Alaska's Railbelt Electric System: Decarbonization Scenarios For 2050

Researchers at the Alaska Center for Energy and Power at UAF looked at four scenarios for Railbelt electric power supply and demand in 2050. The full report is available at https://www.uaf.edu/acep/.

Baseline assumptions common to all scenarios

- **Electricity generation in 2050** is 8,704 gigawatt-hours (GWh), about 85% more than in 2021. Peak demand equals 1,626 megawatts (MW), more than double the 2021 level. These higher loads come from population growth, electric vehicles, and heat pumps.
- **Additional baseline resources** include the Bernice-Beluga HVDC line, upgrading Kenai-Anchorage transmission to 230 kilovolts (kV), the Dixon Diversion hydro project, and 30 MW of new wind at Little Mount Susitna, plus 228 MW of residential rooftop solar. Healy unit 2 is retired. New batteries bring total battery capacity to 216 MW.

Scenario descriptions

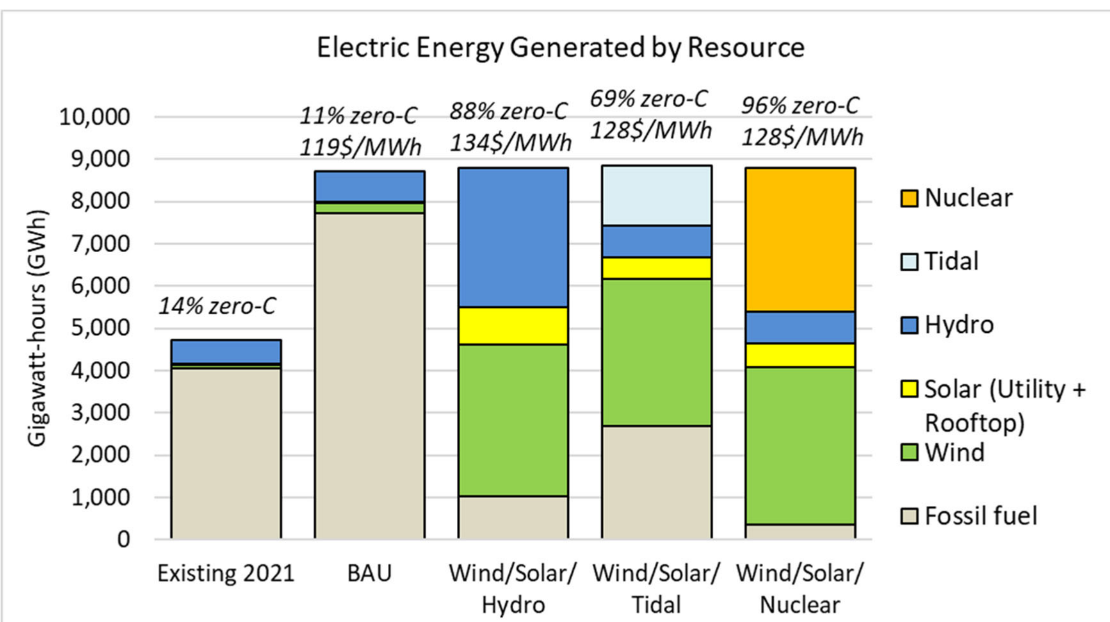
Business as Usual (BAU). Existing power plants, plus several new fossil fuel units, provide all generation. Renewables generate 11% of required energy. 50 MW of new batteries help maintain reliability. Required capital investment, after use of investment tax credits (ITC), is $2.3 billion in 2023 dollars. The generation & transmission cost of electricity (G&T cost) is $119 per megawatt-hour (MWh).

Wind/Solar/Hydro adds Susitna-Watana hydro (475 MW), plus 1,022 MW wind and 472 MW utility solar. Renewables generate 88% of required energy. 1,243 MW of new batteries help smooth wind & solar output and maintain reliability. The Alaska Intertie from Southcentral to Fairbanks is upgraded to 230 kV, which helps share energy. Required capital investment = $11.8 billion; G&T cost = $134/MWh.

Wind/Solar/Tidal adds a 400 MW tidal plant in Cook Inlet plus 924 MW wind and 190 MW utility solar. Renewables generate 70% percent of required energy. 750 MW of new batteries and the Alaska Intertie upgrade are added. Required capital investment = $7.7 billion; G&T cost = $128/MWh.

Wind/Solar/Nuclear. Small modular nuclear reactors in the Northern (243 MW) and Southern (324 MW) regions, plus 1,056 MW of new wind and 328 MW of new utility solar are added. Generated energy is 96% zero-carbon. 1,518 MW of new batteries and the Alaska Intertie upgrade are added. Required capital investment = $10.1 billion; G&T cost = $128/MWh

Results at a glance



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	2021 Existing	2050 BAU	2050 Wind/Solar/ Hydro	2050 Wind/Solar/ Tidal	2050 Wind/Solar/ Nuclear
Electric energy demand GWh	4,725	8,704	8,704	8,704	8,704
Peak load MW	765	1,626	1,626	1,626	1,626
Installed capacity MW					
Fossil fuel	1,692	2,086	1,332	1,332	1,332
Wind	45	75	1,096	998	1,130
Solar (Utility + Rooftop)	21	237	709	427	475
Hydro	179	179	659	184	184
Tidal	0	0	0	400	0
Nuclear	0	0	0	0	567
Batteries	87	267	1,243	750	1,518
Energy generated GWh					
Fossil fuel	4,041	7,716	1,037	2,683	352
Wind	105	262	3,590	3,479	3,731
Solar (Utility + Rooftop)	2	12	879	511	568
Hydro	581	727	3,296	745	742
Tidal	0	0	0	1,440	0
Nuclear	0	0	0	0	3,410
Batteries	(4)	(9)	(71)	(73)	(60)
Total energy generated	4,725	8,708	8,731	8,785	8,744
% carbon-free	*14%*	*11%*	*88%*	*69%*	*96%*
Cost					
Capital investment (post-ITC, $Billion)		2.3	11.8	7.7	10.1
Gen & Trans Cost of Service $/MWh:					
Base case		119	134	128	128
Sensitivity: Fuel cost +20%		137	136	135	129
Sensitivity: Interest 6% vs 5%		121	143	134	135
Sensitivity: 50% ITC (vs 30%)		118	113	114	108

Takeaways

- These scenarios are illustrative. They demonstrate what is possible, not necessarily what is optimal.
- A low-carbon grid in 2050 with 70-95% carbon-free generation is possible, but it will still require significant sources of firm dispatchable generation, such as fossil, hydro, or nuclear, in addition to large amounts of wind and solar.
- The low-carbon grid in 2050 would be operated very differently than it is today, with extensive use of batteries and fossil fuel generators to follow load and to handle intermittent wind and solar output. Additional flexibility of natural gas supply would be needed that does not exist today.
- Interregional power flows would greatly increase as renewable generation is sited in the best places.
- Maintaining the stability and the reliability of the relatively weak Railbelt grid will be a challenge with fewer synchronous generators online to provide inertia and grid strength. That challenge can be met, but doing so will require significant resources and new technologies such as grid-forming inverters, some of which are still emerging. Alaska's experience operating rural microgrids should prove useful.
- The cost of power in these low-carbon scenarios is in the same ballpark as the cost of continued reliance on fossil fuels, but the cost structure would be quite different, shifting from fuel to capital and O&M.
- The remaining path to 100% decarbonization is not yet clear and could be very expensive.

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ACEP Alaska Center for Energy and Power

UAF University of Alaska Fairbanks