Railbelt Wind Integration Study

Submitted to
Matanuska Electric Association

Revision 1

January 26, 2024

Summary of Changes

Revision	Revision Date	Revision Description
0	December 22, 2023	Initial draft release for comment
1	January 26, 2024	Edits and clarifications per comments from the Railbelt

Written by:
Neil P. Flodin, E.I.T., nflodin@epsinc.com
James W. Cote, Jr., Ph.D., P.E., jcote@epsinc.com
David W. Burlingame, P.E., dburlingame@epsinc.com
EPS Job #23-0314

Table of Contents

List of Figures

List of Tables

Executive Summary

Electric Power Systems Inc. (EPS) has conducted a Railbelt Wind Integration Study. This study was a feasibility and impact study for the addition of 300 MW of wind projects to the system. This study evaluated two proposed wind projects, the Little Mount Susitna Wind Project (“Little Mt. Susitna”) and Shovel Creek Wind Project (“Shovel Creek”) with a total capacity of 300 MW, per the Railbelt review team guiding this study.

This study evaluated the electrical performance impact and feasibility of the proposed wind projects. In this study, Little Mt. Susitna was sized at 160 MW and Shovel Creek was sized at 140 MW.

The scope of this study was to start with the existing system, add the new wind projects to the system along with the minimum transmission additions required to interconnect the new projects to the system, and assess the performance of the system with the new projects in service. Whenever the assessment of system performance identified a problem, changes to intertie flow levels or changes to generation commitment and dispatch were evaluated to meet the planning criteria. Therefore, intertie flow and regional generation constraints were established with the new projects in place.

The identification of significant Railbelt transmission system improvements to integrate these new projects into the system was not within the scope of this study and was not considered. Existing thermal and hydro generation was committed and operated within each of the Railbelt regions in such a way as to ensure system stability with the new projects in operation, while minimizing any required transmission improvements. Constraints to the operation of the existing system generation, required to maintain system stability, were identified for each region of the Railbelt, with the new projects in service.

It should also be noted that the minimum generation constraints found in this study ignore any existing gas supply constraints. The economic and gas supply implications of operating the system with the wind and minimum generation results of this study are beyond the scope of this study and should be further evaluated.

The feasibility of different interconnection designs for each of the two projects was evaluated. The following recommendations are made for the proposed interconnection.

Little Mt. Susitna should be connected to one of the Beluga – Point MacKenzie 230 kV lines with two lines, on separate sets of transmission towers so no single point of failure (including a transmission tower outage) results in a loss-of-generation exceeding 60 MW.

For Shovel Creek, three different interconnection designs were found to be acceptable and meet the planning criteria. The interconnection proposed by Golden Valley Electric Association (GVEA), including the following additions, is an acceptable interconnection option for the Shovel Creek project:

- New “Fort Knox Tap” substation along the Gold Hill – Fort Knox line
- Two new lines from Shovel Creek to either a new Fort Knox Tap substation or looped in and out of the existing Gold Hill – Fort Knox line

- One new line from the new Fort Knox Tap substation to North Pole Industrial substation, or from a new Fort Knox substation to North Pole Industrial substation

One interconnection option that was found to be unacceptable for Shovel Creek is the interconnection of the project with two lines to the existing Nenana – Ester line. This interconnection option is not feasible because of dynamic instability and steady-state voltage collapse if the Shovel Creek – Ester, or Ester – Gold Hill line is tripped. Reconductoring the lines between Healy and Gold Hill does not mitigate the dynamic instability and steady-state voltage collapse issues for this interconnection option.

The minimum conventional, synchronous generation that must be kept online in each region of the system was evaluated, including when a portion of the system is islanded by opening either the Kenai Tie or the Alaska Intertie. The load balancing regulation requirements due to the proposed wind projects were not considered in the development of the minimum generation constraints. Existing minimum generation requirements for applicable regions of the current system were not determined and the impact of the wind projects on those minimum requirements is not known.

The minimum generation requirements were found to be dependent on whether P2 contingencies (from the AKTPL-001 transmission planning criteria) are included in the analysis. For example, there is a breaker fault contingency at Bradley Lake that can trip both Bradley Lake units. If such a fault is included in the planning criteria, then some thermal generation must always be run on the Kenai to meet the minimum generation requirements. Additionally, this outage can create a single point of failure that results in a loss of more than 60 MW. If P2 contingencies are excluded from the planning criteria, then with the Kenai Tie closed, running only Bradley Lake units without thermal generation on the Kenai satisfies the minimum generation requirements, from a transient stability perspective. Note that there are known control issues on the Kenai associated with operating the Kenai islanded, with more than one Bradley Lake unit online, per comments from HEA. This study was not able to reproduce these control problems on the Kenai under these conditions, within the PSS/e model.

In the Anchorage / Southcentral region, at least two units total (including steam units) between Plant 2A (Sullivan) and Southcentral Power Plant (SPP) must be run. Additionally, depending on load in Matanuska Electric Association (MEA), a minimum number of units at Eklutna Generating Station (EGS) and Eklutna Hydro are required to provide voltage support in MEA for certain line outages. Depending on the MEA load, up to 5 units are required to provide the voltage support.

In the GVEA / Fairbanks region, when the Alaska Intertie is initially open, at least one North Pole unit and two additional units in GVEA are required. When the Alaska Intertie is initially closed, running only North Pole Combined Cycle or another North Pole unit in GVEA is acceptable, but there must be a small amount of additional generation online in the Anchorage area to avoid load shedding if the North Pole unit is tripped. Transitions between one unit commitment condition and another and the time required to make such a transition were not evaluated in this study.

The steady-state impact of each of the proposed wind projects, under varying seasonal load conditions and the generation constraints described previously, was evaluated. Adding Little Mt. Susitna and Shovel Creek to the system did not cause any lines to become thermally overloaded or bus voltages to fall outside acceptable limits. No additional voltage control or support equipment, such as capacitors or reactors, are required for the projects to maintain voltage within acceptable limits at the point of interconnection. However, as noted earlier, additional EGS units are required to provide voltage support as load increases and generation constraints in each of the areas must be adhered to. This study did not assess the ability of the minimum generation conditions to meet the regulation requirements imposed by the proposed projects.

Dynamic stability of the system was assessed with both proposed wind projects in-service at maximum output with minimum conventional synchronous generation online. Adding the proposed wind projects to the system did not cause any contingencies to exhibit instability or other violations of the planning criteria. The addition of the projects to the system is feasible from a dynamic stability perspective, as long as the voltage and transient stability minimum generation constraints for each region are met.

The impact of Little Mt. Susitna and Shovel Creek on the transfer limits of the Kenai Tie and Alaska Intertie was also evaluated. Transfer limits were evaluated for the three seasonal load conditions commonly included in Railbelt studies (Summer Valley, Summer Peak, and Winter Peak load), and for conditions where one of the interties is initially out-of-service. Transfer limits were evaluated for both interties in the north and south directions. Other than a small (within the margin of error) reduction in the Kenai Tie northern transfer limits, the proposed wind projects did not result in any reduction in transfer limits. The transfer limits of the interties with the proposed wind projects added are provided in Table 21 through Table 23 of this report.

The protection system relies on adequate fault current to detect and isolate faults. Faults were simulated at two locations in the system with and without Little Mt. Susitna and Shovel Creek, and the change in fault current levels was compared. In most cases, fault current levels decreased, as did bus voltages around the system during the fault. The change in fault current levels should not affect the protection of transmission lines utilizing line differential relaying schemes. Other protection schemes based on mho or quad based protection or ground overcurrent schemes will require additional study and communications assisted protection for all transmission lines will likely be required. Once a final decision has been made for the wind turbines to be used at Little Mt. Susitna and Shovel Creek, protection should be re-checked, particularly near the proposed wind projects, to ensure the protection system continues to operate reliably.

1 Introduction

Electric Power Systems Inc. (EPS) has completed a feasibility and impact study for the addition of 300 MW of wind projects into the Railbelt. This was a joint study for the four largest Railbelt utilities, namely Chugach Electric Association, Inc. (Chugach), Matanuska Electric Association, Inc. (MEA), Homer Electric Association, Inc. (HEA), and Golden Valley Electric Association, Inc. (GVEA). The Railbelt review team requested that the study evaluate the impact of the combined addition of two proposed wind projects, namely the Little Mount Susitna Wind Project ("Little Mt. Susitna") and the Shovel Creek Wind Project ("Shovel Creek"). Little Mt. Susitna is a proposed wind project that would interconnect to the Railbelt between Beluga and Point MacKenzie substations. For this study, the LMS project was modeled at a capacity of 160 MW. Shovel Creek is a proposed wind project that would interconnect to the Railbelt near Fairbanks. For this study, Shovel Creek was modeled at a capacity of 140 MW. The project ratings were determined by the Railbelt review team for this study.

The addition of both projects to the system would significantly increase the penetration of renewables in the Railbelt, adding 300 MW of wind generation to a system with a peak load of about 900 MW. This study assessed the electrical impact of the proposed wind projects, in accordance with existing Railbelt operational and planning criteria.

The impact of the proposed wind projects on the steady-state, dynamic stability, and short-circuit performance of the system was assessed. The new projects were added to the Railbelt planning database, with the minimum transmission additions required for the interconnection. Minimum generation requirements for each region within the Railbelt, including when tie lines are open, were determined with the proposed wind projects in-service. Transfer limits along the interties were also determined, assuming no new significant transmission additions to the system beyond the direct interconnection of each new project. Different interconnection designs for each project were also evaluated.

This study focused on the feasibility of the new projects and electrical system impact from a planning perspective. Existing Railbelt standards and operating practices were used to develop the criteria for evaluating the wind projects. The primary Railbelt standards that apply to evaluating the impact of the new projects are: AKTPL-001, AKMOD-028, AKVAR-001, and AKVAR-002. Additional discussion of these standards and the criteria used to evaluate the projects is included in the report.

2 Background

The proposed Little Mount Susitna Wind Project would be located approximately 35 miles northwest of Anchorage across the Cook Inlet and north of Tyonek. Little Mt. Susitna would connect to the system via one of the existing 230 kV lines between Beluga substation and Point MacKenzie substation. A map of the Little Mt. Susitna project, provided by the developer, is shown in Figure 1. Wind turbines are shown in orange, the proposed path for the interconnection is shown in light green, and existing transmission lines between Beluga and Point MacKenzie are shown in dark green. For this study, multiple options for interconnecting Little Mt. Susitna were evaluated and a detailed discussion of these options is provided in section 4, “Interconnection Designs”.

Orange Dots: Proposed Wind Turbine Site
Neon Green Solid Line: New Transmission Line
Pink Solid Line: New Access Roads
Black Solid Lines: Existing Roads
Yellow Dotted Line: Lease Area
Dark Green Line: Existing Transmission Lines

Figure 1 – Little Mount Susitna Wind Project Overview (Credit: Alaska Renewables)

The proposed Shovel Creek Wind Project would be located approximately 20 miles northwest of Fairbanks near Murphy Dome. A map of the Shovel Creek project, provided by the developer, showing the location of the project in relation to existing transmission lines is provided in Figure 2. Note that the map shows a larger size for Shovel Creek (198 MW) than was investigated in this study. Two potential new transmission paths (the “Rosie Creek Alignment” and the “Moose Creek Alignment”) and two potential new substations (“Rosie Creek Switching Station” and “Moose Creek Switching Station”) are also shown. As part of this study, several interconnection options for Shovel Creek were evaluated. A detailed analysis of the various interconnection options for Shovel Creek is provided in section 4, “Interconnection Designs”.

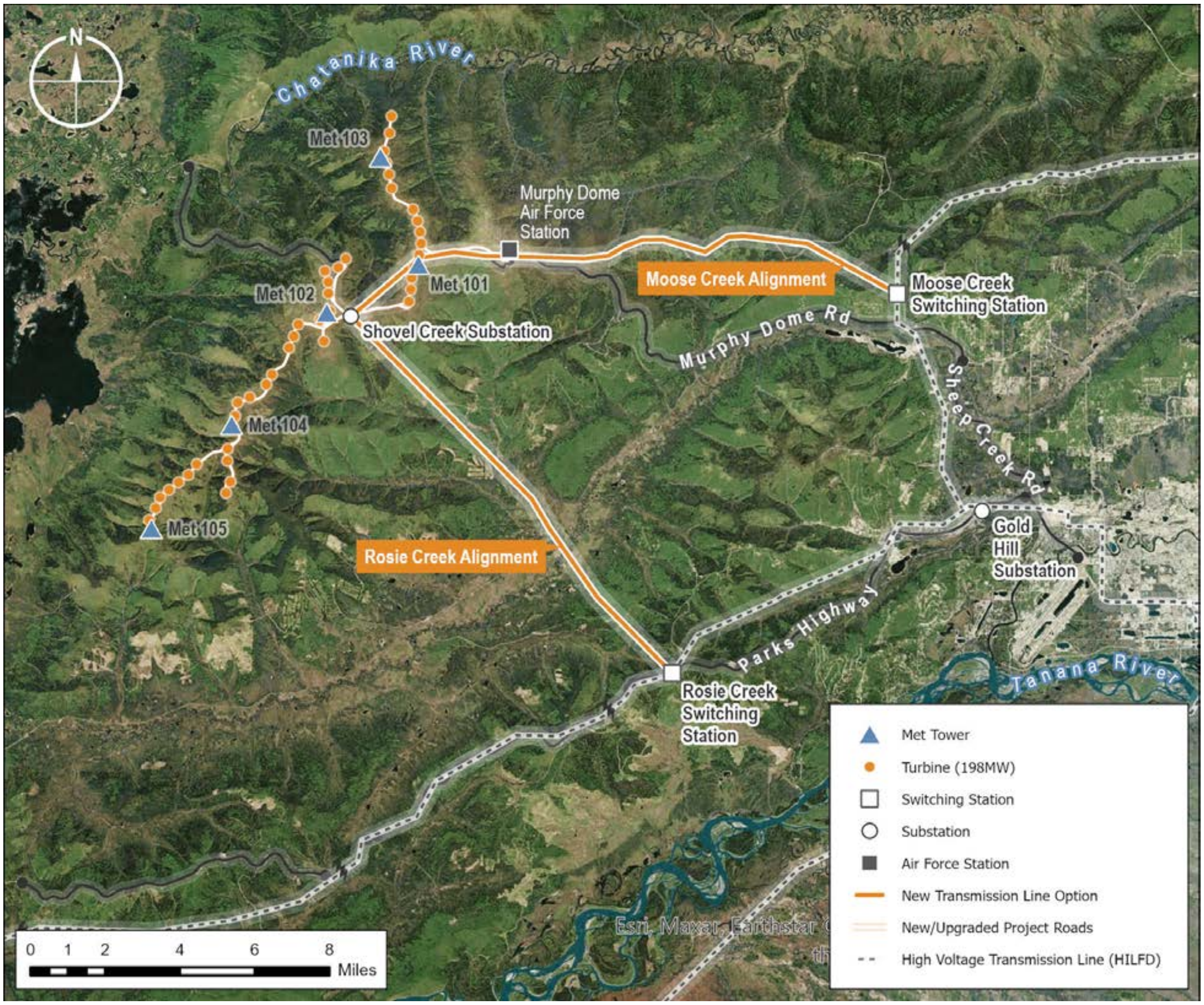

Figure 2 – Shovel Creek Wind Project Overview (Credit: Alaska Renewables)

This study investigated the impact of an additional 300 MW of wind on the steady-state and dynamic performance of the Railbelt. Existing Railbelt reliability standards were used to develop the criteria for evaluating the impact of additional wind, particularly the following standards: AKTPL-001, AKMOD-028, AKVAR-001, and AKVAR-002.

The AKTPL-001 standard describes what system performance is acceptable in response to different types of contingencies. A detailed discussion of the AKTPL-001 standard, and its relevance to the planning criteria used for this study, is provided in section 2.1.

The AKMOD-028 standard provides criteria for determining maximum transfer capability along critical paths, such as the Alaska Intertie and the Kenai Tie. The AKMOD-028 standard states that the methodology for evaluating transfer limits must account for transient stability, voltage stability, and thermal rating limits. All these considerations were included when evaluating the impact of additional wind on transfer limits in section 7.1 of the report.

The AKVAR-001 standard states that each generator facility must meet a voltage or reactive power schedule at its POI with the transmission operator. The AKVAR-002 standard states that each generator must operate with its automatic voltage regulator (AVR) or controller in-service unless the transmission operator has been notified. Discussion of whether additional wind projects are compliant with the AKVAR-001 and AKVAR-002 standards is provided in section 6, "Steady-State Impact".

To perform the impact study, the Power Systems Simulator for Engineering (PSS/e) software tool was used. PSS/e can simulate the steady-state and transient response of the system to a variety of disturbances, including those outlined in the AKTPL-001 standard. In addition to investigating the impact of the proposed wind projects in accordance with relevant planning standards, PSS/e was also used to investigate any sensitivity in the results to variations in system load, control settings, dispatch, and other relevant parameters.

2.1 Planning Criteria

This study investigated the impact of Little Mt. Susitna and Shovel Creek on the steady-state and dynamic performance of the Railbelt, in accordance with defined performance criteria. The criteria were developed for the study given existing Railbelt reliability standards and operating practices.

The AKTPL-001 standard defines different types of contingencies to be studied and describes what acceptable steady-state and dynamic response is for each type of contingency. Different types of contingencies are organized into different categories, denoted "P1" through "P7", with each category having different requirements for what constitutes acceptable system response. For example, line faults are P1-category contingencies, and no under-frequency load shedding is allowed in response to a P1 fault. An outage of multiple circuits on a single transmission tower, however, is a P7-category contingency, and allows up to 10% of system load to be shed. This study focused on the P1 and P2 contingencies from AKTPL-001, which are N-1 (single outage) contingencies.

P1 category contingencies consist of line, generator, and transformer fault / trips. The P2 category contingencies consist of bus faults and internal breaker faults that must be cleared by protection on both sides of the breaker. An extensive list of P1 and P2 contingencies was developed to assess the impact of 300 MW of wind, and these contingencies are listed in "Appendix A – List of Contingencies". All major line and generator outages are included in the list, along with major transformer outages, bus faults, and breaker faults.

Per the AKTPL-001 standard, no P1 or P2 category contingencies may cause under-frequency load shedding. When defining acceptable performance criteria for this study, this requirement was enforced with a few exceptions. The first exception was for contingencies that open one of the two major interties, either the Kenai Tie or Alaska Intertie. Considering that the scope of this study did not evaluate system wide transmission improvements for these projects, the acceptance of some degree of load shedding is in keeping with the study directives. Therefore, the criteria used for this study allows load shedding for contingencies that open either the Kenai Tie or Alaska Intertie. Contingencies from the contingency list that open the Kenai Tie are listed in Table 1, and contingencies that open the Alaska Intertie are listed in Table 2. Load shedding was allowed for these contingencies.

Table 1 – Contingencies That Open the Kenai Tie

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
33	P1	CEA	Dave's Creek - Hope line fault/trip	Dave's Creek	115	3PH	5	5
34	P1	CEA	Quartz Creek - Dave's Creek line fault/trip	Quartz Creek	115	3PH	5	5
38	P1	HEA	Soldotna - Sterling line fault/trip	Soldotna	115	3PH	5	5
167	P2	CEA	University 115 kV bus fault	115 kV bus	115	SLG	5	
177	P2	CEA	Dave's Creek 115 kV bus fault	115 kV bus	115	SLG	5	
186	P2	HEA	Soldotna breaker 2226 internal fault	Bkr 2226	115	SLG	5	

Table 2 – Contingencies That Open the Alaska Intertie

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
45	P1	CEA/MEA	Point MacKenzie - Teeland line fault/trip [1]	Point MacKenzie	230	3PH	5	5
46	P1	CEA/MEA		Teeland	230	3PH	5	5
47	P1	MEA	Teeland - Douglas line fault/trip	Teeland	138	3PH	5	5
48	P1	MEA		Douglas	138	3PH	5	5
59	P1	MEA/GVEA	Douglas - Healy line fault/trip	Douglas	138	3PH	4	30
60	P1	MEA/GVEA		Healy	138	3PH	4	28
160	P2	CEA	Point MacKenzie breaker 4276 internal fault [1]	Bkr 4276	230	SLG	5	
169	P2	MEA	Teeland breaker 4472 internal fault [1]	Bkr 4472	230	SLG	5	
170	P2	MEA	Teeland breaker 4672 internal fault [1]	Bkr 4672	230	SLG	5	
172	P2	MEA	Teeland breaker 538 internal fault	Bkr 538	138	SLG	5	
188	P2	GVEA	Healy 138 kV bus fault	138 kV bus	138	SLG	4	

[1] Opens the Pt. MacKenzie - Teeland line, which, when Teeland - Douglas flow > 50 MVA, will activate the remedial action scheme that opens the Teeland - Douglas line.

The AKTPL-001 standard does not include any category of contingency where a line is initially out-of-service, and a generator outage occurs (N-1-1). Therefore, it is unclear what the AKTPL-001 criteria are with regards to generator outages that occur with one or both major interties initially out-of-service. Simulations showed that, when one area (Kenai / Anchorage / Fairbanks) is islanded from the rest of the system with one or both intertie(s) initially open, generator outages in the islanded area could cause load shedding unless a non-economic unit commitment and dispatch is used. Therefore, load shedding was considered acceptable in the following areas under the following conditions:

- On the Kenai, when the Kenai Tie is open.
- In Anchorage / Southcentral, when both the Kenai Tie and Alaska Intertie are open.
- In GVEA / Fairbanks when the Alaska Intertie is open.

When two or more areas (Kenai / Anchorage / Fairbanks) are interconnected by either the Kenai Tie or Alaska Intertie, load shedding was not considered acceptable for generator outages in those areas. For example, with the Kenai Tie initially open but the Alaska Intertie initially closed, load shedding was not considered acceptable in Anchorage or Fairbanks for generator outages.

No contingency was allowed to cause dynamic instability or loss-of-synchronism. Under steady-state post-contingency conditions, after transients have settled, no contingency was allowed to overload equipment beyond their thermal ratings or result in bus voltages outside 0.95 to 1.05 per-unit.

2.1.1 P2 Contingencies Causing Large Generation Outage

Historically, P2 contingencies (bus and breaker faults) have not been included in the required contingency evaluation list for Railbelt studies. In this study, for completeness, P2 contingencies were simulated and the results of those outages are included here. When evaluating the P2 contingencies, two contingencies were found that could potentially result in a loss-of-generation significantly exceeding the typical 60 MW of contingency reserves carried in the Railbelt for the largest single generating contingency (LSGC). These two contingencies are shown in Table 3.

Table 3 – P2 Contingencies Causing Large Generation Outage

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Clearing Time (Cycles) Far
166	P2	CEA	International (ITSS) breaker 5266 internal fault Lose SPP units 12 and 13 **Up to 100 MW generation trip**	Bkr 5266	138	SLG	5	
183	P2	HEA	Bradley Lake breaker 1310 internal fault Lose Bradley Lake Unit 1 and Unit 2 **Up to 120 MW generation trip**	Bkr 1310	115	SLG	5	

If a breaker fault occurs at International breaker 5266, then both Southcentral Power Plant (SPP) units 12 and 13 are disconnected, and up to 100 MW of generation may be immediately disconnected. Additionally, SPP unit 10 would reduce output due to the loss of steam from unit 12 and unit 13.

If a breaker fault occurs at Bradley Lake breaker 1310 (or breaker 1210), then both Bradley Lake units are disconnected, and a loss of up all the Bradley Lake generation occurs.

Both outages exceed the typical ~60 MW of contingency reserves that are carried in the Railbelt for the largest single generating contingency (LSGC). When configuring cases for this study (see "Appendix B – Dispatch Summaries"), cases were configured assuming a 60 MW contingency reserve requirement. However, this means that for some of the cases shown in "Appendix B – Dispatch Summaries", the outages in Table 3 cause load shedding.

Contingency #183 also affects the minimum generation requirements for the Kenai Peninsula. If the breaker fault at Bradley Lake is included as a possible outage, then some generation at Nikiski or Soldotna must always be run to avoid voltage collapse on the Kenai if both Bradley Lake units are disconnected. More discussion of this is provided in section 5, "Minimum Generation Requirements".

Simulations also showed that, with high output from Bradley Lake or SPP, the contingencies in Table 3 may cause an out-of-step condition along either the Kenai Tie or Alaska Intertie. An out-of-step condition may occur even when tie flows are very low, due to the large power swing that occurs when 100+ MW of generation is tripped. The contingencies in Table 3 were excluded when evaluating intertie transfer limits in section 7.1, otherwise the transfer limits would be severely reduced from historical. Section 7.1 includes discussion of the transfer limit impact if all P2 contingencies, and not just those shown in Table 3, are excluded.

The P2 category contingencies have not historically been evaluated and the issues associated with the contingencies in Table 3 have not previously been seen. Comment from the study committee is needed regarding the P2 contingencies.

3 Model Development

3.1 Railbelt PSS/e Model

The Railbelt PSS/e model is a complete electrical model of the Railbelt, including all significant generators, transmission lines, transformers, and loads. Based on previous studies, routine updates to the Railbelt base cases were made to improve model accuracy. The updates to the Railbelt PSS/e model included the following:

- Fixed Nikiski combustion turbine (CT) unit and steam turbine (ST) unit step-up transformer tap ratios to match documentation from Homer Electric Association (per HEA)
- Removed modeling error for the load at Clear Substation (per GVEA)
- Changed the Soldotna BESS (Battery Energy Storage System) state-of-charge and over-frequency droop parameters (per HEA)
- Fixed erroneous Teeland SVC MVA rating in Winter Peak case

The next system wide Railbelt PSS/e model update should include these modeling changes.

3.2 New International BESS

The new International BESS, which is currently under construction, was included in the model for both the baseline cases and the future cases with the proposed wind projects. The new International BESS was modeled as a 40 MW, 80 MWh BESS that interconnects to the International 34.5 kV bus. No dynamic models for the International BESS have been provided, so the existing Soldotna BESS models were modified to represent the International BESS model. The International BESS was configured with frequency droop and a 0.1 Hz deadband, with the droop set so that, at 59.1 Hz, the full 40 MW output is provided by the BESS.

The new International BESS will provide fast-acting contingency reserves, reducing the need for contingency reserves on thermal units. This reduces operating costs by increasing fuel efficiency. For this study, thermal units were dispatched at or near maximum output when possible and the contingency reserve requirement in each case was met by contributions from the Soldotna BESS, the new International BESS, and contingency reserves within GVEA, including from the Wilson BESS.

3.3 Little Mt. Susitna and Shovel Creek

Little Mt. Susitna and Shovel Creek were added to the existing Railbelt PSS/e model using information from Alaska Renewables and General Electric (GE), and in-line with existing industry practices for modeling wind generation. Preliminary geographic data, wind turbine data, single-line diagrams, and dynamic models were provided by Alaska Renewables and GE. This information was then used to model the proposed wind projects in PSS/e for this study. Where information was unavailable, typical values were assumed.

Preliminary single-line diagrams provided by Alaska Renewables showed Little Mt. Susitna and Shovel Creek each with two medium-voltage / high-voltage transformers, with two 34.5 / 138 kV transformers at Shovel Creek (interconnecting to the 138 kV transmission network) and two 34.5 / 230 kV transformers at Little Mt. Susitna (interconnecting to the 230 kV transmission network). In PSS/e, each project was also modeled with two medium-voltage / high-voltage transformers.

One important modeling assumption made for this study was that the largest single point of failure at either of the new wind projects can create at most a generation outage of 60 MW. This assumption means that the contingency reserve requirement for the Railbelt would not be significantly increased by the addition of new wind projects to the system.

To simulate a 60 MW generation outage at either of the proposed wind projects, one of the two medium-voltage / high-voltage transformers was modeled with 60 MW of wind turbines supplying it, so an outage of this transformer could simulate a loss of 60 MW of wind turbines. The transformer with 60 MW of wind turbines was assumed to have 8% impedance on a 60 MVA base. The other transformer at each project was modeled in PSS/e carrying the rest of the plant output, which was done to simplify the model of each project in PSS/e and does not necessarily reflect how each project substation would be designed to limit the largest single-point-of-failure outage to 60 MW. For example, for a 160 MW wind project, three medium-voltage / high-voltage transformers would likely be required so the outage of a single transformer doesn't cause a loss-of-generation exceeding 60 MW. The second transformer at Little Mt. Susitna, with 100 MW of wind turbines behind it, was modeled with 8% impedance on a 100 MVA base, and the second transformer at Shovel Creek, with 80 MW of wind turbines behind it, was modeled with 8% impedance on an 80 MVA base. No off-nominal tap positions or tap changers were modeled for the medium-voltage / high-voltage transformers.

The industry-standard method[1] of representing wind projects in phasor-domain simulation tools such as PSS/e involves reducing the project's collector system, wind turbine transformers, and wind turbines into a single equivalent collector system impedance, wind turbine transformer, and wind turbine, for each collector circuit. No detailed collector system design or impedance data was available for Little Mt. Susitna or Shovel Creek, so a typical collector system design and reduced equivalent impedance for each collector

[1] E. Muljadi et al., "Equivalencing the collector system of a large wind power plant," *2006 IEEE Power Engineering Society General Meeting*, Montreal, QC, Canada, 2006, pp. 9 pp.-, doi: 10.1109/PES.2006.1708945.

circuit was created and used. Variations in collector system design have minimal impact on the overall project impact to the Railbelt.

No final purchasing decisions have been made for the wind turbines or wind turbine transformers at either Little Mt. Susitna or Shovel Creek. One candidate that has been considered by Alaska Renewables is the GE Sierra platform 3.4-140 wind turbines, and modeling data for these wind turbines (and the transformer included with each wind turbine) was provided to EPS by GE. This information was then used to model the wind turbines at Little Mt. Susitna and Shovel Creek in PSS/e. The GE Sierra 3.4-140 wind turbines are capable of a maximum gross output power of 3.4 MW. Little Mt. Susitna was modeled with 48 of the GE Sierra 3.4-140 wind turbines, with a maximum gross output of 163.2 MW and a net output at the POI of 160 MW (after collector system and transformer losses). Similarly, Shovel Creek was modeled with 42 of the GE Sierra 3.4-140 wind turbines, capable of 142.8 MW gross output and 140 MW net output at the POI (after collector system and transformer losses).

The PSS/e dynamic models for Little Mt. Susitna and Shovel Creek were provided by GE and are custom user-defined models of the GE Sierra 3.4-140 wind turbines. Generic PSS/e renewable models (the "REGC" family of models) were also provided by GE for the Sierra 3.4-140 wind turbines, but simulation convergence problems appeared when the generic models were used, particularly for faults near the proposed wind projects. Convergence problems with the generic renewable models in PSS/e are a well-known issue, so the custom GE models were used instead.

One critical aspect of the dynamic model performance is how wind turbines ride-through faults and low-voltage conditions. When inverter-based resources such as wind turbines detect a low voltage at the inverter terminals, the inverters limit MW output to protect equipment from damage and will only restore the output to the pre-fault MW level in a controlled fashion after the fault is cleared and voltage has recovered. Simulations show that the GE Sierra 3.4-140 wind turbines take about 0.15 seconds (9 cycles) to recover to 100% of the pre-fault MW output (see Figure 3 below). The dynamic stability impact of the proposed wind projects is highly sensitive to how quickly the projects can recover to their pre-fault MW output after a nearby fault. For example, a prolonged reduction in a plant's real power output (for example, up to 160 MW at Little Mt. Susitna) would cause large frequency swings and possible load shedding or instability across the interties. None of these issues were seen with the GE Sierra 3.4-140 wind turbine models, but other wind turbines that have a longer recovery period would have a more severe dynamic stability related impact.

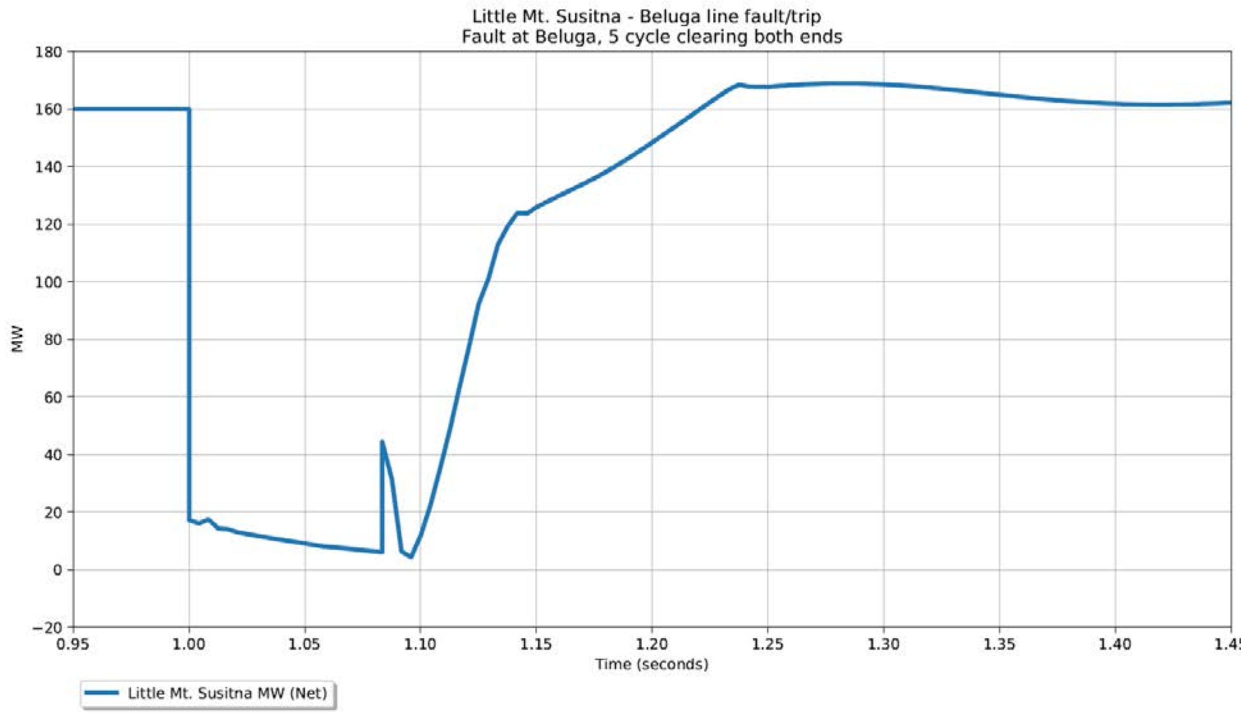

Figure 3 – GE Sierra Wind Turbine MW Recovery After Fault

4 Interconnection Designs

For each of the proposed wind projects, multiple interconnection designs have been considered. Each interconnection design was evaluated in terms of steady-state and dynamic impact to the system, and in terms of the design's ability to meet the Railbelt performance criteria.

For Little Mt. Susitna, two interconnection options were considered. For option #1, two new lines from Little Mt. Susitna on separate towers are built to one of the existing 230 kV lines between Beluga substation and Point MacKenzie substation. This interconnection option has no steady-state or dynamic performance issues and is compliant with the Railbelt planning standards and criteria. A diagram showing interconnection option #1 for Little Mt. Susitna is provided in Figure 4. New additions to the system are highlighted in yellow.

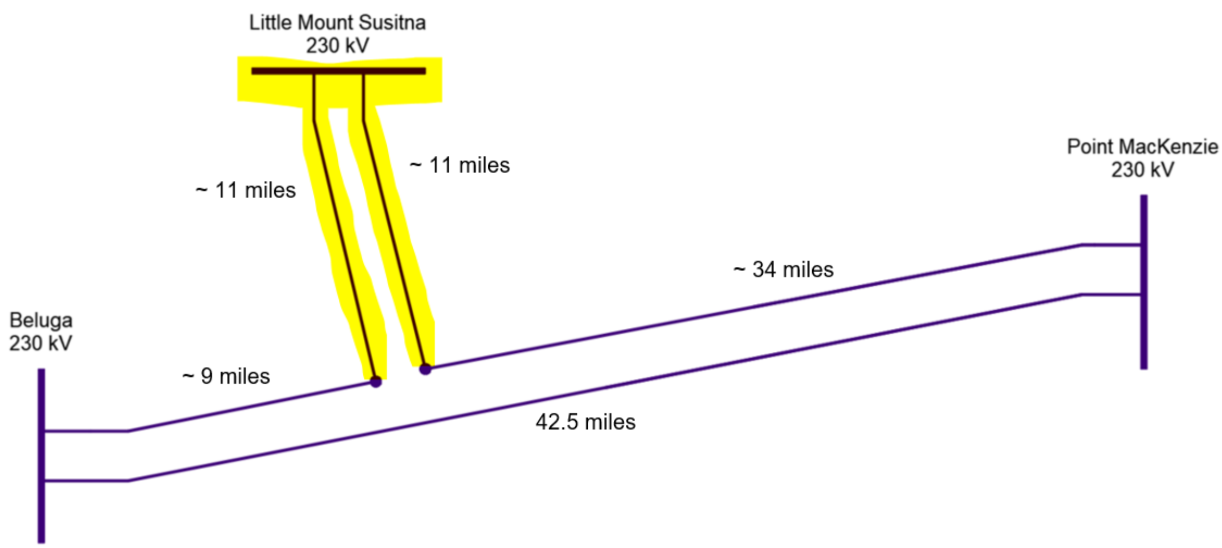

Figure 4 – Little Mount Susitna Interconnection Option #1

Option #2 for interconnecting Little Mt. Susitna to the system is to build a single line from Little Mt. Susitna to a new substation, "Lewis River Switching Station", along one of the 230 kV Beluga – Point MacKenzie lines. Figure 5 shows interconnection option #2, with the new additions highlighted in yellow.

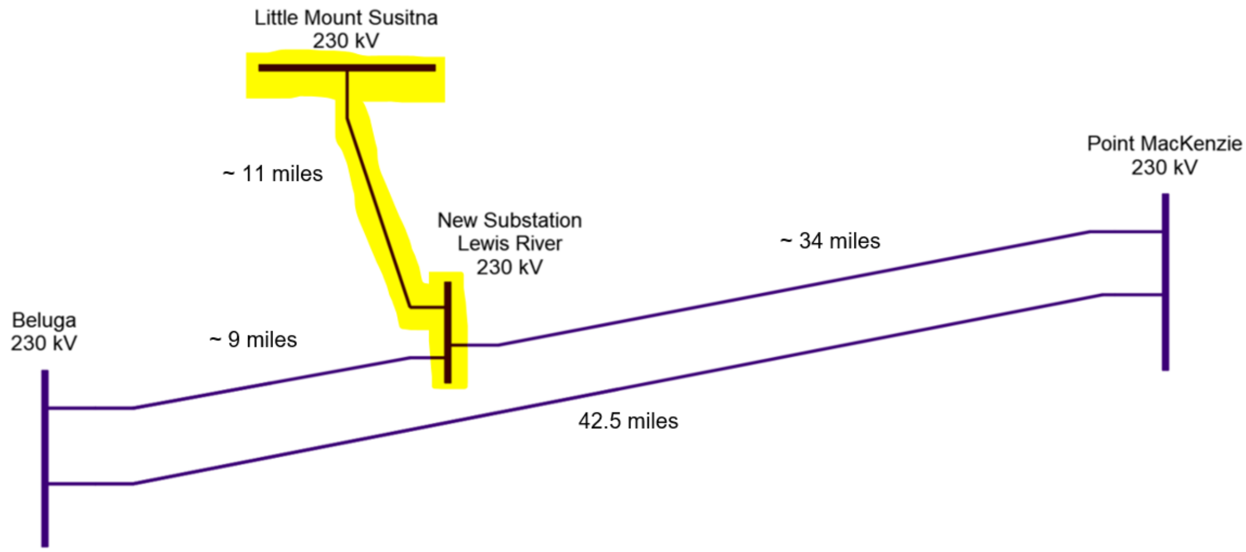

Figure 5 – Little Mount Susitna Interconnection Option #2

Interconnection option #2 does not work for Little Mt. Susitna because, if the single line from Little Mt. Susitna is tripped, under peak wind conditions, a 160 MW loss-of-generation would occur which causes instability and / or large amounts of load shedding.

If interconnection option #1 is chosen, but the two lines leaving Little Mt. Susitna share a common set of towers, then this results in an invalid interconnection option for similar reasons as option #2. A single point of failure outage of one of the towers carrying both lines from Little Mt. Susitna (a “P7” category contingency in the AKTPL-001 standard) would disconnect Little Mt. Susitna entirely from the system, causing instability and / or load shedding in violation of Railbelt planning criteria.

Table 4 shows these three interconnection options for Little Mt. Susitna, noting whether each option is a valid method (based on the planning criteria) of interconnecting Little Mt. Susitna to the system.

Table 4 – Little Mt. Susitna Interconnection Options

Option	Description	Valid?
1	Two new lines from Little Mt. Susitna to existing Beluga - Pt. MacKenzie 230 kV line, lines built on separate towers	Yes
1a	Two new lines from Little Mt. Susitna to existing Beluga - Pt. MacKenzie 230 kV line, lines share common towers	No
2	1) New "Lewis River" substation built along existing Beluga - Pt. MacKenzie 230 kV line 2) One new line from Little Mt. Susitna to Lewis River substation	No

Several interconnection designs were also considered for Shovel Creek. Interconnection option #1 has been proposed by GVEA and includes building a new substation, “Fort Knox Tap”, along the existing Gold Hill – Fort Knox line. Two new lines from Shovel Creek would be built from Shovel Creek to the new Fort Knox Tap substation, and a new line from Fort Knox Tap would be built to North Pole Industrial substation. This interconnection design, shown in Figure 6 below, meets the performance criteria and is an acceptable design for interconnecting Shovel Creek to the system.

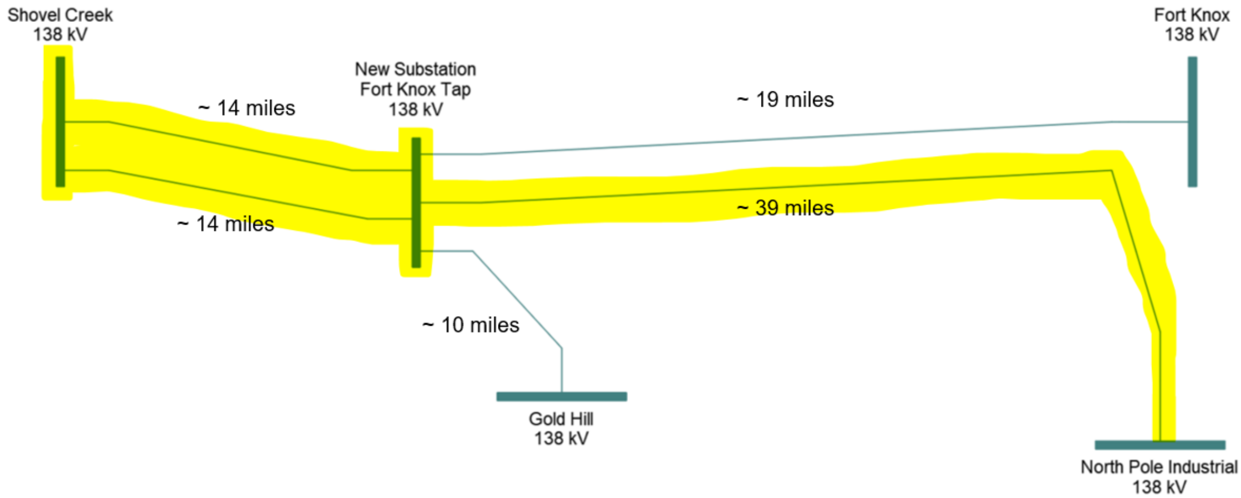

Figure 6 – Shovel Creek Interconnection Option #1

Another option was evaluated, option #2, that does not include building a new substation along the Gold Hill – Fort Knox line but does still include two lines from Shovel Creek to the existing Gold Hill – Fort Knox line. Additionally, a new line from Fort Knox to North Pole Industrial would be built. This interconnection option, shown in Figure 7, is also valid (acceptable based on the planning criteria) and has no issues.

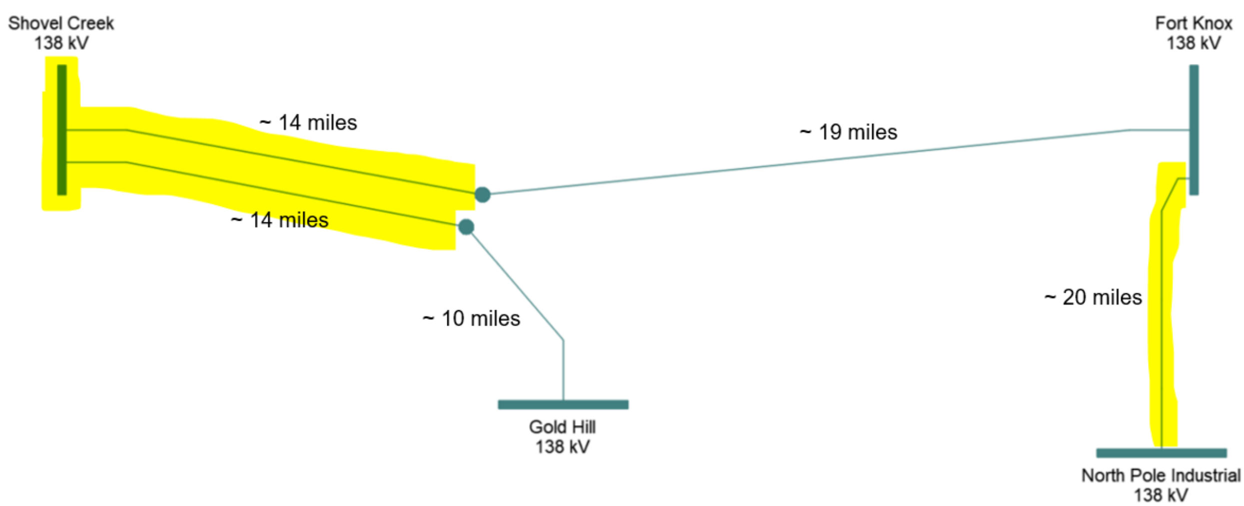

Figure 7 – Shovel Creek Interconnection Option #2

Option #3 was considered and includes two new substations, one along the existing Nenana – Ester line and another along the existing Gold Hill – Fort Knox line and includes a new line from Shovel Creek to each new substation. This interconnection option is shown in Figure 8. No dynamic stability issues were found with this interconnection design, but one case showed a slight (less than 5%) thermal overload of the Rosie Creek – Ester and Ester – Gold Hill lines, if the Shovel Creek – Fort Knox Tap line is tripped. More details of this thermal overload are provided in section 6, "Steady-State Impact", Table 14.

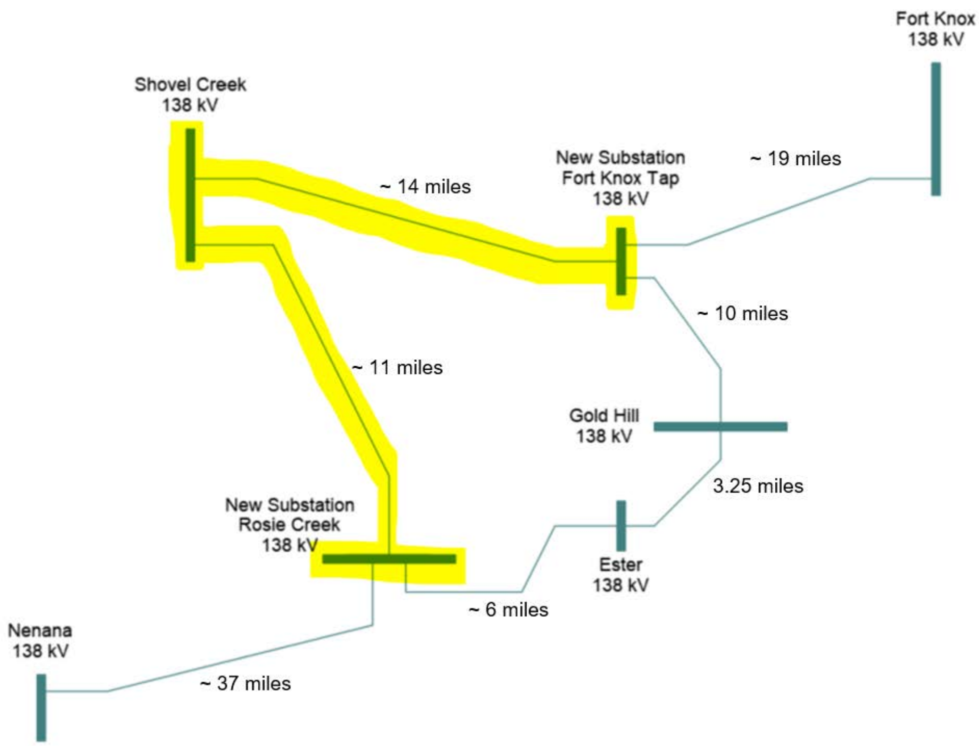

Figure 8 – Shovel Creek Interconnection Option #3

Option #4 includes two lines from Shovel Creek to the existing Nenana – Ester line. This option, shown in Figure 9 below, is not an acceptable interconnection option for connecting Shovel Creek to the system because a fault and trip of the Shovel Creek – Ester line or Ester – Gold Hill line causes dynamic instability. Sensitivity cases were run with all lines between Healy and Gold Hill reconductored to 954 ACSR conductor, but these cases showed dynamic instability for Shovel Creek – Ester and Ester – Gold Hill outages as well. Option #4 is not a valid interconnection option for Shovel Creek.

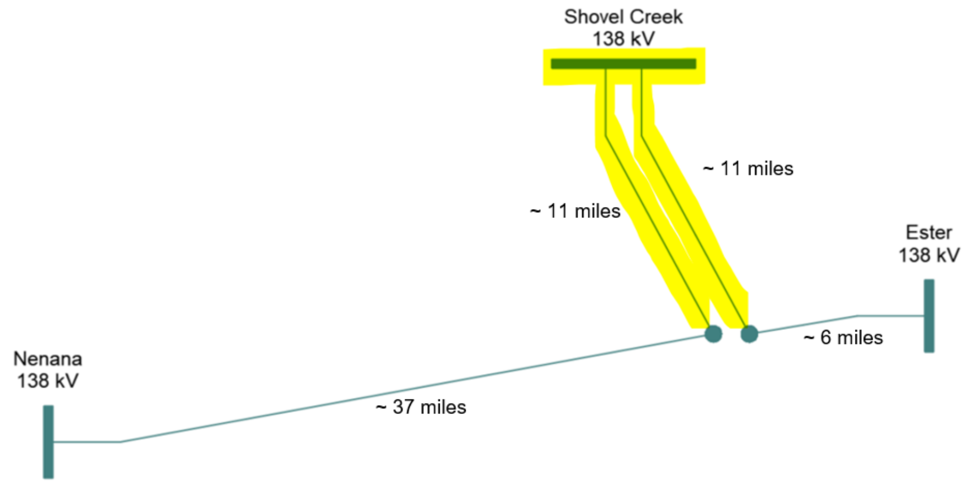

Figure 9 – Shovel Creek Interconnection Option #4

Interconnection option #5 is like option #2, but no new line is built from Fort Knox to North Pole Industrial. This interconnection option does not work because an outage of the Shovel Creek – Gold Hill line disconnects Shovel Creek from the system entirely, tripping up to 140 MW of generation and violating the Railbelt criteria that no single loss-of-generation exceeds 60 MW. Additionally, if Shovel Creek is disconnected from the system via a Shovel Creek – Gold Hill line outage, simulations showed the loss of 140 MW can cause instability across the Alaska Intertie.

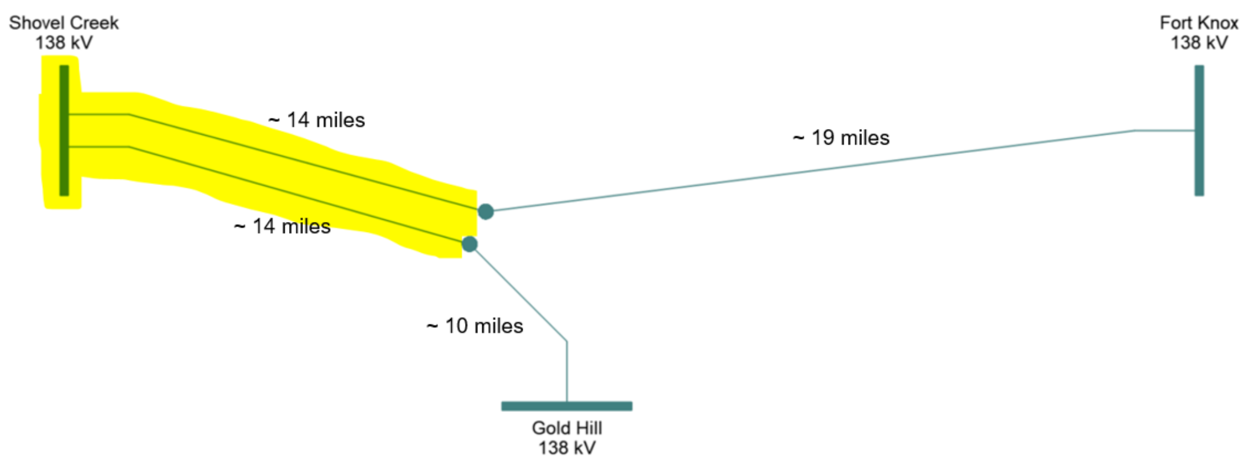

Figure 10 – Shovel Creek Interconnection Option #5

A summary of the various interconnection options investigated for Shovel Creek, including whether each option is valid (meets the performance criteria), is provided in Table 5.

Table 5 – Shovel Creek Interconnection Options

Option	Description	Valid?
1	1) New "Fort Knox Tap" substation built along existing Gold Hill - Fort Knox line 2) Two new lines from Shovel Creek to Fort Knox Tap 3) One new line from Fort Knox Tap to North Pole Industrial	Yes
2	1) Two new lines from Shovel Creek to existing Gold Hill - Fort Knox line 2) One new line from Fort Knox to North Pole Industrial	Yes
3	1) New "Fort Knox Tap" substation built along existing Gold Hill - Fort Knox line 2) New "Rosie Creek" substation built along existing Nenana - Ester line 3) New line from Shovel Creek to Fort Knox Tap 4) New line from Shovel Creek to Rosie Creek	Yes[1]
4	Two new lines from Shovel Creek to existing Nenana - Ester line	No
4a	Two new lines from Shovel Creek to existing Nenana - Ester line, all lines between Healy and Gold Hill reconductored with 954 ACSR	No
5	Two new lines from Shovel Creek to existing Gold Hill - Fort Knox line	No

[1] Slight thermal overload of the Rosie Creek - Ester and Ester - Gold Hill lines for a Shovel Creek - Fort Knox Tap line outage.

5 Minimum Generation Requirements

If Little Mt. Susitna and Shovel Creek are added to the system, then under maximum wind / minimum load conditions, over half of the instantaneous system load could be served by wind generation. Under such operating conditions, significantly less thermal generation would likely be run than in the present-day system, because less thermal units are required to serve load. There are several steady-state and dynamic performance impacts to the system of running less thermal generation, including reductions in system inertia and voltage support. To determine what conventional thermal and hydro units (if any) must be kept online to maintain acceptable system performance from an electrical system performance perspective, simulations were run in each portion of the system, including under conditions when one or both interties are initially out-of-service.

The methodology and criteria for determining the minimum generation requirements were as follows. First, each of the three seasonal base cases (consisting of Summer Valley, Summer Peak, and Winter Peak load) were configured with maximum wind output (including maximum output from Little Mt. Susitna and Shovel Creek). To serve the remaining load in each case, thermal and hydro units were configured under a variety of minimum generation conditions so different minimum generation scenarios could be evaluated with respect to the performance criteria (see section 2.1). For each minimum generation scenario, the contingencies in “Appendix A – List of Contingencies” were simulated to evaluate system performance with minimal generation online.

First, the minimum generation requirements for the Kenai region of the system were assessed. Simulations showed that when the Kenai Tie is initially open north of Dave’s Creek, the Kenai is susceptible to undamped, unacceptable voltage oscillations for some outages. This occurs because of control action at the Soldotna SVC and Dave’s Creek

SVC. Figure 11 below shows the unacceptable voltage oscillations, and Figure 12 shows the MVAR outputs of the SVCs, Bradley Lake, and the Soldotna BESS, for a fault and trip of the Nikiski CC plant. A sensitivity case was run with the Bradley Lake voltage regulation system turned off, and the oscillations remained, further confirming that the oscillations are due to control action from the Soldotna SVC and Dave's Creek SVC.

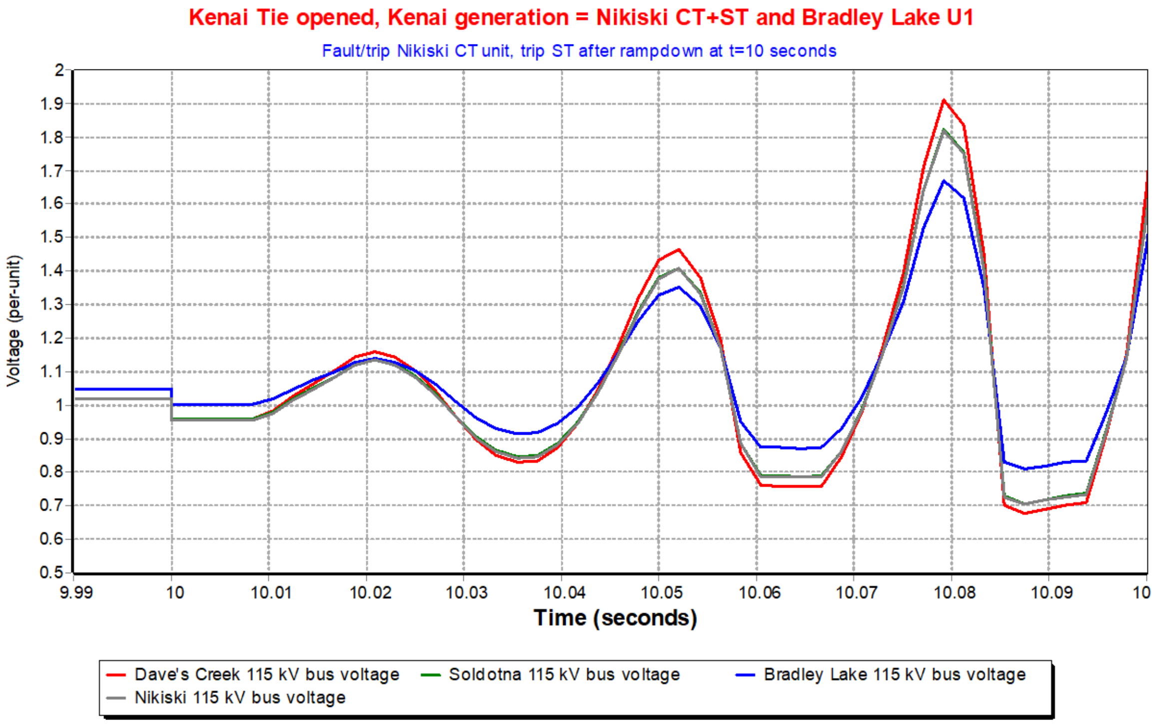

Figure 11 – Bus Voltages for Unstable Kenai Voltage Oscillations

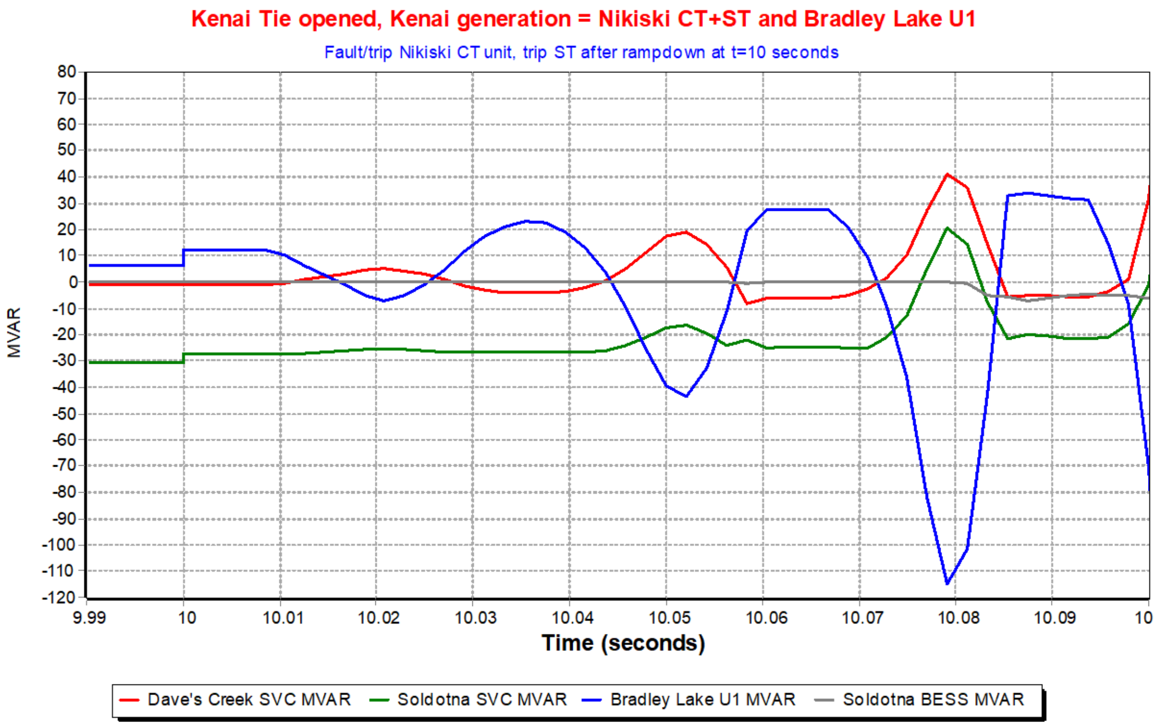

Figure 12 – Unit/BESS/SVC MVAR for Unstable Kenai Voltage Oscillations

The same simulation was rerun with the Soldotna SVC and Dave's Creek SVC voltage regulator gains (KI, CON[J+1] within PSS/e) decreased by a factor of 2, to see if tuning the Soldotna SVC and Dave's Creek SVC could potentially fix the undamped voltage oscillations. Decreasing the voltage control gain at both SVCs prevented the unstable voltage oscillations from occurring. Figure 13 shows Kenai bus voltages for the same simulation shown in Figure 11, but with the SVC voltage gains reduced by half, and Figure 14 shows MVAR outputs for the same simulation. Voltage oscillations still appear in the results, but with the SVC voltage regulator gains cut in half, the oscillations are damped, and the Kenai remains stable. Further reduction of the SVC gains or other tuning of the SVCs would likely reduce the oscillations further and prevent undamped voltage oscillations from occurring on the Kenai when the Kenai Tie is initially open and a disturbance occurs on the Kenai, or the Kenai Tie is initially closed, and a contingency opens the Kenai Tie.

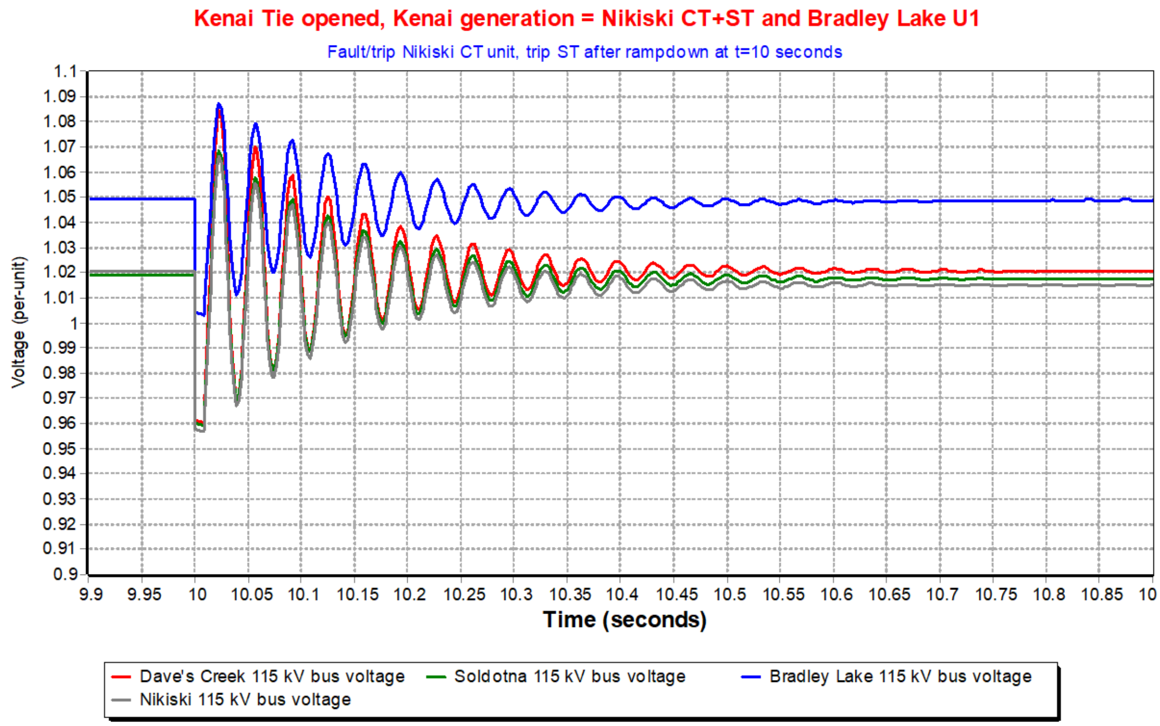

Figure 13 – Bus Voltages (SVC Voltage Regulator Gain Reduced)

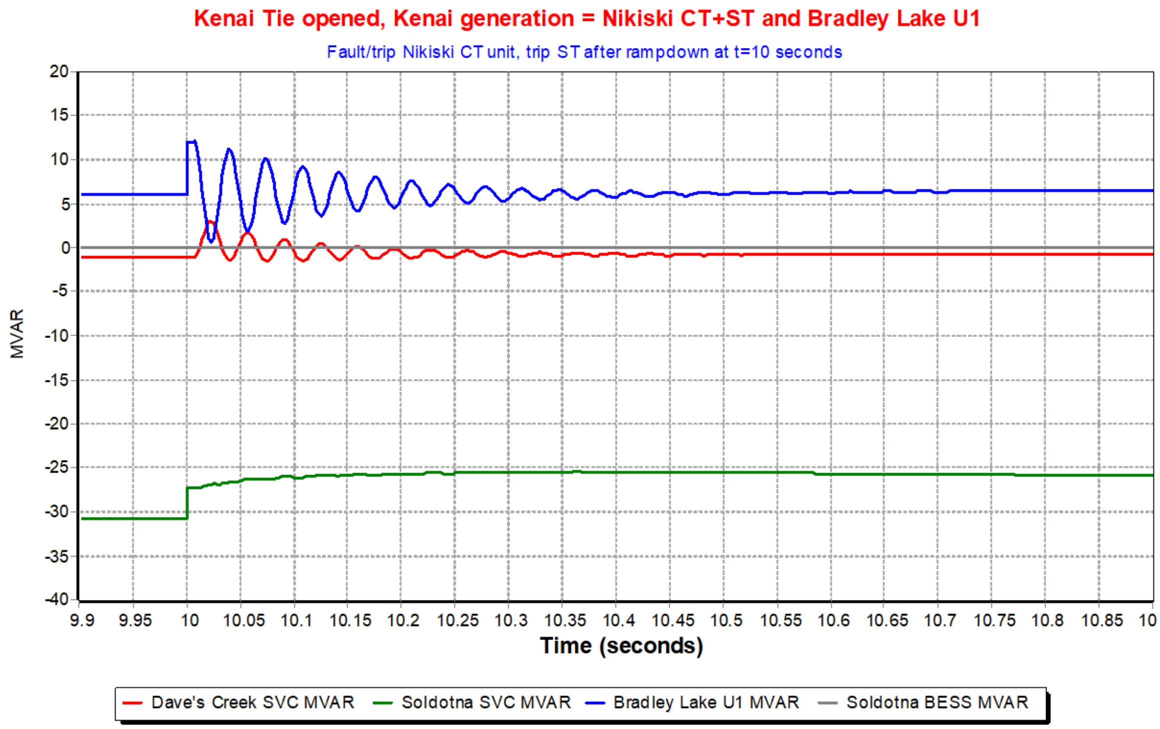

Figure 14 – Unit/BESS/SVC MVAR (SVC Voltage Regulator Gain Reduced)

The minimum generation requirements for the Kenai were found assuming that the SVC tuning issue can be mitigated with future re-tuning of the SVC's. The minimum generation requirements for the Kenai were found for conditions both with the Kenai Tie initially open and initially closed, and for a varying number of units online at Bradley Lake. The Kenai minimum generation requirements are different depending on whether P2 contingencies are included as possible contingencies for defining minimum generation requirements, as there are two P2 contingencies on the Kenai that affect the minimum generation requirements. Table 6 below shows the Kenai minimum generation requirements for two cases, one where P2 contingencies are included in the analysis and one where P2 contingencies are excluded (leaving only P1 contingencies). Table 7 shows the two P2 contingencies that were found to have an impact on Kenai minimum generation requirements. If P2 contingencies are included, at least some Kenai thermal generation must always be online to satisfy the minimum generation requirements, regardless of how many Bradley Lake units are online.

Table 6 – Minimum Generation Required on the Kenai

Kenai Tie Initial Status	Total Bradley Lake Units Online	Additional Kenai Generation Required		Reasoning
		P2 contingencies excluded	P2 contingencies included	
Closed	0	Nikiski CC **and** Soldotna CT	Nikiski CC **and** Soldotna CT	If a contingency occurs and no Nikiski CC, Soldotna CT, or Bradley Lake unit(s) are left online on the Kenai, then voltage collapse occurs. So, with 0 Bradley Lake units online, both Nikiski CC and Soldotna CT must be online so, if an outage occurs, either Nikiski CC or Soldotna CT remains online. With 1 Bradley Lake unit online, either Nikiski CC or Soldotna CT must be online for the same reason. WIth 2 Bradley Lake units online, if P2 contingencies are included, a Bradley Lake breaker 1310 fault (contingency #183) may occur which trips both Bradley Lake units and causes voltage collapse unless Nikiski CC or Soldotna CT is also online. If P2 contingencies are excluded, the Bradley Lake breaker 1310 fault is not considered, and 2 Bradley Lake units alone meets the minimum generation requirements.
	1	Nikiski CC **or** Soldotna CT	Nikiski CC **or** Soldotna CT	
	2	None	Nikiski CC **or** Soldotna CT	
Open	0	Nikiski CC **and** Soldotna CT	Nikiski CC **and** Soldotna CT	With 0 Bradley Lake units online, both Nikiski CC and Soldotna CT must be online so a single outage doesn't cause a blackout on the Kenai. With 1 or 2 Bradley Lake units online, generation at Nikiski CC or Soldotna CT is needed otherwise faults at or near Bradley Lake cause voltage collapse. If P2 contingencies are included in the analysis, then running only a Soldotna CT + Bradley Lake unit(s) does not meet the minimum generation requirements because a fault of Soldotna breaker 2426 (contingency #187) trips both the Soldotna CT and Bradley Lake - Soldotna line, causing voltage collapse. Therefore, if P2 contingencies are included, with 1 or 2 Bradley Lake unit(s) online, Nikiski CC must be online as well.
	1	Nikiski CC **or** Soldotna CT	Nikiski CC	
	2	Nikiski CC **or** Soldotna CT	Nikiski CC	

Table 7 – P2 Contingencies Relevant to Kenai Minimum Generation Requirements

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles)	
							Near	Far
183	P2	HEA	Bradley Lake breaker 1310 internal fault (Both Bradley Lake units disconnected)	Bkr 1310	115	SLG	5	
187	P2	HEA	Soldotna breaker 2426 internal fault (Soldotna CT trips, Bradley Lake - Soldotna line trips)	Bkr 2426	115	SLG	5	

The Anchorage / Southcentral minimum generation requirements were found with a similar methodology to that used to find the Kenai minimum generation requirements, by running the full set of contingencies in "Appendix A – List of Contingencies" and observing system response. Unlike the minimum generation requirements for the Kenai, the minimum generation requirements for Anchorage / Southcentral do not vary depending on whether P2 contingencies are included. Regardless of whether the Kenai Tie and Alaska Intertie are open or closed, two basic minimum generation requirements were found for Anchorage / Southcentral. One is that at least two units total (note that in this context, we count a combined cycle (CC) unit as two units consisting of the CT and the steam unit) must be online between Plant 2A (Sullivan) and SPP, or else a unit fault and trip could cause voltage collapse. The other basic minimum generation requirement is that a minimum number of total units between Eklutna Hydro and Eklutna Generating Station (EGS) must be online so that no line outages cause steady-state bus voltages in MEA to fall below 0.95 per-unit. The line outages that could potentially cause low voltages in MEA are shown in Table 8, and the minimum generation requirements for the Anchorage / Southcentral area are shown in Table 9.

Table 8 – Contingencies Causing Low Voltages in MEA

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles)	
							Near	Far
23	P1	CEA/MEA	Plant 2 - EGS line fault/trip	Plant 2	115	3PH	5	5
24	P1	CEA/MEA		EGS	115	3PH	5	5
49	P1	MEA	Teeland - Cottle - Herning line fault/trip	Teeland	115	3PH	5	5

Table 9 – Minimum Generation Requirements for Anchorage / Southcentral

MEA Load (MW)	Minimum Generation Requirement		Reasoning
	Total (EGS + Eklutna Hydro) Units	Other Units	
< 60	0	At least 2 units total (including steam units) between Plant 2A (Sullivan) and SPP	EGS / Eklutna Hydro units are needed to provide voltage support and keep bus voltages above 0.95 per-unit for certain line outages. At least 2 units total are required between Plant 2A and SPP so that a fault and trip of a unit does not cause voltage collapse.
60 - 70	1		
70 - 80	2		
80 - 100	3		
100 - 120	4		
> 120	5		

In the GVEA / Fairbanks area, the minimum generation requirements do vary depending on whether the Alaska Intertie is initially open or closed. With the Alaska Intertie initially open, at least one North Pole unit (with North Pole Combined Cycle counting as a single unit) and two other units are required so unit faults do not cause voltage collapse. The minimum generation requirements for GVEA / Fairbanks, with the Alaska Intertie initially open, are shown in Table 10.

Table 10 – GVEA / Fairbanks Minimum Generation Requirements (Alaska Intertie Open)

Alaska Intertie Initial Status	Minimum Generation Requirement	Reasoning
Open	At least **one** of the following units: 1) North Pole CC 2) North Pole U1 3) North Pole U2 Also, at least **two** of the following units: 1) Healy Unit 1 2) Chena (Aurora Energy) Unit 5 3) Zehnder Unit 1 or Unit 2 4) Additional North Pole unit (CC, U1, or U2)	Without meeting the minimum generation requirements, if the Alaska Intertie is initially open, unit faults can cause voltage collapse in the GVEA / Fairbanks system.

With the Alaska Intertie initially closed, at least some synchronous generation must be online in GVEA / Fairbanks so that a trip of the Alaska Intertie doesn't cause a blackout in GVEA. Running North Pole Combined Cycle or another North Pole unit is sufficient to avoid blackout for an Alaska Intertie trip. However, simulations showed that, even when the Wilson BESS auto-schedules for the North Pole unit outage, without adequate generation online in the system, load shedding may occur for a North Pole unit outage. To avoid load shedding for a North Pole unit outage (which, when the Alaska Intertie is closed, violates the planning criteria established in section 2.1), additional generation must be online in either the Southcentral area or GVEA area to provide inertia and slow the frequency decline. Table 11 shows several options that prevent load shedding for a North Pole unit trip so that, with the Alaska Intertie closed, no generator outages cause load shedding in violation of the planning criteria.

Table 11 – Minimum Generation Requirement (Alaska Intertie Closed)

Alaska Intertie Initial Status	Minimum Generation Requirement for GVEA / Fairbanks	Additional Generation Required [1]	Reasoning
Closed	One of the following: 1) North Pole CC 2) North Pole U1 or U2	Any of the following: 1) SPP CT + ST 2) Plant 2A (Sullivan) CT + ST, **plus one of the following options**: a) Additional CT at Plant 2A or SPP b) 2 Eklutna Hydro units c) 1 Eklutna Hydro unit and 1 EGS unit d) 3 EGS units 3) Additional North Pole unit 4) Healy Unit 1 5) Chena (Aurora Energy) Unit 5 6) Zehnder Unit 1 or Unit 2	At least some synchronous generation is required in GVEA so that, if the Alaska Intertie trips, a blackout does not occur in GVEA. North Pole CC (the most economic unit) or another North Pole unit is sufficient. With this requirement met, additional generation is required to avoid load shedding if the North Pole unit trips. Several options, seen in the left column, provide enough generation to avoid load shedding for a North Pole unit trip when the Alaska Intertie is initially closed.

[1] Depending on MEA load, enough EGS or Eklutna Hydro units must still be online to provide voltage support and prevent certain line outages from causing bus voltages in MEA to drop below 0.95 per-unit. The "minimum EGS + Eklutna Hydro units as a function of MEA load" requirement must still be enforced.

Note that, when the Alaska Intertie is closed, in addition to the requirements shown in Table 11, the minimum generation requirements for the Anchorage / Southcentral area shown in Table 9 must continue to be enforced. That is, there must still be adequate EGS or Eklutna Hydro units, depending on MEA load, so that no line outages cause steady-state bus voltages in MEA to drop below 0.95 per-unit.

6 Steady-State Impact

The planning criteria state that, under steady-state conditions, bus voltages should remain within 0.95 to 1.05 per-unit and no lines or transformers should become thermally overloaded. To determine whether the addition of the Little Mt. Susitna and Shovel Creek projects impact the ability of the system to meet these requirements, or if additional voltage control devices such as reactors or capacitors are required, power flows were run for each project under varying seasonal load conditions.

With each proposed wind project at maximum MW output, and for each valid interconnection option shown in Table 4 and Table 5, lines associated with the interconnection were taken out-of-service. The power flow was re-solved to determine if the proposed wind projects cause any lines to become thermally overloaded or to determine if voltage control issues occur in the system. Additionally, for each outage, the MVAR flow at each project's POI was recorded to determine the power factor capability that would be required from the projects.

The results of the steady-state analysis for Little Mt. Susitna are shown in Table 12. An outage of either of the lines leaving Little Mt. Susitna does not cause voltage or thermal violations, and the reactive power required to maintain an example voltage schedule (1.00 p.u.) at the POI is well-within reasonable MVAR limits at Little Mt. Susitna. Little Mt. Susitna can maintain a voltage schedule at the POI without the need of additional reactors or capacitors to aid in voltage control. Also, the addition of Little Mt. Susitna to the system does not cause thermal overloading of any lines or transformers, for all N-1 outage conditions. Two of the N-1 outages tested (outages of the lines leaving Little Mt. Susitna) are shown in Table 12. The results in Table 12 show conditions with maximum Little Mt. Susitna output and both interties closed. Other power flows were run with one or both interties opened, and in these cases Little Mt. Susitna was also found to not cause voltage or thermal limit violations.

Table 12 – Little Mt. Susitna Steady-State Results (Both Ties Closed)

Interconnection Option	Outage	System Load	All voltages within 0.95 - 1.05 per-unit?	No thermal limits exceeded?	Little Mount Susitna POI		
					Voltage (p.u.)	MW	MVAR
1	None (all equipment in-service)	Summer Valley	Yes	Yes	1.00	160.0	-25.0
		Summer Peak	Yes	Yes	1.00	160.0	-21.6
		Winter Peak	Yes	Yes	1.00	160.0	-21.2
	Little Mt. Susitna - Beluga line	Summer Valley	Yes	Yes	1.00	160.0	-13.6
		Summer Peak	Yes	Yes	1.00	160.0	-11.5
		Winter Peak	Yes	Yes	1.00	160.0	-11.2
	Little Mt. Susitna - Pt. MacKenzie line	Summer Valley	Yes	Yes	1.00	160.0	-9.4
		Summer Peak	Yes	Yes	1.00	160.0	-9.2
		Winter Peak	Yes	Yes	1.00	160.0	-9.0

Similar analysis was done for Shovel Creek, with maximum Shovel Creek output and both interties in-service. The results are shown in Table 13, showing that, with both interties closed, Shovel Creek does not cause voltage or thermal violations and can maintain voltage control without the need for additional equipment. Additional power flows were also run for each interconnection option for cases with one or both interties out-of-service, and although voltages stayed within 0.95 – 1.05 for all three interconnection options, one case run with interconnection option #3 showed slight thermal overloads in the Summer Peak case if the Alaska Intertie is opened. Sensitivity cases showed that the overload may also occur if the Alaska Intertie is closed and flows along the intertie are near-zero. If interconnection option #3 is used, and the initial flow along the Alaska Intertie is low (or it is initially open), an outage of the Shovel Creek – Fort Knox Tap line can cause a slight thermal overload condition on the Rosie Creek – Ester and Ester – Gold Hill lines (less than 5% above normal rating), as shown in Table 14.

Table 13 – Shovel Creek Steady-State Results (Both Ties Closed)

Interconnection Option	Outage	System Load	All voltages within 0.95 - 1.05 per-unit?	No thermal limits exceeded?	Shovel Creek POI		
					Voltage (p.u.)	MW	MVAR
1	None (all equipment in-service)	Summer Valley	Yes	Yes	1.00	140.0	-16.6
		Summer Peak	Yes	Yes	1.00	140.0	-16.3
		Winter Peak	Yes	Yes	1.00	140.0	-23.3
	Shovel Creek - Fort Knox Tap line	Summer Valley	Yes	Yes	1.00	140.0	-4.3
		Summer Peak	Yes	Yes	1.00	140.0	-10.8
		Winter Peak	Yes	Yes	1.00	140.0	-15.9
	Fort Knox Tap - North Pole Industrial line	Summer Valley	Yes	Yes	1.00	140.0	-2.8
		Summer Peak	Yes	Yes	1.00	140.0	-12.1
		Winter Peak	Yes	Yes	1.00	140.0	-18.3
2	None (all equipment in-service)	Summer Valley	Yes	Yes	1.00	140.0	-16.5
		Summer Peak	Yes	Yes	1.00	140.0	-16.5
		Winter Peak	Yes	Yes	1.00	140.0	-23.1
	Shovel Creek - Fort Knox line	Summer Valley	Yes	Yes	1.00	140.0	-7.6
		Summer Peak	Yes	Yes	1.00	140.0	-7.5
		Winter Peak	Yes	Yes	1.00	140.0	-14.4
	Shovel Creek - Gold Hill line	Summer Valley	Yes	Yes	1.00	140.0	-0.1
		Summer Peak	Yes	Yes	1.00	140.0	-0.9
		Winter Peak	Yes	Yes	1.00	140.0	-0.4
	Fort Knox - North Pole Industrial line	Summer Valley	Yes	Yes	1.00	140.0	-11.4
		Summer Peak	Yes	Yes	1.00	140.0	-10.0
		Winter Peak	Yes	Yes	1.00	140.0	-12.6
3	None (all equipment in-service)	Summer Valley	Yes	Yes	1.00	140.0	-15.9
		Summer Peak	Yes	Yes	1.00	140.0	-15.2
		Winter Peak	Yes	Yes	1.00	140.0	-24.7
	Shovel Creek - Fort Knox Tap line	Summer Valley	Yes	Yes	1.00	140.0	-13.2
		Summer Peak	Yes	Yes	1.00	140.0	-13.1
		Winter Peak	Yes	Yes	1.00	140.0	-19.8
	Shovel Creek - Rosie Creek line	Summer Valley	Yes	Yes	1.00	140.0	-8.2
		Summer Peak	Yes	Yes	1.00	140.0	-7.4
		Winter Peak	Yes	Yes	1.00	140.0	-12.1

Table 14 – Interconnection Option #3 Thermal Overloads

Interconnection Option	Alaska Intertie Status	System Load	Outage	Line Overloads			
				Line	Rating (MVA)	Flow (MVA)	Overload %
3	Opened	Summer Peak	Shovel Creek - Fort Knox Tap line	Rosie Creek - Ester	103	105.2	102.1%
				Ester - Gold Hill	103	106.3	103.2%

Reconductoring the Rosie Creek – Ester and Ester – Gold Hill lines to either 795 ACSR or 954 ACSR would alleviate the thermal overloads if interconnection option #3 is used. Otherwise, no voltage or thermal violations were seen for Shovel Creek, and Shovel Creek is compliant with the steady-state performance requirements outlined in the planning criteria.

7 Stability Impact

The dynamic performance and stability of the system is different with Little Mt. Susitna and Shovel Creek added. Less thermal units are online with 300 MW of new wind added to the system, resulting in lowered system inertia and short-circuit capacity. Additionally, wind turbines behave differently during transient events than conventional synchronous generators. To assess the stability of the system with the proposed wind projects added, a series of contingencies were simulated with both projects added to the system at maximum output, under all three seasonal load conditions (Summer Valley, Summer Peak, and Winter Peak). Then, the results of the simulations were analyzed to determine if any outages cause dynamic instability.

The contingencies that were run to determine the stability impact of Little Mt. Susitna and Shovel Creek include contingencies defined in the AKTPL-001 reliability standard. The AKTPL-001 standard organizes contingencies into categories which differ based on the likelihood of the contingency occurring. To assess the impact of the proposed wind projects, "P1" and "P2" category contingencies were simulated. The "P1" category contingencies consist of line, generator, transformer, BESS, and static VAR compensator (SVC) outages. The "P2" category contingencies consist of bus faults and breaker faults that must be cleared by adjacent protection.

The full contingency list contains all significant line outages in the system, as well as all significant generator, transformer, BESS, and SVC outages as well. Bus and breaker faults were included for most major substations to further assess the potential impact of the projects. It is important to note that the existing Railbelt (without the new wind projects) has not been fully evaluated for compliance with all category "P2" contingencies, to date. P2 contingencies were evaluated in this study to provide the Railbelt with feedback for contingencies that may not be currently compliant. Other contingencies from the AKTPL-001 standard which are less common and do not inform the assessment of the impact of Little Mt. Susitna or Shovel Creek were not evaluated. The planning criteria discussed in section 2.1 of the report were used to evaluate the system response to all contingencies.

With both proposed wind projects added to the system at maximum output, only two contingencies showed dynamic instability or other dynamic performance issues, for conditions with the system at nominal transfer levels on the tie lines. Nominal transfer levels are defined here to be well below the known transfer limits for the existing system. Higher transfer levels were also evaluated, and those results are discussed below. The two contingencies that violate the planning criteria are P2 contingencies, shown in Table 15, and these were previously discussed in section 2.1.1. The contingencies shown in Table 15 violate the planning criteria for the system without added wind, so the addition of 300 MW of wind to the system is irrelevant to why the contingencies in Table 15 violate the planning criteria.

Table 15 – P2 Contingencies Causing Large Generation Outage

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
166	P2	CEA	International (ITSS) breaker 5266 internal fault Lose SPP units 12 and 13 **Up to 100 MW generation trip**	Bkr 5266	138	SLG	5	
183	P2	HEA	Bradley Lake breaker 1310 internal fault Lose Bradley Lake Unit 1 and Unit 2 **Up to 120 MW generation trip**	Bkr 1310	115	SLG	5	

The Little Mt. Susitna and Shovel Creek projects were not found to create any new instabilities to the system, under any of the three seasonal load conditions, under nominal transfer levels. None of the valid (acceptable per the planning criteria) interconnection options discussed in section 4 showed instabilities or a degraded transient response compared to the other valid interconnection options. Simulations showed that the addition of the proposed wind projects to the system is feasible, from a steady-state and transient stability perspective.

7.1 Transfer Limits

One potential stability-related impact of the proposed wind projects is a possible change in the transfer limits along the critical interties. There are two critical interties in the Railbelt. The first is the Kenai Tie, which connects the Kenai Peninsula to the rest of the system. The second is the Alaska Intertie, which connects GVEA and the Fairbanks area to the rest of the system. If the Little Mt. Susitna and / or Shovel Creek projects change the transfer limits of the Kenai Tie or the Alaska Intertie, this would impact operations and could negatively impact system economics. Simulations were run to determine the transfer limits on the Kenai Tie and on the Alaska Intertie with the proposed wind projects in service.

7.1.1 Methodology

The AKTPL-001 standard provides the criteria for acceptable system steady-state and stability performance in response to contingencies. The AKMOD-028 standard provides criteria for determining transfer limits and the methodology to use. The AKMOD-028 standard states that the transfer limits methodology must account for steady-state voltage stability, dynamic stability, and thermal limits considerations. The results of the study showed that dynamic stability and steady-state voltage stability were more limiting considerations than the thermal limits of each intertie. The thermal limits used in this study are provided in Table 16. The thermal limits were taken from the Railbelt PSS/e database and are defined as the lowest MVA rating of any segment of the intertie.

Table 16 – Intertie Thermal Limits

Intertie	Thermal Limit (MVA) Summer	Winter
Kenai Tie	96	173
Alaska Intertie	103	241

To determine the transfer limits of each intertie, intertie flows were varied in 5 MW increments until one or more contingencies violated the planning criteria by causing dynamic instability or steady-state bus voltages outside 0.95 – 1.05 per-unit. Transfer limits were found both for the case where P1 and P2 contingencies are included, and for the case where only P1 contingencies are included. The transfer limit is the maximum transfer at which no contingencies cause planning criteria violations. No safety margin or additional safety factor was included in the transfer limits results. To change intertie transfers, generation commitment and dispatch were varied in each region of the system while trying to maintain an economic dispatch, assuming the entire Railbelt is operated as a single load balancing area (LBA). The Kenai Tie transfer was measured from Dave's Creek to Hope, and the Alaska Intertie transfer was measured from Douglas to Stevens (at Douglas breaker B1).

The minimum generation requirements for each region were enforced for all cases. On the Kenai, it was assumed that P2 contingencies were excluded when determining the minimum generation requirements, so Bradley Lake units could be run without any thermal generation on the Kenai.

To determine the impact of the Little Mt. Susitna and Shovel Creek projects on transfer limits, the transfer limits were first found for the system without adding the projects to establish baseline results. Then, the transfer limits were assessed with Little Mt. Susitna and Shovel Creek added to the system, and the results were compared. The transfer limits were found with both interties initially closed, and with either the Kenai Tie or Alaska Intertie initially opened, so any changes in transfer capacity that occur with one of the interties out-of-service could be determined. The new International BESS was included in all cases, and Healy Unit 2 was offline in all cases.

7.1.2 Baseline Results

The transfer limits for the system without the proposed wind projects, and with both interties closed, are shown in Table 17. Maximum transfer north was found for both the Kenai Tie and Alaska Intertie, but maximum transfer south was only found for the Kenai Tie, as system economics dictate the present-day system is not likely to experience high Alaska Intertie flows south (from Fairbanks to Anchorage). Descriptions of the limiting contingencies are provided in Table 18. Under Summer Peak load conditions, with both interties initially closed, the Alaska Intertie transfer limit was found to be 10 MW greater if P2 contingencies are excluded. No Kenai Tie southern transfer limit was found under Summer Valley load conditions due to low load on the Kenai and a resultant inability to achieve high flows south onto the Kenai. Dispatch summaries for the baseline cases with both interties closed are provided in "Appendix B – Dispatch Summaries", Table 27 and Table 28.

Table 17 – Baseline Transfer Limits (Both Interties Closed)

	Kenai Tie Transfer North			Kenai Tie Transfer South			Alaska Intertie Transfer North		
System Load	Limit (MW)	Limiting Contingencies	Limited by...	Limit (MW)	Limiting Contingencies	Limited by...	Limit (MW)	Limiting Contingencies	Limited by...
Summer Valley	90	43	Voltage	N/A [1]	None	N/A	75	2, 4, 23	Stability
Summer Peak	85	43	Voltage	75	23	Stability	70	194 [2]	Voltage
Winter Peak	85	43	Voltage	60	23	Stability	70	2	Stability

[1] No transfer limit found due to lack of load on the Kenai.

[2] Note that this a category P2 contingency. If P2 contingencies are excluded, the limit goes from 70 MW to 80 MW and is stability limited by contingency 2, 4, and 23.

Table 18 – Limiting Contingencies

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Clearing Time (Cycles) Far
2	P1	CEA	230 kV undersea cable fault/trip	Plant 2 Tap	230	3PH	5	5
4	P1	CEA	138 kV undersea cable fault/trip	International	138	3PH	5	5
23	P1	CEA/MEA	Plant 2 - EGS line fault/trip	Plant 2	115	3PH	5	5
43	P1	CEA	Dave's Creek SVC fault/trip	Dave's Creek	115	3PH	5	5
194	P2	GVEA	Wilson breaker B5 internal fault Trip Wilson BESS and Wilson - Gold Hill line	Bkr B5	138	SLG	4	

The transfer limits north along the Alaska Intertie with the Kenai Tie initially open were also found, for the system without the proposed wind projects. These transfer limits are shown in Table 19 below, and dispatch summaries of these cases are provided in Table 29. If P2 contingencies are excluded, under Summer Peak load conditions, the transfer limit is increased from 70 MW to 75 MW.

Table 19 – Baseline Alaska Intertie Transfer Limits with Kenai Tie Open

	Alaska Intertie Transfer North		
System Load	Limit (MW)	Limiting Contingencies	Limited by...
Summer Valley	70	2, 4, 23	Stability
Summer Peak	70	194 [1]	Voltage
Winter Peak	65	2, 4, 23	Stability

[1] Note that this is a category P2 contingency. If P2 contingencies are excluded, the limit goes from 70 MW to 75 MW and is stability-limited by contingencies 2, 4, and 23.

The transfer limits north and south along the Kenai Tie when the Alaska Intertie is initially open were also found. These results are shown in Table 20, and dispatch summaries for these cases are provided in Table 30 and Table 31.

Table 20 – Baseline Kenai Tie Transfer Limits with Alaska Intertie Open

	Kenai Tie Transfer North			Kenai Tie Transfer South		
System Load	Limit (MW)	Limiting Contingencies	Limited by…	Limit (MW)	Limiting Contingencies	Limited by…
Summer Valley	90	43	Voltage	N/A [1]	None	N/A
Summer Peak	85	43	Voltage	70	23	Stability
Winter Peak	85	43	Voltage	65	23	Stability

[1] No transfer limit found due to lack of load on the Kenai.

7.1.3 Results with Little Mt. Susitna and Shovel Creek Added

Transfer limits were then found with the Little Mt. Susitna and Shovel Creek projects added to the system.

With both interties closed, the only reduction in transfer limits found with the proposed wind projects in-service was a 5 MW decrease in the Kenai Tie northern transfer limit under Summer Peak and Winter Peak load conditions. The analysis uses a 5 MW “step size” when determining transfer limits. Therefore a 5 MW reduction in a transfer limit is considered within the margin of error when determining the transfer limits, based on the accuracy of the PSS/e models and input data. Table 21 shows the change in transfer limits with the proposed wind projects in-service and both the Kenai Tie and Alaska Intertie initially closed.

When determining the transfer limits with Little Mt. Susitna and Shovel Creek added, it was assumed that the largest single contingency outage at either wind project did not exceed 60 MW. Additionally, it was assumed that the Wilson BESS could be configured to auto-schedule for Shovel Creek outages in the same manner that the Wilson BESS currently auto-schedules for GVEA unit outages. Transfer limits that are dependent on the Wilson BESS auto-scheduling for Shovel Creek outages are noted in Table 21.

The limiting contingency for the reduction in the Kenai Tie transfer limit north was a Dave’s Creek SVC outage (contingency #43). Dispatch summaries for the cases shown in Table 21 are provided in Table 32 and Table 33.

Electric Power Systems inc. Consulting Engineers

Table 21 – Future Transfer Limits (Both Interties Closed)

Intertie	Direction	System Load	Transfer Limit (MW)	Change From Present-Day (MW)
Kenai Tie	North	Summer Valley	90	0
		Summer Peak	80	-5
		Winter Peak	80	-5
	South	Summer Valley	N/A [1]	0
		Summer Peak	75	0
		Winter Peak	60	0
Alaska Intertie	North	Summer Valley	75 [2]	0
		Summer Peak	70 [2, 3]	0
		Winter Peak	70 [2]	0
	South	Summer Valley	75	N/A[4]
		Summer Peak	80	N/A[4]
		Winter Peak	80	N/A[4]

[1] No transfer limit found due to lack of load on the Kenai.
[2] Result dependent on Wilson BESS auto-scheduling for Shovel Creek outages.
[3] If P2 contingencies are excluded, limit is 80 MW and there is no change from present-day.
[4] No Alaska Intertie southern transfer limits were found for the present-day cases.

The impact of Little Mt. Susitna and Shovel Creek on Alaska Intertie transfer limits when the Kenai Tie is initially open was also found. Simulations showed the proposed wind projects do not affect the Alaska Intertie transfer limits when the Kenai Tie is initially open. These results are shown in Table 22, and dispatch summaries for these cases are provided in Table 34 and Table 35.

Table 22 – Future Alaska Intertie Transfer Limits with Kenai Tie Opened

		Alaska Intertie	
Direction	System Load	Transfer Limit (MW)	Change From Present-Day (MW)
North	Summer Valley	70	0
	Summer Peak	70 [1, 2]	0
	Winter Peak	65 [1]	0
South	Summer Valley	70	N/A[3]
	Summer Peak	80	N/A[3]
	Winter Peak	80	N/A[3]

[1] Result dependent on Wilson BESS auto-scheduling for Shovel Creek outages.
[2] If P2 contingencies are excluded, limit is 75 MW and there is no change from present-day.
[3] No Alaska Intertie southern transfer limits were found for the present-day cases.

With the Alaska Intertie initially open, Little Mt. Susitna and Shovel Creek were found to reduce the Kenai Tie northern transfer limit slightly (by 5 MW) for all three seasonal load conditions. The Kenai Tie southern transfer limits were unchanged. These results are shown in Table 23, and dispatch summaries for these cases are provided in Table 36 and Table 37. The limiting contingency for Kenai Tie transfers north was an outage of the Dave's Creek SVC (contingency #43).

Table 23 – Future Kenai Tie Transfer Limits with Alaska Intertie Opened

		Kenai Tie	
Direction	System Load	Transfer Limit (MW)	Change From Present-Day (MW)
North	Summer Valley	85	-5
	Summer Peak	80	-5
	Winter Peak	80	-5
South	Summer Valley	N/A [1]	0
	Summer Peak	70	0
	Winter Peak	65	0

[1] No transfer limit found due to lack of load on the Kenai.

The only reduction in transfer limits seen with Little Mt. Susitna and Shovel Creek added to the system was a 5 MW reduction to the Kenai Tie northern transfer limit. A 5 MW reduction is a single "step" using the transfer limits methodology and is within the error margin when determining transfer limits. Under all seasonal load conditions, and with varying intertie status combinations, Little Mt. Susitna and Shovel Creek were not found to have a significant stability or transfer limit impact on the system.

8 Protection Impact

Wind turbines (and other inverter-based resources) typically provide less fault current than similarly sized conventional generation. Under high wind output conditions, less thermal units may be run, resulting in further reduction in fault current levels. Lowered fault current levels also result in changes to the system voltages during faults. In addition to the level of fault currents, inverter-based generation may not provide fault current at a constant fault angle during transmission faults. The lack of a consistent fault angle and low source impedance behind the protection will negatively impact the operation of impedance based or directional overcurrent based protective systems.

Two faults were simulated, both with and without the proposed wind projects, to assess the change in fault current that may occur with Little Mt. Susitna and Shovel Creek added to the system. Three-phase bolted faults were simulated at the Point MacKenzie 230 kV bus and the Wilson 138 kV bus, both for the baseline cases without added wind and the future cases with both wind projects at maximum output. The results, showing the change in fault current levels across the three seasonal load cases, are shown in Table 24.

Under Summer Peak and Winter Peak load levels, the addition of the proposed wind projects showed a 12%-15% decrease in fault current at Point MacKenzie and Wilson. Under Summer Valley load, there was a large decrease in fault current available at Point MacKenzie, and a large increase in available fault current at Wilson. The increase in fault current at Wilson occurs because, in the two "Summer Valley" cases shown below with and without the proposed wind projects, unit commitment in Fairbanks is not different, except for the addition of Shovel Creek. The case with Little Mt. Susitna and Shovel Creek has an additional fault current contribution from Shovel Creek within the GVEA region. For the cases with Little Mt. Susitna and Shovel Creek added, all the thermal units that were turned off were in Anchorage and on the Kenai. This explains why the fault current decreased for a fault near Anchorage but increased for a fault in Fairbanks in the summer valley case.

Table 24 – Fault Current Comparison

Fault Location	Fault Type	System Load	Fault Current (kA)		% change
			Without Little Mt. Susitna and Shovel Creek	With Little Mt. Susitna and Shovel Creek	
Point MacKenzie 230 kV	Bolted 3Ø	Summer Valley	3.37	1.76	-48%
		Summer Peak	4.52	3.84	-15%
		Winter Peak	4.57	4.02	-12%
Wilson 138 kV	Bolted 3Ø	Summer Valley	1.53	2.33	52%
		Summer Peak	2.71	2.39	-12%
		Winter Peak	2.78	2.43	-13%

As shown in Table 24, fault current levels vary significantly with system load. During heavy load conditions, more units are online, and fault current levels are greater. Under lighter load conditions, less units are online, and fault current levels are reduced.

Reductions in fault current levels change bus voltages around the system during faults. For the Pt. MacKenzie 230 kV bus fault shown in Table 24, fault current levels were reduced in all three seasonal load cases with the proposed wind projects in-service. For these faults, bus voltages at other buses in the system during the fault at Point MacKenzie were measured and compared, both for the cases without the proposed wind projects and the cases with the proposed wind projects. The results are shown in Table 25 below. At all three of the buses measured, during the fault at Point MacKenzie, bus voltages were lower in the cases with reduced fault current.

Table 25 – Comparison of System Voltages During Fault

Fault Location	Fault Type	System Load	Remote Bus Voltage (p.u.) During Fault			
			Bus Name	Without Little Mt. Susitna or Shovel Creek	With Little Mt. Susitna and Shovel Creek	% change
Point MacKenzie 230 kV	Bolted 3Ø	Summer Valley	University 138 kV	0.28	0.09	-68%
			International 138 kV	0.32	0.09	-72%
			Hospital 115 kV	0.38	0.12	-68%
		Summer Peak	University 138 kV	0.32	0.28	-13%
			International 138 kV	0.35	0.31	-11%
			Hospital 115 kV	0.52	0.34	-36%
		Winter Peak	University 138 kV	0.32	0.28	-12%
			International 138 kV	0.35	0.32	-9%
			Hospital 115 kV	0.54	0.40	-27%

Research is currently ongoing as to how to protect systems with high shares of inverter-based resources (IBRs), such as wind turbines. Preliminary results[2] from a system with a high share of IBRs (including wind turbines) show that, while differential relaying should continue to operate correctly, other protection schemes such as distance relaying or permissive over-reaching transfer trip (POTT) schemes may mis-operate with high shares of IBRs.

No final selection of wind turbines at Little Mt. Susitna and Shovel Creek has been made. Once wind turbines are selected and more information is known about the short-circuit and protection system behavior of the wind turbines, protection schemes should be checked for coordination (particularly near the proposed wind projects) to ensure reliable operation.

9 Conclusions

EPS has completed an impact and feasibility study for the Little Mount Susitna Wind Project and Shovel Creek Wind Project. This study evaluated the electrical performance impacts of the projects in accordance with defined performance criteria. This study also evaluated the feasibility of different interconnection options for each project, and the minimum generation requirements of the system.

Several interconnection options were evaluated for each project. It was assumed that new wind projects cannot have a single-point-of-failure that causes a greater than 60 MW loss-of-generation, so interconnection options that allow for this were considered unacceptable. Each interconnection option was also evaluated in terms of planning criteria violations or dynamic instability. One acceptable interconnection option was presented for Little Mt. Susitna, and multiple acceptable interconnection options were presented for Shovel Creek that meet the performance requirements and criteria.

[2] S. Sano, Evolution of Protection Schemes for a High Share of IBR, https://www.esig.energy/event/webinar-evolution-of-protection-schemes-for-a-high-share-of-ibr/

The minimum generation requirements for the system were also evaluated in accordance with the planning criteria. In each region of the system (Kenai, Anchorage, Fairbanks), the minimum generation required to meet steady-state and dynamic performance requirements was evaluated, both for conditions with intertie(s) initially open and intertie(s) initially closed.

Power flows were run to evaluate the steady-state impact of each project, under varying seasonal load conditions and with different interconnection options. The addition of the proposed wind projects to the system was not found to cause steady-state planning criteria violations, and each project was found to have no issues maintaining voltage control at the POI.

Dynamic stability of the system was evaluated with both proposed wind projects in-service at maximum output. The projects were not found to cause dynamic instability or planning criteria violations at nominal transfer levels. Intertie transfer limits, which in some cases are constrained by dynamic stability limitations, were also evaluated with the proposed wind projects in-service. Other than for a small (within the margin-of-error) reduction in the Kenai Tie northern transfer limit, the proposed wind projects were not found to cause any reductions in transfer limits.

The change in available short-circuit current was evaluated with Little Mt. Susitna and Shovel Creek in-service, and in most cases some reduction in fault current was found, as expected. Despite the change in fault current levels, the primary protection scheme, i.e. line differential relaying, should continue to operate correctly. Whether other protection schemes need to be modified is highly dependent on the wind turbines used and what the short-circuit behavior is of the wind turbines. Once a final selection is made for the wind turbines to be used at Little Mt. Susitna and Shovel Creek, and detailed short-circuit models are available, further review of the protection schemes (particularly near the proposed wind projects) should be done to ensure correct protection system operation.

10 Appendix A – List of Contingencies

Table 26 – Contingency List

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
1	P1	CEA	230 kV undersea cable fault/trip	Point MacKenzie	230	3PH	5	5
2	P1	CEA		Plant 2 Tap	230	3PH	5	5
3	P1	CEA	138 kV undersea cable fault/trip	Point MacKenzie	138	3PH	5	5
4	P1	CEA		International	138	3PH	5	5
5	P1	CEA	Beluga - Point MacKenzie 230 kV line fault/trip	Beluga	230	3PH	5	5
6	P1	CEA		Point MacKenzie	230	3PH	5	5
7	P1	CEA	Beluga - Point MacKenzie 138 kV line fault/trip	Beluga	138	3PH	5	5
8	P1	CEA		Point MacKenzie	138	3PH	5	5
9	P1	CEA	International - University line fault/trip	International	138	3PH	5	5
10	P1	CEA		University	138	3PH	5	5
11	P1	CEA	International - Retherford line fault/trip	International	138	3PH	5	5
12	P1	CEA		Retherford	138	3PH	5	5
13	P1	CEA	International transformer T3 fault/trip	115 kV winding	115	3PH	5	5
14	P1	CEA		138 kV winding	138	3PH	5	5
15	P1	CEA	University - Hane line fault/trip	University	138	3PH	5	5
16	P1	CEA		Hane	138	3PH	5	5
17	P1	CEA	Retherford - Hane line fault/trip	Retherford	138	3PH	5	5
18	P1	CEA		Hane	138	3PH	5	5
19	P1	CEA	University - Plant 2 line fault/trip	University	230	3PH	5	5
20	P1	CEA		Plant 2	230	3PH	5	5
21	P1	CEA	University - Anchorage line fault/trip	University	115	3PH	5	5
22	P1	CEA		Anchorage	115	3PH	5	5
23	P1	CEA/MEA	Plant 2 - EGS line fault/trip	Plant 2	115	3PH	5	5
24	P1	CEA/MEA		EGS	115	3PH	5	5
25	P1	CEA	Plant 2 - Sub #20 ("Line 1") fault/trip	Plant 2	115	3PH	5	5
26	P1	CEA		Sub #20	115	3PH	5	5
27	P1	CEA	Plant 2 - Sub #14 ("Line 2") fault/trip	Plant 2	115	3PH	5	5
28	P1	CEA		Sub #14	115	3PH	5	5
29	P1	CEA	Plant 2 - Anchorage ("Line 3") fault/trip	Plant 2	115	3PH	5	5
30	P1	CEA		Anchorage	115	3PH	5	5
31	P1	CEA	Plant 2 Tap transformer TT-9 fault/trip	115 kV winding	115	3PH	5	5
32	P1	CEA		230 kV winding	230	3PH	5	5
33	P1	CEA	Dave's Creek - Hope line fault/trip	Dave's Creek	115	3PH	5	5
34	P1	CEA	Quartz Creek - Dave's Creek line fault/trip	Quartz Creek	115	3PH	5	5
35	P1	HEA	Soldotna - Tesoro line fault/trip	Soldotna	115	3PH	5	5
36	P1	HEA	Soldotna - Beaver Creek - Marathon line fault/trip	Soldotna	115	3PH	5	5
37	P1	HEA	Soldotna - Thompson - Kasilof line fault/trip	Soldotna	115	3PH	5	5
38	P1	HEA	Soldotna - Sterling line fault/trip	Soldotna	115	3PH	5	5
39	P1	HEA	Bradley Lake - Fritz Creek - Diamond Ridge line fault/trip	Bradley Lake	115	3PH	5	5
40	P1	HEA	Bradley Lake - Soldotna line fault/trip	Bradley Lake	115	3PH	5	5
41	P1	HEA		Soldotna	115	3PH	5	5
42	P1	HEA	Soldotna SVC fault/trip	Soldotna	115	3PH	5	5
43	P1	CEA	Dave's Creek SVC fault/trip	Dave's Creek	115	3PH	5	5
44	P1	CEA/SES	Dave's Creek - Lawing (City of Seward) line fault/trip	Dave's Creek	115	3PH	5	5
45	P1	CEA/MEA	Point MacKenzie - Teeland line fault/trip	Point MacKenzie	230	3PH	5	5
46	P1	CEA/MEA		Teeland	230	3PH	5	5
47	P1	MEA	Teeland - Douglas line fault/trip	Teeland	138	3PH	5	5
48	P1	MEA		Douglas	138	3PH	5	5
49	P1	MEA	Teeland - Cottle - Herning line fault/trip	Teeland	115	3PH	5	5
50	P1	MEA	EGS - Hospital line #1 fault/trip	EGS	115	3PH	5	5
51	P1	MEA		Hospital	115	3PH	5	5
52	P1	MEA	Eklutna Hydro - Hospital line fault/trip	Eklutna Hydro	115	3PH	5	5
53	P1	MEA		Hospital	115	3PH	5	5
54	P1	MEA	EGS - Eklutna Hydro ("Eklutna Express") line fault/trip	EGS	115	3PH	5	5
55	P1	MEA		Eklutna Hydro	115	3PH	5	5
56	P1	MEA	Teeland SVC fault/trip	Teeland SVC	13.8	3PH	5	5
57	P1	GVEA	Healy SVC fault/trip	Healy SVC	12	3PH	5	5
58	P1	GVEA	Gold Hill SVC fault/trip	Gold Hill SVC	13.8	3PH	5	5

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
59	P1	MEA/GVEA	Douglas - Healy line fault/trip	Douglas	138	3PH	4	30
60	P1	MEA/GVEA		Healy	138	3PH	4	28
61	P1	GVEA	Healy - Eva Creek line fault/trip	Healy	138	3PH	4	4
62	P1	GVEA		Eva Creek	138	3PH	4	4
63	P1	GVEA	Eva Creek - Wilson line fault/trip	Eva Creek	138	3PH	4	4
64	P1	GVEA		Wilson	138	3PH	4	4
65	P1	GVEA	Healy - Clear line fault/trip	Healy	138	3PH	4	4
66	P1	GVEA		Clear	138	3PH	4	4
67	P1	GVEA	Clear - Gold Hill line fault/trip	Clear	138	3PH	4	4
68	P1	GVEA		Gold Hill	138	3PH	4	4
69	P1	GVEA	Gold Hill - Fort Knox line fault/trip	Gold Hill	138	3PH	4	4
70	P1	GVEA		Fort Knox	138	3PH	18	18
71	P1	GVEA	Gold Hill - Wilson line fault/trip	Gold Hill	138	3PH	4	4
72	P1	GVEA		Wilson	138	3PH	4	4
73	P1	GVEA	Wilson - Fort Wainwright line fault/trip	Wilson	138	3PH	4	4
74	P1	GVEA		Fort Wainwright	138	3PH	4	4
75	P1	GVEA	Fort Wainwright - North Pole Industrial line fault/trip	Fort Wainwright	138	3PH	4	4
76	P1	GVEA		North Pole Ind.	138	3PH	4	4
77	P1	GVEA	Fort Wainwright - Fort Wainwright Generation line fault/trip	Fort Wainwright	138	3PH	4	4
78	P1	GVEA		FTWW Gen.	138	3PH	4	4
79	P1	GVEA	North Pole Industrial - North Pole line fault/trip	North Pole Ind.	138	3PH	4	4
80	P1	GVEA		North Pole	138	3PH	4	4
81	P1	GVEA	North Pole Industrial - Carney line fault/trip	North Pole Ind.	138	3PH	4	28
82	P1	GVEA		Carney	138	3PH	4	28
83	P1	GVEA	Carney - Pogo Tap line fault/trip	Carney	138	3PH	4	28
84	P1	GVEA		Pogo Tap	138	3PH	4	28
85	P1	GVEA	Pogo Tap - Teck Pogo line fault/trip	Pogo Tap	138	3PH	4	4
86	P1	GVEA		Teck Pogo	138	3PH	10	10
87	P1	GVEA	Pogo Tap - Jarvis line fault/trip	Pogo Tap	138	3PH	4	28
88	P1	GVEA		Jarvis	138	3PH	4	28
89	P1	GVEA	Jarvis - Fort Greely line fault/trip	Jarvis	138	3PH	4	4
90	P1	GVEA		Fort Greely	138	3PH	4	4
91	P1	GVEA	Fort Greely - Pump 9 Tap line fault/trip	Fort Greely	138	3PH	4	4
92	P1	GVEA		Pump 9 Tap	138	3PH	4	4
93	P1	GVEA	Gold Hill - Musk Ox line fault/trip	Gold Hill	69	3PH	4	4
94	P1	GVEA		Musk Ox	69	3PH	18	18
95	P1	GVEA	Gold Hill - Zehnder line fault/trip	Gold Hill	69	3PH	4	4
96	P1	GVEA		Zehnder	69	3PH	4	4
97	P1	GVEA	Gold Hill - South Side - Fort Wainwright line fault/trip	Gold Hill	69	3PH	4	4
98	P1	GVEA		South Side	69	3PH	4	4
99	P1	GVEA		Fort Wainwright	69	3PH	4	4
100	P1	GVEA	Zehnder - UAF line fault/trip	Zehnder	69	3PH	4	4
101	P1	GVEA		UAF	69	3PH	4	4
102	P1	GVEA	Zehnder - Fox line fault/trip	Zehnder	69	3PH	4	4
103	P1	GVEA		Fox	69	3PH	28	28
104	P1	GVEA	Zehnder - Chena line fault/trip	Zehnder	69	3PH	4	4
105	P1	GVEA		Chena	69	3PH	4	4
106	P1	GVEA	Zehnder - Fort Wainwright line fault/trip	Zehnder	69	3PH	4	28
107	P1	GVEA		Fort Wainwright	69	3PH	4	28
108	P1	GVEA	Chena - South Side line fault/trip	Chena	69	3PH	4	28
109	P1	GVEA		South Side	69	3PH	4	28
110	P1	GVEA	Fort Wainwright - Highway Park line fault/trip	Fort Wainwright	69	3PH	4	28
111	P1	GVEA		Highway Park	69	3PH	4	28
112	P1	GVEA	Highway Park - Mapco line fault/trip	Highway Park	69	3PH	4	4
113	P1	GVEA		Mapco	69	3PH	4	4
114	P1	GVEA	North Pole - Mapco line fault/trip	North Pole	69	3PH	4	4
115	P1	GVEA		Mapco	69	3PH	4	4

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
116	P1	GVEA	Highway Park - Carney line fault/trip	Highway Park	69	3PH	4	28
117	P1	GVEA		Carney	69	3PH	4	28
118	P1	GVEA	Gold Hill transformer T1 fault/trip	69 kV winding	69	3PH	4	4
119	P1	GVEA		138 kV winding	138	3PH	4	4
120	P1	GVEA	Fort Wainwright transformer T1 fault/trip	69 kV winding	69	3PH	4	4
121	P1	GVEA		138 kV winding	138	3PH	4	4
122	P1	GVEA	Carney transformer T1 fault/trip	69 kV winding	69	3PH	4	4
123	P1	GVEA		138 kV winding	138	3PH	4	4
124	P1	HEA	Bradley Lake U1 trip					
125	P1	HEA	Bradley Lake U1 fault/trip	Unit terminals	13.8	3PH	5	
126	P1	HEA	Bradley Lake U2 trip					
127	P1	HEA	Bradley Lake U2 fault/trip	Unit terminals	13.8	3PH	5	
128	P1	HEA	Nikiski CT trip					
129	P1	HEA	Nikiski CT fault/trip	Unit terminals	13.8	3PH	5	
130	P1	HEA	Nikiski ST trip					
131	P1	HEA	Nikiski ST fault/trip	Unit terminals	13.8	3PH	5	
132	P1	HEA	Soldotna CT trip					
133	P1	HEA	Soldotna CT fault/trip	Unit terminals	13.8	3PH	5	
134	P1	CEA	Cooper Lake U1 and U2 trip					
135	P1	CEA	Cooper Lake U1 and U2 fault/trip	Unit terminals	13.8	3PH	5	
136	P1	CEA	Sullivan (Plant 2A) U9 trip					
137	P1	CEA	Sullivan (Plant 2A) U9 fault/trip	Unit terminals	13.8	3PH	5	
138	P1	CEA	SPP 11 trip					
139	P1	CEA	SPP 11 fault/trip	Unit terminals	13.8	3PH	5	
140	P1	GVEA	Healy U1 trip					
141	P1	GVEA	Healy U1 fault/trip	Unit terminals	13.8	3PH	4	
142	P1	GVEA	Chena (Aurora Energy) U5 trip					
143	P1	GVEA	Chena (Aurora Energy) U5 fault/trip	Unit terminals	13.8	3PH	4	
144	P1	GVEA	Zehnder U1 trip					
145	P1	GVEA	Zehnder U1 fault/trip	Unit terminals	13.8	3PH	4	
146	P1	GVEA	Zehnder U2 trip					
147	P1	GVEA	Zehnder U2 fault/trip	Unit terminals	13.8	3PH	4	
148	P1	GVEA	North Pole U1 trip					
149	P1	GVEA	North Pole U1 fault/trip	Unit terminals	13.8	3PH	4	
150	P1	GVEA	North Pole U2 trip					
151	P1	GVEA	North Pole U2 fault/trip	Unit terminals	13.8	3PH	4	
152	P1	GVEA	North Pole Combined Cycle U3 and U4 trip					
153	P1	GVEA	North Pole Combined Cycle U3 and U4 fault/trip	Unit terminals	13.8	3PH	4	
154	P2	CEA	Beluga breaker 1172 internal fault	Bkr 1172	230	SLG	5	
155	P2	CEA	Beluga breaker 1276 internal fault	Bkr 1276	230	SLG	5	
156	P2	CEA	Beluga breaker 2276 internal fault	Bkr 2276	230	SLG	5	
157	P2	CEA	Beluga 138 kV bus fault	138 kV bus	138	SLG	5	
158	P2	CEA	Point MacKenzie breaker 2172 internal fault	Bkr 2172	230	SLG	5	
159	P2	CEA	Point MacKenzie breaker 2276 internal fault	Bkr 2276	230	SLG	5	
160	P2	CEA	Point MacKenzie breaker 4276 internal fault	Bkr 4276	230	SLG	5	
161	P2	CEA	Point MacKenzie 138 kV bus fault	138 kV bus	138	SLG	5	
162	P2	CEA	International (ITSS) breaker 1266 internal fault	Bkr 1266	138	SLG	5	
163	P2	CEA	International (ITSS) breaker 2266 internal fault	Bkr 2266	138	SLG	5	
164	P2	CEA	International (ITSS) breaker 3266 internal fault	Bkr 3266	138	SLG	5	
165	P2	CEA	International (ITSS) breaker 4266 internal fault	Bkr 4266	138	SLG	5	
166	P2	CEA	International (ITSS) breaker 5266 internal fault	Bkr 5266	138	SLG	5	
167	P2	CEA	University 115 kV bus fault	115 kV bus	115	SLG	5	
168	P2	CEA	University 138 kV bus fault	138 kV bus	138	SLG	5	
169	P2	MEA	Teeland breaker 4472 internal fault	Bkr 4472	230	SLG	5	
170	P2	MEA	Teeland breaker 4672 internal fault	Bkr 4672	230	SLG	5	
171	P2	MEA	Teeland breaker 4710 internal fault	Bkr 4710	230	SLG	5	
172	P2	MEA	Teeland breaker 538 internal fault	Bkr 538	138	SLG	5	
173	P2	MEA	Teeland 115 kV bus fault	115 kV bus	115	SLG	5	

#	AKTPL-001 Category	Area	Description	Fault Location	Nominal Voltage (kV, L-L)	Fault Type	Clearing Time (Cycles) Near	Far
174	P2	CEA	Plant 2 Tap breaker 4510 internal fault	Bkr 4510	230	SLG	5	
175	P2	CEA	Plant 2 Tap breaker 4520 internal fault	Bkr 4520	230	SLG	5	
176	P2	CEA	Plant 2 Tap breaker 4610 internal fault	Bkr 4610	230	SLG	5	
177	P2	CEA	Dave's Creek 115 kV bus fault	115 kV bus	115	SLG	5	
178	P2	MEA	EGS breaker 1356 internal fault	Bkr 1356	115	SLG	5	
179	P2	MEA	EGS breaker 2356 internal fault	Bkr 2356	115	SLG	5	
180	P2	MEA	EGS breaker 3356 internal fault	Bkr 3356	115	SLG	5	
181	P2	MEA	EGS breaker 4356 internal fault	Bkr 4356	115	SLG	5	
182	P2	MEA	EGS breaker 5356 internal fault	Bkr 5356	115	SLG	5	
183	P2	HEA	Bradley Lake breaker 1310 internal fault	Bkr 1310	115	SLG	5	
184	P2	HEA	Nikiski 115 kV bus fault	115 kV bus	115	SLG	5	
185	P2	HEA	Soldotna breaker 2126 internal fault	Bkr 2126	115	SLG	5	
186	P2	HEA	Soldotna breaker 2226 internal fault	Bkr 2226	115	SLG	5	
187	P2	HEA	Soldotna breaker 2426 internal fault	Bkr 2426	115	SLG	5	
188	P2	GVEA	Healy 138 kV bus fault	138 kV bus	138	SLG	4	
189	P2	GVEA	Gold Hill 138 kV bus fault	138 kV bus	138	SLG	4	
190	P2	GVEA	Gold Hill 69 kV bus fault	69 kV bus	69	SLG	4	
191	P2	GVEA	Wilson breaker B1 internal fault	Bkr B1	138	SLG	4	
192	P2	GVEA	Wilson breaker B2 internal fault	Bkr B2	138	SLG	4	
193	P2	GVEA	Wilson breaker B4 internal fault	Bkr B4	138	SLG	4	
194	P2	GVEA	Wilson breaker B5 internal fault	Bkr B5	138	SLG	4	
195	P2	GVEA	Wilson breaker B6 internal fault	Bkr B6	138	SLG	4	
196	P2	GVEA	Fort Wainwright 138 kV bus fault	138 kV bus	138	SLG	4	
197	P2	GVEA	Fort Wainwright 69 kV bus fault	69 kV bus	69	SLG	4	
198	P2	GVEA	North Pole Industrial breaker B2 internal fault	Bkr B2	138	SLG	4	
199	P2	GVEA	North Pole Industrial breaker B8 internal fault	Bkr B8	138	SLG	4	
200	P1	CEA	Little Mt. Susitna trip 60 MW					
201	P1	CEA	Little Mt. Susitna fault/trip 60 MW	POI	230	3PH	5	
202	P1	CEA	Little Mt. Susitna - Beluga line fault/trip	Little Mt. Susitna	230	3PH	5	5
203	P1	CEA		Beluga	230	3PH	5	5
204	P1	CEA	Little Mt. Susitna - Point MacKenzie line fault/trip	Little Mt. Susitna	230	3PH	5	5
205	P1	CEA		Point MacKenzie	230	3PH	5	5
206	P1	GVEA	Shovel Creek trip 60 MW					
207	P1	GVEA	Shovel Creek fault/trip 60 MW	POI	138	3PH	4	
208	P1	GVEA	Shovel Creek - Fort Knox Tap line fault/trip	Shovel Creek	138	3PH	4	4
209	P1	GVEA		Fort Knox Tap	138	3PH	4	4
210	P1	GVEA	Fort Knox Tap - North Pole Industrial line fault/trip	Fort Knox Tap	138	3PH	4	4
211	P1	GVEA		North Pole Ind.	138	3PH	4	4
212	P1	GVEA	Shovel Creek - Gold Hill line fault/trip	Shovel Creek	138	3PH	4	4
213	P1	GVEA		Gold Hill	138	3PH	4	4
214	P1	GVEA	Shovel Creek - Fort Knox line fault/trip	Shovel Creek	138	3PH	4	4
215	P1	GVEA		Fort Knox	138	3PH	4	4
216	P1	GVEA	Fort Knox - North Pole Industrial line fault/trip	Fort Knox	138	3PH	4	4
217	P1	GVEA		North Pole Ind.	138	3PH	4	4
218	P1	GVEA	Shovel Creek - Rosie Creek line fault/trip	Shovel Creek	138	3PH	4	4
219	P1	GVEA		Rosie Creek	138	3PH	4	4
220	P1	GVEA	Shovel Creek - Nenana - Clear line fault/trip	Shovel Creek	138	3PH	4	4
221	P1	GVEA		Clear	138	3PH	4	4
222	P1	GVEA	Shovel Creek - Ester - Gold Hill line fault/trip	Shovel Creek	138	3PH	4	4
223	P1	GVEA		Gold Hill	138	3PH	4	4

11 Appendix B – Dispatch Summaries

Table 27 – Baseline Cases (No Intertie Outages, Max Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	90		85		85	
Alaska Intertie (Douglas to Stevens)	75		70		70	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna CT			28.0	40.1	28.0	49.2
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	45.0	60.0	45.0	60.0	45.0	60.0
Bradley Lake U2	45.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	32.4	37.1	36.2	37.1	41.9	42.4
Nikiski ST	13.4	15.5	20.8	20.8	17.4	17.8
Cooper Lake U1	9.8	9.8	9.8	9.8	9.8	9.8
Cooper Lake U2	9.8	9.8	9.8	9.8	9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Nikkels (Plant 1) U3					20.5	30.0
Sullivan (Plant 2A) U9	39.2	43.4	30.7	37.4	50.0	50.0
Sullivan (Plant 2A) U10	39.2	43.4	31.8	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	21.8	24.1	17.7	20.8	25.0	25.0
SPP U10 (HRSG)	22.3	33.4	28.8	28.8	38.5	38.5
SPP U11	43.4	43.4	37.4	37.4	50.0	50.0
SPP U12	43.4	43.4	37.4	37.4	50.0	50.0
SPP U13			37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			17.0	17.0	17.0	17.0
EGS U2			17.0	17.0	17.0	17.0
EGS U3			17.0	17.0	17.0	17.0
EGS U4			17.0	17.0	17.0	17.0
EGS U5			17.0	17.0	17.0	17.0
EGS U6			17.0	17.0	17.0	17.0
EGS U7			17.0	17.0	17.0	17.0
EGS U8			17.0	17.0	17.0	17.0
EGS U9					17.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1			26.4	26.4	27.9	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1			19.6	39.0	28.8	64.0
North Pole CC U3	20.1	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	5.0	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	26.7		30.6		34.2	
Net Load (MW)	427.3		712.7		883.2	

Table 28 – Baseline Cases (No Intertie Outages, Max Kenai Transfer South)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	-51		-75		-60	
Alaska Intertie (Douglas to Stevens)	75		70		70	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	5.0	60.0	27.5	60.0	23.3	60.0
Bradley Lake U2	-0.65	60.0	-0.65	60.0	20.0	60.0
Cooper Lake U1	2.0	11.4	2.0	11.4	2.0	11.4
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Nikkels (Plant 1) U3			28.3	28.3	30.0	30.0
Sullivan (Plant 2) U7			68.5	68.5	90.0	90.0
Sullivan (Plant 2A) U9	38.2	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U10	38.1	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	21.2	24.1	20.8	20.8	25.0	25.0
Beluga U3			32.6	55.6	44.1	76.0
SPP U10 (HRSG)	33.4	33.4	28.8	28.8	38.5	38.5
SPP U11	43.4	43.4	37.4	37.4	50.0	50.0
SPP U12	43.4	43.4	37.4	37.4	50.0	50.0
SPP U13	43.4	43.4	37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1	17.0	17.0	17.0	17.0	17.0	17.0
EGS U2	17.0	17.0	17.0	17.0	17.0	17.0
EGS U3	17.0	17.0	17.0	17.0	17.0	17.0
EGS U4	17.0	17.0	17.0	17.0	17.0	17.0
EGS U5	17.0	17.0	17.0	17.0	17.0	17.0
EGS U6			17.0	17.0	17.0	17.0
EGS U7			17.0	17.0	17.0	17.0
EGS U8			17.0	17.0	17.0	17.0
EGS U9			17.0	17.0	17.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1			26.4	26.4	27.9	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1			19.6	39.0	28.8	64.0
North Pole CC U3	20.1	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	5.0	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	14.4		26.6		26.2	
Net Load (MW)	415.0		708.7		875.2	

Table 29 – Baseline Cases (Kenai Tie Open, Max Alaska Intertie Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Alaska Intertie (Douglas to Stevens)	70		70		65	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	27.2	60.0	25.1	60.0	38.7	60.0
Bradley Lake U2	20.0	60.0	20.0	60.0	40.0	60.0
Nikiski CT	5.0	37.1	35.0	37.1	5.0	42.4
Nikiski ST	2.1	15.5	19.0	20.8	2.1	17.8
Cooper Lake U1	2.0	11.4	2.0	11.4	9.8	9.8
Cooper Lake U2					9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Nikkels (Plant 1) U3			28.3	28.3	30.0	30.0
Sullivan (Plant 2) U7			18.8	68.5	64.0	90.0
Sullivan (Plant 2A) U9	41.9	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U10	41.9	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	23.3	24.1	20.8	20.8	25.0	25.0
SPP U10 (HRSG)	33.4	33.4	28.8	28.8	38.5	38.5
SPP U11	43.4	43.4	37.4	37.4	50.0	50.0
SPP U12	43.4	43.4	37.4	37.4	50.0	50.0
SPP U13	43.4	43.4	37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1	8.0	17.0	17.0	17.0	17.0	17.0
EGS U2	8.0	17.0	17.0	17.0	17.0	17.0
EGS U3			17.0	17.0	17.0	17.0
EGS U4			17.0	17.0	17.0	17.0
EGS U5			17.0	17.0	17.0	17.0
EGS U6			17.0	17.0	17.0	17.0
EGS U7			17.0	17.0	17.0	17.0
EGS U8			17.0	17.0	17.0	17.0
EGS U9			17.0	17.0	17.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1			26.4	26.4	27.9	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1			19.6	39.0	33.4	64.0
North Pole CC U3	23.5	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	5.9	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	9.3		16.6		20.8	
Net Load (MW)	409.9		698.7		869.8	

Table 30 – Baseline Cases (Alaska Intertie Open, Max Kenai Tie Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	90		85		85	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna CT			28.0	40.1	28.0	49.2
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	45.0	60.0	45.0	60.0	45.0	60.0
Bradley Lake U2	45.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	32.4	37.1	36.1	37.1	41.8	42.4
Nikiski ST	13.4	15.5	20.8	20.8	17.8	17.8
Cooper Lake U1	9.8	9.8	9.8	9.8	9.8	9.8
Cooper Lake U2	9.8	9.8	9.8	9.8	9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	30.2	43.4	29.0	37.4	41.3	50.0
Sullivan (Plant 2A) U10	30.2	43.4	29.0	37.4	41.3	50.0
Sullivan (Plant 2A) U11 (HRSG)	16.8	24.1	16.1	20.8	23.0	25.0
SPP U10 (HRSG)	11.1	11.1	28.8	28.8	38.5	38.5
SPP U11	43.4	43.4	37.4	37.4	50.0	50.0
SPP U12			37.4	37.4	50.0	50.0
SPP U13			37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			17.0	17.0	17.0	17.0
EGS U2			17.0	17.0	17.0	17.0
EGS U3			17.0	17.0	17.0	17.0
EGS U4			17.0	17.0	17.0	17.0
EGS U5					17.0	17.0
EGS U6					17.0	17.0
EGS U7					17.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1	27.0	27.0	26.4	26.4	27.9	27.9
Zehnder U1			13.6	13.6		
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1	15.4	48.2	35.0	39.0	46.7	64.0
North Pole U2			37.5	41.8	48.9	67.0
North Pole CC U3	43.6	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	11.0	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	21.1		22.9		27.4	
Net Load (MW)	421.7		705.0		876.4	

Table 31 – Baseline Cases (Alaska Intertie Open, Max Kenai Tie Transfer South)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	-51		-70		-65	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna CT						
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	5.0	60.0	16.5	60.0	18.5	60.0
Bradley Lake U2	-0.65	60.0	15.0	60.0	20.0	60.0
Cooper Lake U1	2.0	11.4	2.0	11.4	2.0	11.4
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Nikkels (Plant 1) U3			28.3	28.3	30.0	30.0
Sullivan (Plant 2) U7			22.7	68.5	67.2	90.0
Sullivan (Plant 2A) U9	40.9	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U10	40.9	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	22.7	24.1	20.8	20.8	25.0	25.0
SPP U10 (HRSG)	33.4	33.4	28.8	28.8	38.5	38.5
SPP U11	43.4	43.4	37.4	37.4	50.0	50.0
SPP U12	43.4	43.4	37.4	37.4	50.0	50.0
SPP U13	43.4	43.4	37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			17.0	17.0	17.0	17.0
EGS U2			17.0	17.0	17.0	17.0
EGS U3			17.0	17.0	17.0	17.0
EGS U4			17.0	17.0	17.0	17.0
EGS U5			17.0	17.0	17.0	17.0
EGS U6			17.0	17.0	17.0	17.0
EGS U7			17.0	17.0	17.0	17.0
EGS U8			17.0	17.0	17.0	17.0
EGS U9			17.0	17.0	17.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1	27.0	27.0	26.4	26.4	27.9	27.9
Zehnder U1			13.6	13.6		
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1	15.4	48.2	35.0	39.0	46.7	64.0
North Pole U2			37.5	41.8	48.9	67.0
North Pole CC U3	43.6	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	11.0	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	8.4		19.3		21.2	
Net Load (MW)	409.0		701.4		870.2	

Table 32 – Future Cases (No Intertie Outages, Max Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	90		80		80	
Alaska Intertie (Douglas to Stevens)	75		70		70	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna CT			28.0	40.1	28.0	49.2
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	45.0	60.0	45.0	60.0	38.2	60.0
Bradley Lake U2	45.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	32.4	37.1	36.1	37.1	42.4	42.4
Nikiski ST	13.4	15.5	15.0	20.8	17.6	17.8
Cooper Lake U1	9.8	9.8	9.8	9.8	9.8	9.8
Cooper Lake U2	9.8	9.8	9.8	9.8	9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	160.0	160.0	160.0	160.0	160.0	160.0
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	19.6	43.4	37.4	37.4	45.9	50.0
Sullivan (Plant 2A) U10	19.6	43.4	37.4	37.4	45.9	50.0
Sullivan (Plant 2A) U11 (HRSG)	10.9	21.7	20.8	20.8	25.0	25.0
SPP U10 (HRSG)			19.2	19.2	38.5	38.5
SPP U11			37.4	37.4	50.0	50.0
SPP U12			37.4	37.4	50.0	50.0
SPP U13					50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			10.3	17.0	8.0	17.0
EGS U2					8.0	17.0
EGS U3					8.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	17.5	140.0	80.2	140.0	114.2	140.0
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole CC U3	6.0	43.8	6.0	33.8	6.0	53.0
North Pole CC U4 (HRSG)	1.5	11.0	1.5	8.5	1.5	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	27.7		26.7		30.4	
Net Load (MW)	428.3		708.8		879.5	

Table 33 – Future Cases (No Intertie Outages, Max Transfer South)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	-51		-75		-60	
Alaska Intertie (Douglas to Stevens)	-75		-80		-80	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	5.0	60.0	27.7	60.0	23.4	60.0
Bradley Lake U2	-0.65	60.0	-0.65	60.0	20.0	60.0
Cooper Lake U1	2.0	11.4	2.0	11.4	2.0	11.4
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	160.0	160.0	160.0	160.0	160.0	160.0
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	28.9	43.4	30.9	37.4	41.3	50.0
Sullivan (Plant 2A) U10			30.9	37.4	41.3	50.0
Sullivan (Plant 2A) U11 (HRSG)	8.0	12.1	17.2	20.8	23.0	25.0
SPP U10 (HRSG)			24.5	28.8	38.5	38.5
SPP U11			31.8	37.4	50.0	50.0
SPP U12			31.8	37.4	50.0	50.0
SPP U13			31.8	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			8.0	17.0	8.0	17.0
EGS U2					8.0	17.0
EGS U3					8.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	140.0	140.0	140.0	140.0	140.0	140.0
Eva Creek Wind	24.4	24.4	24.4	24.4	24.4	24.4
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1			23.6	26.4	27.9	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1			10.0	39.0	16.3	64.0
North Pole CC U3	10.8	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	2.7	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	18.2		26.8		25.7	
Net Load (MW)	418.8		708.9		874.7	

Table 34 – Future Cases (Kenai Tie Open, Max Alaska Intertie Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Alaska Intertie (Douglas to Stevens)	70		70		65	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	17.4	60.0	39.8	60.0	33.7	60.0
Bradley Lake U2	20.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	5.0	37.1	5.0	37.1	5.0	42.4
Nikiski ST	2.1	15.5	2.1	20.8	2.1	17.8
Cooper Lake U1	11.4	11.4	11.4	11.4	9.8	9.8
Cooper Lake U2					9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	160.0	160.0	160.0	160.0	160.0	160.0
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	43.4	43.4	37.0	37.4	49.9	50.0
Sullivan (Plant 2A) U10	43.4	43.4	37.0	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	24.1	21.7	20.6	20.8	25.0	25.0
SPP U10 (HRSG)			28.8	28.8	38.5	38.5
SPP U11	16.8	43.4	37.4	37.4	50.0	50.0
SPP U12			37.4	37.4	50.0	50.0
SPP U13			37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			13.0	17.0	14.3	17.0
EGS U2			13.0	17.0	14.3	17.0
EGS U3			13.0	17.0	14.3	17.0
EGS U4					14.3	17.0
EGS U5					14.3	17.0
EGS U6					14.3	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	22.0	140.0	80.2	140.0	118.9	140.0
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole CC U3	6.0	43.8	6.0	33.8	6.0	53.0
North Pole CC U4 (HRSG)	1.5	11.0	1.5	8.5	1.5	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	10.1		16.1		19.5	
Net Load (MW)	410.7		698.2		868.5	

Table 35 – Future Cases (Kenai Tie Open, Max Alaska Intertie Transfer South)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Alaska Intertie (Douglas to Stevens)	-70		-80		-80	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	17.4	60.0	39.8	60.0	33.7	60.0
Bradley Lake U2	20.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	5.0	37.1	5.0	37.1	5.0	42.4
Nikiski ST	2.1	15.5	2.1	20.8	2.1	17.8
Cooper Lake U1	11.4	11.4	11.4	11.4	9.8	9.8
Cooper Lake U2					9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	141.8	160.0	160.0	160.0	160.0	160.0
Fire Island Wind			17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	18.0	43.4	37.4	37.4	40.6	50.0
Sullivan (Plant 2A) U10			37.4	37.4	40.7	50.0
Sullivan (Plant 2A) U11 (HRSG)	5.0	12.1	20.8	20.8	22.6	25.0
SPP U10 (HRSG)					25.7	25.7
SPP U11			21.4	37.4	50.0	50.0
SPP U12					50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			8.0	17.0	8.0	17.0
EGS U2					8.0	17.0
EGS U3					8.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	140.0	140.0	140.0	140.0	140.0	140.0
Eva Creek Wind	24.4	24.4	24.4	24.4	24.4	24.4
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1			23.7	26.4	27.9	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole U1			10.0	39.0	16.2	64.0
North Pole CC U3	6.2	43.8	33.8	33.8	53.0	53.0
North Pole CC U4 (HRSG)	1.6	11.0	8.5	8.5	12.0	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	12.3		19.2		21.1	
Net Load (MW)	412.9		701.3		870.1	

Table 36 – Future Cases (Alaska Intertie Open, Max Kenai Tie Transfer North)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	85		80		80	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna CT			28.0	40.1	28.0	49.2
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	45.0	60.0	43.5	60.0	45.0	60.0
Bradley Lake U2	45.0	60.0	45.0	60.0	45.0	60.0
Nikiski CT	28.3	37.1	37.1	37.1	37.9	42.4
Nikiski ST	11.8	15.5	15.4	20.8	15.7	17.8
Cooper Lake U1	9.8	9.8	9.8	9.8	9.8	9.8
Cooper Lake U2	9.8	9.8	9.8	9.8	9.8	9.8
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	131.2	160.0	160.0	160.0	160.0	160.0
Fire Island Wind			17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	18.0	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U10			37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	5.0	12.1	20.8	20.8	25.0	25.0
SPP U10 (HRSG)					22.1	25.7
SPP U11			24.7	37.4	43.1	50.0
SPP U12					43.1	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			8.0	17.0	8.0	17.0
EGS U2					8.0	17.0
EGS U3					8.0	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	61.1	140.0	111.5	140.0	139.9	140.0
Eva Creek Wind	10.3	24.4	18.6	24.4	24.3	24.4
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1	18.0	27.0	18.0	26.4	18.0	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole CC U3	6.0	43.8	6.0	33.8	6.0	53.0
North Pole CC U4 (HRSG)	1.5	11.0	1.5	8.5	1.5	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	20.2		22.9		27.0	
Net Load (MW)	420.8		705.0		876.0	

Table 37 – Future Cases (Alaska Intertie Open, Max Kenai Tie Transfer South)

System Load	Summer Valley		Summer Peak		Winter Peak	
Tie Flows (MW)						
Kenai Tie (Dave's Creek to Hope)	-51		-70		-65	
Kenai Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Soldotna BESS	0.0	10.0	0.0	10.0	0.0	10.0
Bradley Lake U1	5.0	60.0	16.4	60.0	18.5	60.0
Bradley Lake U2	-0.65	60.0	15.0	60.0	20.0	60.0
Cooper Lake U1	2.0	11.4	2.0	11.4	2.0	11.4
Anchorage / Southcentral Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Little Mount Susitna Wind (Net)	160.0	160.0	160.0	160.0	160.0	160.0
Fire Island Wind	17.6	17.6	17.6	17.6	17.6	17.6
Anchorage BESS	0.0	40.0	0.0	40.0	0.0	40.0
Sullivan (Plant 2A) U9	41.0	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U10	41.0	43.4	37.4	37.4	50.0	50.0
Sullivan (Plant 2A) U11 (HRSG)	22.8	21.7	20.8	20.8	25.0	25.0
SPP U10 (HRSG)			28.8	28.8	38.5	38.5
SPP U11	5.0	43.4	37.4	37.4	50.0	50.0
SPP U12			37.4	37.4	50.0	50.0
SPP U13			37.4	37.4	50.0	50.0
Eklutna Hydro U1			17.5	20.0	20.0	20.0
Eklutna Hydro U2			17.5	20.0	20.0	20.0
EGS U1			10.7	17.0	12.8	17.0
EGS U2			10.7	17.0	12.8	17.0
EGS U3			10.7	17.0	12.8	17.0
EGS U4			10.7	17.0	12.8	17.0
EGS U5					12.8	17.0
EGS U6					12.8	17.0
EGS U7					12.8	17.0
Fairbanks / Interior Units	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)	Pgen (MW)	Pmax (MW)
Shovel Creek Wind (Net)	61.1	140.0	111.5	140.0	139.9	140.0
Eva Creek Wind	10.3	24.4	18.6	24.4	24.3	24.4
Wilson BESS	26 MW assigned to the Wilson BESS spinning reserve mode					
Healy U1	18.0	27.0	18.0	26.4	18.0	27.9
Chena (Aurora) U5	20.0	20.0	20.0	20.0	20.0	20.0
North Pole CC U3	6.0	43.8	6.0	33.8	6.0	53.0
North Pole CC U4 (HRSG)	1.5	11.0	1.5	8.5	1.5	12.0
Total Load (MW)	400.6		682.1		849.0	
Total Losses (MW)	10.1		18.7		21.8	
Net Load (MW)	410.7		700.8		870.9	