

Pumped Energy Storage for Alaska

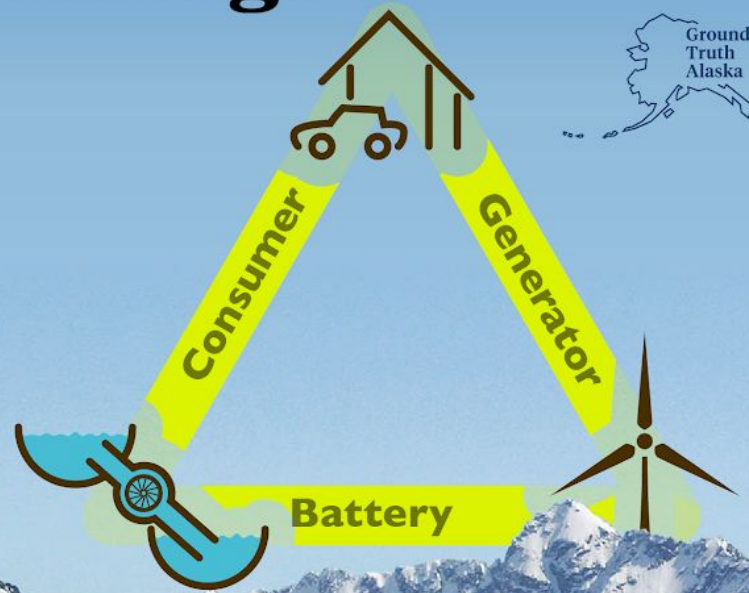
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A path to lower energy costs
for Alaska's new energy future.



Photo: Paxson Woebler

Executive Summary

Alaska’s Railbelt has expensive electricity, generated from expensive fuel. Most of it comes from a single source -- Cook Inlet Natural Gas -- leaving us vulnerable to swings in price or supply. Prices may increase further, due to taxes and regulations aimed at emissions reductions, or decreases in fossil fuel subsidies. Here we outline a way to meet our power needs more economically and cleanly by combining two proven cost-effective technologies: wind power and pumped energy storage (PES). Wind power is exploding across the lower 48, as technology has improved and costs have dropped. One thing that has stymied power producers from bringing wind into Alaska is the challenge of integrating large amounts of variable power into our small and isolated grid. PES can solve this problem, pumping water uphill when energy is abundant, and running it back down when power is needed. This decades-old technology is long-proven, fish-friendly, and can create the cheapest “batteries” in the world.

In 2010 Alaska adopted a non-binding goal of generating 50% of electricity from renewable energy sources by 2025. Currently, the Railbelt generates only 15% of its power from renewable sources. Railbelt utilities emit 2.5 million metric tons of carbon dioxide per year,¹ and charge prices higher than any state except Hawaii. This report offers a preliminary comparison between two proposals which could meet this renewable goal: the Susitna-Watana Hydro project, and a combination of wind and PES.

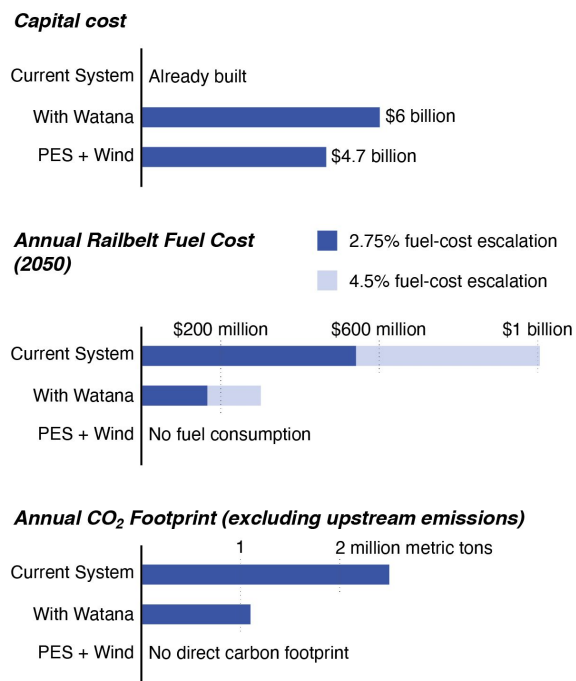


Figure 1. Comparison of Projects. Comparison of capital cost, fuel cost, and CO₂ footprint between the current Railbelt electric grid and future scenarios.

¹ Climate Footprint of the Alaska Railbelt Energy Grid: 2009-2018
https://static1.squarespace.com/static/5b08d371ee175932febdb9a7/t/5d9bd2113dc97713cd053102/1570492947451/Carbon_Emissions_Intensity_Railbelt_2009-2018+%281%29.pdf

Other renewables like solar and tidal energy may improve the resilience and cost-effectiveness of this system, especially if the timing of energy production reduces the need for storage. However, based on available technology and Alaska conditions, they are vastly more expensive per megawatt hour of energy generated, and cannot economically meet the 50% target. For purposes of this preliminary report, we consider only PES and wind.

All energy sources have environmental impacts, with our existing fossil fuel generation creating significantly more damage than either Watana or PES and wind. While both of these potential scenarios incur environmental trade-offs, Eklutna, the main PES system discussed in this paper, has clear benefits; it will utilize existing hydroelectric and transmission infrastructure, inundate far less area than Watana, reduce emissions nearly twice as much. If constructed with an aerial tram, it could reduce costs and impacts and improve access to remote areas of Chugach State Park. In addition, the Eklutna PES has the potential to help manage energy generation, assist with salmon restoration efforts and regulate Anchorage's dwindling water supply from Eklutna Lake.

While both Watana or PES plus wind would result in substantial fuel cost savings over time, PES plus wind can create more power with a lower initial outlay, and could be constructed in phases to stagger costs.

The state estimated costs of \$6 billion for Watana (adjusted to 2019 dollars), with \$4.5 billion in capital costs² and \$1.5 billion in required transmission upgrades and transmission lines,³ with a completion date of 2029. Based on a simple comparison of capital costs and projected fuel costs, fuel savings will equal capital costs in around 20 years (with a 2.75% yearly escalation in fuel cost) or 15 years (with a 4.5% cost escalation). However, Watana and existing renewables will only meet around 75% of current energy demand. A quarter of our power will continue to be produced by coal, oil, and gas. The state's engineering feasibility study⁴ models that Watana will displace only natural gas and oil generation, leaving coal generation intact. Coal combustion is more polluting than natural gas. As a result, even though renewable energy will increase fivefold, CO2 emissions will only be halved. In this scenario, 1.1 million metric tons of CO2 will continue to be released annually. In 2050, total fuel costs for this remaining non-renewable power are estimated between \$160 and \$300 million per year.

In combination with existing renewable production, PES and wind can supply 100% of Railbelt energy needs. Our preliminary estimates find that Railbelt PES could be constructed for around \$1.5 billion, and associated wind farms could be constructed for under \$2 billion. Soft costs including permitting could add substantially to this price-tag, perhaps approaching \$1.5 billion. All together, we estimate a system cost for PES plus wind of about \$4.7 billion. This is less than the \$6 billion estimated for Watana, and provides substantially more energy production. Power plant CO2 emissions will be eliminated entirely. With an online date of 2029 (equivalent to the Watana study for comparison purposes), and fuel costs escalating at a rate of 2.75% per year, fuel savings would equal capital costs in around 13 years (2041). With fuel costs escalating at 4.5% per year, that \$4.7 billion in fuel savings would be reached in only 10 years.

²Susitna-Watana Hydroelectric Project: Benefit-Cost and Economic Impact Analyses, Alaska Energy Authority, March 2015

<http://www.susitna-watanahydro.org/wp-content/uploads/2015/08/Watana-BCA-and-IO-Report-Final-Version-March-31-20152.pdf>

³ Alaska Energy Authority, Pre/Post - Watana Transmission Study Draft Report Project #11-0514, March 17, 2014

⁴ Alaska Energy Authority AEA 11-022 Engineering Feasibility Report 5. Integration into the Railbelt System. <http://www.susitna-watanahydro.org/wp-content/uploads/2015/01/Section-05-Integration-Into-the-Railbelt-System.pdf>

While consumer electricity prices are a combination of many factors outside the scope of this report, it is clear that PES and wind will save consumers money. Fuel represents a third of the utilities' current costs. Once capital costs are paid off, 100% renewable energy will save consumers at least 33% percent on their bills. If fuel costs increase faster than expected, savings could be much higher. Utilities may also be able to shut down existing infrastructure, creating additional savings.

Project	Annual CO ₂ Emissions (millions of metric tons)	Proportion Renewables	Capital Cost (\$billions)	Fuel Price Escalation	Annual Fuel Cost in 2050 (\$millions)	Payoff Time (years)
Current Railbelt Generation	2.5	15%	Already Built	2.75%	541	N/A
				4.5%	1,005	N/A
Susitna-Watana Hydropower	1.1	75%	6	2.75%	166	20
				4.5%	301	15
Pumped Energy Storage + Wind	0	100%	4.7	2.75%	0	13
				4.5%	0	10

Table 1. Comparison of Susitna-Watana Hydro with Status Quo. All scenarios are based on a flat power use equivalent to 2018 levels, with costs increasing at the rate specified. Watana is assumed to cut fuel costs by 70%, as expected generation of 2.8TWh/yr is equivalent to 70% of current fossil fuel power. Emissions for the Watana scenario are calculated by leaving coal emissions and coal power equivalent to 2018, and assuming the remaining power is produced by a gas plant with an emissions intensity of the average 2018 gas plant on the Railbelt. Upstream emissions are not included for any scenario, but will be particularly high for natural gas. To allow comparison with PES and wind, payoff time is based on the same simple calculation of capital vs. fuel costs. More complex modeling by AEA has found greater savings for Watana, based on operations and maintenance savings and plant retirements. We expect that similar increases in savings will apply to both projects, improving the outlook for Watana and PES plus wind vs the status quo.

Current Situation

More than two thirds of Alaska's population receives power from the "Railbelt" grid -- a network of six interconnected utilities stretching from the tip of the Kenai Peninsula to Fairbanks. At an average residential rate of 21¢/kWh, the Railbelt has more expensive power than any state except Hawaii. The sprawling nature of the grid and Alaska's small population means that fixed costs are borne among a smaller number of customers. Also, the fuel that powers our generators is expensive.

Two thirds of the Railbelt grid runs on Cook Inlet natural gas, which is the primary power source for five of the six utilities: Chugach, Matanuska Electric Association, Municipal Light & Power, Homer Electric Association, and the City of Seward (a sole customer of Chugach). The price of this gas has increased more than 350% since 2000, while prices in the lower 48 have dropped.

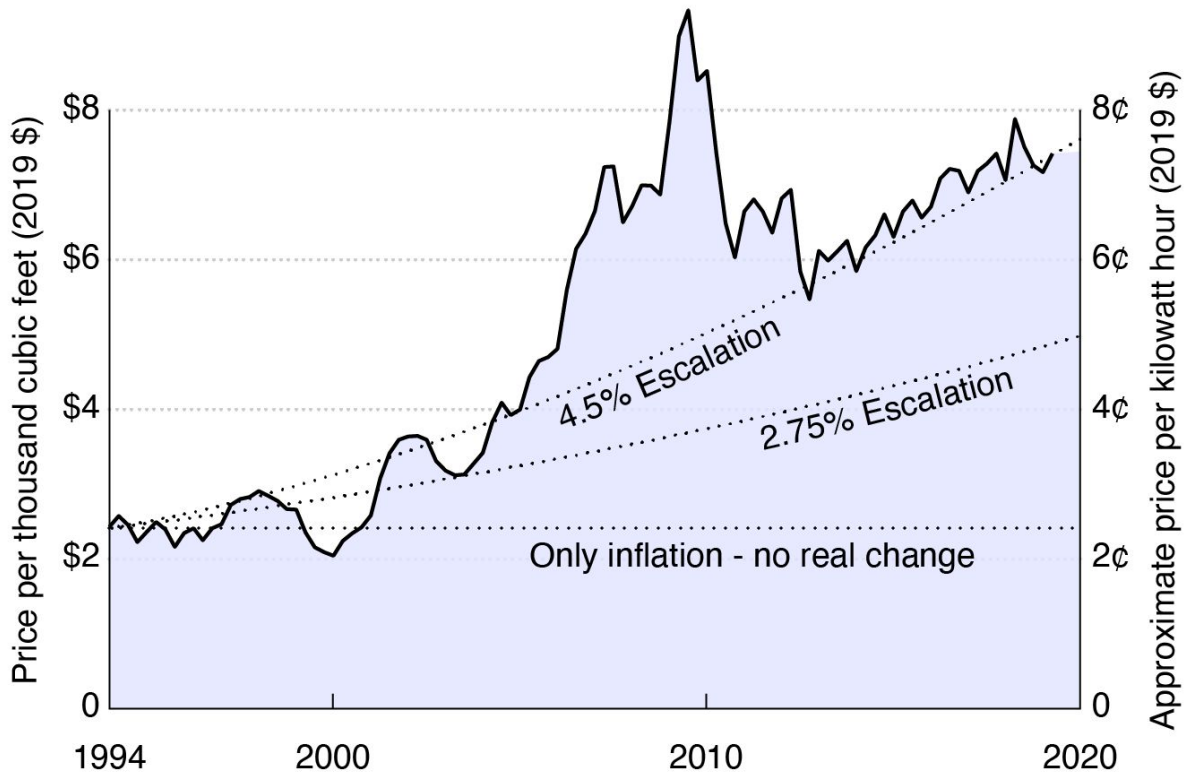


Fig 2. Natural Gas Prices. Prevailing value (Mcf and kWh) of Cook Inlet Natural Gas, adjusted to 2019 dollars, from Alaska Dept. of Revenue quarterly reports: <http://www.tax.alaska.gov/programs/oil/prevailing/cook.aspx>. This prevailing price is the weighted average price of significant sales of gas to publicly regulated utilities in Cook Inlet. Values do not include the costs of state tax credits paid to oil and gas companies. 2.75% and 4.5% escalation curves are provided for reference, given those values are used elsewhere in our analysis.

17% of the grid runs on coal and oil. This is in Golden Valley Electric Association's service area exclusively, where natural gas is not available. These plants are significantly more expensive to run than gas plants. Golden Valley buys around 27% of its power from southern utilities, and can be constrained by the capacity of the intertie that connects it to the Anchorage area.

The rest runs on renewable sources, primarily hydropower. Bradley Lake provides around 9% of the Railbelt's electricity, with Eklutna and Cooper Lake providing another 4%. Existing wind generation is 2.5%, and solar is well under 1%.

On average, electric utilities spend a third of their budget on fuel, totalling around \$250 million dollars in 2018.



Figure 3. Current Railbelt Infrastructure

Future Scenarios

Natural Gas: Electricity generated from natural gas is unlikely to become cheaper. While Cook Inlet has large reserves of gas, older fields are declining, and continual investment is required to maintain production levels. Current gas prices are around \$7.50/Mcf. A 2018 State of Alaska Department of Oil and Gas study⁵ predicted that by the late 2020s, prices of at least \$10/Mcf will likely be required to bring online the necessary production to supply local demand. In calculating the costs and benefits of Watana, the state assumed costs in 2029 of more than \$14/Mcf. Growing political opposition to fossil fuel use could add an additional layer of costs, through taxes, regulations, or decreases in fossil fuel subsidies.

Any increases will be reflected in the prices paid by utilities and their consumers. Looking beyond Cook Inlet, imported LNG from the Pacific market is highly variable in price, and historically has almost always been more expensive than our prices. A gas line from the North Slope is prohibitively expensive for our small market. Generating electricity on the North Slope using natural gas and building transmission lines to the Railbelt would also be prohibitively expensive.

Not only is gas expensive, the overwhelming dependence on a single energy source leaves utilities and consumers extremely vulnerable to market fluctuations, price swings, and supply crises. Around 2009, Cook Inlet natural gas production was in steep decline. This prompted a state of near crisis, with utilities gearing up for expensive LNG imports and possible blackouts. In that case, crisis was averted by Hilcorp's better-than-expected production, and by state payments of \$1.4 billion (inflation adjusted to 2019 \$) to Cook Inlet oil and gas operators. In recent years, several smaller producers have left the inlet or gone bankrupt, leaving only one producer to bid on long-term contracts. Future gas supply and cost constraints are quite possible, and their budgetary implications could be even more extreme.

Susitna-Watana Hydro: Large dam hydropower projects are long-lasting and reliable sources of electricity. They have high capital costs but are cheap to operate. The Watana Dam project would produce around 60% of the power needs of the Railbelt. However there are several significant downsides. Watana is an all-or-nothing proposition, at a cost of around \$6 billion for the project and the necessary transmission upgrades. Public financing would likely be necessary for the entire capital cost. It cannot be scaled up to cover the rest of the Railbelt's power, nor replicated in most of rural Alaska. Utilities will continue to incur substantial fuel costs to supply the remainder of the power, and continued reliance on coal means that CO2 emissions will only decrease by half. Finally, large hydro in the lower 48 bears much of the responsibility for the devastation of Pacific Northwest salmon runs, a history which has helped galvanize strong opposition to developing hydropower in the Susitna-Watana watershed.

⁵ Michael Redlinger, Ph.D., John Burdick, and Laura Gregersen, Cook Inlet Natural Gas Availability, Alaska Department of Natural Resources, Division of Oil and Gas, http://dog.dnr.alaska.gov/Documents/ResourceEvaluation/CI_Natural_Gas_Availability_Study_2018.pdf

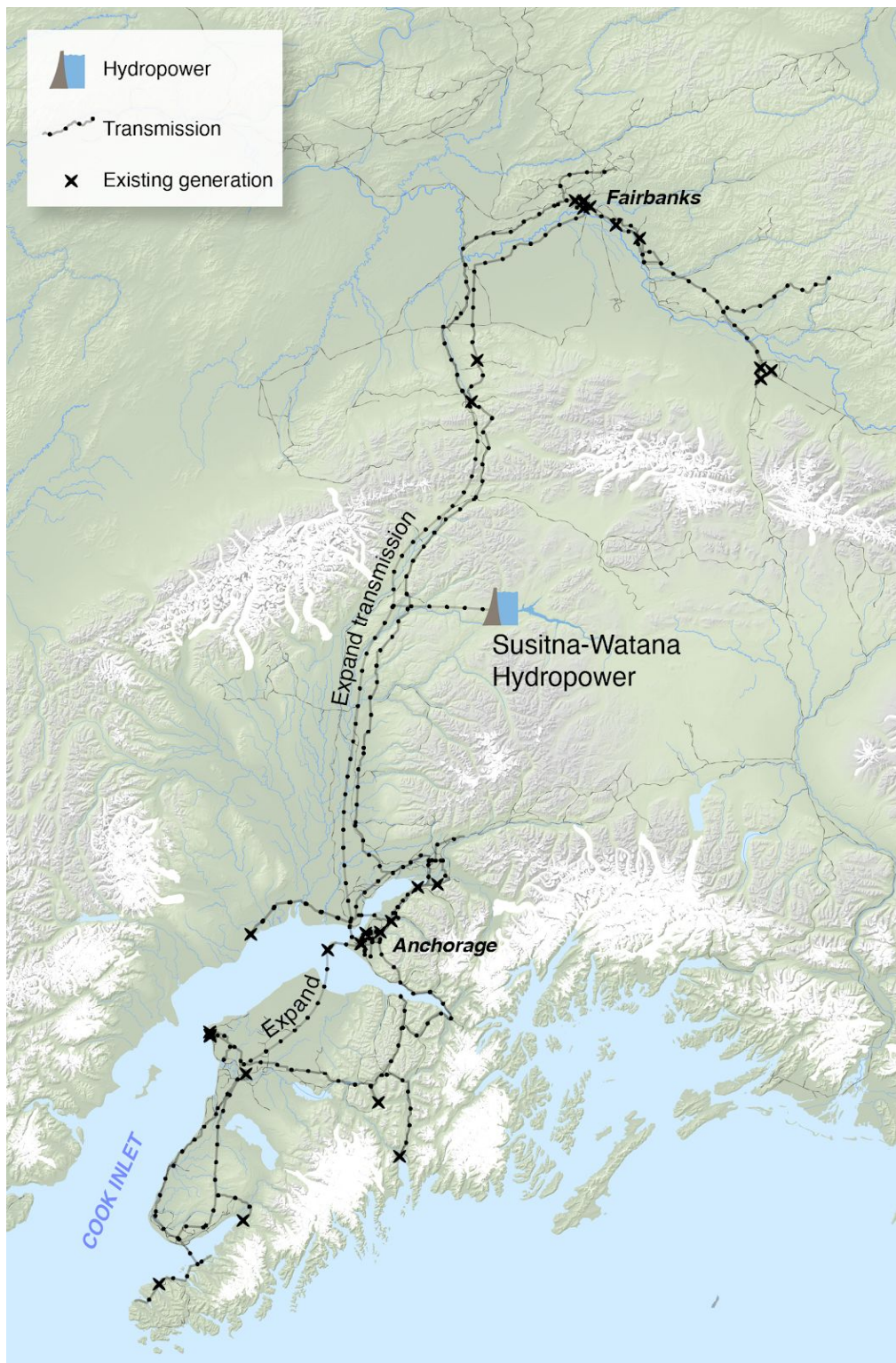


Figure 4. Railbelt with Susitna-Watana Hydropower

Wind + Pumped Energy Storage: Across the country, wind is the cheapest way to generate electricity available today. However, wind can be difficult to integrate into existing grids because the energy it generates is highly variable and not very predictable. Utilities must have a way to rapidly up or

downregulate other power plants or storage devices to balance out the spikes and drops in wind production. Multiple private power companies in Alaska, including CIRI and Delta Wind, have abandoned wind power proposals because the utilities' limited ability to handle variable power led to prohibitively high integration cost.

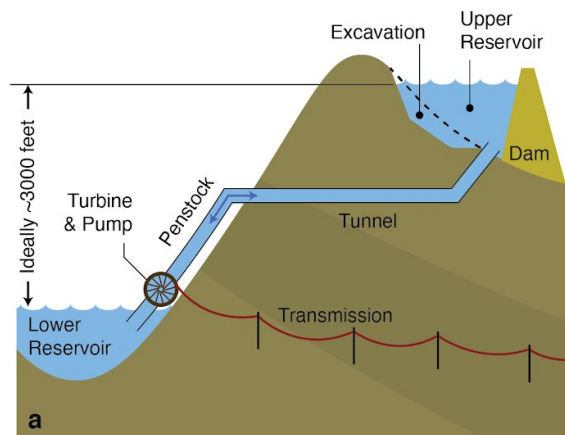
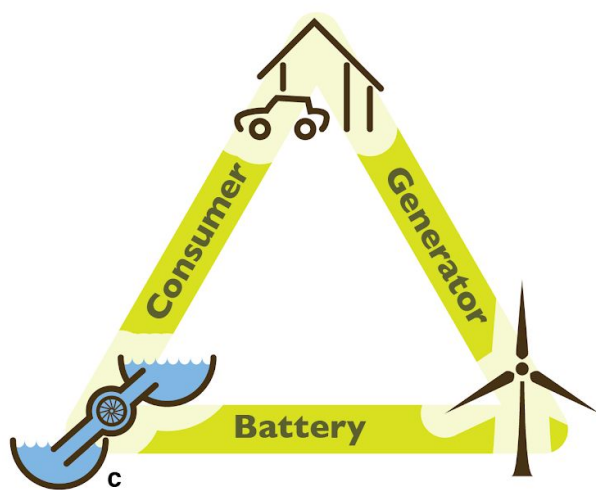
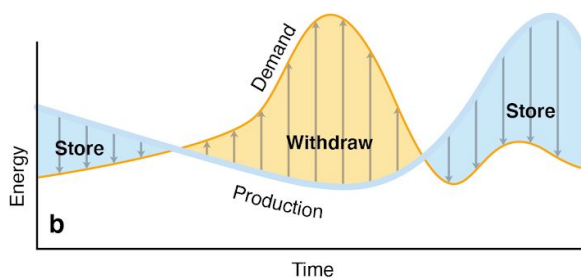


Figure 5: PES works to store energy by pumping water uphill, and converting that stored energy back to electricity by allowing the water flow back downhill through a turbine (a). Construction involves developing reservoirs using excavations and dams, building tunnels and penstocks to connect them, installing generation, and running transmission to connect the facility to the grid. A PES facility like this serves to balance demand against generation (b). Generation, consumption, and storage work together to create a functioning electric grid (c)



This is where Pumped Energy Storage (PES) comes in. Combined with PES, wind power can produce all of the power needs of the Railbelt at a cost lower than Watana. Furthermore, this model is scalable. It can be constructed in pieces, each of which provides independent benefits, and can be replicated at a smaller scale in multiple sites in rural Alaska. Transmission expenses would be less than Watana, since independent wind + PES systems could be located on different parts of the grid. While the

storage system would require public financing, independent power producers from the private sector (including Alaska Native corporations) are well placed to build and profit from the wind farms.

The centerpiece of our Railbelt PES plan is located at the existing Eklutna hydroelectric project, taking advantage of both pre-existing infrastructure and a centralized location within the Railbelt grid. The Eklutna Battery would operate as a closed-loop pumped storage system, and thus have few negative downstream impacts on salmon runs. In fact, as designed, the Eklutna Battery could improve salmon habitat and aid restoration efforts currently underway by raising the level of the lake and increasing downstream flows.

National scale studies confirm that wind is currently the cheapest power source, and pumped energy hydroelectricity is the cheapest storage technology. According to Lazard's Levelized Cost of Energy report from 2019, new wind comes in at \$28 to \$54/MWh, less expensive than new gas plants even at the lower 48's cheaper gas prices.⁶ Also, even though the costs of lithium and flow batteries are dropping rapidly, PES is vastly cheaper than any chemical battery storage technology over the long term, and will have the long life of a conventional hydroelectricity plant, rather than a shorter-life battery. Chemical battery technology currently costs around \$204/MWh - \$275/MWh over 20 years (Lazard's Levelized Cost of Storage 2019), while PES is estimated at \$177/MWh for the first 50 years, and as low as \$58/MWh for the next 50 years.⁷ A 2017 study found that Alaska energy storage costs were equivalent to global costs across many different technologies,⁸ and confirmed that while there are no PES projects in Alaska currently, these projects are the cheapest form of storage worldwide. Furthermore, PES relies on local resources - water and extreme topography - and will be built by local contractors, rather than being shipped in from distant factories like lithium batteries.

⁶ Lazard's Levelized Cost of Energy Analysis 13.0, 2019

<https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf>

⁷ Victor, D.G., PhD, et al. A White Paper. Pumped Energy Storage: Vital to California's Renewable Energy Future, May 21, 2019,

<https://www.sdcwa.org/sites/default/files/White%20Paper%20-%20Pumped%20Energy%20Storage%20V.16.pdf>

⁸ An Alaska case study: Energy storage technologies Jeremy VanderMeer, Marc Mueller-Stoffels, and Erin Whitney Alaska Center for Energy and Power, University of Alaska Fairbanks, 2017

http://acep.uaf.edu/media/254012/EnergyStorage_AlaskaCaseStudy_14986580.pdf

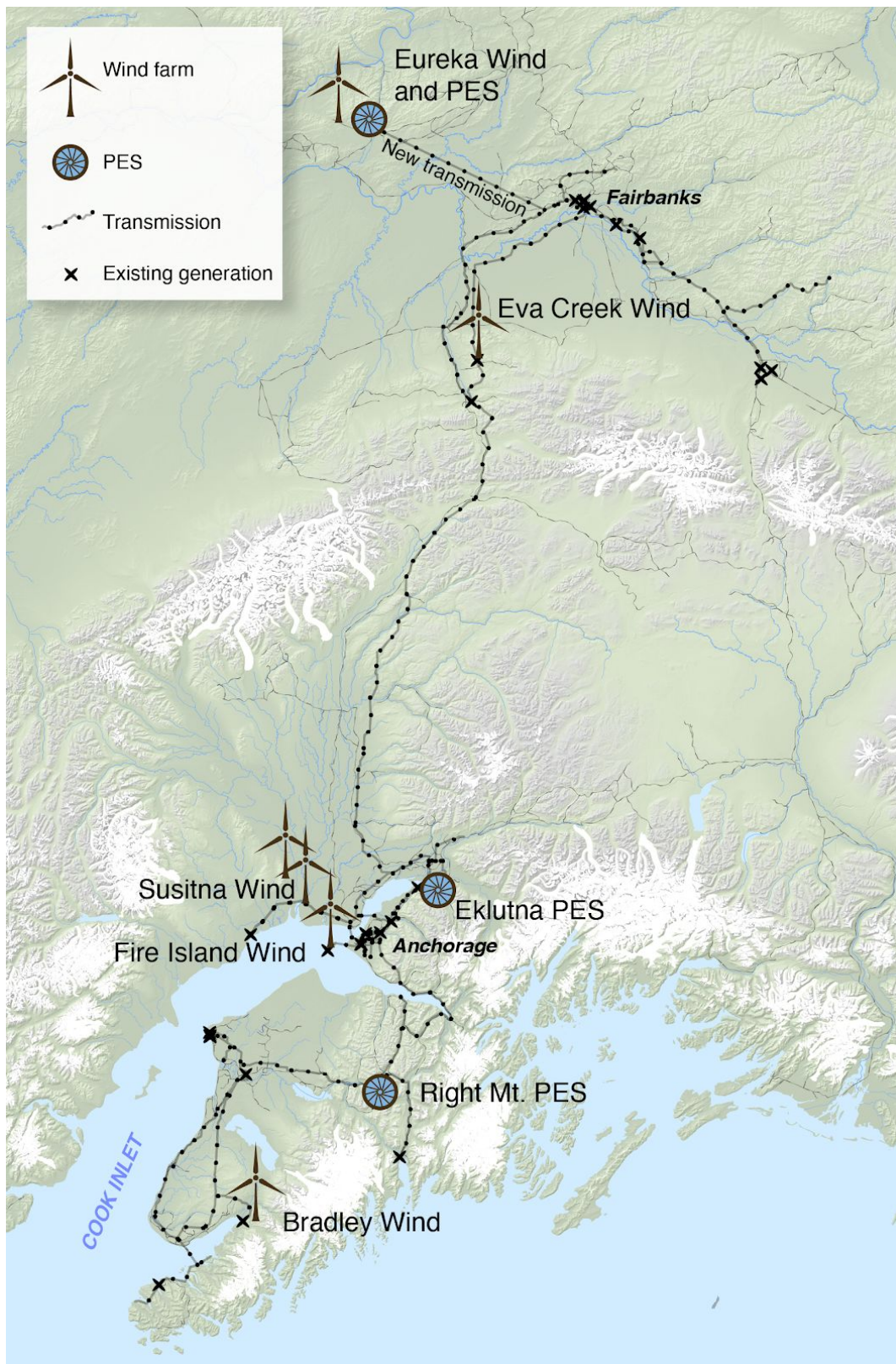


Figure 6. Pumped Energy Storage plus Wind Generation. *This system would replace 85% of Alaska's existing generation infrastructure, leaving only renewable, zero-fuel generation.*

Other Renewable Technologies: Wind and hydro are the only technologies currently capable of economically meeting the 50% renewable target in Alaska conditions. However, the integration of other technologies at a smaller scale and in a more distributed fashion may decrease costs and increase resiliency. Future analyses can investigate how to combine this proposal with energy efficiency, conservation measures, and integration of resources such as solar and tidal power.

Scenario Analysis: The twin technologies of pumped energy storage supporting wind power can work across the state, and at many different scales. Here we offer a preliminary analysis of a Railbelt-specific proposal, including three pumped storage facilities (in Eklutna, Eureka, and Right Mountain), and six wind farms (spread from Eureka, near Fairbanks, to Bradley Lake). Construction of the entire system would take approximately 5-7 years, with a preliminary estimated cost of \$1.5 billion for the PES, and \$1.7 billion for the wind farms. Any pair of facilities (one or more wind farms and one pumped storage facility) could be constructed as an independent project, with a lower initial cost and a proportional benefit.

Methodology of Cost Estimates and Comparisons: In this document, estimated costs for PES include capital costs for construction of the reservoirs, penstocks, turbines, and all associated infrastructure, as well as the required transmission to connect to the existing Railbelt grid. Estimated costs for wind energy are based on Lazard's Levelized Cost of Energy 13.0 (2019). Financing is not included, though financing through Rural Utility Service (RUS) is likely available. Permitting and Operations and Maintenance costs are not included. In the interest of a fair comparison, these costs have also been left out of estimations for existing Railbelt infrastructure.

In essence, we are making a simple comparison between the capital costs for new infrastructure, and the costs of fuel this energy will displace, using a fuel price escalation of 2.75% per year as a default case or 4.5% per year as a high case.

In order to clearly compare the two projects, we use the same simplified calculation of payback time for Watana hydro and PES plus wind. The projected savings for the Watana project in the state's 2014 engineering feasibility report⁹ (AEA11-022) are similar to our 4.5% gas escalation price -- with savings topping \$1 billion per year in 30 years. Those estimates use a more detailed modeling approach that includes operations and maintenance costs, plant retirements, financing, and hourly modeling of electricity dispatch. The PES plus wind scenario should be modeled in similar detail by the Alaska Energy Authority. This preliminary estimate is intended to be a starting point for further analysis, rather than a final amount.

⁹ Susitna-Watana Hydro, Engineering Feasibility Report, Alaska Energy Authority, <https://www.arlis.org/docs/vol1/Susitna2/2/SuWa280/SuWa280sec5.pdf>

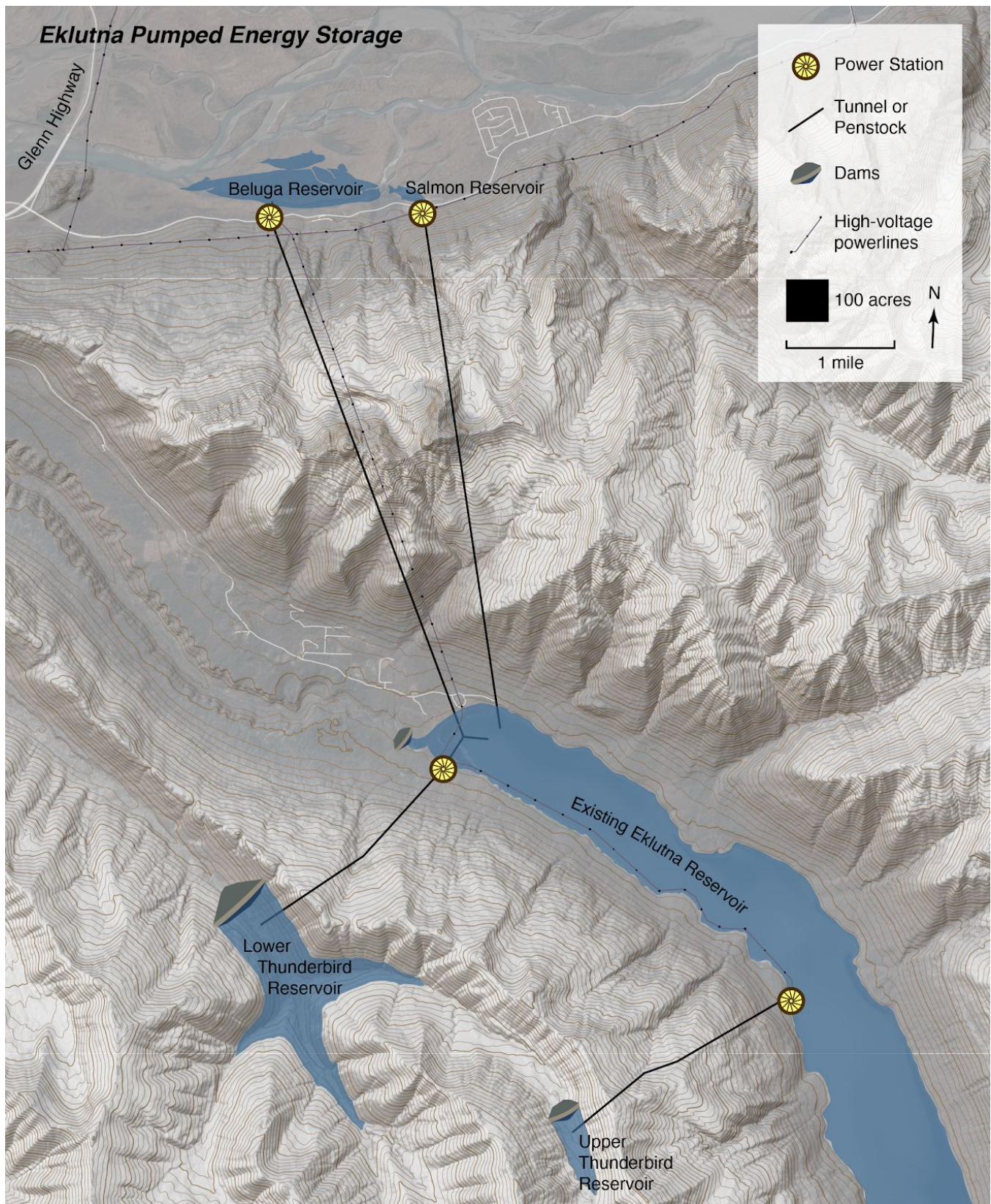


Figure 7. Eklutna Pumped Energy Storage. This complex consists of five reservoirs, two in the Thunderbird watershed, two in the Knik River floodplain, plus Eklutna Lake.

The Upper Thunderbird system (consisting of the 104-acre Upper Thunderbird reservoir, tunnel and powerhouse on Eklutna Lake and the converted pumped hydro at the 18.5-acre Salmon reservoir) are designed as a couplet. They have an equal maximum flow rate, so when they are both generating or storing energy at the maximum rate, one will be adding 725 cfs to Eklutna Lake while the other will be taking 725 cfs from the lake, thus maintaining the lake at an even level. By regulating the flow rate, the lake level can be raised or lowered at will, according to seasonal variations of inflow, thus allowing lake levels to be held high enough for salmon to return to Eklutna Lake and the drainage below without reducing Anchorage's water usage from Eklutna Lake.

Preliminary estimates suggest the couplet would cost about \$29 million at the Salmon reservoir and \$211 million for Upper Thunderbird. The Upper Thunderbird reservoir would store 147 GWh of energy, and Eklutna Lake 118 GWh of energy. The head from Upper Thunderbird reservoir to Salmon reservoir is 3,079 feet. Transmission would be through a 9.7-mile submarine line running from the Upper Thunderbird powerhouse to the existing tunnel down to the existing transmission.

The Lower Thunderbird and Beluga tunnels would also have equal maximum flow rates, thus making those two systems a similar couplet also capable of holding the lake at a given surface elevation level, or adjusting the lake level as needed (such as to enhance river flow during salmon runs).

We estimate that the couplet would cost about \$333 million for the 764-acre Lower Thunderbird and \$282 million for the 316-acre Beluga reservoir for 159 MW and 85 MW respectively. The head from Lower Thunderbird reservoir to the Beluga reservoir is 3,360 feet. Those two tunnels are 50% larger than immediately necessary so that only additional penstocks and turbines would be needed to upsize that couplet by an extra 122 MW. The Lower Thunderbird reservoir would store 242 GWh of energy. Transmission would be on the same submarine transmission line installed for Upper Thunderbird.

Altogether the Eklutna Battery would store 507 GWh. This is enough to meet average Railbelt demand for 30 days, more than enough to deal with a high level of variability in wind output. If necessary for more power or storage, another reservoir could be constructed halfway between the Upper and Lower Thunderbird reservoirs and another tunnel to the Beluga reservoir for a third couplet.

Eklutna PES Component	Capital Cost (\$millions)	Generation Capacity (MW)	Energy Storage (GWh)
Convert Existing System to PES	29	39	118
Upper Thunderbird	211	143	147
Lower Thunderbird	333	159	242
Beluga Reservoir	282	85	N/A
TOTAL	855	426	507

Table 2. Eklutna Pumped Energy Storage Components. *Fully upgrading Eklutna comprises the largest component of the proposed PES + wind system, and can be completed in four steps, each providing stand-alone benefits and functionality.*

Pumped Energy Storage Facility	Capital Cost (\$millions)	Generation Capacity (MW)	Energy Storage (GWh)
Eklutna	855	426	507
Eureka	407	210	53
Right Mt.	254	83	16
TOTAL	1,516	720	576

Table 3. Pumped Energy Storage Facilities. Three separate PES facilities distributed across the Railbelt help ensure continued operation even if GVEA (Eureka PES Facility) or HEA (Right Mt. PES Facility) are islanded. The Right Mt. Facility doesn't need to have the high capacity and storage of other facilities because the existing Bradley Lake Hydropower Facility, and planned HEA Battery Energy Storage System help ensure reliability here even if HEA is islanded.

Wind Facility	Capital Cost (\$millions)	Nameplate Capacity (MW)	Capacity Factor	Generation (TWh / year)
Tannana-Eureka	630	420	50%	1.8
Susitna River	387	258	50%	1.1
Right Mt.	207	138	60%	0.7
Mt. Susitna	219	146	50%	0.6
Eva Creek	268	179	50%	0.8
Fire Island	50	33	48%	0.1
TOTAL	1,761	1,174		5.3

Table 4. Wind Facilities. Upgrading existing wind facilities at Fire Island and Eva Creek, plus building four new facilities would provide 5.3 TWh per year of generation for the operation of the Railbelt. This is more than needed to run the Railbelt entirely on renewable energy. Currently fossil fuels provide 4 TWh of electricity on the Railbelt Electric Grid. Capacity factors taken from the Global Wind Atlas: <https://globalwindatlas.info/>

Soft Costs	Proportion added to Capital Construction Cost	Cost (\$millions)
Design & Engineering	10%	328
Insurance & Bonding	2%	66
Program Management	4%	131
Construction Management & Inspection	6%	197
Licensing, Permitting & Mitigation	20%	655
Engineering Services During Construction	2%	66
TOTAL	48%	1,442

Table 5. Soft Costs for Pumped Energy Storage plus Wind. *Soft costs are associated with the planning, design and coordination of the project. These include design engineering, insurance and bonding, program management, construction management and inspection, and engineering services during construction.*

Breakdown of Project Components	Cost (\$millions)
Pumped Energy Storage	1,516
Wind Facilities	1,761
Soft Costs	1,442
TOTAL	4,719

Table 6. Total Costs. *Our estimated total costs for Pumped Energy Storage plus Wind is about 4.7 billion dollars, reflecting building of both generation capacity and storage, as well as soft costs for construction.*

Sequencing

A major benefit of this scenario is its flexibility. All projects described in this paper are independent of each other, and can be sequenced in many different ways. In general, a PES project should precede a major wind project, or be constructed simultaneously with it, to allow for integration of the wind energy.

Additionally, the Eklutna PES proposal can be further broken down into four distinct phases, each of which provides immediate benefits. First the existing conventional hydro could be upgraded, providing 39 MW of PES capacity. Second, the Upper Thunderbird PES would add another 143 MW of capacity that would reduce the cost of energy noticeably. Lower Thunderbird and Beluga reservoirs are the third and fourth phases respectively. Beyond these four projects more capacity could be added in the future with a central Thunderbird reservoir and/or capacity added at the Beluga reservoir.

Reliability and Resiliency

One of the most costly components of Alaska's grid is transmission. By distributing the wind farms and pumped hydro storage facilities from one end of the Railbelt to the other, the need for new transmission is reduced by hundreds of millions of dollars.

Under normal conditions, the widely separated wind farms will help level the intermittency of wind power, effectively averaging wind power across the state. Additionally, this distribution will maintain resilience for all three regions in the Railbelt grid (Northern, Central, and Southern). Each region must function as an independent micro-grid when cut off from the rest of the Railbelt grid by intertie failures and scheduled outages. These happen regularly, sometimes for months at a time. Greater reliance on a centralized power source such as Watana requires a significant increase in transmission to provide the necessary reliability of those connections (estimated at \$1.5 billion in the 2014 pre/post Watana transmission study), without increasing regional system resilience in the same way as distributed wind and PES.

Environmental and Legal Considerations

Railbelt PES: Because closed-loop pumped energy storage systems can be physically separated from river ecosystems, PES has the potential to greatly reduce fisheries and aquatic impacts typically associated with conventional hydroelectric dams like Watana. After the initial filling of the reservoirs, the only additional water requirement is for minimal operational make-up and to offset evaporation or seepage losses. In addition, because closed-loop pumped storage systems do not need to be located on or near an existing river system or body of water, with the right topographical features, they can be located and scaled as needed to provide storage on or off the Railbelt grid.

New reservoirs required for Eklutna PES would inundate 1,200 acres, less than 6% of the proposed Susitna-Watana reservoir.

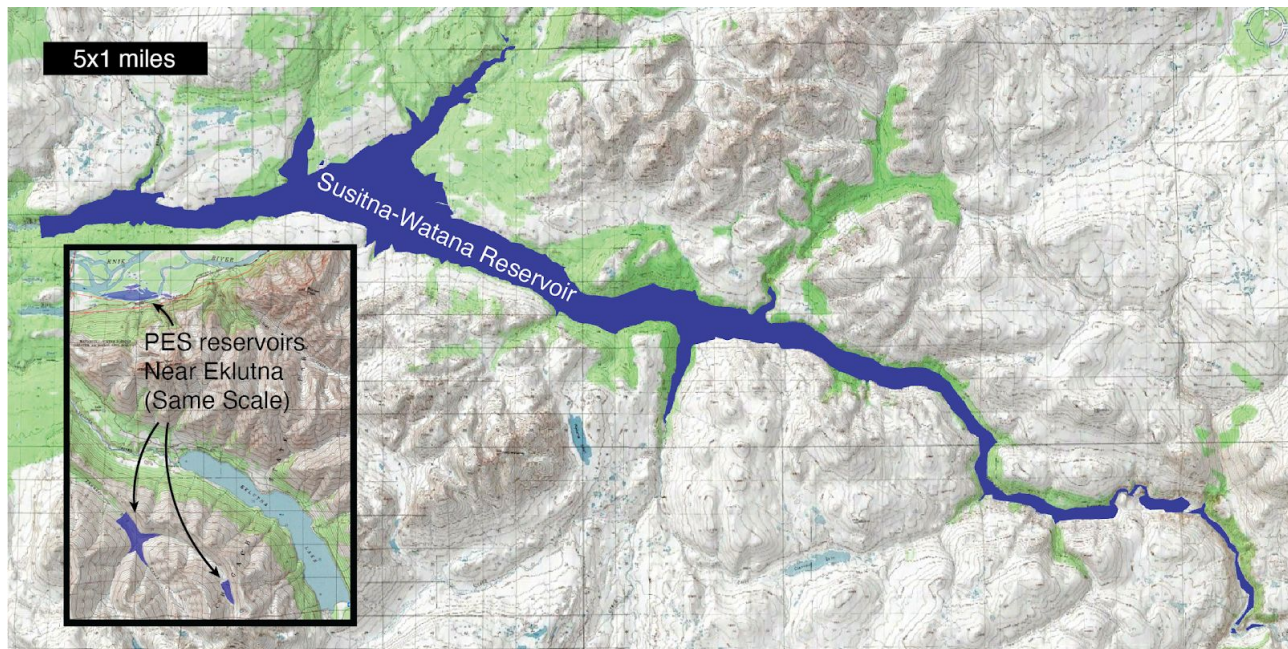


Figure 8. Eklutna vs Watana Reservoir Size Comparison. This figure shows both the Eklutna and Susitna-Watana reservoirs at the same scale. Not including the already existing reservoir at Eklutna, only 1200 acres would be inundated by this PES system, less than 6% of the area flooded by Watana.

Siting at Eklutna: While PES can potentially work in other locations, the primary focus of this paper is on the Eklutna project, at the request of the governor. Eklutna is located inside Chugach State Park, centrally located near existing high-capacity transmission, the highway, the port of Anchorage, and the majority of the Railbelt energy consumers. As a result, it is likely to provide the greatest energy benefits at the lowest cost.

Additionally, the Eklutna PES project has the potential to help mitigate long-standing water resource conflicts in the Eklutna watershed. By raising the level of Eklutna Lake, increasing downstream flows and improving water management, the Eklutna PES could increase water availability for energy generation, stabilize the water supply for Anchorage and assist salmon restoration efforts currently underway.¹⁰ It would also help Chugach and Matanuska Electric Association fulfill their legal obligations to mitigate fish and wildlife resources affected by the original Eklutna Hydroelectric project.¹¹ Analysis of these additional potential benefits exceeds the scope of this paper.

Our initial review suggests that no Federal or State threatened or endangered species or species of concern will be affected by the Eklutna PES, although Thunderbird Creek supports Dall Sheep, Mountain Goat, and moose calving, wintering and rutting habitat.

The largest siting issue is that Upper and Lower Thunderbird reservoirs are in an area of the park that is operated as state wilderness. According to the Chugach State Park Management Plan,¹² "in these areas no human-made improvement should be provided except for the most rudimentary trails, bridges and signing. Developments or other improvements will be undertaken only for the purpose of public safety or to minimize adverse impact on the area's resources". While the area of inundation is very small compared to that of Watana, wilderness values need to be carefully weighed against the potential benefits of siting PES at Eklutna. It is reasonable to expect public opposition to the project, which could potentially be resolved via alternative siting, land exchange or other means.

Because of its proximity to the State's major population center, Chugach State Park experiences a high level of use by residents of these communities, close to half of the State's population. Anchorage and the surrounding communities have grown rapidly since the Park was created, straining Park facilities located near these communities and increasing the demand for Park access.¹³ Careful design and construction of an aerial tram system instead of roads to build and maintain the Upper and Lower Thunderbird reservoirs could be a cost effective means of also providing low-impact access to the high country above Eklutna Lake.

Neither Right Mountain nor Eureka are in designated wilderness areas, but land status issues have yet to be resolved for any of these potential projects. Should land ownership issues prove irresolvable, there are other possible PES locations on the Railbelt, which could be analyzed in a future report.

¹⁰ Eklutna Dam Removal and Diversion Project, Eklutna Inc., <https://www.eklutnainc.com/eklutna-dam-project/>

¹¹ Divestiture Summary Report, Sale of Eklutna and Snettisham Hydroelectric Projects, Alaska Power Administration, US Department of Energy, Fish and Wildlife Agreement, April 1992: <http://akenergyinventory.org/hyd/SSH-1992-0042.pd>

¹² Chugach State Park Management Plan, February 2016, (page 39), <http://dnr.alaska.gov/parks/plans/chugach/chugachmplan.htm>

¹³ Chugach State Park Access Inventory, Analysis & Recommendations, October 2002, Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, <http://dnr.alaska.gov/parks/plans/cspaccess/cspaccessbody.pdf>

All potential impacts of PES projects, including cultural resources, will require full review, consultation and evaluation as part of the formal Environmental Assessment under FERC.

Susitna-Watana Hydro: Due to its location on a large and productive salmon-spawning river, the Susitna-Watana Hydro project has drawn stiff opposition since its inception from a variety of communities, tribes, citizens, and environmental groups. As a result, the FERC licensing process is likely to be extended by legal challenges on the question of how well Alaska Energy Authority models predict the complex and interrelated facets of the Susitna River ecosystem and if the data collected thus far support model development for key physical processes.¹⁴

Status Quo Generation: Current Railbelt generation is responsible for 2.5 million metric tons of CO₂ emissions annually, adding to the costly impacts of climate change. In Alaska, these include fires, droughts, fisheries impacts, infrastructure impacts, erosion, and more. Additionally, coal-fired power produces other air pollutants, and oil-fired power carries a risk of oil spills.

Licensing

As large-scale hydroelectric projects involving dams and reservoirs, both Watana and the proposed Railbelt PES projects require licensing from the Federal Energy Regulatory Commission (FERC).

PES plus Wind: While none of the proposed pumped energy projects have the head start on the permitting process that Susitna-Watana has, they can follow FERC's simpler and expedited Environmental Assessment path.

Since 2019, FERC has used an expedited licensing process for closed-loop pumped storage projects that seeks to ensure a final licensing decision no later than two years after receipt of a completed application.¹⁵ Licensing process time for five similarly sized PES projects approved by FERC since 2015 ranged from 1.21 years to 2.01 years. Four of the five projects followed the more extensive Integrated Licensing Process, the default FERC licensing process. Although it was some years in preparation, the Gordon-Butte PS had the shortest processing time of 1.21 years and followed the Traditional Licensing Process that required additional Commission approval.¹⁶

Susitna-Watana Hydro: The FERC Integrated Licensing Process (ILP) used for Watana is a front-loaded, iterative, milestone-driven process that provides a defined structure, including timeframes for licensing activities, study plan development, formal study plan determination, reporting on study implementation, stakeholder engagement and early National Environmental Policy Act (NEPA) scoping. The Environmental Study Plan for Susitna-Watana included 58 studies. As of June 2017 Susitna-Watana Hydro completed approximately two-thirds of the ILP process before being put into abeyance, with 17 of the original studies marked as needing modification at that time. In its June 2017

¹⁴ Federal Energy Regulatory Commission, Determination on Request for Study Modifications and New Studies - Susitna-Watana Hydroelectric Project, June 22, 2017, http://www.susitna-watanahydro.org/wp-content/uploads/2017/10/20170622_FERC_2017SPD.pdf

¹⁵ FERC Finalizes Expedited Hydro Licensing Process, Federal Energy Regulatory Commission, News release, 4.18.19, <https://www.ferc.gov/media/news-releases/2019/2019-2/04-18-19-H-1.pdf>

¹⁶ Federal Energy Regulatory Commission, Filing a Hydropower License Application with the Commission, <https://www.ferc.gov/industries/hydropower/gen-info/licensing/licen-pro.asp>

Determination Letter,¹⁷ FERC indicated that additional scoping and modifications to the approved study plan would be required. Given that five years have passed since the original studies, it's possible that Watana would require a restart of the ILP process.

Status Quo Generation: Over the coming decades, concern over the impacts of fossil-fuel generation may lead to additional costs placed on the use of fossil fuels, in the form of taxes, regulations, or a decrease in subsidies. This may impact coal generation sooner and more heavily than natural gas generation. Depending on the scale and timing, this could drastically increase electricity prices to consumers, and/or force the rapid replacement of current generation assets.

A New Energy Future

Alaska has world class renewable energy resources and emerging expertise in microgrid design and construction that positions the state to become a leader in the new energy economy. As costs continue to plummet in response to technological innovation and expanding markets, now is the time for Alaska to transition away from costly fossil fuels.

The high electricity prices on the Railbelt have been a significant burden to consumers and businesses alike. Lower energy costs will encourage business, and may be particularly attractive to energy-intensive new industries such as server farms and data centers. Existing consumers may switch from conventional fuel technology to electric technology, such as electric cars and air-source heat pumps. This will result in savings to consumers that go far beyond their electric bill.

Next Steps

To further analyze the possibilities and savings, we recommend that the Alaska Energy Authority do a full feasibility study of the Railbelt PES projects and other potential PES sites around the state (see map below), or contract such a study from a consultant familiar with PES (such as Black & Veatch¹⁸¹⁹ who also already has an extensive knowledge of the Railbelt grid²⁰). The feasibility study should further evaluate wind resource potential by installing anemometers in the identified wind locations and other promising locations around the state. Lastly, we recommend that AEA assess how the Railbelt grid must evolve with a shift to renewable energy rapid enough to meet the states 50% renewable energy generation cost-effectively and equitably by 2025.

¹⁷ Determination on Requests for Study Modifications and New Studies – Susitna-Watana Hydroelectric Project, Federal Energy Regulatory Commission, June 22, 2017,

http://www.susitna-watanahydro.org/wp-content/uploads/2017/10/20170622_FERC_2017SPD.pdf

¹⁸ “Gordon Butte Pumped Storage Project, Montana”,

<https://www.nsenergybusiness.com/projects/gordon-butte-pumped-storage-project-montana/>

¹⁹ “Black & Veatch to Assist in San Diego Hydropower Project”,

<https://tunnelingonline.com/black-veatch-assist-san-diego-hydropower-project/>

²⁰ “Alaska Railbelt Electrical Grid Authority (REGA) Study”, September, 2008

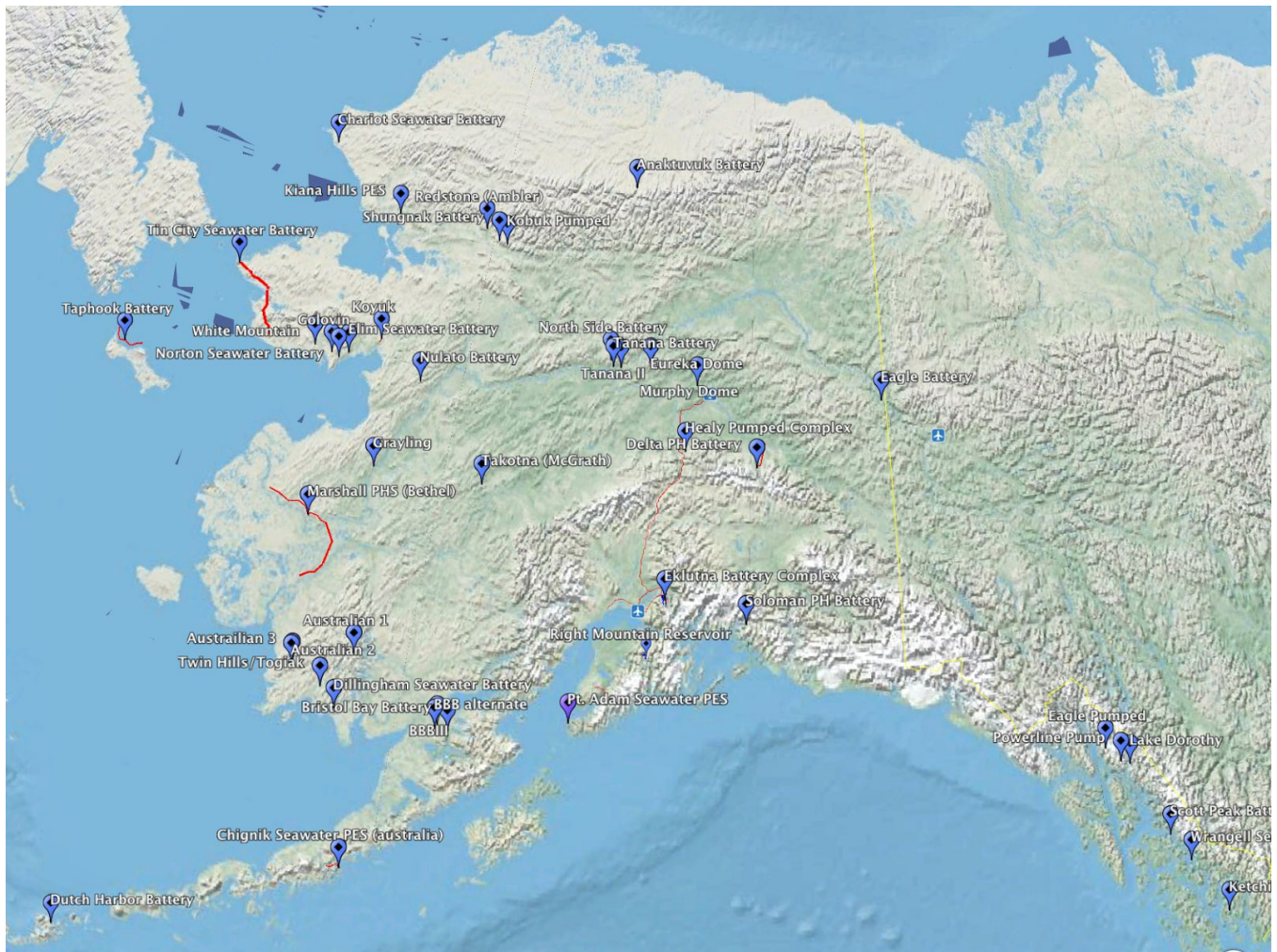


Figure 9. Potential PES sites in Alaska. PES can be sited in locations that have sufficient relief (preferably ~ 3000') and a source of fresh or sea water sufficient to fill and periodically replenish a semi, or fully closed-loop reservoir. There are potentially thousands of sites in Alaska - this map shows potential PES sites that are in proximity to Railbelt, rural or coastal markets.

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