ALASKA STATE LEGISLATURE
SENATE RESOURCES STANDING COMMITTEE
April 5, 2024
3:31 p.m.

MEMBERS PRESENT

Senator Click Bishop, Co-Chair
Senator Cathy Giessel, Co-Chair
Senator Bill Wielechowski, Vice Chair
Senator Scott Kawasaki
Senator James Kaufman
Senator Forrest Dunbar
Senator Matt Claman

MEMBERS ABSENT

All members present

COMMITTEE CALENDAR

PRESENTATION: NATIONAL RENEWABLE ENERGY LABORATORY

- HEARD

PREVIOUS COMMITTEE ACTION

No previous action to record

WITNESS REGISTER

PAUL DENHOLM, Senior Research Fellow
National Renewable Energy Laboratory (NREL)
Jefferson County, Colorado
POSITION STATEMENT: Presented an overview of the National Energy Laboratory (NREL).

ACTION NARRATIVE

3:31:00 PM
CO-CHAIR CATHY GIESSEL called the Senate Resources Standing Committee meeting to order at 3:31 p.m. Present at the call to order were Senators Wielechowski, Dunbar, Claman, Co-Chair Giessel, and Co-Chair Bishop. Senators Kawasaki and Kaufman arrived thereafter.

PRESENTATION: NATIONAL RENEWABLE ENERGY LABORATORY

3:31:36 PM

CO-CHAIR GIESSEL announced a presentation by the National Renewable Energy Laboratory (NREL). She noted that this study was published in March 2024.

3:32:28 PM

PAUL DENHOLM, Senior Research Fellow, National Renewable Energy Laboratory (NREL), Jefferson County, Colorado, stated that he has worked at the National Renewable Energy Laboratory (NREL) for the past 20 years, focusing on renewable energy integration, power optimization, and analyzing the associated costs, benefits, and impacts. His expertise in the field led to his recognition as a fellow of the IEEE Power and Energy Society, the primary international association for electrical engineers. NREL, part of the National Lab System established after World War II, originally centered on nuclear research but has since expanded to support a broad array of scientific and engineering initiatives within the Department of Energy, with a primary focus on renewable energy technologies like wind, solar, and geothermal. Within NREL, he collaborates with approximately 100 electrical and other engineers to explore how renewable energy can be effectively integrated into the national power grid, aiming to enhance grid reliability, resilience, and cost stability. He noted that, while he has studied most of the U.S. power grid, the Alaska power system was one of the last regions he analyzed. The Alaska project originated from requests by the governor and Senator Murkowski's office, focusing initially on assessing the feasibility of achieving an 80 percent renewable portfolio standard (RPS) in the state. The first study, published three years ago, confirmed that there were sufficient wind and solar resources for such a target, although it did not address economic feasibility. The current study aims to provide a comprehensive cost analysis of deploying renewable energy on the Alaska Railbelt system. Funding for the study was sourced exclusively from the Department of Energy, without state or advocacy funding.

3:34:16 PM

SENATOR KAUFMAN joined the meeting.

3:34:59 PM

MR. DENHOLM moved to slide 4 and explained the scope of study for the Alaska Railbelt:

[Original punctuation provided.]

Scope of Study – The Alaska Railbelt

About 75 percent of state's electricity demand Average Railbelt residential electricity cost in 2022 was about 23 cents/kWh. U.S. average was about 14 cents/kWh.

[Data table on presentation slide]

MR. DENHOLM emphasized that Alaska's electricity costs are already significantly higher than those in the lower 48 states, with residential consumers in the Railbelt paying approximately 60 percent more on average. A major concern is the potential rise in costs due to Alaska's increasing reliance on imported liquefied natural gas (LNG), driven by declining natural gas production in the Cook Inlet.

3:35:37 PM
MR. DENHOLM moved to slide 5 and spoke to a graph and table demonstrating potential cost increases for liquified natural gas (LNG) imports. He explained that, based on utility projections in the Railbelt region, illustrated by the purple line on the left-hand graph, natural gas prices are expected to rise significantly. Current costs of approximately $8 per million BTU are projected to increase to over $12 per million BTU by 2028-2029, primarily due to the need to import liquefied natural gas (LNG). This price surge is anticipated to add approximately $75 million per year in electricity costs. Given that Alaskan electricity rates are already 60 percent higher than those in the lower 48 states, these increases underline the study's importance. The study seeks to determine whether renewable energy can help stabilize or offset these rising costs.

3:36:28 PM
MR. DENHOLM moved to slide 6 and summarized the fuel purchase price trends for the four most efficient natural gas generators in the Railbelt region. This includes the Eklutna Generation Station, the George Sullivan Plant, Southcentral plants (two separate facilities in the Chugach region), and the Nikiski Plant in Kenai. These four plants supply the majority of the region's natural gas-fired electricity. By the 2028-2029 timeframe, fuel costs for these plants are expected to exceed 10 cents per kilowatt-hour, or $100 per megawatt-hour. He raised the critical question of whether long-term power purchase agreements could enable these utilities to procure electricity at rates below this threshold. Within this study, wind and solar

energy are considered solely for their fuel-offsetting potential, without attributing reliability benefits. Since wind and solar are not reliable during peak demand—given that sunlight is unavailable, and wind is intermittent during such times—these renewable sources are assumed only to reduce natural gas usage. The goal is to allow natural gas to remain available for heating, a critical need for Railbelt customers, rather than exhaust it on electricity generation.

3:38:14 PM
SENATOR CLAMAN noted past criticisms of renewable energy sources like solar and wind, and to a lesser extent hydro, regarding their inability to generate power when the sun isn't shining or the wind isn't blowing, which limits their capability to provide a stable base load. He confirmed his understanding of Mr. Denholm's comments, suggesting that while alternative energy sources do not replace base load power, increasing their usage reduces dependence on base load generation. This approach could preserve more base load power in reserve for critical heating needs during cold periods.

3:38:55 PM
MR. DENHOLM confirmed that wind and solar cannot replace Alaska's existing thermal and hydropower capacity. These resources are essential for providing energy during periods of low wind and solar output. The role of renewable energy in this context is to reduce fuel consumption for these plants, thereby saving costs, but not to substitute base load power sources.

3:39:17 PM
MR. DENHOLM moved to slide 7 and detailed approaches to offsetting energy. He discussed the potential for wind and solar to offset the anticipated 10-cent-per-kilowatt-hour fuel costs in Alaska. He highlighted the historical and projected declines in wind and solar costs, referencing power purchase agreements in the lower 48, where wind is now available for as low as two cents per kilowatt-hour in some areas. However, he noted that Alaska’s wind resources are less optimal, and installation costs are higher, so such low prices are not achievable in the state. Instead, Alaska’s wind energy costs are more comparable to higher-cost regions like New England and New York. For a more accurate projection, the study utilizes Alaska-specific cost analyses to estimate realistic renewable energy costs for the region.

3:40:26 PM

MR. DENHOLM moved to slide 8 and briefly highlighted the cost differences that were considered in the study. He said this does not demonstrate a comprehensive rate study predicting consumer electricity rates. Instead, the analysis aims to assess the costs involved in investing in renewable energy, including expenses for wind turbines, solar systems, integration costs, natural gas, and storage. In exchange for these investments, renewables primarily offset fuel costs. He explained that the study seeks to determine the trade-offs between continuing to purchase natural gas and using alternative technologies to reduce natural gas consumption, providing insight into future cost dynamics.

3:41:31 PM
MR. DENHOLM moved to slide 9 and spoke to the modeling approach that follows the standard integrated resource planning process:

[Original punctuation provided.]

Modeling Approach - Follows Standard Integrated Resource Planning Process

- Capacity Expansion model to determine cost-optimal mix of resources
- Production cost modeling to validate load balance and operating reserves

MR. DENHOLM outlined the analysis process, which follows the integrated resource planning (IRP) methodology, a decades-old practice adopted by utilities globally. This approach involves running a series of utility-grade computer models, including both standard commercial software commonly used by utilities and proprietary internal models for maximum transparency. The goal is to determine the least-cost mix of resources while simulating the power grid on an hourly basis. The simulation covers every hour from 2024 to 2040 to ensure reliability is maintained. He emphasized the importance of validating that the proposed solutions adhere to or exceed existing reliability standards. The process involves extensive testing to identify potential system failures, addressing them to develop solutions that consistently meet reliability requirements. Results that do not meet these standards are not published, as doing so would render the results invalid.

3:42:56 PM
MR. DENHOLM moved to slide 10 and described the analysis framework:

[Original punctuation provided.]

Analysis Framework

- Three reliability zones. MEA/CEA combined into "central zone"
- We assume resources are planned and dispatched in a coordinated manner
- But we do not assume consolidated utilities.

MR. DENHOLM highlighted key caveats in the analysis framework regarding the optimal approach for advancing renewable energy integration. A primary assumption is that consumer resources will be planned, dispatched, and operated in a more coordinated manner than currently practiced. While the analysis does not prescribe a specific pathway to achieve this coordination, it acknowledges that significant changes will be necessary. He provided examples from the lower 48 states, where large power plants, such as nuclear and coal facilities, often involve multiple utilities sharing ownership. For instance, a 1,000-megawatt plant might have ownership percentages distributed among various utilities. In Alaska, a similar model could apply, such as a new 200-megawatt wind farm being 50 percent owned by one utility and 25 percent by another. While specific ownership ratios are not defined in the analysis, this type of collaboration is expected to help maximize economies of scale. Additionally, the framework assumes coordinated dispatch of resources to ensure that effectiveness is maximized and costs are minimized.

3:44:23 PM

MR. DENHOLM moved to slide 11 and listed potential scenarios:

[Original punctuation provided.]

Scenarios

- No New RE - only existing renewables, new fossil allowed
- Reference - all generation resources allowed
- Reference with RE cost +20 percent and -10 percent
- RPS - meet the 80 percent by 2040 RPS
    - o Eligible technologies based on SB 101: wind, solar, geothermal, tidal, hydropower,

biomass, and landfill gas, and include both existing and new deployments

MR. DENHOLM outlined the range of scenarios considered in the analysis, starting with the baseline scenario, which represents a "no new renewables" case. This scenario examines the existing generation fleet while allowing for the construction of new fossil fuel plants, including a few small facilities. The primary objective is to assess the costs associated with continued reliance on natural gas, coal, and oil, particularly in regions like Fairbanks, where oil is predominant and natural gas is used in the southern areas. He described the reference case as one that permits the construction of any resource deemed least cost—be it renewables or fossil fuels—without restrictions. The goal is to identify the most economical options available. Additionally, the analysis included an RPS (Renewable Portfolio Standard) case, which mandates achieving 80 percent renewable energy by 2040, with eligible technologies determined based on SB 101. This structured approach aims to evaluate the implications of different pathways for integrating renewable energy into the system.

3:45:16 PM
MR. DENHOLM moved to slide 12 and highlighted generation options. He noted that one conservative limitation of the study is the exclusion of new hydropower options. While a small amount of run-of-river hydro is permitted, larger projects like the Dixon diversion and other significant hydro plants that could potentially reduce costs were not included in the analysis. He emphasized that the study presents a conservative estimate of costs, acknowledging that lower-cost options may exist but were excluded due to the availability of high-quality data sets. The study focused solely on technologies that have been deployed at scale. Although there are promising tidal resources in southern Kenai and good offshore wind potential, these technologies have not been implemented at scale in the U.S. despite successful deployments in Europe. Therefore, he opted not to include these somewhat speculative technologies. The analysis is grounded in established technologies, relying on the National Renewable Energy Laboratory's (NREL) well-defined annual technology baseline to ensure accurate component cost understanding. As such, the study allows for the construction of new coal and natural gas plants, alongside commonly built renewable technologies in the U.S.

3:46:47 PM

SENATOR BISHOP asked whether the hydro technology to model conventional hydro is available.

3:47:00 PM
MR. DENHOLM confirmed the capability to model hydro resources, stating that NREL regularly models all existing hydro and evaluates options for new hydro across the U.S. However, he expressed discomfort with the quality of the data sets available for assessing potential costs and development timelines for new hydro projects, which led to their exclusion from the current analysis. He expressed a desire to explore hydro options in future work, acknowledging that these technologies could significantly reduce the cost of renewables.

3:47:39 PM
MR. DENHOLM moved to slide 13 and spoke to assumptions about load growth:

[Original punctuation provided.]

Load Growth

- Scaled based on projected population growth (about 4 percent) by 2040
- Electric vehicle adoption values from ACEP, about 20 percent of vehicles by 2040 - adds abound additional 16 percent growth in electricity demand

MR. DENHOLM highlighted NREL's commitment to transparency in conducting these studies. He explained that the projected growth used was modest, based on population projections from the State of Alaska and a conservative estimate for electric vehicle adoption provided by the Alaska Center for Energy and Power. Combined, these factors contribute to an anticipated 20 percent increase in electric demand by 2040.

3:48:16 PM
CO-CHAIR GIESSEL asked why AI is not mentioned in the analysis, noting that AI technology is known for its high energy demands.

3:48:30 PM
MR. DENHOLM said that increased electricity demand for AI and other computer-related activities, such as data centers, is generally occurring in areas with low electricity rates. He noted that while renewable technologies could help stabilize Alaska's electricity costs, Alaska is unlikely to become a low-

cost electricity provider in the near future. Consequently, he expects data centers and similar energy-intensive facilities to develop in regions like Iowa, where electricity costs are substantially lower.

3:49:29 PM
CO-CHAIR GIESSEL said while that makes sense, she noted that everyday citizens using AI on their personal computers are consuming significantly more energy—up to four times the amount used in a typical Google search.

3:49:44 PM
MR. DENHOLM confirmed that increased electricity demand from AI use in Alaska would likely raise the load beyond current projections. He explained that while there are limited forecasts on electricity usage specific to Alaska, any growth in demand would likely enhance the cost-effectiveness of renewables. As renewables become relatively lower-cost options, their benefit increases with higher demand. This reinforces the conservative nature of the current estimates, as increased demand would likely improve the financial outlook for renewable energy options in the state.

3:50:35 PM
SENATOR WIELECHOWSKI mentioned that the committee is currently discussing whether transmission planning should be managed by the same organization responsible for generation planning. He inquired whether he has any expertise in this area.

3:50:50 PM
MR. DENHOLM expressed that while he is unable to discuss various ways to achieve the integration of renewable energy, he is uncomfortable delving into specific policies most suitable for Alaska. He emphasized his preference for exploring different methods to reach the goal without endorsing any particular approach.

3:51:18 PM
MR. DENHOLM moved to slide 14 and explained transmission and interconnection:

[Original punctuation provided.]

Transmission & Interconnection

- AK Intertie - 78 MW of available transfer capacity. No upgrades. Kenai intertie - 75 MW.

Upgraded to 185 MW in 2033 in all scenarios as part of the Railbelt Innovative Resiliency Project. Solar and PV interconnections are added as needed and optimized by the model (assumed eligible for ITC).

MR. DENHOLM said there are two major lines in Alaska that can use major power in Alaska. He said the lab feels comfortable through group funding that the line is upgraded to 185 mW, but it did not complete any upgrades to the Alaska Intertie. He said upgrades would likely increase the efficiency of power.

3:54:06 PM
CO-CHAIR GIESSEL inquired about the variation.

3:54:18 PM
MR. DENHOLM replied that the variation is tied to resource quality.

3:54:56 PM
CO-CHAIR GIESSEL asked whether that includes AC lines.

3:55:01 PM
MR. DENHOLM replied yes, absolutely. It can be accomplished with AC lines.

3:55:14 PM
MR. DENHOLM moved to slide 16 and spoke to costs of acquiring new renewables:

[Original punctuation provided.]

Costs of Acquiring New Renewables All Included in This Study

- Capital cost - Captured in a power purchase agreement
- Fixed O&M - Captured in a power purchase agreement
- Interconnection
- Transmission spur lines
- Integration costs

MR. DENHOLM discussed the financial considerations when transitioning away from natural gas to renewable energy sources. He explained that costs related to acquiring new renewables, including capital and fixed operation and maintenance, were factored into the study, primarily captured in power purchase agreements (PPAs). He addressed a critical question: whether utilities would need to incur new debt. He clarified that there is no mandate for utilities to take on debt, though they may opt for debt financing if they choose to handle developments independently. In the lower 48 states, he noted, 84 percent of wind projects are managed by independent power producers (IPPs) and are acquired by utilities mainly through PPAs. However, some investor-owned utilities have recently begun developing renewable technologies in-house, similar to when they managed coal or nuclear plants. This approach allows them to leverage rate basing, available expertise, and labor. PPAs offer utilities a delivered energy model, with payments made per unit of power purchased, avoiding debt, capital, or upfront costs. However, utilities must still address certain costs requiring additional financing, such as interconnection expenses, substation upgrades, and a whole host of integration costs associated with renewables. He noted that renewable energy integration poses uncertainties, particularly due to Alaska's limited spatial diversity, which can increase fluctuations in solar and wind output compared to the more expansive grid systems in the lower 48. Calculating integration costs while maintaining reliability is a significant part of his role. Failing to address these costs could lead to reliability issues, underscoring the necessity of precise calculations to ensure grid stability without redundant or inflated costs.

3:58:55 PM
SENATOR WIELECHOWSKI asked whether he assumed that an economic dispatch system was in place.

3:59:04 PM
MR. DENHOLM affirmed that NREL assumes a joint dispatch system with coordinated energy dispatch but noted certain limitations. He explained that NREL does not assume shared operating reserves or the use of interties for reliability, recognizing that interties may occasionally fail. Each zone is expected to maintain independent resource adequacy, operating as an isolated system when interties are down. Under normal conditions, the zones are expected to coordinate to minimize costs.

3:59:40 PM
SENATOR WIELECHOWSKI asked whether an economic dispatch system dramatically impacts the output.

3:59:46 PM

MR. DENHOLM replied that he is unsure. This is the most economical way to do it. If forced, NREL could absolutely figure out what the costs of an uneconomic dispatch is. We have done that in the past. But given the limited costs of actually creating economic dispatch through whatever mechanism you want, I would assume that is the direction you take, and calculate the benefits that way.

4:00:21 PM
MR. DENHOLM clarified that all costs discussed would be in 2023 dollars. He emphasized the importance of assuming the availability of a 40 percent investment tax credit, contingent on the entire Railbelt region qualifying as an energy community.

4:00:37 PM
MR. DENHOLM moved to slide 18 to discuss a graph illustrating the renewable cost multiplier in Alaska. He acknowledged uncertainty in the total costs but noted that NREL analyzed available data to estimate the increased expense of renewable energy in Alaska. He explained that solar installation costs are expected to be about 50 percent higher in Alaska compared to other regions, due to both purchase costs and Alaska's lower solar resource quality. Similarly, wind installations are assumed to be approximately 85 percent more expensive than in the lower 48, although this cost multiplier is projected to decrease over time as the marketplace matures. He clarified that NREL's assumptions do not rely on technological advancements but rather on the emergence of a more competitive market, potentially requiring regulatory initiatives. He outlined the types of electricity markets in the U.S., noting that a wholesale restructured market, common in two-thirds of the country, is unlikely in Alaska due to its smaller market size. Instead, Alaska could adopt a model similar to states with vertically integrated monopolies, such as Colorado, where utilities issue all-source requests for proposals (RFPs). This process invites diverse bids from various developers for energy supply, without specifying technology, allowing utilities to select the most cost-effective option. The regulatory push behind Renewable Portfolio Standards (RPS) aims to foster competitive bidding and a diverse resource base. NREL anticipates that a similar approach in Alaska could yield a competitive marketplace that would drive down costs. However, NREL does not expect renewable energy costs in Alaska to ever fully align with those in the lower 48, estimating that wind renewables will consistently remain around 60 percent higher in costs and photovoltaics are always 35 percent more expensive than they are in the lower 48.

4:04:14 PM
CO-CHAIR BISHOP asked why that assumption was made.

4:04:20 PM
MR. DENHOLM explained that NREL's cost assumptions rely on an anticipated increase in the number of developers in Alaska to help lower costs. He clarified that if the state does not see a growth in developer presence and instead only attracts a few developers, the expected cost reductions may not materialize. Thus, the assumption of an expanded competitive marketplace is crucial for achieving these projected cost decreases.

4:04:55 PM
MR. DENHOLM moved to slide 19 and explained a bar graph depicting renewable capital costs, specifically for current wind and solar projects. The graph illustrates costs per kilowatt (KW), a standard measure for new power plant expenses. Dotted lines on the graph represent NREL's estimates of wind and solar costs in both the lower 48 states and Alaska. He noted that the projected price reductions on the graph are driven by two factors: increased market competition and ongoing technology improvements, shown by the lower dashed lines indicating lower 48 prices as technology advances. He pointed to the label "GFM" at the top of the graph, referring to grid-forming inverters, a stability measure. Due to stability limitations on the Alaska Railbelt grid, additional hardware, including GFMs, will be needed starting in the late 2020s, which will slightly increase costs for these renewable technologies.

4:06:03 PM
SENATOR KAUFMAN asked about the role of federal subsidies in building the cost models. He inquired whether there is any risk factored into the estimate that the costs could increase if federal subsidies were to be removed. He expressed concern that the technologies may have been significantly driven by subsidies and sought clarification on how this factor is accounted for in the model.

4:06:34 PM
MR. DENHOLM clarified that the assumption in the cost models is that the 40 percent investment tax credit (ITC) remains available, as per current IRS guidance and statute. He acknowledged that if the ITC were to be removed, there would be a significant decrease in the cost competitiveness of these renewable technologies. While the reduction in costs is not exactly 40 percent, it is close enough to consider it a rough

estimate. Without the subsidy, the technologies would still provide a net benefit, but that benefit would be much smaller.

4:07:34 PM
SENATOR KAUFMAN inquired about the potential for revenue loss in Alaska, noting that as oil and gas production is displaced by renewable energy, the state would lose royalty and tax revenue, as renewable technologies do not pay royalties. He asked whether any modeling has been done to account for this, particularly considering that the state currently benefits from revenue generated through oil and gas, which would be lost if these resources are replaced by renewables. He sought insights on how this revenue stream loss is factored into the transition to renewable energy.

4:08:33 PM
MR. DENHOLM replied that the consideration is not part of this analysis. However, most of the natural gas avoided here is based on the assumption of LNG imports. He noted that he doesn't believe there would be revenue loss from this, as the main focus is displacing imported LNG. He acknowledged that any potential revenue loss could be tied to oil used in the Fairbanks area, particularly for the North Pole combined cycle unit. However, he emphasized that, as he is not an oil and gas expert, he could not speak definitively on the matter.

4:09:23 PM
SENATOR KAUFMAN said that if the assumption is that LNG imports are being displaced rather than in-state production, he agrees. He noted that displacing costly oil would likely result in a net benefit. However, he emphasized the need to consider the potential loss of revenue when evaluating the shift to other energy sources.

4:09:52 PM
MR. DENHOLM moved to slide 20 and noted that the dotted chart on the far-left side of the slide demonstrates the average agreement in the lower 48, which was around $30 per MWh or about 3 cents per kWh. He mentioned that while this is a fairly sizable range, most of these projects were designed well below 4 cents per kWh. The working assumption for Alaska is that costs are north of 6 cents per kWh. He acknowledged that these are higher costs, but emphasized that they reflect the comparison of higher natural gas costs in Alaska, which pays quite a bit less.

4:10:35 PM

SENATOR WIELECHOWSKI said the state has plenty of generation capacity with natural gas but asked how this might play out with major wind and solar farms potentially coming online. He assumed that a 200 MW wind farm would negotiate a 25-year power purchase agreement and questioned whether this could crowd out other projects. He noted that Alaska is constrained and lacks sufficient demand. He asked if there could be a crowd-out issue where future smaller independent power producers (IPPs) might struggle to find a market for their energy due to capacity being filled by larger projects and whether this was factored into the analysis.

4:11:22 PM
MR. DENHOLM replied that there are absolutely limits to how much wind and solar can be added to the grid before it becomes unusable. He explained that the state reached 76 percent renewable energy and stopped building more renewables because they couldn't use it effectively. He noted that while the 80 percent scenario wasn't significantly more expensive, the model was concluded due to the saturation of wind and solar capacity in meeting electricity demand for many hours of the year. He highlighted that there are still several hundred hours each year when the wind isn't blowing and the sun isn't shining, requiring reliance on hydropower and thermal plants. He stressed that this limitation is not unique to Alaska and is seen in other places like California, where solar energy value drops in the middle of the day due to excess supply.

4:12:21 PM
SENATOR WIELECHOWSKI cited slide 20 and pointed out that costs are declining, at least on the left side of the chart. He asked whether the addition of a couple of major producers in the next few years would crowd out any future wind farms.

4:12:37 PM
MR. DENHOLM asked whether, when talking about crowding out, the concern is due to the resource being used up or because there is no longer a market left.

4:12:46 PM
SENATOR WIELECHOWSKI clarified his question, and wondered if 400-500 MW of wind and solar come online and secure 25-year power purchase agreements, the state would be at peak capacity at that point. He questioned whether there would be no more capacity to sell and whether utilities would no longer be able to buy additional energy.

4:13:07 PM
MR. DENHOLM replied that the bottom line is that NREL models about 1500 MW of wind and several hundred MW of solar in their scenarios. He acknowledged that it might seem strange to build 1500 MW of wind in an 800-MW peaking system, but emphasized that wind doesn't blow consistently at full capacity. Most of the time, the wind produces between 0 and full capacity, often generating around 400-500 MW of energy. During many hours of the year, excess wind energy is discarded by shutting down turbines because they produce more than is needed. He explained that 1500 MW of wind, on average, only produces about 500 MW, which is well within the grid's capacity to accommodate. He noted that his work focuses on determining how much of this energy displaces gas. NREL sees substantial potential for around 1500 MW of wind and several hundred MW of solar.

4:14:37 PM
MR. DENHOLM moved to slide 21 and detailed wind sites. He explained that the best wind resources are in the Kenai region or around Fairbanks. He highlighted that the slide shows locations and sites evaluated by NREL, but noted that these are not the same sites being evaluated by utilities. NREL's dataset is generated by mass and provides broad geographical coverage, but lacks the specific site details of individual locations. He emphasized that evaluating specific sites requires installing an anemometer or using laser-based instruments to measure local wind speeds, and that complete data for these sites is often proprietary to individual developers. He also pointed out that having more developers is beneficial as it leads to more resources being explored. He clarified that while NREL's dataset provides a general idea of potential wind sites, the mix they built is unlikely to reflect the exact sites, but rather gives a broad overview of where these sites may be located.

4:15:46 PM
SENATOR DUNBAR referred to the map on slide 21 and expressed surprise and noted that from a layperson's perspective, the Mat-Su Valley seems like a very windy place, and most people in the region likely think the same. He asked what it is about the nature of the Mat-Su area that prevents any wind projects from being developed in that whole region.

4:16:09 PM
MR. DENHOLM replied that, based on the map on slide 21, he would guess that there are restrictions on the amount of developable land in the Mat-Su region due to local conditions. This could include state or national parks, land that is not developable,

or particularly unfavorable terrain, such as hilly or marshy areas that pose challenges for development. He mentioned that it has been 23 years since he was in the area, so he couldn't provide a more specific answer about the terrain. He clarified that the map shows dark greenish-blue colors indicating better wind resources, while white areas represent either very poor wind resources or areas where developers are not allowed to build. He noted that dedicated geospatial analysts evaluate each land parcel to determine suitability for wind projects and offered to provide that specific information in the future.

4:17:18 PM
SENATOR DUNBAR noted that it was just a curiosity, as it always seems like the wind is blowing in the Mat-Su Valley.

4:17:27 PM
MR. DENHOLM moved to slide 22 and presented an example of potential opportunities for developing wind and solar to achieve costs lower than 10 cents per kWh. He explained that by signing a long-term power purchase agreement for these technologies, the cost of purchasing 7-cent wind or solar instead of 10-cent gas would result in savings of three cents per kWh, which could be passed on to consumers. However, he clarified that this calculation is before accounting for the cost of integrating the wind or solar power. He noted that while the analysis includes the cost of the spur line and other costs, it doesn't provide a complete picture of potential savings. He explained that this is the starting point for the analysis, after which more complex simulations are needed to determine the necessary steps to integrate wind, ensuring that every kWh produced by wind or solar can offset gas plant operations for a period of time.

4:18:44 PM
SENATOR DUNBAR expressed confusion about the graph, noting that it seems to be missing a lot of detail. He pointed out that below the avoided cost of natural gas, there is no line indicating the avoided cost of natural gas. He said the graph is missing the line that indicates the avoided cost for natural gas. He noted costs are in dollars and asked if there was a line for natural gas would it run horizontally at $0.07 - $0.10 per kWh ($70 or $100 per MWh).

4:19:16 PM
MR. DENHOLM explained that the numbers on the graph represent dollars per mW which are typically used for wholesale electricity pricing. To convert this into cents per kWh, you shift the decimal place, so $70 per MWh corresponds to $0.07

per kWh. He clarified that although this graph does not show the avoided cost of natural gas, he mentioned earlier that around 2028 - 2029, a spike will occur when the cost of natural gas fuel reaches $0.10 per kwh or $100 per MWh.

4:20:00 PM
CO-CHAIR BISHOP asked him to clarify whether the graph depicts the imported cost of gas or the current cost of gas in Cook Inlet.

4:20:13 PM
MR. DENHOLM moved to slide 6 and explained that the graph represents the assumed cost of natural gas paid by utilities for their large power plants. He stated that, for 2028-2029, the assumption is that LNG imports will need to be purchased at roughly $12 per million BTU. This translates, based on the heat rate and the power plant's efficiency, into approximately 10 cents per kWh for fuel costs.

4:21:00 PM
CO-CHAIR BISHOP asked whether the assumption is for LNG imported prices.

4:21:02 PM
MR. DENHOLM replied yes, that is the marginal or avoided cost for these power plants.

4:21:10 PM
MR. DENHOLM moved to slide 23 and discussed integration costs. He explained that this slide shows some of the integration costs considered, including physical hardware and connections. Due to the fluctuating output from natural gas plants, additional natural gas storage will likely be required. Alaska's extensive natural gas network offers some buffer against this, unlike lower 48 states, where such storage is a larger concern. Other costs include communication with multiple power plants, as currently, dispatching the Railbelt system involves fewer plants compared to potentially a dozen or more when integrating renewables. Further costs arise from the increased frequency of starting and stopping power plants, which incurs direct fuel costs, additional operation and maintenance (O&M) costs, wear and tear, and thermal stresses. By 2040, the increased cost of starting plants will add an estimated $3-4 million per year. These additional costs will be incurred by local utilities due to the integration of renewables into their power grid, which reduces the overall value of renewables.

4:23:57 PM

MR. DENHOLM moved to slide 24 and discussed the reliability benefits of renewables. He explained that in places like Arizona, there would be a discussion about effective load carrying capability. However, in Alaska, this is not a major consideration, as there are no reliability benefits from renewables. Renewables cannot offset the need to keep existing power plants operational. Instead, their primary benefit is fuel savings.

4:24:25 PM

SENATOR DUNBAR cited slide 24 and asked if, when referring to renewables, he is primarily talking about wind and solar energy, rather than new hydro plants.

4:24:39 PM

MR. DENHOLM replied yes, some renewable resources, particularly geothermal, biomass, and hydropower, add reliability benefits, especially when you have water stored behind a dam, allowing you to schedule and ensure availability when needed. However, since wind and solar are the major providers, these resources primarily offer fuel savings benefits rather than capacity credits.

4:25:17 PM

MR. DENHOLM moved to slide 26 and spoke to key findings. Given the high cost of natural gas and the ability of renewables to provide energy at a lower cost, modeling efforts indicate that by 2040, approximately 76 percent of the Railbelt's electricity could be generated by renewables. Significant growth is expected in the early years due to high natural gas costs. The model suggests keeping existing power plants operational but reducing their generation to avoid fuel costs as much as possible until further integration of renewables becomes uneconomical. The 76 percent figure reflects the point where marginal costs exceed marginal benefits. He added that significant uncertainty remains regarding the future cost of natural gas in the 2030s and the potential for further cost reductions in renewable energy.

4:26:27 PM

MR. DENHOLM moved to slide 27 and spoke to the primary goal of annual costs. He reiterated the importance of examining the cost objectives of study tools, highlighting potential costs, savings, and benefits. The analysis focused on specific cost components that may fluctuate over time, excluding general costs associated with billing and maintaining the distribution network. He explained that the left-hand curve represented fossil fuel purchase costs, the middle curve showed renewable purchase costs, and the most critical curve, on the right, displayed the cost differences. Investing hundreds of millions of dollars in renewable energy technologies includes integration costs but offsets these by avoiding even greater fossil fuel expenses. By the early 2030s, this investment approach is projected to yield a net savings, with all integration costs factored in, underscoring the importance of net savings in this analysis.

4:27:39 PM
MR. DENHOLM moved to slide 28 and projected approximately $100 million per year in net savings, contingent on the numerous assumptions previously discussed. This annual savings translates to cumulative net savings exceeding $1 billion by the end of the analysis period. He clarified that the analysis considers an initial $2.9 billion investment in building wind farms, solar power plants, and related integration infrastructure, resulting in $4.2 billion in avoided fuel and other expenses. This approach yields a cumulative net savings of $1.3 billion, underscoring the financial benefits of renewable energy investment over the analysis period.

4:28:13 PM
CO-CHAIR BISHOP asked how much of the $100 million in annual savings will reach the consumer.

4:28:23 PM
MR. DENHOLM explained that all projected savings should directly benefit consumers through pass-through charges incurred by the utility. He compared this mechanism to fluctuations in natural gas prices, stating that if prices doubled or decreased by 50 percent in a day, these cost changes would similarly flow through to the consumer, impacting their utility charges accordingly.

4:28:51 PM
SENATOR DUNBAR referred to slide 27 and asked for confirmation of his understanding that, while the graph may not depict it, the $100 million in net savings does not represent a decrease in consumer billing amounts. Rather, costs will continue to increase but at a slower rate than they otherwise would have. He clarified that the $100 million net savings may not reduce consumer bills outright but would likely mean that rates increase less than they otherwise would. He asked if this interpretation was accurate.

4:29:14 PM
MR. DENHOLM replied that he thinks that is the correct description.

4:29:27 PM
CO-CHAIR BISHOP questioned whether the information on the graph needed restating.

4:29:31 PM
SENATOR DUNBAR replied no, the graphs show that overall costs are going up so bills will go up; but they will go up less than if the state relied on very expensive LNG imports. While consumer bills will rise, they will increase more slowly compared to reliance on higher-cost energy sources.

4:29:51 PM
MR. DENHOLM moved to slide 29 and explained that the energy mix is primarily wind-based, with wind resources in Alaska proving more favorable than solar, though the solar resource is better than initially expected. By 2040, approximately 50 percent of electricity generation is projected to come from wind. He emphasized that physical capacity will be maintained by keeping the existing fossil and hydro power infrastructure, with Healey Unit 2 as the only planned retirement. This capacity retention is essential for system reliability, with wind and solar primarily offsetting fuel purchases rather than replacing capacity.

4:30:33 PM
MR. DENHOLM moved to slide 30 and spoke to installed capacity. He discussed the anticipated locations for renewable energy development, noting that precise sites would depend on developers prospecting optimal wind and solar resources. Preliminary assessments indicate high-quality wind resources near Fairbanks and on the Kenai Peninsula are perhaps the best, with additional viable resources in central Alaska. Development is expected across regions, with particular emphasis on utilizing the upgraded Kenai intertie and the new HVDC line to support growth on the Kenai. Additionally, the Alaska intertie will be maximized to transmit energy from Fairbanks and central regions. He highlighted a major operational shift: currently, energy flows predominantly from south to north along the Alaska intertie, but this shift would reverse, flowing north to south most of the time under the new system. While this directional change does not impact the physical infrastructure, it represents a significant contractual and policy adjustment, diverging from the usual operations. Implementing these changes

will require extensive documentation and legal supports to support this transition from traditional practices.

4:32:01 PM
MR. DENHOLM moved to slide 31 and explained finding 3. He referenced the 80 percent Renewable Portfolio Standard (RPS) target, explaining that most of his discussion thus far had centered on a reference case aligned with this goal. He noted that the 80 percent RPS could potentially be slightly cheaper or more expensive, but that the greater impact lies in fluctuations in renewable and natural gas costs, which drive overall system costs more significantly. While he suggested that 76 percent renewable integration might be optimal based on current assumptions, he acknowledged that this could vary. Nevertheless, a substantial level of renewables is likely to be cost-optimal, resulting in notable net savings. He highlighted the role of contingency measures, or "escape valves," in many RPS plans, which provide flexibility if circumstances change—such as economic disruptions from events like COVID-19 or geopolitical conflicts impacting supply chains. Although the last two years of the 80 percent RPS period carry the most uncertainty, he expressed confidence that a significant investment in renewable energy remains a cost-effective strategy for reducing natural gas costs in the near and midterm projections.

4:33:51 PM
SENATOR DUNBAR questioned the rationale for setting an 80 percent RPS target when the projected optimal renewable percentage is around 76 percent, noting that even a 70 percent target appears viable based on market trends. He asked if the market could naturally reach or even exceed this level.

4:34:09 PM
MR. DENHOLM replied that the choice of an 80 percent RPS target for the study reflects the proposed 80 percent RPS. He emphasized that his role is to provide the data, leaving it to others to adjust the target as they see fit.

4:34:26 PM
SENATOR KAUFMAN wondered about the supply chain risk, referencing the large percentage of solar panel production currently coming from China, highlighting the significant reliance on this source.

4:34:48 PM
MR. DENHOLM clarified that the U.S. does not currently import solar panels from China. While most solar panels are imported,

they primarily come from other parts of Asia, such as Vietnam and Korea, rather than China.

4:35:06 PM
SENATOR KAUFMAN expressed concern about supply chain risks, particularly in the event of a disagreement with China. He inquired whether the precursors, such as glass and active components used in solar panels, are sourced from China and if this could lead to a significant supply shock.

4:35:38 PM
MR. DENHOLM noted that while the U.S. imports solar panels primarily from Asia, the basic materials used in solar panel production, such as sand, silicon, and glass, are often locally sourced and are not significant supply chain risks. Similarly, for wind energy, most of the materials, including steel, concrete, and copper, are sourced domestically. There are some concerns about rare earth elements, particularly neodymium in wind turbine magnets, which are primarily sourced from China, but overall, the supply chain for wind energy is diverse. He emphasized that while there are challenges, particularly related to critical materials like neodymium, both wind and solar have robust supply chains. He noted that batteries are a different story and offered to provide more detailed market reports and highlighted the U.S. Department of Energy's dedicated program to address these concerns regarding critical materials.

4:37:31 PM
MR. DENHOLM moved to slide 32 and emphasized the importance of hydropower and fossil resources during periods of high demand. He explained that wind resources were not credited with any capacity and solar was given almost zero capacity credit, recognizing that these resources are not reliable during peak demand times. This approach was taken to ensure that the analysis accounts for reliability concerns, ensuring that there would be no over-reliance on intermittent renewable sources like wind and solar for grid stability.

4:38:22 PM
MR. DENHOLM moved to slide 33 and highlighted a "scary" graph that illustrates the shift in how the power system will operate in 2040. The graph shows that, on an hourly basis, between zero and nearly 100 percent of electricity demand will be met by wind and solar, particularly inverter-based technologies. This shift requires new methods for monitoring the grid, responding to variability, and integrating new hardware. He emphasized that while this transition presents challenges, there are successful

examples, such as Kauai in Hawaii, and the committee would benefit from a trip to Kauai, which has been operating with over 90 percent of its electricity from renewables for years. Although Kauai's grid is smaller and primarily solar-based, it demonstrates the technical feasibility of achieving high renewable penetration. MR. D acknowledged that the transition is difficult, but the resulting savings, including the estimated $100 million annually, make it a worthwhile goal.

4:40:33 PM
SENATOR KAUFMAN asked whether the modeling of wind energy took into account the observation that the stillest days, which often have low wind production, tend to coincide with the coldest days, which are peak demand periods.

4:40:55 PM
MR. DENHOLM moved to slide 32 and spoke to a graph that demonstrates wind production at a low point. He explained that the modeling does account for periods with low wind production, such as the evening of December 13, when wind production dropped almost to zero. He explained that there are several instances where this occurs, especially during the worst combination of high demand and low wind. While some periods show lower demand, there are indeed instances where wind production drops off significantly.

4:41:34 PM
SENATOR KAUFMAN asked about the duck curve, a situation often observed with solar generation, where there's an oversupply of electricity during midday. He mentioned hearing about this condition in Hawaii and noted that it typically occurs when solar generation peaks. He inquired whether he had further thoughts on this issue.

4:42:04 PM
MR. DENHOLM moved to slide 33 explained that his group was the first to observe the now-known "duck curve" phenomenon, though it was named by the California ecosystem operator. He clarified that the duck curve phenomenon occurs when solar energy saturates the grid during midday, leading to periods where additional solar generation has no value. While storage technology has helped mitigate this issue, it remains a concern in regions with high solar capacity like California. In Alaska, however, the solar resource isn't large enough to generate a duck curve, but a similar issue exists with wind and solar overproduction. The capacity of wind and solar exceeds what can be used during certain times, leading to marginal curtailment.

He referred to a graph illustrating hours where wind and solar production exceeds demand and noted that even though production doesn't hit 100 percent, there are times when wind and solar energy is effectively wasted, as shown by periods reaching 97 percent generation but still unable to fully utilize all available energy.

4:44:13 PM

MR. DENHOLM moved to slide 35 and discussed the integration costs associated with variable renewable resources, noting that tens of millions of dollars in additional costs arise from integrating these resources into the grid. He explained that the left side of the graph lists these costs, with a significant portion attributed to operating reserves, often referred to as spinning reserves, though the term is outdated as reserves are increasingly provided by batteries. Batteries, while not "spinning," incur costs related to their use and the need to maintain them as underutilized assets. He highlighted that the opportunity cost of not utilizing these batteries for grid benefits, just in case wind stops blowing, is a real expense. The total operating reserve costs amount to tens of millions of dollars annually. Despite these costs, he emphasized that the analysis already accounts for them, and the $100 million annual savings still reflects the inclusion of integration costs.

4:45:57 PM

MR. DENHOLM moved to slide 36 and emphasized the potential of new renewable generation through long-term power purchase agreements to offset the costs associated with gas-fired power. He highlighted that this approach not only reduces costs but also provides price stability, particularly for industrial consumers in Alaska, who benefit from predictable energy prices for their operations. While acknowledging the uncertainties in the analysis, he noted that additional data on hydropower could further reduce costs, though its impact remains unclear without specific data. He addressed potential concerns from utilities about grid stability, stating that the analysis, which includes grid funding and inverters, addresses most of these issues, but recognized the possibility of needing traditional spinning machines to supplement renewable resources. He estimated that incorporating spinning machines would reduce benefits by about 10 percent, which he considered the upper bound of potential cost reduction. Despite these uncertainties, he believes the analysis captures most of the costs and benefits of integrating renewable energy.

4:48:41 PM

There being no further business to come before the committee, Co-Chair Giessel adjourned the Senate Resources Standing Committee meeting at 4:48 p.m.