Since a model is only as good as the data used to construct it, the weak data base implies that it would not be productive to construct a highly sophisticated forecasting model for use in Activity I.

Our current thinking is that the MAP Model of the Institute of Social and Economic Research might be an appropriate method for forecasting future demographic and economic trends in the Railbelt. An additional simple model involving a few equations would then be constructed to relate the economic and demographic variables forecast by the MAP model to total energy demand in the major geographic regions and economic sectors of the Railbelt. Finally, historical data from utilities would be used to estimate load factors and load duration curves associated with the projected total energy demand.

The use of historical data from utilities implicitly assumes that no significant load management measures will be undertaken in the future. Such measures would be analyzed in Activity II, and the forecasts obtained in Activity I will be modified as appropriate when these forecasts are used in Activity III.

Activity II, Identification of Alternatives, will consider the alternatives that are available to deal with different levels of demand. This task will require considerable collection and analysis of relevant information. The activity will require the development of a comprehensive list of evaluation measures which cover all important characteristics necessary to describe each alternative. Careful thought will be needed to decide on the specific evaluation measures, but we expect that these will cover at least the following areas:

- cost,
- resource availability,
- technical feasibility,
- licensing, scheduling and financing risks,
- public health and safety,
- environmental effects,
- socioeconomic effects, and
- institutional factors.

Once the list of evaluation measures has been selected, it will be necessary to determine levels for these measures for each alternative. Although this task will be relatively straightforward, it will require considerable work to provide defensible estimates for the levels associated with each alternative. We anticipate that a major portion of the effort put into the entire alternatives study by Acres, Woodward-Clyde, and other subcontractors will be spent on this task.

It is likely that there will be considerable uncertainty about the levels of some evaluation measures. We propose to quantify this through the use of standard judgmental probability encoding techniques which we have successfully used in a variety of similar situations in the past.

The principal result of Activity II will be a matrix describing the characteristics of a wide range of alternatives that have potential for dealing with future power needs in the Railbelt. After review by interested outside groups and individuals, it may be possible to drop certain alternatives from further consideration as obviously inferior.

We noted earlier that Activity III was the central activity in the evaluation of options for meeting Railbelt electric power requirements, and that Activities I and II provide necessary information for this evaluation. Activity IV will be a re-doing of the analysis in Activity III with updated information. Our understanding is that the primary updating will be with respect to information about the Susitna hydro alternatives. Since, as indicated below, Woodward-Clyde does not have a role in developing information about the hydro alternatives, we anticipate that we will have only a limited role in Activity IV.

3.0
DETAILED DISCUSSION OF APPROACH

This section discusses the various Subactivities that we propose to carry out within each of the four activities outlined in the previous section. In order to present the activities as unified wholes we will show both those subactivities that Woodward-Clyde would carry out and those that Acres or its other subcontractors would have responsibility for. In several cases responsibilities would be jointly shared. The specific split of responsibilities that we propose is indicated on the figures throughout this section that summarize the subactivities.

3.1 Activity I: Electric Demand Forecasting

The objective of this activity is to provide projections of future electric energy demand for the Railbelt area under various plausible economic and regulatory scenarios. Demand projections will be probabilistic and "nominal" i.e., they will be probabistically stated and will not include conservation and/or load management efforts. The effects of conservation and load management are separately considered under Activity II.

Two different approaches are proposed for Activity I. Our preferred approach presumes that Woodward-Clyde will undertake demand forecasting, perhaps with assistance and input from ISER or other knowledgeable organizations or individuals. This approach, discussed in more detail below, will result in a probabilistic projection of demand. The second approach, not described in detail, assumes that total demand forecasts are provided by ISER and that Woodward-Clyde would attempt to attach a probabilistic distribution to the output of the ISER work. The first approach will be more costly than the second, but is expected to result in forecasts that are better integrated with the rest of the work being done.

Activity I (first approach) consists of six subactivities (see Figure 3.1) as outlined below:

I.1. Identification of Demand Parameters - The purpose of this subactivity is to identify the major parameters and driving forces that affect electric consumption in the Railbelt over the long-run (for examples see Figure 3.1). These parameters would be the major inputs that determine future demand for electricity.

I.2. Identification of Demand Projection Techniques - Following a study of available forecasting models/techniques, one will be chosen to project future electric energy demand in the Railbelt. (It is likely that ISER's MAP model would be used to provide population, demographic and economic projections based on inputs provided by Woodward-Clyde). The projections produced by the model or technique would then form the basis for total electric demand forecasts and load duration curves.

I.3. Assessment of Uncertainties in Demand Parameters - Since the parameters identified in Subactivity I.1 above are subject to variations over the long-run, experts' professional judgments will be elicited to put bounds on the range and likelihood of variations. This subactivity will result in probability distributions for the parameters.

I.4. Generation of Demand Projections - Total electricity demand and load duration curves will be projected using the technique/model adopted in Subactivity I.2. The forecast will be probabilistic (e.g., *Proposed Activity I: Electric Demand Forecasting

I.1. Identification of Demand Parameters
- Alaskan Economy
- National and International Economy
- Demographic Trends
- Income and Taxes
- Price of Energy and Relative Price of Electricity
- Government Decisions
- Electrical Consumption Patterns

I.2. Identification of Demand Projection Techniques
- Total Electricity Demand
- Load Duration Curves

I.3. Assessment of Uncertainties in Demand Parameters
- Identification of Experts and Information Sources
- Assessment of Probability Distributions
- Resolution of Conflicts of Judgment
- Structuring of Scenarios

I.4. Generation of Demand Projections
- Total Electricity Demand
- Load Durations

I.5. Comparison of Demand Projections with Other Forecasts

I.6. Panel Screen

I.7. Preparation of OGP-5 Input

Figure 3.1. Subactivities Proposed for Activity I (Preferred Approach)

*Under our proposed Approach 1 Woodward-Clyde would have principal responsibility for all of Activity I, except I.6 and I.7. Under proposed Approach 2 ISER would have responsibility for total energy demand forecasting.

it would project that total demand in the year 2,000 would not exceed x with probability p).

I.5. Comparison of Demand Projections with Other Forecasts - The results of the previous subactivity will be compared to previous studies of Railbelt electricity demand. Major differences, if any, will be reconciled and/or discussed.

I.6. Panel Screen - In keeping with Acres' proposal to the Alaska Power Authority, the results of Activity I will be reviewed by an outside panel and modified as necessary.

I.7. Preparation of OGP-5 Input - Acres intends to use GE's OGP-5 program during Activity III, and it will be necessary to prepare demand forecasts in a format compatible with that program. The data base for Alaska may be insufficient to provide a complete basis for some inputs required by OGP-5, and Acres will retain ultimate responsibility for determining these inputs. However, Woodward-Clyde will provide the best available estimates for the required inputs within the schedule and budget constraints of this subactivity.

3.2 Activity II: Consideration of Alternatives

The objective of this activity is to provide the necessary information for an evaluation of each generation technology or other means of addressing the Railbelt's future power requirements. This activity does not evaluate the alternatives, except for the elimination of clearly inferior alternatives.

Activity II consists of six subactivities (see Figure 3.2) as outlined below:

Proposed Activity II: Consideration of Alternatives

***II.1. Identification of Evaluation Measures
- Cost Consideration (Capital Costs, O&M Costs, Busbar Costs, etc.)
- Technical Feasibility
- Public Health & Safety
- Environmental Considerations
- Socioeconomic Effects
- Institutional Considerations
- Reliability
- Licensing & Regulatory Considerations
- Lead Time

***II.2. Selection of Alternatives Considered
- Susitna
- Other Generation Alternatives
- Non-Generation Alternatives

***II.3. Development of Information Base for Alternatives
- Identification of Uncertainties
- Development of Information Matrix

**II.4. Preliminary Evaluation of Alternatives
- Classification of Alternatives Based on Type & Size
- Elimination of Clearly Inferior Alternatives

***II.5. Panel Screen

**II.6. Preparation of OGP-5 Inputs

Figure 3.2. Subactivities Proposed for Activity II

*Woodward-Clyde has principal responsibility
**Acres has principal responsibility
***Responsibility is jointly shared

<u>II.1. Identification of Evaluation Measures</u> - There are a number of characteristics which must be considered to defensibly evaluate alternatives and discriminate between them. A preliminary list of important characteristics is presented in Figure 3.2. These characteristics will be identified in this subactivity, and evaluation measures developed that can be used to summarize how well each alternative addresses each characteristic.

<u>II.2. Selection of Alternatives Considered</u> - All potential alternative means for meeting the need for power in the Railbelt will be identified and discussed. A preliminary list of alternatives to be considered is presented in Figure 3.3. These alternatives can be classified into three broad categories as shown in Figure 3.2, II.2.

<u>II.3. Development of Information Base for Alternatives</u> - Relevant information on important characteristics will be collected for each of the alternatives under consideration. This will also include assessment of significant uncertainties affecting each alternative. This information will be used to determine the level of each evaluation measure associated with each alternative.

<u>II.4. Preliminary Evaluation of Alternatives</u> - If alternative A is no worse than alternative B on all characteristics and is superior to alternative B on at least one characteristic, then alternative A is clearly superior to alternative B. This concept, known as "dominance," may be useful to identify certain clearly inferior alternatives within the initial list of alternatives. The remaining alternatives will be evaluated using more detailed analysis in Activity III.

<u>II.5. Panel Screen</u> - In keeping with Acres proposal to the Alaska Power Authority, the results of Activity II will be reviewed by an outside panel and modified as necessary.

**• Susitna Hydroelectric Project

• Other Generation Alternatives

*Fossil Fuel Alternatives
- Coal-Fired Steam Cycle
- Oil-Fired Steam Cycle
- Natural Gas-fired Steam Cycle
- Oil-fired Combined Cycle
- Natural Gas-fired Combined Cycle
- Oil-fired Combustion Turbines
- Natural Gas-fired Combustion Turbines

*Nuclear Alternatives
- Converter Reactors (LWR, HWR)
- Breeder Reactors
- Fusion

*Municipal Solid Waste
*Wood-fired and Peat-fired Steam Cycle
*Biomas Gasification Applications
**Biomass-fired Steam Cycle
**Wind Energy Driven Turbines
**Geothermal Energy Driven Turbines
*Solar Thermal Steam Cycle
*Solar Photovoltaic
**Solar Satellite
**Cogeneration (Industry, District Heating, Institutional)

***Hydro and Tidal Alternative
- Other Conventional Hydro Developments
- Small-scale Hydropower Plant Potential
- Tidal Power Resources of the Cook Inlet Region

**• Non-Generation Alternatives
- Conservation (Forced or Induced)
- Load-Management
- Other

Figure 3.3. A Preliminary List of Alternatives Considered

*Woodward-Clyde has principal responsibility
**Acres has principal responsibility

II.6. Preparation of OGP-5 Input - Acres intends to use GE's OGP-5 program during Activity III, and it will be necessary to prepare information about alternatives for meeting demand in a format that is compatible with the program's input requirements. OGP-5 requires considerably more detailed information about some aspects of the alternatives than needed for Subactivity II.4. Thus, additional work will be needed to prepare the OGP-5 input. The data base for Alaska may be insufficient to provide a complete basis for some inputs required by OGP-5, and Acres will retain ultimate responsibility for determining these inputs. However, Woodward-Clyde will provide the best available estimates for the inputs within the schedule and budget constraints of this subactivity.

3.3 Activity III: Preliminary Evaluation of Sequential Decision Options

The purpose of this activity is to analyze the information generated by Activity I and Activity II to arrive at a preferred strategy for electrical development in the Railbelt. Because of the sequential nature of development decisions and because of the uncertainties surrounding these decisions, it is unlikely that a single development plan will be most desirable under all circumstances. It is likely that while the best initial step in the development process may be clear, the best decisions further in the future will be dependent on how uncertainties are resolved over time. To analyze this type of situation it is necessary to develop a model which can simultaneously analyze many possible future scenarios. One of the most successful approaches to this type of problem has been through the use of a decision tree of the type shown in Figure 1.1.

Activity III consists of six subactivities (see Figure 3.4) as outlined below:

Proposed Activity III: Preliminary Evaluation of Sequential Decision Options

***III.1 Development of Evaluation Measures
- Economic Factors
- Public Health and Safety
- Environmental Impacts
- Socioeconomic Impacts
- Institutional Factors

*III.2 Assessment of Evaluation Function

***III.3 Identification of Sequential Decision Options

*III.4 Identification and Analysis of Uncertainties
- Uncertainties in Demand
- Uncertainties in Fuel Prices
- Uncertainties in Other Economic Considerations
- Uncertainties in Leadtimes for Alternatives
- Uncertainties in Other Evaluation Measures

***III.5 Identification of Preferred Options
- Finalize Decision Tree Structure
- Make Necessary Simplifying Assumptions
- Implement Computer Algorithm
- Make Model Runs

*III.6 Performing Sensitivity Analysis

***III.7 Panel Screen

***III.8 Documentation and Interim Report Preparation

Figure 3.4. Subactivities Proposed for Activity III.

*Woodward-Clyde has principal responsibility
**Acres has principal responsibility
***Responsibility is jointly shared

III.1 Development of Evaluation Measures-A critical initial step in developing a decision analysis type of model is to identify the objectives that are to be achieved in selecting a development strategy. Discussions will be held with a variety of experts and interest groups to identify the widest range of concerns related to electrical development. These concerns will be organized and consolidated into a hierarchy of objectives. Some objectives likely to be included are:

- Minimize costs
- Minimize impacts to public health & safety
- Minimize environmental impacts
- Minimize adverse socioeconomic impacts
- Minimize adverse institutional effects

Once the objectives have been agreed upon, a set of evaluation measures will be developed. These will be quantitative scales that explicity express how well a development scenario achieves a particular objective.

III.2 Assessment of Evaluation Function - The evaluation measures defined in Subactivity III.1 characterize the "quality" of a particular development scenario. It is unlikely that a particular scenario will be more superior or inferior on all the measures than the others. Thus to identify a preferred scenario it will be necessary to make tradeoffs between various levels of the different measures. This is a task that necessarily involves subjective judgement. We propose to use techniques from multiattribute utility theory to assess the preferences for these tradeoffs of a group of individuals identified by Woodward-Clyde and Acres and to encode these in the form of a multiattribute utility function. This function will allow the evaluation measure values to be combined into a single number which indicates a scenario's overall desireability.

III.3 Identification of Sequential Decision Options - Each generation scenario will consist of two elements: a string of expansion decisions interspersed with a string of resolutions of uncertainty over time. This subactivity will use the results of the identification of alternatives in Activity II and of Acres' OGP-5 computer analysis as the basis for construction of sets of sequential decision options that will be available at particular points in time. The OGP-5 analysis should be particulary useful for estimating the financial consequences of including various generation alternatives. Of course, there are an almost infinite number of alternatives which may be chosen at a given time (e.g., "continue Susitna feasibility studies and construct a 100 MW turbine unit and implement a time of day pricing scheme" might be an alternative that is chosen at a single time). In order to keep the size of the problem tractable, a representative set of alternatives will be identified for analysis for each stage. In addition, it may be desireable to break certain large projects such as Susitna into sections (e.g. Feasibility Studies, Licensing and Construction). Once the initial set of alternatives (i.e. the alternatives for the first decision stage) is identified, the consequences of selecting each alternative must be assessed. These include changes in the set of alternatives that may be selected at the next stage, and impacts on the evaluation measures as a result of including the alternative in a development strategy.

III.4 Identification and Analysis of Uncertainties - The second major component of the decision tree model will be a careful analysis of the uncertainties which influence the choice of alternatives at each decision stage. These uncertainties fall into two categories: demand uncertainties and uncertainties in the consequences of selecting a particular alternative. Demand uncertainties were structured in Activity I. Here these uncertainties will be incorporated into the decision tree model. Uncertainties affecting the alternatives were initially structured in Activity II. Care must be taken at this stage to make sure that interdependencies and uncertainties affecting more than one alternative are properly incorporated into the decision tree structure. Subactivities III.3 and III.4 must, of course, proceed simultaneously and will result in the completion of the decision tree structure.

III.5 Identification of Preferred Options - With the completion of subactivities III.3 and III.4 the decision tree model is essentially complete. Conceptually it is a simple matter to "solve" this type of model based on logically defensible principles of decision analysis and identify the optimum decision at each stage given all possible future outcomes. However there are two difficulties with performing this computation. First, the evaluation measures will have been developed to consider complete generation scenarios. Thus accounting procedures will have to be developed to allow the individual impacts of decisions made over time to be aggregated into overall levels of the evaluation measures and thus into a single value using the multiattribute utility function of subactivity III.2. This will be straightforward if care has been used during earlier subactivities in defining the measures and in characterizing the various alternatives.

The second difficulty is computational in nature. The large number of alternatives, uncertainties and decision stages can be combined into a tremendously large number of complete generation scenarios. It may be extremely costly to analyze each of these scenarios. If so, methods will be investigated to identify the optimum solutions without analyzing the entire tree. Possible approaches include Monte Carlo simulation and algorithms using the concept of probabilistic dominance.

Much research has been done in the area of developing computer algorithms to analyze decision trees. It is likely that a previously developed algorithm can be modified for the current problem without extensive developmental effort. Significant programming effort will be required in structuring the data base and interfaces with whatever existing code is used; however this is expected to be straightforward.

III.6 Performing Sensitivity Analysis - Once the decision tree model has been completed and an initial preferred strategy has been identified, it will be necessary to make additional model runs to see if the optimum strategy changes if the modeling assumptions are changed. These "sensitivity" runs will examine the effects of such things as changes in the relative importance of the evaluation measures and changes in the probability distributions of certain critical paramaters. Additional runs may be based on the results of the panel screen, described below. The sensitivity analysis process will provide additional confidence and defensibility in the results produced by the model.

III.7 Panel Screen - In keeping with Acres' proposal to the Alaska Power Authority, the results of Activity III will be reviewed by an outside panel and modified, as necessary.

III.8 Documentation & Interim Report Preparation - Due to the intense public scrutiny that is expected of the forecasting and modeling effort, it is necessary that each step be carefully documented. In addition, it is planned that after completion of the modeling effort an interim report will be prepared and delivered to the review panel and other interested parties.

Summary of Activity III

Figure 3.4 summarizes the modeling steps described above. The implementation of the approach described above will provide a state-of-the art approach to the planning of generation needs for the Railbelt. It will have the advantage of explicity considering uncertainties in variables such as demand and fuel prices. In addition, it will explicitly identify areas where subjective judgements have been used and will help focus discussion on these critical judgements. The technical elements of the model are well defined and have been successfully used in many other applications. Available computer codes can be modified to suit the particular needs of this problem.

3.4 Activity IV: Revised and Updated Evaluation of Sequential Decision Options

The purpose of this activity is two-fold:

(i) to update the data base by integrating additional information which will be available on all alternatives, particular.y Susitna hydro-electyric alternative, and

(ii) to revise the evaluation process, if necessary, in response to comments and suggestions made following the release of Activity III Interim Progress Report. This activity can be subdivided into four sub-activities:

IV.1 Revision and Updating of Information Base - The objective of this subactivity is to integrate whatever new information becomes available which may affect the results of the previous three activities. In particular, it is expected that much useful information about the Susitna hydroelectric alternative, not previously known, would become available. In addition, it might be necessary to revise and udpate the electric demand forecasts if given parameters have changed or new data has become available. Similarly, new developments on alternative energy sources may become available.

IV.2 Integration of Public Input - Following the release of interim progress reports, particularly Activity III Interim Progress Report, interested parties may have certain objections or suggest improvements in the evaluation process. These suggestions can be integrated into the evaluation process at this point.

IV.3 Revision of Activity III Approach - If necessary, the proposed approach of Activity III (and for that matter, those of Activities I and II), would be revised to accommodate the new information base and public participation input.

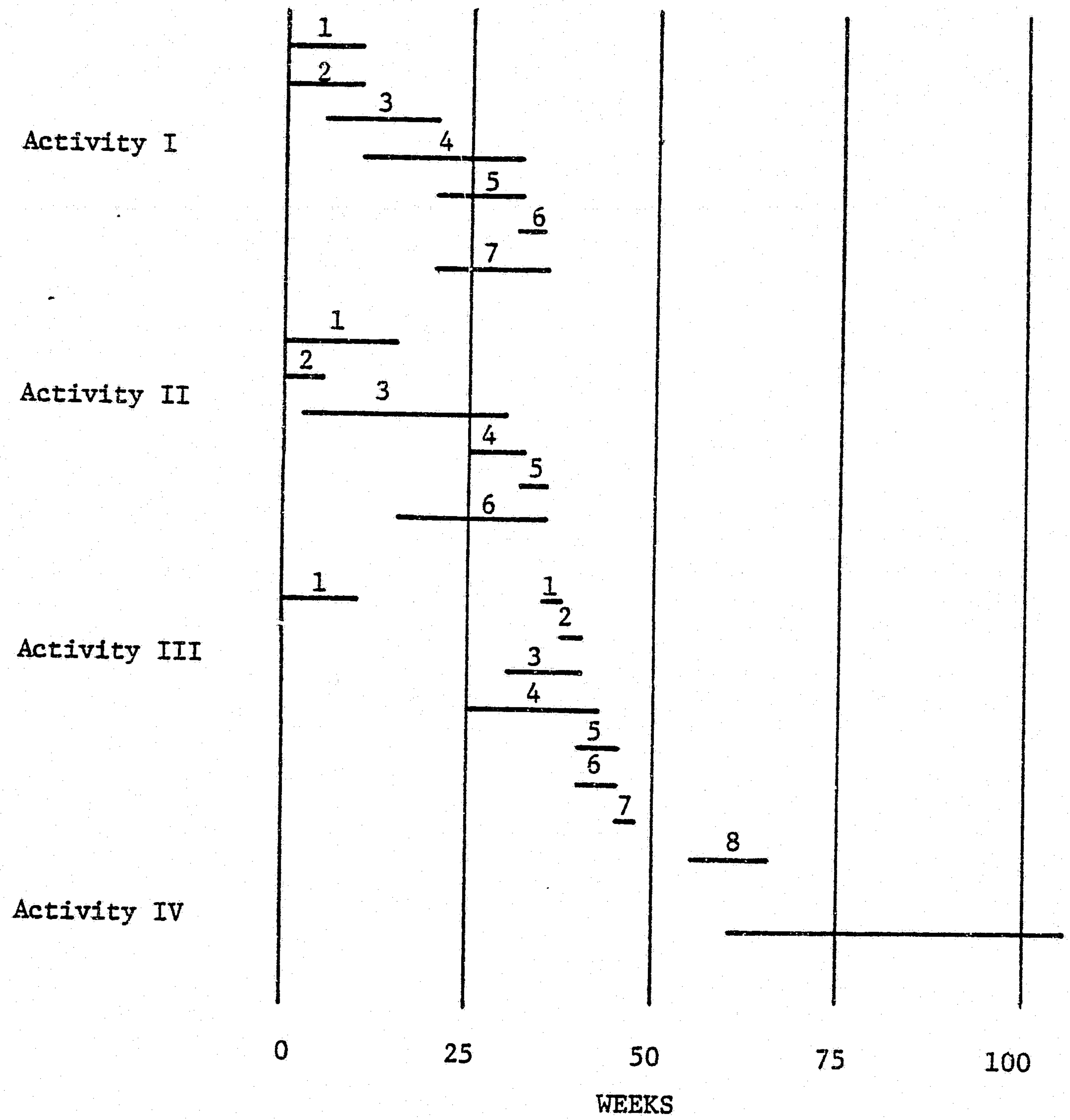
IV.4 Revision of Activity III Results - The results of Activity III will be revised and updated as necessary by the previous three sub-activities.

The end result of the above four activities (see Figure 3.1) will be fully documented and presented in the Final Report. Since the major work in this Activity will involve re-analysis of Susitna hydroelectric alternatives we anticipate that Woodward-Clyde would have a relatively small role in Activity IV.

4.0

SCHEDULE OF ACTIVITIES

Figure 4.1 presents our proposed schedule for carrying out the Woodward-Clyde portion of the Activities described in the previous sections.



(The numbers above the bars refer to subtasks.)

Figure 4.1 SCHEDULE OF PROPOSED ACTIVITIES

K - ACRES PROPOSED METHODOLOGY FOR EVALUATING POWER GENERATION ALTERNATIVES - THE DELPHI METHOD

THE DELPHI METHOD

The use of the expert panel under Task 1 revised scope of work (May 7, 1980) was and is intended to be based on a form of structured interaction among a group which eliminates the face-to-face "committee-type" sessions. This method, which replaces the group discussion with individual interrogations, is known as the Delphi method when applied to the problem of forecasting.

The individual interrogatory will be accomplished by questionnaires with regard to their expectations for a series of future events such as:

- energy and peak load demand growths;
- applicability of cost incentive and mandatory energy conservation and load management measures (extent, effects and cost implications);
- availability of various resources for electric generation in the Railbelt, their expected generic, economic, environmental and institutional impacts in the study area and in the state of Alaska;
- overall impacts (economic, environmental, financial and marketing) of alternatives and alternative scenarios in the study area and in the State of Alaska.

As obvious from the above, the panel of experts will be utilized under this method throughout the Task 1 study period and will participate in evaluating uncertainties inherent in forecasting electric demand (Subtasks 1.01 and 1.02) in analyzing alternatives and conservation measures (Subtask 1.03) in assessing alternative scenarios (Subtask 1.05). The panel input within the application of the Delphi method is structured as a self-contained activity, namely Subtask 1.07.

The panel will be solicited at least four times during the two-year Task 1 study. The four sessions will start probably during the weeks 24, 28, 42 and 94 and each session will last for three or four weeks. The last two screening sessions are scheduled conveniently to provide input into the two decision points. The multidisciplinary panel of experts will be established and the selection of its members will be made by APA.

During each session, three subsequent rounds of questionnaires will be completed. After the first set of questionnaires will be obtained from individual panel members, the numerical answers will be assembled as distributions defined in terms of means and quartiles and the qualitative estimates will be categorized in anonymous groups. These summaries and some additional questions by the interrogators (the project team) will be presented to the panel participants. Respondents will then be asked to submit revised estimates together with reasons for agreeing or disagreeing with the initial consensus (the mean and a confidence interval). In the third and last round, the procedure is repeated, with additional commentary and impersonal debate.

It is envisaged that three rounds will be sufficient to result in a convergence and narrowing of the range of estimates and opinions.

It is also hoped that the panel operation under the Delphi Method will eliminate major objections to the use of committees which decrease the overall efficiency, such as: reluctance to back down from publicly announced positions, personal relationships among individuals (antipathy or excessive respect), differential skills in verbal debate, etc.

In order to avoid a potential bias of the pollster (it may be that the interrogators, by selecting the questions, can to some extent guide the trend of the answers), the questionnaires will be reviewed by the client before being sent to the panel members. Additional comments on related matters, including the structure of the questionnaires, will be welcomed.

The panel should include at least 12 to 15 experts to render the method effective, but a larger number would normally be required to allow for the effect of self-selection among respondents (some experts may decide not to respond to particular questions). The self-selection is an important principle as it replaces subjective group interactions, such as implicit weight factors which committee members instantly attach to each other's opinions (giving least weight on a given issue to the opinion of the least informed).

Previous experiences in applying the Delphi Method (TWR and Rand Corporations) have demonstrated that the distribution of individual forecasts tends to become progressively narrower and more sharply peaked as the successive rounds of interrogation and commentary occur. In successful cases, the result is a balanced forecast in which the best information available has been utilized in a way that no sample model or statistical extrapolation could have been able to duplicate.

Alexis C. Vircol (6/6/80)

L - "NOTES ON MULTIPLE CRITERION DECISION ANALYSIS AND THE ACRES APPROACH TO SUSITNA FALLS" (SIC)

BY DR. CHRIS CHAPMAN

NOTES ON

MULTIPLE CRITERION* DECISION ANALYSIS

AND THE

"ACRES APPROACH"

TO SUSITNA FALLS

as requested by Gavin Warnock
during a meeting June 5, 1980

-Chris Chapman June 6, 1980

*The Woodward-Clyde document uses the term "multiattribute utility function" which is a special form of multiple criterion decision analysis

Taking a decision like whether or not to proceed with the Susitna Falls Project can be associated with five aspects:

(1) option identification

(2) qualitative option evaluation

(3) quantitative option evaluation

(4) inefficient option elimination

(5) option selection.

These aspects follow a logical sequence, but they must be pursued in an iterative manner, and they are not strictly independent. In particular, the fourth (inefficient option elimination) aspect has to overlap the first three using some of the values associated with the fifth to keep the task manageable. However, when the decision is public and politically sensitive, it is extremely important to avoid a restrictive approach to the first three aspects, and a questionable approach to the fourth.

Cost effectiveness analysis (CE) is a widely used tool concerned with the third and fourth aspects (quantitative option evaluation and inefficient option elimination). It seeks to remove options which are "dominated" in the sense that they are worse than some other option with respect to all measurable criterion. It is a very reasonable first step in terms of attempting formal decision analysis. However, it has its critics. They argue it obscures the second aspect (qualitative option evaluation), and tends to make the option selection process dominated by technocrats. If it is to be used successfully, it must be seen as a part of the total decision taking process, carefully and sensitively integrated with the other aspects.

Cost benefit analysis (CB or BC) attempts to take the formal decision analysis process a stage further than CE analysis, by employing an aggregation process for the separate criterion measures generated for qualitative evaluation. This aggregation process is usually in money forms. It is indirectly defined in forms of perceived public preferences (revealed preferences) as defined by past behavior, and other considerations of this kind. It can be seen as an attempt to make even the final option selection process a formal decision analytic process, but most proponents would advocate restricting its use to inefficient option elimination. It is a very reasonable notion in some respects, but it has much stronger critics than CE. In addition to furthering the technocratic smokescreen aspect, it has fundamental conceptual weaknesses. For example, in 1980 all the people in Alaska might agree that of options A, B and C, they prefer A; but in 1985, these same people might all agree they prefer B. In both cases, they may agree for very different reasons. For example, for some a new project may be a source of employment; for others, it may be a source of pride; for others it may be the least unattractive source of environmental, pollution, and so on. The changes in these preferences may be for reasons difficult to quantify. For example, expectations for the future may change, concern for future generations may change, as a consequence of a major accident, market change, and so on. A perfectly performed CB study in 1985 based on 1980 "revealed preferences" would not only choose A instead of the unanimous "correct" choice B, it would do so in terms of "public preferences" which are a non-existent "average" of views wholly irreconsillable, needing discussion of the case for B versus A quite impossible in terms of the CB itself. Some opponents of CB would argue it is precisely because it stifles discussion it is politically attractive, bearing in mind the scope for selecting a way of measuring preferences which supports any choice you might care to argue.

Risk and uncertainty can be made measurable criterion in a CE or CB context, in the limited sense that uncertainty with respect to quantifiable criterion can be measured and considered in conjunction with other measurable criterion. The more usual approach is sensitivity analysis with respect to major and crucial sources of uncertainty--separate "what-if" evaluations.

Multiattribute utility function analysis (MA) does not have the extensive development history of CE or CB, which have been used world wide for many years. It is a recent comparatively academic development of statistical decision theory. Its advocates (Raiffa and Keeney at Harvard and MIT, Moore and Howard at the London Graduate School of Business Studies, and others) claim to have applied it with success. However, it is a great deal more restrictive than CB analysis; it is theoretically based on a specific axiomatic framework which is not easy to understand; and it could easily attract substantial expert criticism. In effect, it takes the CB framework several stages farther, imposing special preference structure forms on the way measurable criterion are linked in order to achieve a particular form of "consistent" treatment of risk, insisting upon probabilistic treatment of risk as a basis for analysis, and suggesting a formal decision analytic procedure can be used with minimal reference to non-quantifiable "attributes." The concern for consistency is well founded in the context of repetitive discussions by single decision takers if non-measurable attributes are constant or unimportant. It is not unreasonable in terms of a Susitna type decision, but it is not worth the price required by a multiattribute utility theory approach. Historically, I perceive the emphasis on a total quantitative final choice selection arises from a wish to deal directly with multistage decision forces. The Woodward-Clyde document reflects this, with its strong emphasis on 5-year decision point trees. This sort of decision tree structure clearly does underlie the problem situation, but it is not at all clear it needs to be treated by the rather simple-minded sledgehammer approach suggested. To stick one's neck out with specific utility functions in order to deal explicitly with such forces is a very risky posture to adopt, since no one apart from the panel involved will necessarily agree with the tradeoffs.

As I understand the "Acres Approach," we are suggesting the use of a wide range of engineering and other skills (political, economic, etc.) to pursue aspects one to four as fully as possible. We have clearly overplayed the engineering side, underplayed the rest, but this balance is being redressed. Our intention is to use some clearly defensible engineering, economic and political judgments to weed out inefficient options. However, we could also use (I think should use) descriptive risk analysis techniques of the BP type to make similar structured judgments with respect to costs, market/cost combinations, and so on.

That is, we could use formal analysis techniques which are concerned with identifying and structuring the total picture, including participant responses to risks, providing a rational and consistent explanation for the set of choices and scenarios we intend to assess. Having identified and assessed a defensably representative set of scenarios, we would not wish to suggest a specific optional choice at this stage. One concern is "robustness," in the sense that we would suggest looking for options which preserve a satisfactory situation over a wide range of potential outcomes, and do not court disaster for any forseeable possibilities. Attempts to measure robustness have been made (Rosenhead, LSE, et al). Its importance is widely recognized. It is comparatively simple to eliminate non-robust solutions in a scenario framework, but it is not a concept which can be optimized in the MA sense, no matter how detailed the decision tree structure employed. Another concern is the "feasibility gap" between options which look attractive and parameters which participants may be able to change or may have to wait to change. That is, the analysis would suggest which options are currently feasible and robust, if any, and which would become robust under what circumstances. Detailed quantitative and qualitative assessment would be provided for these choices. However, Acres would presume to use quantitative tradeoffs of the CE, CB or MA type only if it proved impossible to decide between a few remaining options, including the same basic project with different timings. If such techniques are required, they ought to be applied to such a basis, and there is no reason for ~~prejudging~~ which might be appropriate. Only when the first three aspects have been thoroughly addressed can a clear decision be made with respect to a suitable mechanism for final option selection; but it is more important to be clear about a degree of formality and structuring for the inefficient option elimination aspect.

As a consequence, the goal of an "Acres Approach" based on aspects one to four is a carefully detailed set of potentially viable options, properly evaluated in qualitative and quantitative terms, with clearly explained recommendations based upon both formal analysis and judgments as appropriate. Acres would not attempt to put probabilities on possibilities which do not need probabilities in order to understand their implications; Acres would not attempt to measure considerations which would not be clarified by measurement; Acres would not attempt to use a specific valuation procedure like CE, CB or MA unless it would clarify a particular set of options in terms of relevant tradeoffs, and Acres would concentrate upon providing an information base which would allow those concerned to make a rational choice based on a clear understanding of the implications of that decision, including the actions necessary to ensure its success, and the conditions necessary to make it viable.

TEXT OF LETTER RECEIVED FROM DR. C. B. CHAPMAN June 20, 1980

June 16, 1980

Dear Gavin:

A few more comments on the Woodward-Clyde document in response to your cable.

I now understand Ralph Keeny is an associate of Woodward-Clyde, which explains their interest and experience with multi-attribute decision analysis, and their emphasis on its "state-of-the-art" and "logical, defensible" nature.

On rereading the document, it all makes reasonable sense, apart from the conviction that trees will have to be examined in activity III and the conviction that attribute functions will have to be measured, as distinct from measuring attributes, which I do agree with.

The use of complex sequential decision trees is conceptually interesting in this context. Such models underlie all the BP risk analysis, although we make the analysis process more efficient by employing a "Semi-Markov Process" type memory-pruning the decision tree by restricting the memory of previous decisions to only those characteristics which matter, and we concentrate on cost-risk trade-offs for such model decision purposes. As noted before, there are two main reasons for avoiding a direct decision tree approach of the kind proposed. One is conflicting objectives which cannot be put into a single preference function by a panel. If a decision theoretic approach were needed, Meta game approaches are more relevant. A paper is enclosed to illustrate these ideas. The second is the "optional solution" decision idea (which) is simply not relevant to such decisions in my view--robustness is what must be sought, because any probabilities are highly objective, the planning horizon is so long, and so many people are involved who cannot participate directly in the decision. Multiattribute decision functions depend on the notion that there is a best or optimal decision given a consistent set of preferences and a valid set of subjective probabilities. When the validity of the preferences and the probabilities is in doubt, this is not a defensible emphasis, and it is certainly not a defensible premise. The Woodward-Clyde document does discuss sensitivity analysis, but it plays down the notion that an "optimal" decision in a decision theoretic sense may turn out to be an unmitigated disaster, or "non-optimal" by a wide margin in the majority of possible outcomes. A "robustness based" approach would explicitly try to avoid these possibilities, and it would provide information of the form

if fuel cost x is greater than y by a factor of z for at least
w years and cost is deemed most important, provided no major...
and ______
etc.
then choice A will be best -- we think these are reasonable assumptions if x relative to y ......
however B saves only ... relative to A

etc.

This sort of information is what will be needed to make future decisions at the decision points associated with the Woodward-Clyde approach - not the multiattribute decision functions, and there is no comparative advantage for their tree based analysis as a description of the future.

Hope all goes well in your discussions with them. Please let me know if you want further comments.

Best wishes,

Chris

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Metagame Analysis of the Poplar River Conflict

NIALL M. FRASER and KEITH W. HIPEL

Department of Systems Design Engineering, University of Waterloo, Waterloo, Ontario, Canada

The technique of metagame analysis enables the assessment of the political feasibility of engineering projects. The building of a large power plant in Saskatchewan, Canada, has resulted in a conflict between Canadian and U.S. interests over the apportionment of water in the Poplar River, which flows across the international border from Saskatchewan into the American State of Montana. Metagame analysis is used to determine political resolutions to the Poplar conflict based on the published preferences of the interested parties. It is shown that metagame analysis conveniently organizes information and provides insight into conflict resolution.

INTRODUCTION

In 1974 the Saskatchewan Power Corporation announced a plan to build a thermal power plant which would use water from the Poplar River in southern Saskatchewan, Canada. Because the Poplar River flows from Canada across the international boundary into the United States (U.S.), protests were immediately made by the potentially affected parties. The conflict does not possess a simple solution due to the divergent interests of the concerned groups and the international scope of the project. Consequently, the Poplar conflict constitutes a current political problem for which some type of operational research technique can be used to aid in the analysis.

Metagame Analysis or *the analysis of options* has been suggested as a tool for analyzing water resources conflicts[1,2] and has been used for the analysis of other forms of conflict.[3–5] In metagame analysis a conflict is considered as a *game* with a limited number of *players*, where each player has a specified number of *options*. Information about the preferences of the players for *outcomes* associated with the conflict is used to determine possible *equilibria* or resolutions to the conflict. A detailed explanation of the technique is given by Howard[6] and also Hipel *et al.*[1]

Following a description of the Poplar River conflict, the problem is formulated as a game. Metagame analysis is then employed for predicting feasible political solutions to the conflict, using published information to assess the preferences of the interested parties. If special knowledge about the conflict exists, the analysis should be performed with the preference structure, player selection, or possible options which are most relevant.

HISTORY OF THE CONFLICT

The Poplar River Basin lies in the southern part of the Canadian Province of Saskatchewan and the northern part of the U.S. State of Montana. The river and its tributaries flow southward to join the Missouri River near Poplar, Montana. The Poplar watershed encompasses an area of 8620 km², which is about the same size as the basin of the River Thames. The northern third of the Poplar watershed is in Saskatchewan, while the southern third lies within the Fort Peck Indian Reserve, in Montana. Except for a few small towns the area is rural, with a population of about 7–8000. The Poplar River region has been subject to severe droughts which have lasted as long as a decade. The Poplar River has an average annual flow of 42,000 cubic decameters at the international boundary, three-quarters of which occurs in the spring runoff which may last from 10 days to 3 weeks.[7] This can be compared with a flow of 1,000,000 cubic decameters annually at the mouth of the Thames.

ORS 31/5—a

TABLE 1. PLAYERS AND OPTIONS FOR THE POPLAR CONFLICT

Player	Option
Saskatchewan Power Corporation	—build initial power plant —build extended power plant —build to full capacity —import water
Province of Saskatchewan	—legal action based on Boundary Treaty and Helsinki Rules
Fort Peck Indian Tribes	—build full irrigation project —build reduced irrigation project —legal action based on Boundary Treaty —legal action based on Winters' Doctrine
State of Montana	—legal action based on environmental concerns
U.S. State Department	—legal action based on environmental concerns
Canadian Government	—action based on environmental concerns
U.S. Government	—action based on environmental concerns
International Joint Commission	—support apportionment favouring Canada —support apportionment favouring U.S. —support 50–50 apportionment —action based on environmental concerns

For the Fort Peck Tribes, two options include all the possible irrigation projects which are available. It is assumed that there will be enough water to support the full irrigation project with a 70–30 split favouring U.S.A. and the partial project with either a 70–30 split favouring Canada, or else a 50–50 apportionment.

In 1977, the I.J.C., the Canadian and U.S. governments, and the State of Montana all indicated that water and air quality studies are underway. Until these studies are completed these parties cannot express positions on the conflict relating to water and air quality. The other player which expressed concern about environmental quality is the U.S. State Department, but it has also indicated that it is in supporrt of any apportionment agreement.[7]

The aforesaid would suggest that the two aspects of the Poplar conflict, apportionment and environmental concerns, can effectively be separated. They are of course interdependent, but because of the time factor, expressed options relating to environmental concerns cannot be freely chosen by the participants to have bearing on the apportionment conflict. This separation reduces the number of significant players in the conflict. Further simplification can be made by noting that the interests of the Province of Saskatchewan and the S.P.C. are identical. They are then considered as one player, whose total options include the options of both. The list of players and options for the apportionment conflict as adjusted in this manner may be found as Table 2.

The ordering of players and options in Table 2 is used in the ensuing metagame analysis of the Poplar conflict. An *outcome* is indicated by a vector of ones and zeros,

TABLE 2. PLAYERS AND OPTIONS FOR THE APPORTIONMENT CONFLICT

Player	Option
Saskatchewan Power Corporation	—build initial power plant —build extended power plant —build to full capacity —import water —legal action based on Boundary Treaty
Fort Peck Indian Tribes	—build full irrigation project —build reduced irrigation project —legal action based on Boundary Treaty —legal action based on Winters' Doctrine
International Joint Commission	—suppport apportionment favouring Canada —support apportionment favouring U.S. —support 50–50 apportionment

where a "1" opposite an option indicates that the option is chosen by a player, and a "0" opposite an option means it is not selected. An outcome is written as a column in the metagame analysis tables, as can be seen in Table 5, or is written horizontally in the text, where each position corresponds to an understood option. Thus [10000 0001 100] is determined from Table 2 to mean the outcome where the S.P.C. builds its initial plant, the Fort Peck Tribes pursue legal action on the basis of the Winters' Doctrine, and the I.J.C. supports an apportionment scheme which favours Canada. Sometimes it is convenient to place a dash, denoted by "—", opposite an option to indicate either a "1" or a "0". Hence a column which contains n dashes represents 2^n specific outcomes.

PREFERENCES

The preferences of the players in a conflict must be ascertained in order to perform a metagame analysis. In the Poplar conflict, the S.P.C. would prefer as large a power plant as possible, but would prefer not to import water because of the great expense involved. The Fort Peck Tribes would prefer a full irrigation project to a partial project.

A general assumption can be made concerning the decision on the parts of the S.P.C. and the Fort Peck Tribes to initiate "legal" action. It is reasonable to say that a party would favour legal action if it anticipated winning, and would not favour legal action if it expected to lose. In some situations this would not be true, such as a suit advanced to satisfy political pressure, but in the Poplar River conflict it is reasonable to determine the players' preferences for court action on this basis. Since the I.J.C.'s recommendation can be expected to parallel a judgement made by it should such a judgement be required, and the opinion of the I.J.C. represents the most sound analysis available, it is assumed that legal action based on the Boundary Waters Treaty will fail unless supported by the I.J.C. recommendation. Thus either the S.P.C. or the Fort Peck Tribes are likely to initiate legal action when supported by the I.J.C., but not otherwise. The Fort Peck Tribes indicated that they may initiate legal action under the Winters' Doctrine under any circumstances other than a 70–30 split favouring the U.S.[7]

The I.J.C. must "secure the interests of both countries".[7] Because it is in the interests of both Canada and the U.S. to have the conflict resolved, it would be preferred by the I.J.C. to make a recommendation. However, beyond this no preferences are permissible for the I.J.C. This player must remain impartial, and hence the I.J.C. cannot even levy sanctions against other players when performing the metagame analysis.

OUTCOME REMOVAL AND METAGAME ANALYSIS

The 12 options in the Poplar conflict imply 2^{12}, or 4096, possible outcomes. There is no need to exhaustively examine all of these outcomes because only a few of them are worth considering as possible equilibria. The process of determining which outcomes constitute likely equilibria can be called "outcome removal" because outcomes that are identified as not being likely equilibria are removed from the full set of outcomes.

A large number of outcomes can be removed from the model on the basis of logical infeasibility. One form of logical infeasibility is where options are mutually exclusive. For example, the S.P.C. cannot build more than one plant, the Fort Peck Tribes cannot build more than one irrigation project, and the I.J.C. cannot support more than one allocation plan. The removal of logically infeasible outcomes cannot incur any possible loss of information, and the number of outcomes remaining in the model will often be very small. For example, in the hypothetical dam allocation problem examined by Hipel *et al.*,[1] removal of the logically infeasible outcomes reduces the set of possible equilibria from 1024 to a mere 16. After removing logically infeasible outcomes from the Poplar conflict, 768 outcomes remain.

To further reduce the number of outcomes to consider for analysis, it can be noted that many outcomes can be removed on the basis that they recognisably will not form an equilibrium. For example, consider the set of outcomes [————— 1——— 1——], which means

TABLE 3. LIST OF REMOVED OUTCOMES

Outcomes			Reasons
11---	----	---	—logically infeasible
1-1--	----	---	—logically infeasible
-11--	---	---	—logically infeasible
-----	11--	---	—logically infeasible
-----	----	11-	—logically infeasible
-----	----	1-1	—logically infeasible
-----	----	-11	—logically infeasible
-1-0-	----	-1-	—extended plant not possible with only 30% apportionment without imported water
--10-	----	-1-	—complete plant not possible with only 30% apportionment without imported water
--10-	----	--1	—complete plant not possible with only 50% apportionment without imported water
-----	1---	1--	—full irrigation project not possible with only 30% apportionment for U.S.
-----	1---	--1	—full irrigation project not possible with only 50% apportionment for U.S.
----1	----	-1-	—S.P.C. will not go to court if not supported
-----	--1-	1--	—Fort Peck will not go to court under the Boundary Treaty if not supported
-----	---0	1--	—Fort Peck will go to court under Winters' Doctrine unless favoured
-----	---0	--1	—Fort Peck will go to court under Winters' Doctrine unless favoured
-----	----	000	—the I.J.C. should make a recommendation
000--	----	---	—the S.P.C. will build some size of power plant
-----	00--	---	—Fort Peck will build some sort of irrigation project
---1-	----	---	—it is too expensive to import water under any circumstances

TABLE 4. METAGAME ANALYSIS OF THE REDUCED SET OF OUTCOMES

	outcomes examined																					
S.P.C.																						
Initial plant	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Extended plant	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Complete plant	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Import water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Legal—Boundary	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Fort Peck																						
Build project	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Partial project	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Legal—Boundary	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Legal—Winters'	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1
I.J.C.																						
Favour Canada	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Favour U.S.A.	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Support 50–50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
*Stability**																						
S.P.C.	i	i	i	i	r	i	s	r	s	r	s	r	s	r	i	i	i	i	r	r	i	i
Ft.P.	r	s	s	r	s	r	r	i	i	i	i	i	i	i	s	i	s	i	r	i	r	i
I.J.C.	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
overall	u	u	u	u	E	u	E	u	u	u	u	u	u	u	u	u	u	u	E	u	u	u
Notes†	1, 3	1	1	1, 3		3		3	3	3	2, 5	2, 3	2, 3	2, 3	1	1, 3	1, 3	1, 3		4	3, 4	3, 4

* Notation: r = rational; s = symmetric metarational; i = inescapable improvement; u = unstable for some player; E = equilibrium.

† Notes:
1: The S.P.C. would inescapably improve to a larger plant.
2: Fort Peck would inescapably improve to a larger project.
3: No need for court action.
4: Fort Peck would drop the Boundary Treaty legal action.
5: See Table 5.

TABLE 5. STABILITY ANALYSIS OF OUTCOME [10000 0100 010] FOR THE SASKATCHEWAN POWER CORPORATION

	Preferred		Particular outcome	Not preferred	
S.P.C.					
Initial plant	—	—	1	—	—
Extended plant	1	—	0	—	—
Complete plant	—	1	0	—	—
Import water	0	0	0	—	—
Legal—Boundary	—	—	0	—	—
Fort Peck					
Build project	0	0	0	—	—
Partial project	1	1	1	—	—
Legal—Boundary	0	0	0	1	—
Legal—Winters'	0	0	0	—	1
I.J.C.					
Favour Canada	0	0	0	0	0
Favour U.S.A.	1	1	1	1	1
Support 50–50	0	0	0	0	0

Unilateral improvement

Inescapable sanction

that the Fort Peck Tribes build their full irrigation project and the I.J.C. supports an apportionment scheme which favours Canada. Clearly any outcome in this set is not a likely equilibrium because the Fort Peck Tribes would always prefer not to build the full irrigation project if there is not enough water to supply it.

Table 3 lists sets of outcomes which have been removed from the complete model. All these outcomes are either logically infeasible, or may be removed on the basis of published preferences. Removal of these outcomes leaves 22 in the model for further consideration.

A computer program was used to remove the outcomes in Table 3 from the total set of outcomes, and each of the resulting outcomes was subjected to a complete metagame analysis. The final results for the 22 remaining outcomes are found in Table 4, and an example of the actual analysis required to obtain the stability results for the outcomes in Table 4 is shown in Table 5. The mathematical theory defining the various stability states listed in Table 4 may be found in the references[1,6], and examples are presented below.

Consider analyzing the particular outcome [10000 0100 010] for stability using the metagame analysis algorithm. This is the situation where the S.P.C. builds its initial plant, the Fort Peck Indian Tribes build a partial irrigation project, and the I.J.C. supports an apportionment scheme which favours the U.S. Table 5 illustrates the metagame analysis from the point of view of the S.P.C. From the particular outcome, the S.P.C. can *unilaterally improve* itself by building the extended or complete power plant. However, there is an *inescapable sanction* available to the Fort Peck Tribes in this situation, since they can initiate legal action based on the Boundary Waters Treaty, or on the Winters' Doctrine. The sanction is inescapable because the S.P.C. can choose no options that would subsequently result in an outcome which would be preferred to the particular outcome, as denoted by the dashes opposite its options on the not preferred side. Because the I.J.C. supports an apportionment scheme that does not permit an extended or complete plant on the part of the S.P.C., the legal action would likely be successful. This *credible* sanction would deter the S.P.C. from unilaterally moving away from the particular outcome to a more preferred outcome. An outcome which possesses stability of this type for a given player is said to be *symmetric metarational*.[1,6]

By choosing to build a full irrigation scheme, the Fort Peck Tribes also have a unilateral improvement from the particular outcome which is under consideration. This is an *inescapable improvement* because no matter what the S.P.C. subsequently does, the outcome produced is invariably preferred to the particular outcome. Consequently, the outcome [10000 0100 010] is *unstable* for the Fort Peck Tribes.

Because the I.J.C. must act in an impartial manner, all recommendations are equally preferred and thus there is no outcome which is preferred to the outcome [10000 0100 010]. Therefore, no unilateral improvements exist for the I.J.C. and the particular outcome is *rational* for that player.

The outcome [10000 0100 010] is the eleventh outcome from the left in Table 4. Following down the column, a code indicates the stability of the outcome from the point of view of each of the players. As has just been determined, the table indicates that the outcome [10000 0100 010] is symmetric metarationally stable for the S.P.C., that there is an inescapable improvement for the Fort Peck Tribes, and the outcome is rational for the I.J.C. If an outcome is unstable for any player, as [10000 0100 010] is for the Fort Peck Tribes, it is not a possible equilibrium in the game. This is denoted in Table 4 by a "u" opposite "overall". When an outcome is stable for all players, it is an equilibrium, denoted by "E", and a possible resolution to the conflict.

In the Poplar analysis there are three equilibria, each of which depends upon a possible I.J.C. recommendation. In the situation of an apportionment favouring Canada, the analysis suggests that an equilibrium will occur with the S.P.C. building the complete plant, and the Fort Peck Tribes building a reduced irrigation project while going to court on the basis of the Winters' Doctrine (fifth column from the left in Table 4). Where the apportionment favours the U.S., the suggested equilibrium is with the S.P.C. building the initial plant only, and the Fort Peck Tribes building the full irrigation project (seventh column in Table 4). With a 50–50 split, the equilibrium has the S.P.C. building the extended plant and the Fort Peck Tribes building a reduced irrigation project and going to court on the Winters' Doctrine (nineteenth column in Table 4). Resolutions to the conflict are suggested for each of the three likely I.J.C. recommendations because the I.J.C. is considered an inactive player.

At this point in the study, if the analyst determined that the I.J.C. would be more likely to choose to support one apportionment plan, the corresponding equilibrium would suggest the expected activities of the other players. For example, if the S.P.C. determines that the I.J.C. is likely to choose to support a 70–30 apportionment favouring Canada, it may wish to make commitments for a greater amount of power than available from a smaller plant. However, the metagame analysis suggests that the Fort Peck Tribes are likely to pursue legal action based on the Winters' Doctrine, and the S.P.C. should be prepared to counter such action should they feel the threat is significant.

From the point of view of the I.J.C. an analysis such as this may be useful in selecting a recommendation. It appears that if the I.J.C. supports either a 70–30 split favouring Canada or a 50–50 split, the conflict will not be resolved, because the Fort Peck Tribes will pursue legal action based on the Winters' Doctrine. As it is important for the conflict to be resolved, the I.J.C. may consider this a rationale for selecting to support an apportionment plan favouring the U.S.

It will be interesting to see how the conflict develops, although the associated environmental conflict will also have an influence. The final I.J.C. recommendation was a 50–50 split, with modifications to accomodate Saskatchewan, although an apportionment agreement will not be signed until the U.S. government submits an Environmental Impact Statement.[15] As of December, 1978, the initial stage of the S.P.C. power plant is near completion, and the Fort Peck Tribes have not followed through with any legal action based on the Winters' Doctrine,[15] although they may do so in the future.

CONCLUSIONS

The technique of metagame analysis has been used to successfully study the political implications of the complex Poplar River apportionment conflict. The method provides:

1. a systematic procedure for interpreting conflict information,

2. a framework for forcing a thorough understanding of the conflict,
3. new insight into the conflict,
4. a means for predicting possible solutions to the conflict.

For the Poplar River conflict, metagame analysis predicts that, based on the apportionment situation in late 1977, the responses of the interested parties were dependent on the forthcoming recommendation of the I.J.C. Both the S.P.C. and the Fort Peck Tribes would build projects which would use up as much water as permitted under the I.J.C. recommendation, and in addition, the Fort Peck Tribes would go to court on the basis of the Winters' Doctrine if the I.J.C. did not support an apportionment plan favouring them.

ACKNOWLEDGEMENTS

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M - PRELIMINARY DRAFT REPORT ON WIND POWER

ACRES

SUSITNA HYDROELECTRIC PROJECT

OFFICE MEMORANDUM

TO: DISTRIBUTION   Date: June 18, 1980

FROM: J.K. Landman - Anchorage   File: P5700.14.01

SUBJECT: Wind Power Study - Preliminary Draft

Attached please find a copy of my report on Wind Energy in the Alaskan Railbelt.

Due to the ongoing foul-up on Task 1, I have not had this draft retyped. Also, I recognize that some areas may need additional work. This version is intended to gather internal comments on format and content. It is my impression that the client expects at least this amount of effort for each alternative examined.

Please examine the report and return your comments and suggestions to me in the next couple of weeks. If it would be any easier, simply mark up a copy of the affected page (s) and send that.

JKL/ja

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WIND ENERGY

A. A BRIEF HISTORY [1]

Although windmills have been used to generate electricity since the 1890's, the ancestry of the modern large wind turbines dates back to the early 1940's. In 1941 the first wind turbine rated over one megawatt was assembled near Rutland, Vermont. This experimental machine, rated at 1.25 megawatts, sat atop a 110 foot high tower and had two stainless steel blades, each weighing more than eight tons, circumscribing a 175 foot diameter circle. The turbine operated successfully from late 1941 until 1943 when it was taken out of service for the replacement of a bearing. Because of the war, such parts were virtually impossible to obtain and repairs were not completed until 1945. Shortly after being returned to service in 1945, a turbine blade failed and caused the shutdown of the machine. Analysis by the project's backers showed that the economics of wind power at that time did not warrant further study and the experiment was abandoned.

Some experimental work continued after the failure of the Vermont unit, but subsequent efforts were on a smaller scale: on the order of 100 to 500 kilowatts. Most of the development work done in the '50's and '60's was carried out in European countries, notably Denmark, Germany, and France..

3. RECENT U.S. RESEARCH [2], [3]

The present activity in the United States in large turbine research began in 1972, when the National Science Foundation and NASA made the joint recommendation that wind energy be developed to broaden those energy alternatives open to the nation in the future. In 1973, the National Science Foundation was given the responsibility for the Federal Solar Energy Program. The National Science Foundation, in turn, designated NASA's Lewis Research Center in Cleveland, Ohio, to manage the development and early installation of large wind turbines.

As a part of this work, NASA began work in 1974 to design, construct, and operate a wind turbine for research purposes. This turbine, designated "MOD-0" sits atop a 100 foot high tower, and has a two-bladed rotor 125 feet in diameter. The turbine's generator is rated 100 kW at a design wind speed of 18 miles per hour. The MOD-0 unit went into operation in September 1975, near Sandusky, Ohio. The MOD-0 has been used to conduct research studies in the areas of blade dynamics, aerodynamic performance of large wind turbines, and the dynamic interaction between the wind turbine generator system and the utility system to which it is connected. As such, this machine ~~the MOD-0~~ is being used primarily as a vehicle by which to test new wind turbine components and design ideas.

The MOD-0 wind turbine test program was followed up, beginning in 1975, by the MOD-OA program.[4] The object of this effort was to bring large wind turbine technology out of the research phase and make it available to the utility industry.

Three MOD-OA wind turbines are presently on-line and operating at Clayton, New Mexico, Culebra, Puerto Rico, and Block Island, Rhode Island, with a fourth scheduled to be brought into service in 1980 in Hawaii.[3]

Except for its ~~the~~ larger generator of 200 kW (compared to the MOD-O's 100 kW), the MOD-OA is essentially identical to the MOD-O. Some equipment design deficiencies were uncovered early in the program, but these were corrected as they appeared. So far, no serious problems have been encountered, and all three MOD-OA machines are operating successfully as the first modern units to be incorporated into U.S. utility systems.

The next step in the evolution of modern large wind turbines in the U.S. was the MOD-1 design. With conceptual design work beginning in 1974, the first MOD-1 unit was dedicated in July 1979, at Boone, North Carolina.[3] [5] This turbine is equipped with two blades sweeping a 200 foot diameter circle (compared to the 125 feet of the MOD-O series). The generator installed at the Boone site is rated at 2000 kW (compared to the 100-200 kW of the MOD-O and -OA units). As of this writing (May, 1980), this first MOD-1 unit, although operational, is not without its problems. The spinning blades cause a flickering television picture on some TV receivers within a 1 to 1½ mile circle. This problem was anticipated by NASA engineers from the beginning of design work. The problem seems to affect only those residences having specific receiver/turbine/TV-station relationships. In early or mid 1981, NASA plans to ~~will~~ install a set of composite (fiberglass) blades on the Boone machine. This is expected to greatly reduce the severity of the interference problem.

A problem neither anticipated nor understood yet is a low-frequency sound created by the spinning turbine blades. This noise, called "infrasound," is apparently the result of resonances between certain local topographic features and the turbine. The effect has been noticed mainly in an area within 1 to 1½ miles from the unit site. NASA is planning on trying a lower rotational speed for the turbines, hoping to reduce or eliminate these resonance problems.[10]

C. PRESENT STATE OF THE ART

The present state of the art in large wind turbines is exemplified by the MOD-1 unit installed at Boone, the 4 megawatt units presently undergoing fabrication for installation at Medicine Bow, Wyoming,[6] and the three units being manufactured under the NASA-sponsored MOD-2 program.[3][7]

The sizes of these units represent nearly an order of magnitude difference in terms of power output over the earlier designs. The MOD-0 and -0A units have served their purpose well as test units. The knowledge gained from their operation has been incorporated in the larger units. The MOD-2 units for example, will be constructed with a tubular tower rather than an open truss tower; a special "tettering" hub will be used on the rotor to allow the blades to rock to-and-fro as winds of different velocities strike different parts of the blades; a hydraulic coupling will be installed between the rotor and the generator to reduce the speed variations imparted to the power train components by gusting winds. Many of these design improvements have served to reduce the amount of materials needed for structural strength of the assembly, thereby reducing the cost of the units and making the cost of the energy produced by those units lower.

The unit being installed at Medicine Bow, Wyoming, is part of an ambitious plan by the Department of the Interior's Bureau of Reclamation to develop a large windmill "farm." [6] Their ultimate plan is to install approximately 49 large turbines at Medicine Bow and feed the energy produced by this farm into the existing interconnected electrical system serving the area. Since the Bureau of Reclamation also feeds this system with a number of hydroelectric projects located throughout the West, the energy produced by the wind turbines could be substituted for that normally supplied by the hydro units. In this manner the amount of energy produced by the wind turbines is stored in the reservoirs for later use.

The Alaska Power Administration, formerly a part of the Bureau of Reclamation, is presently exploring the possibilities for incorporating a large wind turbine with the operation of their 35 megawatt Eklunta hydroelectric plant northeast of Anchorage. [9] Although not on as large a scale as that being considered by the Bureau of Reclamation, the Alaska Power Administration's wind/hydro system would be functionally similar.

D. LIKELY FUTURE DEVELOPMENTS

Most near-term future work (1980-1990) on wind turbines will likely produce no radically new designs or larger units. Generator sizes are not likely to go above 5 megawatts; blade sizes will likely remain below 400 feet in diameter. Work will concentrate in evolving designs which are attractive to utilities from both economic and operational standpoints.

NASA is presently administering contracts for the MOD-5 and MOD-6 wind turbine designs. (There will be no MOD-3 or MOD-4).[7] These two designs, both having completion dates of late 1983 or early 1984, have the following project goals:

MOD-5

This will consist of a series of large machines in the 3 to 4 megawatt range. Early design proposals have rotors with 300 to 350 foot diameters. One of the contract's design requirements is that the contractor produce a machine capable of producing electrical energy for a cost of not more than 3 cents per kilowatt hour in 1977 dollars. Designs are based on the availability of a site with a mean wind speed of 14 miles per hour at an elevation of 30 feet.

MOD-6

The product of this work will be an intermediate sized unit whose only constraints will be a 125 foot diameter rotor and a 1977 cost of electricity of less than 6 cents per kilowatthour. The design and wind will be the same as that mentioned in the MOD-5 description.

The units produced by this work will be applicable in two distinctly different utility situations, both which may be of interest to Alaskan utility planners. The MOD-5 units would be useful to relatively large interconnected systems such as those in the Railbelt. The smaller MOD-6 machines would be more useful to small isolated systems such as the remote villages. Application of any type of machine is, obviously, dependent on finding a suitable site for their installation. This topic will be further explored in Section G.

E. COSTS AND TRENDS

As with virtually any emerging technology, the costs of large wind turbines built to date have been exorbitant. The experimental unit installed in Vermont in the 1940's cost $1.25 million.[1] In terms of today's dollars, this would represent nearly $13 million (6 percent annual inflation assumed). The MOD-OA unit was erected in 1975 at a cost of about $1.61 million, or just over $2.1 million in terms of today's dollars (again assuming a 6 percent inflation rate). The Vermont machine was more than five times larger than the MOD-OA unit in terms of power ratings, so on a per-kilowatt basis, the newer machine would appear somewhat less expensive.

Capital costs of wind turbines have fallen drastically as newer designs have been developed and more units are built. NASA gives

The following data for capital costs of prototype units:[3]

	MOD-OA (Installed 1977)	MOD-1 (Installed 1979)	MOD-2 (Installed 1981)
Capital Cost (millions)	$ 1.61	$ 5.4	$ 3.37
Cost Per Kilowatt	$8,050	$2,700	$1,350

align figures

These costs are all given in terms of 1977 dollars, the basis of comparison used by NASA's wind program group.

As the large utility-sized machines gain acceptance and make the transition from one-of-a-kind prototype machines to standardized production units, costs can be expected to come down further. For the MOD-2 units, NASA studies have produced data to support the following comparison:

close up!

	PROTOTYPE MOD-2	PRODUCTION MOD-2
Capital Cost (millions)	$ 3.37	$ 1.72
Cost Per Kilowatt	$1,350	$ 860

align

Studies of smaller machines, offspring of the MOD-OA program, show the following cost projections:

close up

	MOD-OA	Advanced 200 kw Unit
Capital Cost (millions)	$ 1.61	$ 0.203
Cost Per Kilowatt	$8,050	$1,015

align

Again, these figures are given in terms of 1977 dollars.

NASA is not the only organization forecasting costs of wind turbines, although a literature search seems to show that they have produced the most detailed cost summaries. A firm in Massachusetts, JBF Scientific Corporation, has also done a great amount of work in the field of wind energy. They have summarized the results of eight other studies on wind energy system economics to provide a common basis to compare the variations of conclusions among researchers. [11] A summary of the capital costs identified by the JBF study are shown below. Also shown is NASA's estimate of the MOD-2 cost.

JBF STUDY		COST ($/kW) (1977)
Lockheed-California Company		1150
Southwest Research Institute		815
Honeywell		700
Kaman Aerospace Corporation		650
Aerospace Corporation		560
General Electric Company		480
	Average	725
NASA (Production MOD-2)		860

The JBF costs, originally given in terms of 1975 dollars are shown above as adjusted to 1977 costs by using an inflation rate of 6 percent annually. The NASA cost of $860/kw differs from the averaged JBF figures by about 25 percent. Considering the level of experience in wind turbine system use, this seems to be a good correlation. For further work, the figure of $800/kw will be used (1977 dollars) and later adjusted to 1980 levels. This figure is approximately the average of the JBF and the NASA estimates.

NASA has broken the costs of their units down into various components.[3] To adequately incorporate these values in the complete alternatives study, certain adjustments must be made. First, all of the costs must be scaled down to the $800/kw level; then some correction must be made for transportation to and within Alaska and erection there; finally, the 1977 dollars must be inflated to 1980 levels. The process is summarized below:

need to apply Handy-Whitman here!

Columns should not overlap

CATEGORY	ORIGINAL NASA COSTS	$800/kw COSTS	ALASKAN COSTS	1980 COSTS
Rotor	$ 329,000	$ 306,000	$ 306,000	
Drive Train	379,000	353,000	353,000	
Nacelle	184,000	171,000	171,000	
Tower	271,000	252,000	252,000	
Transportation	29,000	27,000	54,000	
Site Preparation	162,000	151,000	211,000	
Erection and Testing	137,000	127,000	178,000	
Spares and Maint.Equip.	35,000	33,000	33,000	
Misc.	35,000	33,000	33,000	
SUBTOTAL	$1,561,000	$1,453,000	$1,591,000	
FEE (10%)	156,000	145,000	159,000	
TOTAL	$1,717,000	$1,600,000	$1,750,000	

The adjustments to transportation, site preparation, and erection and testing costs are only very rough estimates,[12] but should suffice for purposes of this report. Inflation figures used to derive 1980 costs were taken from those categories of the Handy-Whitman Index that seemed to best match the components list.

Other costs which will be incurred by operators of wind turbine systems will be those associated with operating and maintaining the units. For this data, NASA figures will be used as a starting point.[3] Again, adjustments must be made to take into account inflation and Alaskan cost differentials:

CATEGORY	ORIGINAL NASA COSTS	ALASKAN COSTS	1980 COSTS
Labor	$ 8,000	$ 11,200	$ 14,100
Parts	7,000	7,000	8,800
TOTAL	$ 15,000	$ 18,200	$ 22,900

The 1980 costs assume an annual inflation rate of 1.08 PERCENT.

These figures are based upon per-unit costs for operation and maintenance of a 25 unit cluster.

A figure of merit commonly applied to any type of generating facility is the cost of electricity as sent into the power system to which it is connected. This figure is called the cost of electricity (COE) and is usually expressed in terms of cents per kilowatthour or mills per kilowatthour (a mil is one tenth of a cent). The cost of electricity is computed as follows:[3]

$$\text{COE} = \frac{(\text{Total Capital Cost (\$)} \times (\text{Fixed Charge Rate(\%)}))}{\text{Annual Energy Production (kWh)}} + \frac{(\text{Annual O\&M Costs (\$)} \times (\text{Levelizing Factor}) \times (100)}{\text{Annual Energy Production (kWh)}}$$

WHERE: the total capital cost and the annual O&M costs are developed as described above; the fixed charge rate is a capital levelizing factor which takes account of items such as returns to investors, depreciation, taxes, insurance, and cost of money; the levelizing factor applied to the O&M costs is used to levelize those costs which tend to increase with time (labor costs, etc.) as well as to account for cost or capital and real escalation. The levelizing factor applied to this work will be 2.0.

F. INSTALLATION AND SITING CONSIDERATIONS

By the nature of the work carried out in the wind research programs to date, the installations in existence may not be representative of future large wind energy systems. In these future systems, it is quite probable that a number of geographically dispersed sites, each consisting of a cluster of individual turbines, will feed an interconnected power system. Such an arrangement has at least two distinct advantages over either small numbers of units at a site or only one group of machines connected to the system. The advantages of a large number of units at one site include shared transmission facilities; shared costs of site operations and maintenance; a reduction of the number of spare parts which must be kept on hand for each unit (presuming that individual units are not unique); simplified permitting procedures; a smoothing out of the average power produced at the site under conditions of gusting winds. The advantages of the development of a number of wind energy sites within an interconnected power system include a reduction in the probability that no contribution to the system's energy supply will be made by the wind turbines; in the cases of geographically variable winds a reduction in the vulnerability of the wind energy supply to loss of transmission facilities. The number of sites which are attractive for development of wind energy systems is dependent upon the economics and availability of those resources which the wind energy systems are intended to replace. As these other resources become more expensive or scarce, more marginal wind energy sites will become economically feasible to develop. Early in the course of wind energy resources development, only those sites having the greatest potential for annual energy production will be developed, with the less desirable sites being developed later.

At the individual sites there is also a limitation on the extent to which the wind energy can be exploited. As wind passes through the blades of a wind turbine the airflow becomes somewhat turbulent. This turbulence dies out away from the turbine. Since wind turbines operate more efficiently in undisturbed airflows, it is desirable to avoid this turbulence. At least one study[13] has been done which shows that this turbulence is not present at a distance of 15 rotor diameters from the turbine originally causing the disturbance. This same reference also makes mention of researchers using machine spacings of 8 and 10 rotor diameters. For purposes of this study, clustered machines will be assumed to be spaced 10 diameters. It may be that in the case of a site having highly directional prevailing winds, the crosswind spacing of machines within a cluster could be significantly reduced without reducing the efficiency of the group. No studies of this area of concern have been located, so the extent to which advantage of this idea can be exploited cannot be estimated.

A critical factor in the evaluation of wind energy systems is the availability of the wind necessary to drive the turbines. The characteristics of the wind at a particular site determine the suitability of that site for development. A record of the amount of time that a site experiences a particular wind velocity for a given period (daily, monthly, yearly, etc.) is used to describe the wind characteristics at that site. When presented graphically, such information is called a wind duration curve. The source of data used to derive wind duration is generally hourly wind data taken at meteorological stations. In many cases, these stations are located at airports or in cities -- developments deliberately located in areas of relatively calm winds. For this reason, the energy potential of a particular site cannot normally be estimated from data established stations. Thus, for final decision making purposes, instrumentation must be installed at any proposed site to establish, with some degree of confidence, the true energy potential of that site. Fortunately, it is not necessary to blanket a study area with meteorological stations to make a rough estimate of the sites within the area which may be candidates for development. Studies have been done in recent years to "...assess the potential for wind energy conversion systems on a national scale and to identify high potential application (areas) for WECS." [13][14] Unfortunately, these studies are concerned with very large geographic areas and cannot be used for more than a very crude estimate of where wind energy sites may be found. As a first pass for identifying potential sites within a study area, an examination of a topographic map can provide a number of clues for the researcher. In general, broad flat areas such as plains have relatively little wind potential; rugged mountainous areas may cause such turbulence so as to not be useful as wind turbine sites; tops of smoothly rounded hills set in relatively open areas can make excellent sites; mountain passes or saddles aligned with prevailing winds are also good candidates as are narrow valleys leading out of flat open areas when aligned with prevailing winds.

By studying a topographic map of the study area and looking for specific features which would tend to channel prevailing winds into a relatively small area, investigators can identify the ~~valleys and passes~~ surface features which may indicate the presence of a relatively high wind potential. From that point, if the number of candidate sites identified is greater than that which would be practical or economic to instrument, there are a couple of methods which an be used to verify the researcher's suspicions.

At least one study has been located which draws an inference of wind conditions at a particular site from the deformation noted in vegetation growing at the site. [15] This study shows that trees growing in consistently windy areas will tend to grow with their branches bent toward the lee side of the tree. It is also shown that tree trunks tend to grow eliptically, with their centers offset to the windward side of the trunk. The information gained from such tree growth, while it can show the presence of a strong wind potential, establishment of the average wind speed at the site cannot be done with much certainty. At sites where no distinct prevailing wind direction is present, distortions may not be present since the trees are subjected to winds from various directions. Additionally, deformation of trees can sometimes result from competition from other trees for space or sunlight, or other causes. Such a situation can be misleading to unwary researchers. Despite these drawbacks, this phenomenon can be applied to confirm, to some degree, a researcher's initial hunch about a particular candidate site. It can also identify the presence of high wind areas which may have been overlooked on an initial study of available topographic maps.

Another promising method for identifying areas of high wind potential uses high-altitude aerial photographs or LANDSAT imagery.[16] By using such information, researchers can identify ground features which are created or changed by wind action. To date, the techniques needed to estimate the available wind energy at a specific site from information taken from sattelite photos do ~~does~~ not exist. Future research will no doubt refine the knowledge in this area, but reliable information cannot be gathered in this manner presently.

Another method which may prove useful in the future is that of numerical analysis on computer modeling. As a part of the Federal Wind Energy Program, the Lawrence Livermore Laboratory is undertaking the development of a methodology to estimate wind energy potentials in mountainous areas. [17] Their work involves the development of a computer model which simulates the interactions between airflow and topographic features to identify those areas having high wind potential. At this point, these methods are in the developmental stage, with researchers refining their models and attempting to verify the computer study results. No consideration will be given to use of these techniques for the remainder of this study.

Beyond those condiderations of wind energy available at a particular site, there are a number of environmental impacts associated with the installation of wind turbines. It would seem that a source of energy such as the wind turbine would be environmentally benign, but this is not necessarily true. The most obvious impact would be the aesthetics of a wind turbine or wind turbine cluster. In virtually all installations, the wind turbines will be the tallest, and most prominent, objects in the surrounding area. There are those who may object strenuously to the idea of a group of, or even a single wind turbine, intruding on a favorite view. This, to some extent is understandable with the newer large units, with proposed blade sizes of up to nearly 400 feet the wind turbines will exhibit a profile unlike any other man-made object. The aesthetics of a wind turbine installation and their implications on the decision to proceed with construction is a subject which will be resolved in public debate. Land use impacts associated with wind turbines is relatively small on a per unit basis. A small clearing at the base of the unit is required for tower installation and space for assembly of this turbine and its blades. Additionally, access roads must be cut and transmission line rights-of-way established. These last two requirements could conceivably share the same space. No consistently adverse impacts on animals, birds, or insects living in the vicinity of any of the operating wind turbines has been noted.[18] Another serious matter deserving consideration is that of safety. When the blade on the early Vermont machine failed, it was thrown about 750 feet away from the machine.[1] A wind turbine installation in Ugashik, Alaska failed in 1975, scattering debris for a quarter of a mile. [19] The consequences of being struck by flying blade parts could be serious indeed. A single MOD-1 blade weighs roughly ten tons. Studies done by NASA estimate that a large wind turbine operating at 40 RPM could conceivably throw a blade 550 feet.[20] The slower machines, such as the MOD-1 (35 RPM) or the newer MOD-2 units (17.5 RPM) will have correspondingly lesser throw distances.

Another problem associated with wind turbine operation is that of electromagnetic signal interference. This phenomonenon has manifested itself at the Boone, North Carolina MOD-1 site, with reports of television interference being received from residents as far as 1-1/2 miles from the site. The television interference appears as a "ghost" which fluctuates or flickers in time with the rotation of the blades. In severe cases, the entire picture can exhibit a pulsed brightening and even a disruption of the vertical synchronism of the TV receiver with complete breakup of the picture.[20] A more critical form of interference may be the potential for interaction with aircraft navigational systems. The Federal Aviation Administration has established regulations concerning the maximum tolerable level of interference with VOR (Very High Frequency Omnidirectional Range) stations and has indicated minimum allowable distances of scattering source locations from VOR sites. Analyses carried out to examine this problem have indicated that if wind turbine siting is carried out within FAA guidelines, there should be no signicant interference with air navigation signals.[20]

G. ALASKAN STUDIES AND INSTALLATIONS

The most definitive work completed to date on wind energy in Alaska has been carried out by Professor Tunis Wentink, Jr., of the Geophysical Institute of the University of Alaska at Fairbanks.[19][21][22] Presently, Dr. Wentink is collaborating with Mr. J. Wise of the Arctic Environmental Information and Data Center (AEIDC) to produce a "Wind Energy Atlas" for the U.S. Department of Energy's wind analysis program. Their work is being carried out under contract to Batelle Pacific Northwest Laboratories in Richland, Washington. A final report is scheduled for release during the fall of 1980.

A report has been prepared under contract to the Alaska Center For Policy Studies[23] to explore the potential of energy resources within the Railbelt area. While apparently neglecting the fact that weather reporting stations are generally located away from windy areas, this report ~~implied~~ concluded that there is little hope for the development of wind energy in the Railbelt. The report stated that "....examination of [records from] 19 weather stations indicate only marginal potential for two locations (Gulkana and Homer)...."

Another study is being conducted by Batelle Pacific Northwest Laboratories on behalf of the Alaska Power Administration. The purpose of this study is to identify sites within the Railbelt region having wind potential which may be developed to act as a supplement to the Administration's Eklutna hydroelectric plant near Eagle River. The final report from Batelle to the Administration is due in June,1980,and is expected to identify a number of sites which Batelle feels are worthy of instrument installation.[9] Presumably, data collected from these additional data collection stations could be used to make decisions as to where and if wind turbines could be constructed. The Batelle study is somewhat constrained to the area served by the interconnected utility system serving the Anchorage/Kenai Peninsula/Matanuska Valley area.

In the Nome area, General Electric has carried out a study showing that the installation of a number of 200 kilowatt wind turbines could be economically competitive with the oil-fired diesel generators now in use.[24]

Wentink's 1976 report[19] concluded that if one one-thousandth of the total kinetic energy available in the wind over Alaska was extracted by wind turbines, a resource of 3,400 megawatts would be available. This conclusion was followed by the admission that the factor of 1/1000 was arbitrary and that the actual power potential developable was dependent upon economics.

Wentink emphasized the study of "mainland coastal Alaska, including the Alaska Peninsula, and the Aleutian and other Alaskan islands." Since Acres ~~this~~ study examines only those sites located between ~~59° N.~~ 59°N and 66°N, and 144° and 152° W, much of the data found in Wentink's reports are ~~it is~~ not usable for ~~Acres'~~ this study. Nonetheless, it provides a good basis for establishment of methodologies to be followed in future ~~our further~~ work.

As a result of the early part of his research, Wentink installed a 6 kilowatt turbine at Ugashik on the Alaska Peninsula (57° 30' N, 157° 37' W). During the four months ~~that~~ the machine ~~was available~~ survived (first energy produced early September 1975, machine destroyed by high winds in late December 1975) Wentink's report notes that ". . . the system functioned quite well . . ." A number of relatively minor, but apparently troublesome problems plagued the operation of the unit throughout its brief life, but more careful design work of both the installation and the unit itself could likely have eliminated these problems.

H. RAILBELT WEATHER DATA

There are a number of meteorological stations located throughout the Railbelt. The vast majority of these stations which are equipped to record wind data in the detail needed for a wind potential survey are located at airports--locations normally sited so as to avoid windy areas. Nonetheless, some of this wind data may be used to draw some conclusions as to general wind patterns in the vicinity of the stations. From this work, it may be possible to identify areas of possibly high wind potential which should be instrumented to determine in greater detail the nature of their winds.

The stations for which detailed wind data have been obtained are:

Station Name	Nearest City or Town	Remarks
Tanana	Tanana	
Manley Hot Springs	Manley Hot Springs	Poor Data
Fairbanks International	Fairbanks	
Big Delta	Delta	Poor Data
Nenana	Nenana	
Summit	Summit	

Station Name	Nearest City or Town	Remarks
Healy	Healy	
Homer	Homer	
Kenai	Kenai	
Talkeetna	Talkeetna	
Cordova	Cordova	
Gulkana	Gulkana	
Middleton Island	Cordova	Island in Gulf of Alaska
North Dutch	Whittier	Island in Prince William Sound
Anchorage International	Anchorage	

This data was taken from records on file at the Arctic Environmental Information and Data Center in Anchorage.

Analysis of the data to derive the wind energy potential at the meteorological station is a mathematically straightforward process. To estimate the amount of that energy which can be extracted by a wind turbine involves some arbitrary assumptions as to the operational characteristics of the machines under consideration. The process involved will be fully explained below.

For a given volume of air with mass (m) and a velocity (V), there is an associated kinetic energy (K.E.) such that:

$$K.E. = 1/2\ mV^2 \qquad \text{(eq 1)}$$

The mass of the air flow of given cross-sectional area (A) passing a point in any period of time is a funciton of its density(ρ) and its velocity such that:

$$m = \rho\ VA \qquad \text{(eq 2)}$$

Combining equations 1 and 2, and understanding that ~~given~~ fixed areas are discussed, we can see that the power of an air flow passing through an area in a unit of time is:

$$P = 1/2\ (\rho V)\ (V^2)$$

$$\text{or} \quad P = 1/2\ \rho V^3 \qquad \text{(eq 3)}$$

In the metric system, if density (ρ) is expressed in kilograms per ~~for~~ cubic meter (kg/m^3) and velocity (V) in meters per second (m/S), the result, power (P) comes out in Watts (W) per unit cross sectional area or Watts per square meter (W/m^2). [25]

Taking the density (ρ) of air to be approximately 1.2047 kg/m^3, [26] we can develop the equation:

$$P = (\tfrac{1}{2})\ (1.2047)\ V^3$$

$$\text{or} \quad P = (0.60235)\ V^3 \qquad \text{(eq 4)}$$

Where: P is wind stream power, in W/m^2

V is wind stream velocity, in m/S

Note that this gives us the power density of the wind stream itself - - not the power which can be developed by a wind turbine exposed to that wind. There is a theoretical limit to the amount of power which a wind turbine can extract from a wind stream. This is known as the Betz limit and states that only about 59 percent of the wind's potential power can be obtained from a turbine.[25] Machines in operation to date have power extraction efficiencies in the neighborhood of 35 percent, with improvements forseen which could raise that figure to 45 percent. Ultimately, Mechanical losses should be checked with J. Murray Columbia

researchers feel that efficiencies in the neighborhood of 50 percent are about as high as can be expected.[19] This report will assume a turbine efficiency of 40 percent. When speed reducer losses (8 percent), generator losses (5 percent), and transformer losses (3 percent) are accounted for, the true machine efficiency is about 34~~.0~~ percent. Including this in our equation 4, we find that:

$$P = (0.340)\ (0.60235)\ V^3 \qquad \text{(eq 5)}$$

$$P = 0.205\ V^3$$

This equation predicts fairly well, the actual performance characteristics of the MOD-1 unit now in operation at Boone.[27] Other considerations which must be included in wind energy discussions are those of the wind speed at which the turbine can begin producing energy; the speed at which it achieves its rated output; and the speed at which the turbine must be shut down to avoid damage to its components. These speeds, known as the cut-in, rated, and cut-out speed respectively (V_{ci}, V_r, V_{co}), can vary from machine to machine, but have the following general ranges:

Cut-In	4.9	m/s (Mod-1)
Rated	11.4	m/s (Mod-1)
Cut-Out	15.6	m/s (Mod-1)

The relationship between wind velocity and power output in the region between cut-in and rated speeds, while in theory following a simple cubic function, is, in actual machines, a more complex third order polynomial. This study will use a simple linear relationship between power and velocity in the ~~this~~ region between V_{ci} and V_r.

Correlating weather data, machine characteristics, and cost information, we can arrive at the following ranking of site potential and resultant energy costs.

Station Name	INTERMEDIATE MACHINE Annual Energy Production	INTERMEDIATE MACHINE Cost of Electricity	LARGE MACHINE Annual Energy Production	LARGE MACHINE Cost of Electricity
Middleton Island	2120 mwh	¢/kwh	8393 mwh	¢/kwh
Summit	1445		5023	
North Dutch	1238		4440	
Kenai	955		3024	
Gulkana	832		2945	
Homer	768		2323	
Anchorage Int'l	709		2056	
Nenana	685		2323	
Tanana	622		1740	
Cordova	569		1657	
Talkeetna	457		1201	
Fairbanks Int'l	416		1004	

Note that even the best of these stations permits operation of the large (2.5 mw) machine at less than a 40 percent plant factor or less than 50 percent for the imtermediate size (500 kw) machine. This station, Middleton Island is located on an island in the Gulf of Alaska. Its accessability (70 nautical miles south of Cordova) would seem to preclude its exploitation as a wind turbine site. The best land-based station, Summit, would permit operation of large and intermediate wind turbines at capacity factors of about 23 and 33 percent, respectively. Other land stations trail Summit's potential by a wide margin.

By the above discussion, it may be deduced that the possibilities for the economical development of wind energy are quite limited. From the data available, this is a reasonable conclusion. However, it must be kept in mind that most of the weather data stations are deliberately sited at locations not subject to strong winds.

What is needed, is a program to gather detailed wind data from locations where terrain features may tend to channel and concentrate wind energies. Such a program would involve the installation of a number of 10 meter high meteorological towers equipped with recording anemometers. From a brief examination of a topographic map, the following areas would appear to be condidates for such a preliminary instrumentation:

Site	Feature Making Site Attractive
1. Windy Pass Area (from mile 215 to mile 230 of the Parks Highway)	Low notch in Alaska Range should tend to channel northerly and southerly winds through pass area
2. Black Rapids Area (from mile 220 to mile 235 of the Richardson Highway)	Low notch in Alaska Range should tend to channel northerly and southerly flows
3. Portage Area (from end of Turnagain Arm across Portage Pass avoiding glaciated areas where possible)	High terrain of Kenai Peninsula and Chugach Mountains should channel westerly flows. Also, water surface of Turnagain Arm provides unobstructed path for more than 40 miles
4. Glenn Highway from about mile 60 to mile 120	High terrain of Chugach and Talkeetna mountains should channel westerly and easterly flows

There may be other areas which could hold promise for wind energy development and these should be sought out. The Department of Energy, working through Batelle Pacific Northwest Laboratories and the University of Alaska (Fairbanks) and the Arctic Environmental Information and Data Center (Anchorage), will be issuing a 'Wind Energy Atlas" of Alaska. This document should be available to the public in 1981. The Atlas will attempt to show average wind energy in all parts of the state. In mid-1980, Batelle will submit their findings on wind energy to the Alaska Power Administration as a part of their contract to study wind resources in the Anchorage area. The findings of these two studies may help to expand the list of candidate sites.

To the extent appropriate, it may be advantageous for the Alaska Power Authority to enter into a joint study with the Alaska Power Administration in wind prospecting work.

Should the wind prospecting work described in the preceding paragraphs identify sites which tentatively exhibit wind resources which could be exploited attractively further instrumentation of those sites would be appropriate prior to commitment to construction.

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In this second phase of instrumentation, towers at least as high as the uppermost reaches of the blades of the wind turbine under consideration for installation would be used. The purpose of this extra instrumentation step is to investigate the wind shear at the proposed site. Wind shear is the name for the phenomenon of winds at different heights flowing at different velocities. A convential rule of thumb is that wind velocity tends to increase at the one-seventh power of elevation, or:

$$V_{upper} = V_{lower} \left(\frac{h_{upper}}{h_{lower}}\right)^{1/7}$$

where: V_{upper}, V_{lower} are the wind velocities at the upper and lower heights

h_{upper}, h_{lower} are the elevations of interest

From this equation, we could expect that if a 10 meter per second wind were encountered at a height of 8 meters, a 12.9 meter per second wind would be found at 48 meters.

Although much of the wind energy literature mentions this one-seventh power rule, it is just as frequently mentioned with a caveat: The exponent has been observed to vary from about one and a half to approximately negative one.[14] This range implies that wind speeds have been observed to increase more rapidly than height; to remain constant with height; or to decrease with height. These latter two conditions are admittedly rare, but the characteristics of wind shear should be carefully investigated at each site under consideration for construction of a wind turbine.

Wind shear has at least two important implications to wind turbine installations. The first, and most obvious, is that depending on the magnitude of the shear exponent, more (or less) power could be developed by a wind turbine operating at a height different from that at which initial wind measurements are taken. The second implication of wind shear is that as the turbine blades turn from an area of high wind velocity to an area of low wind velocity, they are subject to variable stresses. These stresses tend to flex the blades, fatiguing the blade materials and, if not designed properly, leading to premature blade failure.

I. MODEL OF FUTURE RAILBELT INSTALLATIONS

The costs associated with wind turbine installations in Alaska were developed in Section E and will not be treated in detail here. In this section, discussion will focus on the relationship between wind turbine operation and the utility system to which they are connected.

In most utility systems, generators are put on-line and their outputs adjusted in response to instantaneously varying load conditions. Conventional generating stations are designed, to a greater or lesser degree, to respond directly and rapidly to orders to change output.

This degree of control has a number of advantages for the utility system operators. They can select the units which operate at the lowest per-kilowatthour cost to supply as much of the load as possible, using more expensive units only as they are absolutely needed. The conventional generation sources also provide the operators a very reliable system to operate: It is generally presumed that, unless a particular unit is out of service for maintenance or repairs, it is available for operation as needed.

Wind turbines, by the nature of their driving power supply, do not offer power system operators either of these advantages. An operator cannot predict to any degree of confidence, how much energy a wind turbine will be capable of producing, if it produces any at all, in any future period. This unpredictibility of the wind resource has been a major obstacle to the acceptance of wind turbine systems by utilities. Power companies have an obligation to provide their customers with reliable service at a reasonable ~~the least practical~~ cost. It is unlikely that wind machines will meet this reliability ~~first~~ criteria in the foreseeable future; the price criteria ~~second~~ will be met as fuel prices rise and research continues in the field of wind turbines.

There is a way around the natural unpredictibility of wind turbine operation. The wind turbine installation can be operated in conjunction with some form of energy storage system. At times when wind turbine output was available but not needed, the available energy could be stored; when energy from the turbines was needed but not available, the stored energy could be released. Studies [14] have shown that storage systems which are constructed solely to absorb wind turbine excess energy cannot be economically justified. Thus, their incorporation in the utility systems in conjunction with wind turbines will not be considered further.

A more economically justifiable role for the wind turbine, and one which is commonly assumed by utilities operating wind turbines, is that of a fuel saver. In this type of operation, the operating utility simply takes as much of the wind turbines output as it can absorb at any given time, reducing the output of its conventional units and saving the fuel which would have been used in their operation. It is obvious that as the costs of fuel for the conventional units rise, the savings accrued by operation of the wind turbines will mount. This is the operational mode which will be presumed for the operation of wind turbines in this study. In the cost evaluation of Section E, the construction of a group, or cluster, of wind turbines at any particular site was assumed. This type of construction allows the cost of operations and maintenance to be shared among the units at the site. Also, to some extent, costs associated with construction, such as site preparation and transmission facilities, can also be shared. For this study, the construction of clusters of 25 units at any one site will be assumed.

As with any other utility equipment, wind turbines require periodic maintenance. The period of time that modern wind turbines are expected to be out of service ranges from 5 to 10 percent of the time on an annual basis. The outage figure of 10 percent is in line with most other generation equipment and will be assumed for this study.

As far as site availability is concerned, it will be presumed that three sites, each with the potential of producing 25 percent more energy from a cluster of large units than would be available at the best known land based station (Summit), will be found. Such a site would produce:

(5023 MWh/machine) X (1.25) X (25 machines) X (0.90 availability)
141,000
= ~~14.1.000~~ MWh

The three sites would be capable, then, of producing a total of approximately 420,000 MWh of electrical energy. At a cost of electricity of ______________ $/kWh, computed as outlined in Section E, total costs would be $________________. The energy produced by the wind turbines, if it were supplied by oil-fired generation, would require approximately 30 million gallons of oil. Assuming a cost of fuel oil of $__________ per gallon. As shown from the above, a savings of $__________ is represented. No capacity credit will be given to wind units due to the unreliability of the wind.

It will be presumed that one site will be available for development in time for an on-line date of 1990. The two other sites will be assumed to be available in 1995 and 1996 respectively.

To summarize the characteristics of wind turbines as they will be viewed by this report, the following table has been prepared:

SITE	ON-LINE DATE	INSTALLED CAPACITY	CAPACITY ASSUMED FOR LOLP CALCULATIONS	ANNUAL ENERGY PROJECTION	COST OF ELECTRICITY 1980	ANNUAL COST 1980
No. 1	1990	62.5 MW	0 MW	141,000 MWh	$/kWh	$
No. 2	1995	62.5	0	141,000		
No. 3	1996	62.5	0	141,000		

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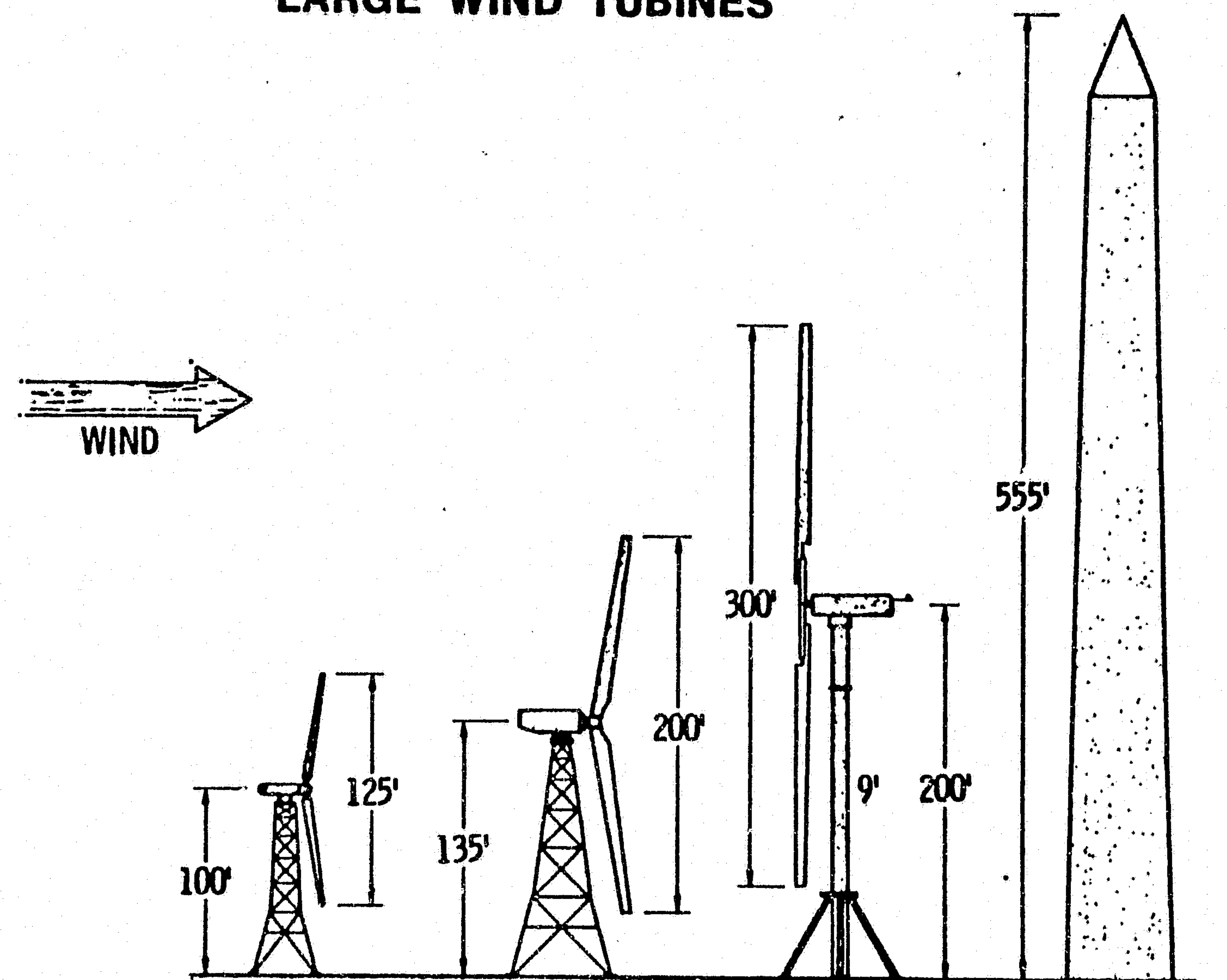
FIGURES OBTAINED
FROM NASA

LARGE WIND TUBINES



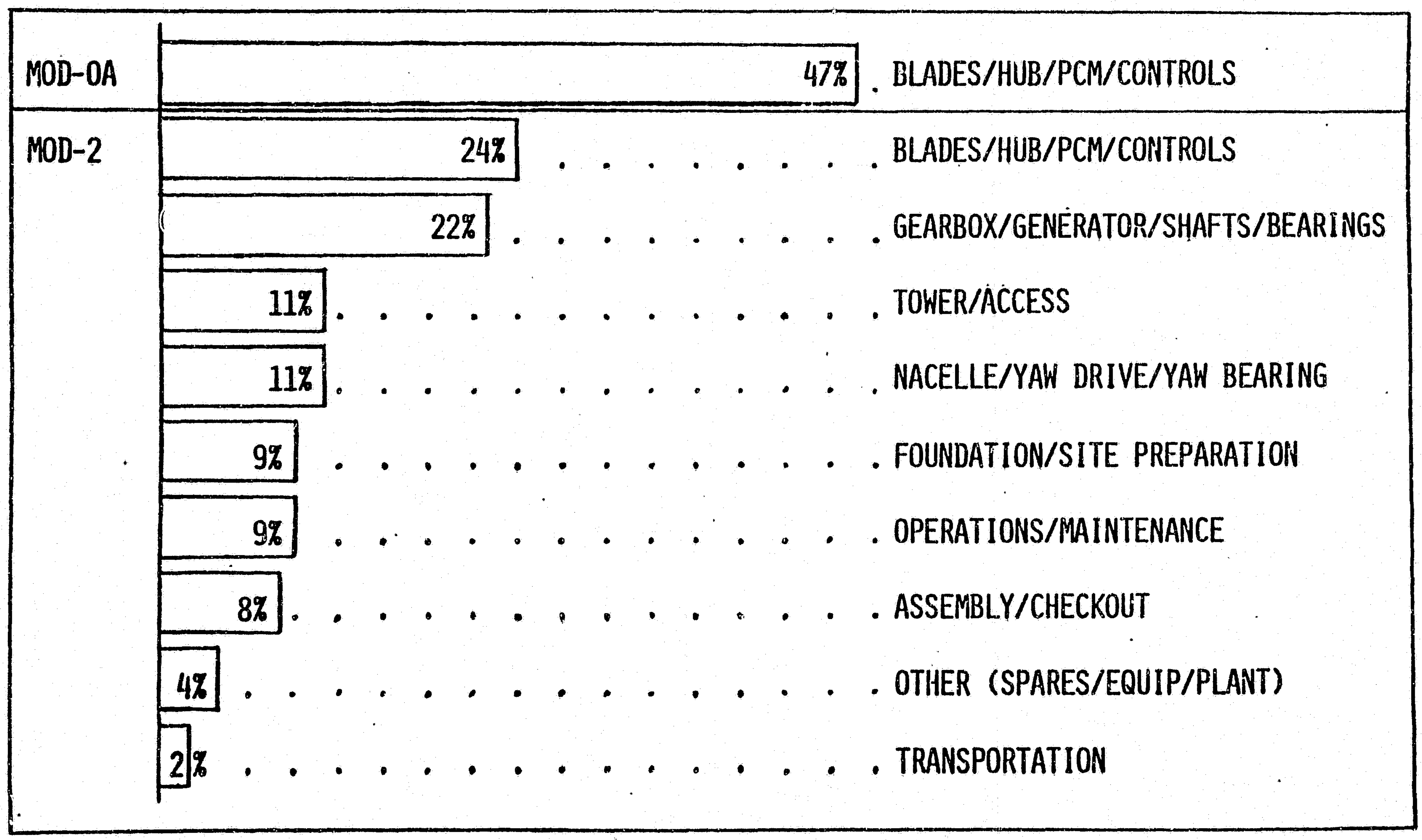
	MOD-0 MOD-0A	MOD-1	MOD-2	WASHINGTON MONUMENT
MAX. POWER OUTPUT:	100-200 kW	2000 kW	2500 kW	
POWER OUTPUT (15 mph):	127 kW	450 kW	1420 kW	

CS-78-2756

FIRST GENERATION

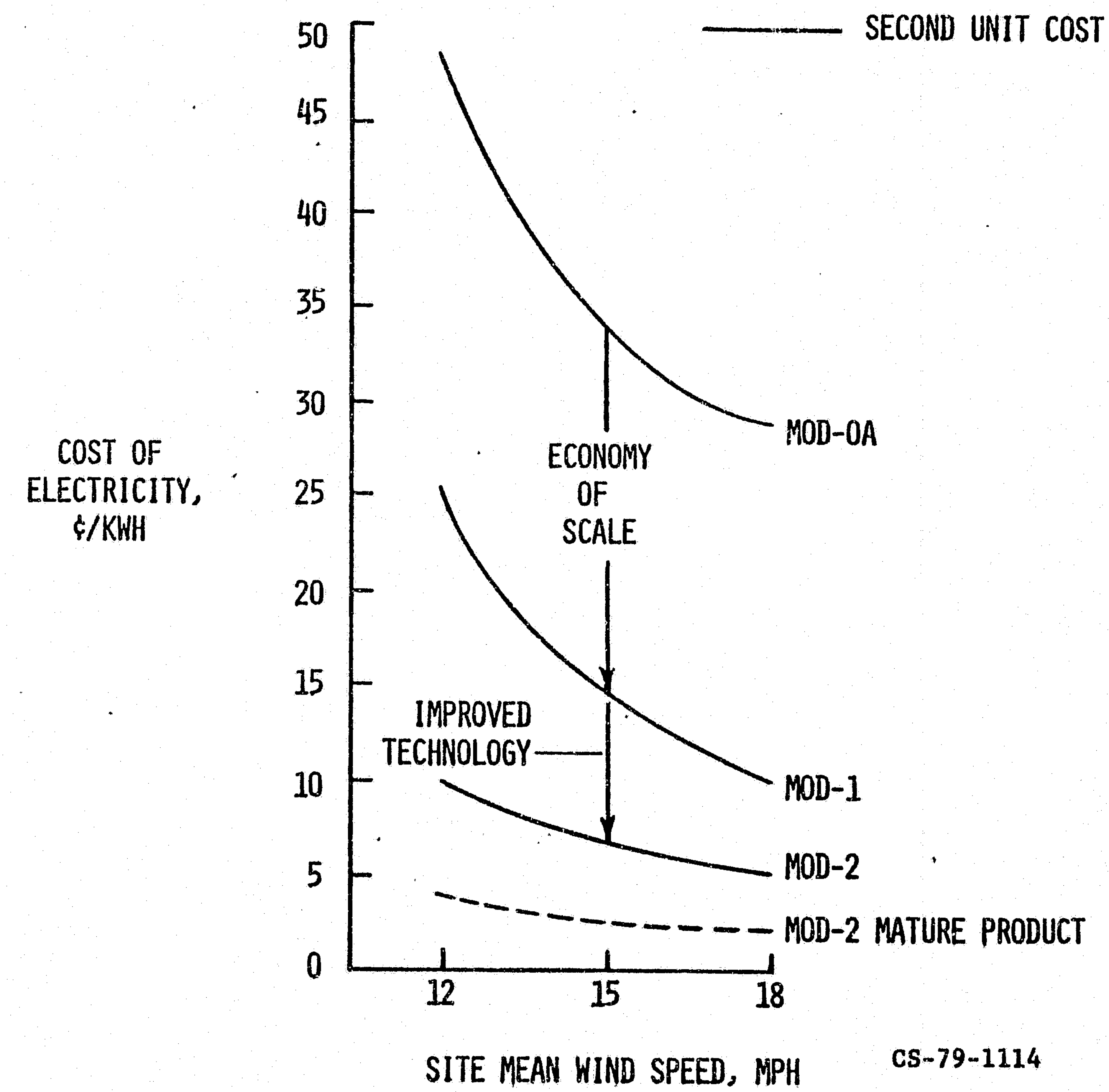
SECOND GENERATION

CONTRIBUTION OF DESIGN ELEMENTS TO COST-OF-ELECTRICITY



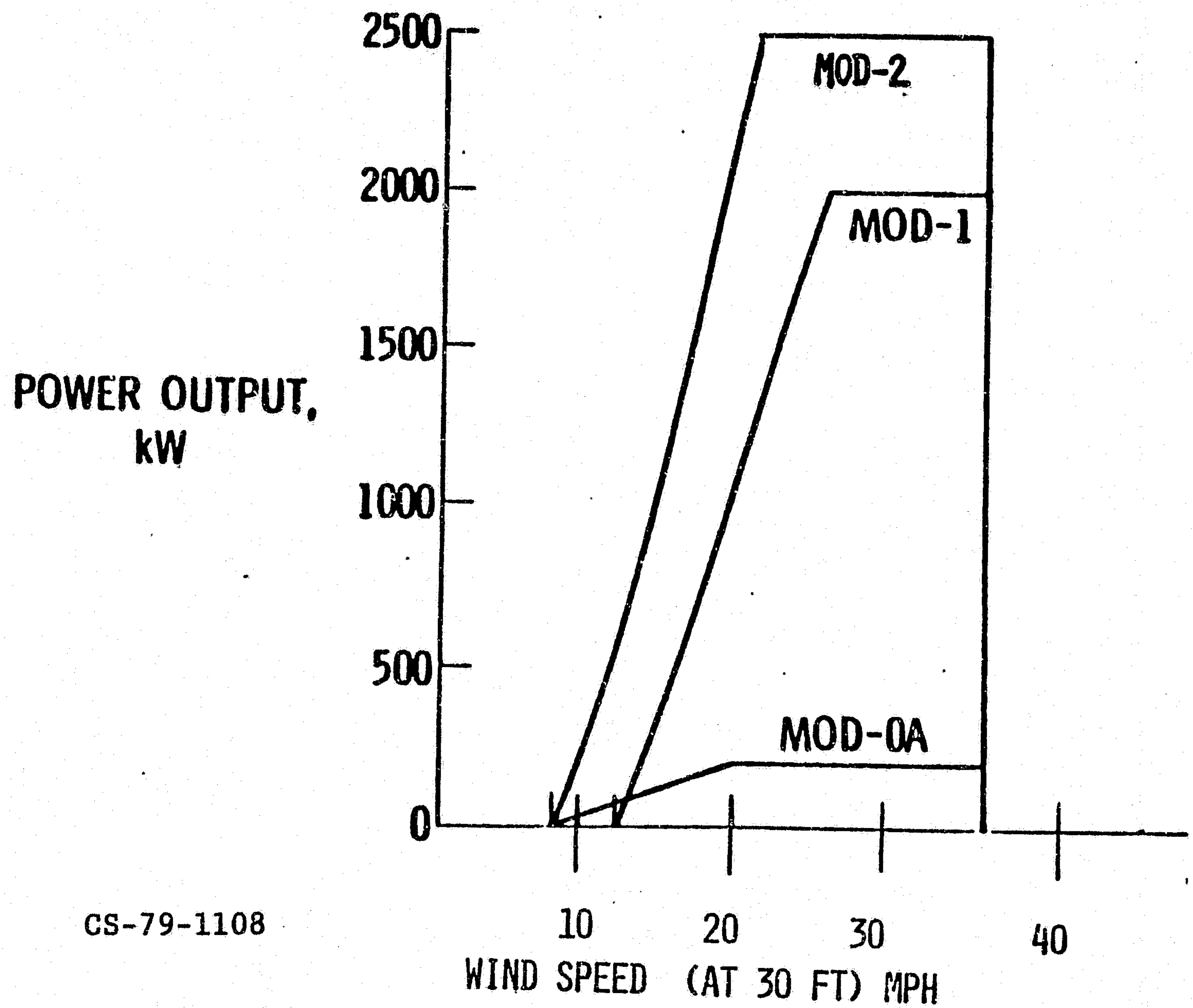
CS-79-1111

COST OF ELECTRICITY

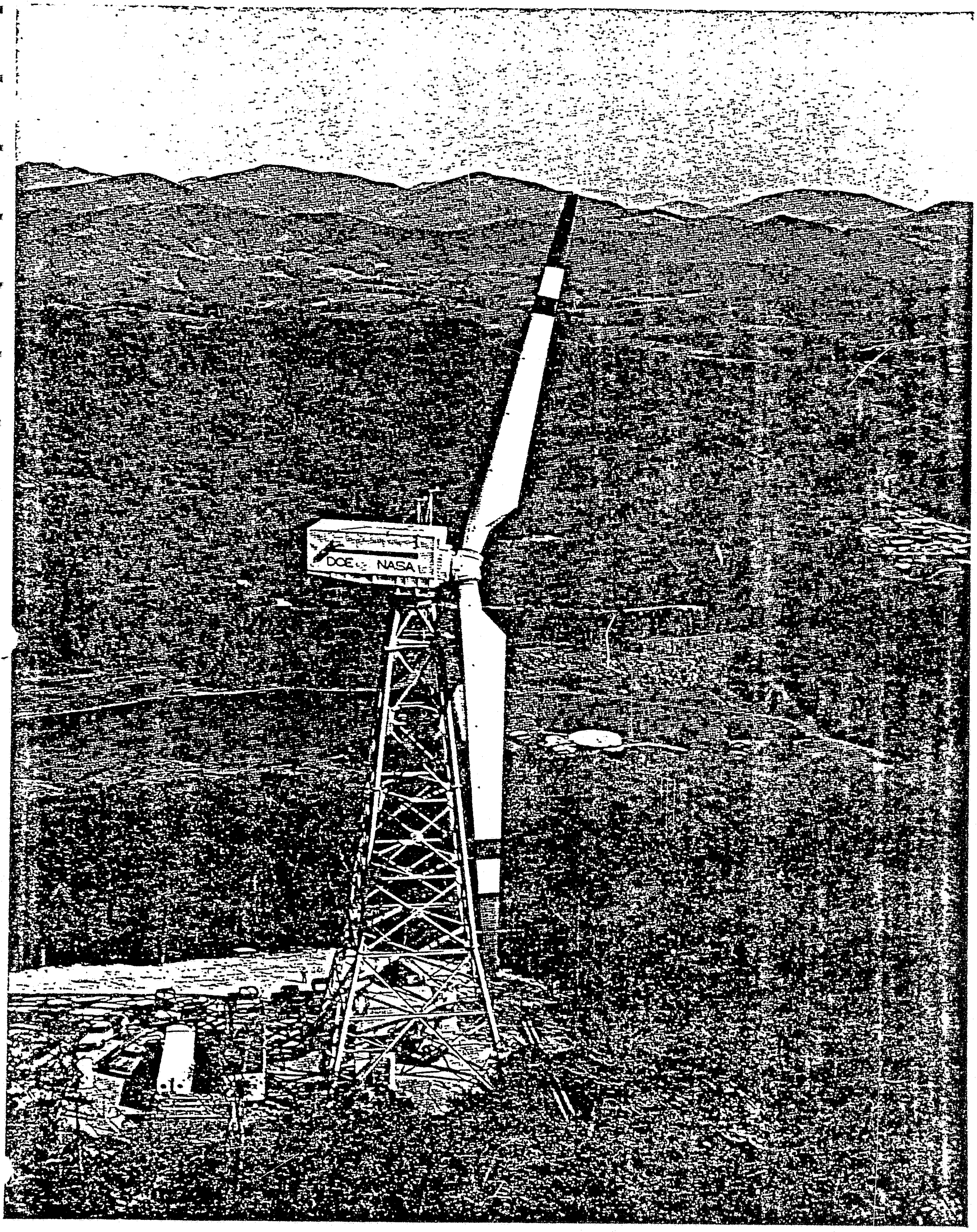


CS-79-1114

WIND TURBINE OPERATING RANGE



CS-79-1108



DOE/NASA 2000kW EXPERIMENTAL WIND TURBINE

Howard's Knob, Boone, North Carolina

2000 KILOWATT WIND TURBINE SPECIFICATION

Rotor

Number of blades	2
Diameter, ft.	200
Speed, rpm	35
Direction of rotation	Counterclockwise (looking upwind)
Location relative to tower	Downwind
Type of hub	Rigid
Method of power regulation	Variable Pitch
Cone angle, deg	9
Tilt angle, deg	0

Blade

Length, ft.	97
Material	Steel Spar/Foam Trailing Edge
Weight, lb/blade	21,500
Airfoil	NACA 44XX
Twist, deg.	11
Tip chord, ft	2.8
Root chord, ft.	12
Chord taper	Linear

Tower

Type	Pipe truss
Height, ft.	131
Ground clearance, ft.	40
Hub height, ft.	140
Access	Hoist

Transmission

Type	Three-stage conventional
Ratio	51
Rating, hp.	2209

Generator

Type	Synchronous ac
Rating, kVA	2225
Power factor	0.8
Voltage, V.	4160 (three phase)
Speed, rpm.	1800
Frequency, Hz	60

Orientation drive

Type	Ring gear
Yaw rate, degree/sec.	.25
Yaw drive	Hydraulic

Control system

Supervisory	Computer
Pitch actuator	Hydraulic

Performance

Rated power, kW	2 000
Wind speed at 30 ft, mph:	
Cut-in	11
Rated	25.5
Cut-out	35
Maximum design	125

Weight klb)

Rotor (including blades)	103
Above tower	330
Tower	320
Total	650

N - INVENTORY OF HYDROELECTRIC SITES IN THE RAILBELT

INVENTORY OF HYDROELECTRIC SITES

IN THE RAILBELT REGION

JUNE 1980

R.L. POWELL

INVENTORY OF HYDROELECTRIC SITES IN THE RAILBELT REGION

A preliminary examination was made of existing inventories of potential hydroelectric sites in the Railbelt region. The purpose of this examination was to divide sites into various ranges of capacity which would later be used in the screening process, and to determine the number of sites in each of the major Railbelt river basins. The primary inventories used include the DOE study "Hydroelectric Alternatives for the Alaska Railbelt", published in February 1980, and the Corps of Engineers "Preliminary Inventory of Hydropower Resources, Pacific Northwest Region", published in July 1979. For some sites, these two inventories presented differing data for the potential capacity and energy developable. The probable explanation of some of these inconsistencies is the different plant factors used in each inventory. Also, the Corps inventory capacity data does not account for 1) reduction in head due to rising tailwater levels during high flows, 2) diversion or evaporation, 3) head losses and turbine inefficiency, and 4) plant shutdown during high flows. The data obtained from these two inventories was supplemental by additional reports that covered a very limited number of sites and contained data essentially agreeing with the DOE and/or Corps inventories.

The reports used contained little or nothing in the way of specific environmental comments on the sites covered by the inventories. This is considered to be a significant lack of information for initial screening of potential hydroelectric sites in the Railbelt Region.

The total number of sites identified in the Railbelt is 117. These sites are divided among river basins as follows:

Cook Inlet	- 6
Susitna	- 33
Kenai	- 20
Copper	- 27
Tanana	- 17
Mantanuska	- 8
Yukon	- 1
Other	- 5

The capacity ranges into which the sites were divided are:

a) greater than 100 MW
b) 25 MW - 100 MW
c) less than 25 MW

The results of grouping sites by capacity ranges are as follows:

Range	Number of Sites
greater than 100 MW	33
25 MW - 100 MW	60
less than 25 MW	36

Due to the differing capacity data of the inventories used, some of the 117 sites are included in more than one range.

The preliminary power and energy parameters as well as hydraulic parameters are given in Tables A, B, and C for sites greater than 100 MW, sites between 25 MW and 100 MW, and sites less than 25 MW, respectively.

REFERENCES

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Alaska Department of Commerce and Economic Development, Division of Energy and Development, Alaska Regional Energy Resources, Planning Project Phase 1, Volume 1, October 1977

U.S. Geological Survey, Anchorage Sheet (NP 5, 6) 1:1,000,000 series

U.S. Geological Survey, Fairbanks Sheet (NQ 5, 6) 1:1,000,000 series

ACRES **Calculations**

SUBJECT: Table A) Susitna Hydro Alternatives - Sites Greater than 100 MW

JOB NUMBER P5700
FILE NUMBER .H.01
SHEET A1 OF 3
BY AEP DATE 5/8[illegible]
APP DATE

Gr. Basin *	Site	Stream	Lat, Long	D.A. (mi.²)	Head (ft)	Percent Regulation	Height of Dam (ft)	Capacity (MW) +*	Energy (GWh)	Plant Factor	
s ①	Chakachamna	Chakachatna R.	61°13', 152°22'	1120	793	100	793	366 DOE 413 COE	1600 1700	50 47	
s ②	Lane	Susitna R.	62°33', 150°05'	6280	169	100	—	451 COE 240 DOE	1195 1052	30 50	
s ③	Gold	Susitna R.	62°44', 149°42'	6160	189	100	—	260	1139	50	
k ④	Kenai Lake	Kenai R.	Seward B-8	660	341	97	—	115	552	55	Alternative to Stetler
c ⑤	Million Dollar	Copper R.	60°40', 144°44'	24200	89	71	—	440 DOE 1177 COE	1927 2327	50 23	
c ⑥	Wood Canyon	Copper R.	61°25', 144°20'	20600	950	100	950	3600 DOE 10694 COE	21900 25685	69.4 27	
c ⑦	Tazlina	Tazlina R.	62°01', 146°09'	1970	273	100	—	104	503	55	
c ⑧	Gakona	Copper R.	62°26', 145°40'	3965	266	75	—	150	727	55	Alt to Sanford (see S.S. <100MW)
s ⑨	Tokichitna	Chulitna	62°34', 150°12'	2560	186	85	—	184 DOE (86) COE	806 350	50 46	
s ⑩	Yentna Talachulitna Skwentna	Yentna Skwentna Skwentna		6400 2250 950	82 124 291	79	- - -	145 75 98 DOE	1390	50	Assume operation as a system
s ⑪	Yentna	Yentna	61°37", 150°32'	6400	82		82	116.8 COE	496	48	
⑫	Talachulitna	Skwentna	61°52', 151°22'	2250	124		124	227.25 COE	565	28	
s ⑬	Skwentna	Skwentna	61°52', 152°07'	950	291		291	225.2 COE	559.5	28	

ACRES **Calculations**

SUBJECT: Table A Susitna Hydro Alternatives - Sites Greater than 100 MW

JOB NUMBER 15700
FILE NUMBER 14.01
SHEET A2 OF 3
BY [illegible] DATE [illegible]
APP DATE

No.	Site	Stream	Lat, Long	D.A	Head	Percent Regulation	Dam Height	Capacity **	Energy	Plant Fct.	
S (14)	Vee	Susitna R	62°42', 147°32'	4140	430	100	430	756.4 COE 386 DOE	2003	30	Part of DC, W., V., D. system
S (15)	Denali	Susitna R	62°58', 147°14'	1260	530	100		668.8 COE	1459.7	25	"
T (16)	Junction Island	Tanana R.	64°52.1', 150°20'	42490	114 114	100	 125	532 DOE 481.4 COE	2330 1650	50 39	Cordova Pub. Util.
T (17)	Healy Carlo Brushkana	Nenana R. see Site > 50 MW see Site > 50 MW	↓	1900 1190 650	291 166 212	83		(130) (30) (40) DOE	840	50	Assumes operation as a system
- (18)	Healy	Nenana R.	63°49', 148°57'	1900	291		291	292 COE	726.1	28	
T (19)	Big Delta	Tanana R	64°09.3', 145°03'	15300	99	98	99	226 DOE 365.5 COE	987 1204.8	50 38	
(20)	Gerstle	Tanana R	63°50', 144°48'	10700	59		59	100 DOE 153.13 COE	438 427.2	50 32	
T (21)	Johnson	Tanana R.	63°43.2', 144°37'	10450	149	97	180	210 DOE 377.67 COE	920 1053.6	50 32	Owned by Cordova Public Utility
T (22)	Cathedral Bluff	Tanana R	63°23.2', 143°44.3'	8550	146	100	146	158 DOE 302.8 COE	693 844.7	50 32	
K (23)	Bradley Lake	Bradley Cr	59°45', 150°57'	88	1155	93	1155	(94) DOE 216.2 COE 125 ARCR	410 545.3 913	50 29 83	
K (24)	Bradley Lake Alt	Bradley Cr.	59°45', 150°57'	88	1146		1146	214.5 COE	541.1		
K (25)	Stetler (St. Mary's Rapids)	Kenai R.	60°28', 150°08'	849	199	97	199	(94) DOE [illegible]7.9	403 448	55	

80.04.01 Form 148A

Calculations

ACRES

SUBJECT: Table A Susitna Hydro Alternatives - Sites Greater than 100 MW

JOB NUMBER P5700
FILE NUMBER 14.01
SHEET A3 OF 3
BY [illegible] DATE 5/80
APP ______ DATE ______

*	Site	Stream	Lat, Long	D.A.	Head (ft)	Percent Regulation	Height of Dam (ft)	Capacity (MW) **	Energy (GWh)	Plant Factor	
C (26)	Beluga Upper	Beluga R	61°16', 151°15'	840	142	100	142	(48) DOE 126.6 COE	210 291.2	50 26	
M (27)	Boulder Creek 1	Boulder Creek	61°40', 149°05'	90	1317	80	—	(44) DOE 134.6 COE	69 270.6	55 23	
S (28)	Cache	Talkeetna R	62°34', 149°11'	750	300		300	(37) DOE 108.4 COE	269.7	28	
S (29)	Keetna	Talkeetna R	62°26', 149°41'	1250	286	82	286	(74) DOE 215.4 COE	324 526.7	50 28	
S (30)	Sheep River	Sheep R.	62°18', 149°28'	369	790		790	132.1 COE	320.2	28	
S (31)	Talkeetna 3	Talkeetna R.	62°26.2', 149°41'	1150	350		350	242.5 COE	593.0	28	
C (32)	Chisana R	Chisana R.	62°18.3', 144°50.4'	732	883		883	170 DOE, COE	797	55	
T (33)	Kantishna R	Kantishna R	64°45.6', 150°30'	5440	95 95	99	363	(82) DOE 1577.6 COE	394 4294.2	55 31	Owner - Cordova Pub Util.
T (34)	McKinley R.	McKinley R.	63°51.6', 151°33'	710	297 297	90	363	(42) DOE 643.7 COE	201 1732.2	55 31	Cordova Pub. Util.
Y (35)	Rampart	Yukon R.	65°19.8', 151°01'	200,000	445 445	100	457	5040 15236	34200 40164	75 30	Cordova Pub Util.

* C = Copper S = Susitna Y = Yukon K = Kenai M = Matanuska CI = Cook Inlet T = Tanana O = Other

** DOE - Hydroelectric Alternatives for the Alaska Railbelt
COE - Preliminary Inventory of Hydropower Resources - Pacific Northwest Region
AREA - Alaska Regional Energy Resources

60.04.01 Form 148A

0 0 0 3 2

Calculations

SUBJECT: Table [?] Susitna Hydro Alternatives - Sites 25-100 MW

JOB NUMBER P5700
FILE NUMBER 14.01
SHEET B1 OF 4
BY [illegible] DATE 1/80
APP DATE

Basin #	Site	Stream	Lat, Long	D.A.	Head	Percent Regulation	Height of Dam	Capacity **	Energy	Plant Factor	
s ①	Hayes (S.R.)	Skwentna R.	61°58', 151°51'	1730	187 DOE 107 COE	80		89 DOE 89 COE	429 429	55 55	
s ②	Talachulitna	see Sites >100 MW									
s ③	Skwentna	"									
s ④	Lower Chulitna	Chulitna R	62°34', 150°14'	2600	89 DOE 89 COE	84		90 DOE 90 COE	394 394	50 50	
s ⑤	Kahiltna	see Sites >100 MW									
s ⑥	Granite Gorge	Talkeetna R.	62°27', 149°27'	865	416 416	97		72 DOE 72 COE	345 345	55 55	
s ⑦	Greenstone	Talkeetna R	62°32', 149°02'	790	304 304	65		51 DOE 51 COE	246 246	55 55	
s ⑧	Whiskers	Susitna	62°28', 150°06'	6320	59 59	100	59	84 DOE 65.14 COE	368 273.9	50 48	
s ⑨	McLaren R.	McLaren R.	62°57', 146°22'	485	263	85		55 DOE, COE	263	55	
n ⑩	Coal Creek	Matanuska R	61°47', 148°10'	1128	291	80		64 DOE, COE	307	55	Alt. to King Mtn. site
n ⑪	Purinton Creek	Matanuska R	61°46', 148°0'	1082	291	90		67 DOE, COE	321	55	Alt. to Hicks Site
n ⑫	Hicks Site	Matanuska R	61°48', 147°48'	950	281	90		57 DOE, COE	286	55	
k ⑬	Lower Kenai	Kenai R.	60°29', 150°50'	1650	84	88		55 DOE, COE	263	55	
k ⑭	Moose Horn	Kenai R	60°31', 150°23.8'	1540	95	93		60 DOE, COE	290	55	

Form 145A 04.01

0 0 0 3 2

ACRES Calculations

SUBJECT: Susitna Hydro Alternatives – Sites 25MW–100MW

Table B

JOB NUMBER P5700
FILE NUMBER 14.01
SHEET B2 OF 4
BY AHP DATE 5/80
APP DATE

Ref#	Site	Stream	Lat Long	D.A.	Head	Percent Regulation	Height of Dam	Capacity **	Energy	Plant Factor	
K (15)	Stetters Ranch	see Sites >100MW									
K (16)	Snow	Snow R.	60°18', 149°18'	85	653 653	97	653	63 DOE 32.5 COE 60 ACRES	278 134 271	50 47	
K (17)	Bradley Lake	see Sites >100MW									
O (18)	Lowe	Lowe R.	61°06', 145°30'	190	334 DOE 324 COE	66		55 DOE 36.6 COE	254 86.5	50 27	
C (19)	Klutina	Klutina R	61°33', 145°28'	670	335	100		54 DOE, COE	263	55	
C (20)	Sanford	Copper R	62°20', 145°21'	3365	178	70		80 DOE 80 COE	385 385	55 55	
T (21)	Kantishna River	see Sites >100MW									
T (22)	Teklanika	Teklanika R.	63°59', 149°33'	520	457	100		57 DOE 93.8 COE	272 227.3	55 28	
T (23)	Browne	Nenana R	64°11', 149°15'	2450	207	66		80 DOE, COE	385	55	
T (24)	Yanert No 2	Nenana R	63°46', 148°57'	1190	232	93		62 DOE, COE	298	55	
T (25)	Tanana R. (near Delta)	Tanana R.	64°30', 146°45'	18080	107	25		65 DOE, COE	315	55	
S (26)	Talkeetna 2	Talkeetna R.	62°28', 149°22'	850	370			92.8 COE	406	.50	
S (27)	Tokichitna	see Sites >100MW									
T (28)	Bruskansa	Nenana R	63°24', 148°30'	650	212		250	66.4 DOE	165.2	28	Cordova Pub. Util (See Sites >100MW Healy, Carlo, Bruskana)

80.04.01 Form 148A

ACRES Calculations

SUBJECT: Susitna Hydro Alternatives - Sites 25-100 MW
Table B

JOB NUMBER 15700
FILE NUMBER 14.01
SHEET B3 OF 4
BY [illegible] DATE [illegible]
APP DATE

Region #	Site	Stream	Lat, Long	D A.	Head	Percent Regulation	Dam Height	Capacity **	Energy	Plant Factor	
T 29	Carlo	Nenana	63°40', 148°49'	650	212		212	72.8	181	28	Possible COE Data ERROR (See Sites > 100MW)
S 30	McKinley R	see Sites > 100 MW									
T 31	Walker Creek	Nenana R.	63°57', 149°10'	2330	166	35		35 DOE, COE	166	55	
CI 32	Crescent L.'l	Crescent R.	60°18', 152°55'	200	517	98		41 DOE, COE	179	50	
CI 33	Coffee	Beluga R	61°12', 151°12'	860	109	100		37 DOE COE	160	50	
CI 34	Upper Beluga	See Sites > 100 MW									
S 35	Talachulitna R.	Talachulitna	61°46', 151°29'	360	231	100		28 DOE, COE	137	55	
S 36	Emerald	Skwentna R	———	370	366			37 DOE, COE	177	55	
S 37	Talkeetna R. (Sheep)	Talkeetna R	62°25', 149°57'	1790	91	50		31 DOE, COE	149	55	
S 38	Iron Creek	Iron Creek	62°22', 149°37'	210	750	60		31 DOE, COE	147	55	
S 39	Trapper	Talkeetna R	62°33', 149°03'	760	245	94		45 DOE, COE	216	55	
S 40	Coal	Chulitna R.	62°54', 149°40'	985	241	40		40 DOE, COE	193	55	
S 41	Ohio	Chulitna R.	63°0', 149°45'	916	224	35		30 DOE 36 COE	144 144	55 46	
S 42	Chulitna Hurricane	Chulitna R.	63°5', 149°45'	795	207	50		34 DOE, COE	166	55	
S 43	Deadman Creek	Deadman Cr.	62°46', 148°05'	160	962	60		34 DOE, COE	165	55	
M 44	King Mountain	Matanuska R.	61°15', 148°20'	1635	276	40		44 DOE, COE	210	55	

60.04.01 Form 148A

Calculations

ACRES

SUBJECT: Susitna Hydro Alternatives - Sites 25 - 100 MW
Table 3

JOB NUMBER P5700
FILE NUMBER 14.01
SHEET B4 OF 4
BY [illegible] DATE 5/80
APP ______ DATE ______

*	Site	Stream	Lat, Long	D.A.	Head	% Regulation	Dam Height	Capacity **	Energy	Plant Fctr	
K 45	Kasilof R.	Kasilof R.	60°16', 151°10'	738	136	100		40 DOE, COE	193	55	
C 46	S.Fk. Bremner R.	S.FK. Bremner R	60°56', 144°09'	148	537	75		32 DOE, COE	156	55	
C 47	Three Mile Canyon	Bremner R.	60°59', 144°10'	526	228	41		26 DOE, COE	127	55	
C 48	N.F.k. Bremner R.	N.Fk. Bremner R.	60°58', 143°42'	150	490	97		35 DOE, COE	166	55	
C 49	Hanagita Lake	Hanagita R.	61°27', 144°04'	100	1010	85		33 DOE, COE	160	55	
C 50	Tebay Lakes	Tebay R.	61°26', 144°12'	105	1007	95		40 DOE, COE 64 APCR	193 264	55	
C 51	Canyon Creek	Canyon Cr	61°5', 142°10'	100	1308	45		27 DOE, COE	131	55	
C 52	Ketina R.	Ketina R	61°38', 144°11'	209	524	70		28 DOE, COE	133	55	
C 53	Nelchina R	Nelchina R	62°0', 146°42'	820	285	97		45 DOE, COE	219	55	
C 54	Gulkana R.	Gulkana R	62°35', 145°56'	575	405	80		34 DOE, COE	164	55	
K 55	Fox	Fox R	59°58.4', 150°48'	105	300		300	27.5 COE	115.7	48	
T 56	Totatlanika R.	Totatlanika R	64°13.3', 148°44.3'	250	420	100	420	(24) DOE 41.5 COE	114 100.4	55 28	
K 57	Grant Lake	Grant Lake	60°28', 149°21'	44	294		294	44.8 COE	83.1	21	
K 58	Lost Lake	Lost Creek	60°16', 149°22'	7	1390		1390	33.7 COE	62.3	21	
59	Mc Clure Bay	Hanley Cr.	60°34', 148°10.3'	710	297	90		42 DOE, COE	201	55	
T 60	Jack River	Jack River	63°19.8', 148°50'	135	467		363	30.4 COE	75.6	28	Cordova Pub. Util

* (see table A)

80.04.01 Form 148A

JOB NUMBER	P5700
FILE NUMBER	14.01
SHEET	C1 OF 3
BY	[illegible] DATE 6/80
APP	DATE

ACRES Calculations

SUBJECT: Table C Susitna Hydro Alternative Sites < 25 MW

Basin	Site	Stream	Lat, Long	D.A	Head	% Regulation	Height of Dam	Capacity MW	Energy	Plant Factor
T	① Chatanika R	Chatanika R.	65°7', 148°07'	770	91	99		7 DOE, COE	32	55
T	② Totatlanika R	see Sites 25-100MW								
S	③ Chuitna	Chuitna R	61°5', 151°20'	66	552	70		9 DOE, COE	45	55
Ci	④ Lower Beluga	Beluga R	61°15', 151°0'	950	49	100		15 DOE, COE	72	55
Ci	⑤ Strandline Lake	Beluga R	61°29', 152°0'	54	852	100		17 DOE, COE	81	55
S	⑥ Lower Lake Creek	Lake Creek	62°7', 151°0'	335	305	60		22 DOE, COE	105	55
S	⑦ Upper Lake Creek	Lake Creek	62°26', 151°28'	85	560	90		15 DOE, COE	74	55
S	⑧ Chulitna Creek	Chulitna Cr.	62°50', 150°0'	240	198	40		5 DOE, COE	25	55
S	⑨ Lucy	Chulitna R.	62°55', 149°58'	1080	166	20		15 DOE, COE	71	55
N	⑩ Boulder Cr 1	See Sites >100MW								
N	⑪ Rush Lake	Boulder Cr.	61°55', 148°1'	89	892	79		9 DOE COE	45	55
N	⑫ Caribou Cr.	Caribou Cr.	61°47', 147°35'	260	527	93		19 DOE, COE	90	55
N	⑬ Eagle River	Eagle R.	61°18', 149°39'	194	167	82		9 DOE, COE	45	55
S	⑭ Sunrise	Sixmile Cr.	60°52' 149°27'	238	327	55		11 DOE, COE	52	55
K	⑮ Killey River	Killey R.	60°20', 150°25'	160	358	90		21 DOE, COE	100	55
K	⑯ Crescent Lake 2	Crescent Lake		23	934	100		6	29	55

60.04.01 Form 148A

00032

Calculations

ACRES

SUBJECT: Table C Susitna Hydro Alternatives - Sites < 25 MW

JOB NUMBER 15700
FILE NUMBER 14.61
SHEET C2 OF 9
BY AP DATE 6/1
APP DATE

r Basin*	Site	Stream	Lat Long	D.A.	Head	% Regulation	Dam Height	Capacity **	Energy	Plant Factor	
K 17	Tustumena	Tustumena Glacier	60°7', 150°37'	57	1100	85		21 DOE, COE	102	55	
K 18	Sheep Creek	Sheep Creek	59°47' 150°46'	101	382	54		20 DOE, COE	94	55	
K 19	Resurrection River	Resurrection River	60°52', 149°42'	141	233	75		18 DOE, COE	86	55	
K 20	Nellie Juan River	Nellie Juan R.	60°27', 148°47'	130	240	34		10 DOE, COE (40) ARER	47 184	55	
K 21	Upper Nellie Juan R.	Nellie Juan R.	60°24', 148°50'	35	421	90		12 DOE, COE	57.	55	
O 22	Allison Creek	Allison Cr.	61°7', 146°10'	6	1191	55		4 DOE, COE	18	55	
C 23	Solomon Gulch	Solomon Gulch	61°31', 146°16'	18	608	20		2 DOE 24.6 COE 12 ARER	11 57.4	55 27	
O 24	Silver Lake	Duck River	60°56', 146°20'	25	346	95		10 DOE, COE	48	55	
O 25	Power Creek	Power Cr.	60°15', 145°50'	21	490 380	90		14 DOE 3 COE 12 ARER	66 4 32.6	55 15	Cordova Pub. Util
C 26	Van Cleve	Unnamed	61°10', 144°50'	17	475	25		2 DOE, COE	10	55	
C 27	Little Bremner R.	Little Bremner R	60°59' 144° 9'	182	272	62		15 DOE, COE	70	55	
C 28	Bremner R. Salmon St.	Bremner R.	61° 144°	660	166	30		18 DOE, COE	86	55	
C 29	Tsina	Tsina	61°9', 145°31'	104	360	90		12 DOE, COE	58	55	
C 30	Tiekel R.	Tiekel R.	61°10', 144°59'	421	400	35		21 DOE, COE	105	55	
C 31	Kuskulana R.	Kuskulana R.	61°33', 143°57'	260	508	50		24 DOE, COE	114	55	

80.04.01 Form 148A

ACRES

Calculations

SUBJECT: Susitna Hydro Alternatives - Sites < 25MW
Table C

JOB NUMBER 15700
FILE NUMBER 14.01
SHEET C 3 OF 3
BY AH DATE 6/10
APP ______ DATE ______

Sub Basin*	Site	Stream	Lat Long	D.A.	Head	% Regulation	Dam Height	Capacity **	Energy	Plt Fctr
c 34	Tolsona Cr	Tolsona Cr	62° 5', 146° 16'	174	460	70		11 DOE, COE	53	55
c 37	Lower Gulkana R.	Gulkana R	62° 35', 145° 29'	1850	232	11		9 DOE,	42	55
c 38	Upper Gulkana R	Gulkana R.	62° 27', 145° 30'	1770	124	23		9 DOE, COE	45	55
c 35	W. Fk. Gulkana R	W. F. Gulkana R.	62° 35', 146° 5'	398	192	100		14 DOE, COE	69	55
c 36	Summit Lake	Gulkana R.	63° 5', 145° 32'	83	500	100		8 DOE, COE	36	55

*(see table A)
**(see table A)

O - LIST OF TECHNICAL REPORTS REVIEWED

ACRES

OFFICE MEMORANDUM

TO:	A. Vircol, Columbia	*Date:*	June 10, 1980
FROM:	G. Krishnan, Buffalo	*File:*	P5700.14.01
SUBJECT:	Susitna Hydroelectric Project Task 1 - Power Studies Review of Available Reports		

Enclosed is a list of technical reports which were reviewed at a preliminary level in Buffalo with regard to their input to Task 1 studies. A short summary and the possible use of the information contained in each of these reports is attached.

This is for your information and possible incorporation in the wrap-up report as you may think fit.

G. Krishnan

GK:cl
Enclosures

TASK 1

DATA SOURCE

LIST OF REPORTS REVIEWED

1. CH2M Hill - Review of South Central Alaska Hydropower Potential, Fairbanks Area and Anchorage Area - for U.S. Army Corps of Engineers, Alaska District, 1978.

2. U.S. Army Corps of Engineers, Alaska District - Harbors and Rivers in Alaska-Survey Report
   - Interim Report No. 2 - Cook Inlet and Tributaries, 1950
   - Interim Report No. 3 - Copper River and Gulf Coast, Alaska, 1950
   - Interim Report No. 4 - Tanana River Basin, 1951

3. Jones & Jones - Upper Susitna, Alaska. An Inventory and Evaluation of the Environmental Aesthetic and Recreational Resources - for U.S. Army Corps of Engineers, Alaska District, 1975.

4. Glenn Bacon - Archeology in the Upper Susitna River Basin - for U.S. Army Corps of Engineers, Alaska District, 1978.

5. U.S. Geological Survey, Anchorage - Water Resources (Surface and Subsurface) of the Cook Inlet Basin - a rough, final draft, 1980.

6. The Federal Power Commission - The 1976 Alaska Power Survey, Volumes 1 and 2.

7. U.S. Army Corps of Engineers Institute for Water Resources, The Hydrologic Engineering Center - National Hydroelectric Power Resources Study, Preliminary Inventory of Hydropower Resources, Volume 1, Pacific Northwest Region, 1979.

8. U.S. Department of Energy, Alaska Power Administration - Hydroelectric Alternatives for the Alaska Railbelt, 1980.

9. U.S. Department of the Interior - Susitna River Basin - A Report on the Potential Development of Water Resources in the Susitna River Basin of Alaska - for U.S. Bureau of Reclamation, 1952.

10. U.S. Department of the Interior - Alaska Natural Resources and the Rampart Project-Summary Report. 1967.

11. U.S. Army Corps of Engineers, Alaska District - Report on Rampart Canyon Dam and Lake, Yukon River Basin, Alaska, 1971.

12. U.S. Army Corps of Engineers, Alaska District - Interim Report No. 2, Cook Inlet and Tributaries - Part A Hydroelectric Power, Bradley Lake, Alaska, 1962.

LIST OF REPORTS REVIEWED (Continued)

13. State of Alaska, Department of Natural Resources. Report of the Technical Advisory Committee on Resources and Electric Power Generation - for Alaska Power Administration, 1974.

14. U.S. Department of Energy - Alaska Power Administration - Upper Susitna River Project - Power Market Analyses, 1979.

15. Federal Power Commission - Alaska Power Survey, 1969.

16. U.S. Department of the Interior - Devil Canyon Project, Alaska, 1974.

17. U.S. Department of the Interior - Bureau of Reclamation, Alaska. Reconnaissance Report on the Potential Development of Water Resources in the Territory of Alaska, 1952.

18. Corps of Engineers - Feasibility Study. 1975
Public Meetings.

19. APA - Analysis of Impact on HE Potential of the Administration's Recommendation for the Alaska D-2 Lands. 1978

20. APA - Analysis of Impact of HR 39 on HE Potential of Alaska - 1977.

Draft

DATA REVIEW

1. CH2M Hill - for Corps, 1978

Reconnaissance level study to identify the degree of potential acceptability of 61 sites - selected by Corps in the South-Central Railbelt - relating to environmental and land use constraints. Report develops criteria for rating and scale of evaluation (as attributes) for the contraints in consultation with participating agencies. Comments during public meetings are addressed and answered. Inventory excludes Susitna alternatives.

cc DNR, ADF&G etc

- Rating and evaluation scales form a good base for parametric screening model to be developed under Task 1. List of contacts and concerned agencies useful for further work.

2. Corps Studies, 1950-51

Reconnaissance level engineering study of identifying, among other things, potential hydropower sites.

- 18 sites in the Cook Inlet Basin (partly superceded by further work)
- 17 sites in Copper River Gulf Coast
- 11 sites in the Tanana Basin.

Mainly historical value. Some engineering detail as input for screening model. Most information ~~raised~~ revised or included in later reports by various agencies.

3. Jones & Jones - for Corps, 1975

Environmental quality assessment reach by reach of 4-dam alternative on Susitna.

- Useful list of environmental, aesthetic and recreational evaluation parameters and scale of evaluation.

DATA REVIEW (Continued)

4. Glenn Bacon - for Corps, 1978

Only report on archeology in Upper Susitna Basin.

- Identifies sites of archeological significance in the Watana, D.C. project area.
- Necessary input into environmental impact assessment.
- Forerunner to proposed work in Task 7.

5. USGS, 1980 - Rough Draft

Hydrological analysis of water resource (subsurface and surface) in Cook Inlet Basin.

Some useful technical data for regional analysis.

6. 1976 Power Survey - F.P.C.

Reviews the present (1976) Alaska Power System. Projects demands for the next 25 years. Presents guidelines for future power system planning. Discusses future fuel costs, impact of extensi~~on~~ve oil and natural gas discoveries on Alaska economy, environmental and consumer interest viewpoints.

- Survey is exploratory and suggestive
- Includes reports of technical advisory committees on:
  - Resources and electric power generation
  - Economic analysis and load projections
  - System coordination and interconnection
  - Environmental considerations and consumer affairs.

Good starting point ~~of~~ for energy generation planning, study, screening model. Lists 76 more favorable hydro sites.

DATA REVIEW (Continued)

7. Corps NHPR Study, 1979 - Volume 1 NW Pacific Region

Part of national inventory level study of hydropower resources based on site specific analysis and evaluation of existing and potentially feasible sites. Includes site specific information on 465 sites including 427 undeveloped sites.

- Useful inventory (includes 76 listed in Ref. 6)

8. APA, US DOE, 1980

Most recent inventory grade evaluation (engineering) of 252 favorable sites selected out of some 2,000 potential sites.

- Reconnaissance level calculations available for 76 (same as in Ref.6) of the more favorable sites.
- Technical information useful as input to screening model.

9. USBR, 1952 - First Study

First report on Susitna Basin hydro potential. Identifies 29 sites with engineering and some environmental details.

- Also describes a few large alternative development (to Susitna). Engineering information useful.

10. USDI, Rampart Project, 1967

Summary report - ~~detailed~~ reporting on aspects of Rampart project including marketing potential for power. Discusses alternative sources of energy including thermal, nuclear and other large hydro preliminary cost comparisons.

DATA REVIEW (Continued)

10. USDI, Rampart Project, 1967 (Continued)

- Mostly out-of-date information but useful in screening model input.

11. Corps, 1971 - Rampart Canyon

Most comprehensive report, yet, on subject. Engineering and other inputs for screening model.

12. Corps - Cook Inlet Tributaries - Bradley Lake, 1962

Extension of 1950 studies (ref. 2 above) - describes over 17 projects based on demand and possible future growth with specific description & details of Bradley Lake Projects
- useful engineering details on Bradley lake projects

13. State of Alaska, DNR - for APA, 1974

Included in 6 above.

14. US DOE/APA, 1979

Latest APA/DOE report on power market for the Upper Susitna Project. Update of previous analyses used in 1975. Feasibility study by Corps includes a new set of load projections for railbelt area through the year 2025 and a reviw of alternative power sources; load/resource and power system cost analyses are prepared for different scenarios. Useful input to screening model. Check/comparison of ISER work - data

DATA REVIEW (Continued)

15. FPC, 1969

Report is superceded by 1976 power survey.

16. USDI - Devil Canyon, 1974

Latest USDI report on Devil Canyon project. Engineering and other data for evaluating this Susitna alternative. Input to screening model.

17. USDI, 1952

Early report on reconnaissance level study of potential hydro development in Alaska. Lists over 100 sites. Mostly superceded by later inventions.

18. Corps - Feasibility, 1975

Public Meetings -

Information on public views, discussions and responses on Upper Susitna Project. Important input.

19 & 20 -

APA assessment of impact of new administrative policy - directive on HE development in Alaska. specifically describes effect on 76 more favorable hydro sites (ref: 6)

SUSITNA MATERIALS COLLECTION - LOCATED IN HYDRAULICS DEPARTMENT

Alaska Dept. of Commerce	ALASKA POWER & ECONOMIC DEVELOPMENT PROGRAM 2 Vol.	(798) 621.22.3 Al
	JOBS AND POWER FOR ALASKANS: A PROGRAM FOR POWER & ECONOMIC DEVELOPMENT 2 copies	"
Alaska Power Adm.	INVENTORY TYPE CALCULATIONS FOR SOME POTENTIAL HYDROELECTRIC PROJECTS IN ALASKA	"
Alaska Power Authority	ANCHORAGE-FAIRBANKS TRANSMISSION: ECONOMIC FEASIBILITY STUDY REPORT. DRAFT.	(798) 621.22.1 Al
	FUTURE POWER REQUIREMENTS - REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON ECONOMIC ANALYSIS & LOAD PROJECTIONS	(798) 621.22.3 Al
	FUTURE ALASKA POWER SUPPLIES - REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON RESOURCES & ELECTRIC POWER GENERATION	"
	REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON ENVIRONMENTAL CONSIDERATION & CONSUMER AFFAIRS 2 copies	(798) 621.22.1 ;581.57 Al
	SUSITNA HYDROELECTRIC PROJECT: A DETAILED PLAN OF STUDY 2 copies	(798) 621.22.3 Al
	SUSITNA HYDROELECTRIC PROJECT: PLAN OF STUDY FOR PROJECT FEASIBILITY AND FERC LICENSE APPLICATION	"
Arctic Environmental Information & Data Center	CLIMATOLOGICAL DATA	(798) 621.22.1 Ar
Bacon, Glenn	ARCHEOLOGY IN THE UPPER SUSITNA RIVER BASIN	(798) 621.22.1 Ba

<u>SUSITNA MATERIALS</u> continued

Behlke, Dr. Charles E.	AN INVESTIGATION OF SMALL TIDAL POWER PLANT POSSIBILITIES ON COOK INLET, ALASKA	(798) 621.22.3 Be
Bishops, Daniel M.	A HYDROLOGIC RECONNAISSANCE OF THE SUSITNA RIVER BELOW DEVIL'S CANYON	(798) 621.22.1 (282.41) Bi
Burrows, Robert L.	SEDIMENT TRANSPORT IN THE TANANA RIVER IN THE VICINITY OF FAIRBANKS, ALASKA	"
Carlson, Robert F.	EVALUATION OF THE NATIONAL WEATHER SERVICE RIVER FORECEASE SYSTEM MODEL FOR USE IN NORTHERN REGIONS	(798) 621.22.1 Ca
Federal Power Commission	ALASKA POWER SURVEY	(798) 621.22.3 Fe
	THE 1976 ALASKA POWER SURVEY, VOL. I & II 2 copies	"
Gray, T.J.	TIDAL POWER (COOK INLET)	(798) 621.22.3 Gr
Hartman, Charles W.	ENVIRONMENTAL ATLAS OF ALASKA	(798) 621.22.1 Ha
Henry, J. Kaiser Co.	REASSESSMENT REPORT ON UPPER SUSITNA RIVER HYDROELECTRIC DEVELOPMENT FOR THE STATE OF ALASKA	(798) 621.22.1 (282.4) He
Inst. of Water Resources Univ. of Alaska	STUDY OF THE BREAKUP CHARACTERISTICS OF THE CHENA RIVER BASIN USING ERTS IMAGERY	(798) 621.22.1 (282.41) In
Johnson, Roy W.	HARNESSING COOK INLET'S TIDAL ACTIVITY	(798) 621.22.3 Jo
Jones & Jones	UPPER SUSITNA RIVER, ALASKA: AN INVENTORY & EVALUATION OF ENVIRONMENTAL, AESTHETICS & RECREATIONAL RESOURCES	(798) 621.22.1

SUSITNA MATERIALS COntinued

Lamke, R.D.	FLOOD CHARACTERISTICS OF ALASKAN STREAMS	(798) 621.22.1 La
Naske, Claus M.	THE POLITICS OF HYDROELECTRIC POWER IN ALASKA: RAMPART & DEVIL CANYON, A CASE STUDY	(798) 621.22.3 Na
Project Software & Development Inc.	PROJECT/2: SAMPLE RUN ACTIVITY-ON-ARROW	(798) 621.22.1 Pr
Salomon Brothers	NORTH CAROLINA MUNICIPAL POWER AGENCY, No. 3. PROPOSAL	621.22.3 (756) Sa
Scully, David R.	SURFACE WATER RECORDS OF COOK INLET BASIN, ALASKA, THROUGH SEPT. 1975 3 copies	(798) 621.22.1 (282.4) Sc
Shira, Donald L.	HYDROELECTRIC POWER PLANT SITING IN GLACIAL AREAS OF ALASKA	(798) 621.22.3 Sh
U.S. ARmy Corps of Engineers	COOK INLET & TRIBUTARIES, HARBORS & RIVERS IN ALASKA. SURVEY REPORT	(798) 621.22.1 (282.4) Un
	COPPER RIVER & GULF COAST. HARBORS & RIVERS IN ALASKA SURVEY REPORT	(798) 621.22.1 (282.41) Un
	DRAFT & REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT. (HYDROELEC-TRIC POWER DEVELOPMENT - SUSITNA RIVER BASIN, SOUTHCENTRAL RAIL BELT AREA	(798) 621.22.1 :581.57 Un
	FINAL ENVIRONMENTAL IMPACT STATEMENT (as above)	"
	HARBORS & RIVERS IN ALASKA. SURVEY REPORT, YUKON & KUSKOKWIN RIVER BASINS	(798) 621.22.1 Un
	HYDROELECTRIC POWER & RELATED PURPOSES - INTERIM FEASIBILITY REPORT SOUTH CENTRAL RAILBE[illegible]A, ALASKA UPPER SUSITNA RIVER BASIN	(798) 621.22.3 Un

SUSITNA MATERIALS continued

U.S. Army Corps of Engineers	INTERIM REPORT NO. 2, COOK INLET & TRIBUTARIES, PART NO. 1 - HYDROELECTRIC POWER, BRADLEY LAKE, ALASKA	(798) 621.22.1 (282.4) Un
	NATIONAL HYDROELECTRIC POWER RESOURCES STUDY - PRELIMINARY INVENTORY OF HYDRO POWER RESOURCES, PACIFIC NORTHWEST	(798) 621.22.3 Un
	1978 SEISMIC REFRACTION SURVEY. SUSITNA HYDROELECTRIC PROJECT, WATANA DAMSITE, DEVIL'S CANYON DAMSITE	(798) 621.22.2 .006 Un
	REPORT ON RAMPART CANYON DAM & LAKE YUKON RIVER BASIN	(798) 621.22.1 Un
	REVIEW OF REPORTS: COOK INLET & TRIBUTARIES, COPPER RIVER & GULF COAST, TANANA RIVER BASINS, YUKON & KUSKOKWIN BASINS, SOUTHCENTRAL RAILBELT AREA. PUBLIC HEARING - FAIRBANKS, ALASKA 1974	(798) 621.22.3 Un
	REVIEW OF REPORTS...as above ANCHORAGE & FAIRBANKS PUBLIC MEETING 1975 tw copies	(798) 621.22.1 (282.4) Un
	REVIEW OF SOUTHCENTRAL ALASKA. HYDRO POWER POTENTIAL, ANCHORAGE 2 copies	(798) 621.22.3 U
	SOUTHCENTRAL-RAILBELT AREA, ALASKA. (HYDROELECTRIC POWER STUDY-PUBLIC HEARING, ANCHORAGE ALASKA.) 1974	"
	SOUTHCENTRAL RAILBELT AREA, ALASKA UPPER SUSITNA RIVER BASIN. INTERIM FEASIBILITY REPORT. Appendix 1 & 2.	(798) 621.22.1 (282.4) Un
	SOUTHCENTRAL RAILBELT AREA, ALSKA UPPER SUSITNA RIVER BASIN. MAIN REPORT	(798) 621.22.3 Un
	SUBSURFACE GEOPHYSICAL EXPLORATION, PROPOSED WATANA DAMSITE ON THE SUSITNA RIVER	(798) 621.22.2 .00[illegible] Un

SUSITNA MATERIALS continued

U.S. Army Corps of Engineers	TANANA RIVER BASIN, HARBORS & RIVERS IN ALASKA SURVEY REPORT	(798) 621.22.1 (282.41) Un
	TRANSCRIPT OF COORDINATION CONFERENCE FOR SOUTHCENTRAL RAILBELT AREA, ALASKA INVESTIGATION	(798) 621.22.3 Un
U.S. Bureau of Reclamation	DEVIL CANYON PROJECT, ALASKA FEASIBILITY REPORT	(798) 621.22.2 .006 Un
	ENGINEERING GEOLOGY REPORT, FEASIBILITY STAGE, DEVIL CANYON DAM	"
	REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN THE SUSITNA RIVER BASIN OF ALASKA. DISTRICT MANAGER'S RECONNAISSANCE REPORT	(798) 621.22.1 (282.4) Un
	VEE CANYON PROJECT, SUSITNA RIVER ALASKA _ ENGINEERING GEOLOGY OF VEE CANYON DEMSITE	(798) 621.22.2 .006.1 Un
U.S. Dept. of Commerce	ALASKA ECONOMY: YEAR END PERFORMANCE REPORT 1978	(798) 621.22.1 Un
	CLIMATE OF ALASKA: CLIMATOGRAPHY OF THE U.S.	"
U.S. Dept. of Energy	ANALYSIS OF IMPACT ON HYDROELECTRIC POTENTIAL OF THE ADMINISTRATION' RECOMMENDATIONS FOR THE ALASKA D-2 LANDS	(798) 621.22.3 Un
	HYDROELECTRIC ALTERNATIVES FOR THE ALASKA RAILBELT 2 copies	"
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U.S. Dept. of the Interior	ALASKA NATURAL RESOURCES & THE RAMPART PROJECT VOL. I & II 2 copies	(798) 621.22.1 Un

SUSITNA MATERIALS continued

U.S. Dept. of the Interior	ALASKA - RECONNAISSANCE REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN THE TERRITORY OF ALASKA	(798) 621.22.1 Un
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	SUSITNA RIVER BASIN: A REPORT ON THE POTENTIAL DEVELOPMENT OF WATER RESOURCES IN SUSITNA RIVER BASIN	(798) 621.22.1 (282.4) Un
U.S. Fish & Wildlife Service	SUBSTANTIATING REPORT ON THE FISH & WILDLIFE RESOURCES OF THE YUKON AND KUSKOKWIN RIVER BASINS	(798) 621.22.1 :581.57 Un
U.S. Geological Survey	WATER RESOURCES DATA FOR ALASKA WATER YEAR 1977 2 copies	(798) 621.22.1 Un
	WATER RESOURCES (SURFACE & SUBSURFACE) OF THE COOK INLET BASIN - ROUGH FINAL DRAFT	(798) 621.22.1 (282.4) Un

P - NOTES ON MEETINGS BETWEEN APA, ACRES, WCC
AND REPRESENTATIVES OF THE GOVERNOR'S OFFICE,
JUNE 10 AND 11, 1980

June 30, 1980
P5700700.11
T.248

Mr. Robert Mohn
Alaska Power Authority
333 West 4th Avenue
Suite 31
Anchorage, Alaska 99501

Dear Robert:

Susitna Hydroelectric Project
Task I Partial Termination

I am forwarding herewith a copy of notes and attachments prepared during our meetings June 10 and 11. Please advise if you note any inaccuracies in this record.

I also confirm my understanding of your letters dated June 13 and 16 (2), as modified following our telecon June 23, as follows:

1. The budget limitation for Subtasks 1.01 and 1.02 of $82,900 per your letter dated June 13 should be revised to reflect budgets which currently exist in the Acres/CDC cost reporting system. Revisions should also reflect the changes which have resulted from consideration of the Tussing Report and providing additional responses to public comment per your letters dated June 13aand June 16. Details of this budget should be forwarded as soon as possible.

2. The requested Plan for Forecast Improvement", per your letter dated June 13, should be in summary form, tailored to the available budget, rather than a detailed plan.

3. Early confirmation of the cost of partial termination is requested together with the actual termination report for which $7,000 has been budgeted.

4. An updated detailed summary of sunk costs to June 6 should be forwarded as soon as possible.

5. A clear indication of Revised Scope statements, cost estimates and schedules indicating interfacing requirements between the Susitna studies and the remaining Task I studies, should be forwarded as soon assposs1ble.

6. The estimate of costs for undertaking Item 5 should also be forwarded: this work should be charged to Subtask 1.03 and kept to a minimum.

7. Acres should assume for planning purposes that the additional $200,000 in Task 6 and $100,000 in Task 11 requested as a result of the Tussing Report (excluding Alternative Risk Assessments) will be available.

We are dealing with each of the above as rapidly as possible and hope to respond within a week.

Sincerely,

John D. Lawrence
Project Manager

JDL:jh JDL

SUSITNA HYDROELECTRIC PROJECT

NOTES ON MEETINGS - ALASKA POWER AUTHORITY

JUNE 10 & 11, 1980, ANCHORAGE

1. Meeting of June 10

Present:	R. Mohn) D. Baxter)	APA
	J. Lawrence) J. Hayden) J. Landman)	Acres
	C. Kirkwood) R. Firth)	WCC (part time)

1.1 Introduction

The purpose of the meeting was to review with APA/WCC the current status of Task I studies and to discuss the remaining differences between Acres and WCC's proposed approaches. The meeting continued in the absence of WCC to discuss the options available to APA and the Governor's office for continuation of Task I studies.

1.2 Status of Task I

Robert Mohn complained that Acres had still not submitted the detailed scope for Part 2 of the revised (post-Tussing) scope nor the revised budgets. He had hoped to be able to present to the Governor's office representatives an agreed plan fully responsive to Tussing and in line with the overall cost estimates already submitted. Acres advised that this had not been possible because, following meetings May 6 and 7, WCC had submitted a new proposal for its increased involvement in Task I beyond that previously suggested by Acres. This proposal was not received by Acres until May 27. We were concerned that the WCC approach would cause further increases in cost and might in any case not be appropirate for the alternatives study. By June 4 (6 working days later), the date of termination of Task I work, Acres' review of the proposal had reached a point where further discussions with WCC were about to be scheduled to attempt the resolution of the differences. It had been hoped that this resolution would have been successfully accomplished. However, the main point of difference between Acres and WCC concerned the method to be used for screening, ranking and selection of load forecasts, the list of alternatives for further consideration and finally the load gorwth scenarios themselves.

Kirkwood explained WCC's case that the approach to the alternatives study should be a planning exercise in which the State of Alaska should be attempting to decide the best options available for meeting project power needs in the Railbelt on a continuing basis and not specifically for the with or without - Susitna Project cases as currently proposed (See Attachment 1). There appeared to be some room still for accomplishing an approach similar to this proposal within the framework of Acres' proposed plan for Task I.

1.3 Options for Continuation of Task I Work

This part of the discussion took place in the absence of WCC. The available options presented by Acres were discussed at some length and modified as shown in Tables 1 and 2 attached to the notes on the meeting of June 11.

A great deal of the discussion centered on

(a) the questionable objectivity of WCC to continue in Task I studies, when they themselves had more than $1 million of work in Task 4 through mid-1982 and the prospect of continued work in this area

(b) the desirability of retaining sub-tasks 1.01 and 1.02 as currently proposed and of allowing Acres to continue with development of Sub-task 1.03 at least in the gathering of all technical data for the already agreed list of alternatives. This data would then be reviewed and if necessary modified by the selected A/E, to preserve objectivity.

(c) The desirability of allowing Acres to continue Susitna - Task 6 studies of alternatives using the appropriate Sub-task 1.03 technical data input, thus avoiding excessive termination costs and delays of up to 4 months while the new A/E is selected and familiarizes.

2. Meeting of June 11

Present: John Halterman (Deputy Director)) Office of the Governor,
Tom Singer) DPDP

R. Mohn)
T. McGuire) APA
D. Baxter)
N. Blunck)

J. D. Lawrence)
J. W. Hayden) Acres
J. K. Landman)

2.1 Introduction

The purpose of the meeting was to discuss with representatives of the Governor's Office the intent and interpretation of recent legislation concerning Susitna marketing and alternatives studies (see Agenda, Attachment 2) and the options available for implementation of the legislation and its impact on continuation of the Acres' Susitna Studies.

2.2 Governor's Office Interpretation of Legislation

John Halterman stated that the legislation would be interpreted literally in excluding Acres from all further alternatives studies. However, his recommendation at this time would be that APA retain responsibility for management of the Task I Studies. This would not preclude the selection by DPDP of an independent consultant to oversee the work.

2.3 Status Report on Task I Activities

The following presentation was made by J. Lawrence (Attachment 3, pages A3-1 through A 3-9)

(a) Subtask 1.01 - Review of ISER Forecast (Pages A3.1, A3.2)
Activity 90% complete; final report currently in draft form. Forecasts to be used in alternatives study will be based on this report.

(b) Subtask 1.02 - Peak Load Forecast and Load Duration Curves
Activity about 20% complete in data gathering and establishment of methodology. Required as input to generation expansion studies.

(c) Subtask 1.03 - Identification of Power Alternatives (Pages A3.3 through A3.6)
Activity about 10% complete in assembly of list of alternatives in consultation with APA, the public and other agencies. A

proposed list of parameters associated with alternatives for purposes of screening and ranking in Subtasks 1.04 and 1.05 has also been assembled.

(d) Subtask 1.04 - Selection of Viable Expansion Sequences

Activity restricted to discussion with Woodward-Clyde Consultants on methodology to be used. WCC have submitted a proposal for an amended study approach which was under consideration by Acres when work was stopped on June 6. This proposal also covered work to be done under Subtasks 1.05, 1.06 and 1.07, and involved significant cost increases (see Page A3.9)

(e) Sunk Costs (Page A3.7)

The estimated sunk costs are not exact at this time, but reasonably accurate. Revised POS costs were incurred developing the amended scope of work as a result of the Tussing Report, mostly under Subtask 1.03. The total budgets for Task 1, pre- and proposed post-Tussing, are indicated on Page A3.8. The proposed post-Tussing budget had been based on Acres in-house estimates and scope of work, and were significantly lower than those now proposed by WCC.

2.4 Revised Power Market and Alternatives Study (Attachment 4)

A presentation of the Acres proposed revised Task I study was made by John Hayden. This proposal was the subject of revised scope descriptions and cost estimate summaries which were being prepared by Acres when work was stopped June 6.

2.5 Options for Continuation of Task I Studies (Attachment 5)

R. Mohn described the available options and the advantages and disadvantages of each. Cost implications are indicated on Page A5.6.

Option 1 was clearly unacceptable to the Governor's Office under their interpretation of the legislation. Option 4 was not feasible under the current contractual arrangements between Acres and WCC. Option 2 would involve minimal cost and schedule impact and could probably be handled essentially as a change in scope of existing contracts.

Option 3 could involve delays of up to 4 months which would in turn delay submission of the FERC license. This option would have to be regarded as a partial termination with its attendant increases in cost. No attempt had been made to estimate additional costs resulting from a potential 4 to 5 month lengthening of the contract period.

2.6 Discussion

The Governor's Office undertook to make its decision by the end of the week, but agreed that Subtasks 1.01 and 1.02 should be continued to completion. The costs associated with the potential delay in submission of the FERC license application will have to be established at some point.

There was some discussion of the questionable objectivity of continued participation of WCC in Task I studies in light of their significant involvement in seismic studies.

Halterman believed that APA should continue to manage the alternatives studies, possibly with counseling by a select committee, and also to manage the proposed tidal studies.

A Logical and Defensible Approach to Evaluating Power Alternatives

Step 1: Structuring the problem
- Determine areas of concern in the evaluation as well as evaluation measures for these
- Determine the alternative courses of action of interest
- Set up a timetable for collecting information and making sequential decisions

Step 2: Estimate the consequences of each alternative course of action
- Forecast impacts of each alternative in terms of the various evaluation measures
- Quantify major uncertainties (using professional judgment where appropriate)

Step 3: Determine preference model to be used in evaluating tradeoffs
- Develop quantitative preference model to assess tradeoffs between competing areas of concern

Step 4: Evaluate alternative courses of action
- Combine results of steps 1, 2 and 3 in a logical and defensible manner
- Investigate the effects of differing judgments (Step 2) and preferences (Step 3) on the evaluation

0 0 0 3 2

ATTACHMENT 2

ALASKA POWER AUTHORITY

SUSITNA ALTERNATIVES STUDY MEETING

Wednesday, June 11, 1980

Anchorage, Alaska

PROPOSED AGENDA

1. Discussion of Legislative Intent and Office of the Governor's Interpretation.

   PURPOSE: Establish the constraints in broad terms John Halterman
   (OFFICE OF THE GOVERNOR)

2. Status Report on Task 1 Activities.

   PURPOSE: Identify progress to date and sunk costs so that the implications of program changes are known.
   (ACRES) J. Lawrence

3. Description of the Revised Power Market and Alternatives Study.

   PURPOSE: (a) Explore the extent to which the current POS meets the criticisms of Tussing and Woodward-Clyde. J. Hayden

   (b) Separate the issue of POS adequacy from the related but different issue of objectivity.
   (ACRES, APA) R. Mohn

4. Proposed Program changes to comply with Legislative Intent.

   PURPOSE: Offer options with accounting of advantages and disadvantages. R. Mohn
   (APA)

5. Discussion and Decision APA recommends option 2

6. Other Issues

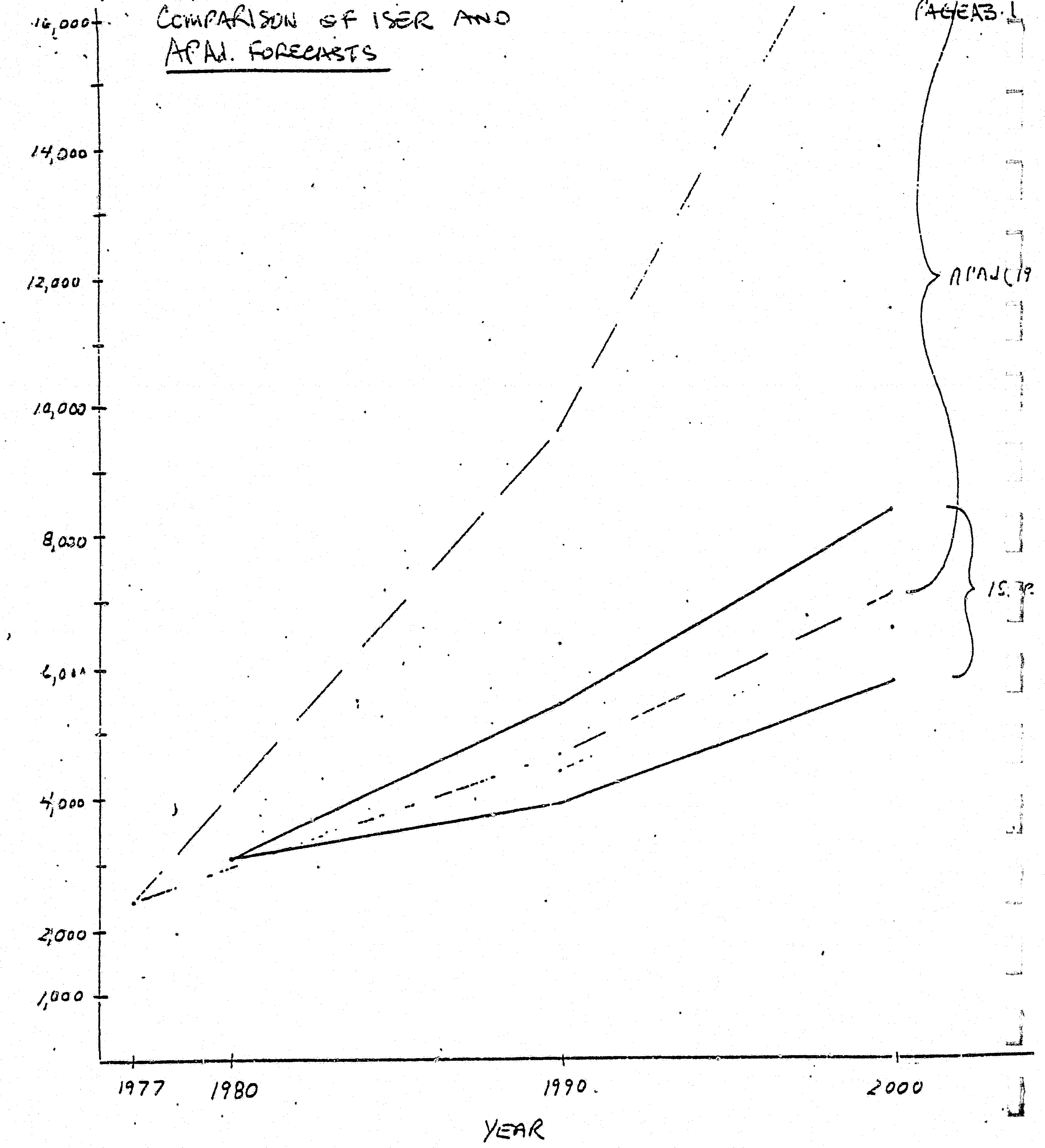
   (a) Availability of Funds $1.3 million appropriated.

   (b) Tidal Power Study

   ($500,000 for Rothschild study / probably to be monitored by APA)

ATTACHMENT 13
PAGE 13.1

COMPARISON OF ISER AND APA. FORECASTS



SUBTASK 1.01

ELECTRIC POWER REQUIREMENTS FOR THE RAILBELT

Executive Summary

Results of the Analysis

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

TABLE A. PROJECTED ALASKAN GROWTH RATES

(Average Annual Percent)

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

SUBTASK 1.03

**• Susitna Hydroelectric Project

• Other Generation Alternatives

*Fossil Fuel Alternatives
- Coal-Fired Steam Cycle
- Oil-Fired Steam Cycle
- Natural Gas-fired Steam Cycle
- Oil-fired Combined Cycle
- Natural Gas-fired Combined Cycle
- Oil-fired Combustion Turbines
- Natural Gas-fired Combustion Turbines

*Nuclear Alternatives
- Converter Reactors (LWR, HWR)
- Breeder Reactors
- Fusion

*Municipal Solid Waste
*Wood-fired and Peat-fired Steam Cycle
*Biomas Gasification Applications
**Biomass-fired Steam Cycle
**Wind Energy Driven Turbines
**Geothermal Energy Driven Turbines
*Solar Thermal Steam Cycle
*Solar Photovoltaic
**Solar Satellite
**Cogeneration (Industry, District Heating, Institutional)

***Hydro and Tidal Alternative
- Other Conventional Hydro Developments
- Small-scale Hydropower Plant Potential
- Tidal Power Resources of the Cook Inlet Region

**• Non-Generation Alternatives
- Conservation (Forced or Induced)
- Load-Management
- Other

Figure 3.3. A Preliminary List of Alternatives Considered

*Woodward-Clyde has principal responsibility
**Acres has principal responsibility

SUBTASKS 1.03/1.05.

SUGGESTED SCREENING CRITERIA AND ASSOCIATED ELEMENTS

Criteria	Elements	Types of Attribute
Economic	- Capital Cost	$
	- Cost/kWh	$
Technical	- installed capacity	MW
	- plant factor	#
	- resource availability ✓	Quantity
	- transmission facilities	$
	- access	$
Environmental		
Physical	- water	Descriptive
	- land	Descriptive
	- atmosphere	Descriptive
Ecological	- fisheries	Descriptive
	- wildlife	Descriptive
	- vegetation	Descriptive
Social	- land use	Descriptive
	- quality of life	Descriptive
Institutional	- licensing	Descriptive
	- schedule	Descriptive
	- finance	Descriptive

Details of the environmental criteria are as shown below:

	Environment Type	Effects
Physical/Chemical effects (direct effects)	Water - groundwater - surface water - coastal waters	- detertoration of water quality - change in flow rate - alteration of waterway - change in water table, water availability - change in ice conditions
	Land - topography - soils - natural cover	- geomorphic processed induced (erosion, sedimentation) - remobal of natural cover - alter topography - deterioration of soils - alternation of geologically important areas - soild waste disposal
	Atmospher	- air quality change (emissions) - long term atmospheric effects (green house effect-example)

SUBTASKS 1.05/1.05

	Environment Type	Effects
Physical/Chemical effects (direct effects) cont.	Meteorological	- change in local temp - energy loss from environment which effects local climate (e.g., large solar may cause lose of heat to earth) - long term atmospheric effects - fogging, ice formation, change in natural patterns
	Geological	- alteration of geologically important area - alteration of chain of natural events (e.g., prevention of natural scouring of river valley by periodic floods - induced seismicity
	Noise	- Distub human/natural population
	Consumption of natural resources	- water, forests, natural energy
Ecological Effects	Fisheries	- loss of natural passageways - loss of spawing grounds - destruction of population - alteration of natural food chains - loss of endangered and important species or other unique species
	Vegetation	- removal of natural cover - alteration of food chain - introduction of incompatible species
Social Effects	Land Use land quality land planning	- loss/alteration of land use - wilderness, scenic - recreational opportunities - forestry - archeological and historic - traditional livelihoods (hunting, fishing, trapping) - urban - (residential, commerical, industrial) - mining - agriculture - ownership

SUBTASKS 1.03/1.05

	Environment Type	Effects
Social Effects (cont.)	Quality of Life	- loss/alteration/improvement of Q.O.L factors
	- community	- disturbance/creation of community
	- opportunities	
	- economics	- create/destroy - effects of temporary economic stimulation - change in property values
	- infracstructure	- overburden existing public facilities - change in property values
	- demography	- short term/long term creation of job market

PAGE A

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

SUNK COSTS THROUGH JUNE 6, 1980

	ORIGINAL POS $	REVISED POS * $	TOTAL $
ACRES	50,100	31,000	81,100
WOODWARD-CLYDE	41,100	19,000	60,100
TES	800	500	1,300
TOTAL	92,000	50,500	142,500

* REVISIONS FOLLOWING TUSSING REPORT

0 0 0 3 2

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

BUDGET SUMMARIES

	ORIGINAL POS	REVISED POS *		
	IN 1980 $	IN 1980 $	ESCALATION $	TOTAL $
ACRES	74,000	373,000	51,000	424,000
WOODWARD-CLYDE	230,000	396,000	54,000	450,000
TES	55,000	114,000	16,000	130,000
SUB-TOTAL	359,000	883,000	121,000	1,004,000
ISER	60,000	148,000	12,000	160,000
REVIEW PANEL	-	66,000	9,000	75,000
TOTALS	419,000	1,097,000	142,000	1,239,000
SUBTASKS 6.01 THROUGH 6.08 (ACRES)	355,000	531,000	73,000	604,000
SUBTASKS 11.01 THROUGH 11.12 (ACRES)	233,000	431,000	59,000	490,000
TOTALS	1,007,000	2,059,000	274,000	2,333,000

* BUDGETS PROPOSED FOLLOWING TUSSING REPORT, WCC COMPONENT CURRENTLY UNDER NEGOTIATION (TOTALS EXCLUSIVE OF ORIGINAL POS)

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

WCC PROPOSAL COMPARISONS (1980 $ X 1000)

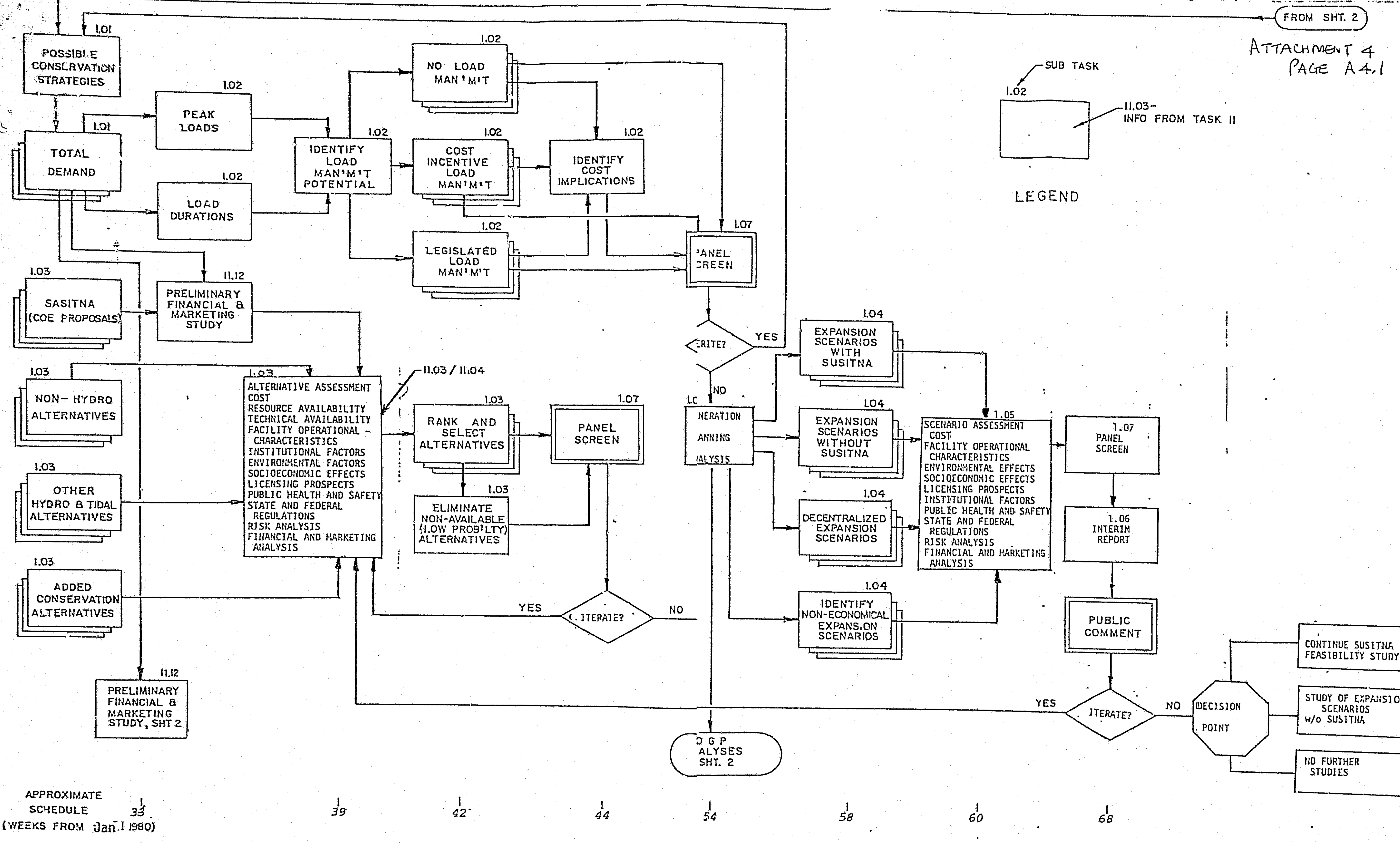
	WCC PROPOSAL*				ACRES ESTIMATE			
SUBTASK	WCC	ACRES	TES	TOTAL	WCC	ACRES	TES	TOTAL
1.01	60**	29	-	89	46	29	-	75
1.02	44	30	-	74	100	30	-	130
1.03	116	133	9	258	118	133	9	260
1.04	130	60***	-	170	-	88	-	88
1.05	115	16	105	236	132	16	105	253
1.06	63	60***	-	103	-	77	-	77
TOTAL	526	328	114	970	396	373	114	883

* FOLLOWING TUSSING REPORT

** INCLUDING $32,000 ALREADY EXPENDED

*** ACRES INVOLVEMENT REDUCED ASSUMING WCC INVOLVEMENT INCREASES

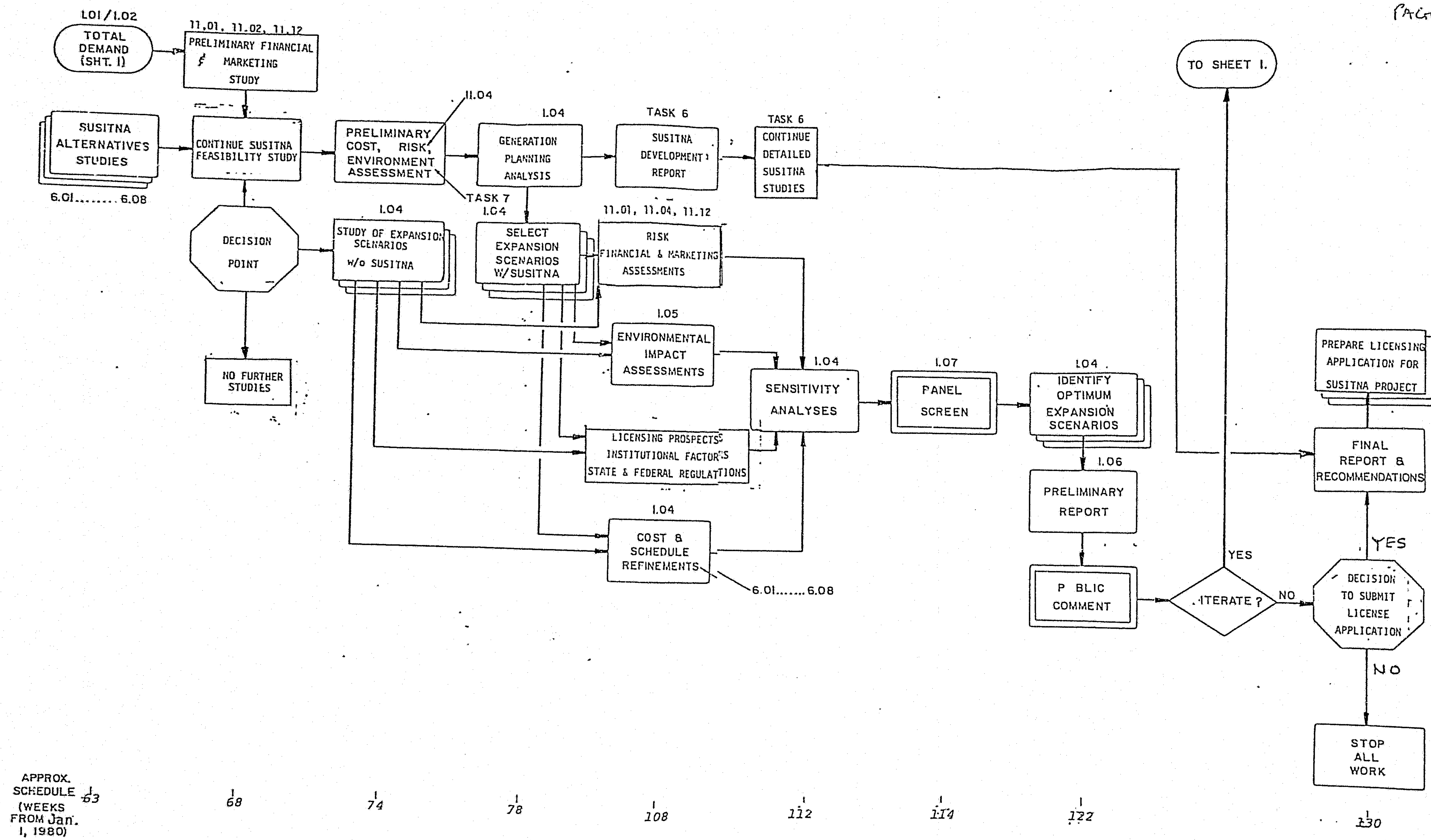
ATTACHMENT 4
PAGE A4.1



SUSITNA HYDROELECTRIC PROJECT- PLAN OF STUDY

TASK I- POWER STUDIES / FIRST PART

ATTACHME[NT]
PAGE



(1) INCLUDES DECENTRALIZED SCENARIOS

SUSITNA HYDROELECTRIC PROJECT—PLAN OF STUDY
TASK 1—POWER STUDIES/SECOND PART
ATTATCHMENT 1 SHEET 2 OF 2

TABLE 1
WORK CHANGES ASSOCIATED WITH OPTIONS AVAILABLE FOR DISPOSITION OF TASK 1 WORK

SUBTASK NUMBER AND DESCRIPTION	OPTION No. 1 WORK REMAINS AS IS, BUT GOVERNOR'S PANEL REVIEWS ACRES' ACTIVITIES	OPTION No. 1 OPPORTUNITIES FOR PANEL REVIEW	OPTION No. 2 ACRES DEVELOPS DATA ON ALTERNATIVES. . . INDEPENDENT FIRM TO CARRY OUT GENERATION PLANNING	OPTION No. 3 ACRES TO STOP TASK 1 WORK. . . INDEPENDENT FIRM TO CONTINUE PLANNING	OPTION No. 4 ACRES AND WOODWARD-CLYDE TO REVERSE CONTRACTOR/SUBCONTRACTOR ROLES
1.01 REVIEW OF ISER WORK PLAN AND METHODOLOGIES	AS PROPOSED	-FORECASTING MODELS -INPUT PARAMATERS -GROWTH SCENARIOS -RESULTS	WOODWARD-CLYDE TO COMPLETE REVIEW OF ISER CURRENT WORK; INDEPENDENT FIRM TO REVIEW FUTURE UPDATES	SAME AS FOR OPTION 2 (See Note 1)	SAME AS FOR OPTION 1 WORK TOO FAR ADVANCED TO CHANGE
1.02 ELECTRIC PEAK LOAD DEMAND FORECASTS	AS PROPOSED	-METHODOLOGY -RESULTS	WOODWARD-CLYDE TO COMPLETE THEIR WORK NOW UNDERWAY, INDEPENDENT FIRM TO REVIEW AND UPDATE WHERE NEEDED	SAME AS FOR OPTION 2 (See Note 1)	SAME AS FOR OPTION 1 WORK TOO FAR ADVANCED TO CHANGE
1.03 IDENTIFICATION OF POWER ALTERNATIVES	AS PROPOSED NON-HYDRO: WCC HYDRO: ACRES/TES CONSERVATION: ACRES	-ALTERNATIVES SELECTED -CHARACTERIZATION OF ALTERNATIVES -SCREENING METHOD-OLOGIES -RESULTS	DATA NEEDED FOR CHARACTER-IZATION OF ALTERNATIVES TO BE DONE BY ACRES AND WOODWARD-CLYDE... INDEPENDENT FIRM TO REVIEW DATA AND CON-DUCT SCREENING (See Note 3)	NO INVOLVEMENT BY ACRES OR THEIR SUB-CONTRACTORS (See Note 1)	WOODWARD-CLYDE TO SUPERVISE AND DIRECT WORK. . . NON-HYDRO ALTERNATIVES STUDIED BY ACRES AND WCC; WIND, GEO-THERMAL, AND COGENERATION BY ACRES; HYDRO AND TIDAL BY ACRES; CONSERVATION BY ACRES. . . (wind study largely complete, hydro and tidal work underway)
1.04 GENERATION PLAN-NING ANALYSIS AND SELECTION OF EXPANSION SCENARIOS	AS PROPOSED, BUT DELPHI TECHNIQUES WOULD BE APPLIED TO SCENARIO FORMU-LATION (See Note 2)	-PLANNING METHOD-OLOGY -SCENARIO FORMULAT-ION -RESULTS	INDEPENDENT FIRM TO CON-DUCT PLANNING STUDIES IN PARALLEL TO ACRES CONTINUING WORK ON SUSITNA FEASIBILITY STUDIES	NO INVOLVEMENT BY ACRES OR THEIR SUB-CONTRACTORS (See Note 1)	WOODWARD-CLYDE TO SUPERVISE AND DIRECT WORK. . . ACRES TO PROVIDE INPUT AND ASSISTANCE FOR ITERATIVE PROCESS
1.05 EXPANSION SEQUENCE IMPACT ASSESMENTS	AS PROPOSED	-METHODOLOGY -RESULTS	INDEPENDENT FIRM TO DIRECT WORK. . . ACRES AND WCC TO PROVIDE DATA AND ASSISTANCE, IF DESIRED	NO INVOLVEMENT BY ACRES OR THEIR SUB-CONTRACTORS (See Note 1)	WOODWARD-CLYDE TO SUPERVISE AND DIRECT WORK. . . ACRES TO PROVIDE DATA AND ASSISTANCE

PAGE A5.1

SUBTASK NUMBER AND DESCRIPTION	OPTION No. 1 WORK REMAINS AS IS, BUT GOVERNOR'S PANEL REVIEWS ACRES' ACTIVITIES	OPPORTUNITIES FOR PANEL REVIEW	OPTION No. 2 ACRES DEVELOPS DATA ON ALTERNATIVES. . . INDEPENDENT FIRM TO CARRY OUT GENERATION PLANNING	OPTION No. 3 ACRES TO STOP TASK 1 WORK. . . INDEPENDENT FIRM TO CONTINUE PLANNING	OPTION No. 4 ACRES AND WOODWARD-CLYDE TO REVERSE CONTRACTOR/SUBCONTRACTOR ROLES
1.06 INTERIM REPORT	AS PROPOSED	-TABLE OF CONTENTS -DRAFT OF REPORT	INDEPENDENT FIRM TO PRODUCE. . . ACRES TO ASSIST WHERE REQUESTED	NO INVOLVEMENT BY ACRES OR THEIR SUB-CONTRACTORS (See Note 1)	WOODWARD-CLYDE TO PRODUCE REPORT. . . ACRES TO ASSIST WHERE REQUESTED
1.07 POWER STUDY PANEL	AS PROPOSED	-PANEL SELECTION (Governor's panel may direct power study panel)	INDEPENDENT FIRM TO WORK WITH PANEL. . . ACRES AND THEIR SUBCONTRACTORS TO PARTICIPATE AS REQUESTED	NO INVOLVEMENT BY ACRES OR THEIR SUB-CONTRACTORS (See Note 1)	WOODWARD-CLYDE TO ACT AS PRINCIPAL CONTACT WITH PANEL
6.01 through 6.08 SUSITNA ALTERNATIVES	AS PROPOSED	-SITE ALTERNATIVES -LEVEL OF ALTERNATIVE DEVELOPMENT	AS PROPOSED	AS PROPOSED	AS PROPOSED
10.03 DATA ACQUISITION FROM OTHERS	AS IN ORIGINAL PLAN OF STUDY	none	INPUT NEEDED FROM INDEPENDENT FIRM TO ACRES TO COMPLETE FERC EXHIBIT "U" INPUT NEEDED FROM INDEPENDENT FIRM TO ACRES TO COMPLETE FERC EXHIBIT "W"	SAME AS FOR OPTION 2	SAME AS FOR OPTION 2. . . INPUT NEEDED FROM WOODWARD-CLYDE TO ACRES TO COMPLETE FERC EXHIBITS
10.04 EXHIBIT PREPARATION COORDINATION	AS IN ORIGINAL PLAN OF STUDY	none	ADDITIONAL COORDINATION EFFORT NEEDED BETWEEN INDEPENDENT FIRM AND ACRES	SAME AS FOR OPTION 2	SAME AS FOR OPTION 2. . . COORDINATION NEEDED WITH WOODWARD-CLYDE
10.09 DOCUMENTATION REVIEW AND DEFECIENCY CORRECTION	AS IN ORIGINAL PLAN OF STUDY	none	PROVISIONS NEEDED FOR INTERACTION BETWEEN ACRES AND INDEPENDENT FIRM	SAME AS FOR OPTION 2	SAME AS FOR OPTION 2. . . COORDINATION NEEDED WITH WOODWARD-CLYDE
11.01 and 11.02	AS PROPOSED	-INPUT TO REPORT PREPARATION	AS PROPOSED	SAME AS FOR OPTION 2 (See Note 1)	WOODWARD-CLYDE TO CONDUCT

SUBTASK NUMBER AND DESCRIPTION	OPTION No. 1 WORK REMAINS AS IS, BUT GOVERNOR'S PANEL REVIEWS ACRES' ACTIVITIES	OPPORTUNITIES FOR PANEL REVIEW	OPTION No. 2 ACRES DEVELOPS DATA ON ALTERNATIVES. . . INDEPENDENT FIRM TO CARRY OUT GENERATION PLANNING	OPTION No. 3 ACRES TO WRAP UP TASK 1 WORK. . . INDEPENDENT FIRM TO CONTINUE PLANNING	OPTION No. 4 ACRES AND WOODWARD-CLYDE TO REVERSE CONTRACTOR/SUBCONTRACTOR ROLES
11.03 ~~AND 11.04~~ ALTERNATIVE POWER SOURCE RISK ANALYSIS	AS PROPOSED	-METHODOLOGY -RESULTS	INDEPENDENT FIRM TO DIRECT WORK. . . ACRES TO PROVIDE INPUT AND ASSISTANCE AS REQUEST-ED	SAME AS FOR OPTION 2 (See Note 1)	WOODWARD-CLYDE TO CONDUCT WORK
11.12 PRELIMINARY MARKETING AND FINANCIAL STUDIES	AS PROPOSED	-METHODOLOGY -RESULTS	INDEPENDENT FIRM TO DIRECT WORK. . . ACRES TO PROVIDE INPUT AND ASSISTANCE AS REQUESTED	SAME AS FOR OPTION 2 (See Note 1)	WOODWARD-CLYDE TO CONDUCT WORK

NOTES:

1. EXACT SCOPE OF WORK, INCLUDING INTERACTION BETWEEN ACRES AND THE NEW INDEPENDENT FIRM, TO BE DEFINED BY ALASKA POWER AUTHORITY AND INDEPENDENT FIRM
2. CONSIDERATION BEING GIVEN TO INCORPORATING TECHNIQUE OF DECISION ANALYSIS AS PROPOSED BY WOODWARD-CLYDE
3. TO STREAMLINE ACTIVITIES, IT WOULD BE ADVANTAGEOUS TO REDUCE NUMBER OF CONSULTANTS INVOLVED TO A MINIMUM

TABLE 2
ARGUMENTS FOR AND AGAINST TASK 1 OPTIONS

SUBTASK NUMBER AND DESCRIPTION	OPTION No. 1	OPTION No. 2	OPTION No. 3	OPTION No. 4
1.01 through 1.07 POWER STUDY	ADVANTAGES -MINIMUM DISRUPTION OF SCHEDULE -GOVERNOR'S OFFICE PARTICIPATION -CONTINUITY OF WORK	ADVANTAGES -REDUCTION IN LEVEL OF APPARENT CONFLICT OF INTEREST -INFUSION OF NEW IDEAS -MINIMUM DISRUPTION OF REMAINDER OF SUSITNA STUDY SCHEDULE -REDUCTION OF APPARENT CONFLICT OF INTEREST -IMPROVED COMMUNICATIONS AND LOGISTICS	ADVANTAGES -ELIMINATION OF APPARENT CONFLICT OF INTEREST -INFUSION OF NEW IDEAS -POTENTIAL FOR REDUCING PROJECT LOGISTIC PROBLEMS RELATIVE TO OPTION 2	ADVANTAGES -MINIMUM DISRUPTION OF SCHEDULE -REDUCTION IN LEVEL OF APPARENT CONFLICT OF INTEREST -CONTINUITY OF WORK
	DISADVANTAGES -APPARENTLY INCONSISTENT WITH WISHES OF ALASKA LEGISLATURE -APPEARANCE OF CONFLICT OF INTEREST REMAINS	DISADVANTAGES -MINOR IMPACT ON SCHEDULE -INCREASED PROJECT LOGISTICS PROBLEMS -NEW COMMUNICATION LINKS NEED TO BE ESTABLISHED	DISADVANTAGES -ACRES, WCC, TES LOCAL EXPERTISE AND CONTACTS NO LONGER AVAILABLE -MAJOR IMPACT ON SCHEDULE 4-5 MONTHS DELAY -NEW COMMUNICATION LINKS NEED TO BE ESTABLISHED	DISADVANTAGES -APPEARANCE OF CONFLICT OF INTEREST REMAINS -NO WCC TASK 1 REPRESENTATIVE PERMANENTLY LOCATED IN ANCHORAGE -NEW COMMUNICATION LINKS NEED TO BE ESTABLISHED
6.01 through 6.08	ADVANTAGES (See Note 1)	ADVANTAGES (See Note 1)	ADVANTAGES (See Note 1)	ADVANTAGES (See Note 1)
DESIGN DEVELOPMENT	DISADVANTAGES (See Note 1)	DISADVANTAGES (See Note 1)	DISADVANTAGES (See Note 1)	DISADVANTAGES (See Note 1)
10.01 through 10.10 LICENSING	ADVANTAGES -MINIMUM DISRUPTION OF SCHEDULE	ADVANTAGES (See Note 2)	ADVANTAGES (See Note 2)	ADVANTAGES -MINIMUM DISRUPTION OF SCHEDULE
	DISADVANTAGES (See Note 2)	DISADVANTAGES -NEW COMMUNICATION LINKS NEED TO BE ESTABLISHED -POTENTIAL ~~MAJOR~~ MINOR IMPACT ON SCHEDULE	DISADVANTAGES -NEW COMMUNICATION LINKS NEED TO BE ESTABLISHED -POTENTIAL MAJOR IMPACT ON SCHEDULE	DISADVANTAGES (See Note 2)

SUBTASK NUMBER AND DESCRIPTION	OPTION No. 1	OPTION No. 2	OPTION No. 3	OPTION No. 4
11.01 through 11.03 and 11.12 MARKETING AND FINANCING	ADVANTAGES -GOVERNOR'S OFFICE PARTICIPATION -CONTINUITY OF WORK	ADVANTAGES -REDUCTION IN LEVEL OF APPARENT CONFLICT OF INTEREST -INFUSION OF NEW IDEAS	ADVANTAGES -ELIMINATION OF APPARENT CONFLICT OF INTEREST -INFUSION OF NEW IDEAS	ADVANTAGES -REDUCTION OF APPARENT LEVEL OF CONFLICT OF INTEREST
	DISADVANTAGES (see note 2)	DISADVANTAGES -INCREASED PROJECT LOGISTICS PROBLEMS -NEW COMMUNICATION LINKS TO BE ESTABLISHED	DISADVANTAGES -NEW COMMUNICATION LINKS TO BE ESTABLISHED	DISADVANTAGES -NEW COMMUNICATION LINES TO BE ESTABLISHED

NOTES:

1. THIS TASK OR SUBTASK TO CONTINUE AS ORIGINALLY PROPOSED AND IS NOT IMPACTED BY ELIMINATION OF TASK 1 FROM ACRES' CONTRACT
2. NO ADVANTAGES OR DISADVANTAGES IDENTIFIED

SUSITNA HYDROELECTRIC PROJECT

TASK 1 - POWER STUDIES

WORK CHANGE OPTIONS - COST IMPLICATIONS

ADDITIONAL COSTS ($1,000)

TASK		OPTION 1	OPTION 2	OPTION 3	OPTION 4
1		-	15+*	90+***	90+***
10		-	10**	10**	10**
11		-	10+*	10+*	-
Governor's Review Panel	Gov. Off.	30	20	-	20
	Acres/WCC	15	10	-	10
TOTALS:		45	70+	110+	130+

NOTES: *ACRES ADDITIONAL COORDINATION COSTS + UNKNOWN COSTS FOR INDEPENDENT A/E

**PREPARATION OF ADDITIONAL MATERIAL FOR LICENSE APPLICATION

***INCLUDING ACRES/WCC/TES TERMINATION COSTS + UNKNOWN COSTS FOR INDEPENDENT A/E

Q - COPIES OF OTHER RELEVANT CORRESPONDENCE

RECEIVED MAR 25 1980

ALASKA POWER AUTHORITY

333 WEST 4th AVENUE - SUITE 31 - ANCHORAGE, ALASKA 99501

Phone: (907) 277-7641
(907) 276-2715

March 19, 1980

Mr. John Lawrence
Project Manager
Acres American Incorporated
900 Liberty Bank Building
Main at Court
Buffalo, New York 14202

Dear John:

Having been very close to the study of the Susitna project for a number of years, we are acutely aware of the controversial aspects of the study process. One of the most controversial is the evaluation of generation alternatives. There are some individuals and organizational entities that are convinced of the superiority of Susitna hydropower development. There are others who are convinced that there has to be a better way. A majority of people are unsure, largely because they haven't been exposed to the options and trade-offs. This group has to be provided with sufficient information to make an informed decision. We also have to be very sensitive to some of the key players in the Administration and Legislature who are skeptical of the Corps of Engineers' study results. In addition, we must be looking ahead to the preparation of the EIS by the Federal Energy Regulatory Commission and to claims by project opponents that the alternatives were not properly evaluated. Finally, and most important to us, is our commitment to insure, before proceeding with Susitna hydropower development, that no better alternative exists.

Acres has similarly espoused a commitment to the objective and thorough search for the best solution. In fact, it can be said without hesitation that the primary reason for the widespread public preference for Acres American over Harza, IECO and the Corps was your preceived dedication to this goal.

The pursuit of a "state-of-the-art" alternatives study has been everyone's objective. It is now time to move from the talking stage into action. Because we had not seen any specific scopes of work or a Power Alternatives Report outline, Jim Landman was asked for such information. The first item Jim showed us was a draft scope of work for WCC's subtasks 1.03 and 1.05. There is very little specificity in the instructions to WCC relating to the type of information needed for each alternative, and we believe that some additional planning needs to be done regarding Task 1.

Jim has requested that we offer our views and indicate our expectations for the alternatives study and report. The following paragraphs do so.

The Dickey-Lincoln School Lakes Project Power Alternatives Study Final Report (April 1977) was provided by Acres as an example of what can be expected for Susitna. We have reviewed that report and have chosen to comment on it as a vehicle for presenting our views and expectations.

The study appears to be done in five major steps:

1. Identification of all potential alternative modes of energy generation (and storage).

2. Initial screening based on:

   a. technical feasibility over the planning period, and

   b. unit scale (the minimum unit size is related to the projected average yearly capacity increment requirement).

3. Formulation of expansion sequences for various load forecasts from among the remaining viable alternatives. This, in effect, is another screening process, this time accomplished by the computer based upon certain input criteria.

4. Screening of expansion sequences based on comparative system costs.

5. Environmental impact assessment done in two parts:

   a. Assessment in qualitative terms of the impact of each of the alternatives that survived step #2.

   b. Quantitative analyses for the more important environmental parameters of the "with" and "without" expansion sequences.

While we judge this five step procedure to be basically sound, we suggest several modifications to adapt it to our specific needs.

First of all, the addition of several steps is requested. Public input should be sought and assessed between steps 2 and 3. The tentative results of the first screening should be presented for public scrutiny and comment, and then the screening should be reconsidered on the basis of comments received. A workshop forum might be ideal for this purpose. After steps 4 and 5 are complete but prior to any conclusions being drawn, public input should again be sought. The purpose would be to find out how the public values the various evaluation parameters. For example, we will need to know if cost is more important than emmissions, or if conservation of fossil fuels is valued higher than decentralization of generation. The second set of public meetings could be well suited to this effort and can be scheduled accordingly. Only after this public input was received would the report be finalized with recommendations. Thus, the evaluation procedure would become an eight step process:

A. Identification of alternatives.

B. Initial screening based on technological availability and scale.

C. Public review and reconsideration of step 2.

D. Formulation of expansion sequences.

E. Expansion sequence screening based on comparative system cost.

F. Environmental assessment in two parts.

G. Public review.

H. Recommendations.

Other suggested modifications to the Dickey-Lincoln study follow in the form of specific comments on procedures followed.

1. Reference the initial screening based on technical feasibility. Alternatives were rejected if technical or economic feasibility was not expected to be proven during the five-year period following power-on-line of the Dickey-Lincoln project. Today we are seeing crash programs and major advances in energy technology. People are beginning to assume that important breakthroughs are to be expected. This environment makes it difficult to argue that an unproven technology should be rejected from consideration when the planning period extends into the next century and the life of the hydropower project exceeds 100 years. Yet, that argument will have to be made in some cases. It would seem that in light of the general optimism regarding technological advancement in this area, the criteria for acceptance of an alternative should be slightly relaxed from that used in the Dickey-Lincoln study. Clearly there are risks involved in such a wait-and-hope approach and there is uncertainty regarding costs. These risks and uncertainties should be highlighted, but the option of accepting such risk should not be summarily rejected.

2. Reference the initial screening based on unit capacity. Certain alternatives were rejected if the unit size was not consistent with the anticipated scale of yearly system expansions. For Dickey-Lincoln the cutoff was 700 MW for base load plants and 400 MW for intermediate load plants. There is some interest in Alaska in the "small is beautiful" approach that calls for decentralized generation systems made up of small, "appropriate technology" components. With this in mind, it would be a mistake to reject an alternative only on the basis of unit scale. Alternatives that are only available in small unit sizes are not necessarily less worthy of consideration. The true test will come in the comparison of costs and environmental impact of these small-unit alternatives as they are evaluated as components of an expansion sequence.

3. Reference the computerized formulation of expansion sequences. As mentioned above, there is a great deal of interest in a decentralized

generation system of smaller scale components. It is likely that such an expansion sequence would be more costly than a more conventional centralized system and may result in greater adverse environmental impact. The point is, we want to formulate this type of expansion sequence so that those cost and impact comparisons can be made. Therefore, some altered computer input criteria will probably have to be used to permit the computer formulation of this type of small-scale decentralized expansion sequence. A minimum of one such expansion sequence should be carried at least through step G of the evaluation process.

4. Reference the screening of expansion sequences based on comparative system costs. As discussed above, we have need to broaden this criteria to allow further consideration of certain type expansion sequences regardless of cost.

5. Reference the qualitative assessment of short and longterm environmental impacts of each alternative. The purpose of this step is not clear from the Dickey-Lincoln report. It does not appear to have been factored into the earlier screening steps. Perhaps it is simply a necessary prelude to the impact assessment of expansion sequences. The purpose of this step should be clarified in the report in the event you decide to retain it.

6. Reference the "specific overall long-term impacts" assessment for the surviving (i.e., 2) expansion sequences. First of all, please note that there might be important short-term impacts of the selected expansion sequences that merit consideration. These should be included in the analysis. Second, you limited the evaluation to four "important" environmental parameters. It is not clear how these parameters were selected from the almost unending list of possible impacts. As you might expect, we are looking towards a much more complete set of parameters; they are factors that key decision makers and the public have identified as being important. A list that can serve as a starting point is included as Attachment A. It is very important that the expansion sequences be presented in site specific terms where possible so that the impacts can be more clearly defined. Also it is imperative that the parameters be related to human experience whenever possible, so that the actual affect on people and property can be evaluated.

7. In addition to the suggested parameters of Attachment A, Attachment B (to follow) will be a list of questions that the general public has asked, or is expected to ask, about the various alternatives. Answers to questions in Attachment B will provide the general public the kind of information they want to understand the alternatives available and the trade-offs involved in this decision. The answers to many of these questions could be covered in the narrative description of the alternatives that will appear in the report.

Mr. John Lawrence
March 19, 1980
Page Five

I hope these thoughts serve to clarify our expectations for the Power Alternatives Study. Naturally, we want to hear your advice.

Sincerely,

FOR THE EXECUTIVE DIRECTOR

Robert A Mohn

Robert A. Mohn
Director of Engineering

Attachments:
As Noted

cc: Jim Landman

ALASKA POWER AUTHORITY

ATTACHMENT A

PARAMETERS FOR COMPARING AND EVALUATING

EXPANSION SEQUENCES

A. COST PARAMETERS

1. Total system costs
2. Costs to consumer (typical household)
3. Cost trend (stable, subject to inflation, cost eventually decreases after amortization, etc.)
4. Ownership/control (municipal, utility, state)
5. Uncertainity and risk regarding cost (reflecting history of cost overruns in constructing the alternatives in this expansion sequence)

B. SAFETY AND HEALTH PARAMETERS

1. Catastrophic failure impacts (probability and costs)
2. Health effects from pollution (probability)
3. Interruption of service (probability)

C. ENVIRONMENTAL PARAMETERS

1. Noise
2. Smell
3. Visual (from populated areas, from air, etc.)
4. Water Quality impacts
5. Solid Waste impacts
6. Impacts on Fish (relative to the size and value of the resource)
7. Impacts on Birds " " "
8. Impacts on Wildlife " " "
9. Impacts on Important Ecosystems
10. Water consumption (relative to supply)
11. Property damage

D. SOCIOECONOMIC PARAMETERS

1. Extent of generation system diversification
2. Employment impact
   a) construction (number, type, and from where)
   b) operation
3. Relocations necessary
4. Surplus power
   a) description
   b) probable effect on growth, industry relocation, etc.
5. State energy independence
6. Regional settlement patterns

E. OTHER PARAMETERS

1. Fossil fuel consumed
2. Efficiency (ratio of energy out to energy in)
3. Natural systems altered
4. Plan flexibility

The following utilities were invited to participate in the Utility and Public meeting on June 10-11, 1980

Mr. Fred Braningham
Comptroller
Fairbanks Municipal Utility System
Post Office Box 2215
Fairbanks, Alaska 99707
456-1000

Mr. R. L. (Bob) Hufman
General Manager
Golden Valley Electric Association, Inc.
Post Office Box 1249
Fairbanks, Alaska 99707
452-1151

Mr. Malcolm Cheek
General Manager
Matanuska Electric Association, Inc.
Post Office Box 1148
Palmer, Alaska
745-3231

Mr. Thomas R. Stahr
General Manager
Anchorage Municipal Light & Power Department
1200 East First Avenue
Anchorage, Alaska 99501

Mr. L. J. (Bud) Schultz
General Manager
Chugach Electric Association, Inc.
Post Office Box 3518
Anchorage, Alaska 99501
276-3500

Mr. Clarence (Johnny) E. Johnson
Utility Manager
City of Seward
Post Office Box 337
Seward, Alaska 99664
224-5215

Mr. Kent C. Wick
General Manager
Homer Electric Association, Inc.
Post Office Box 429
Homer, Alaska 99603
235-8551

Mr. Robert (Bob) Cross
Administrator
Alaska Power Administration
Post Office Box 50
Juneau, Alaska 99802
586-7405

Ms. Clarissa Quinlan, Director
Division of Energy & Power Development
Department of Commerce & Economic Development
338 Denali Street, 7th Floor
Anchorage, Alaska 99501
276-0508

Mr. James S. Palin
Copper Valley Electric Association, Inc.
Post Office Box 45
Glennallen, Alaska 99588
822-3211

April 23, 1980

CAS
LS File –

Mr. John Lawrence
Project Manager
Acres American Incorporated
Main at Court
The Liberty Bank Building
Buffalo, New York 14202

Dear John:

Regarding the Tussing Report: Let's turn it to our advantage and not go on the defensive. We have a chance and even an invitation to improve our plan and attempt to reduce some of the risk and uncertainty surrounding a Susitna decision. Here are some suggestions:

1. Perform additional engineering studies during Task 1 (Subtask 1.03) to better formulate non-Susitna alternatives, including conservation and load management.

2. Identify several most promising expansion sequences at the end of Task 1 (instead of just the one recommended plan).

3. Formulate a plan for improving the data base for future energy and load forecasting, and execute the plan.

4. Incorporate marketing, financing, cost, risk and scheduling analyses into the Susitna development selection (Task 6).

5. Conduct detailed feasibility studies on each of the several most promising expansion sequences, to include marketing, financing, cost risk and scheduling analyses.

6. Based on the improved data base, perform another forecast of energy demand, peak load and load duration curves.

7. Using the results of #5 and #6, perform a second iteration of power studies using OGP or other methods.

8. Establish a multidisciplinary panel to review assumptions and the various analyses.

9. Run the results of #7 backward to assess risk in the face of unlikely but possible scenarios.

10. Identify an additional decision point in early 1982 when the feasibility studies will be complete and when a single plan will be identified for preparation of license application.

Sincerely,

for Eric P. Yould
Executive Director

R - WCC TERMINATION REPORT

RECEIVED SEP 1 5 1980

Three Embarcadero Center, Suite 700
San Francisco, California 94111
415-956-7070

Woodward-Clyde Consultants

Follow Up

September 10, 1980

Project Manager
Susitna Hydroelectric Project
Acres American Incorporated
Liberty Bank Building, Main at Court
Buffalo, New Yprk 14202

Attn: Mr. John D. Lawrence

Re: Technical Termination Report for Subtask 1.03, Identification of Power Alternatives, of the Susitna Hydroelectric Project

Dear Mr. Lawrence:

This letter constitutes the technical termination report for Woodward-Clyde Consultants' activities on Subtask 1.03 of Agreement Number P5700.10.41 for the Susitna Hydroelectric Project. As requested in your letter of June 24, 1980, this report submits the results of work completed to date. The associated costs are discussed in a companion letter.

ALASKA POWER AUTHORITY
SUSITNA
FILE P5700
SEQUENCE NO. F801

By means of a meeting on April 18, 1980 and a subsequent exchange of letters, Acres and Woodward-Clyde agreed to a scope of work for the preliminary stages of Subtask 1.03. In particular, it was agreed that:

1) Woodward-Clyde would describe in detail and submit to Acres for consideration and approval an analytical approach (decision analysis) to be used in making the global evaluation of alternatives.

2) WCC would be responsible for the global evaluation of the following alternatives:

- Fossil Fuel Alternatives

    coal-fired steam cycle
    oil-fired steam cycle
    natural gas-fired steam cycle
    oil-fired combined cycle
    natural gas-fired combined cycle
    oil-fired combustion turbines
    natural gas-fired combustion turbines

- Nuclear Alternatives

    converter reactors (LWR, HWR)
    breeder reactors
    fusion

- Other Generation Alternatives and Alternative Fuels

    municipal solid waste
    wood-fired steam cycle
    biomass gasification applications
    biomass-fired steam cycle
    solar thermal steam cycle
    solar photovoltaic
    solar satellite

3) The criteria to be used in the global evaluation should include the following:

    -- energy resource availability in Alaska
    -- technical and commercial use availability
    -- expected fuel dependency
    -- site availability
    -- preliminary safety and environmental concerns
    -- global cost estimates in mills/kWh and
    -- corresponding ranking.

Following this agreement we began work on Subtask 1.03, concentrating on preparation of a proposal for a decision analysis approach to the global evaluation of alternatives. This proposed approach was submitted to Acres in a memorandum on May 19, 1980.

We also pursued limited activities to identify sources of information for the global evaluation of the various alternatives identified above. These activities were exploratory in nature, and there are no specific results to be reported regarding them.

After receiving Acres' telephone call and telex of June 5, 1980 ordering a termination of Task 1 work, we immediately ceased all technical work on Subtask 1.03. Since that time our only activities on this Subtask have been those needed to prepare this termination report.

Sincerely,

Craig W. Kirkwood

Craig W. Kirkwood

CWK/jh

S - TES TERMINATION REPORT

Terrestrial Environmental Specialists, inc.

R.D. 1 BOX 388 PHOENIX, N.Y. 13135

ALASKA POWER AUTHORITY
SUSITNA
FILE P5700
1.3
SEQUENCE NO.

ACTION	INFORM.	DISTRIB.	INITIAL
		DCW	
		JDL	
		CAD	
		JDG	
		JWH	
		JPS	
		IPGH	
		ENS	
		SNT	
		DWL	
		MRV	
		HRC	
		TES FILE	

August 21, 1980
218.281

Project Manager
Susitna Hydroelectric Project
Acres American, Inc.
Liberty Bank Building, Main at Court
Buffalo, New York 14202

Attention: Mr. John Lawrence
Re: Task 1 Termination Report

Dear John:

Enclosed is the technical portion of the Termination Report for TES involvement in Task 1 of the Susitna Hydroelectric Project. As I discussed with John Hayden on August 20, the cost portion of the Termination Report will be submitted to you at a later date.

Sincerely,

Vince

Vincent J. Lucid, Ph.D.
Project Environmental Study Director

VJL:aj
Enclosure

SUSITNA HYDROELECTRIC PROJECT
TASK 1 TERMINATION REPORT
Subtasks 1.03 and 1.05

Prepared by Terrestrial Environmental Specialists, Inc.
August 1980

When the notice to stop work on Task 1 of the Susitna Hydroelectric Project was received from Acres, little effort had been invested in this task by Terrestrial Environmental Specialists, Inc. This effort had consisted of the beginnings of a literature search on hydroelectric alternatives and the development of logic diagrams for proposed approachs to each of the subtasks (1.03 and 1.05) in which TES was involved.

Literature Search

The literature search had consisted primarily of a review of the subject index of the Rasmuson Library at the University of Alaska, Fairbanks. The subject headings checked were the names of the rivers identified in the Plan of Study under Subtask 1.03. Additional references were found incidental to other aspects of the environmental study. The potentially applicable references found are cited on the list addended to this report. Few of these references were actually inspected to determine their applicability or usefulness.

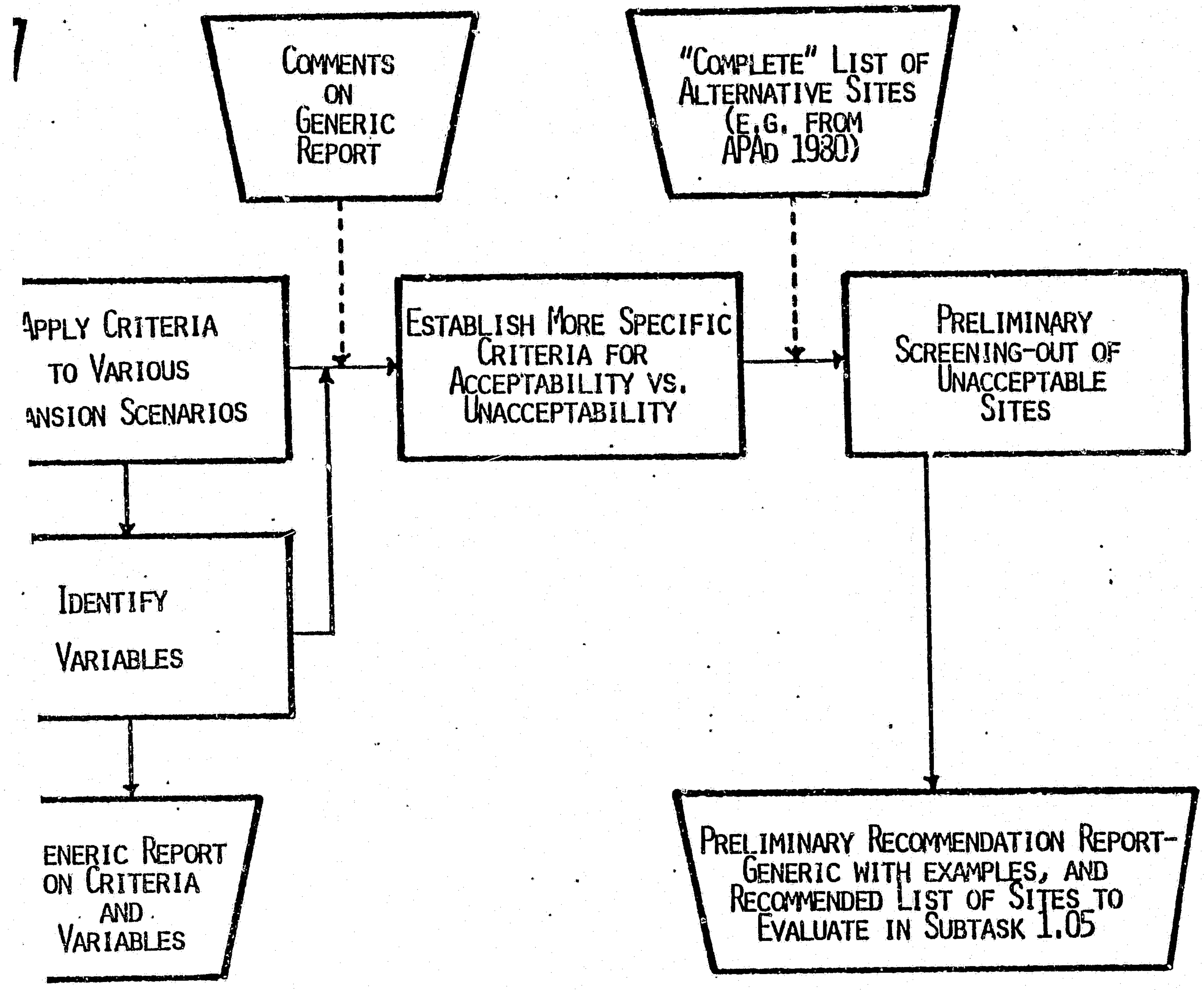
Approach Planning

The proposed schemes of approach for TES involvement in Subtasks 1.03 and 1.05 are illustrated on Figures 1 and 2, respectively. These flowcharts were developed, for discussion purposes, without availability to Acres revised schedule for Task 1. An oral presentation and discussion of these approach schemes at a meeting in Acres Columbia office on May 29, 1980 revealed that some modification would be required to the approach to make it compatible with the overall approach to Task 1. Plans were made to exchange flowcharts with Acres and work out incompatibilities, but the stop work order was received before this was done. Thus, Figures 1 and 2 illustrate the approach proposed prior to the May 29 discussion.

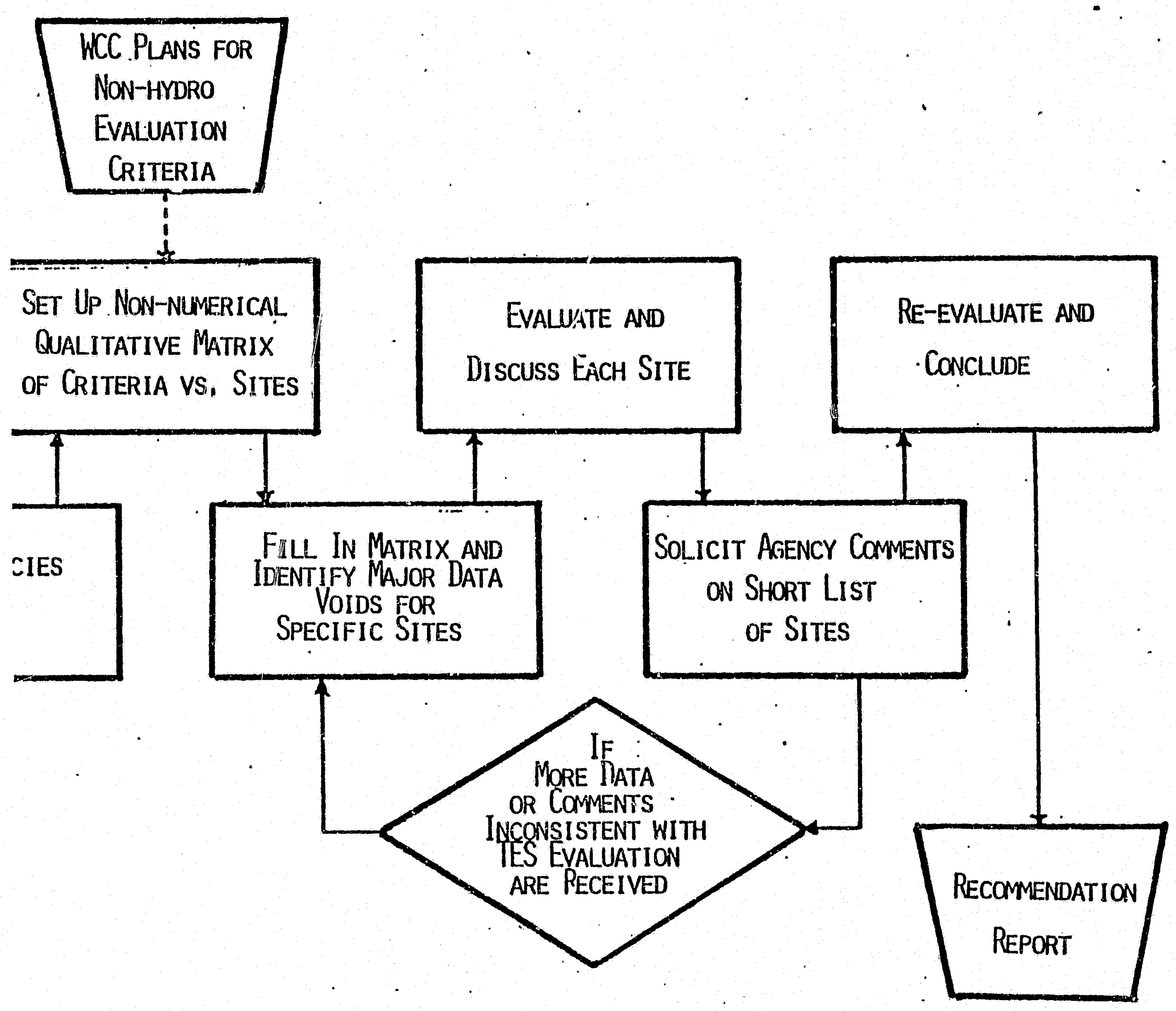
Consequences of Task 1 Termination

As previously discussed with Acres, the severance of Subtasks 1.03 and 1.05 has several consequences in relation to the environmental study program for the Susitna Hydroelectric Project. One ramification is that, with the exception of Socio-economic Analysis, the evaluation of Susitna alternatives (as well as alternatives to Susitna) were part of the Task 1 environmental effort. The Task 7 program is based upon the two-dam scheme (Watana and Devils Canyon) proposed by the Corps of Engineers. Therefore, under the remaining Scope of Work (Task 7) TES will be unable to assist Acres in the evaluation of alternatives to this two-dam scheme. However, recommendations for mitigating impacts by means of project design at Watana and Devils Canyon will still be made.

Another ramification of Task 1 termination is that, to comply with FERC regulations, the Environmental Report (Exhibit W) must still contain a discussion of "all realistic alternatives" to the proposed action. Both the absence of a scope of work and associated budget for liaison with the Task 1 consultant selected by the Governor's Office, and the schedule for completion of the alternatives report by this consultant, prohibit TES from assuming any responsibility whatsoever for incorporation (including discussion or summary) of the alternatives evaluation into the Environmental Report.



NTIFICATION OF HYDROELECTRIC POWER ALTERNATIVES - SUBTASK 1.03.



YDROELECTRIC AND TIDAL POWER ALTERNATIVES - SUBTASK 1.05.

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- August 1980 -

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