Why Don't We Design Net-Zero Schools in Alaska?

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A4LE ALASKA STATE CONFERENCE

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Session Abstract

- Alaska features some of the most challenging climates in the world for building, operating and maintaining educational facilities. Remote locations with extreme cold weather drive high energy costs for school districts operating traditional buildings.
  - What if these facilities could produce as much energy as they use?
  - What would it mean for remote Alaska communities to have energy independence?
  - Is Net-Zero possible in Alaska?
  - If so, why don't we design our schools this way?
- This session explores these questions in an effort to kick-start creative thinking and conversation about a more sustainable future for Alaskan learning environments.

AIA Learning Objectives

1. Participants will understand the cost drivers of constructing net zero energy school facilities in northern Alaska and potential strategies to reduce upfront expenses through design, financing, and procurement innovations.
2. Participants will learn about the availability and performance of renewable energy resources in Arctic climates and how hybrid systems can meet year-round net zero energy demands.
3. Participants will consider the role of political will, community engagement, and stakeholder priorities in advancing net zero school projects, and potential approaches to building local support.
4. Participants will learn about the technical expertise, workforce skills, and technologies required for Arctic net zero construction, and how partnerships can close knowledge and capability gaps.

Why Not Net-Zero?

1. Lack of Desire/ Political Will (We Don't Want Net Zero)
2. Net Zero is Too Expensive
3. There isn't Enough Renewable Energy in Alaska
4. Lack of Expertise (We Don't Know How)

Defining Net Zero Energy Buildings

- Net-zero energy buildings represent the ability of a building to supply its own energy over the course of a year through renewable energy sources (typically onsite renewables, though some definitions vary).
- Further development in the definition of Net Zero has pushed beyond energy to include all carbon. This requires the removal of all combustion within the building (excluding emergency generators)
- Net Zero: A net zero carbon building is a highly efficient building that achieves a zero balance of carbon emissions emitted during operations.
- Today's presentation will focus solely on **Net Zero Energy Buildings**

1. We Don't Want Net Zero

Lack of Desire/ Political Will

Funding Challenges

Alternative Funding Approaches

Alternative Energy + Microgrid Projects

1. Shungnak, Alaska
   - Hybrid solar-plus-storage microgrid: 225 kW solar array + ~384 kWh lithium-ion battery storage.
2. Kotzebue, Alaska (Kotzebue Electric Association service area)
   - 576 kW solar PV system + microgrid integration First large solar-microgrid above Arctic Circle.
3. New Stuyahok, Alaska
   - Solar + battery microgrid project: 500 kW PV array + 540 kWh battery + microgrid controller.
4. Commercial Solar Installations
   - Houston Solar Farm: 8.5 MW
   - Willow Solar Farm: 1.2 MW

AK Dept. of Education

- Support for HP Facilities in School Design and Construction Standards
- Design standards don't support State funding of super-efficiency and renewable energy

B. Separate mechanical cooling system from other HVAC system(s) to indepen n during unoccupied times.

4. HIGH PERFORMANCE FACILITIES

DEED encourages high-performance schools for Alaska communities. A high-performance school is designed to conserve natural resources, save money over time, and improve the overall health and well-being of students, staff, and community. Emphasis is placed on low-impact site design, reduced impact on local infrastructure, energy efficiency, water use reduction, non-toxic materials, waste management, indoor air quality, efficient operations, and community engagement.

High performance school design principles can be broken into three general areas of emphasis:

A. Human health and comfort
B. Demand reduction
C. Resiliency

In Part 2 and Part 3, the Standards are grouped into categories with the following definitions:

Baseline: These are design and construction elements that are accepted practice by DEED. Not all of these elements are intended to be incorporated into any one project. Applicability will vary based on design intent, budget, region, climate, and school size/program.

Provisional: These elements are improvements, upgrades, and educational program-related enhancements to Baseline elements. These are also accepted practice by DEED, subject to applicability where noted.

Premium: These elements are considered substantial upgrades to the Baseline and Provisional designations. They can be included in a project but in most cases

[2] See DEED Standard Construction Cost Estimate Format. https://education.alaska.gov/facilities/facilitiescostformat

Alternative Energy Funding

- Alaska Energy Authority – Renewable Energy Fund (REF)

  Alaska State Legislature established the REF in 2008

- Dept of Energy (DOE) Funding

  - Energy Improvements in Rural or Remote Areas (ERA)

  - Community Microgrid Assistance Partnership (C-MAP)

  - Direct Grants / Cooperative Agreements for Clean Energy Projects (Tribal & Community-Scale)

- National Renewable Energy Laboratory (NREL)

ALASKA ENERGY AUTHORITY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Do you see value in Net Zero Energy Educational Facilities? Rate the value 1-10 (10 highest)

2. Net Zero is Too Expensive

FIRST COST: RURAL SCHOOL PROJECT

COST OF RURAL CONSTRUCTION IN ALASKA

ACCOUNTING FOR LIFE CYCLE COST

How is Cost Defined?

- Cost effectiveness is the focus
- How do we balance First Cost and Life Cycle cost in design and funding decision-making?

Part. I. PURPOSE & APPLICATION

Overview

Alaska statutes provide for state aid through debt reimbursement and grants under AS 14.11. This aid is for construction, rehabilitation, and improvement of schools and education-related facilities. The Alaska Department of Education and Early Development (DEED) has the responsibility to execute and oversee such projects when awarded or approved. Design documents for those projects are required to be submitted for approval by the department. This document was developed to assist the parties who are, or will be, responsible for the design of capital improvement projects that include state aid.

These Standards achieve two primary objectives. They fulfill a statutory mandate to provide cost-effective construction standards and they establish consistency for state aid. The focus will always be cost effectiveness from a state perspective. The Standards apply to all new school construction and new additions to existing buildings. Renovation to existing facilities will adhere to the Standards, whenever possible, as approved by DEED.

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7. Provide minimum MERV-13 filtration on all ventilation systems.

Provisional:

8. Consider incorporating the commissioning agent early in the design, such as 35%.
9. Consider re-commissioning systems two months prior to one-year warranty date to help identify failed equipment or components and to correct control system programming errors.
10. Consider providing green spaces, open spaces, and shared community spaces in the building.
11. Consider reusing and recycling materials during construction and occupancy.
12. Consider creating an environment that is a community teaching tool for high-performance buildings and sustainable living.
13. Consider providing access to daylight and views to outdoors from classrooms and other regularly occupied spaces.
14. Consider using energy modeling and iterative design to reduce building energy consumption by 5 percent over ASHRAE-90.1 (current version).
15. Consider using the building control system to monitor indoor air quality and adjust ventilation rates to mitigate contaminants such as VOCs and CO2.
16. Consider providing a building flush-out post construction per LEED, WELL or similar accepted procedures.

Premium:

17. Re-commissioning systems two years after the school opens to ensure the energy conservation features are operating as intended and to adjust to increase efficiency.
18. On-going commissioning of the facility every 5 years.
19. Grey water reclamation systems for use with flushing plumbing fixtures.
20. On-site harvesting of renewable energy such as wind and solar.
21. Ventilation systems providing more than ASHRAE 62.1 minimum outdoor air rates beyond acceptable cost increases. CF-2.

Best Practices/Lessons Learned

A. (Reserved)

Direct Cost of Energy

- Diesel Fuel vs. PV in Rural AK
- Direct costs do not reflect external costs

Side-by-side summary (using today's averages)

Diesel space heat

Fuel price: **$6.58/gal** (Kotzebue Vitus = $7.79) rural average ArcGIS StoryMaps

Energy: **40.3 kWh_{th}/gal** U.S. Energy Information Administration

Diesel Cost: 18–22¢/kWh delivered heat

(depending on 75–90% efficiency)

PV → Resistance heat

PV electricity: **28–53¢/kWh_e**

COP (Coefficient of Performance) =1

Cost: 28–53¢/kWh_{th} → usually worse than diesel

PV → Heat pump

PV electricity: 28–53¢/kWh_e

COP=2–3

Cost: ~9–26¢/kWh_{th}

Often competitive or cheaper than diesel outside the darkest winter weeks

Life Cycle Cost Analysis

- LCCA is a method used to assess the total cost of a building or infrastructure asset over its entire life, from initial design and construction through operation, maintenance, and eventual disposal / deconstruction.
- Building the case for Net Zero Energy Buildings requires using LCCA due to show the payback period throughout the life of the building.
- High fuel oil prices in rural Alaskan communities will help to offset higher initial design and construction cost.
- Ultra-low building operational cost will allow for shorter payback periods.

Do not edit
How to change the design

What's the highest amount you've paid for a gallon of fuel?

There Isn’t Enough Renewable Energy

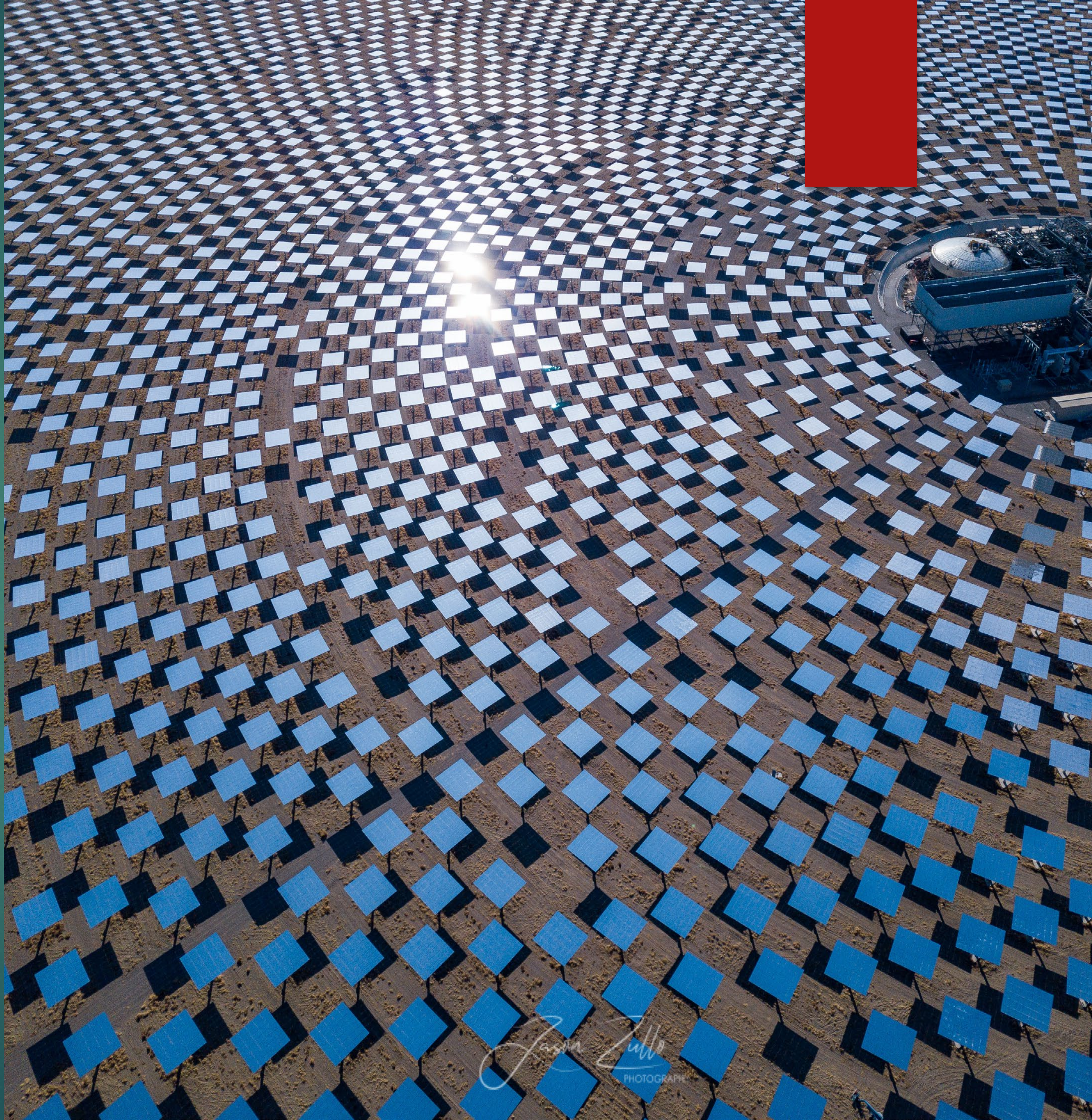
- The Perception of Renewable Energy potential in AK
- Solar wont work due to a lack of sun and too much snow/ice.

Alternative Energy Systems

- Solar energy (PV and solar thermal)
- Wind energy (onshore and offshore)
- Hydropower (run-of-river, small hydro)
- Geothermal energy (electric + direct-use heat)
- Biomass energy (wood waste, biogas, biofuels)
- Marine energy (tidal, wave, ocean thermal)

The majority of alternative energy types have seen a reduction in system cost through the use of market adoption. Cost of Solar has dropped 76% since 2010.

Cost reductions have allowed projects to achieve net-zero more easily and offer a greater return on investment (ROI).



What regions of the state are viable for solar PV systems?

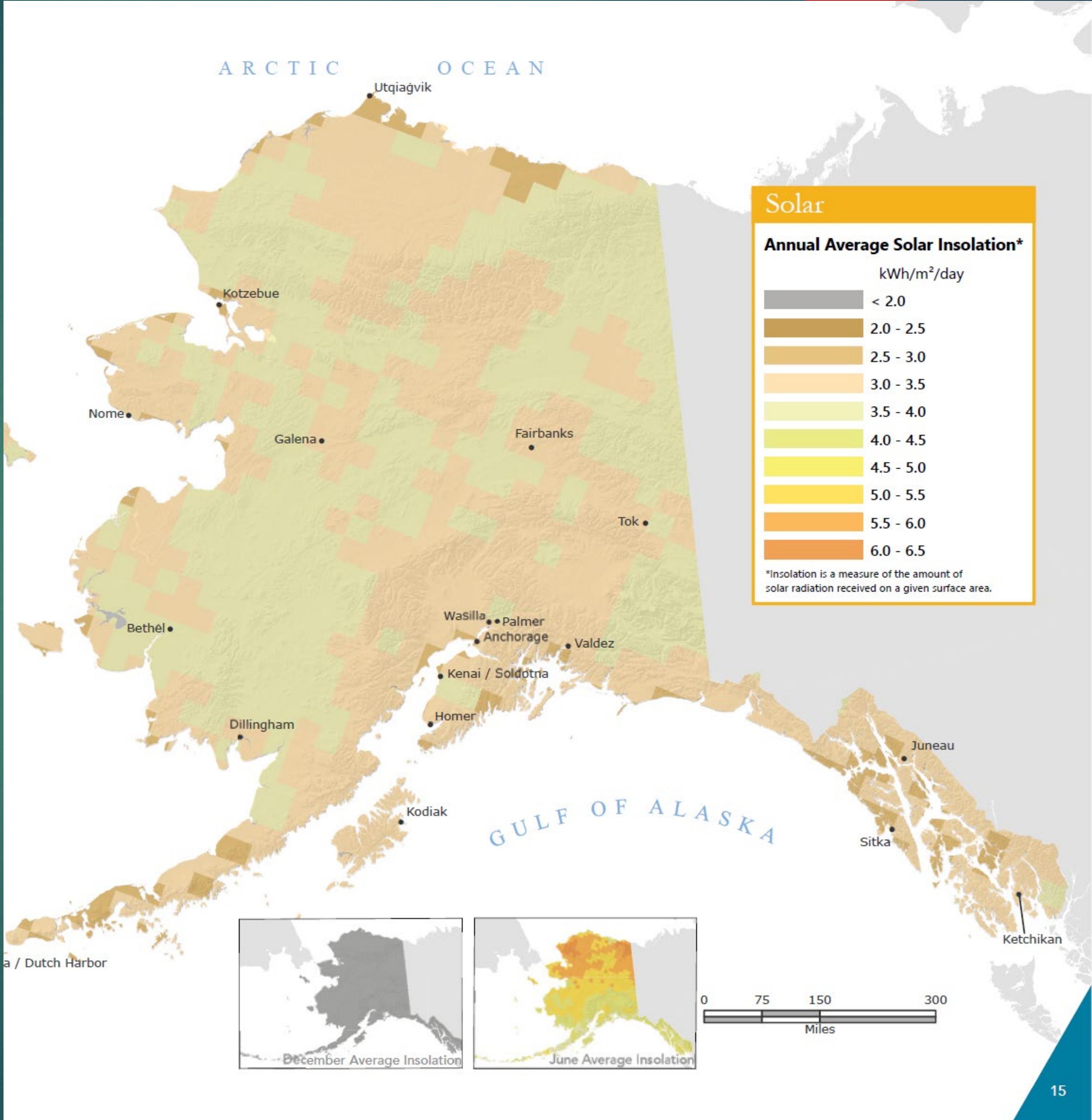
Solar Energy in Alaska

Alaska Energy Authority: Solar Insolation values average between **3.0 -4.0**

As shown in the image the majority of the state falls between the range shown above.

The Solar values are equal to that found in the PNW U.S. regions where solar has been commonly used for achieving **Net Zero Energy** in a high number of commercial buildings.

* Insolation is a measurement of the amount of solar radiation received on a given surface (shown as kWh/m2/day).

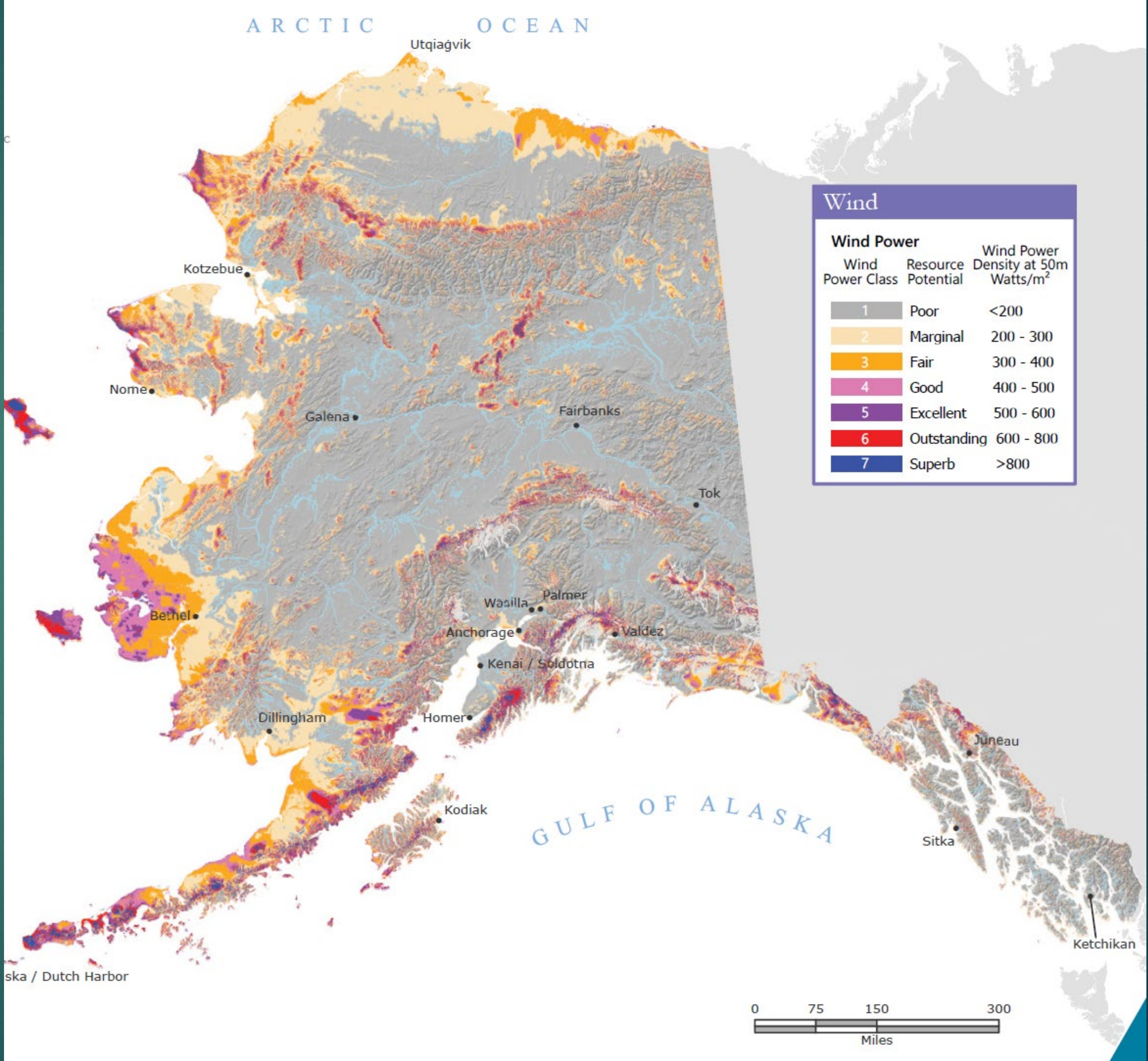


Wind Energy in Alaska

Wind Power Class varies throughout the state, with the much of the interior having a poor rating, while the western coastal areas are rated good to superb.

These coastal locations are well suited to serve remote rural Alaskan communities with clean, renewable energy.

* Wind Power Density measured at 50m Watts/m2

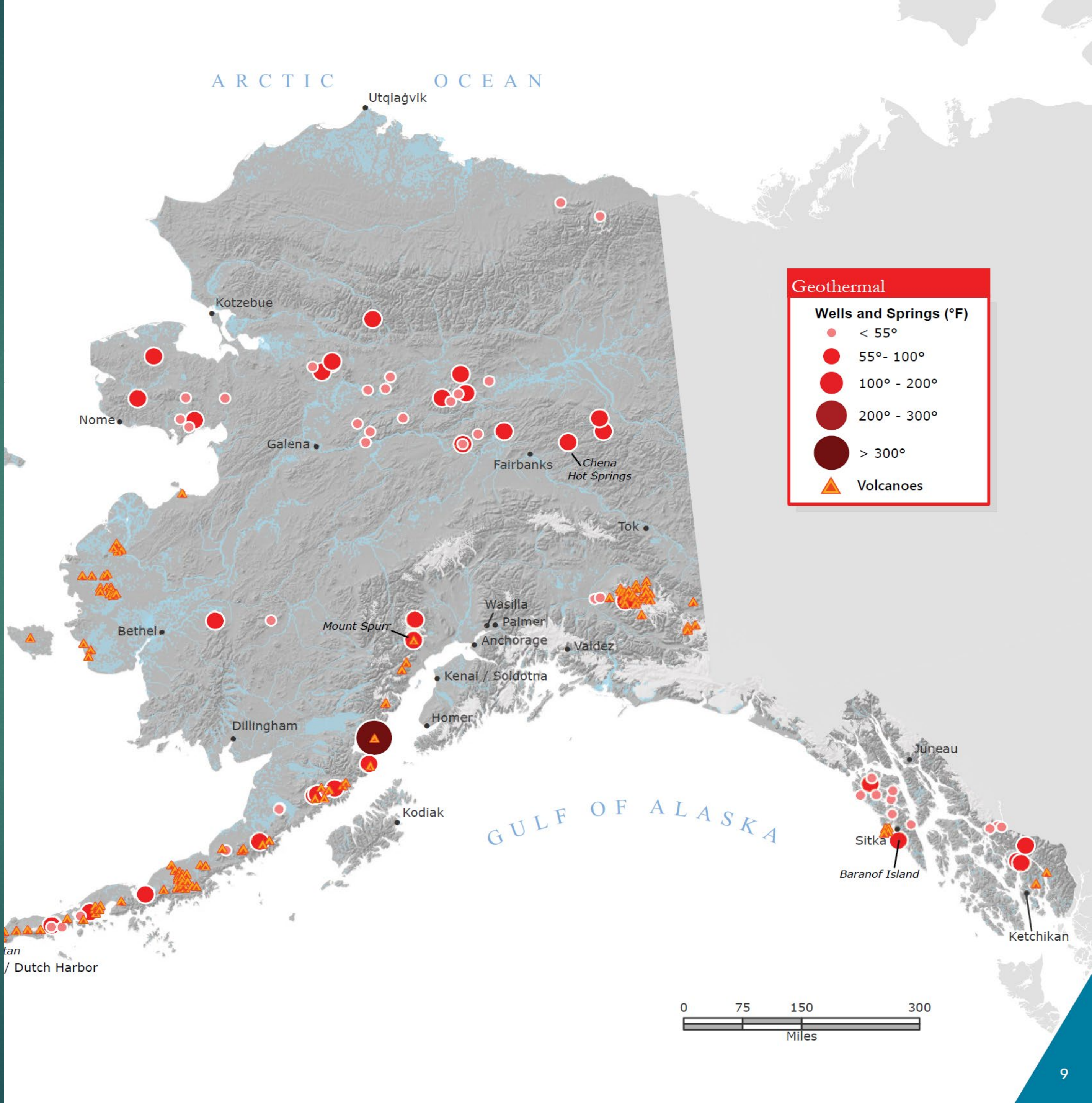


Geothermal Energy in Alaska

Naturally occurring geothermal wells and springs exist but difficult to capture. However, a large portion of the state is ideal for geothermal boreholes coupled with ground source heat pumps (GSHP)

Borehole Thermal Energy Storage (BTES) requires careful consideration to ensure the ground temperature is recharged during the summer months and permafrost line isn't impacted.

A recently completed study by a U.S. Dept of Energy National Lab (NREL) found these combined technologies can reliably heat buildings in arctic climates.



Alaska Alternative Energy Resources

Alaska Energy Authority

https://www.akenergyauthority.org

NREL - National Renewable Energy Lab

https://www.nrel.gov

Arctic Renewable Energy Atlas

https://arcticrenewableenergy.org/event-map/

RMI - Rocky Mountain Institute

https://rmi.org

The Denali Commission

https://denali.gov

We Don’t Know How to Net Zero

- Examples of projects in the arctic circle
- The expertise is available
- Building the test case for Net Zero Energy Schools

Do not edit
How to change the design

Do you have any experience with Alternative Energy System Design?

The Slido app must be installed on every computer you're presenting from

slido

Key Steps for Net Zero Buildings

1. Design a highly efficient building envelope with minimal air infiltration.
2. Select ultra efficient MEP systems for the building.
3. Manage building operations to limit energy consumption.
4. Size Alternative Energy systems after building energy usage has been reduced to lowest possible levels.
5. Integrate the alternative energy system with battery storage and generators to create a microgrid for the building.
6. Incorporate building commissioning into project requirements to ensure all systems are operating as designed.
7. Provide ongoing commissioning plan for building operations teams to ensure Net Zero Energy is achieved during a one performance period.

Designing the Building Envelope

- Incorporate Passive Solar Design and building orientation.
- Utilize energy modeling to determine the correct insulation values needed for the building.
- Select insulation materials that will maintain performance in cold climates.
- Limit the number of building openings and penetrations.
- Design glazing to be triple pane or greater with low-e/argon fill and optimal SHGC.
- Ensure the building exceeds the Passive House standard of ≤ 0.6 air changes per hour (ACH) at a test pressure of 50 Pascals ($n_{50} \leq 0.6\ h^{-1}$).

High Efficiency MEP Systems

1. Ultra-Efficient HVAC Systems
2. Continuous Ventilation with Heat Recovery
3. Building Electrification (Where Possible)
4. High-Efficiency Domestic Hot Water (DHW) Systems
5. Ultra-Low Energy Use Lighting Systems
6. Advanced Controls & Building Automation (BAS/BMS)
7. Plug Load & Process Load Management

Ultra Efficient HVAC

- Ground-source heat pumps (GSHPs) coupled with Geothermal wells for superior efficiency.
- Dedicated outdoor air systems (DOAS) with Heat recovery ventilators.
- HRV with ≥70–85% recovery efficiency
- Demand-controlled ventilation in variable-occupancy spaces
- Variable refrigerant flow (VRF) systems

High Efficiency Domestic Hot Water Systems

- Solar thermal Domestic Hot Water Production (evacuated tube type for cold climate)
- Low-flow fixtures and recirculation optimization
- Pipe insulation and demand-based DHW recirc controls
- Heat pump water heaters (HPWH) – Paired with waste heat interior spaces

Ultra-Low Electrical Lighting Systems + Plug loads

- 100% LED lighting with very low watts/ft² LPD
- Occupancy and daylight sensors
- Daylighting integration (controls + well-designed fenestration)

Building Operations

- Small buildings with complex systems need BAS/BMS
- Plug load controls (smart receptacles, occupancy-based shutoff)
- Energy-efficient appliances and office equipment
- Submetering to monitor plug-heavy zones
- Low-power IT infrastructure

Building Commissioning

- Building Envelope Commissioning
- HVAC & Heat Pump System Commissioning
- Domestic Hot Water (DHW) Systems
- Electrical Systems & Load Management
- Lighting & Daylighting Controls
- Renewable Energy Systems (Solar PV / Wind / Storage)
- Battery Energy Storage Systems (BESS)
- Operations Training & Documentation

Alternative Energy Systems

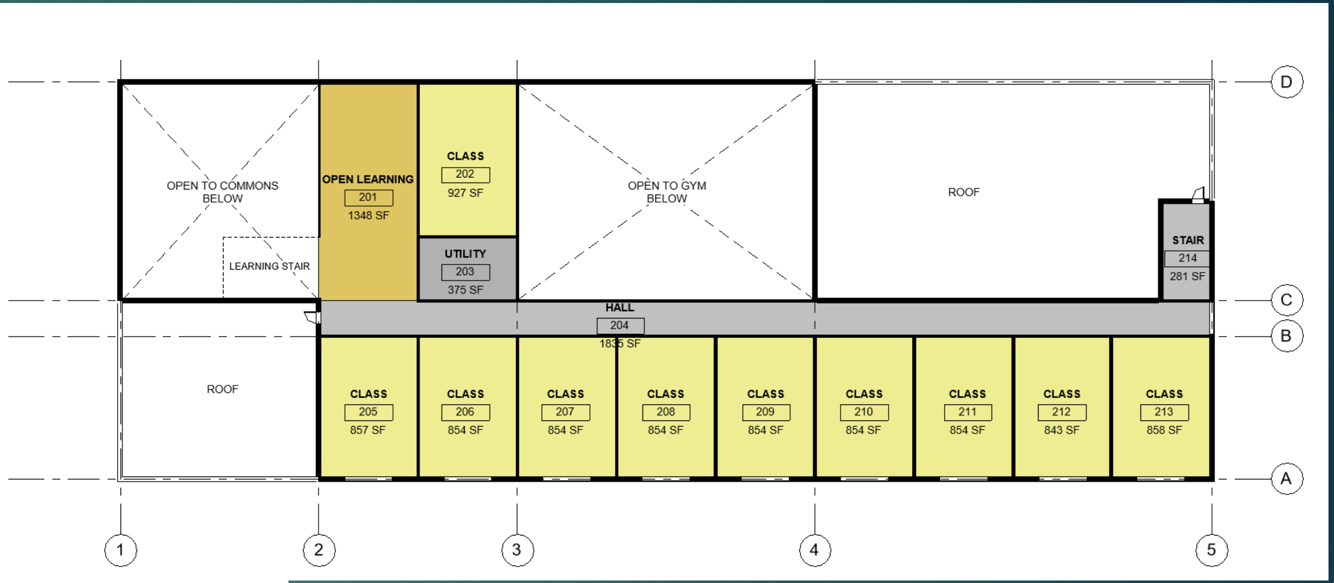
- Size the Alternative Energy System to meet the building demand.
- Alternative energy systems are costly. The smaller the energy demand the smaller the system size.
- Photovoltaic (PV) Solar Power systems will have limited production in winter months
- PV system designed for snow shedding/load with module type selected for cold-temps.
- Wind power system design with extreme cold-weather turbine (low-temperature lubricants, anti-icing systems). Icing issues heated blades or coatings.High-wind survivability → turbines rated for >50 m/s gusts.
- Include a Battery Energy Storage System (BESS) sized for high summer/low winter production.
- Energy systems (Alt Energy + BESS + Backup Power Generators) need to provide resilience for extreme weather events, outages, and other interruptions.

Prototype School Experiment

- Hypothetical K-12 School Design
- Kotzebue, Alaska 66.8N Latitude (Arctic Circle)

Program and Zoning

- Hypothetical K-12 School
- Case Study location: Kotzebue, AK
- 40,000sf 22 classrooms
- Gym, Commons with Food Service

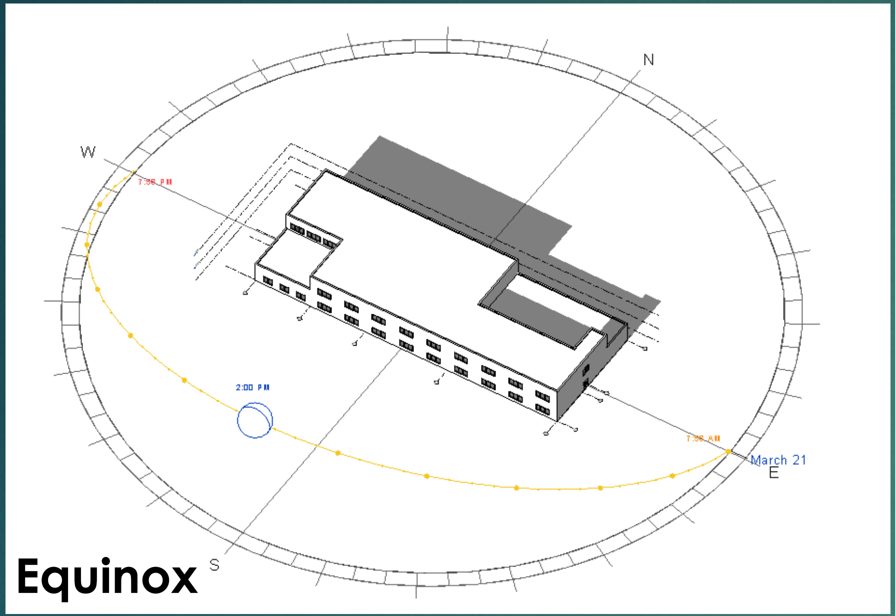


Level 2

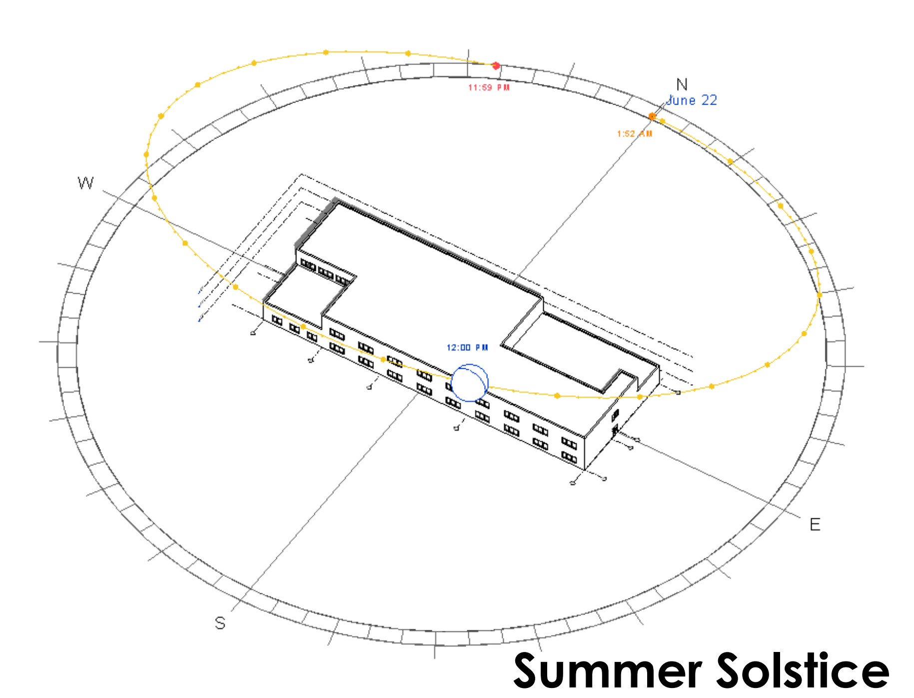
- East-West Orientation
- 2-Story compact volume
- Classrooms and offices on South for daylight
- Gym and Utilities Zoned on North side

Level 1

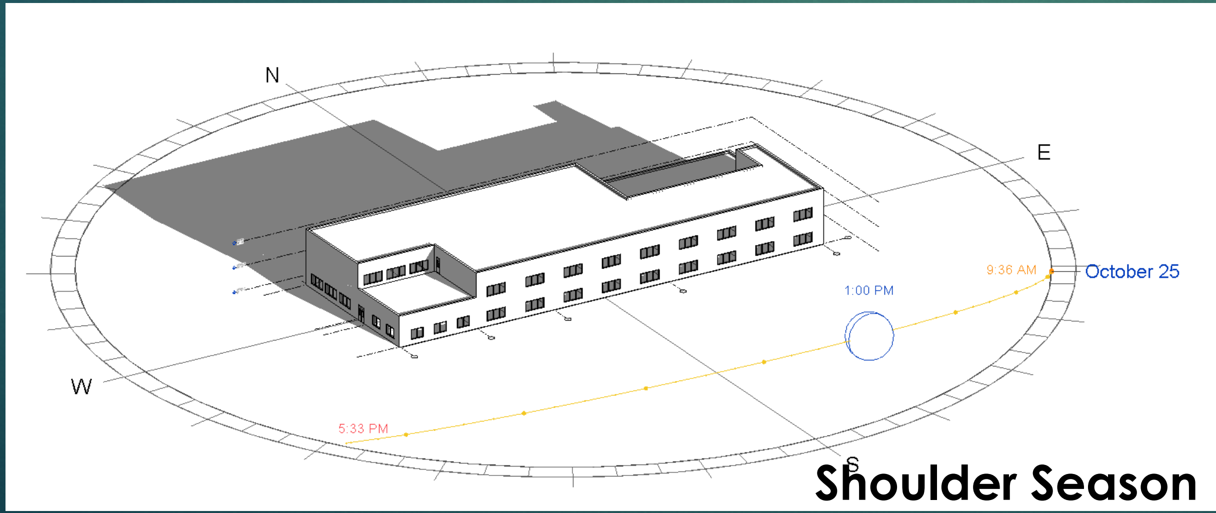
Solar Orientation



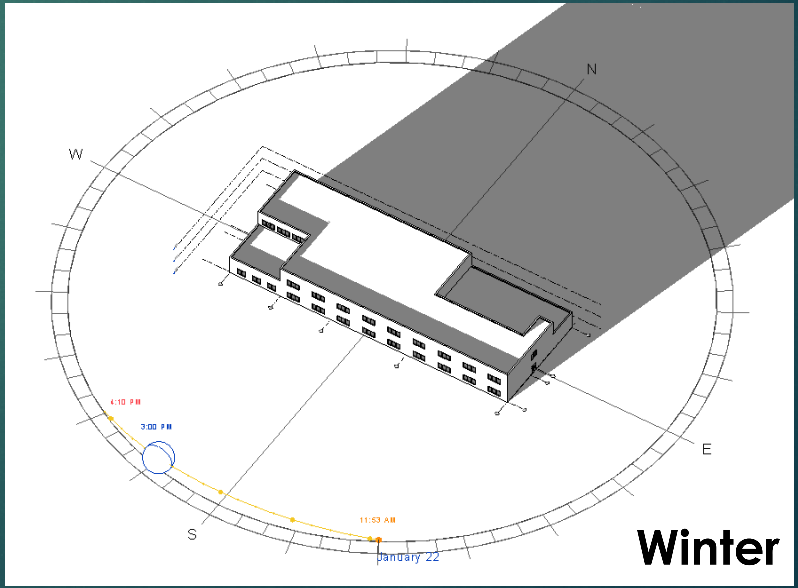
Equinox



Summer Solstice



Shoulder Season



Winter

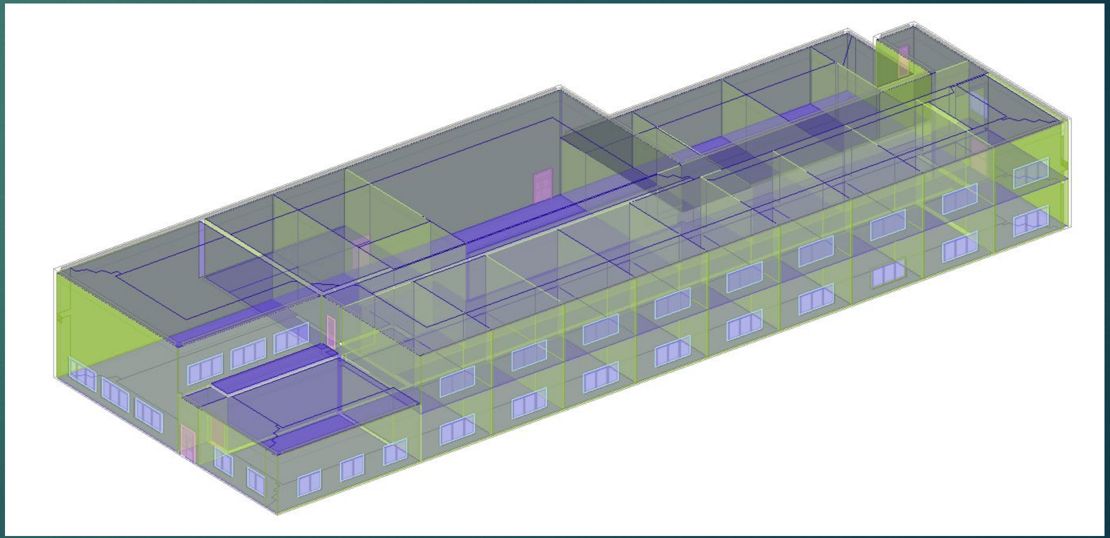
Energy Use Simulation

Degree Days are a measure of the heating or cooling energy required to keep buildings comfortable based on local temperatures. The difference between the mean temp of a given day and 65F equals degree days.

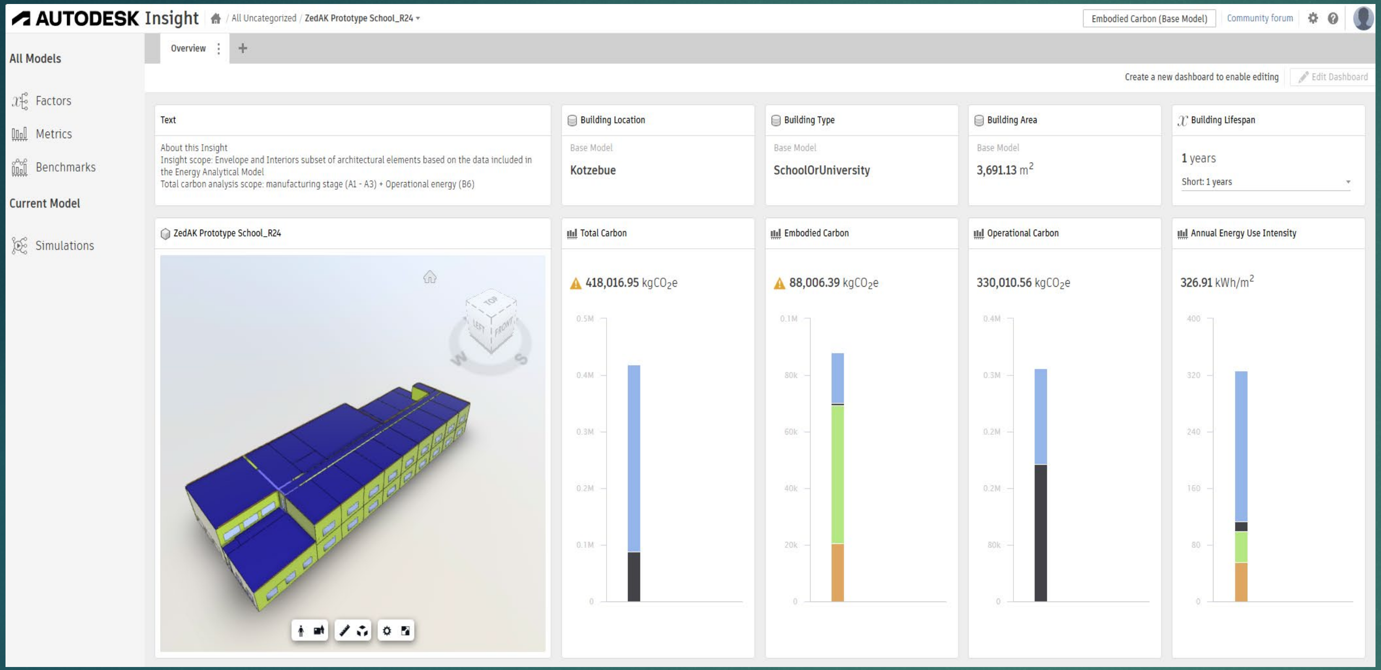
Utqiagvik, AK – 99723 – 71.2N – 19,422 HDD/ 0 CDD
Kotzebue, AK – 99752 – 66.8N – **15,449 HDD**/ 5 CDD
Fairbanks, AK – 99708 – 64.5N – 12,783 HDD/ 49 CDD
Anchorage, AK – 99501 – 61.1N – 10,593 HDD/ 4 CDD
Juneau, AK – 99801 – 58.2N – 8,385 HDD/ 2 CDD
Seattle, WA – 98113 - 47.4N – 4,516 HDD/ 350 CDD

Autodesk Insight Energy Model

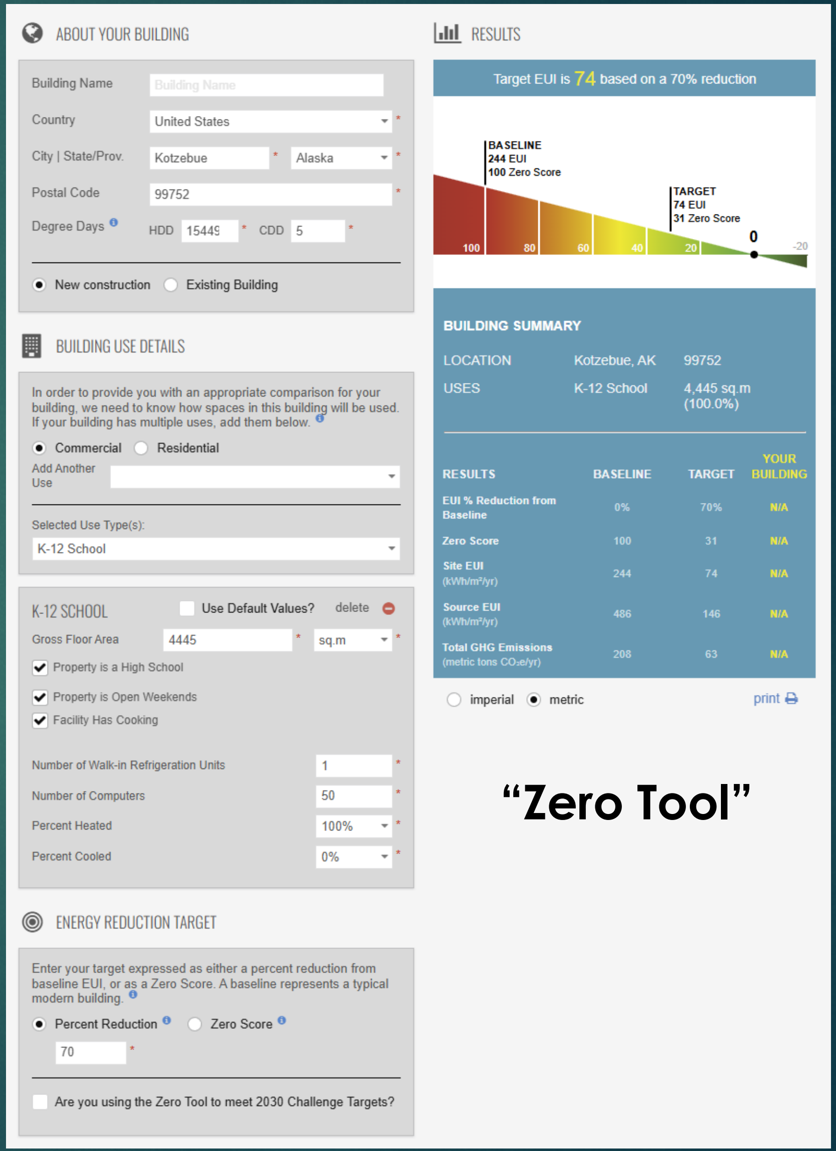
Test Building Envelope
Roof – R70
Walls – R50
Glazing – U0.26
(initial values based on standard cont insulation + triple glazed low-e windows)



Energy Use Simulation



“Autodesk Insight”



“Zero Tool”

EUI – **Energy Use Intensity** – A measure of the projected energy usage (on site) per unit area of a building over the course of one year. (kWh/sq meter)

Onsite Energy Production

“PV Watts”

RESULTS

1,103,481 kWh/Year*

System output may range from 1,057,245 to 1,202,904 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	0.15	3,450
February	1.06	33,271
March	3.24	120,156
April	5.55	191,534
May	5.31	184,980
June	5.15	168,080
July	4.76	156,258
August	3.25	107,838
September	2.67	87,950
October	1.33	44,773
November	0.20	5,184
December	0.00	6
Annual	**2.72**	**1,103,480**

Location and Station Identification

Requested Location	Kotzebue, Alaska
Weather Data Source	(TMY3) KOTZEBUE RALPH WEIN MEMORIAL, AK 1.0 mi
Latitude	66.88° N
Longitude	162.60° W

Baseline

RESULTS

485,057 kWh/Year*

System output may range from 464,733 to 528,760 kWh per year near this location.

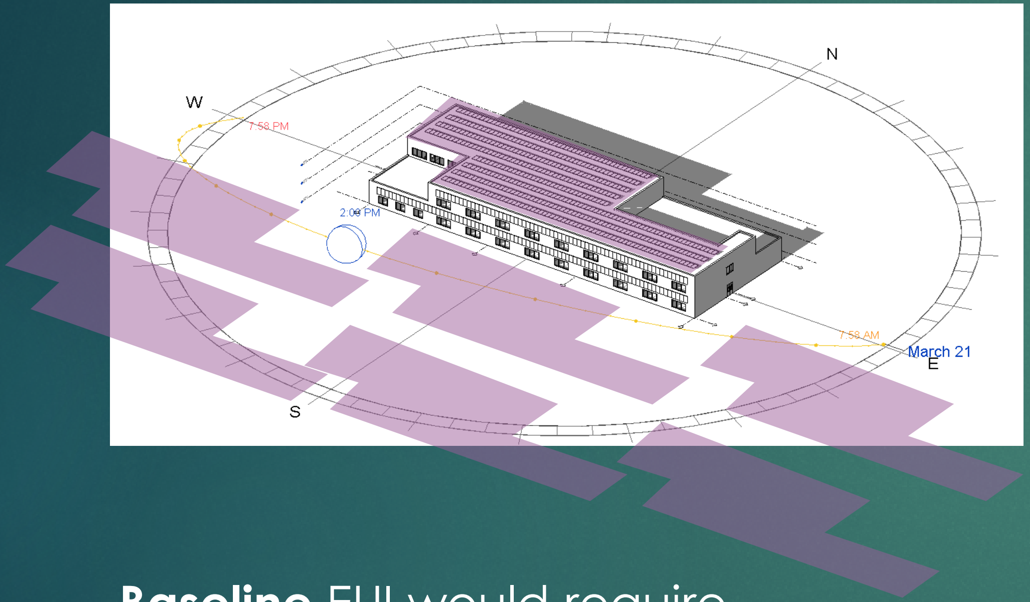
Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	0.15	1,517
February	1.06	14,624
March	3.24	52,814
April	5.56	84,208
May	5.32	81,309
June	5.15	73,881
July	4.76	68,684
August	3.25	47,401
September	2.67	38,658
October	1.33	19,680
November	0.20	2,279
December	0.00	2
Annual	**2.72**	**485,057**

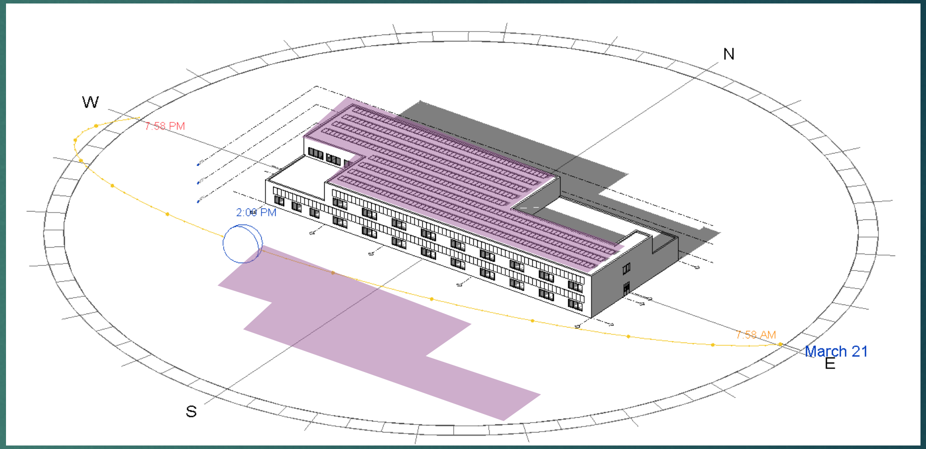
Location and Station Identification

Requested Location	Kotzebue, Alaska
Weather Data Source	(TMY3) KOTZEBUE RALPH WEIN MEMORIAL, AK 1.0 mi
Latitude	66.88° N
Longitude	162.60° W

Target

Onsite Energy Production





Baseline EUI would require a 1300 KW PV system – 7 times larger than the Case Study roof can support!

Target EUI would require a 582 kW PV system

Next Steps/Statement of Intent

1. Further development of the Net-Zero School Case Study
   - The Quest for Lowest EUI possible
   - Managing ventilation and heat loss
   - Energy systems options

2. Understanding Cost Impacts
   - Construction cost comparison
   - Life Cycle Cost Analysis

Q&A

- Garrett will select one person at a time from the Audience!

Net Zero Resources

- U.S. Department of Energy (DOE) — Zero Energy Buildings Resource Hub

https://www.energy.gov/eere/buildings/zero-energy-buildings-resource-hub

- New Buildings Institute (NBI) — Getting to Zero / Getting to Zero Buildings Database

https://newbuildings.org/resource/getting-to-zero-database/

- Zero-Energy / Zero-Carbon Design Guides
- https://zeroenergyproject.com/build/resources-builders-designers/

Net Zero Building Certifications

- **Zero Energy Certification (International Living Future Institute — ILFI)** — ILFI's dedicated Zero Energy certification (and related Zero Carbon programs) that verify operational net-zero energy/carbon performance and align with Living Building principles. Living Future - A future worth living in+1
- **LEED Zero (USGBC / GBCI)** — verifies net-zero performance for Energy, Carbon, Water, and Waste over a 12-month performance period (e.g., *LEED Zero Energy*, *LEED Zero Carbon*). U.S. Green Building Council+1
- **Living Building Challenge (ILFI)** — a regenerative certification that requires net-positive (or net-zero at minimum) energy performance as part of its Energy Petal (often used where teams pursue net-zero/positive outcomes). Living Future - A future worth living in
- **Passive House (Plus / Premium tiers / PHI / PHIUS variants)** — Passive House Classic focuses on ultra-low energy demand; *Passive House Plus* and *Premium* tiers explicitly incorporate on-site renewable generation and are commonly used to demonstrate net-zero or net-positive energy performance. (PHI and PHIUS have different admin paths in North America.) passiv.de+1
- **DOE Zero Energy Ready Home (now DOE Efficient New Homes)** — the U.S. Department of Energy's program recognizing new homes built to extremely high efficiency and "PV-ready" standards (successor name: DOE Efficient New Homes). Primarily for single-family and multifamily residential projects. The Department of Energy's Energy.gov+1
- **Green Globes / GBI — Journey to Net Zero & Green Globes Net Zero options** — Green Building Initiative's Journey to Net Zero (and Green Globes Net Zero Energy/Net Zero Carbon designations) for new and existing commercial buildings and portfolios. Green Building Initiative+1