Alaska Energy Authority
Railbelt Transmission Plan
Project #15-0481

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1 Introduction

This report includes the findings of the transmission system analysis and economic studies completed to determine the future composition of the Railbelt transmission system.

Since the last draft report was issued in March 2014, new reliability and operating standards have been adopted by the Railbelt utilities, and new generation plants for all utilities have been commissioned. Additionally, the Railbelt utilities have spent considerable effort reviewing and updating the economic models used to simulate the Railbelt's cost of power production. As a result of the new standards, new power plants, and the utilities' work on the economic model; the transmission studies have been updated to reflect 2016 conditions, and the economic studies have been updated to use the latest economic models available from the utilities. Since the economic studies do not include the total economic evaluation of the projects, but only evaluate possible fuel savings, they are presented as a separate report, apart from the technical system studies.

The purpose of this plan is to outline a transmission system and improvement projects necessary to meets the requirements of the Railbelt Transmission System Planning Standard, AKTPL-001-4. Per the standard, once a proposed project is identified, each project must undergo a process that includes economic and reliability evaluations to justify its construction. This plan outlines the transmission system improvements required to meet the standard, but does not attempt to complete each projects' analysis required in the standard to determine if and when it should be constructed.

The transmission system improvements needed to support the Watana project, or any other major generation project not currently under construction or completed are not included in the report.

2 Executive Summary

Electric Power Systems (EPS) has completed an analysis to determine the future transmission system in the Railbelt. The need for the transmission plan was driven by the changes in the Railbelt generation and transmission system since the completion of the 2010 Regional Integrated Resource Plan (RIRP) administered by the Alaska Energy Authority (AEA).

The recommended transmission system improves reliability and has the potential to mitigate future cost increases to Railbelt ratepayers and allow significant energy transfers between different areas of the Railbelt system. Constraints for the use of Bradley Lake hydroelectric project energy are removed and the coordination of hydro and thermal generation resources throughout the Railbelt can be optimized. While the proposed reliability improvements are far from what would be required for a transmission system in the Lower 48, they do significantly improve the reliability and economics of the Railbelt and allow the utilities to pursue additional load and resource pooling options not possible with the existing transmission system. The proposed improvements allow increased use of variable renewable generation, such as wind and photovoltaic (PV) in the Railbelt system, which is currently near its limit of renewable resource penetration.

Most transmission improvements are typically justified by the cost of unserved energy, or the value of system reliability, and are rarely justified purely on hard economic benefits. However, there is currently no uniform estimate of unserved energy throughout the Railbelt, nor are there adequate records or criteria to allow it to be equitably evaluated. Typically, in the Lower 48, the types of reliability improvements included within this plan are required as part of the power systems' mandate to meet NERC's and/or the transmission areas' reliability criteria. Projects are not evaluated solely in terms of the pure economic benefit of the project for fuel savings or reduced losses. For this reason, the economic evaluation of these projects is not included in this portion of the study. The economic model developed for the production cost simulations has been made available to the utilities, along with the results of the analysis in a separate document for the utilities to complete the evaluation in accordance with AKTPL-001-4.

This report is not a mandate to construct these projects, but rather should be considered the first step in the transmission planning process outlined in the recently completed transmission planning standard, specifically AKTPL-001-4. Each of the projects must undergo further cost and benefit analysis prior to making the decision to construct each project. Some projects may be deemed feasible and constructed following the assessment and others may be put on hold until economic or other conditions warrant their construction.

All of the projects identified in the study are driven by the reliability improvements, with most having the added benefit of positive economic value. As the projects are evaluated going forward, the value of unserved energy, the value of renewable energy, the value of future load-serving capability, the value of capacity sharing or deferral and the value of a significant reduction in greenhouse gasses should be computed and utilized in each projects' analysis. However, some of the projects are strictly reliability driven projects with little or very small economic benefits and can only be justified by more traditional transmission evaluation methods.

A summary of the projects that have both economic and reliability benefits are included in Table 2.1.

Table 2-1: Economic/Reliability Projects

Priority	Project	Description	Cost (Millions)
1	Bernice Lake-Beluga HVDC	100 MW HVDC Intertie	$ 185.3
2	35 MW/20 MWh BESS	Anchorage area battery	$ 41.1
3	Bradley-Soldotna 115 kV Line	New line & Bradley/Soldotna sub	$ 66.6
4	University-Dave's Creek 230kV	Reconstruct existing line	$ 57.5
5	University-Dave's Substations	Convert line for 230 kV operation	$ 36.3
6	Dave's Creek - Quartz Creek	Upgrade line to Rail conductor, Quartz sub	$ 16.2
1	Lorraine-Douglas	Lorraine - Douglas 230 kV line/stations	$ 128.5
2	Douglas – Healy line	New 230 kV line operated at 138 kV	$ 245.7
1	Healy-Fairbanks 230 kV	Convert 138 kV to 230 kV	$ 107.9
Total Reliability & Economic Projects			**$ 885.0**

Projects that do not include definitive economic benefits are shown in Table 2.2.

Table 2-2: Reliability Projects

Priority	Project	Description	Cost (Millions)
1	Fossil Creek	New 115 kV substation	$ 11.9
3	Eklutna Hydro	New 115 kV substation	$ 10.1
1	115 kV line	Plt 1-Raptor-Fssl Ck	$ 17.3
1	Communications Upgrade	Communications between Anch-Fairbanks	$ 15.0
Total Reliability Only Projects			**$ 54.3**

The recommended transmission plan meets the requirements of AKTPL-001-4 for system reliability and contingency evaluation. However, AKTPL-001-4 also requires each project be evaluated in terms of reliability and costs to determine whether the project should be constructed. The evaluation required by the standard includes the costs identified in this report, but also requires the identification of all benefits, including the benefits not included in the scope of this project, such as generation capacity deferral, value of unserved energy, water management, additional green energy, firm fuel and energy deliveries for all utilities, and Bradley excess energy delivery.

It is recognized that the costs included in this report are estimates and that changes in assumptions can alter the conclusions and recommendations.

3 Detailed Summary

A detailed description of the projects and benefits for each of the Railbelt areas is presented below. The appendix includes detailed, itemized cost estimates for the projects recommended in this plan.

3.1 Kenai- Anchorage Transmission

Transmission between the Kenai Peninsula and the rest of the Railbelt system consists of a single 115 kV transmission line to deliver power to, or receive power from, Southcentral Alaska. This line was completed in 1961 to transfer a relatively small amount of Cooper Lake Hydro power (16 MW) into the Anchorage area. The Bradley Lake Hydroelectric Project, commissioned in 1991, has been constrained in its operation since its completion due to the inadequate transmission system between the Kenai and the northern and southcentral Railbelt systems. In the past, the Bradley Lake project participants successfully mitigated the constraints of the transmission system to the greatest extent possible by cooperative agreements and actions among the utilities. The changing atmosphere of the Cook Inlet gas situation and the evolving landscape of generation in the Railbelt has foreclosed many of the mechanisms historically available to the Railbelt utilities to mitigate the constraints on the Bradley Lake project. As a result of the loss of the mitigation options and the changing aspects of the generation and gas systems, without improvements to the transmission system between Anchorage and Kenai, the utilities will experience substantial increases in both electrical line losses, lost generation capacity, and operating costs due to the transmission constraints placed on transfers from the Kenai.

In addition to the near-term constraints identified above, the Anchorage-Kenai constraints severely inhibit the integration of additional variable resources such as wind energy. These constraints prevent Kenai hydro energy from being used as part of an overall hydro management or coordination strategy to promote the integration of renewable energy. The lack of transmission capacity also limits the amount of other Kenai resources that could be used to mitigate the impacts of variable generation such as wind energy and will significantly increase the cost of integrating renewables into the Railbelt system. The Eklutna hydro facility is the only hydro resource not constrained by the Railbelt transmission system.

The basic constraint of the Bradley Lake project is the lack of an adequate transmission system to deliver the project's energy from Kachemak Bay to Anchorage and Fairbanks. Besides only a single transmission line between the Cooper Lake area and Anchorage, a single 115 kV transmission line from Soldotna to the Cooper Lake area makes up the connection between the majority of the Railbelt and Bradley Lake. These two single lines have a combined length of 146 miles. Although the lines have been well maintained and improved by the utility owners, they were not originally designed to carry large amounts of power over long distances. For comparison, the line between Anchorage and Fairbanks carries slightly less power than the University to Dave's Creek Line, but is constructed to a much higher voltage and uses two large conductors per phase instead of the one small conductor per phase, as used on the Kenai line.

The solution to eliminating the Bradley Lake constraints is an improved transmission system between Anchorage and the Kenai. This can be accomplished by either an additional transmission path between the two regions, upgrading the existing transmission line to a larger capacity line, or a combination of both building a new line and improving the existing line.

The study evaluated all three options. Adding a new transmission line between the regions greatly increases the reliability and relieves some constraints on Bradley Lake, but a new line by itself does not remove constraints on Bradley Lakes' energy, since Bradley Lake must be operated in a manner to continue operation following the loss of either the new or the existing transmission line. Upgrading the existing transmission line from Soldotna to Anchorage in lieu of a new line was also studied, however it was not recommended due to higher costs, construction timing, and constraints associated with continued operation of a transmission system with a single transmission line between Kenai and Anchorage.

The recommended transmission system is composed of improvements to portions of the existing Anchorage – Kenai transmission system, combined with a new transmission line connecting the Southcentral area's 230 kV transmission system at Beluga to the 115 kV transmission system at Bernice Lake or Soldotna. The combination of these two projects results in the lowest overall cost as well as the most benefits and fewest constraints on the Bradley project.

The routing of a new submarine cable and overhead transmission line were based on a paper study of possible routes using our past experience with the previously dismissed Southern Intertie. Other routing options that could reduce the cost of the line may be possible with further evaluation of the project.

In addition to the Bradley Lake constraints, the single contingency line between Anchorage and Kenai requires certain generators to operate on the Kenai. In order to ensure there is not excessive loss of load following the opening of the single transmission line, the Kenai is required to maintain certain levels of generation on-line as opposed to importing generation from other areas. As the generation fleet ages, this may require replacement of thermal units on the Kenai in a Railbelt system that is capacity rich in order to provide a base-loaded, more efficient unit to meet this generation constraint.

A 35 MW/20 MWHr BESS is recommended in conjunction with the transmission improvements. The project's primary purpose is to provide contingency reserves for the loss of the Kenai Intertie or HVDC line. However, it also provides benefits to the entire Railbelt area by supplying contingency reserves and some regulating reserves to the system. The size of the BESS, in conjunction with Hydro and other BESS resources can provide all the contingency reserves required in the Railbelt without thermal generation. The project could be located in any area north of the Kenai to provide these benefits.

A summary of the costs of the proposed projects to relieve the constraints on the Bradley Lake hydroelectric project and the Kenai generation constraints is presented in Table 3-1. The costs are estimated, budgetary figures within +/- 20%.

Table 3-1: Kenai Project Costs

Priority	Project	Description	Cost (Millions)
1	Bernice Lake-Beluga HVDC	100 MW HVDC Intertie	$ 185.3
2	35 MW/20 MWh BESS	Anchorage area battery	$ 41.1
3	Bradley-Soldotna 115 kV Line	New line & Bradley/Soldotna sub	$ 66.6
4	University-Dave's Creek 230kV	Reconstruct existing line	$ 57.5
5	University-Dave's Substations	Convert line for 230 kV operation	$ 36.3
6	Dave's Creek - Quartz Creek	Upgrade line to Rail conductor	$ 16.2
	Electrical Projects Total		$ 403.0

3.2 Southcentral Alaska Reliability

A single 115 kV transmission line between the Anchorage and the Palmer areas connects AML&P's Plant 2 to the Eklutna Hydro Plant. A recent upgrade of this line has added a second circuit, which is not energized due to the lack of a substation at Fossil Creek and inadequate substation space at Eklutna. A portion of this new circuit is energized as a radial line from the EGS power plant. Improvements to the reliability of the Southcentral Railbelt system serving Anchorage and the Mat-Su area consist of two substation projects required to place this additional circuit into service. The substation projects are driven by reliability requirements. In the case of the Eklutna substation project, the existing substation equipment has exceeded its useful life and the station cannot be replaced in its current configuration.

The Fossil Creek Substation allows the interconnection of the second 115 kV transmission line into the Railbelt system and also allows for a second interconnection between the ML&P system and Fossil Creek through Raptor substation. This second path into the AML&P system eliminates generation constraints for the new Eklutna Generation Station and increases the critical clearing time for 115 kV faults to more manageable levels.

A second transmission line into the AML&P system via Raptor Substation increases reliability to the AML&P/JBER area and completes the path between the AML&P 115 kV and the 230 kV systems. This line segment is comprised of a Plant 1 – Raptor (7.0 Mi) section and a Raptor – Fossil Creel (4.1 Mi) section.

A summary of the costs of the proposed projects for the Southcentral Railbelt are presented in Table 3-2.

Table 3-2: Southcentral Project Costs

Priority	Station	Description	Costs (Millions)
1	Fossil Creek	New 115 kV substation	$ 11.9
1	Eklutna Hydro	New 115 kV substation	$ 10.1
1	115 kV line	Plt 1-Raptor-Fssl Ck	$ 17.3
	Total		$ 39.3

3.3 Anchorage-Fairbanks Intertie Reliability

Transfers between the Fairbanks area and the Anchorage/Kenai systems are currently limited to a single line between the areas. Due to the single line, all power transfers are "economic" or transfers that occur only when energy is available in the south through available generation and when the single line is in service. GVEA currently maximizes the use of the existing intertie, but must maintain sufficient generation and fuel resources in its area in case the single intertie between is out of service. The absence of a second transmission line between the areas precludes the contracting for firm power between the Northern and Southern systems and precludes GVEA from contracting for known quantities of fuel or energy from the southern utilities including the sharing of capacity reserves across the Railbelt system.

The addition of a second line between Anchorage and Fairbanks increases the amount of energy capable of being transferred between the areas from 69 MW of non-firm in the existing system to over 189 MW of firm power sales with Healy 2 on-line (all of Fairbanks area load). It is important to note the difference in service between the existing system and the proposed system when comparing the improvements in transfer. Under the existing system, any transfer from Anchorage above 30-40 MW will result in load shedding in the Fairbanks area following the loss of the single line. This is considerably different than the 189 MW limit of the proposed system which would not result in any customer outages for the loss of a single line.

The second transmission line spanning the 171 miles between Healy and Anchorage will prevent loss of load in Fairbanks for single line outages and will allow GVEA to access electrical and gas markets in the Southcentral system. It will also allow GVEA to evaluate the most economic solution for replacement generation capacity as its power production fleet continues to age or if coal resources are retired.

A new substation approximately mid-way between Healy and Douglas substations is proposed to serve as a sectionalizing point between the line sections. The substation would lessen the impact of the loss of one of the two line section between Healy and Douglas, lessoning the power swing due to the loss of the line . The substation also improves the voltage control characteristics and decreases the amount of required equipment needed for voltage control along the Douglas – Healy corridor.

A summary of the costs of the proposed projects to provide reliability and economic energy transfers between the northern and southern systems is presented in Table 3-3.

Table 3-3: Northcentral Project Costs

Group	Item	Description	Costs (Millions)
1	Lorraine-Douglas	Lorraine - Douglas 230 kV line/stations	$ 128.5
2	Douglas – Healy line	New 230 kV line operated at 138 kV	$ 245.7
	Communications Upgrade		$ 15.0
	Total		$ 389.1

The analysis determined that upgrading the 138 kV lines into the Fairbanks area to 230 kV essentially eliminated transfer constraints between southern generation resources and the Fairbanks area. An upgrade of the existing lines to 230 kV operation would satisfy the requirements of AKTPL-001-4 and increase the transfer capacity between the Anchorage and Fairbanks areas. The costs of the 230 kV transmission line upgrades are presented in Table 3-4.

Table 3-4: Northcentral Project Costs –230 kV Line Upgrades

Group	Item	Description	Cost (Millions)
1	Healy-Fairbanks 230 kV	Convert 138 kV to 230 kV	$ 107.9

3.4 Proposed System Transmission Maps

Transmission maps were created for the proposed transmission system and are shown below in Figure *3-1*: Northern Proposed Transmission System and Figure 3-2: Kenai and Southcentral Proposed Transmission System.

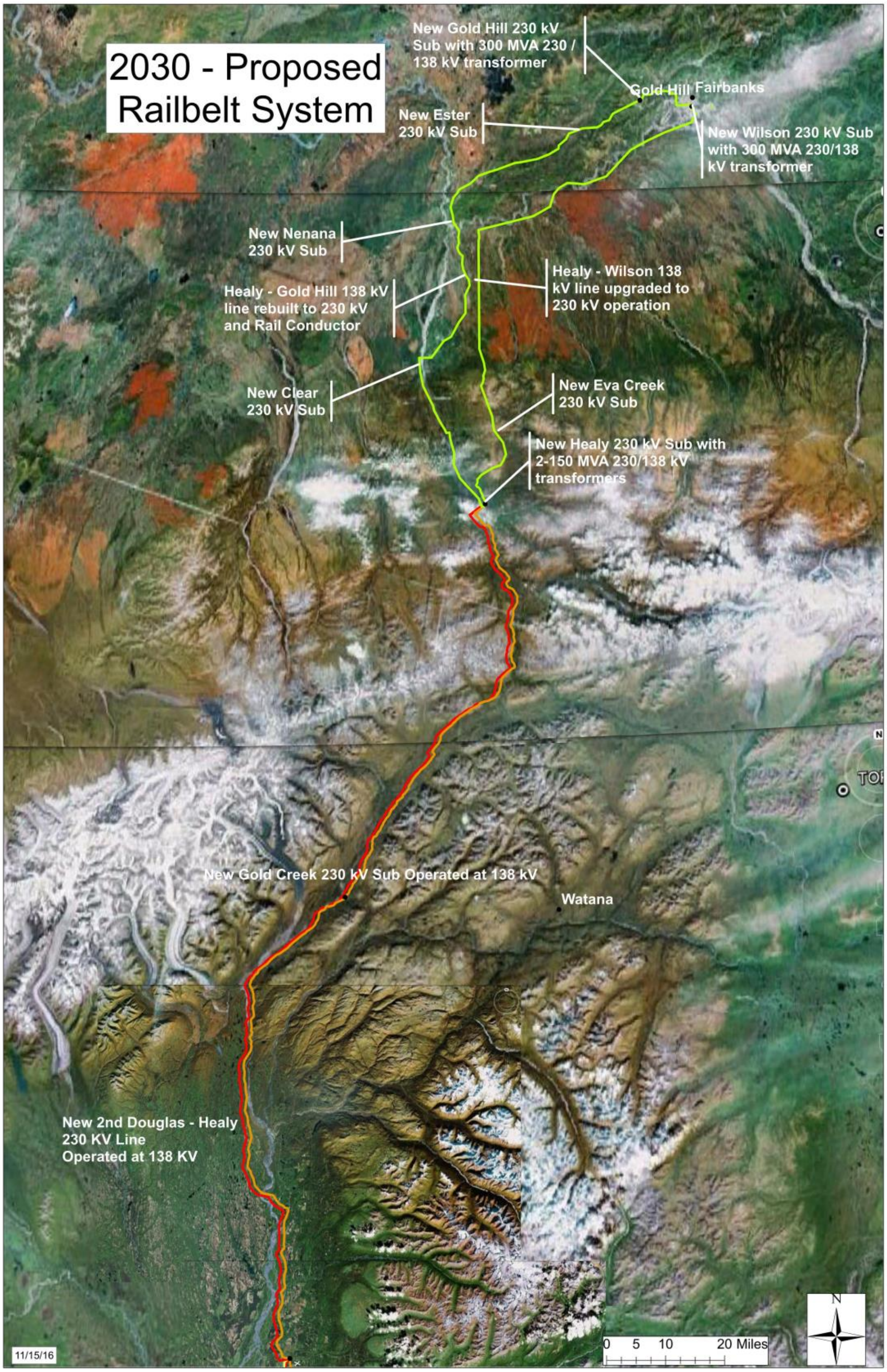

Figure 3-1: Northern Proposed Transmission System

Figure 3-2: Kenai and Southcentral Proposed Transmission System