5. INTEGRATION INTO THE RAILBELT SYSTEM

Electric system studies – and the PROMOD studies described herein – were performed utilizing regular consultation with the Railbelt utilities, to ensure that their input, guidance and comment was available to the team throughout the work. This consultation has been maintained by AEA throughout the course of the feasibility studies. Results of both the system modeling work and project interconnection studies are summarized below.

5.1. Electric System Studies

Transmission studies were performed by Electric Power System Inc. (EPS) under subcontract to MWH during 2012 to identify possible transmission interconnections from the project site to the electrical transmission system of the Railbelt (after improvements expected to be implemented before the projected completion of the Susitna-Watana Project). The studies also assessed the system improvements to the Railbelt electrical system that may be required for effective operation of the Project, and any further system improvements necessary to accommodate the (then) largest proposed generating unit size of 200 MW.

5.2. Transmission Study Improvements Pre-Watana

The Railbelt electrical system, to which the Project will connect to the Alaska Intertie – approximately midway between Anchorage and Fairbanks, currently consists of a single transmission line between Anchorage and Healy (with two lines between Healy and Fairbanks) as well as a single line between the Kenai Peninsula and Anchorage. The Railbelt utilities and the State of Alaska are in the process of evaluating transmission additions to provide for firm energy transfers and improved reliability of the Railbelt electrical system. These "pre-Watana" Railbelt system improvements are independent of the Susitna-Watana Project and would eliminate the single contingency conditions between the Railbelt load areas. The additional transmission facilities would provide for total coordination among all currently available electrical resources and those now in development.

The Railbelt transmission system is expected to undergo substantial configuration changes from the present to 2024, and the system studies for the Susitna-Watana Project interconnection assume that those improvements necessary for the reliability of the Railbelt power supply will have been completed by 2024, and are therefore in service at the commencement of Susitna-Watana interconnection and operation.

The exact electrical and mechanical characteristics of the project generators were not known at the time of the model runs. Representative unit parameters were assumed from similar sized units selected by MWH.

5.3. Study Criteria

The studies for the interconnection of the Project were completed using Railbelt electric system planning and reliability criteria that have been established among the utilities, and the loads and resources expected to be in place in the year 2024. The criteria included:

- No instability following any transmission system fault;
- No loss of load-following any single contingency;
- No abnormal voltages during steady-state or following N-1 contingency; and,
- No overloads of transmission lines or equipment during steady-state conditions.

At the time the system studies were performed, the two sizes of unit that were being considered were 150 MW rated at average head, and 200 MW units rated at average head. These would have provided an output of approximately 200 MW and 272 MW, respectively, at maximum head. At the completion of the feasibility studies a recommended turbine unit size of 153 MW at a reservoir level of El. 1950 ft. was selected – approximately equivalent to 206 MW turbine output at normal maximum operating level of 2050 ft. The conclusions of the system studies are not affected by the slight mismatch between the assumed ratings for the system studies and the ratings of the selected equipment.

5.4. System Study Methodology

The "pre-Watana" transmission system expected to be in service by 2024 was the starting point for the Susitna-Watana Project electrical system studies.

The Susitna-Watana studies can be divided into two distinct categories: (1) transmission system analysis required for the incorporation of the Project into the Railbelt electrical system; and (2) unit sizing studies designed to evaluate the system impacts resulting from two different unit sizes being evaluated for the Project.

The **transmission system studies** evaluated the electrical transmission interconnections between the project site and the Railbelt system and the requirement of any transmission improvements outside the immediate project area.

The **unit sizing studies** focused on the differences in transmission system improvement requirements between a 150 MW unit and a 200 MW unit.

The studies were completed utilizing the Railbelt utilities' PSS/e database for 2020 as the starting point. This database includes the utility improvements and changes the utilities are planning to their transmission and generation systems through 2020. The PSS/e 2020 database was modified to include all the pre-Watana improvements.

The studies consisted of applying faults to transmission lines in the project area and suspected key transmission points in the Railbelt transmission system. The faults were applied and subsequently cleared by opening the faulted line section. The stability of the transmission system was then evaluated by plotting various generator rotor angles relative to each other and system frequency.

To put the studies in context, the units on the Railbelt system are shown in Table 5.4-1.

Table 5.4-1. Existing Generating Units on the Railbelt System, 2014 (MW)

Plant	Unit #	Unit Capacity	Type	Plant	Unit #	Unit Capacity	Type
AURORA	1	24	Coal	EKLUTNA	10	17	Gas-Oil
BELUGA	1	18	Gas-Oil	EKLUTLK	1	23	Hydro
BELUGA	2	18	Gas-Oil	EKLUTLK	2	23	Hydro
BELUGA	3	67	Gas-Oil	EVA CREEK	(total)	25	Wind
BELUGA	5	65	Gas-Oil	HEALY	1	27	Coal
BELUGA	6	82	Gas-Oil	HEALY	2	53	Coal
BELUGA	7	82	Gas-Oil	HEALY D	1	3	Gas-Oil
BERNICE	2	19	Gas-Oil	MLP1	3	29	Gas-Oil
BERNICE	3	26	Gas-Oil	MLP2	5	37	Gas-Oil
BERNICE	4	26	Gas-Oil	MLP2	7	82	Gas-Oil
BRADLEY	1	63 §	Hydro	MLP2	8	88	Gas-Oil
BRADLEY	2	63 §	Hydro	MLP2A	2x1	125 *	Gas-Oil
CHUGACH WIND	(total)	15	Wind	NIKISKI	2	59	Gas-Oil
COOPER	1	10	Hydro	NP	1	63	Gas-Oil
COOPER	2	10	Hydro	NP	2	61	Gas-Oil
DPP	6	26	Gas-Oil	NPCC	3	63	Gas-Oil
EKLUTNA	1	17	Gas-Oil	SEWARD D	1	3	Gas-Oil
EKLUTNA	2	17	Gas-Oil	SEWARD D	2	3	Gas-Oil
EKLUTNA	3	17	Gas-Oil	SOLDOTNA	1	46	Gas-Oil
EKLUTNA	4	17	Gas-Oil	SOUTHAPP	3x1	188 #	Gas-Oil
EKLUTNA	5	17	Gas-Oil	ZEHN IC	5	3	Gas-Oil

Plant	Unit #	Unit Capacity	Type	Plant	Unit #	Unit Capacity	Type
EKLUTNA	6	17	Gas-Oil	ZEHN IC	6	3	Gas-Oil
EKLUTNA	7	17	Gas-Oil	ZEHNDER	1	19	Gas-Oil
EKLUTNA	8	17	Gas-Oil	ZEHNDER	2	20	Gas-Oil
EKLUTNA	9	17	Total MW			1830	

Notes:

* MLP2A unit 1 is a 2x1 combined cycle unit utilizing GE LM6000 CTs. The owners consider that this configuration exhibits equivalent risk to three 62.5 MW units.

\# SOUTHAPP unit 1 is a 3x1 combined cycle unit utilizing GE LM6000 CTs. The owners consider that this configuration exhibits equivalent risk to three 62.5 MW units.

§ The total output of the Bradley plant is limited to 117 MW.

The unit sizing studies were dominated by simulating the loss of a Susitna-Watana unit on the Railbelt transmission system under various loading conditions. As can be seen from Table 5.4-1, both of the evaluated generator sizes are considerably larger than units that will exist in the Railbelt in the 2020 timeframe. Larger units will put strain on the Railbelt system if tripped under full load and mitigating measures will be required. These studies were intended to evaluate the incremental costs of the mitigating measures of the potential unit sizes for Susitna-Watana.

The studies attempted to determine the mitigating measures that would be required to limit the loss of load in the Railbelt system to its first stage of load shedding following the loss of a Susitna-Watana unit, similar to the conditions that exist prior to construction of the project.

5.5. Results

The system studies indicate that the Project can be integrated into the planned infrastructure with few improvements required to the Alaska Intertie (i.e., outside the immediate project area). For transmittal of the power from the Project to the Alaska Intertie, the Project will need to include either:

1. Three 230-kV transmission lines from the Project to the Alaska Intertie and a modest Static VAR Compensator (SVC) located at the point of interconnection; or possibly,
2. Two transmission lines and a much larger SVC at the interconnection location.

The sizes of the proposed Susitna-Watana units (whether 150 or 200 MW) are larger capacity than any generator in the Railbelt system. The modeling indicates that these unit sizes will need to be mitigated by some storage technology. The location of the battery energy storage system (BESS) could be the same as that already planned for the system.

These devices will prevent any excessive load shedding in the Railbelt system following the loss of one of the Susitna-Watana units at peak load, and allow complete coordination of the Project with the existing and planned generation resources in the Railbelt.

The size of the BESS is determined by the loss of the largest Susitna-Watana unit during the minimum load period of the Railbelt. In simulations, the boundary condition of the system model was determined by forcing unequal loading of the Susitna-Watana units. The total Railbelt load during minimum load periods does not require the full use of the plant capacity. Therefore, for modeling of the worst possible operating conditions, the units must be operated with unequal loading to produce the worst-case condition of the loss of a Susitna-Watana unit at full capacity.

Operational agreements could reduce the requirement for energy storage, particularly because hydro units are much more responsive than thermal units. Multiple hydro units in a plant are usually run, in parallel, at part load so that in the event of a trip of one unit, the other unit ramps up quickly to “take over” generation. This is more readily achieved if the units are slightly oversized, and such operation would reduce the required contingency, and the corresponding size of the BESS required for the system.

The initial comparison indicated:

- **For 3 x 200 MW units at Susitna-Watana** - The system would require approximately 180 MW of stored energy devices to limit load shedding to Stage 1 in the Railbelt system during the extreme case of a unit operating at its maximum capability at high reservoir levels during the lightest load condition of the Railbelt. The system requires 150 MW of storage for the loss of a 200 MW unit operating during the summer peak load periods. This is a small increase in compensation requirements over the 150 MW units and does not appear to present any significant challenges or system issues.
- **For 4 x 150 MW units at Susitna-Watana** - The system would require 120 MW of storage devices during the summer minimum load periods to mitigate the loss of a unit that is operating at 150 MW maximum capability, but only a 20 MW storage device would be required during the typical summer loading periods.

5.6. Future Studies

Study results indicated that the 150 MW generating units would require less extra infrastructure (SVCs, storage, etc.) – than the larger 200 MW units – to maintain stability throughout the Railbelt system. However, it was concluded that the incremental increase in cost for the infrastructure associated with the larger 200 MW units is less than two percent of total project cost and the differences between the two unit sizes do not present any large cost increases with respect to the system costs or system implementation issues. The cost comparisons for the construction of the power facilities for each of the two sizes of unit are recorded in Section 7.

The studies reported herein used a wide range of possible energy transfers for the Northern and Southern utilities to evaluate the electrical transmission system. Future studies will need to factor in the actual proposed energy split between the Northern and Southern systems based on the maximum expected capacity of each respective system and the transmission requirements of the final configured energy flow. Those studies would help confirm whether any transient aids are required for either transmission line faults or unit trips and provide acceptable reliability and service characteristics for the utilities.

Future studies will also identify the proposed sizing and location of the storage devices to be implemented on the Railbelt as well as refine the system studies once more information is known regarding the actual Susitna-Watana generating unit characteristics. Future studies should also provide a more detailed analysis of the system response to an expanded list of transmission contingencies, including breaker-fail and N-1-1 contingency analysis.

The future studies will also need to analyze the response of the Railbelt system units, such as Bradley Lake, to the proposed Susitna-Watana Project in addition to the response of the project to the interconnected system.

5.7. Project Operation and Resource Integration

5.7.1. Basis of Studies

Although previous production modeling of generation available to the interconnected system had been undertaken during the preparation of the draft Integrated Resource Plan , the modeling had not considered the detailed performance capabilities of Susitna-Watana, or the various flow constraints that might be in effect. Therefore it was determined that further detailed production modeling needed to be performed in support of project feasibility studies, using current forecasts of Railbelt loads, fuel costs and including Watana hydrology. This update of production modeling reflects the proposed configuration for the Susitna-Watana Project and other Railbelt system facilities to assist in the conceptual design of the Project and its integration into the Railbelt system at its expected on-line date, which for the purposes of the calculations was assumed to be 2024. The updated system production modeling has been performed by Slater Consulting under subcontract to MWH, using PROMOD IV modeling software. The software simulates electric system and markets incorporating extensive details of generating unit operating characteristics, transmission grid topology and constraints, and market system operations to support economic transmission system dispatch and project planning.

The production modeling assumes centralized dispatch of generation on the Railbelt system, which will require – if enacted – mechanisms for payment between utilities, and agreed provisions among utilities for recognition of the financial burden for retired and unused thermal units.

An indication of the economic optimized use of the Susitna-Watana Project was needed to determine parameters including, but not limited to:

- Size of the generating units;
- Extent of generation change; and,
- Power ramping rates and resulting flow releases.

Meetings were held with the various Railbelt utilities to verify and update the various input data needed for PROMOD runs, including:

- Load forecasts;
- Existing generating plants and units;
- Planned unit additions and retirements;
- Fuel prices;
- Operations and Maintenance (O&M) costs;
- Unit availability and maintenance requirements; and,
- Relevant aspects of the present and projected transmission system.

Data were obtained from the utilities using questionnaires, group meetings, telephone calls, and individual face-to-face meetings. Where appropriate, aggregate data for all utilities were collected. AEA provided the fuel cost forecasts used in the model. Publicly available data, (as found in regulatory filings, reports, websites, etc.) were used as a secondary source and for cross-checking. To maintain the required schedule for analysis, it was often necessary to commence model runs using assumed data that was improved after the utilities viewed interim results and provided their comments.

Modeling runs were conducted in 2012, 2013, and early 2014, increasing in sophistication as more and better data emerged. After the initial financial modeling of the project by AEA financial consultants, a final PROMOD run was performed in December 2014 using a key financial scenario.

Elements that have been considered in the model input data are recorded in the following sections.

5.7.2. Plant and System Operation Requirements

Discussions with utilities in 2012 indicated that in recent years the Railbelt utilities overall have experienced negative load growth and were forecasting very low growth over the period through 2024. The utilities indicated that they suspect the drop in load has resulted from electricity conservation efforts that could well have been price induced, and predicted that by 2024, the Railbelt peak load would be less than two percent above 2012 levels.

Compared to systems throughout the Lower 48, the Railbelt system is relatively small, and therefore, the present thermal generating units lack the necessary size to achieve the economies of scale available to most of the industry in the rest of the continental United States. As discussed elsewhere, system security and reliability requirements favor the use of relatively small generating units, compared to the Lower 48.

The age of much of the existing thermal generation is such that modern similarly sized units would provide greater efficiency and reliability. Therefore, it is not surprising that various utilities have committed to acquiring more modern plant with better heat rates and higher availability. The units displaced from the daily dispatch by new generation will be relegated to "standby" status. Some will be retired, but a comprehensive planned "retirement schedule" was not available from any utility, and – it is understood – is not currently in place for the region.

The utilities' near-term plans for additions and retirements of generating capacity include a significant addition of combined cycle capacity and large modern gas-fired diesel units, coupled with the retirement of older inefficient combustion turbine units.

The three existing hydro plants (Bradley Lake, Cooper Lake, and Eklutna) clearly perform a valuable role in reducing the peak demands needed to be served by the thermal units. This role in the reduction in peak demand by the hydro projects also allows some of the older combustion turbine units to avoid costly startups for small amounts of energy production at the peak. This improves overall generation efficiency by permitting the use of more combined cycle capacity with vastly superior heat rates. Because of these drivers, simple cycle combustion turbines will, in the future, populate the ranks of "standby" units.

Because it will have the lowest operating cost and the highest reliability among the generation sources, the addition of further substantial hydro capacity to the system by the construction of the Susitna-Watana Project will reduce the need for gas and oil fired generation, even from combined cycle units.

5.7.3. General Power Plant and Railbelt System Criteria

The utilities' stated objectives are to provide a high reliability electricity supply to their customers at the lowest reasonable cost, in keeping with existing and future environmental concerns. At all times, the Railbelt utilities must have sufficient generating capacity available to service their customer loads and to provide their individual share of the system's required operating reserves. Of course, each generating unit needs to undergo regular maintenance if it is to remain useful. Currently, to provide for these requirements, the utilities have a target reserve margin of 30 percent. That is, installed generating capacity equal to 130 percent of annual peak load. This does not include units that have been placed in a preservation or "mothballed" state.

In examining the potential impact of 200 MW generating units at Susitna-Watana, attention will need to be given to the suitability of the current agreed reliability criteria. It should be noted that, although they would be the largest units on the system, modern hydro experience shows that the Susitna-Watana Project units will have significantly more reliable generation than all others on the Railbelt system (national statistics indicate that hydro exhibits half the number of forced outages compared to thermal units).

The 2012 PROMOD dispatch analysis did not provide any insights into the continued suitability of the 30 percent reserve margin criterion as the actual reserve margins included in model runs, both with and without the Susitna-Watana Project, greatly exceeded the 30 percent target, and no reliability issues appeared. Because construction of the Susitna-Watana Project may hasten the retirement of older generating plant and because of the larger size of combined cycle units and the project units, it is suggested that specific reliability studies be included in the future PROMOD analyses, to check the advisability of retaining or modifying this 30 percent planned reserve margin within the Railbelt system.

5.7.4. Operating Security Criteria

It is generally accepted that, in an isolated system, unforeseen events such as the sudden loss of a generator, or transmission line, can result in significant customer supply interruptions if provisions are not made. It is important that restoration of supply be carried out swiftly. To facilitate this restoration, the current operating criteria for the Railbelt system require that the system carry spinning reserve equal to 100 percent of the capacity of the largest unit on line, and additional operating reserve capacity (such as quick-start reserve or further spinning reserve) equal to 50 percent of that largest unit capacity. Addition of the project's large hydro units raises challenges concerning the application of these operating security criteria, and/or system adjustments to maintain reliability. These questions are addressed in Section 11.

At the time the data for the 2012 model runs were assembled, plans to improve the Railbelt transmission system, irrespective of the building of the project, had not been fully investigated. Furthermore, options being studied for connection of the Susitna-Watana Project to the existing system using either one transmission corridor or two (i.e., two different points of interconnection).

In developing the Railbelt databases, provision was made to represent a variety of operating reserve and system security arrangements, as well as model transmission flow restrictions. In the series of model runs examining the economic impact of the Project, the spinning reserve requirement of 100 percent of the largest unit on line and the additional operating reserve requirement of 50 percent of that largest unit were used. In the model, the representation of transmission flow restrictions was set to describe a transmission system in which flow restrictions did not constrain the economic operation. These same conditions were preserved in the runs that were made to develop a full 8,760-hour representation of the operation of the Susitna-Watana Project for the 2024 calendar year.

As discussed later, impacts of recommended transmission changes and system configurations on the economic operation of the system were included in the PROMOD input data for the 2013-2014 model runs. When firm transmission proposals for the pre-Watana upgrades and the incorporation of the Susitna-Watana Project are available or accepted, any attendant power flow restrictions or additional operating criteria could be examined in future system modeling.

5.7.5. Plant Operation and Maintenance

As noted, each generating plant and unit that is available to serve system load has to be regularly maintained and worn parts replaced. Generating plant has to be protected from the elements with appropriate housing, which has to be maintained. When needed in service, most units require some operating personnel, and in-service units need to be supervised. The costs involved in these activities are known as non-fuel O&M costs.

O&M costs are important items in the planning of new generating capacity. For operating purposes, the total O&M costs are divided into Fixed O&M and Variable O&M costs. Fixed O&M costs are used to keep a generating unit ready to operate and serve load. Variable O&M costs result from the use of that unit to serve load, and are important to the commitment and dispatch of the unit. Utilities often divide the Variable O&M into up to three separate cost items, $ per start, $/hour on line and $/MWh. Historical O&M information was compiled from available data by the modelers for use in the Railbelt model, and then checked and/or modified by the utilities before the final runs. The data were specific to each unit and varied significantly according to the technology, size and age of the particular unit concerned. In 2012 dollars, Fixed O&M costs varied from about $7,000 to $8,000/month for small diesels to over $400,000/month for combined cycle and coal-fired units. Start-up O&M ranged from around $1,000/start for smaller combustion turbines to around $5,000/start for combined cycle units. Must-run units did not have any start-up O&M, as it would have no bearing on their commitment. $/MWh Variable O&M costs ranged from about $1.30/MWh for older combustion turbines to around $12/MWh for diesels. The Railbelt utilities do not appear to separate $/hr. O&M costs from $/MWh costs.

5.7.6. Economic Operation

The economic operation of a utility is generally carried out in three sequential processes:

- First, there is a process of production planning whereby the utility schedules maintenance, makes contract purchases and arranges fuel supplies, with the objective of having sufficient operating capacity at all times to satisfy its customer loads and provide its share of appropriate reserve capacity.
- The second process is unit commitment whereby the utility arranges to have in-service sufficient capacity to serve its current load and provide its share of spinning reserve, and to have readily available any additional capacity needed to fulfill operating reserve and regulation requirements.
- The final process is the dispatch or loading of the in-service capacity to provide, at all times, the exact amount of electricity being consumed by the customers. This process makes use of Automatic Generation Control apparatus, supervised by 24/7 system operating staff.

These three sequential processes are organized and programmed to minimize the variable production costs of the utility (that is fuel, Variable O&M, and purchases from other utilities, less sales to other utilities).

The addition of resources at the Susitna-Watana project capable of generating up to (approximately) 600 MW to serve the total Railbelt system – together with sufficient transmission to incorporate it into that system – will almost certainly result in a re-evaluation of commitment and dispatch practices throughout the Railbelt system. As the maximum benefit from the Project would be realized through a centralized commitment and dispatch process, the modeling work carried out thus far has included the simulation of a centralized dispatch of the Railbelt system, using the average water availability under the postulated river flow rules – with the objective of minimizing total variable production costs.

5.7.7. Modeling Exercise and Results

The PROMOD software was initially used to model production of power on the Railbelt system in 2024 with, and without, the construction of the Susitna-Watana Project, based on the system characteristics represented in the model data, which had been gathered from the utilities and a variety of other sources.

In the "Without Susitna-Watana" case, the Railbelt system was modeled as an isolated multi-area, multi-company system, centrally dispatched, with sufficient transmission so that flow restrictions would not constrain the economic operation. The "With Susitna-Watana" case modeled that same system with the addition of the Susitna-Watana Project and any associated transmission for its interconnection to the Railbelt system. Initial calibration model runs showed that under average water conditions, the project's operation could save nearly $220 million per year in overall Railbelt variable production costs. This figure does not include savings accruable to the overall transmission improvements discussed elsewhere.

After the first runs were made and the model was calibrated, the model was refined to simulate system operation with and without the Project in future years 2024 (i.e., the then expected first year of Susitna-Watana operation), 2034, and 2044. Economic evaluations were then performed against the required debt service and fixed costs for the Project, so that the contributions to system economics could be validated through an extended study period.

To prepare for this modeling, the data that had been included in the model for each utility were provided to that utility for checking of its accuracy. At subsequent face-to-face meetings, utility representatives verified/corrected the data including load forecasts, existing generating plants and units, planned additions and retirements, historic fuel prices, O&M costs, availability, and maintenance requirements. As corrected, the overall Railbelt Utility System was still modeled as an isolated multi-area, multi-company system, centrally dispatched. Because of the significance of future gas prices to the economic value of the Project, AEA provided a set of scenarios of future gas prices to be used in this analysis. MWH/Slater Consulting contributed a further gas price scenario and coal and oil price forecasts were provided by Slater Consulting.

Railbelt production cost savings due to addition of the Susitna-Watana Project were determined for years 2024, 2034, and 2044 for each gas price scenario.

The 2012 model studies were intended to establish a basic measure of Railbelt production cost savings due to the project's hydro generation, and to compare different proposed generating unit configurations. The 2012 model was used to examine the impacts of: (i) four units of about 150 MW each; and, (ii) three units of about 200 MW each.

In addition, the utilities' planned generating resources were examined to determine what possibilities existed for savings in capital costs and fixed costs associated with these resources.

The 2012 modeling studies are summarized below.

Load Projections – The Railbelt load has very little projected growth through 2024, and projected low growth from 2024 onward. Table 5.7-1 below shows the regional capacity and energy load growth projections through the year 2044 – provided by the utilities during discussions with them in 2012.

Table 5.7-1. Railbelt Demand and Energy Forecasts

Year	Peak Demand MW	Annual Energy GWh
2014	805	5149.2
2024	830	5287.2
2034	858	5432.7
2044	888	5620.1

Unit Retirements – The utilities' current commitment to new plant is essentially the acquisition of more efficient plant to operate in base load – to displace older less efficient thermal generating equipment – rather than expanding generation to serve new load. The more useful pieces of the older plant, not required for active generation or reserves, are to be retained as "standby" capacity. Plant clearly at the end of its useful life would be candidates for retirement. If the project is constructed, utilities will have the opportunity to retire older, less efficient "standby" plant without compromising the reliability of the Railbelt system.

Susitna-Watana Power Output and Unit Sizing – The projected generation of the project was used without system generation downtime to predict the hourly generation through a full year (8,760 hours). By this means, the required unit output and the corresponding reservoir elevation have been determined to more fully define the required unit rating and rated head. The comparison between 3 x 200 MW and 4 x 150 MW units at the Susitna-Watana Project did not indicate any conclusive system production cost advantage for either arrangement. (Note, although not modeled, the current proposed arrangement includes 3 x 150 MW.)

System Cost Savings – Modeling results show that there are potential retirements of "standby" plant if the project is built. The accompanying savings in fixed operating costs would be $16,500,000 in 2024, $18,300,000 in 2034, and $23,100,000 in 2044. The PROMOD runs with and without the project show that the inclusion of the Susitna-Watana Project in the system will result in a significant reduction in the use of gas and oil by the Railbelt utilities, and a large decline in the use of what is now (thermal) peaking plant. Table 5.7-2 below indicates the future make-up of Railbelt energy sources in the year 2024, both with and without the Susitna-Watana Project. The reduction in gas and oil consumption is largely responsible for the reduction of variable operating costs on the Railbelt system. Even in the initial years of Susitna-Watana operation, those reductions are comparable with the annual fixed costs of having and operating the Project. Annual fixed costs consist of debt service and fixed O&M.

Table 5.7-2. Railbelt Electrical Energy Sources in 2024

Energy Source	Annual Energy Contribution (GWh)	
	Without Project	With Project
Coal	811.3	811.3
Gas and Oil	3768.8	1080.4
Wind	126.3	126.3
Hydro	580.8	3269.2
Total	5287.2	5287.2

As this computation of variable cost savings was carried out for each of the three years for each of five gas price scenarios, the results are best viewed in tabular form, as presented below in Table 5.7-3 below.

Table 5.7-3. Variable Cost Savings Due to Susitna-Watana Project

(2012 prices escalated)

Year	Natural Gas Price Scenario ($ million)				
	$6[2] / MCF[1]	$8[3] / MCF	$10[4] / MCF	$12[5] / MCF	$6.50[6] / MCF
2024	236.8	299.2	366.2	436.4	283.7
2034	323.8	439.0	525.2	596.7	480.3
2044	436.1	567.7	687.4	817.2	626.5

Notes:

1. MCF – one-thousand cubic feet
2. $6 – 2012 gas price in Anchorage area is $6/MCF, escalation is 2.75 percent
3. $8 – 2012 gas price in Anchorage area is $8/MCF, escalation is 2.75 percent
4. $10 – 2012 gas price in Anchorage area is $10/MCF, escalation is 2.75 percent
5. $12 – 2012 gas price in Anchorage area is $12/MCF, escalation is 2.75 percent
6. $6.50 – 2012 gas price in Anchorage area is $6.5/MCF, escalation is 4 percent

Total annual net savings to the system will depend on the ultimate cost to develop the Susitna-Watana Project, as well as the future price of natural gas. When the Susitna-Watana Project production cost savings, together with fixed cost savings – because of standby plant retirements – are combined with the annual project fixed costs (including project debt service), the result is the impact on system operating costs of building the project. Figure 5.7-1 shows this overall impact (in nominal $) for each year for each gas price scenario.

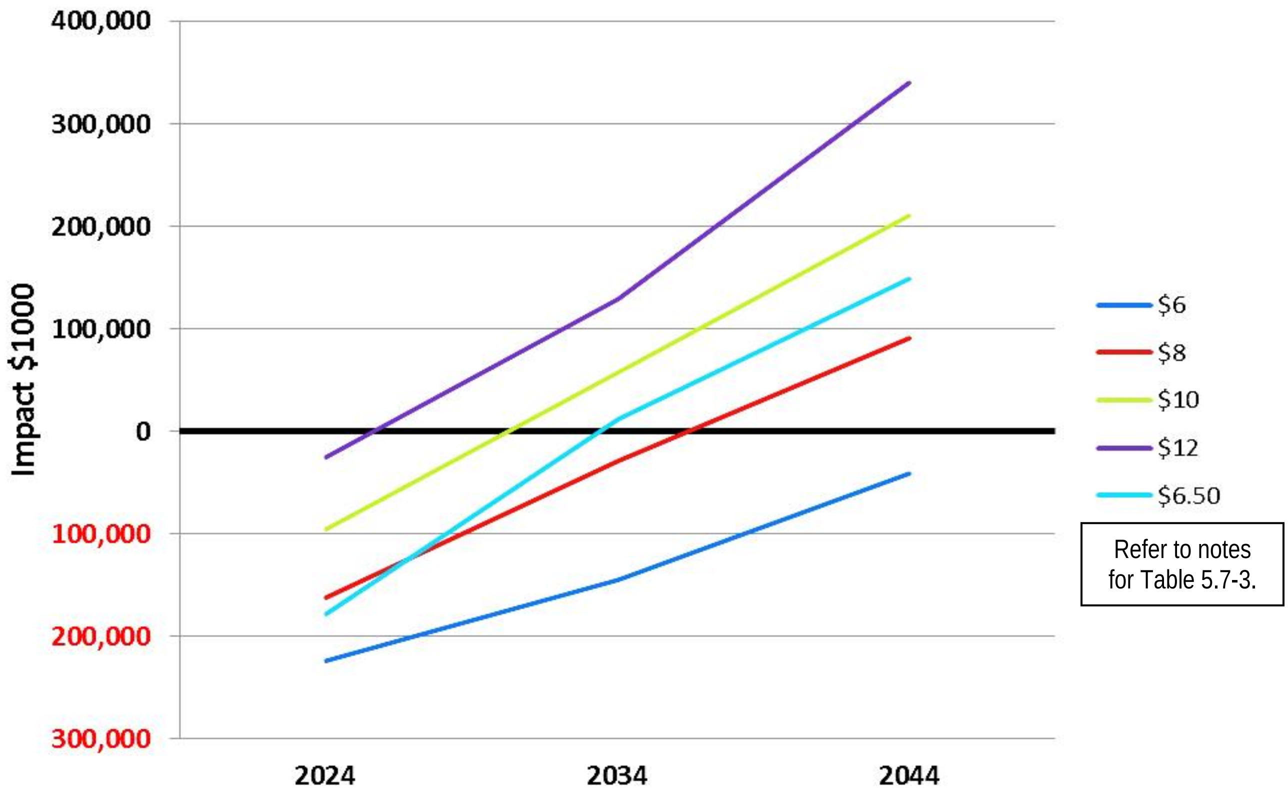

Figure 5.7-1. Overall Impact of Susitna-Watana Project on Railbelt Annual Generation Costs

The overall Railbelt PROMOD model is structured so that it can be used for a variety of future studies by AEA and the utilities involving the economic, operational and reliability impacts of the Susitna-Watana Project in whatever configuration is considered. Each analysis would be carried out by comparing the PROMOD simulations of the Railbelt system both with and without the item or feature of interest, over the years of concern.

5.7.8. 2013 Modeling and Analysis

During late 2012 and through the middle of 2013, Slater Consulting performed further modeling and analysis encompassing the proposed Railbelt transmission improvements – under contractual arrangements separate from those for assistance in the Susitna-Watana project feasibility. Results were, however, provided (as appropriate) to MWH for inclusion in this report, in the context that the system improvements will be required to fully utilize the power potential of the Susitna-Watana Project within the improved, interconnected system.

These proposed system improvements were developed and analyzed by EPS. Slater Consulting used PROMOD on this assignment and worked with EPS and Chugach Electric Association (Chugach) and the other utilities. The purpose of the studies was to investigate the savings in power production costs that could be achieved for the Railbelt utilities through the implementation of transmission improvements, both individually and collectively.

The transmission studies began with the database developed in the 2012 Susitna-Watana studies, and through the course of the analysis, anomalies and further data was identified to enable some corrections and improvements to be made to the modeling of the utilities' physical plant, and to their modeled operating procedures.

The transmission improvements were more appropriately analyzed using the PROMOD IV solution algorithm – best suited for line-by-line transmission studies. Thus the 2012 study data was reconfigured to run in HMC-TAM (hourly Monte Carlo-transmission analysis mode), and paired with appropriate transmission load flow data.

As mentioned above, the work on the transmission studies provided enhanced insights into Railbelt data and operations, and this information was captured for insertion into the Susitna-Watana PROMOD data to ensure that the transmission studies and the ongoing Susitna-Watana studies were compatible.

Overall Railbelt system transmission improvements are divorced from the development of Susitna-Watana, and therefore, the transmission studies were conducted for the pre-Watana period. For use in the ongoing Susitna-Watana studies, the data with all of its improvements was extended through 2044 to match the timeframe of the data used in the 2012 Susitna-Watana analyses.

The final database including all recommended transmission improvements derived from the transmission studies became the "without Watana" database for the 2013 Susitna-Watana analyses. At this point the modelers had updated compatible data for running PROMOD studies in both the Analytical Probabilistic Dispatch (APD) mode and the HMC-TAM mode for the years 2024, 2034 and 2044. The APD was used for optimizing the month-by-month water releases and the HMC-TAM for hour-by-hour dispatch within the month and presentation of the hour-by-hour water releases. For improved accuracy, the modelers also developed a procedure to use the monthly water releases from an initial run to obtain monthly average Watana reservoir elevations to utilize in a second final run.

In early August 2013, there was another set of "face-to-face" meetings with the individual utilities – this time in connection with the transmission studies. During these meetings, some information was gathered allowing further corrections to model data, together with greater insight into how the utilities wished to operate their generation. This information was added to the data sets for Susitna-Watana analyses.

To explore the long-term continuing benefits available from the Susitna-Watana Project, one of the tasks performed in 2013 was the extension of the PROMOD analysis through 2054. This extension of the task captured the development of all Railbelt generation that would have been implemented under a planning scenario that assumed that Susitna-Watana generation was a possibility. Likely unit retirements and – in the "without Watana" case – appropriate generation additions were developed through 2054. It is very important to note again that, it was assumed that beyond 2020, the Railbelt pool would be dispatched as a single system and that over time each utilities' generation planning would reflect this manner of operation.

While the 2013 work was being performed, questions arose concerning the hour-to-hour variations in Susitna-Watana discharge and the consequences of seeking to control these variations. For this reason, the 2013 analyses included a change from hour-by-hour typical week per month dispatch to hour-by-hour weekly dispatch for 53 weeks per year, necessary so that all hours of the year were separately modeled.

5.7.9. Forecast Data and Results for 2013 Analyses

5.7.9.1 Loads

During the transmission studies performed in 2013, the utilities provided further (and updates) details of their own near term load forecasts and long term prospects. To reflect their updated projections, changes were made to the overall utility-by-utility load forecast (previously shown in Table 5.7-1). As demonstrated in Table 5.7-4, forecasts are now for near term increases in total Railbelt load but with a low overall long-term growth trend.

Table 5.7-4. Railbelt Demand and Energy Forecasts – 2013

Year	Peak Demand MW	Annual Energy GWh
2014	805	5149.2
2024	874	5673.7
2034	899	5780.3
2044	916	5904.8
2054	930	5975.5

5.7.9.2 Capacity Additions and Retirements

Given the lack of retirement schedules for plant in the Railbelt system, the development of the updated forecast of future generating capacity retirements and additions can be viewed within three timeframes. The near term, through 2024, was provided entirely by the utilities and consisted of selected retirements of older plant and the completion of planned, more efficient new combined cycle plant and modern larger diesel generation.

The mid-term, 2025 through about 2038, was a combination of utility scheduled retirements and a nominal retirement at age 65 for units without retirement dates. No additions were scheduled or necessary to maintain planning reserves either with or without the completion of Susitna-Watana.

The long term 2038 through 2054 was beyond the planning horizon of any of the utilities. All of the remaining pre-1990 combustion turbine equipment was retired at age 65. In the "without Watana" case, about 366 MW of new generation was added in the form of Combined Cycle equipment and large gas-fired diesels, similar equipment to that being added to the system at this time. This new capacity was added to follow utility plans, to provide sufficient base load capacity to produce the required energy at a reasonable cost, and to provide reasonable generating capacity reliability. In the "with Watana" case, capacity reserve margin, reliability and base load energy supply appeared satisfactory without the addition of additional capacity.

Table 5.7-5. Future Generating Plant Reserves with and without Susitna-Watana Project – 2013 Forecast

Year	Peak Load MW	Railbelt Capacity MW	Reserves %
Without Susitna-Watana Project			
2024	874	1822	108
2034	899	1526	70
2044	916	1335	46
2054	930	1310	41
With Susitna–Watana Project			
2024	874	2462	182
2034	899	2166	141
2044	916	1610	76
2054	930	1584	70

Table 5.7-6. Future Generating Plant with and without Susitna-Watana Project – 2013 Forecast

Year	Coal and Combined Cycle MW	Diesel and Combustion Turbine MW	Hydro MW	Total MW
Without Susitna-Watana Project				
2024	590.5	1049.2	182.2	1822
2034	539.5	804.6	182.2	1526
2044	822.7	330.0	182.2	1335
2054	822.7	304.5	182.2	1310
With Susitna-Watana Project				
2024	590.5	1049.2	782.2	2422
2034	539.5	804.6	782.2	2126
2044	539.5	247.8	782.2	1570
2054	539.5	222.3	782.2	1544

5.7.9.3 Fuel Prices

The fuel price estimates used in the 2013 analyses were developed from present prices, known changes (for example gas pricing recently approved by the Alaska Regulatory Commission for 2018+), and escalation forecasts taken from the preliminary projections prepared for the Federal DOE's Energy Information Administration’s 2014 Annual Energy Outlook.

Because natural gas is the major fuel displaced by the Susitna-Watana generation, the natural gas future price is the major determinant of the extent of the production cost savings resulting from the inclusion of the Susitna-Watana Project in the system. The updating of the natural gas price scenario developed for the later evaluations results in prices considerably different from those used in the 2012 evaluations, and plays a significant role in the scale of the Susitna-Watana benefits identified in the 2013 evaluations.

Table 5.7-7 below compares the 2013 natural gas price scenario with the five scenarios used in the 2012 evaluations.

Table 5.7-7. Comparison of Natural Gas Supplies (US$ - nominal) for Scenarios Studied in 2012

Year	2013 Forecast Scenario 0		2012 Scenarios				
			Scenario 1[2]	Scenario 2[3]	Scenario 3[4]	Scenario 4[5]	Scenario 5[6]
	c/mmBTU[1]	%/yr. increase	c/mm BTU	c/mm BTU	c/mm BTU	c/mm BTU	c/mm BTU
2024	1171.5		831	1108	1385	1662	1041
2034	1741.7	4.05	1090	1453	1816	2180	1540
2044	3002.9	5.60	1429	1906	2382	2859	2280
2054	4887.3	4.99	1875	2500	3125	3750	3375

Notes:
1. c/mmBTU – cents per million British Thermal Units
2. 2012 Anchorage NG price $6/mmBTU escalating at 2.75%/yr.
3. 2012 Anchorage NG price $8/mmBTU escalating at 2.75%/yr.
4. 2012 Anchorage NG price $10/mmBTU escalating at 2.75%/yr.
5. 2012 Anchorage NG price $12/mmBTU escalating at 2.75%/yr.
6. 2012 Anchorage NG price $6.50/mmBTU escalating at 4%/yr.

5.7.9.4 Fixed Costs

In the financial analysis performed in 2012, AEA used an escalation rate of 2.75 percent/yr. for capital costs and O&M costs. This escalation rate was applied to the existing estimates of O&M costs provided by the utilities to produce the long-term projections included in the PROMOD data. For the purposes of this analysis, and in the absence of a final finance plan, the assumptions of the MWH model – which also used this same escalation rate – were included in the fixed costs. That model assumed a fixed annual debt service based on an interest rate of 5.5 percent (which is conservative), and a bond term of 30 years, as well as the accumulation of a debt reserve fund. No Alaska state equity investment was assumed.

5.7.9.5 Results of 2013 Analyses

Because the 2013 analyses did not include the estimation of the capital costs for new thermal generation required for the "without Watana" case beginning in about 2042, the results presented below in Table 5.7-8 show conservative estimates of overall savings in the 2044 and 2054 study years based on the 2013 natural gas price scenario (Scenario 0 above).

Table 5.7-8. Total Annual System Production Cost Impact of Susitna-Watana Project (US$ million-nominal)

Year	Increase in Fixed Costs Due to Susitna-Watana	Decrease in Variable Costs Due to Susitna-Watana	Net Saving in Total Costs Due to Susitna-Watana
2024	461.1	295.5	-165.6
2034	468.0	484.0	16.0
2044	< 457.8	636.8	> 179.0
2054	< 24.8	1,031.5	> 1,006.7

Despite the absence of the capital cost savings, the prospect of production cost savings in excess of $1 billion per year beyond 2050 is compelling.

5.7.10. Updated Analysis 2014

Additional PROMOD runs were performed to update the production modeling analysis with the revised construction cost compiled in July 2014, financing terms, unit sizes and the outlook on future gas prices.

The key details of the financing plan used in the updated analysis (AEA Financing Plan 3) are shown in Table 5.7-9.

Table 5.7-9. AEA Financing Plan 3

2010-2018 Licensing and Engineering Costs		Initially Paid by State, converted to a loan in 2023
2019-2023 Construction Costs	Description	AEA Revenue Bond financing backed by Power Sales Contracts with State Moral Obligation
	Issuance Dates	2019-023
	Assumed Rating	High A, Low AA
	Interest Cost Assumption	5%
	Financing Term	2047 for debt, 2085 for State loan for L&D costs
	Interest Cost During Construction	Capitalized
2024-2028 Construction Costs	Description	Rural Utilities Service (RUS) loans
	Issuance Dates	2024-2027
	Assumed Rating	Not-Rated
	Interest Cost Assumption	4%
	Financing Term	2059
	RUS	Yes
	Interest Cost During Construction	Capitalized

2010-2018 Licensing and Engineering Costs		Initially Paid by State, converted to a loan in 2023
Refinancing	Description	Long-term construction financing refinanced
	Issuance Dates	2047
	Assumed Rating	High A, Low AA
	Interest Cost Assumption	5%
	Financing Term	2077
Term in Which Debt is Paid		2028-2085
Overall TIC		4.015%
Total Unreimbursed State Contribution		$0
State Cash Outlay Amounts		Pre-Construction: $550 million
State Cash Repayment Amounts		Pre-Construction: $550 million
Unreimbursed State Contribution		Zero

The analysis was run with the following inputs – reflecting the design presented in the feasibility report:

- The forecast of future electricity demands was unchanged.
- The projected plant retirements and additions (in the "without Watana" case) were unchanged.
- The Susitna-Watana plant would be operating in 2028, but capital repayment would not commence until 2029. Therefore the years to be modeled were 2029, 2039, 2049 and 2059.
- The Susitna-Watana plant would operate over a headwater range of El. 1850 ft. minimum to El. 2050 ft. maximum, and would include three generating units with nominal ratings of 106 MW at reservoir El. 1850 ft., 153 MW at El. 1950 ft. and 206 MW at El. 2050 ft.
- The future price of Anchorage area natural gas would be 1,459 c/mmBTU in 2029 (nominal cents), rising to 2,379 c/mmBTU in 2039 (nominal cents), 3,278 c/mmBTU in 2049 (nominal cents) and 4,361 c/mmBTU in 2059 (nominal cents).

Between the 2013 and 2014 analyses, and independent of the feasibility study for Susitna-Watana, Slater Consulting had continued work on Railbelt transmission additions and pooling of operations. During this assignment, several refinements were made to the PROMOD databases being used, which were transferred to the "with" and "without Watana" databases used in this analysis. The data refinements were minor in scope, and included the following:

- Actual operating characteristics (minimum capacity, heat rate, maintenance requirements and variable O&M costs) for the Eklutna Generation Station units.

- A heat rate adjustment for SPP, from actual performance, which was also carried over to the MLP2A CC unit.
- MLP2A maintenance requirements were reduced.
- MLP2 unit 5 retirement date was confirmed.

With these changes, the December 2014 production analyses were performed in the same way as the 2013 analyses for the years 2029, 2039, 2049 and 2059. Table 5.7-10 shows the results of this work. As in Table 5.7-8 above, the saving in fixed costs associated with capital cost recovery for the additional generating plant needed by the system in the "without Watana" case have not been evaluated. This results in the inequalities in the Table 5.7-10.

In addition, because the financial plan for Susitna-Watana used in this analysis (AEA Financing Plan 3) took longer to pay down the capital cost of Susitna-Watana than the financing plan incorporated in the 2013 analysis (results shown in Table 5.7-8), the net savings does not increase as quickly as in the 2013 analysis. Therefore, the modeled results for the years 2029-2059 have been extrapolated, (conservatively) to the years 2069 and 2079, to reach a point where the construction cost has been repaid as shown in Table 5.7-10, and net savings accrues faster.

Table 5.7-10 Total System Production Cost Impact of Susitna-Watana Project (US$ million-nominal)

Year	Increase in Fixed Costs	Decrease in Variable Costs	Net Saving in Total Costs
	Due to Susitna-Watana	Due to Susitna-Watana	Due to Susitna-Watana
2029	629.1	394.0	-235.1
2039	638.6	687.8	49.2
2049	<515.4	781.9	>266.5
2059	<523.8	1042.3	>518.5
2069*	<292	1400	>1108
2079*	<91	1870	>1779

Note: The results for 2069 & 2079 are not the result of production modeling analysis, but instead have been conservatively extrapolated from the 2029 – 2059 modeling analysis results.