NREL
Transforming ENERGY

Alaska House Energy- Renewable Portfolio Standards Testimony

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Photo by Dennis Schroeder NREL 40481

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Photo by Dennis Schroeder, NREL

Coast to coast

The **17** National Laboratories have served as leading institutions for scientific innovation in the United States for more than 70 years.

NREL At-A-Glance

3,056 Workforce, including:

- 2,188 regular/limited term
- 454 contingent workers
- 193 postdoctoral researchers
- 132 graduate students
- 89 undergraduate students

World-Class research expertise in:

- Renewable Power
- Energy Efficiency
- Sustainable Transportation
- Energy Systems Integration

Partnerships with

- Industry
- Academia
- Government

3 Campuses operate as living laboratories

Renewable Power

- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation

- Bioenergy
- Vehicle Technologies
- Hydrogen

Energy Efficiency

- Buildings
- Advanced Manufacturing
- Government Energy Management

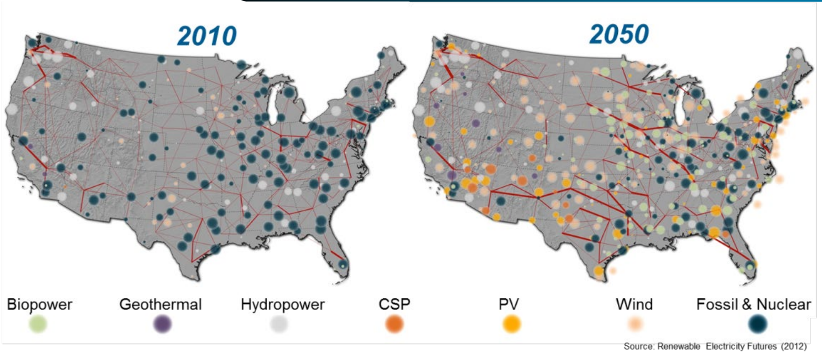
Energy Systems Integration

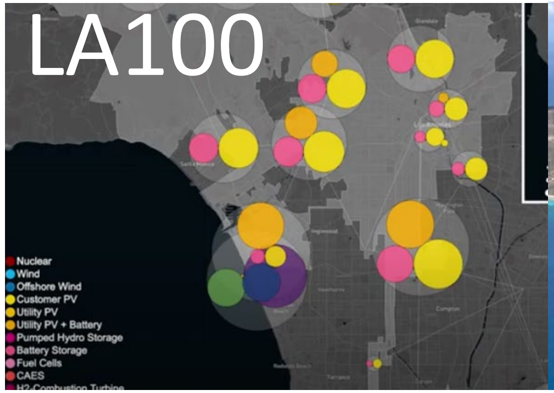
- Grid Integration
- Hybrid Systems
- Energy resilience and security
- Energy transition planning and analysis

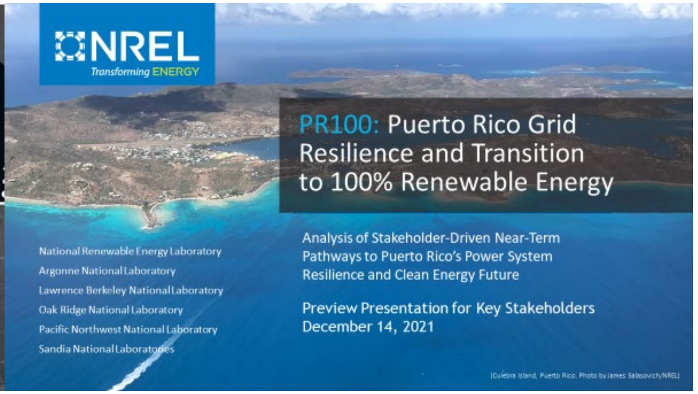
NREL Energy Transition Research: Very High Levels of Renewable Electricity

2012 Renewable Electricity Futures: An exploration of the technical feasibility, challenges, & implications of very high renewable electricity generation in the U.S

- **Volume 1** — Exploration of High-Penetration Renewable Electricity Futures
- **Volume 2** — Renewable Electricity Generation and Storage Technologies
- **Volume 3** — End-Use Electricity Demand
- **Volume 4** — Bulk Electric Power Systems: Operations and Transmission Planning





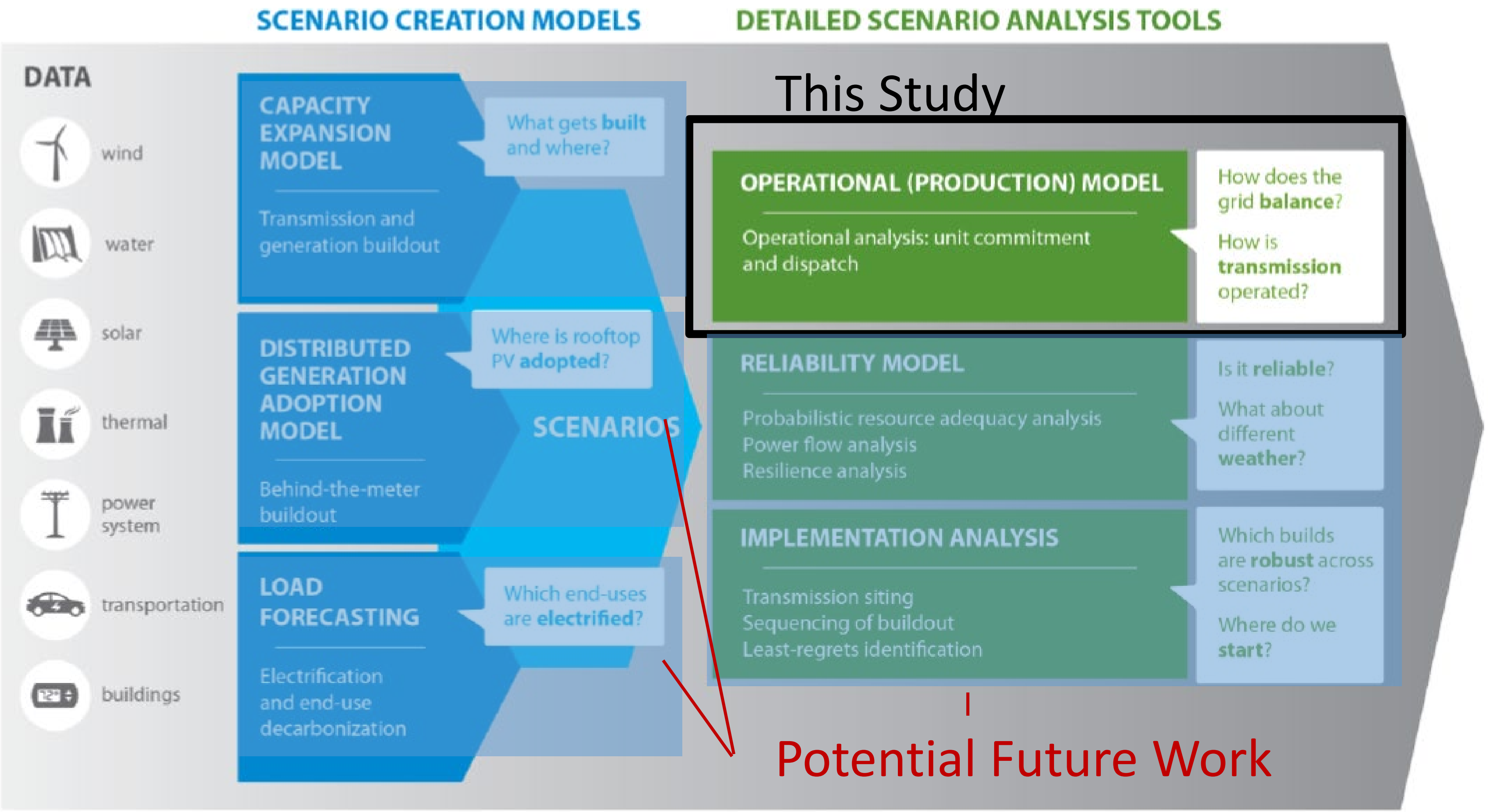


- Brinkman et al. (2017). *Operational Analysis of the <u>Eastern</u> Interconnection at Very High Variable Renewable Penetrations*
- Brinkman (2015). *Renewable Electricity Futures: Operational Analysis of the <u>Western</u> Interconnection at Very High Renewable Penetrations*
- Mai et al. (2014). *Envisioning a Renewable Electricity Future for the United States*
- *+ others*

Goal

- **Provide insight** into the basic techno-economic feasibility of an 80% RPS
- **Help identify** some of the likely elements of such a portfolio, such as the potential need for new transmission and storage, and the role of a diverse mix of new resources

How Does This Compare to Other Utility Planning Studies?



Approach

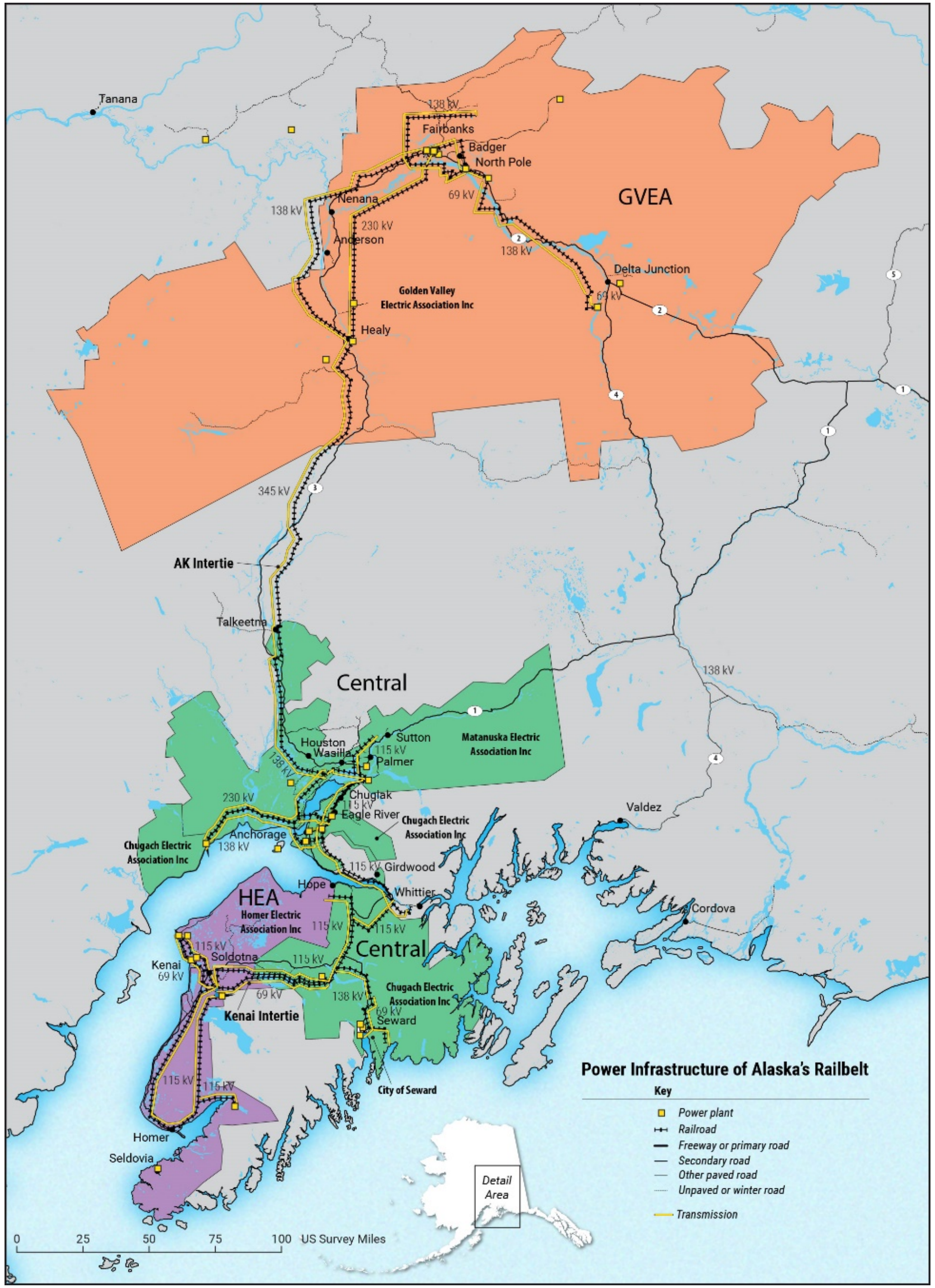
- Developing a set of plausible 80% RPS scenarios, and evaluate:
  1. **Reliability** – Ensuring the envisioned 80% RE systems could balance load in every hour of the year and provide sufficient operating reserve,
  2. **Cost Savings** – Confirming the dispatch resulted in 80% renewable energy supply, along with quantifying fuel savings.

Study Process: Four Steps

1. Develop a 2040 “electrical” model of the railbelt system including:
   – Load growth, expected transmission upgrades
2. Develop six 2040 scenarios
   – A base case (no additional renewables)
   – A range of possible 80% RPS scenarios
3. Test system for reliable operation and modify
4. Confirm 80% RPS is achieved and evaluate fuel savings

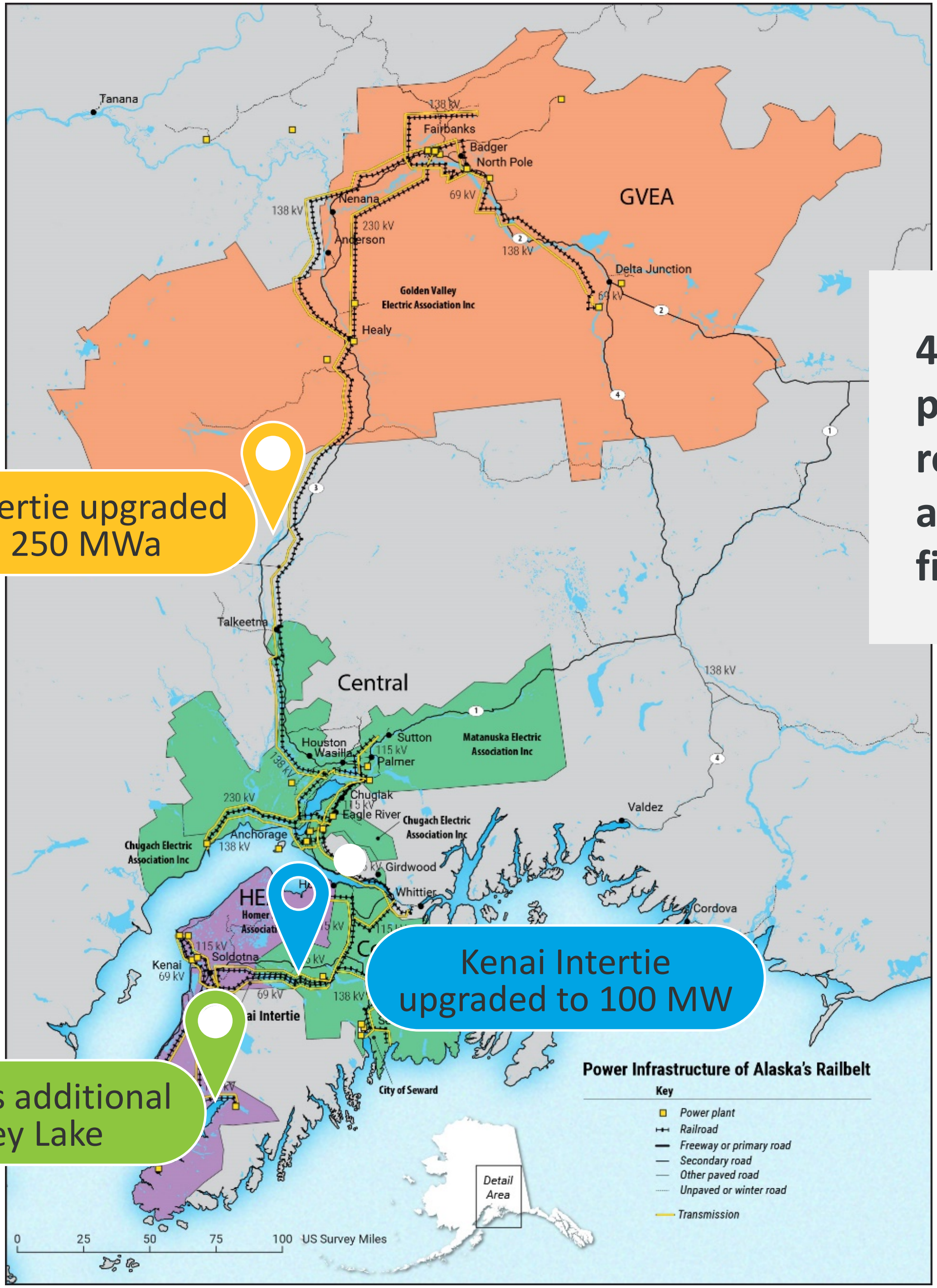
Step 1: System Model

- Three Zones:
  - – GVEA
  - – Central (MEA, Chugach, Seward)
  - – Homer
- 1 Balancing area – coordinated operations but can operate independently as needed
- Zones connected via AK and Kenai Interties



2040 Base Conditions

- Total load of 5.2 TWh (about a 12% increase compared to 2020).
- Peak demand of 820 MW.
- No change in load shape due to electrification, EVs



AK Intertie upgraded to 250 MWa

Kenai Intertie upgraded to 100 MW

Dixon diversion adds additional energy at Bradley Lake

427 MW of fossil plants retired and replaced with various amounts of new gas-fired capacity

GVEA: 28% of total demand

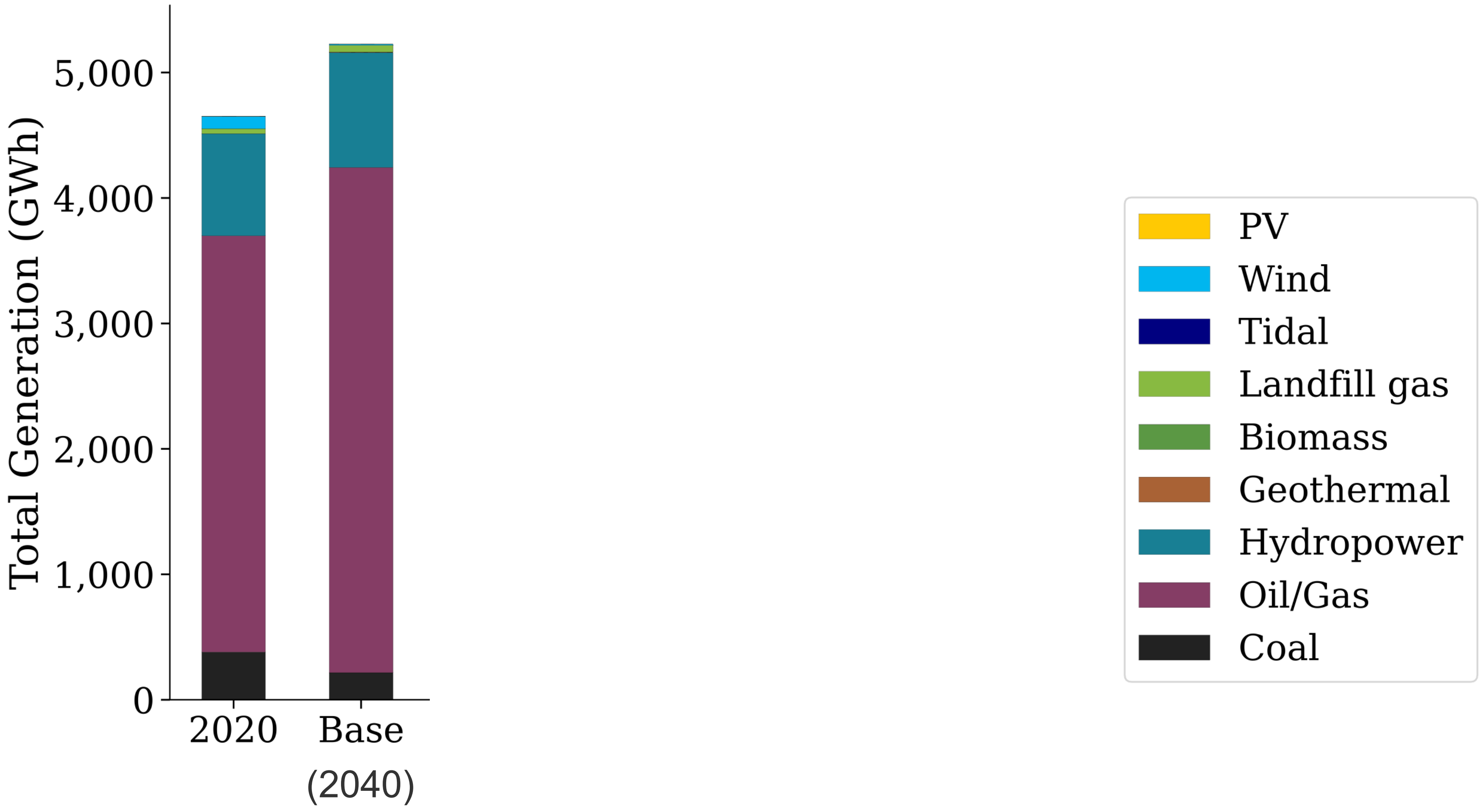
Central: 62% of total demand

Homer: 10% of demand

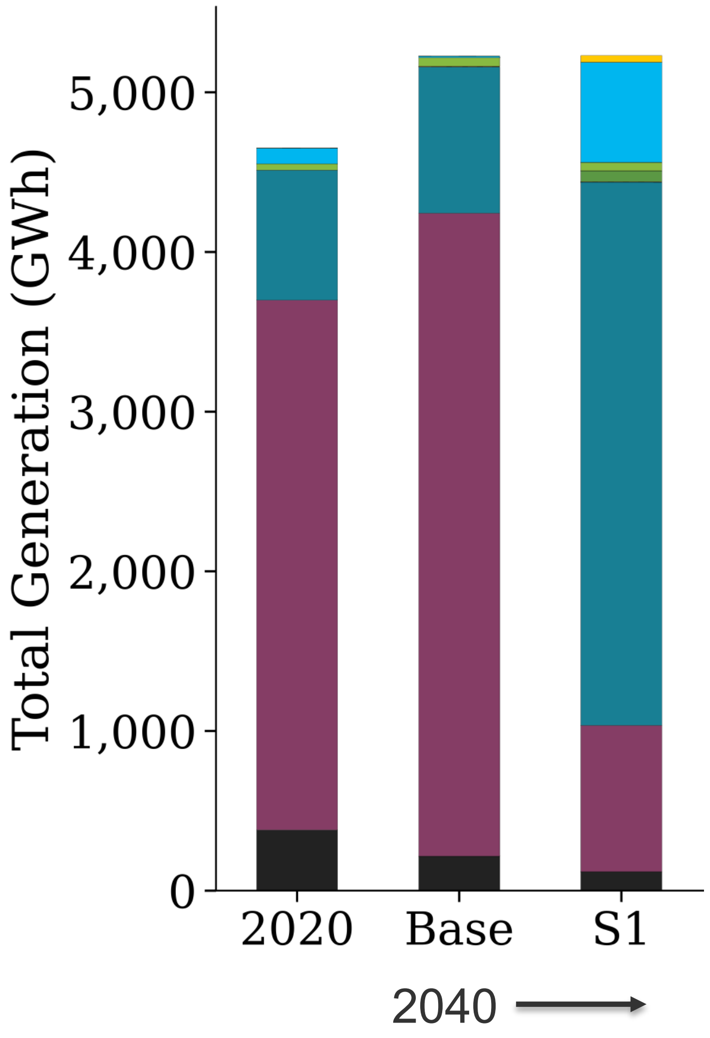
Step 2: Scenarios

- Base case – No additional Renewables
- Five RPS Scenarios. Not intended to be optimal or the most likely scenarios. Goal is to explore a range of possible scenarios.
- The 80% RPS is applied to the entire railbelt.
  - Individual utilities will achieve a higher or lower than 80% to reduce overall costs.
  - No trading out of state, or other offsets
- Eligible renewables:
  - Wind, solar PV, hydropower, geothermal, tidal, existing landfill gas, biomass (wood)

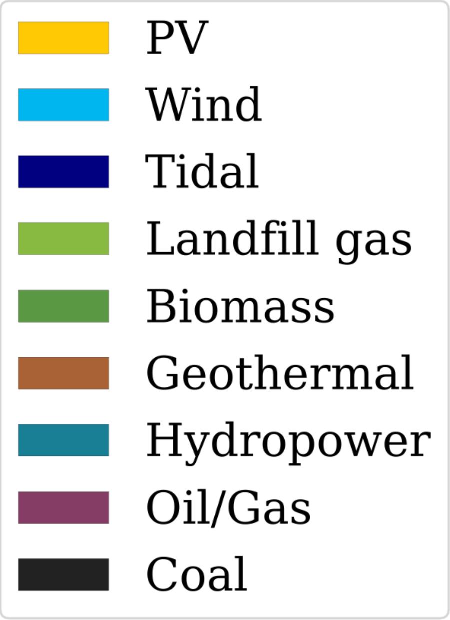
No New Renewables



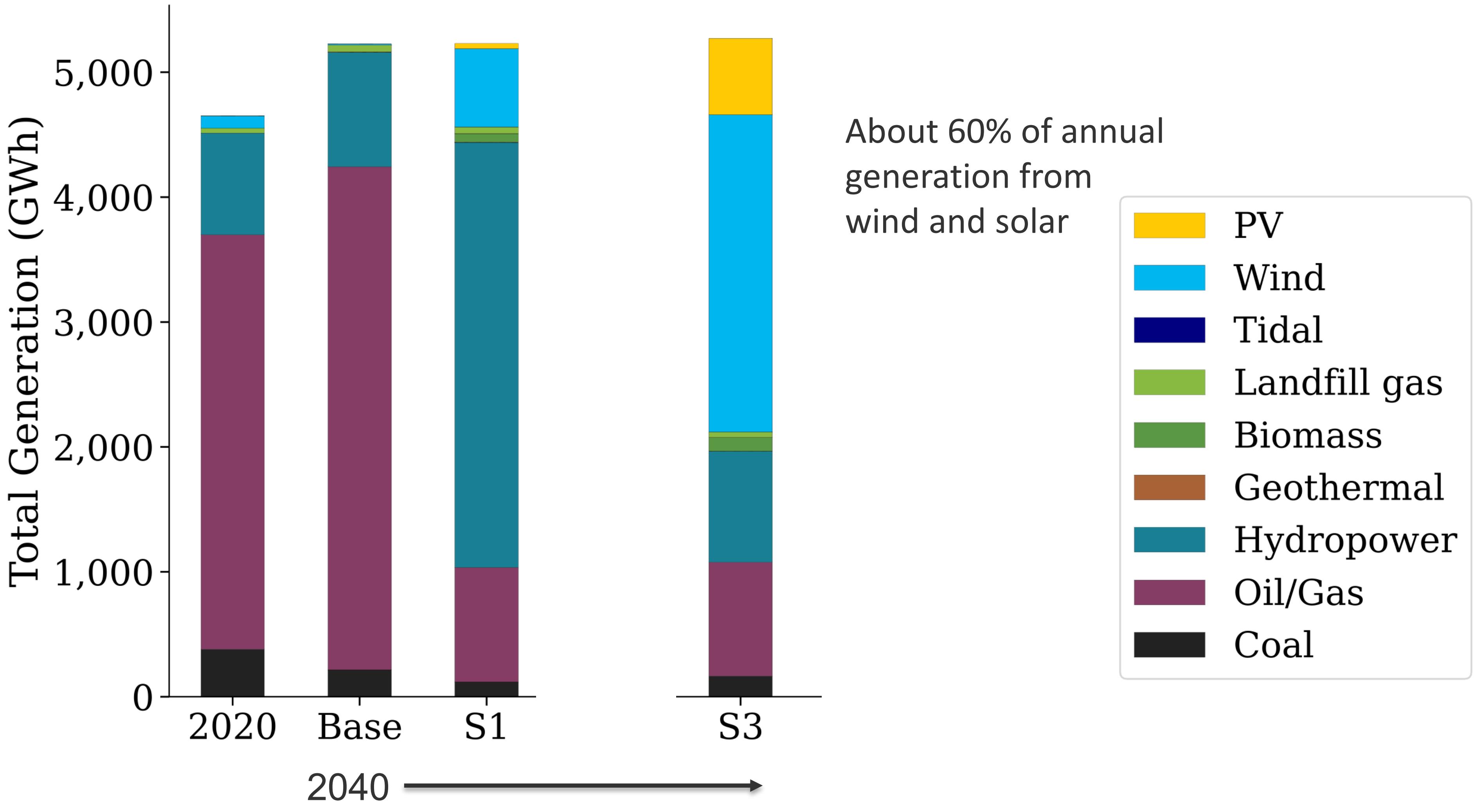
Scenario 1- Largest Hydro



New hydro capacity based on the characteristics of Susitna-Watana, with remainder mostly wind



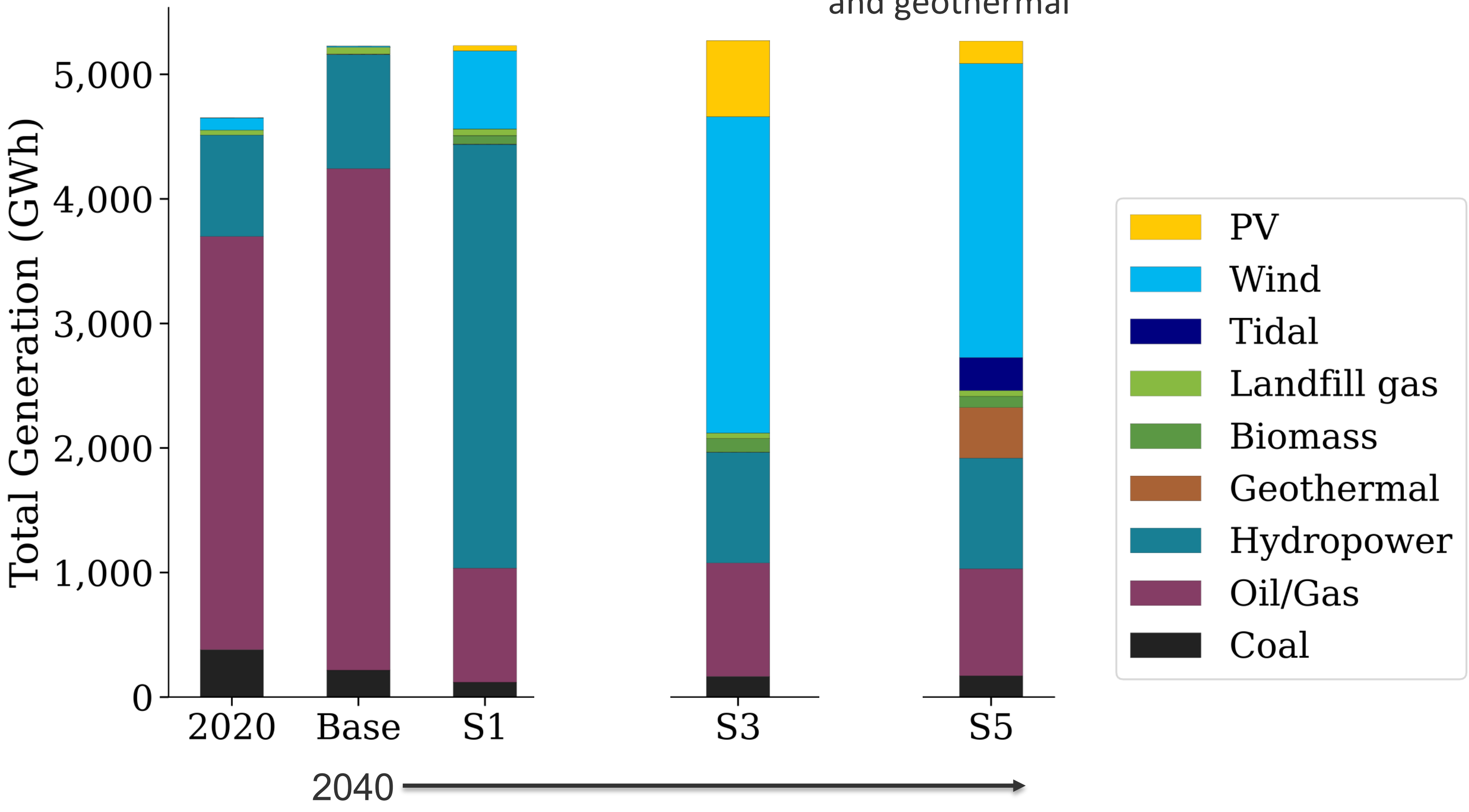
Scenario 3 – Largest Wind/Solar Case



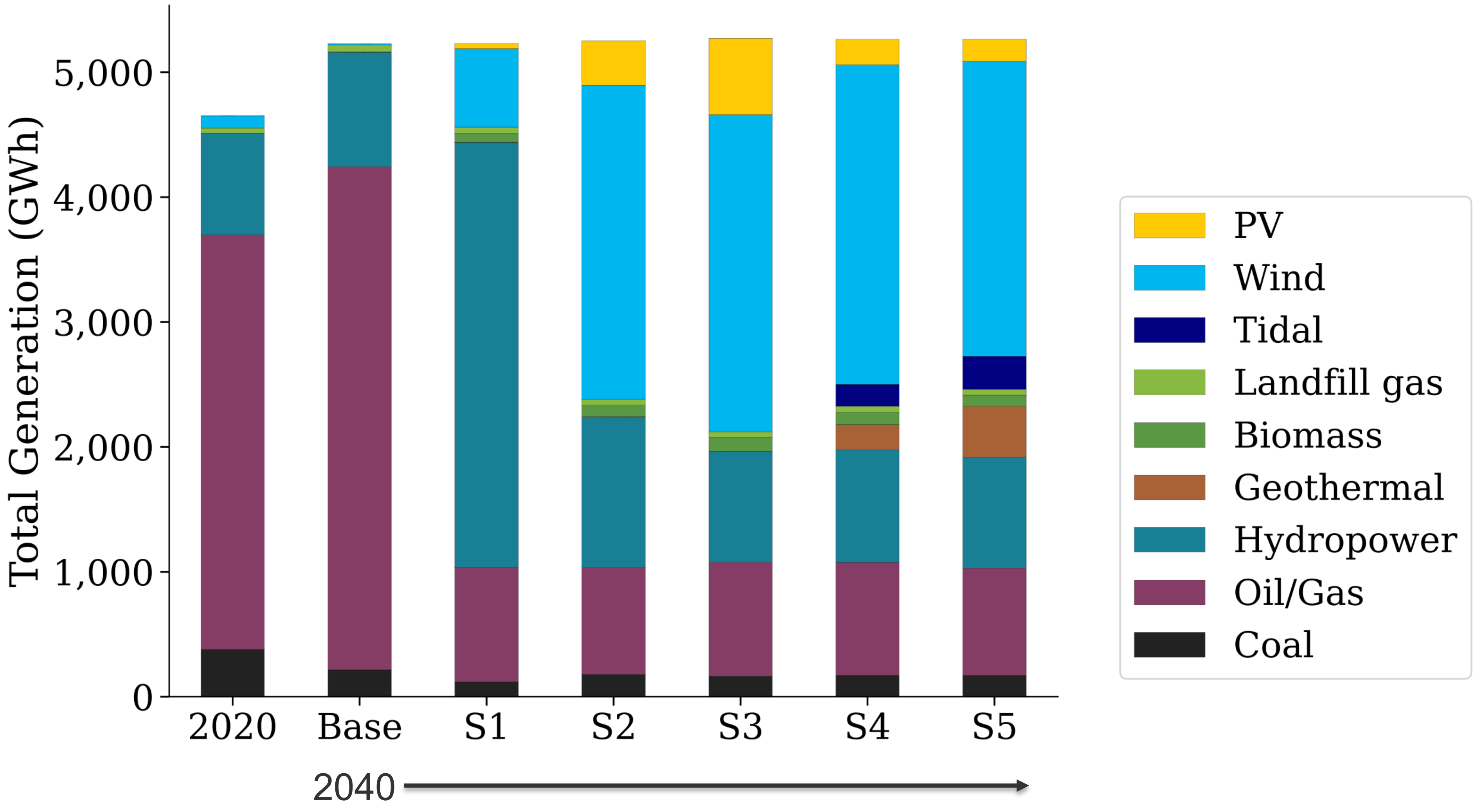
About 60% of annual generation from wind and solar

Scenario 5 – Lowest Hydro Case

Significant addition of tidal and geothermal



Plus In-Between Cases



Step 3: Test for Reliability

- This was the most important analysis step and primary objective of developing the system model.
- We did not (and do not) report on systems that do not meet reliability criteria

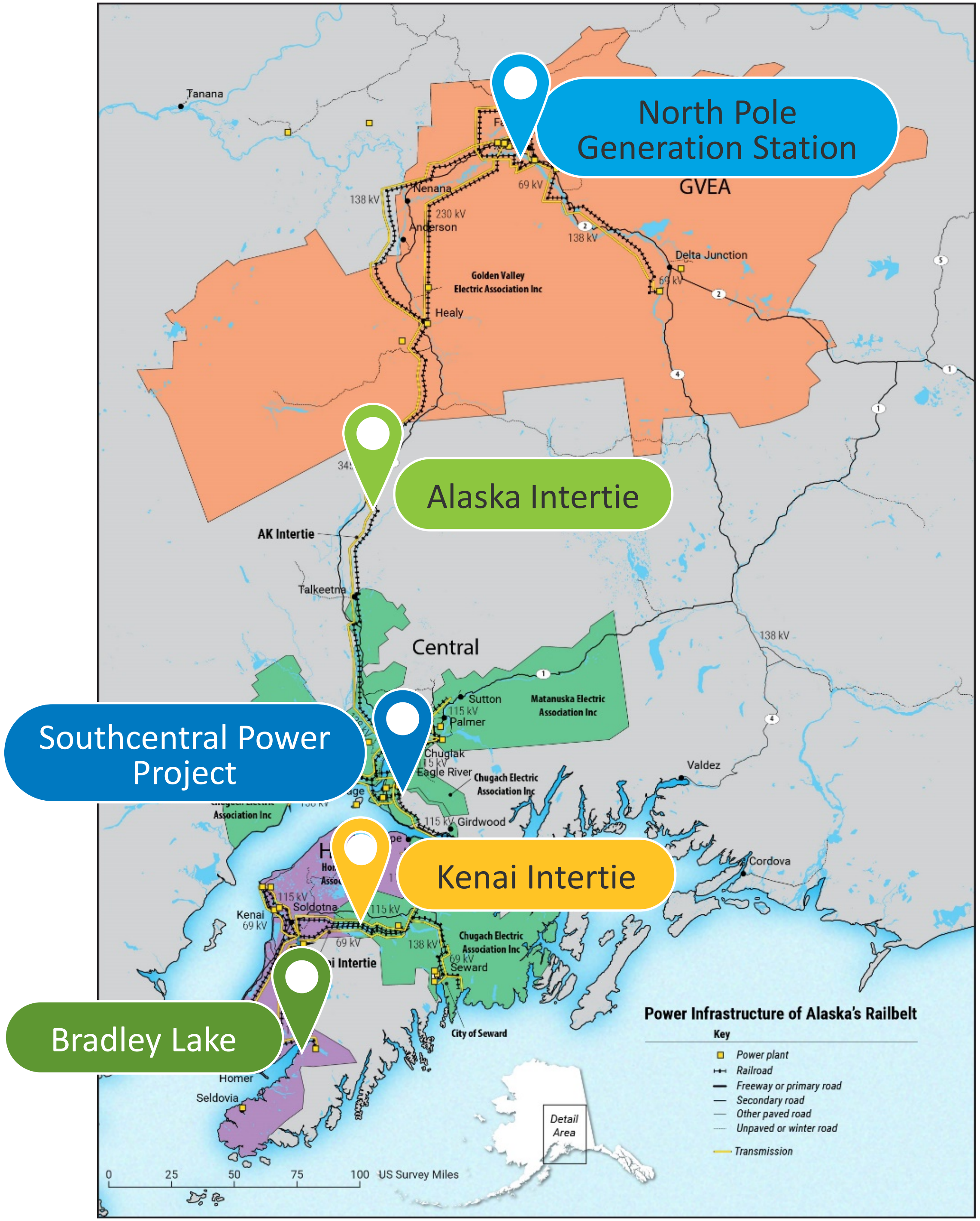
Three Tests for Reliability

During **every hour of the year** the system must:

1. Have sufficient generation resources to meet demand for electricity.
2. Have adequate operating reserves to address rapid failures of the single largest element in each region.
3. Have sufficient generation resources to remain robust to an extended (multi-month), simultaneous outage of BOTH the single largest generator AND the largest intertie connection.

Simulation of Extended Simultaneous Outages

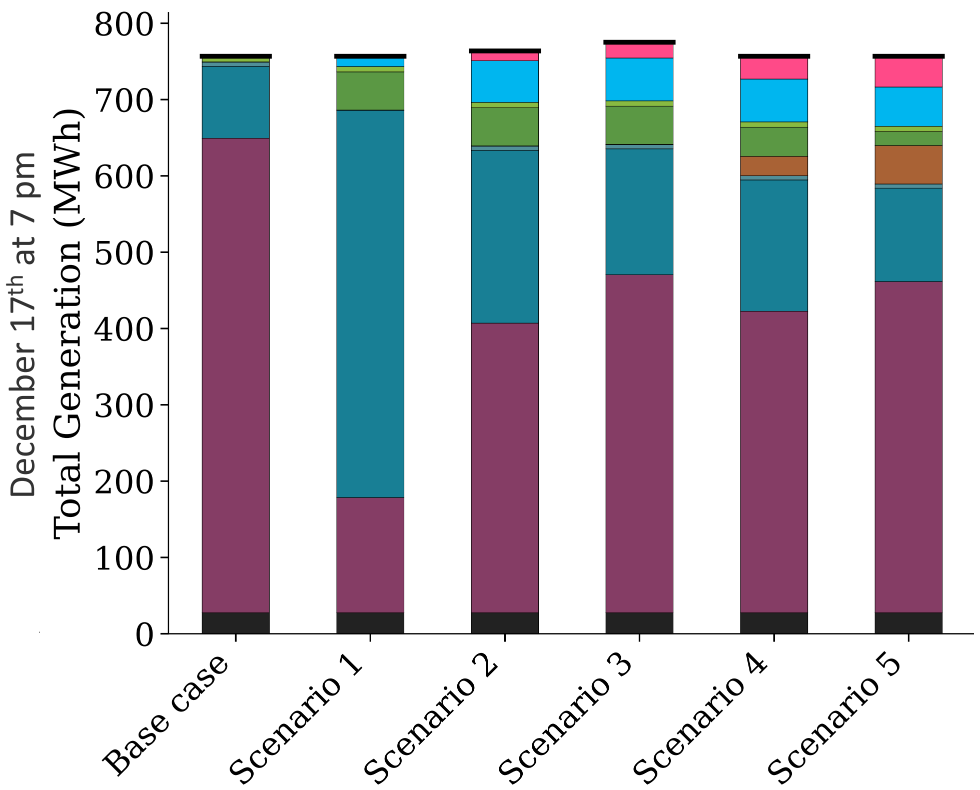
Example outage scenarios in Base case and Scenarios 2-5



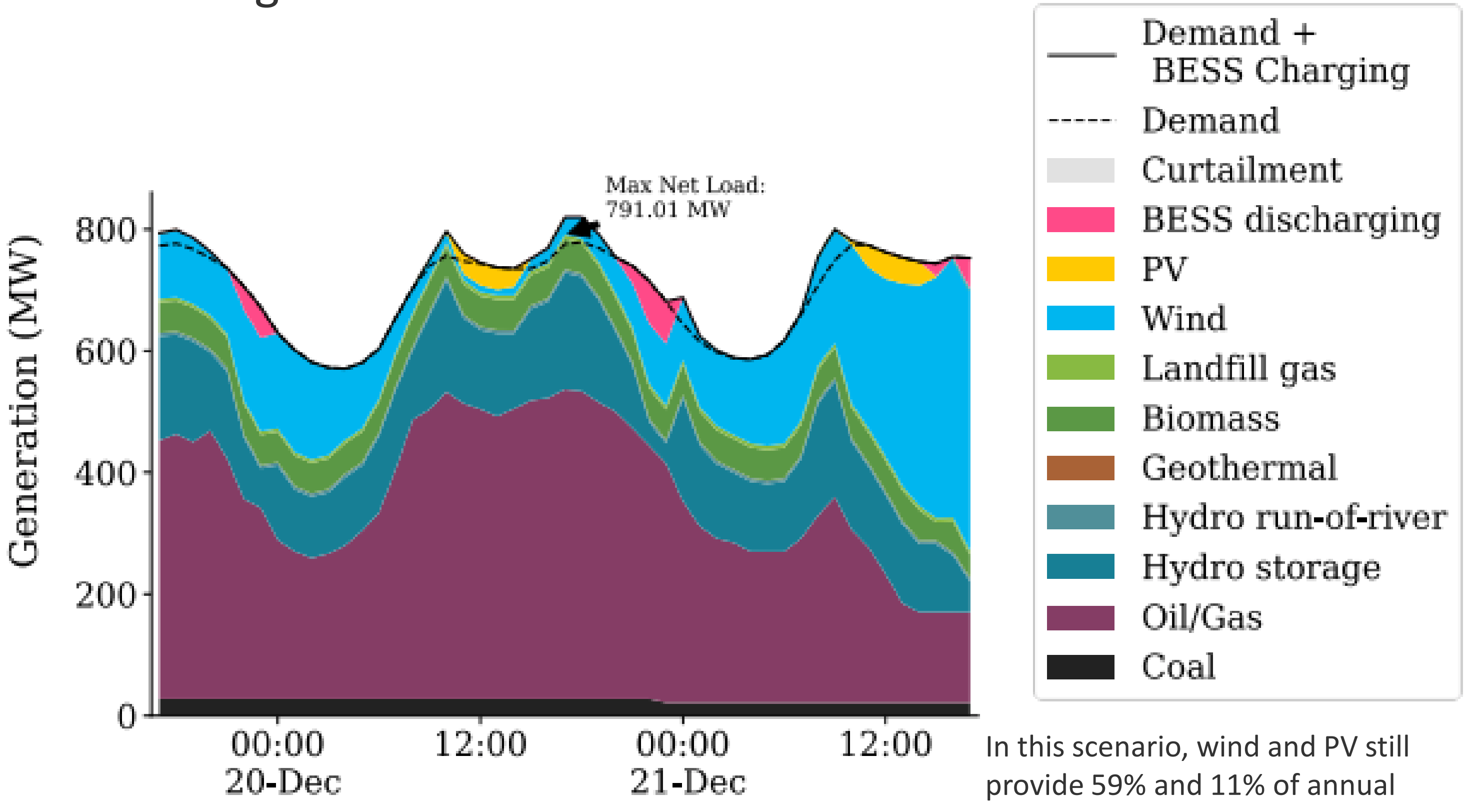
How Do We Keep the Lights On?

- Continued use of existing and new fossil generators
- Continued use of existing and new flexible hydropower generation and energy storage

Source of generation during periods of very low wind and solar conditions



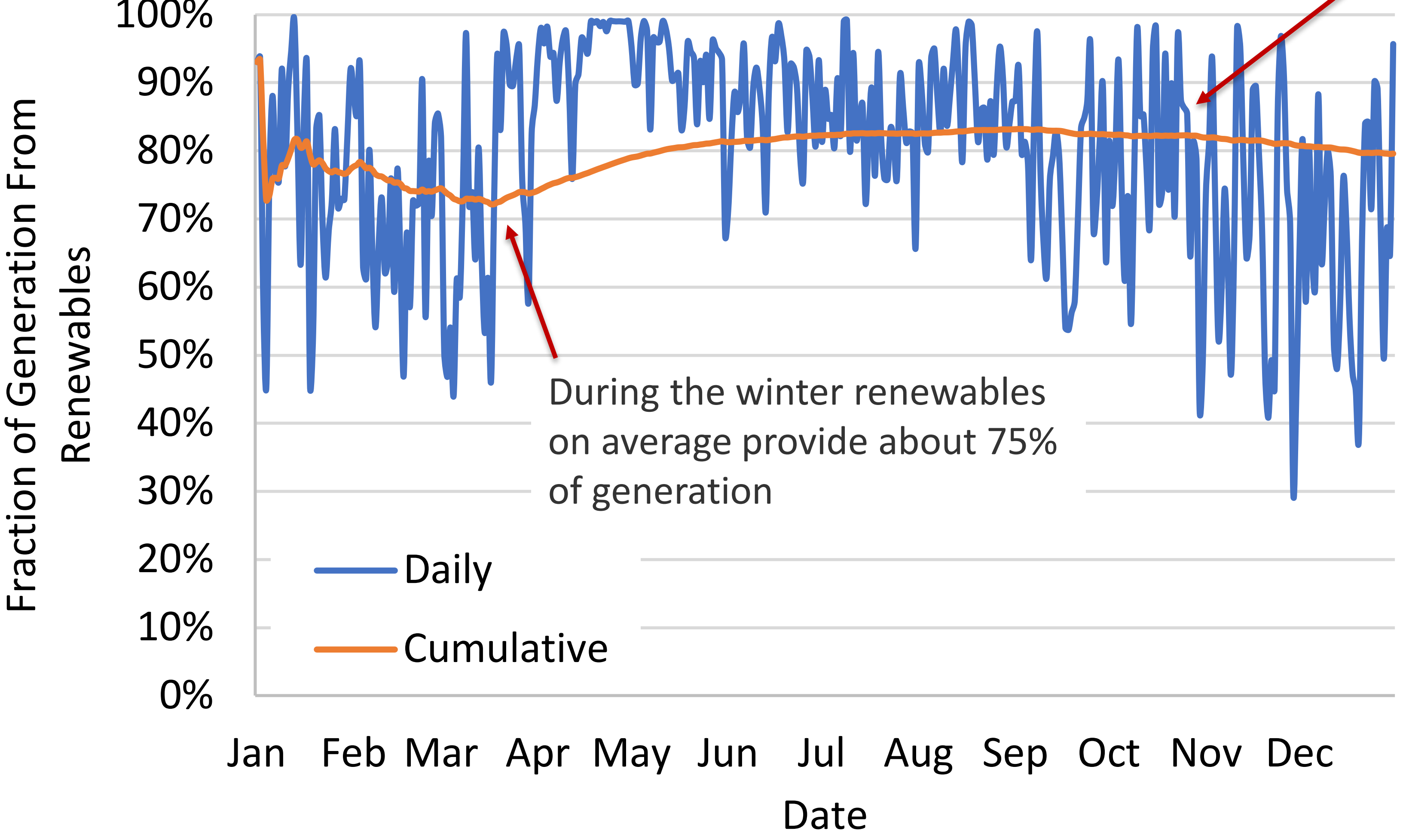
Source of generation during a day with high load and bad wind and solar



In this scenario, wind and PV still provide 59% and 11% of annual electricity demand, respectively.

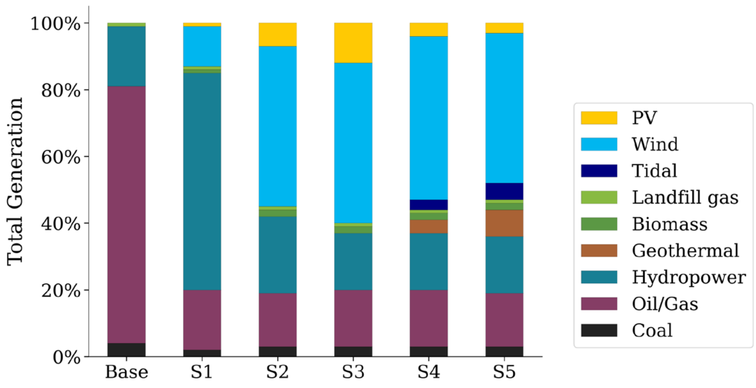
Step 4: Confirm 80% RPS is achieved and evaluate fuel savings

Scenario 3 (Highest wind and solar so most variable and most difficult scenario)

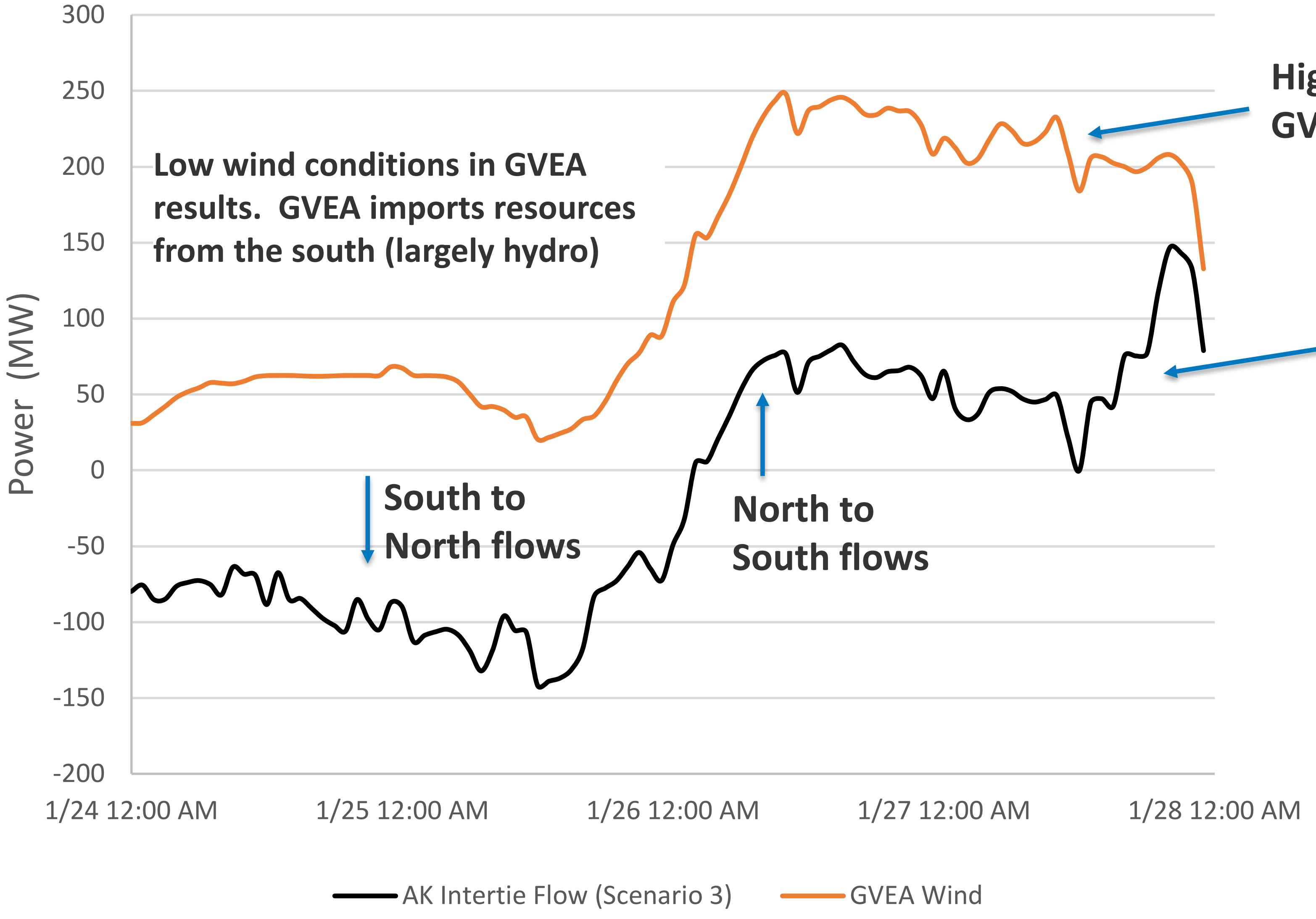


During the summer/fall renewables on average provide a little over 80% of generation

The contribution of renewables on any given day varies significantly



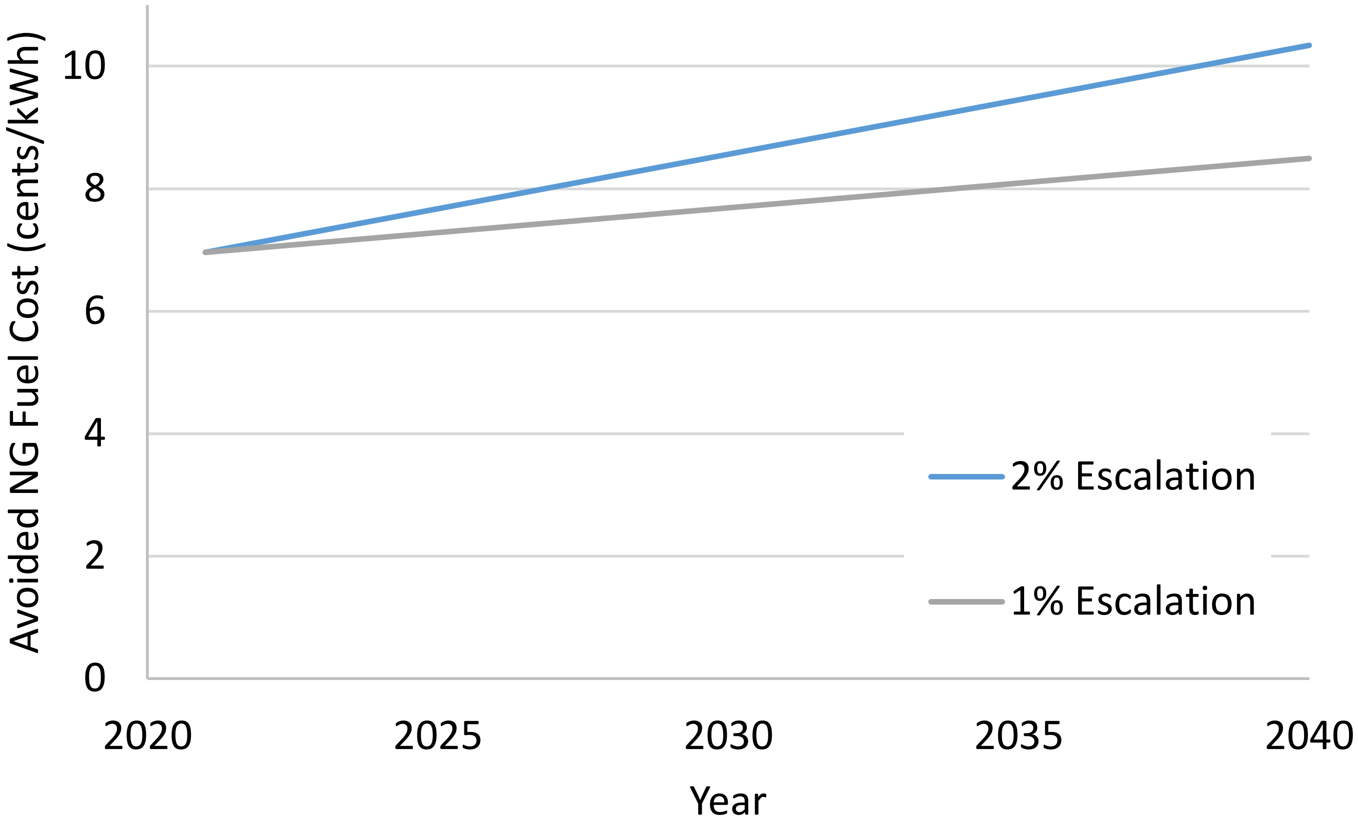
AK Intertie Plays An Important Role



Flexible operation of the AK Intertie allows for efficient operation and reduces operational costs

Fuel Savings and Cost Implications

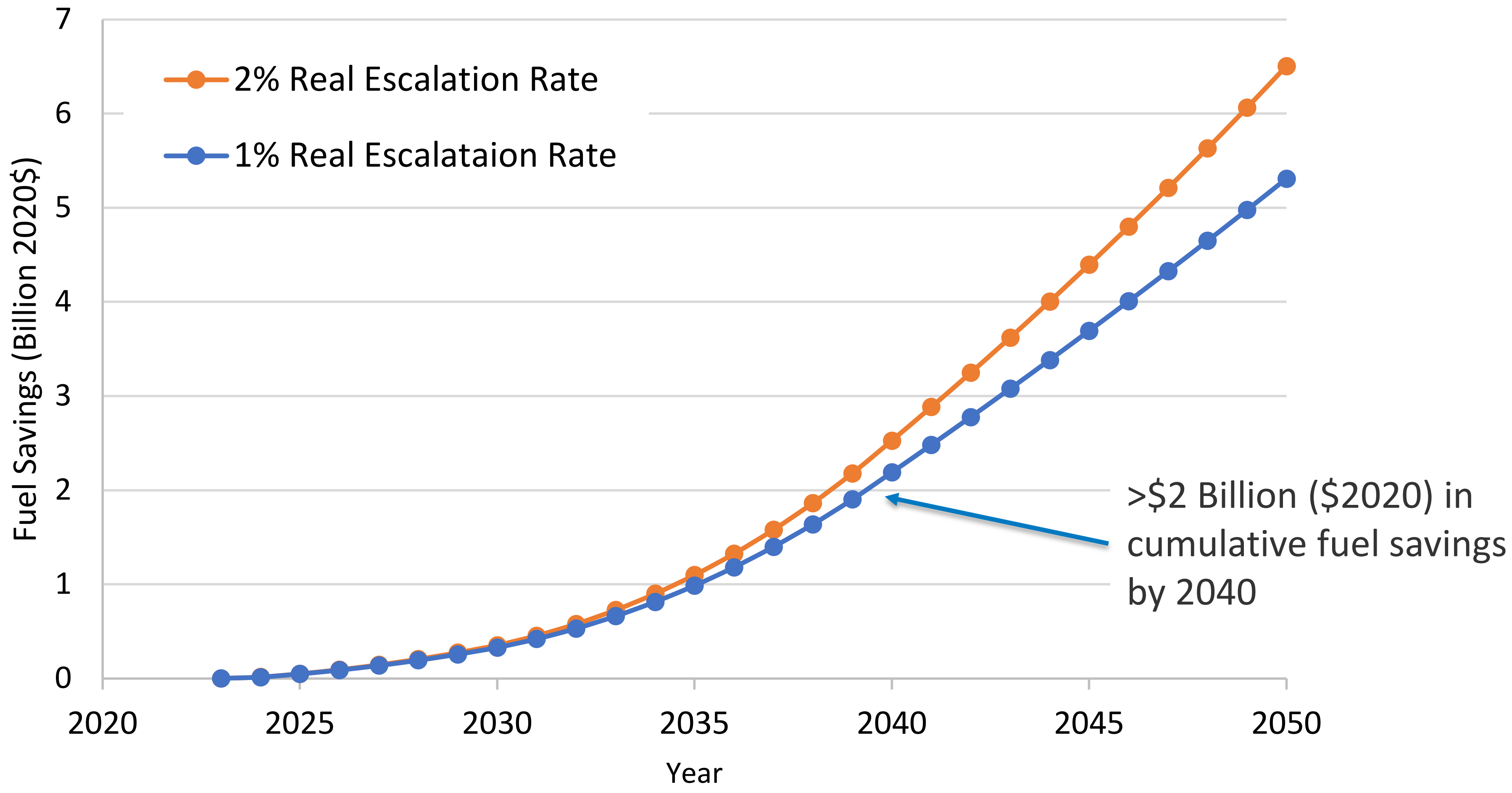
Primary impact of an 80% RPS will be to reduce fuel costs which can be compared to capital cost of new renewables



Example: Avoided costs at the Eklutna power plant with a 8,680 BTU/kWh heat rate and a 2021 (Q4) reported fuel cost of $7.81/MMBTU.

A power purchase agreement at or below this cost will produce a **net savings to consumers** even without any other benefits.

Potential Cumulative Fuel Savings



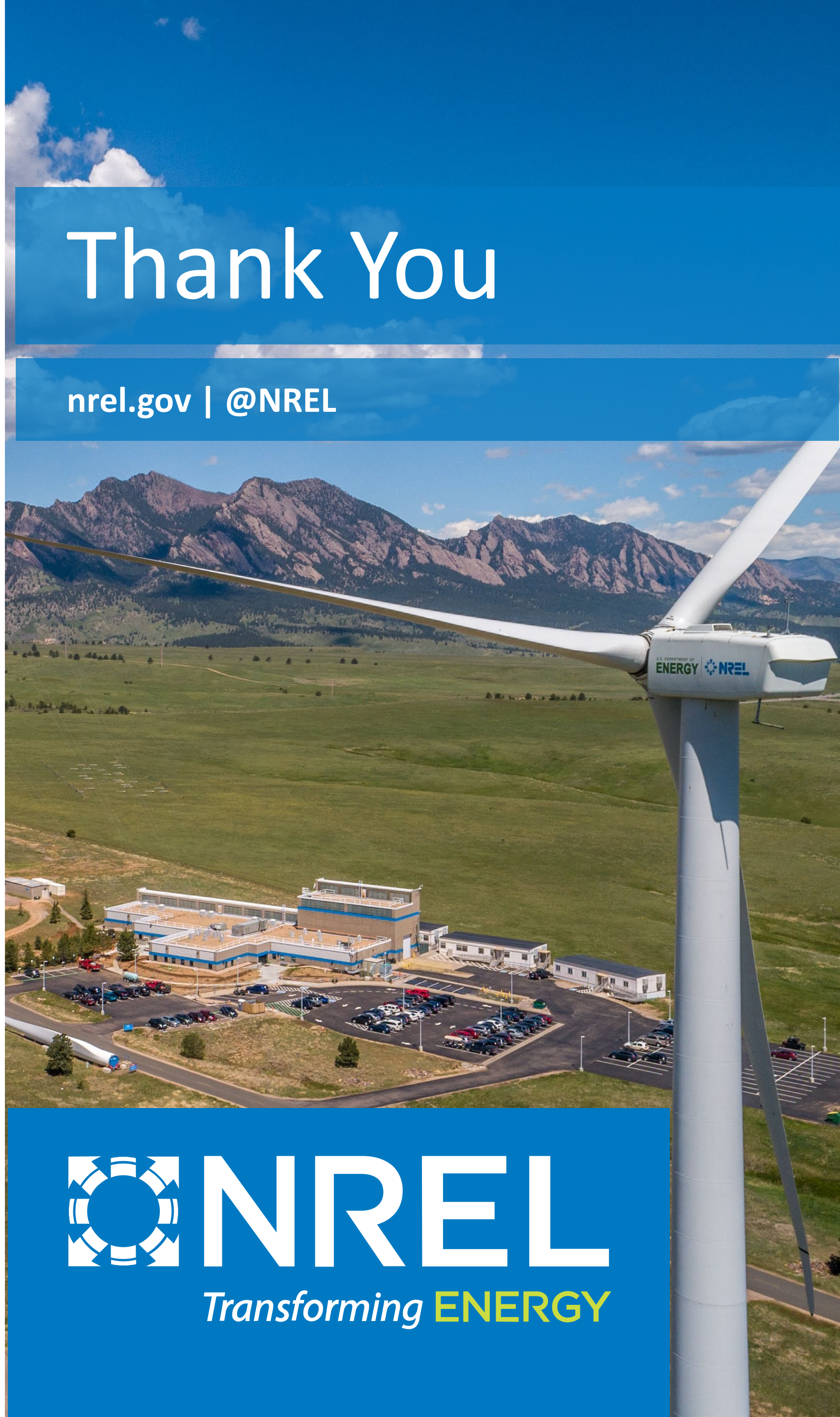
Fuel Savings and Cost Implications

An 80% creates three impacts on total costs:

1. Capital costs of renewable infrastructure ***increase***
2. Capital costs of fossil infrastructure ***decrease***
3. Variable and fuel costs of fossil infrastructure ***decrease***

Conclusions

- Multiple pathways exist for achieving an 80% RPS, and supply/demand balance can be maintained with appropriate system engineering.
- An 80% RPS achieves substantial savings in fuel costs.
- Further analysis is needed to determine an optimal portfolio that minimizes overall costs



Thank You

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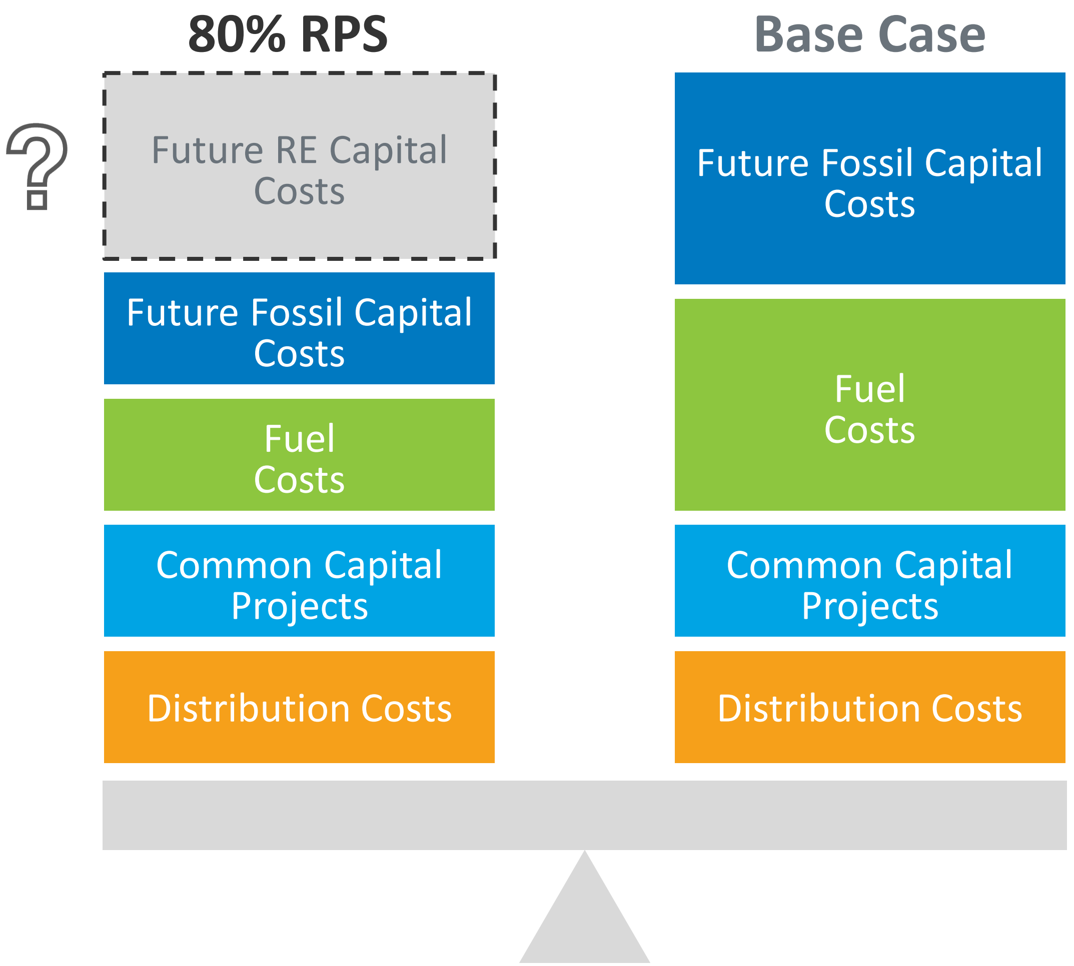
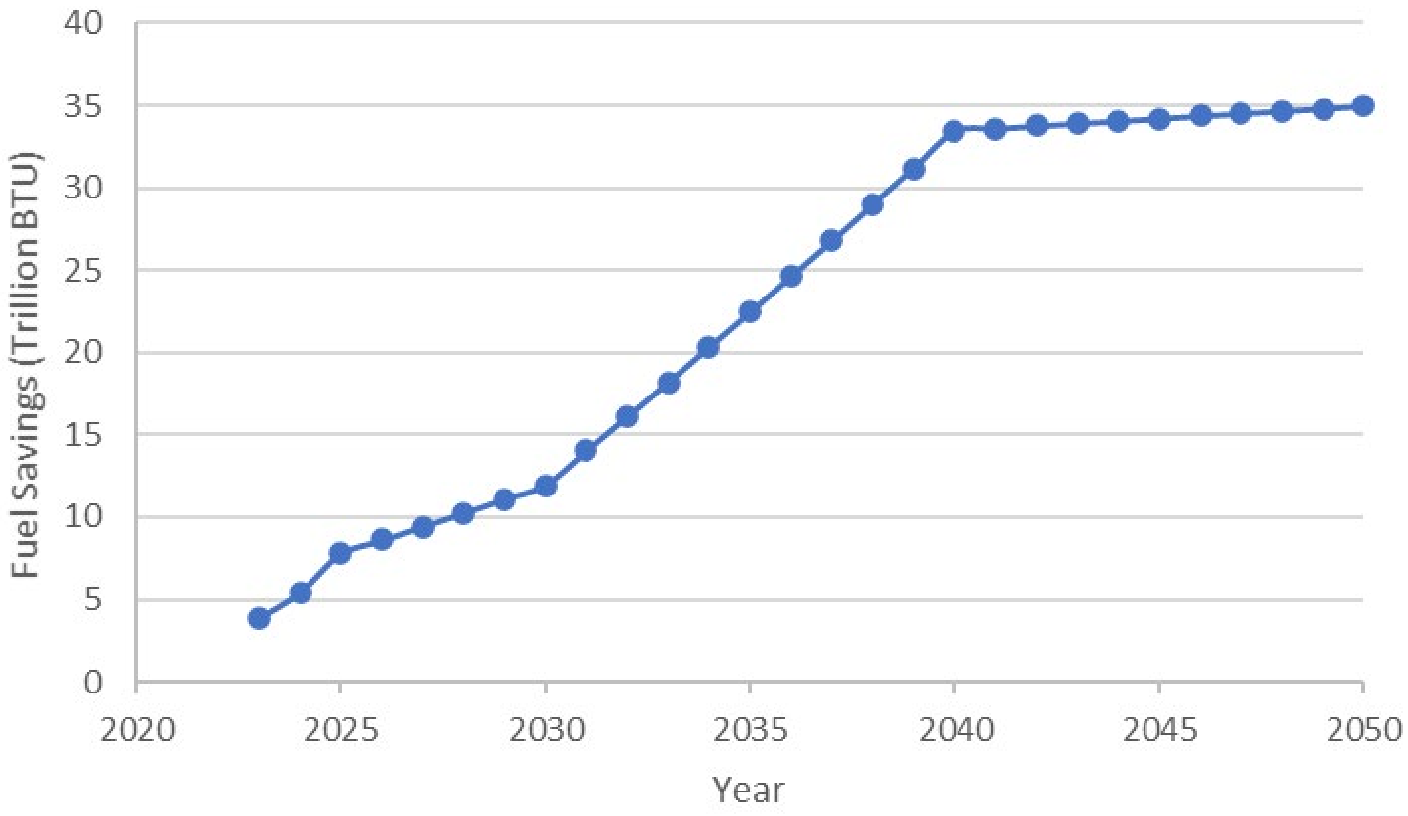
The Missing Piece….

Full cost analysis



Potential Annual Fuel Savings



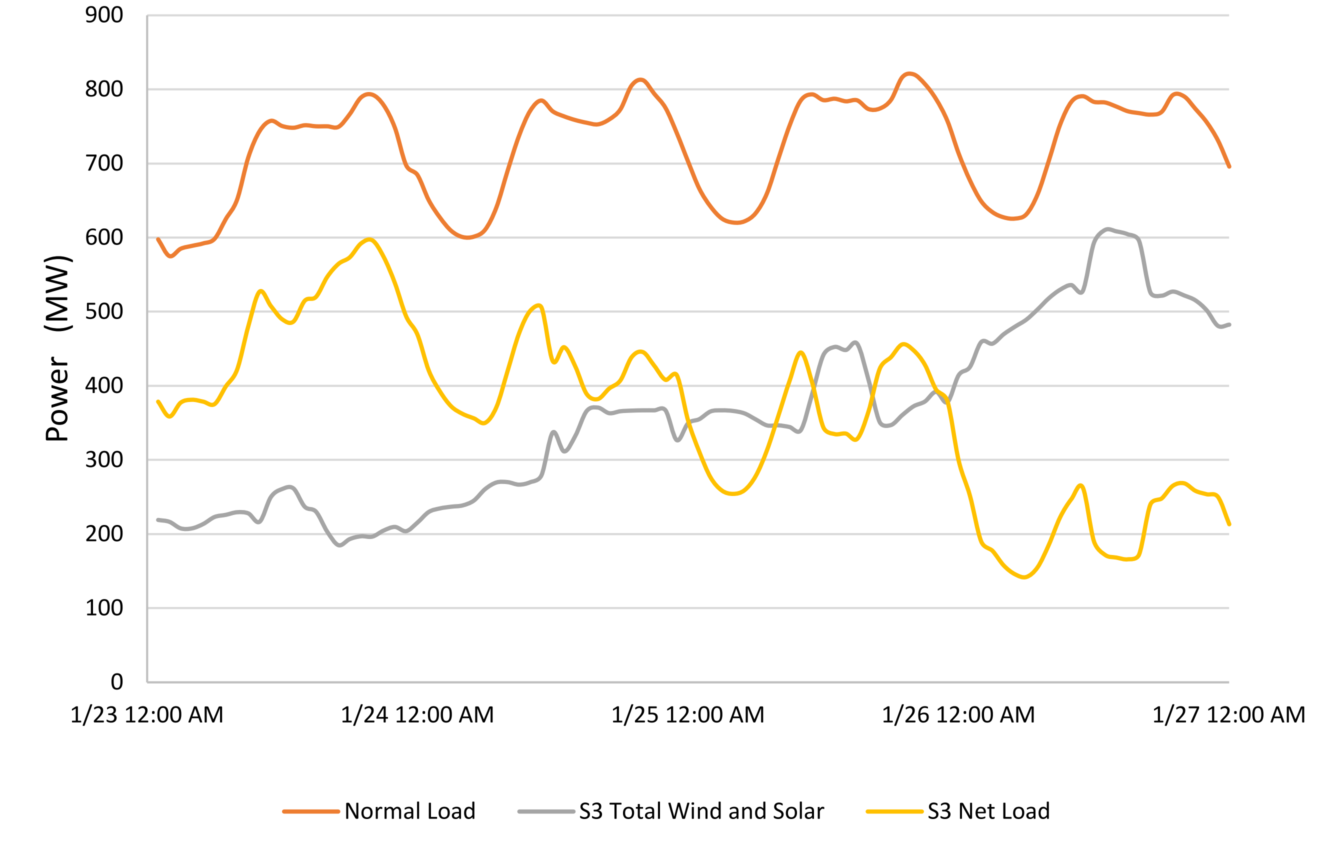
Final Portfolio

Technology (Existing and New)	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Wind	45	202	826	847	847	777
Solar	1	30	258	456	150	132
Hydropower (storage)	186	866	324	248	248	186
Hydropower (run of river)	25	0	25	25	25	25
Geothermal	0.4	0.4	0.4	0.4	25.4	50.4
Biomass	0	50	50	50	50	50
Landfill gas	7	7	7	7	7	7
Tidal	0	0	0	0	50	75
Battery Storage	163	163	163	163	163	163
Fossil thermal	2048	1968	1824	1911	1897	1890
Total	2474	3286	3477	3707	3462	3355

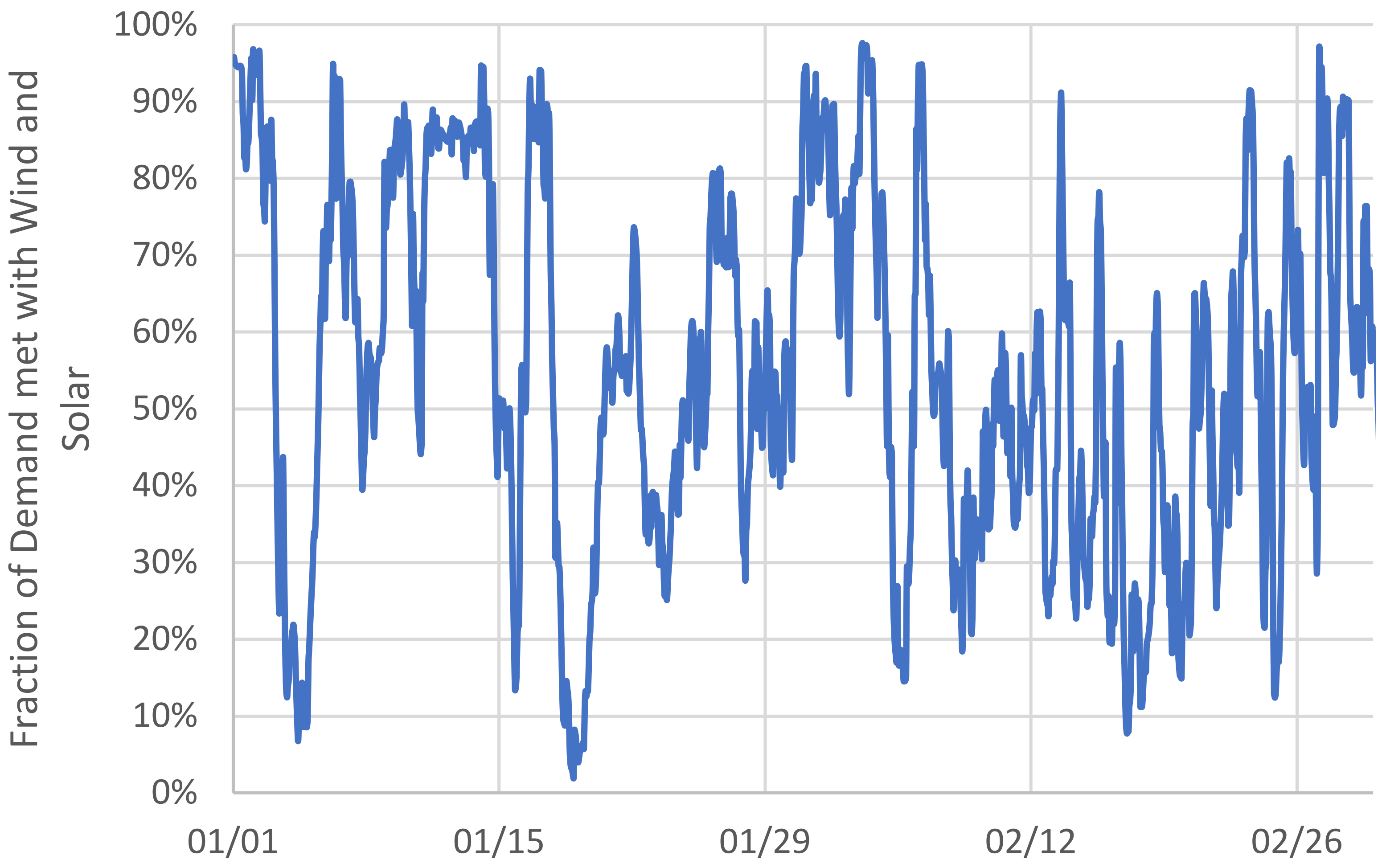
The role of flexible generation

Alaska has pioneered the use of energy storage that's needed for fast frequency response and is helpful in low inertia systems

Substantial increase in net variability is addressed with flexible hydropower, thermal, and energy storage



Variability



Report Key Finding #1

- Supply/demand balance and operational reliability can be maintained under multiple 80% RPS scenarios
  - An 80% RPS allows for continued use of fossil generators.
  - Alaska's flexible hydro system
  - Alaska already has experience and comfort with energy storage needed for fast frequency response and to address declines in inertia.

Scenarios

Technology (includes new and existing)	Base Case	Scenario 1: Maximum. Hydropower	Scenario 2: High Hydropower, High Wind	Scenario 3: Moderate Hydropower, High Wind and Solar	Scenario 4: Moderate Hydropower, New Technologies	Scenario 5: Low Hydropower. High New Technologies
Wind	0%	14%	48%	49%	48%	44%
Solar	0%	2%	7%	11%	6%	6%
Hydropower	16%	61%	23%	17%	17%	15%
Geothermal	0%	0%	0%	0%	4%	8%
Biomass/Landfill Gas	1%	3%	2%	3%	3%	3%
Tidal	0%	0%	0%	0%	3%	5%
Total renewable	17%	80%	80%	80%	80%	80%

Portfolio capacities

Table 4. Final Portfolio: Capacity (MW)

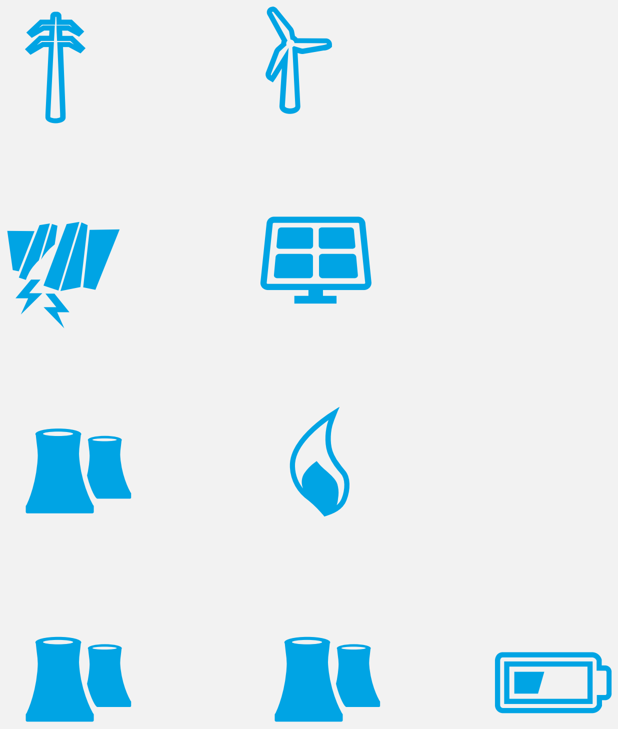
Technology (Existing *and* New)	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Wind	45	202	826	847	847	777
Solar	1	30	258	456	150	132
Hydropower (storage)	186	866	324	248	248	186
Hydropower (run-of-river)	25	0	25	25	25	25
Geothermal	0.4	0.4	0.4	0.4	25.4	50.4
Biomass	0	50	50	50	50	50
Landfill gas	7	7	7	7	7	7
Tidal	0	0	0	0	50	75
Battery Storage	163	163	163	163	163	163
Fossil thermal	2,048	1,968	1,824	1,911	1,897	1,890
Total	**2,474**	**3,286**	**3,477**	**3,707**	**3,462**	**3,355**

	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Additional thermal capacity required in outage conditions	562 MW	482 MW	338 MW	425 MW	411 MW	404 MW

Cost Implications

Investments in a **no new renewables scenario**

Investments in an **80% RPS scenario**



Cost Implications