APPENDIX III: ALASKA ENERGY SECURITY TASK FORCE ENERGY SYMPOSIUM SERIES

Energy Symposium Series Presentations contained in Appendix III

July 13, 2023: Future Natural Gas Supply for the Alaska Railbelt

- Cook Inlet Gas Forecast
- Cook Inlet Gas Supply Project
- Alaska LNG Project

July 20, 2023: Alaska Rural Energy: Challenges and Opportunities for Reducing the Cost

- Providing Electricity in Rural Alaska
- How is AVEC Doing?
- Standalone Rural Electric Utilities
- Challenges for Reducing Costs
- Intelligent Energy Systems

July 27, 2023: Global Trends and Grid of the Future

- Energy Transformation: South Australia as a Case Study
- Opportunities for Electric Load Growth in Alaska
- Insights into the Icelandic Energy Market

August 3, 2023: Railbelt Hydropower Development & Financing: Lessons Learned from the Past, Opportunities for the Future

- Small Hydropower in Southcentral Alaska
- Bradley Lake Operations and Governance
- Railbelt Hydropower: Current and Upcoming Projects
- Susitna-Watana Hydro

August 17, 2023: Alaska Energy Statistics & Economics

- Alaska Energy Data: The Good, the Bad, the Missing
- Alaska Comprehensive Economic Development (CEDS) Strategy
- CEDS Energy-Specific Goals and Objectives

August 24, 2023: Transmission and Storage: Building a More Resilient Grid

- *Energy Storage Options and Selection Considerations*
- *Beneficial and Equitable Electrification*
- *Tidal Power in Alaska*

August 31, 2023: Emerging Technology and Opportunities for Alaska: Small Scale Nuclear

- Copper Valley Electric Association
- Nuclear Energy: State of Micro Reactors
- Small Nuclear Power: An Option for Alaska?

September 7, 2023: Renewable Energy Standards: National Policy Comparisons

- Renewable Energy Standards and Clean Energy Standard Overview

FUTURE NATURAL GAS SUPPLY FOR THE ALASKA RAILBELT

Thursday, July 13, 2023, 11:00 AM – 1:00 PM

- Cook Inlet Gas Forecast
- Cook Inlet Gas Supply Project
- Alaska LNG Project

2022 Cook Inlet Gas Forecast
July 2023 AESTF Presentation

Presented by John Crowther, Derek Nottingham, Jhonny Meza, and John Burdick
Division of Oil & Gas
Alaska Department of Natural Resources

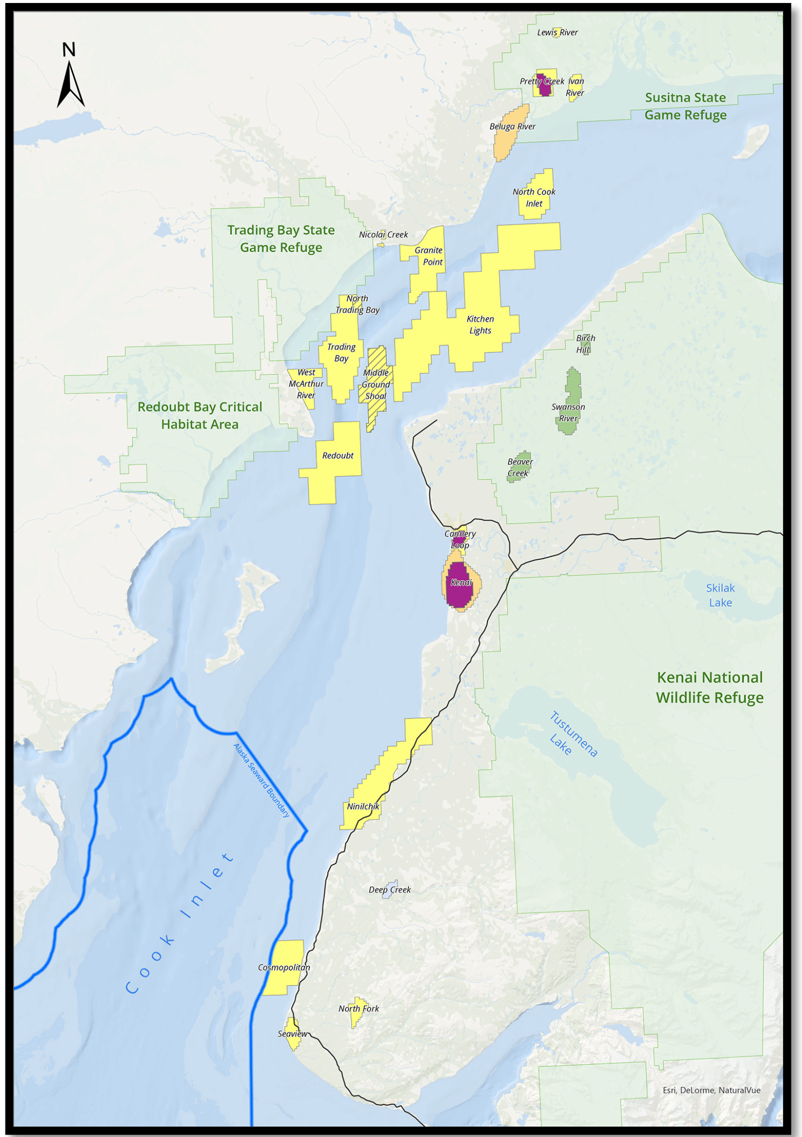



Introduction & Preface

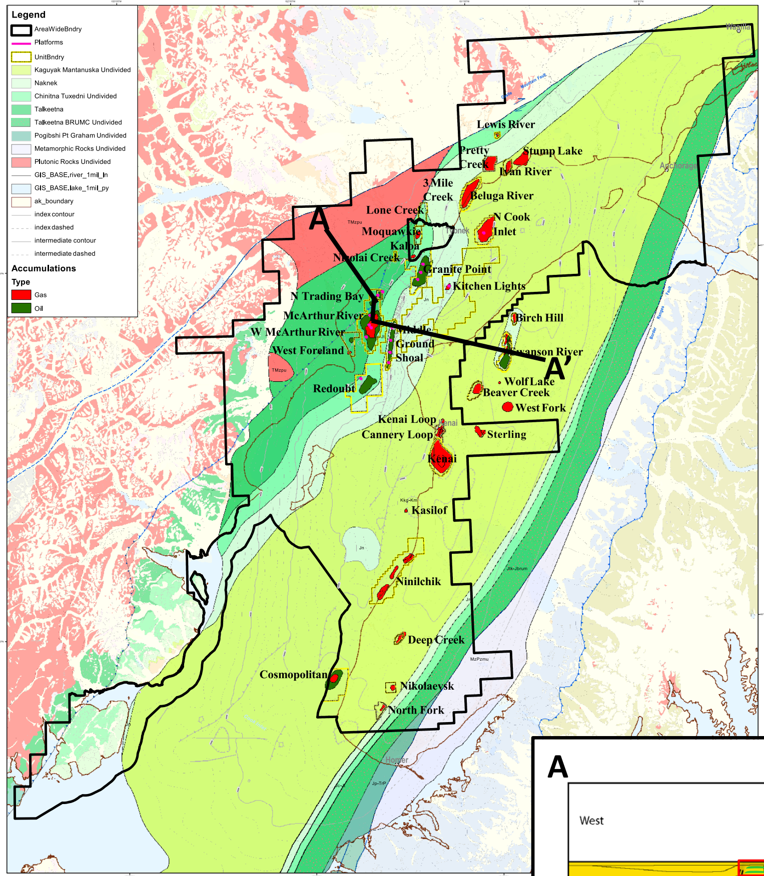
- Department actively manages lease holdings and units in Cook Inlet – through the annual plan of development review process.
- We are evaluating other proactive management actions to support investment and development in Cook Inlet.
- Held last special lease sale in December 2022 to coincide with Congressionally directed federal sale – next state sale coming this Fall/Winter.
- Department is working to facilitate gas storage through lease amendments to existing leases and support further commercial, operational, and regulatory alignment around storage.
- Department is prioritizing the release of tax-credit seismic and well data that is statutorily eligible for release.
- Department continues to be informational resource for all interested parties.

Outline

- **Cook Inlet Geology and Resource**
- **Cook Inlet Supply and Demand Evolution**
- **Cook Inlet Recovery Act and Resulting Activity**
- **Overview of Division of Oil and Gas Cook Inlet Studies**
- **2022 Cook Inlet Gas Forecast**
  - Methodology
  - Economic constraints
  - Forecast - outcomes
  - Comparison to previous studies



Cook Inlet Geology



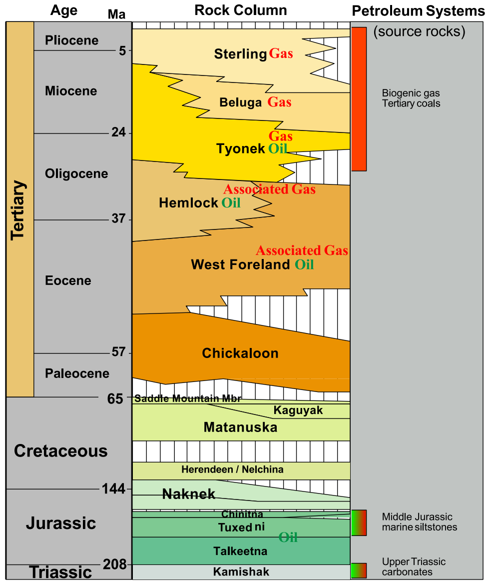
Modified from Gregersen and Shellenbaum, 2016

Top Mesozoic Subcrop Map with Oil and Gas Accumulations, C

Majority of oil and gas production is from Tertiary reservoirs

Oil Seeps; TBU M-28 produced oil

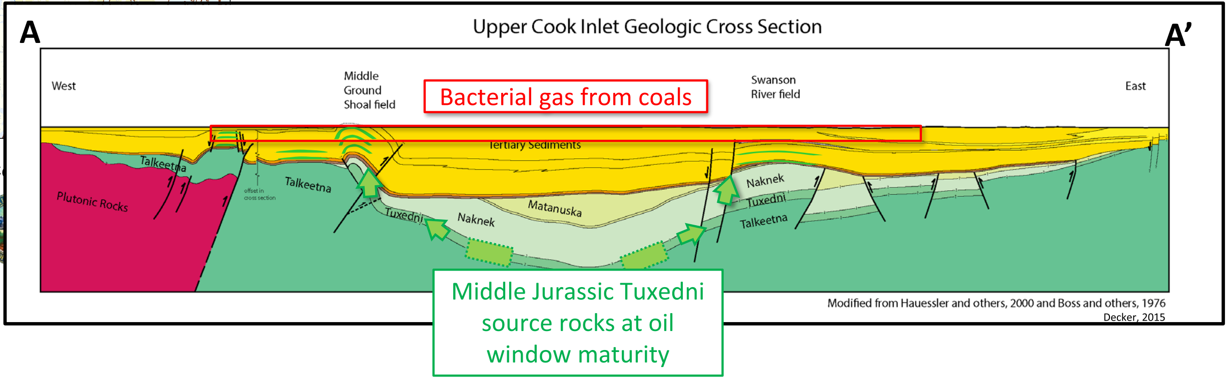
Cook Inlet Stratigraphic Column



Modified by Alaska DOG / DGGS staff from USGS 1995, MMS 1995, Swenson 2003, Curry *et al.* 1993

Two Sources of Gas In Cook Inlet Basin

1. Biogenic gas from coals.
2. Oil migrated from source rocks, creating associated gas.



Modified from Hauessler and others, 2000 and Boss and others, 1976
Decker, 2015

Quick Look Guide to Cook Inlet Oil and Gas
LS Gregersen, 3-13-2020

Cook Inlet Gas Resources

Known accumulations yet to be fully developed (based on various sources) and largely excluded from the scope of the forecast:

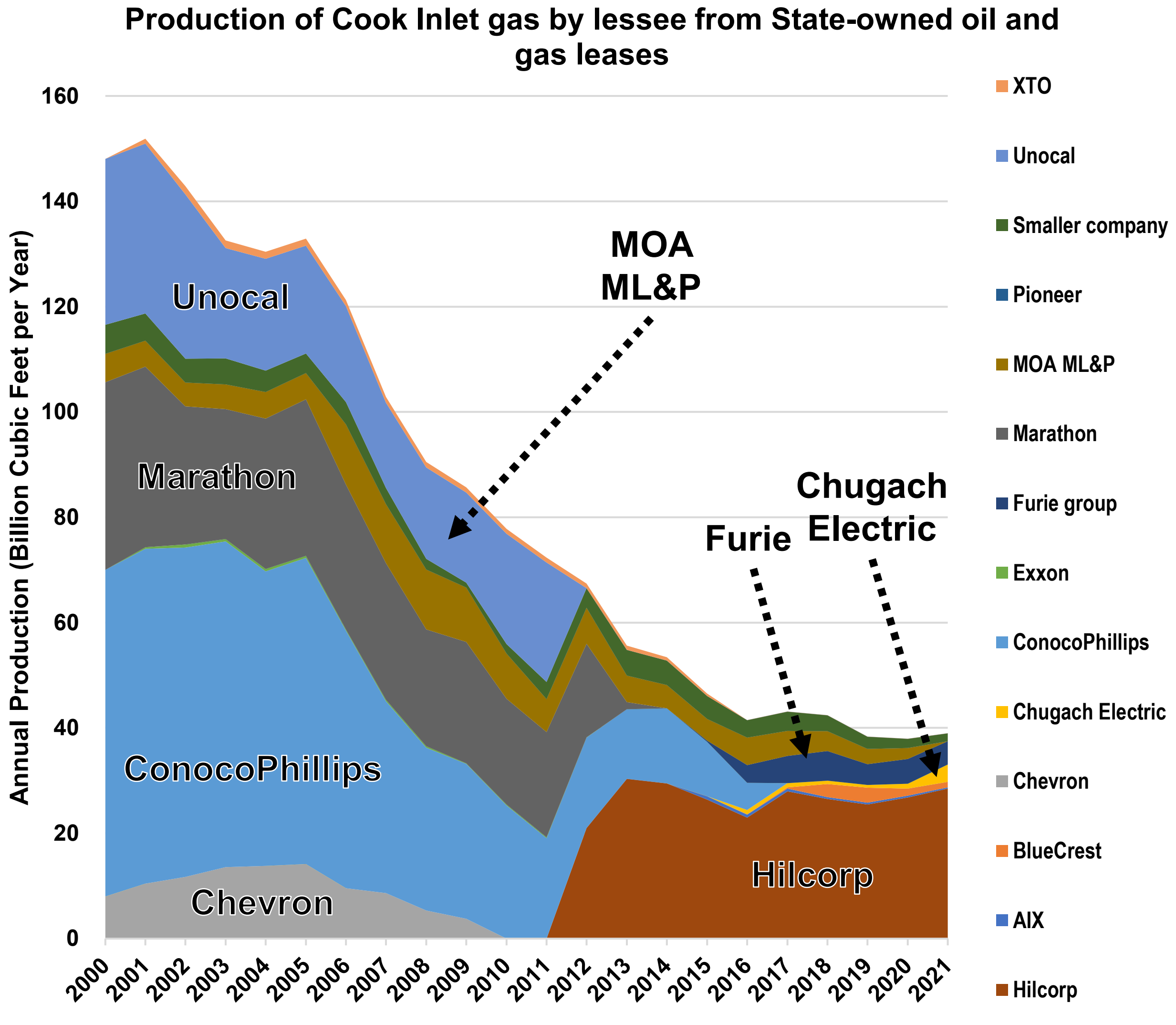
- Cosmopolitan (BlueCrest)
- Kitchen Lights Unit (Furie/HEX)
- North Fork (Vision)
- ~ a dozen additional known prospects
- **Total ~ 300 to 700 BCF**

Undiscovered gas in CI per USGS (Mean Values) – DNR's study is not an alternative or contrary review of this data:

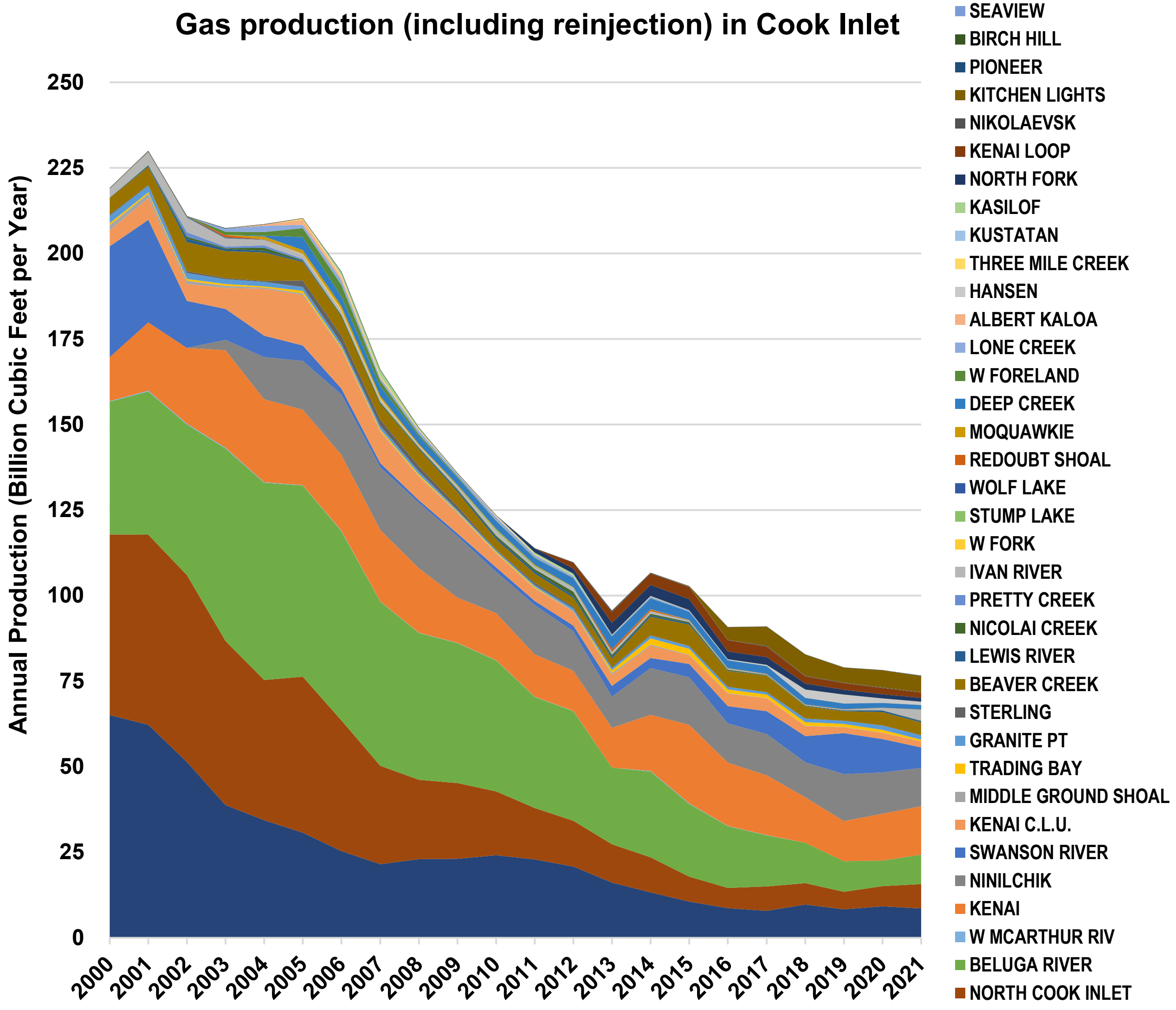
- Conventional gas ~ 13.7 TCF [USGS, 2011]
- Unconventional gas ~ 5.3 TCF [USGS, 2011]
- Southern Cook Inlet OCS ~ 1.2 TCF [BOEM, 2011)
- **Total ~ 20 TCF**

U.S. Department of the Interior
U.S. Geological Survey

Cook Inlet Fields Overview: Gas Production History



Note: State Lands Only



Note: State + Federal + Private Lands

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Cook Inlet Gas Supply Project Phase I Assessment

Regulatory Commission of Alaska

June 28, 2023

Presenters:
John Sims (ENSTAR)
Lieza Wilcox (BRG)

BRG Cornerstone Energy Services

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BRG Cornerstone Energy Services

Working Group Participants

Demand Group

ENSTAR Natural Gas Company

CHUGACH

MEA Matanuska Electric Association

HEA Homer Electric Association, Inc.

GVEA Golden Valley Electric Association

IGU Interior Gas Utility

State Agencies

Alaska Department of Natural Resources

Alaska Energy Authority

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Key Conclusions

- Cook Inlet gas cannot fully meet demand forecast beyond 2026 with current proved reserves or beyond early/mid 2030s assuming incremental local supply development
- While continuing to work on Cook Inlet options, other project(s) must be pursued due to lead time to implement
- It is vital for the Alaska utilities to have control of the pace of option development due to the impending gas shortage
- Several viable options to supplement and Cook Inlet gas supply need to be progressed further in the next phase of this project (“Phase II”) to enable a sanction decision on one option by the end of 2023

Supply and Demand Assumptions

1. Long-term natural gas demand for interconnected Alaska utilities
   - Forecast supplied by the utilities, and provides basis for capacity planning assumptions
   - ENSTAR's stable gas demand for heating, GVEA's plan to incorporate more natural gas generated electricity into its system, and potential range of outcomes for renewable power generation and beneficial electrification all impact potential demand outcomes
   - High, Medium, and Low natural gas demand forecast represents reasonable expectations and timelines for clean energy uptake and a range of winter temperatures

2. Cook Inlet Supply
   - Used DNR's 2022 Cook Inlet Mean Truncated supply forecast as the base case assumption for future gas coming from Cook Inlet
   - Uncontracted Cook Inlet reserves are ~290 BCF in 2027-2040
   - DNR anticipates gas supply gap to develop in 2027
   - Used DNR's 2018 gas availability study to estimate incremental Cook Inlet supply and price levels beyond base case

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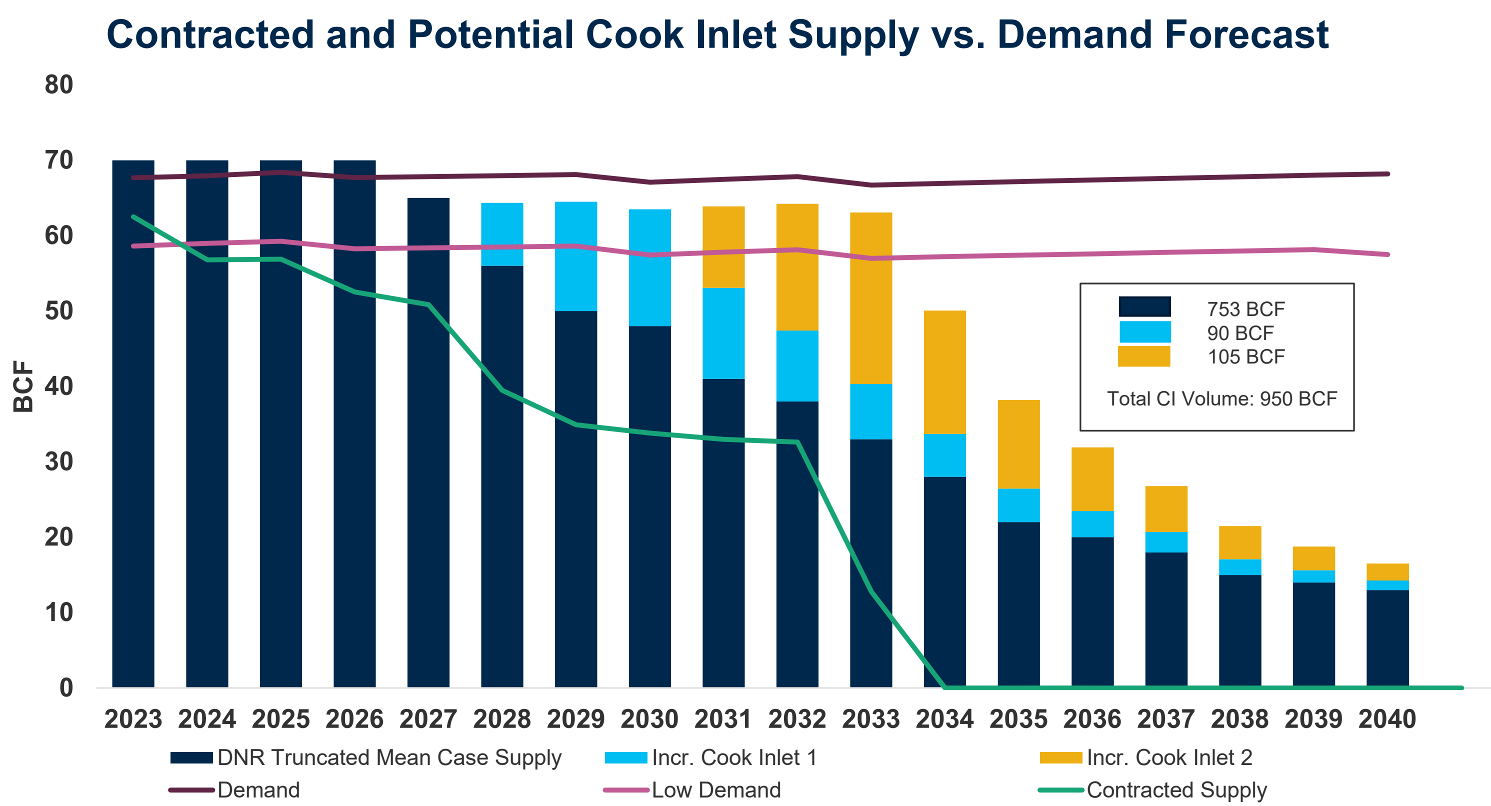
Supply and Demand Assumptions (Cont.)



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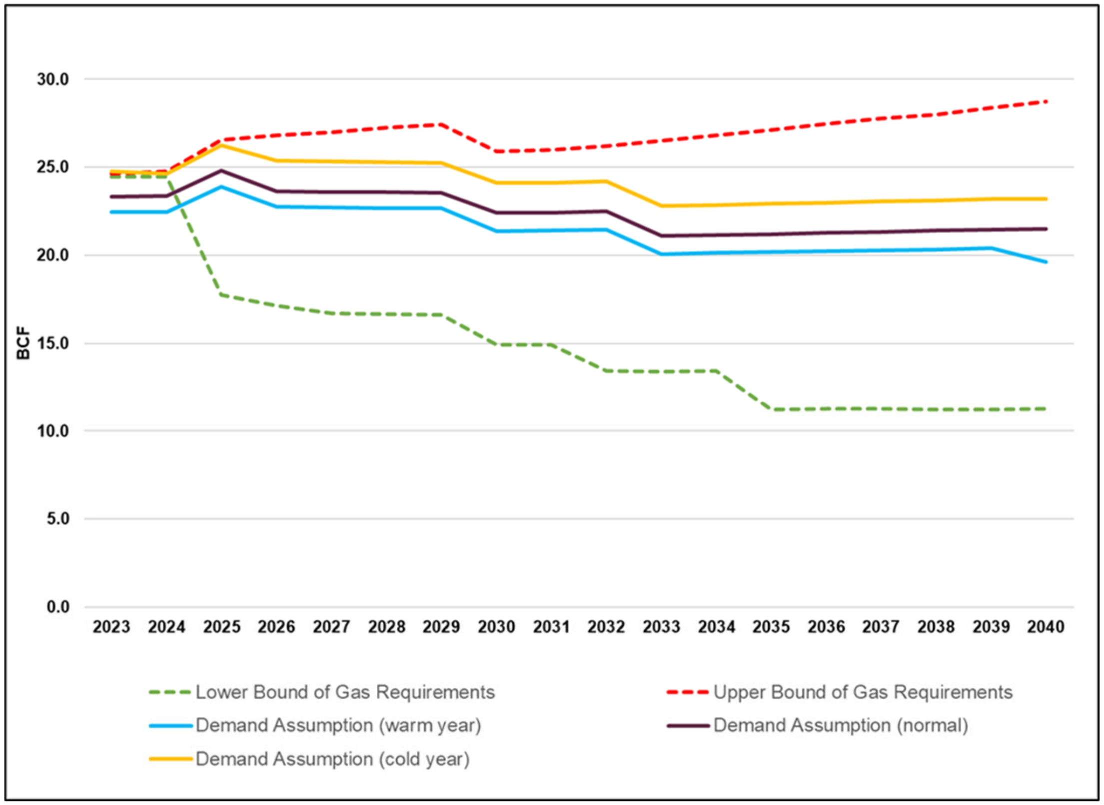
BRG Cornerstone Energy Services

Range of Potential Gas Requirements Associated with Renewable Power Adoption

Electric Utility Gas Demand



Scope and Assessment of Options

1. Option scope development and screening-level evaluation
   - Created or adopted (from project developers) conceptual scope and cost estimates for ten most viable options
   - Developed estimated cost of supply in $2023 (today's dollars) using consistent volumes up to each option's ability to supply gas

Scope and Assessment of Options (Cont.)

2. Created a prioritized system of scoring different options with guidance from the utilities' Working Group on prioritization. Options were scored based on ten criteria. Uniformly, the top three criteria received the highest priority scores.

1) Schedule risk
2) Reliability of supply during operations
3) Delivered cost of supply per Mcf
4) Flexibility / Scalability
5) Project complexity and integration into current system
6) Permitting
7) Environmental impact
8) Size of direct investment by utilities
9) Local economic impact
10) Carbon efficiency

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Key Project Option Metrics

Gas Supply Options (Private Ownership)

Option		Timeline from decision YE2023	Capital Investment	Supply Volume	Cost of Supply: Gas	Cost of Supply: Midstream	Cost of Supply: Total
		years	$ mm	Bcf/year	$/Mcf	$/Mcf	$/Mcf
1	Cook Inlet Gas	3 - 4	up to $1500 - $2000	up to ~23	$9.3 - $25.5	Included	$9.3 - $25.5
2 (a)	In-State Pipeline (Private)	6 - 7	~ $8,790	up to 105	$1.3 – $2.6	$26.8 – $34.2	$28.1 - $37.0
3	Kenai LNG	4 - 5	$768	up to 55	$8.6 - $8.9	$3.4 - $4.7	$12.0 - $13.6
4	Greenfield Port and Regas	6 - 7	$876	up to 55	$8.6 - $8.9	$4.0 - $5.3	$12.6 - $14.2
5	FSRU - Own/Lease	4 - 6	$698	up to 55	$8.6 - $8.9	$3.6 - $5.0	$12.2 - $13.9
6	Barge / Small LNG Carrier	4 - 5	$563	up to 25	$8.6 - $8.9	$13 - $14	$21.6 - $23.0
7	Alaska LNG	7 - 8	~$43,000	up to 183	$1.3 – $2.6	$3.1	$4.4 - $5.8
8	LNG Truck and/or Rail	3 - 4	$321	~9	$2.50	$22.5 - $29.5	$25 - $32
9	Renewable Natural Gas	Unknown	n/a	~1	~$25	Included	~$25
10	Hydrogen (green)	12+	unknown	n/a	n/a	n/a	$>32

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Key Project Option Metrics (Cont.)

The assessment also considered how cost of supply of certain options with long-term benefits to the State of Alaska can be impacted by alternative financing with State participation

Gas Supply Options (State Participation)

Option		Timeline from decision YE2023	Capital Investment	Supply Volume	Cost of Supply: Gas	Cost of Supply: Midstream	Cost of Supply: Total
		years	$ mm	Bcf/year	$/Mcf	$/Mcf	$/Mcf
2 (b)	In-State Pipeline (Subsidized 80%)	6 - 7	~ $8,790	up to 105	$1.3 – $2.6	$7.8 - $9.9	$9.2 - $12.6
2 (c)	In-State Pipeline (State Owned)	6 - 7	~ $8,790	up to 105	$1.3 – $2.6	$5.9 – $7.4	$7.3 - $10.0
4 (b)	Greenfield Port and Regas (Subsidized 80%)	6 - 7	$876	up to 55	$8.6 - $8.9	$2.3 - $3.3	$10.9 - $12.2
4 (c)	Greenfield Port and Regas (State Owned)	6 - 7	$876	up to 55	$8.6 - $8.9	$2.2 - $3.1	$10.8 - $12.0

Top Scoring Options for Meeting Future Demand

A. In-State Pipeline

- Construct a 24-inch pipeline that can meet local demand and provide opportunity for future industrial customer supply
- Only viable with state participation / subsidy due to relatively small utility demand
- Provides broad benefits across the state
- Current forecast indicates that this is a long-term option, and would not meet schedule for near-term shortfall

B. Kenai LNG

- In cooperation with owner, modify existing export facility to utilize dock and potentially storage tanks in the short term, accelerating project timeline to meet shortfall

C. Floating Storage and Regasification Unit (FSRU)

- Pursue options to utilize FSRU at existing or modified dock facilities in Nikiski, accelerating project timeline to meet shortfall

D. Cook Inlet Gas Supply

- Remains a preferred top-scoring option but is not sufficient to meet long-term demand forecast

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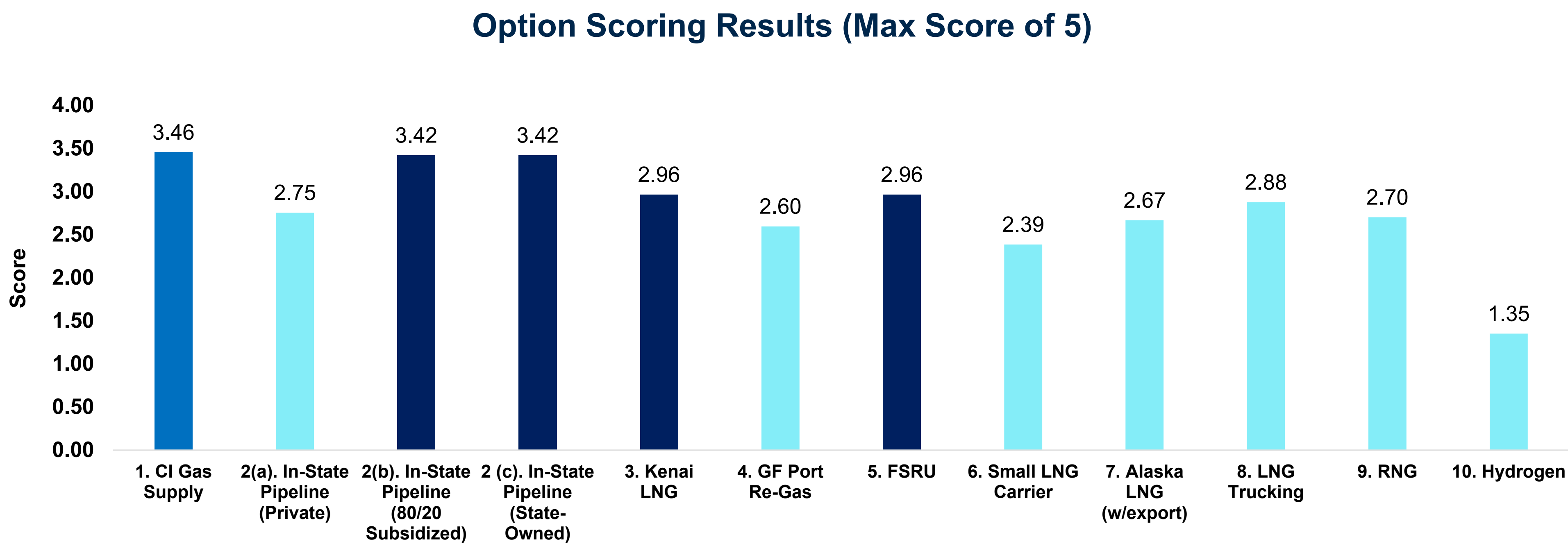
Results of Options Scoring



Recommendations and Next Steps

A. Utilities individually continue to work with Cook Inlet producers and the State to secure additional contracted supply and promote alternative development

B. As the utilities' Working Group, pursue several top-scoring options in order to further define scope, schedule and commercial viability, specifically:
   - Modification of existing Kenai LNG facility (via commercial discussions with owner)
   - Scope definition and planning for FSRU option
   - Greenfield site selection and feasibility assessment for LNG imports if retrofit options become unavailable
   - Market survey to further define availability and cost of LNG
   - Optimization and feasibility assessment of the In-State Pipeline option with AGDC and State of Alaska in areas of permitting critical path and financing structure

Recommendations and Next Steps (Cont.)

C. Refine cost of supply estimates for the three top-scoring options (FRSU, Kenai LNG, In-State Pipeline), develop procurement strategy

D. Complete permitting due diligence of all top-scoring options and identify key bottlenecks and showstoppers

E. For top-scoring options, develop draft venture model, project finance structure and plan of engagement with capital markets

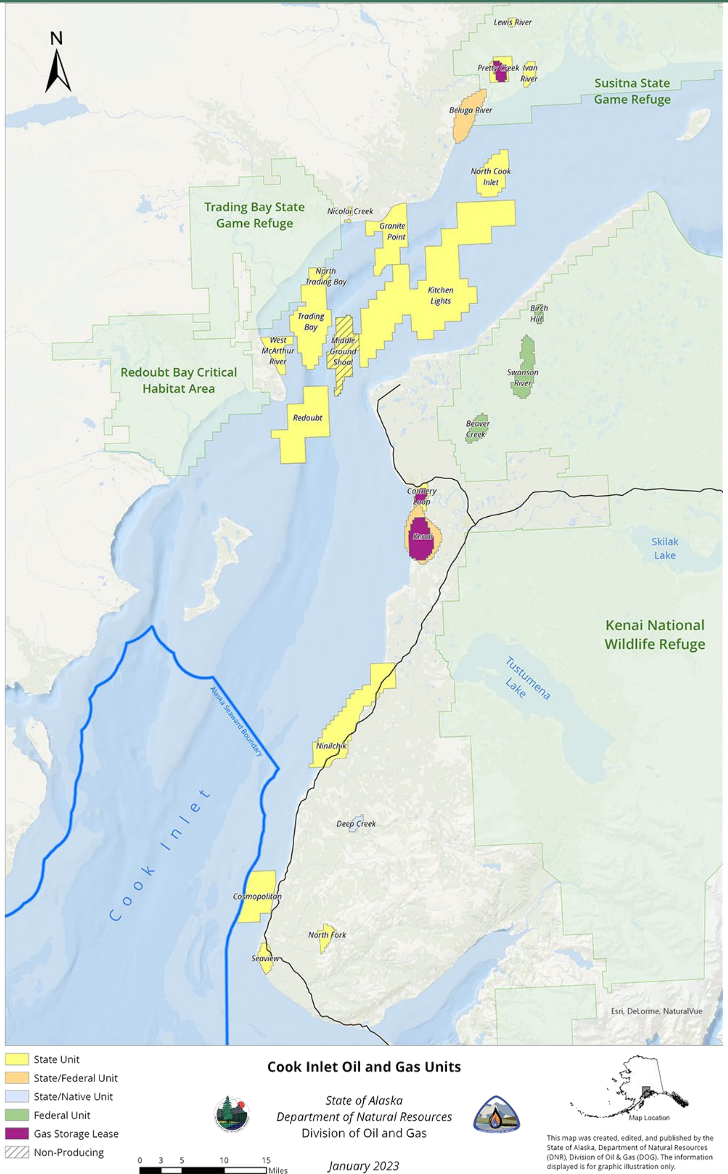
F. Identify one permanent solution or multiple short and long-term options to pursue by 1Q 2024 in order to meet the supply shortfall projected in 2027-2028

Cook Inlet Fields Overview: Production by Field

Field	Operator and lessees	2022 Gas Production	2022 Oil Production
Kenai Loop	AIX Energy LLC	1.17 bcf	
Nicolai Creek	Amaroq Resources, LLC	0.1 bcf	
Hansen	Bluecrest Alaska Operating LLC	0.58 bcf	770 bopd
Redoubt Shoal	Cook Inlet Energy, LLC.	0.07 bcf	879 bopd
West McArthur River	Cook Inlet Energy, LLC.	0.00 bcf	240 bopd
Kitchen Lights	Furie Operating Alaska, LLC; Cornucopia Oil & Gas Company; A. L. Berry; Danny Davis; Taylor Minerals, LLC; Corsair Oil & Gas	4.02 bcf	
Beaver Creek	Hilcorp Alaska, LLC	3.72 bcf	629 bopd
Beluga River	Hilcorp Alaska, LLC; Chugach Electric Association	11.07 bcf	
Deep Creek	Hilcorp Alaska, LLC	1.17 bcf	
Granite Pt	Hilcorp Alaska, LLC	1.16 bcf	2,199 bopd
Ivan River	Hilcorp Alaska, LLC	3.37 bcf	
Kenai	Hilcorp Alaska, LLC	5.53 bcf	
Kenai C.L.U.	Hilcorp Alaska, LLC	0.68 bcf	
Lewis River	Hilcorp Alaska, LLC	0.24 bcf	
McArthur River	Hilcorp Alaska, LLC	6.08 bcf	2,631 bopd
Middle Ground Shoal	Hilcorp Alaska, LLC	0 bcf	0 bopd
Nikolaevsk	Hilcorp Alaska, LLC	0.08 bcf	
Ninilchik	Hilcorp Alaska, LLC	11.52 bcf	
North Cook Inlet	Hilcorp Alaska, LLC	10.93 bcf	
Seaview	Hilcorp Alaska, LLC	0.06 bcf	
Swanson River	Hilcorp Alaska, LLC	3.65 bcf	705 bopd
Trading Bay	Hilcorp Alaska, LLC	0.4 bcf	794 bopd
North Fork	Vision Operating, LLC	1.13 bcf	

bcf = billion cubic feet

bopd = barrels of oil per day



https://dog.dnr.alaska.gov/Information/MapsAndGis

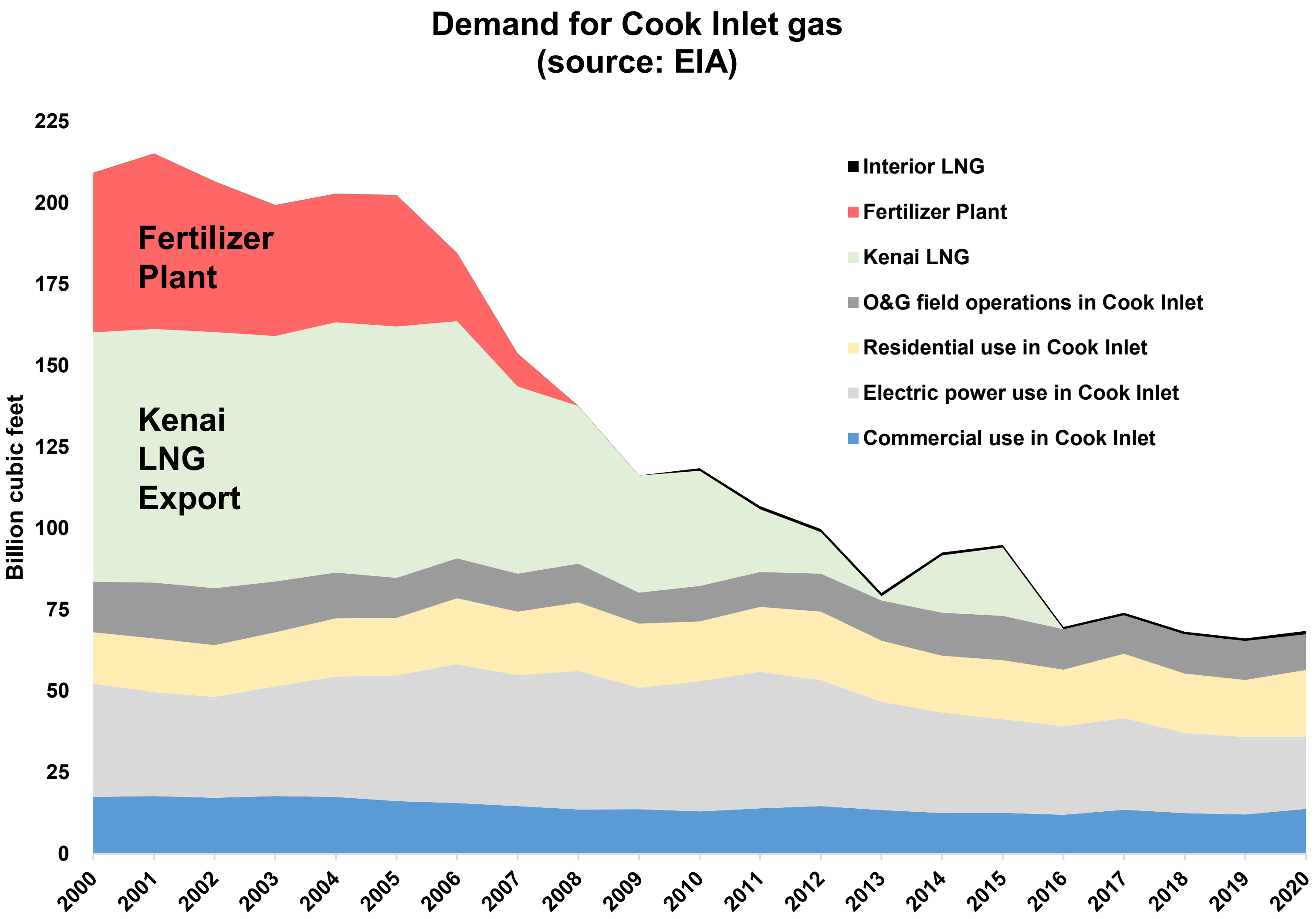
Southcentral Gas Demand: Demand by User Type

Kenai LNG Plant

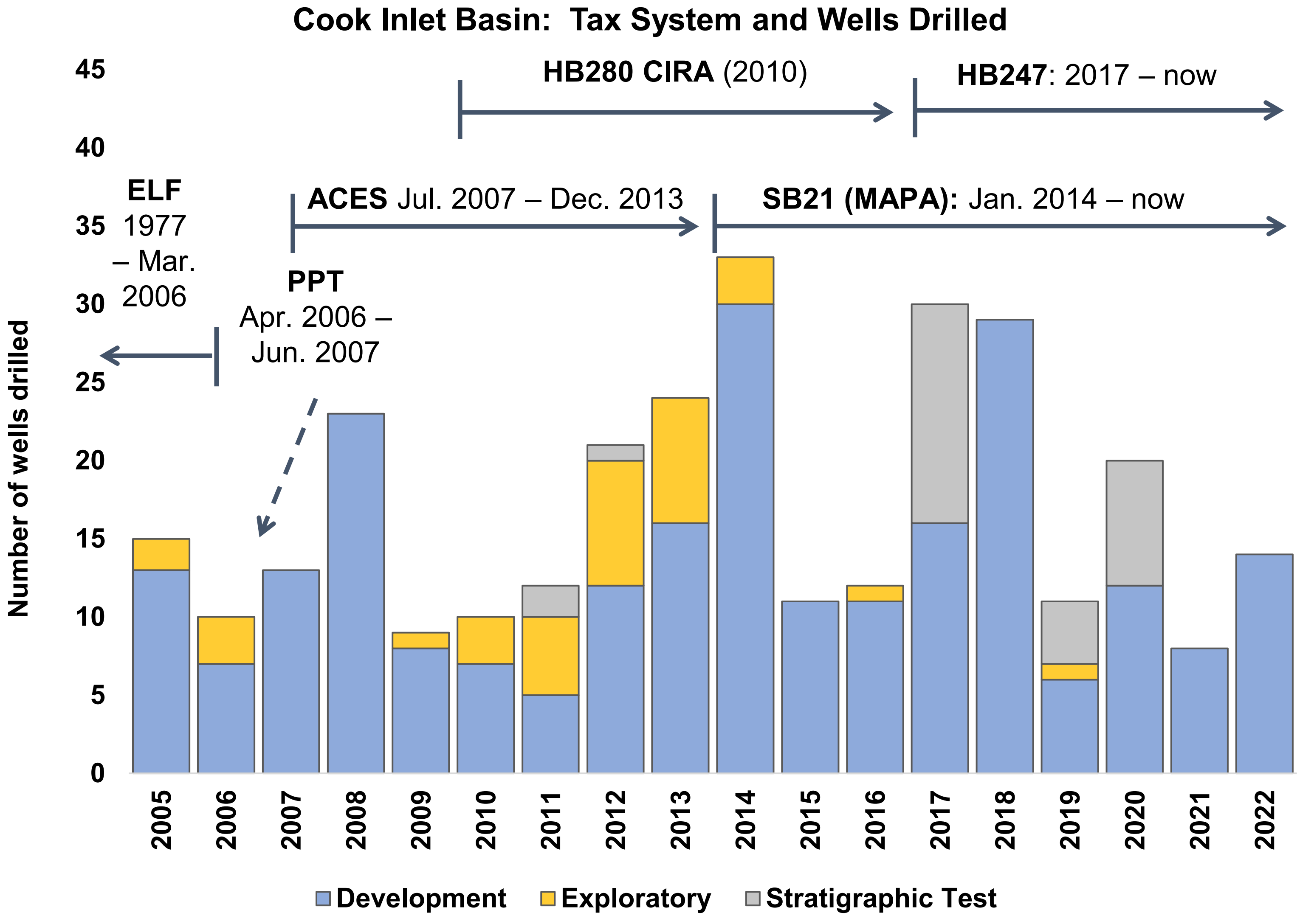
- Nikiski liquified natural gas (LNG) facility is operated by Trans-Foreland Pipeline Co. LLC – which is a sub of Marathon Petroleum.
- Last exported LNG was 2015.
- Department of Energy (DOE) authorization for exporting LNG expired in 2018.
- Dec. 2020 Federal Energy Regulatory Commission (FERC) approved LNG Imports to this facility an annual capacity up to 1.8 billion cubic feet (bcf) per year.

Nutrien Fertilizer Plant

- Second largest ammonia/urea plant in U.S.
- Shut down and mothballed in 2007, however Nutrien maintains permits and remains interested in reopening the plant.
- Gas prices relative to Lower 48 makes economics difficult.
- Potential source for blue hydrogen/blue ammonia.



Cook Inlet Recovery Act and Resulting Activity



- **Active:**
  - Discovery royalty AS 38.05.180(f)(4)
- **Expired or repealed in 2016 or with HB 247:**

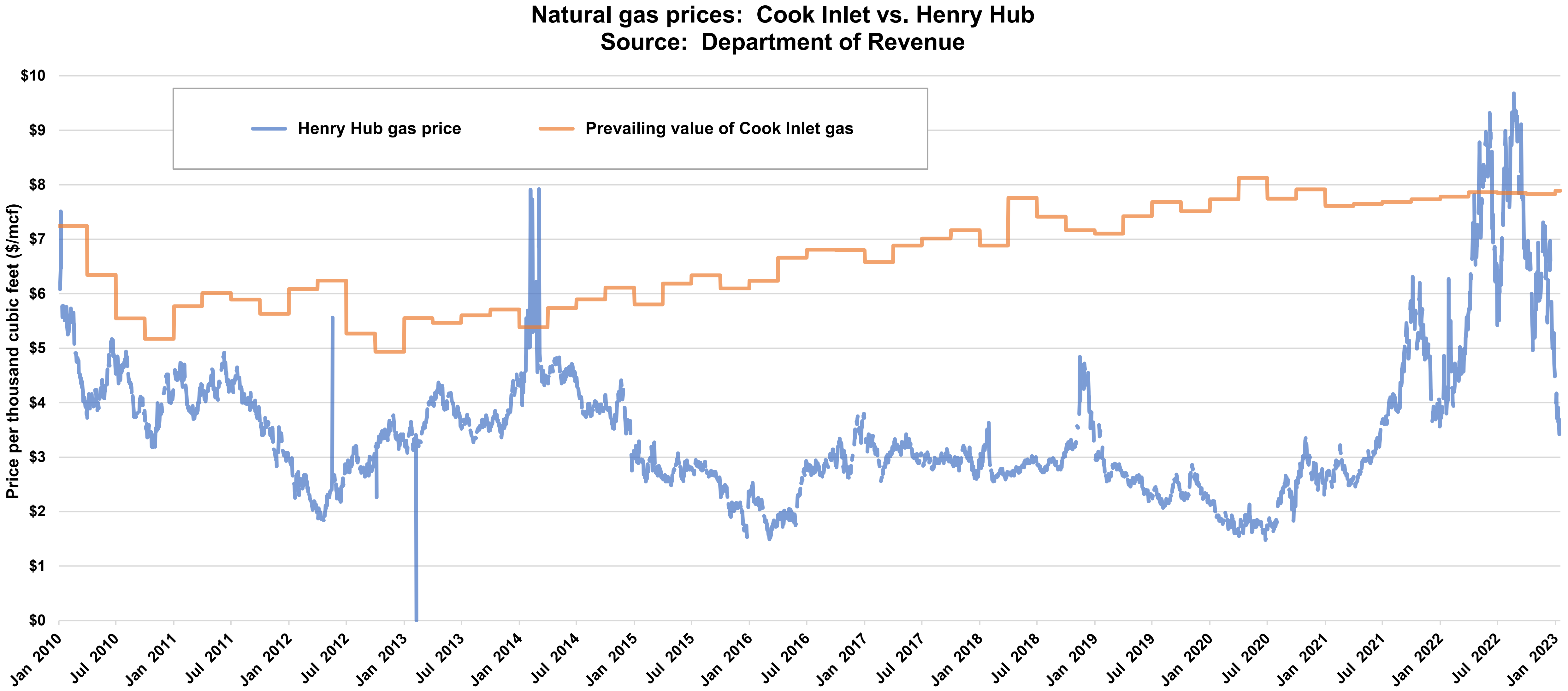
Before CIRA

- Exploration Incentive credit: AS 38.05.180(i)
- Alternative Credit for Exploration: AS 43.55.025(a)
- Gas Exploration and Development credit: AS 43.20.043
- Qualified Capital Expenditure credit: AS 43.55.023(a)
- Small Producer Credit AS 43.55.024: Qualification deadline May 2016
- Carried Forward Annual Loss Credit: Expired with HB 247

CIRA

- Well Lease Expenditure Credit AS 43.55.023(l)
- Gas Storage Facility Credit AS 43.20.046
- Cook Inlet Jack-Up Rig Credit AS 43.55.025(a)(5) and (l)

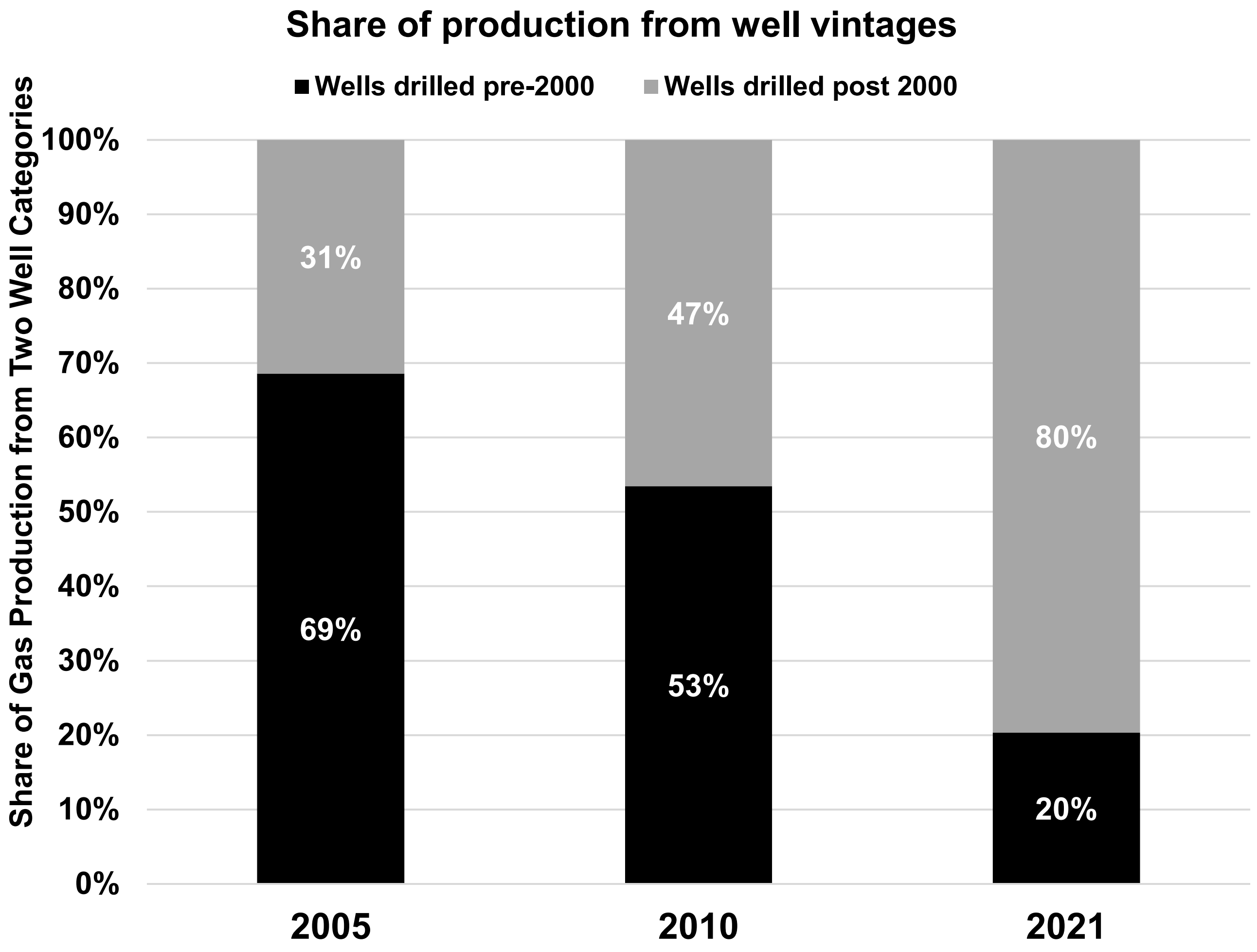
Cook Inlet Natural Gas: Local Prevailing Value vs Henry Hub



Exploration & Development in Cook Inlet: Cook Inlet Future Production

The CI Basin depends on successful exploration.

- The CI Basin has been producing for over 60 years.
- Continuous exploration has led to 13 new oil and gas units coming online, and over 450 wellbores drilled **since year 2000.**
- Of the ~200 million cubic feet per day (mmcfd) of produced gas in 2021, ~80% came from wells drilled less than 20 years ago.
- Exploration/delineation within and outside the units is crucial to continued security of gas supply for the basin.



Overview of Division of Oil & Gas Cook Inlet Studies

2009 - Preliminary Engineering and Geological Evaluation of Remaining Cook Inlet Gas Reserves

- Consisted of engineering and geologic evaluations of 28 currently producing Cook Inlet gas fields to derive estimates of remaining Proved and Probable reserves.
- Applied single deterministic Decline Curve Analysis (DCA) and Material Balance (MBAL) engineering methods to publicly available production and pressure data obtained from Alaska Oil and Gas Conservation Commission (AOGCC).
- Did not address economics of drilling additional wells, recompleting existing wells, optimizing infrastructure, and the ability to sell the gas into the Cook Inlet market.
- Proved + Probable reserves estimated at 1.14 trillion cubic feet (tcf).

2011 - Cook Inlet Natural Gas Production Cost Study

- Investigated investment requirements around various targeted reserves.
- Addressed commercial viability of remaining gas by postulating conceptual plans to produce natural gas from the Cook Inlet Basin to meet a demand of 90 billion cubic feet (bcf) per year.

Overview of Division of Oil & Gas Cook Inlet Studies (Continued)

2015 - Updated Engineering Evaluation of Remaining Cook Inlet Gas Reserves

- An update to 2009's study of 34 currently or historically producing Cook Inlet gas fields to derive estimates of remaining Proved and Probable reserves.
- Applied single deterministic DCA and MBAL engineering methods to publicly available production and pressure data obtained from AOGCC.
- Did not address prospective (undiscovered), contingent (discovered, non-producing), and 3P (Proved + Probable + Possible) reserves.
- Proved + Probable reserves estimated at 1.18 trillion cubic feet (tcf).

2018 - Cook Inlet Natural Gas Availability

- Built on three previous DOG Cook Inlet gas studies, while incorporating future supplies by formulating hypothetical development projects required to produce undeveloped volumes and estimate each project's economic viability.
  - 500–800 bcf of additional gas is economic to develop at a price range around $6-8/thousand cubic feet (real 2016 dollars).
- P50 reserves estimate of 700 bcf when price is $8 per thousand cubic feet (mcf).

Current Study – Scope and Assumptions

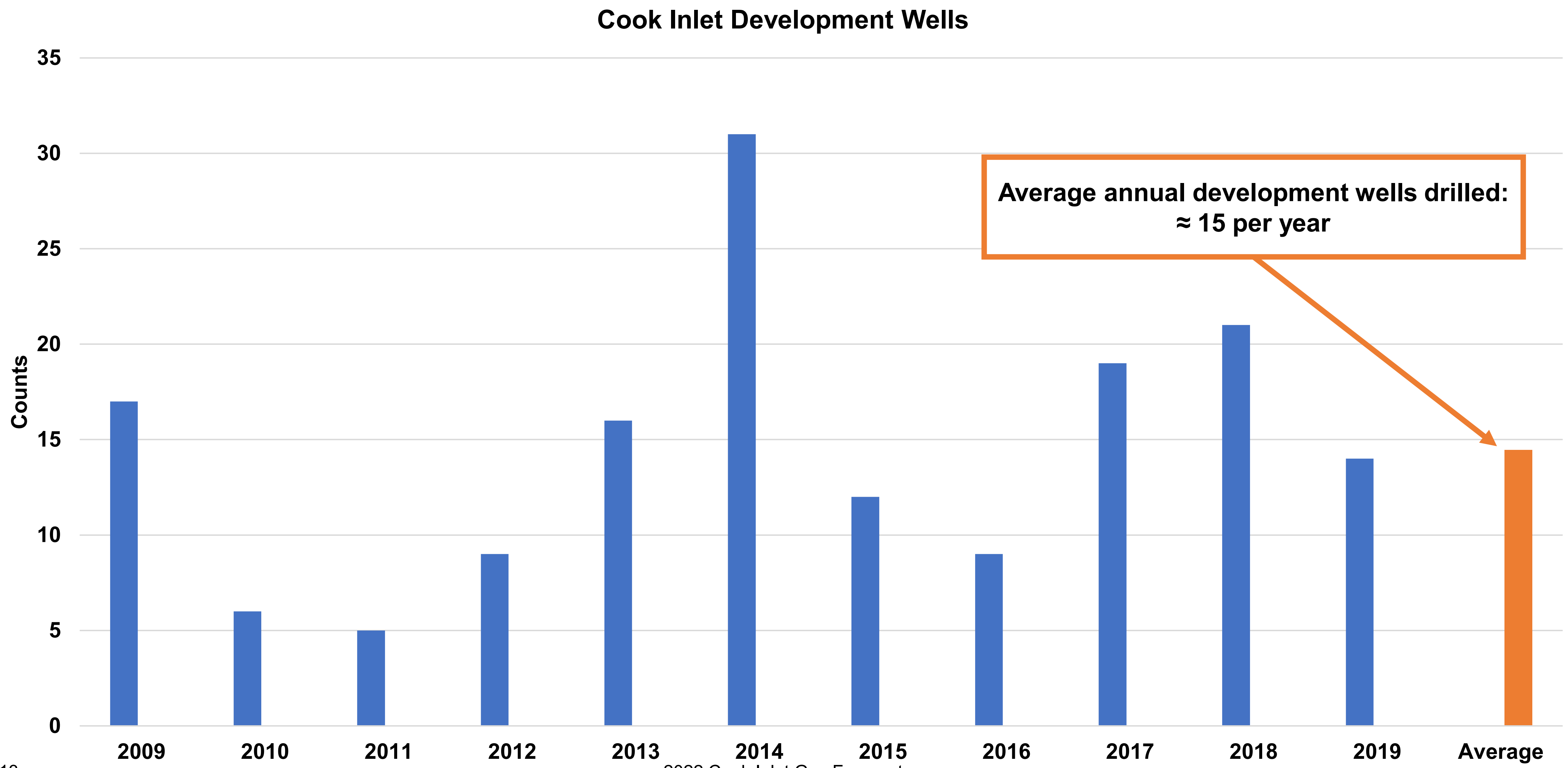
2022 - Cook Inlet Gas Forecast

- Technical reserves assessment of 90 different gas & oil pools using publicly available production data obtained from AOGCC.
- Decline Curve Analysis (DCA) used to estimate volumes from currently producing well set. Type Curve(s) were developed to estimate volumes from future development wells.
- Discovered resources contingent upon more favorable commercial conditions and undiscovered (prospective) resources were not included in the forecast.
- Estimated field level economic limits were used in the “truncated” forecast cases.
- Forecasted volumes do not account for gas produced from gas storage to avoid duplicative gas volumes produced.
- Flat gas demand of 70 billion cubic feet per year does not assume future additional requirements nor does it assume possible substitutes or increasing efficiency in consumption both for energy producers and commercial or domestic consumers.

Key Assumptions:

- Assumes 15 development wells per year until 2030, and no new wells beyond that. That is not a prediction that no drilling will occur after that date, it was the horizon for which 15 wells per year was assumed to be reasonable.
- Assumes gas price is flat, with escalation for inflation. Does not forecast market changes responding to supply/demand.
- Does not include contribution from non-producing known prospects and does not forecast likelihood of their development.

Cook Inlet Development Well History (Pre-Pandemic, 2009-2019)



Modeling the Economic Limit for each Field: Structure of the model

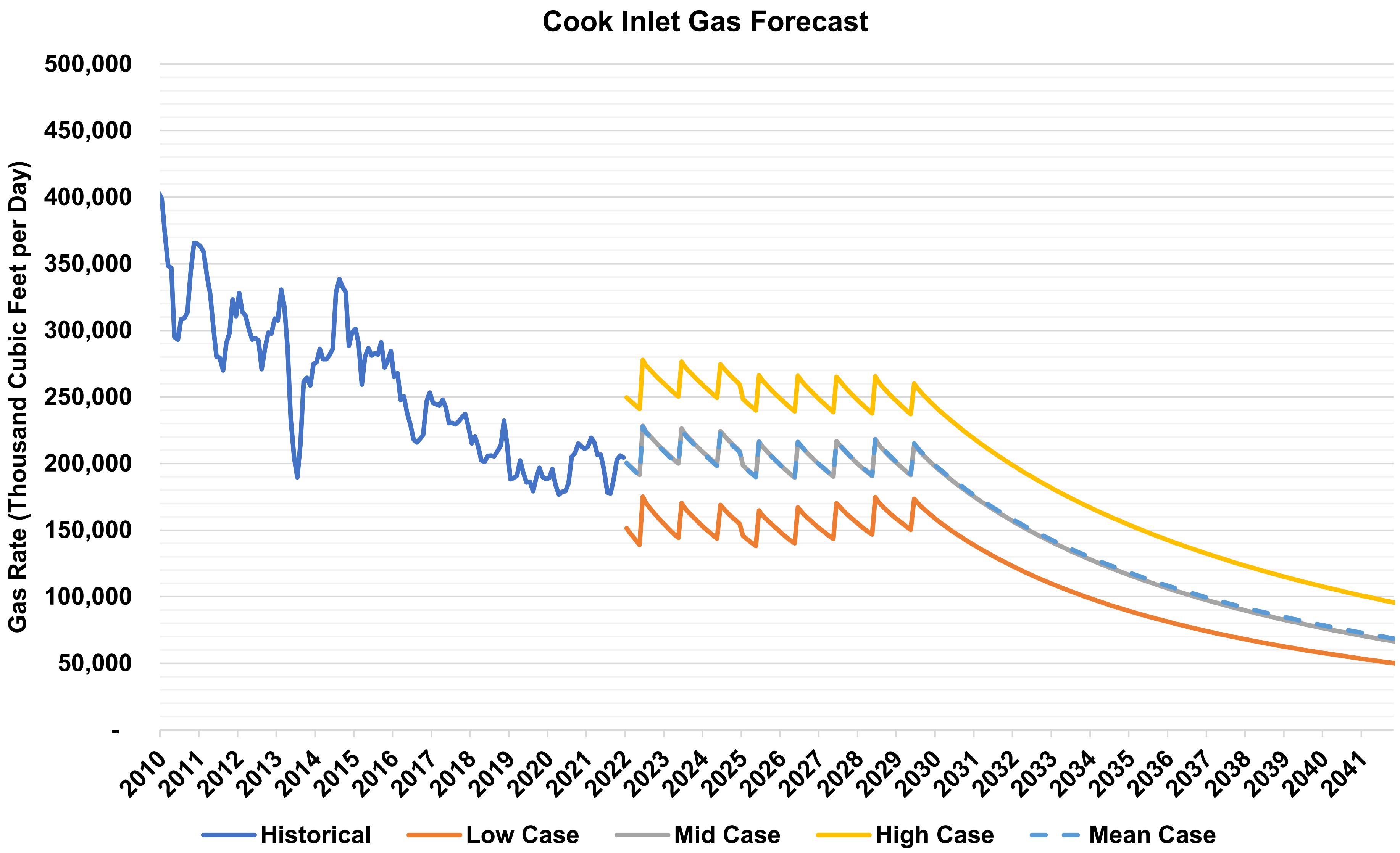
1. **The technical forecast of oil and gas is run through an economic model.**
   - Upstream companies unlikely to operate their fields at a sustained loss (i.e., negative cash flows).
   - If marginal revenue associated with production of oil and gas in a field is not large enough to cover marginal expenditure, then the operator will likely stop production.
   - Marginal expenditure includes costs, royalty / overriding royalty payments, and taxes.
   - Remaining technically recoverable gas production beyond the economic limit point will not be available to the market.

2. **Structure of the economic model:**

Production of gas for sale	Not all gas produced is available to the market: Small share used for in-field operations and enhanced oil recovery.
Revenue	Proxy for gas prices between some Cook Inlet producers and local utilities.
Costs	One-size-fits-all approach for costs allowing for differences based on proximity to infrastructure (offshore vs. onshore, West vs. East).
Royalty	Share of gross revenues: 12.5%.
Overriding royalty interest	Another claim on gross revenues: percentage varies.
Taxes	O&G production tax ($1/bbl and $0.177/mcf ceilings) and O&G property tax.

mcf = thousand cubic feet
bbl = barrel

Forecast Untruncated High-Mid-Low-Mean Streams



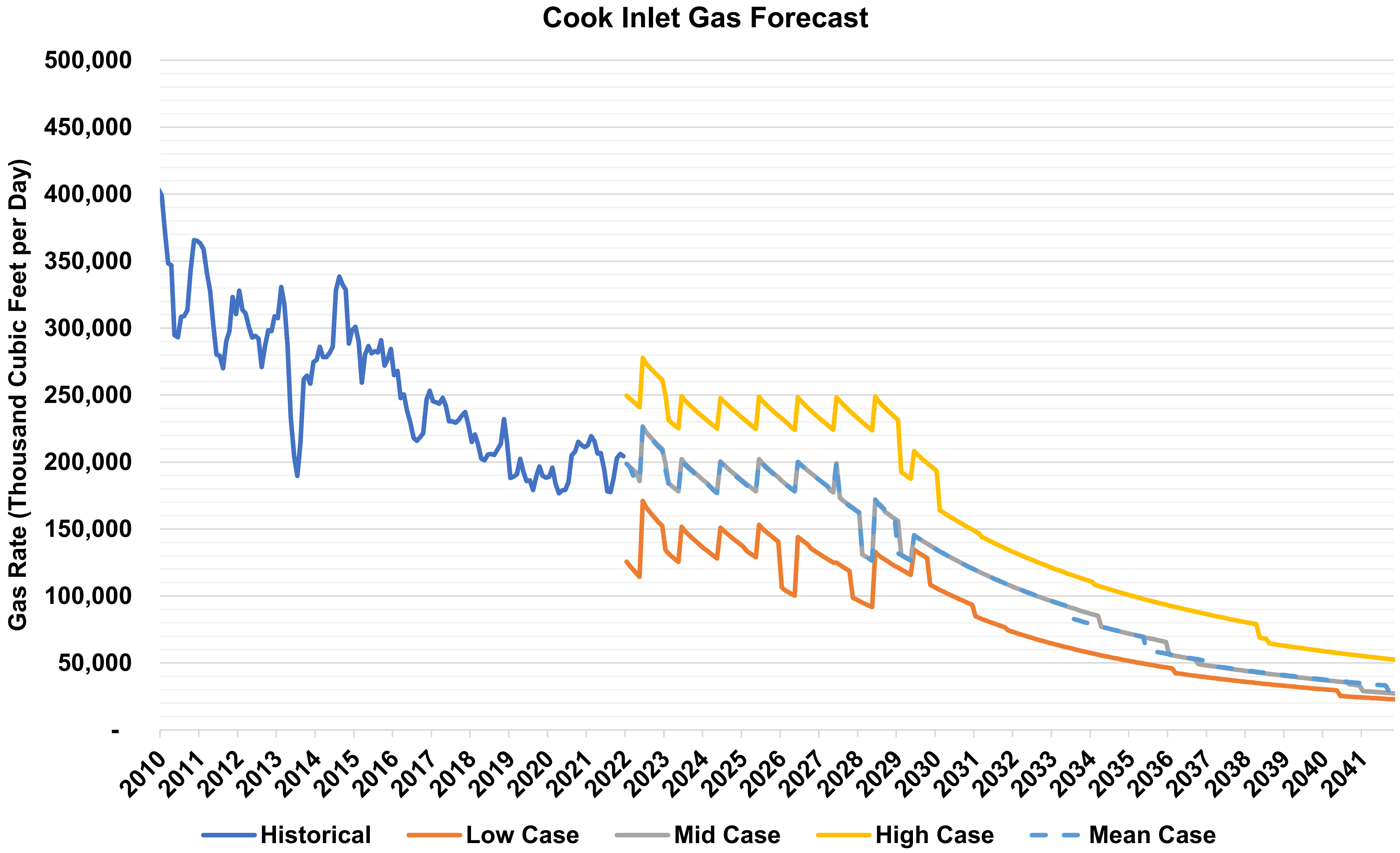
High Case (P1)	
Total Gas Reserves (bcf)	1,404.0
Gas (bcf)	1,361.7
Associated Gas (bcf)	42.3

Mid Case (P1)	
Total Gas Reserves (bcf)	1,101.4
Gas (bcf)	1,079.3
Associated Gas (bcf)	22.1

Low Case (P1)	
Total Gas Reserves (bcf)	843.2
Gas (bcf)	832.4
Associated Gas (bcf)	10.8

Mean Case (P1)	
Total Gas Reserves (bcf)	1,108.8
Gas (bcf)	1,085.2
Associated Gas (bcf)	23.6

Forecast
Truncated High-Mid-Low-Mean Streams



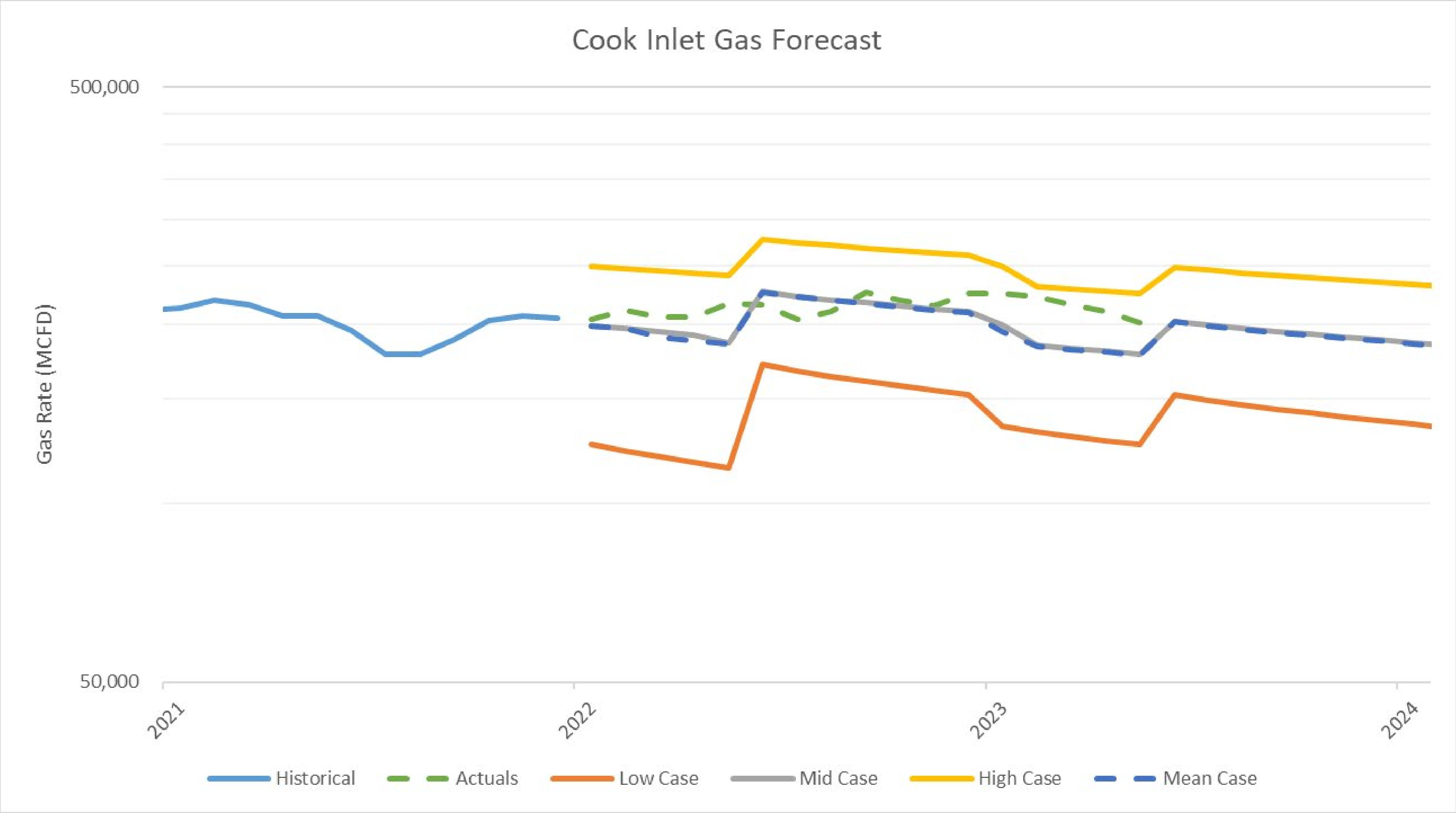
High Case (P1)	
Total Gas Reserves (bcf)	1,108.9
Gas (bcf)	1,066.6
Associated Gas (bcf)	42.3

Mid Case (P1)	
Total Gas Reserves (bcf)	823.9
Gas (bcf)	807.9
Associated Gas (bcf)	16.0

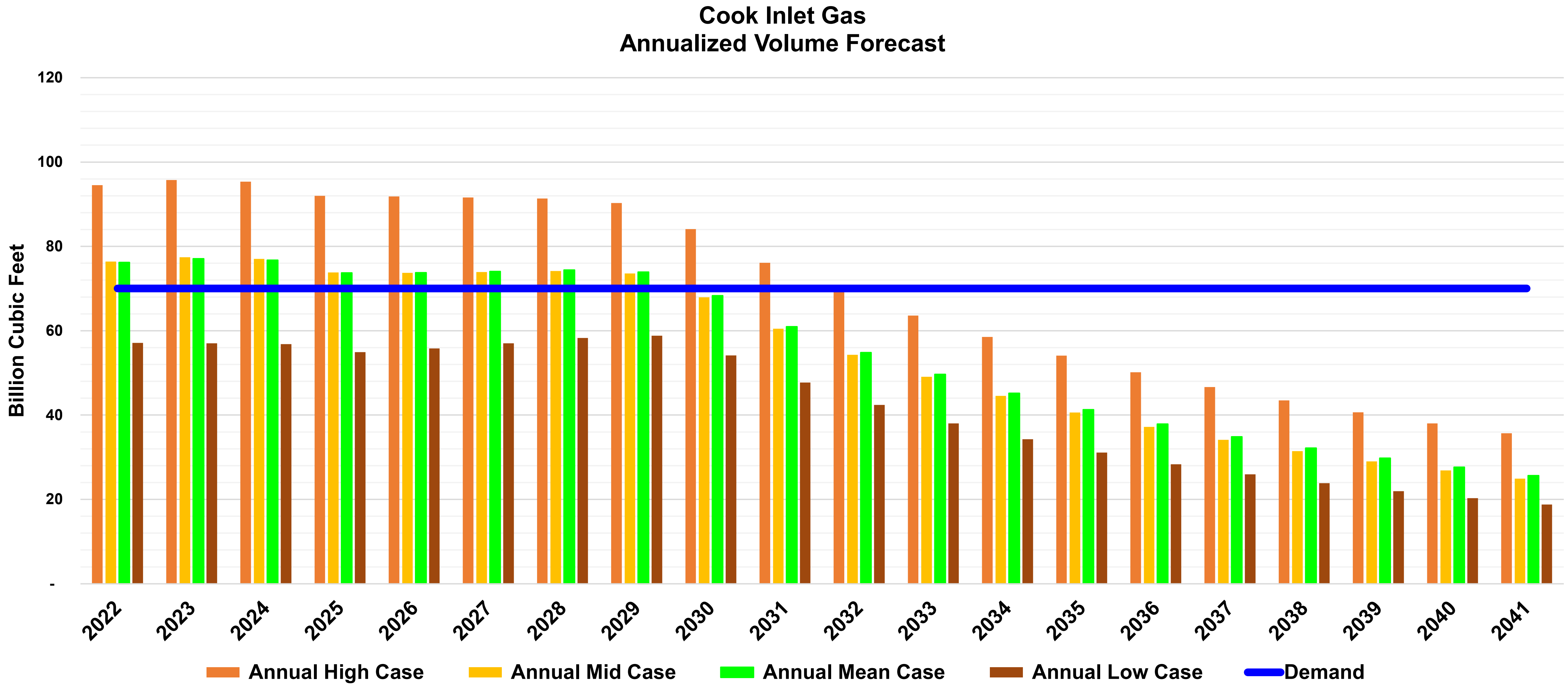
Low Case (P1)	
Total Gas Reserves (bcf)	602.5
Gas (bcf)	597.2
Associated Gas (bcf)	5.3

Mean Case (P1)	
Total Gas Reserves (bcf)	820.2
Gas (bcf)	803.2
Associated Gas (bcf)	17.0

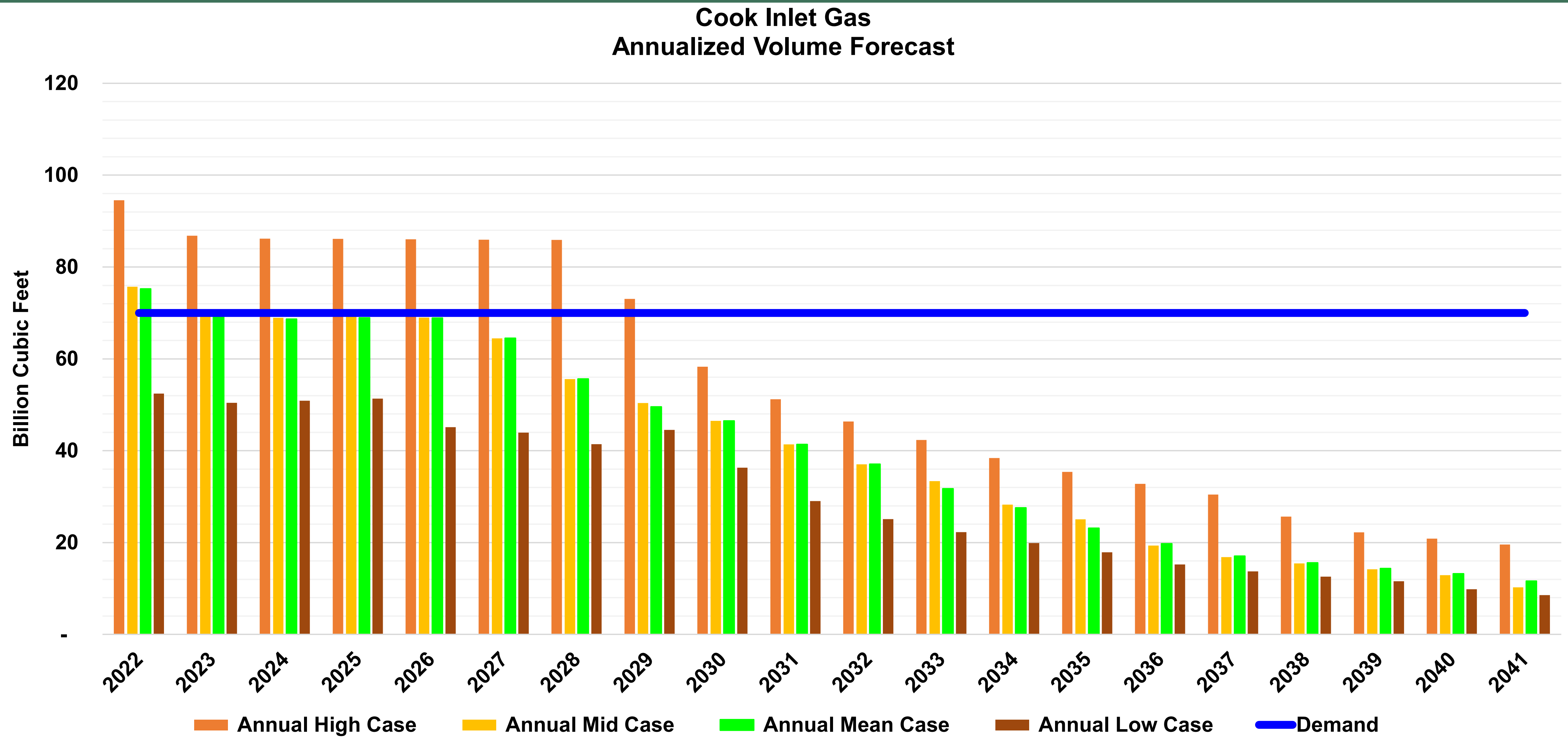
Forecast vs Actuals (Through May 2023)



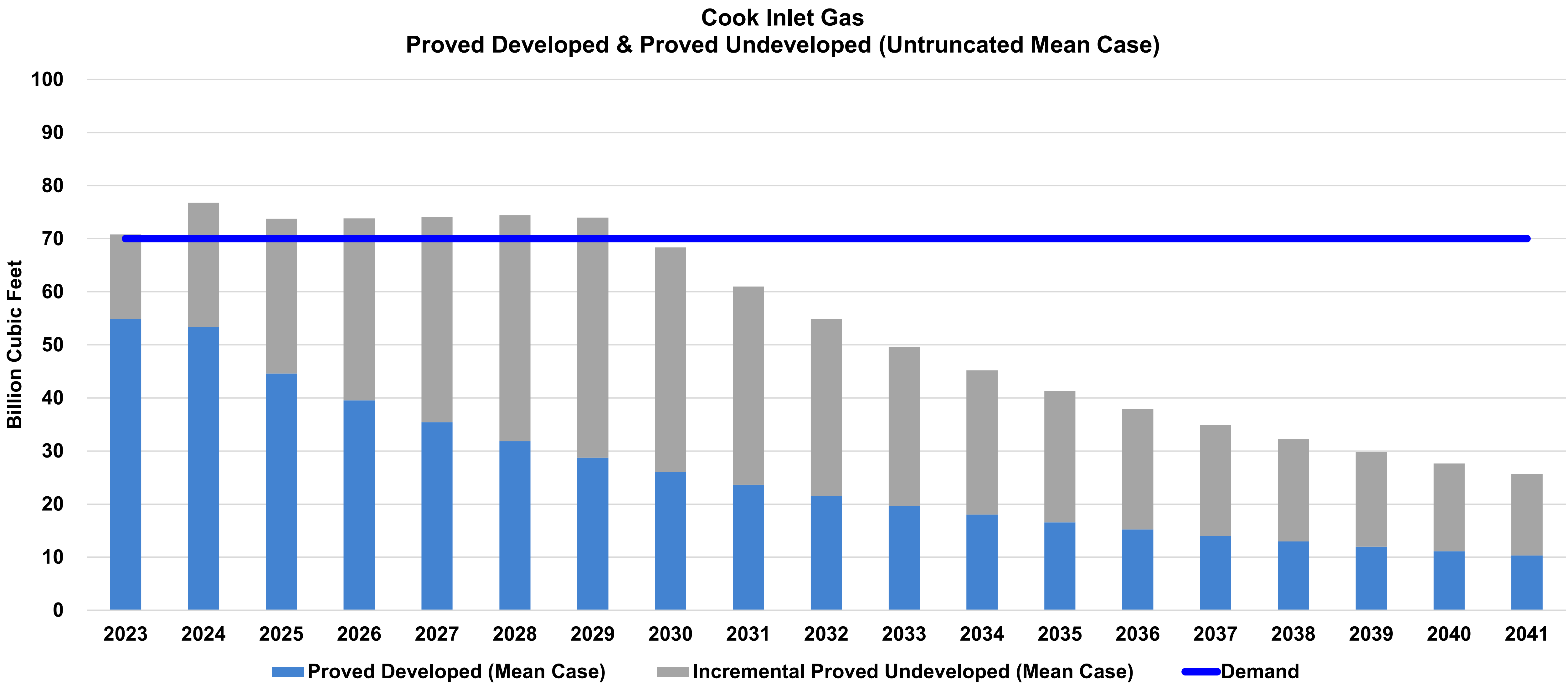
Forecast
Annualized Gas Volume (Untruncated)



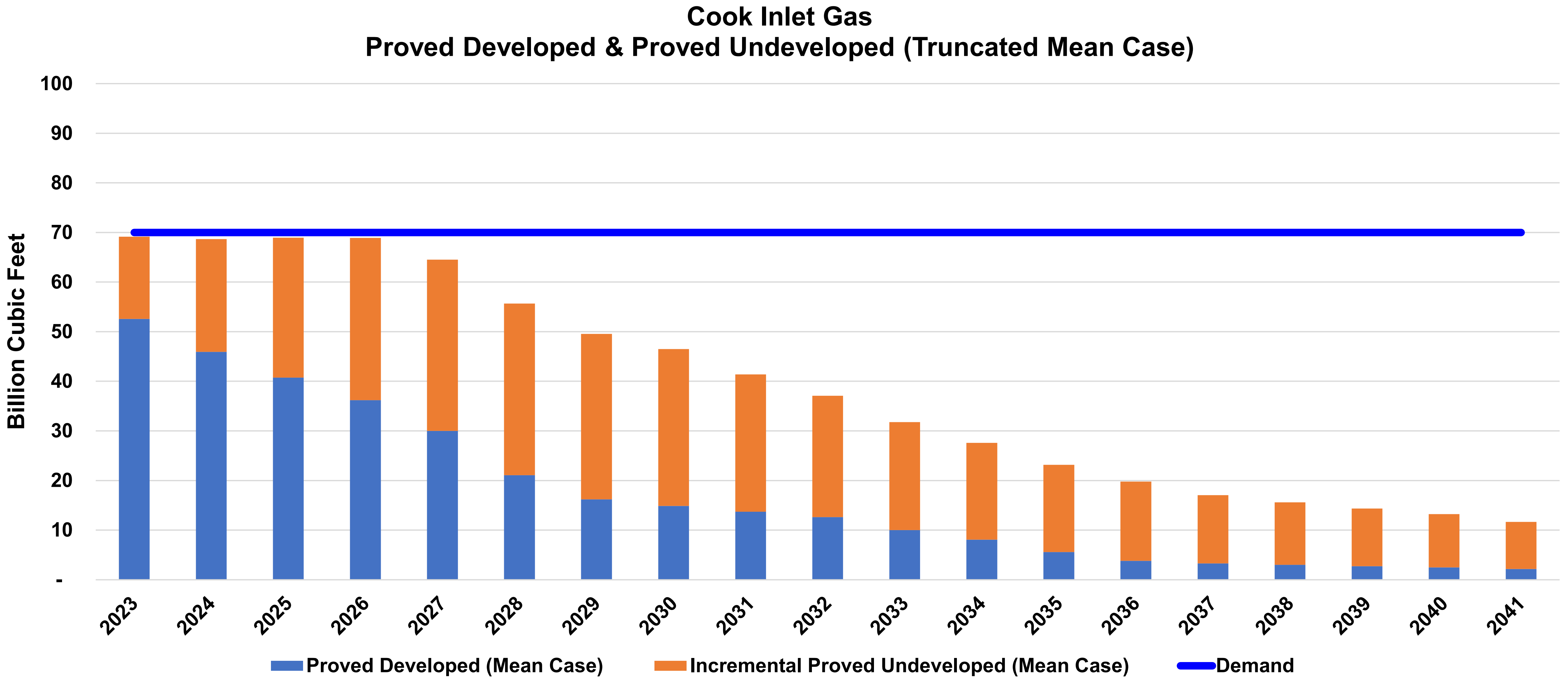
FORECAST ANNUALIZED GAS VOLUME (TRUNCATED)



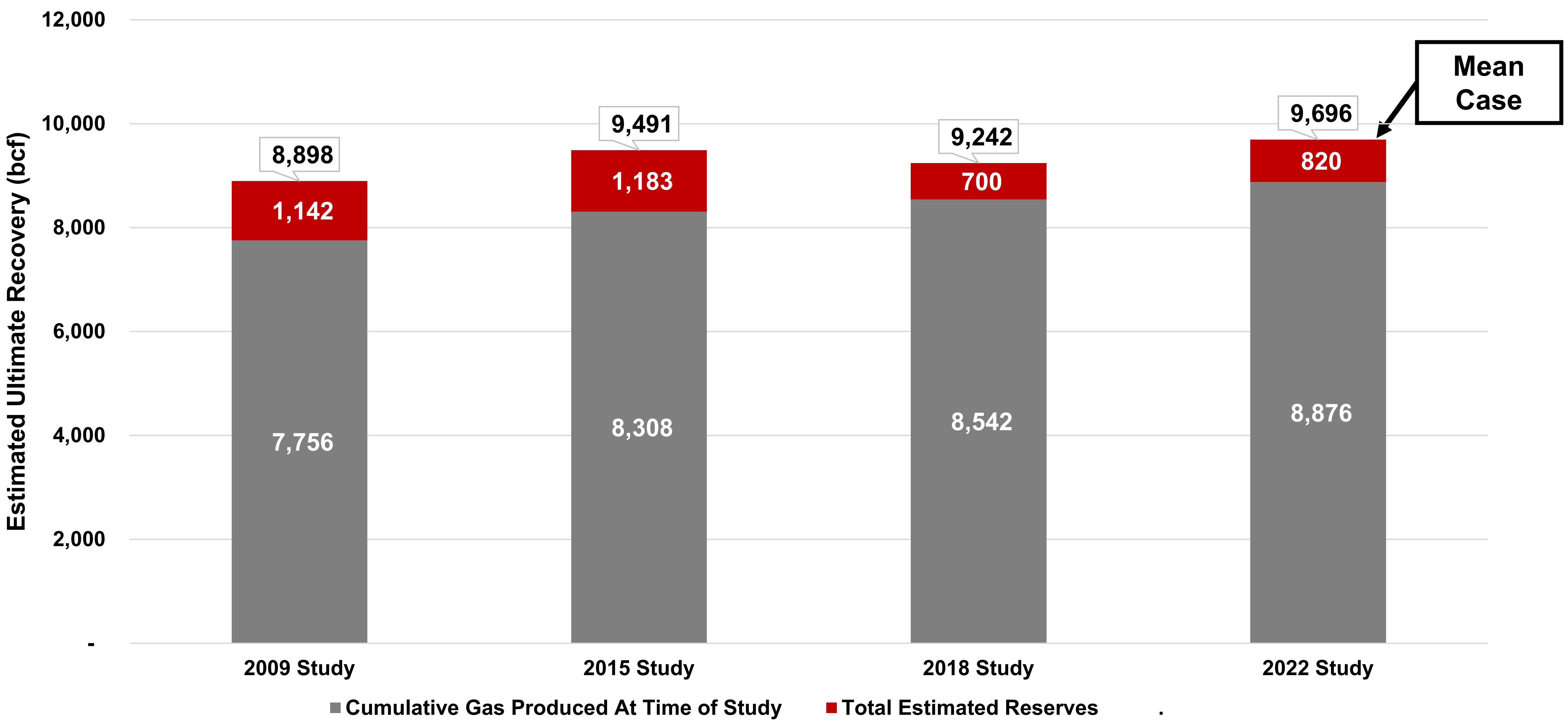
Forecast Proved Developed & Proved Undeveloped



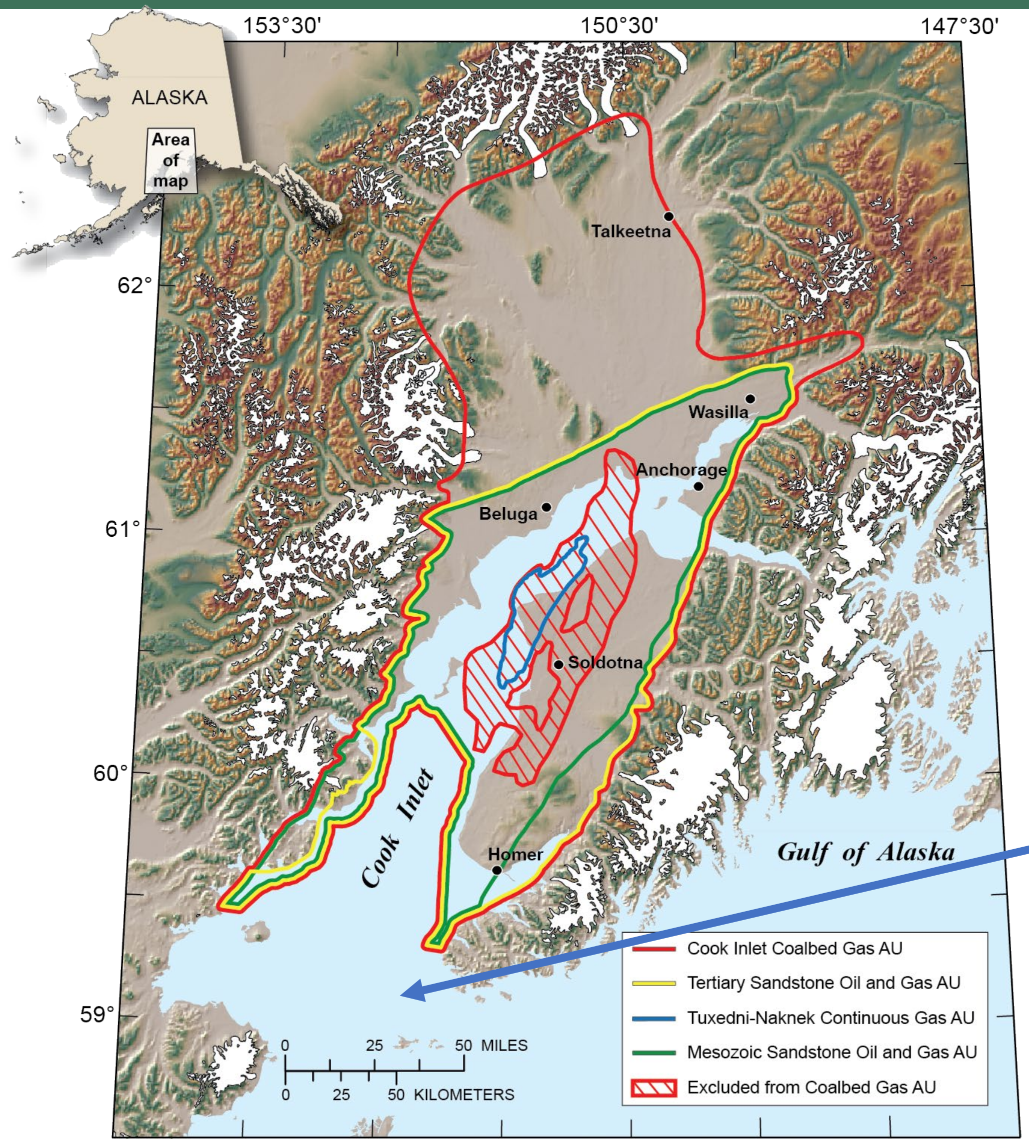
Forecast Proved Developed & Proved Undeveloped



DOG Studies Compared



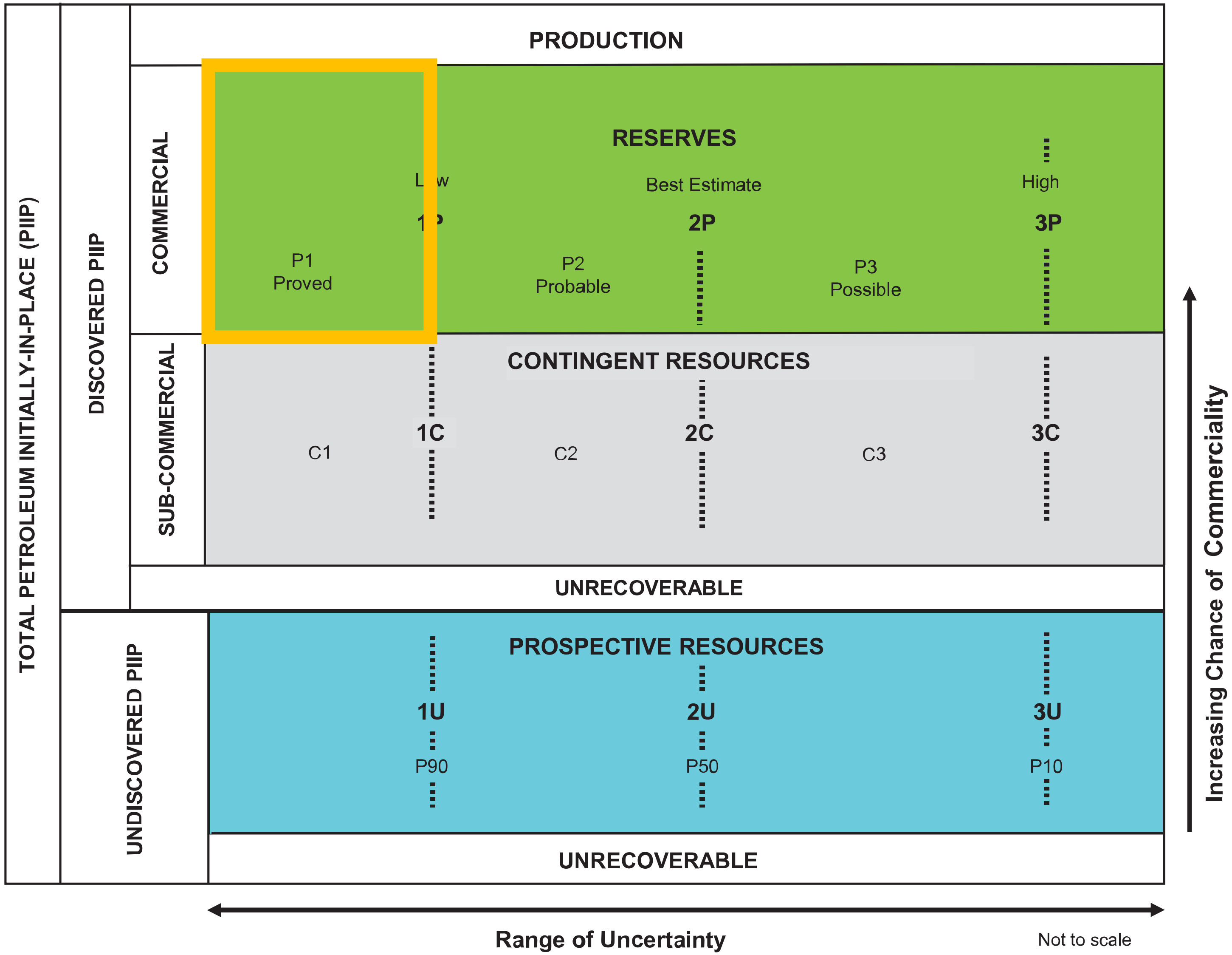
Exploration & Development in Cook Inlet: Cook inlet Undiscovered Resource



- **Undiscovered, Technically Recoverable Oil & Gas (USGS 2011):**
  - mean conventional oil 599 million barrels of oil
  - mean conventional gas 13.7 trillion cubic feet
  - mean unconventional gas 5.3 trillion cubic feet
- **Undiscovered, Technically Recoverable Gas:**
  - 1.2 trillion cubic feet additional mean resource assessed in Southern Cook Inlet OCS (BOEM 2011) *South of the USGS study area.*
- In general, access to additional area provides opportunities for locating and commercializing currently undiscovered resources.

QUESTIONS?

Petroleum Resource Management System



Proved Reserves (P1)

=

Proved Developed Gas Pool-Level Decline Curve Analysis

+

Proved Developed Associated Gas Pool-Level Decline Curve Analysis

+

Proved Undeveloped Type Curve Analysis

Scope & Application

- **Evaluated 90 different gas & oil pools in the Cook Inlet Basin as defined by AOGCC.**
  - Historical production considered through year-end 2021.
- **Probabilistic High-Mid-Low DCA forecasts performed at Pool-level for gas and associated gas.**
  - Pool forecasts begin January 2022.
  - Length of *untruncated* forecast projections mostly held to 20 years, depending on reservoir performance.
  - Field-level oil forecasts were generated to determine economic field oil rate that directly impact produced associated gas forecasts.
- **Type Curves used for future development assumed a steady drilling pace of 15 development wells per year based on historical development wells drilled between 2009 and 2019.**
- **DCA & Type Curve forecasts are run through economic model to derive economic limits for each field by using revenue, fiscal, and cost factors to estimate remaining Proved & Proved Undeveloped reserves.**
- **DCA & Type Curve forecasts are then combined and aggregated to produce a basin-wide forecast.**

Technical Methodology

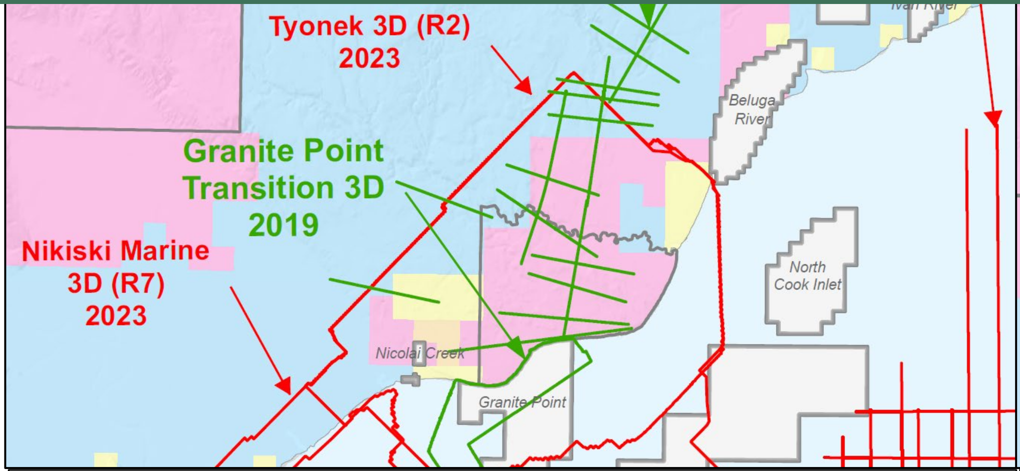
Decline Curve Analysis

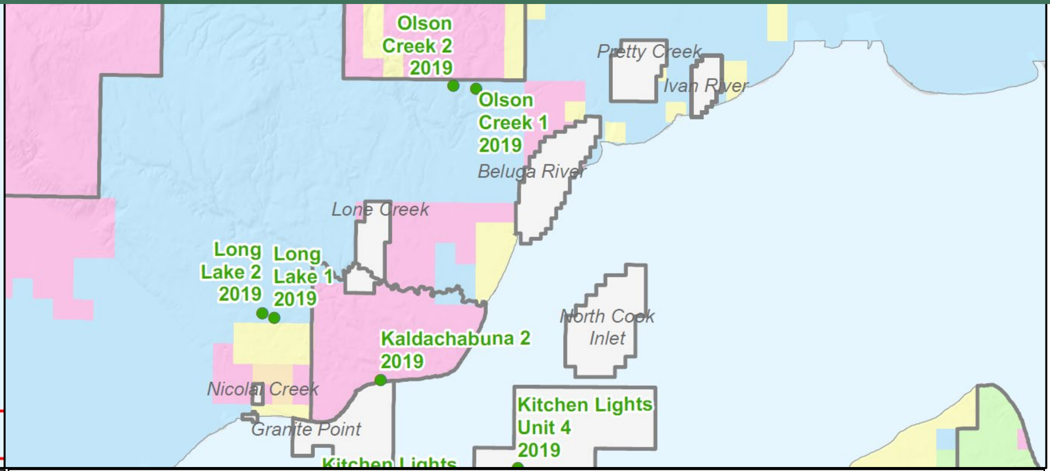
- Extrapolates recent trends of production decline into the future.
- Probabilistic forecasts were generated for currently producing pools to show a range of possible production into the future.
  - Uses statistical bootstrapping method in addition to traditional DCA to derive a quantifiable probabilistic range of outcomes, including High (P10), Mid (P50), and Low (P90) cases.
- Weighted toward recent production history.
- Engineering judgement applied to honor field development and reservoir constraints.

Type Curve Analysis

- Generated from a population of representative wells in respective pools, intended to characterize behavior of future wells drilled in pools.
  - Accounts for both geological parameters and reservoir conditions.
- Grounded in decline curve & statistical analysis using historical production data.
- Based on both historical development wells drilled between 2009 and 2019 and confidential information received from operators for specific fields that remain active and continue to develop in the Cook Inlet basin.

DCA & Type Curve forecasts are then combined and aggregated to produce a basin-wide forecast.





Seismic Data Release Status

Seismic survey, showing data coverage:

2D survey	3D survey	Release Status
Green	Green	Survey released and available at Geological Materials Center
Orange	Orange	Statutory confidentiality period expired; survey eligible for and in preparation for release *(see notes 2, 3, and 4)*
Red	Red	Other survey with tax credit certificate, statutory confidentiality period still in effect; survey not yet eligible for and prepared for release *(see notes 2, 3, 4, and 5)*

Notes:
1. This map is intended as a current snapshot of information that can be disclosed publicly regarding tax credit seismic surveys.
2. Representation on this map does not guarantee public release and is subject to statutory requirements in effect at the time of acquisition and application for tax credit.
3. Release is subject to public notice and permission of private oil and gas mineral estate owner where applicable. Some surveys require clipping to mineral ownership boundaries; actual map extents of released datasets may differ from those shown here.
4. Year label on "Released" surveys denote actual release year. Year label on "Eligible" and "Issued" denote the year in which the data is eligible for release and distribution under AS 43.55.025(f)(2)(c), most tax credit seismic projects are held confidential for 10 years from completion of initial seismic processing.
5. Map does not include surveys whose initial seismic processing was completed less than 10 years ago but prior to legislative adoption of the disclosure clause of AS 43.55.025(f)(5). Seismic surveys acquired with credits under AS 43.55.023 are not subject to disclosure under AS 43.55.025(f)(5), and cannot be represented here until their confidentiality period has expired.
6. Additional qualifying surveys will be added to this map as new tax credit certificates are issued or as changes in confidentiality status allows.

Source: DNR/DOG Tax Credit Seismic Surveys for Public Release Map updated: March 2022

Well Data Release Status

Well bottom hole location

Well	Has VSP Checkshot	Release Status
Green	Green	Well released and available at Geological Materials Center
Orange	Orange	Statutory confidentiality period expired; well data eligible for and in preparation for release *(see notes 2, 3, and 4)*
Red	Red	Wells with issued tax credit certificate, statutory confidentiality period still in effect; well not yet eligible for and prepared for release *(see notes 2, 3, 4, and 5)*

Notes:
1. This map is intended as a snapshot of information that can be disclosed publicly regarding tax credit well data.
2. Representation on this map does not guarantee public release and is subject to statutory requirements in effect at the time of acquisition and application for tax credit.
3. Release is subject to public notice and permission of private oil and gas mineral estate owner where applicable. Some datasets require clipping to mineral ownership boundaries; actual map extents of released datasets may differ from those shown here.
4. Year label on "Released" wells denote actual release year. Year label on "Eligible" and "Issued" denote the year in which the data is eligible for release and distribution under AS 43.55.025(f)(2)(c), most tax credit wells are held confidential for 2 - 10 years from the completion, suspension, or abandonment.
5. Map does not include wells completed, suspected, or abandoned less than 10 years ago but prior to legislative adoption of the disclosure clause of AS 43.55.025(f)(5). Wells acquired with credits under AS 43.55.023 are not subject to disclosure under .025(f)(5), and cannot be represented here until their confidentiality period has expired.
6. Additional qualifying wells will be added to this map as new tax credit certificates are issued or as changes in confidentiality status allows.

Source: DNR/DOG Tax Credit Well Data for Public Release Map updated: December 2020

DNR releases well & seismic data collected under the tax credit program (past the statutory holding period) for a nominal charge.

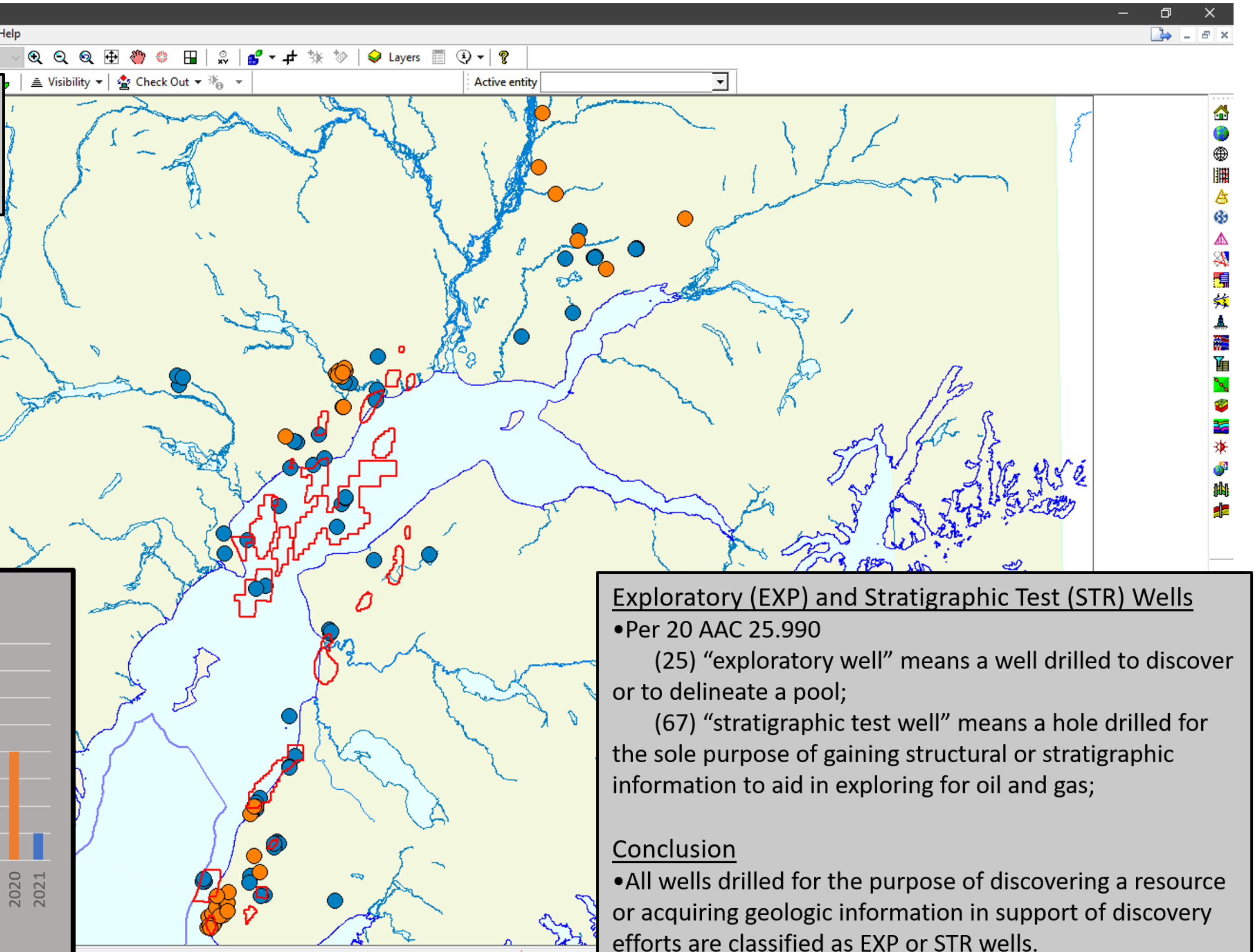
For the State:

- Increases subsurface resource knowledge
- Utility in managing State lands
- Purposed to incentivize new and additional investment

For Industry/Research:

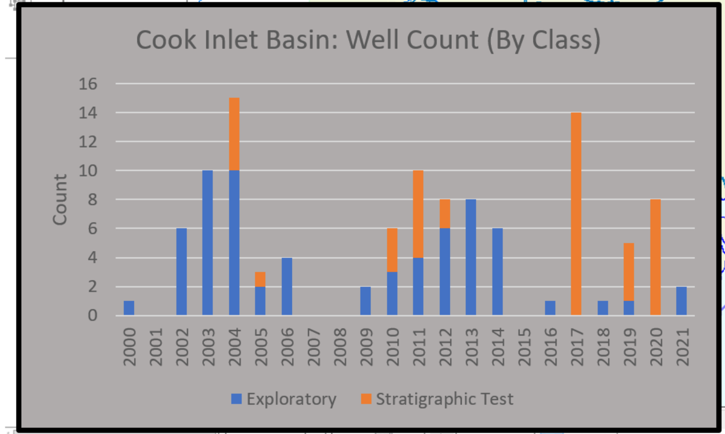
- Lower barrier to entry
- Further published research/training
- Development of new technologies

Exploration & Development in Cook Inlet: 2000 through 2021



2000-2021 Cook Inlet Basin Drilling

- **43 STRATIGRAPHIC TEST wells completed**
- **67 EXPLORATORY wells completed**
- **347 DEVELOPMENT wells completed**



Exploratory (EXP) and Stratigraphic Test (STR) Wells

- Per 20 AAC 25.990
  - (25) "exploratory well" means a well drilled to discover or to delineate a pool;
  - (67) "stratigraphic test well" means a hole drilled for the sole purpose of gaining structural or stratigraphic information to aid in exploring for oil and gas;

Conclusion

- All wells drilled for the purpose of discovering a resource or acquiring geologic information in support of discovery efforts are classified as EXP or STR wells.

Recent Cook Inlet exploration activity comprises seismic, aerial surveys, and drilling of exploratory and stratigraphic test wells.

History of Cook Inlet Tax Credit Program: Design and purpose

The purpose of the Cook Inlet Tax credits is to “entice companies ‘to invest more money in Alaska and drill more wells’ so that the possibility of both discovery and production could be ‘substantially’ increased.”

Minutes, Senate Finance Committee, May 13, 2003, summarizing comments from Sen. Wagoner regarding AS 43.55.025(a) tax credits contained in SB 185

Primary Cook Inlet Credits

AS 43.55.023(l) *

Well Lease Expenditure Credit

- In effect from 2010 – 2017 for Cook Inlet
- Credit equal to 40% of well or seismic cost (decreased to 20% in 2017)
- Not available for North Slope

AS 43.55.025(a) *

Alternative credit for exploration

- In effect from 2003 – 2016 for Cook Inlet (2010 for Jack-Up Rig Credit)
- Credit equal to 30% or 40% of well or seismic cost (increased from 20% in 2008)
- Distance restrictions from existing wells or units to qualify

Other Major Tax Credits

AS 43.55.023(a)

Qualified Capital Expenditure Credit

- In effect from 2006 – 2017 for Cook Inlet
- Credit equal to 10% - 20% of capital expenditures

AS 43.55.023(b)

Carried Forward Annual Loss Credit

- In effect from 2006 – 2017 for Cook Inlet
- Credit equal to 25% of annual loss (increased in 2007)

Additional Considerations

- Credits could be certificated, and either traded or repurchased by the State
- * These credits have DNR data submittal requirements

Alaska LNG Project

Alaska Energy Security Task Force

July 13, 2023

ALASKA GASLINE DEVELOPMENT CORP.

AGDC

- Independent, public corporation owned by the State of Alaska
- Created by the Alaska State Legislature

Mission

- Maximize the benefit of Alaska's vast North Slope natural gas resources through the development of infrastructure necessary to move the gas to local and international markets

Alaska Stand Alone Pipeline (ASAP)

- Environmental Impact Statement and Record of Decision Complete
- Put on hold when focus shifted to Alaska LNG

Alaska LNG Project

- Provides best opportunity for long term, low cost, secure energy for Alaskans

2

Alaska LNG Project

ALASKA GASLINE DEVELOPMENT CORP.

The Alaska LNG Project is not the project you heard or read about over the last 20 years.

Today's Project:

- Cost competitive
- Benefits the state
- Transitions to the private sector
- Environmentally friendly
- Has all major permits and authorizations

3

Alaska LNG: Gas for Alaskans & Export

ALASKA GASLINE DEVELOPMENT CORP.

North Slope Gas Supply

- 40 Tcf of natural gas stranded in Prudhoe Bay and Point Thomson
- More than enough gas for 30-years

Arctic Carbon Capture (ACC) Plant

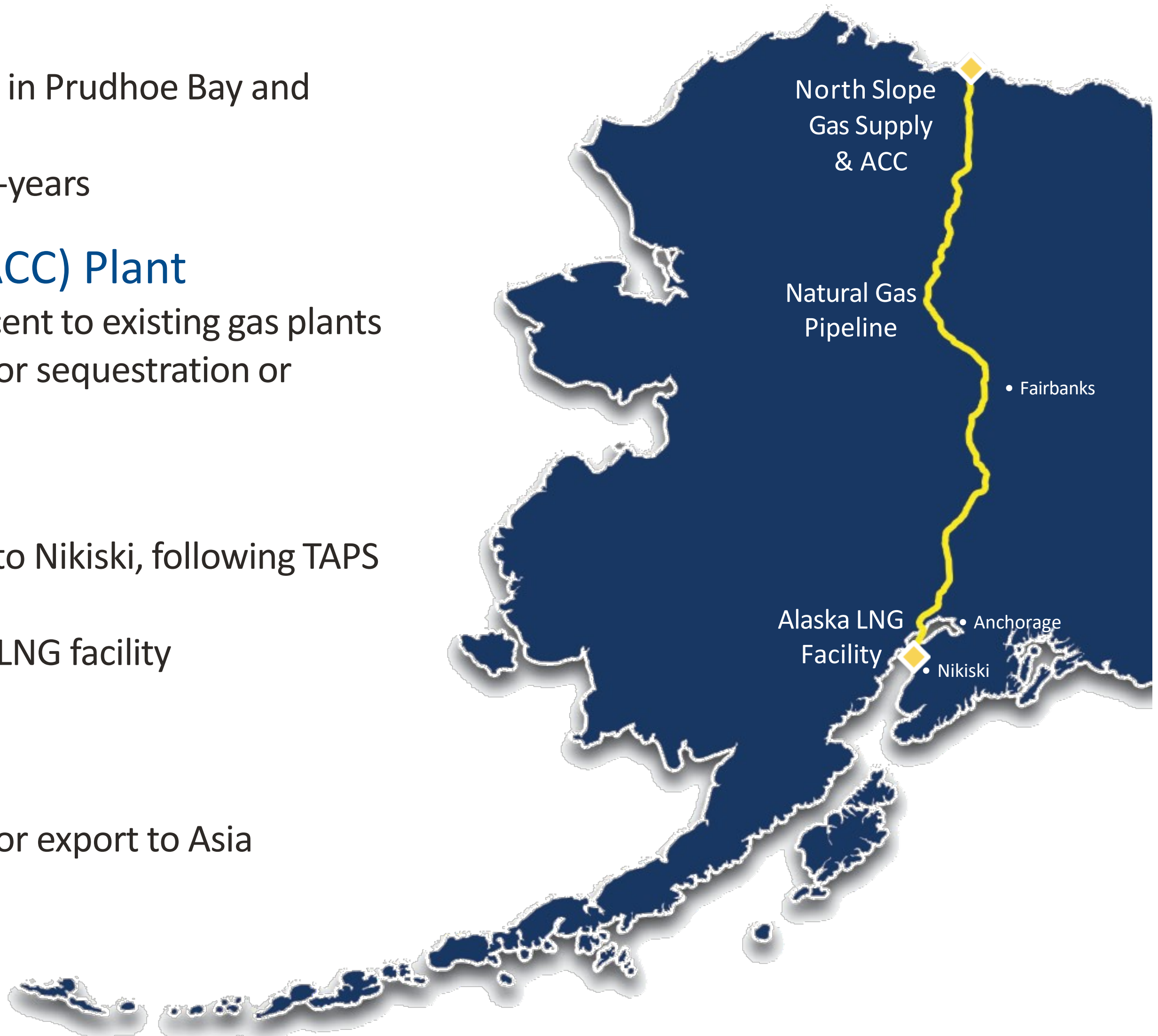
- Located in Prudhoe Bay adjacent to existing gas plants
- Removes CO_2 from feed gas for sequestration or enhanced oil recovery

Natural Gas Pipeline

- 807 miles from Prudhoe Bay to Nikiski, following TAPS and highway system
- Provides gas to Alaskans and LNG facility

Alaska LNG Facility

- 20-MTPA LNG Facility
- Converts natural gas to LNG for export to Asia



Major Permits and Authorizations

ALASKA GASLINE DEVELOPMENT CORP.

Completed

- Federal Energy Regulatory Commission (FERC) Environmental Impact Statement (EIS) and Order
- Department of Energy (DOE) Supplemental EIS and Export Orders
- Land rights-of-way (ROW): about 93% of Project area
- Approved Cultural Resources Management Plan
- Major Facility Air Permits

ALASKA LNG	Federal Permits and Authorizations	
Permit/Authorization	**Date Obtained**	**Complete**
Presidential Finding Concerning Alaska Natural Gas - President Reagan	1/12/1988	✓
BLM Right-of-Way - Grant Offer	1/1/2021	✓
BLM Right-of-Way Record of Decision	7/23/2020	✓
Cultural Resources Management Plan	6/24/2021	✓
DOD Letter of Non-Objection	3/10/2020	✓
DOE Natural Gas Export Order (Free Trade) Order No. 3554	11/21/2014	✓
DOE Natural Gas Export Order (Non-Free Trade) Conditional Order. 3643	5/28/2015	✓
DOE Natural Gas Export Order (Non-Free Trade) Order No. 3643-A	8/20/2020	✓
DOE Order on Rehearing (Non-Free Trade) Order No. 3643-B	4/15/2021	✓
DOE Natural Gas Export Order (Non-Free Trade) Order No. 3643-C	4/13/2023	✓
EPA Section 401 Water Quality Certification	6/22/2020	✓
FAA Determinations GTP	5/6/2021	✓
FAA Determinations LNG	1/5/2021	✓
FERC Final Environmental Impact Statement	3/6/2020	✓
FERC Order Granting Authorization under Section 3 of the Natural Gas Act[1]	5/21/2020	✓
FERC Programmatic Agreement - Cultural Resources	6/24/2020	✓
NMFS Biological Opinion AKR0-2018-01319	6/3/2020	✓
NMFS Cook Inlet Marine Mammals (whales/seals) Incidental Take Rule	8/17/2020	✓
NMFS Cook Inlet Marine Mammals (whales/seals) Letter of Authorization	9/15/2020	✓
NMFS Prudhoe Bay Incidental Harassment Authorization Marine Mammals (whales/seals)	2/16/2021	✓
NPS Right-of-Way Permit	1/5/2021	✓
NPS Right-of-Way Record of Decision, DNPP	7/23/2020	✓
PHMSA Siting Letter of Determination and Analysis - Liquefaction Facility	2/4/2020	✓
PHMSA Special Permit - Crack Arrestor Spacing	9/9/2019	✓
PHMSA Special Permit - Mainline Block Valve Spacing	9/9/2019	✓
PHMSA Special Permit - Pipe-in-Pipe	4/27/2020	✓
PHMSA Special Permit - Strain-Based Design	9/9/2019	✓
PHMSA Special Permit - Three-Layer Polyethylene Coating	9/9/2019	✓
USACE Record of Decision Section 404 Wetlands Permit	6/24/2020	✓
USCG Bridge Permit - Deshka River	9/11/2020	✓
USCG Bridge Permit - East Fork Chulitna	9/11/2020	✓
USCG Bridge Permit - Middle Fork Chulitna	9/11/2020	✓
USCG Bridge Permit - Sag	9/11/2020	✓
USCG Bridge Permit - Tolovana	9/11/2020	✓
USCG Letter of Recommendation Regarding the Waterway Suitability Assessment	8/17/2016	✓
USCG Waterway Suitability Assessment	3/18/2016	✓
USFWS Biological Opinion	6/17/2020	✓
USFWS Cook Inlet Incidental Take Rule Marine Mammals (sea otters)	8/1/2019	✓
USFWS Eagle Take Permit	6/23/2020	✓
USFWS Incidental Take Rule Marine Mammals (polar bear)	8/5/2021	✓

Regulatory Work Took Over a Decade

ALASKA GASLINE DEVELOPMENT CORP.

Major Permitting for Alaska LNG Occurred 2012 - 2023

- Scoping and pre-filing work
- Two major impact statements totaling over 6,000 pages of analysis
- Agency response documentation totally more than 150,000 pages
- Over a billion dollars

Permits and Approvals are Legally Tied to the Project - Not Easily Transferred to New Project/Scope

- Purpose and need
- Impacts
- Footprint

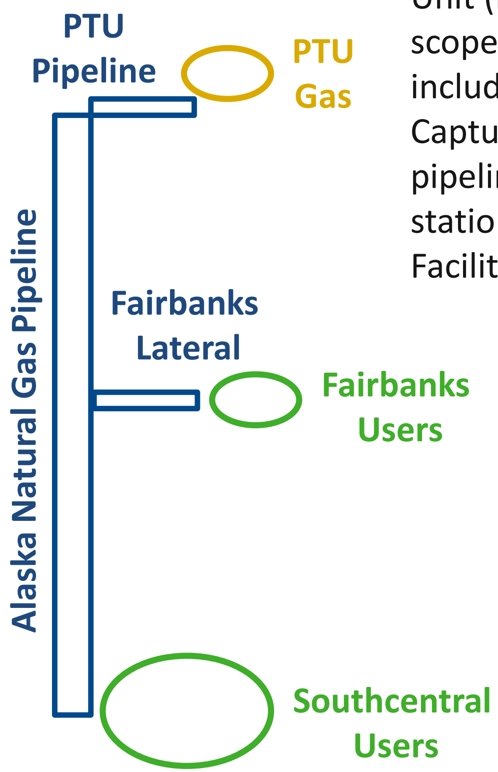
Can Build in Phases

- Examples: Pre-build pipeline, start with one train at the liquefaction facility

Alaska LNG Phase 1 Pipeline

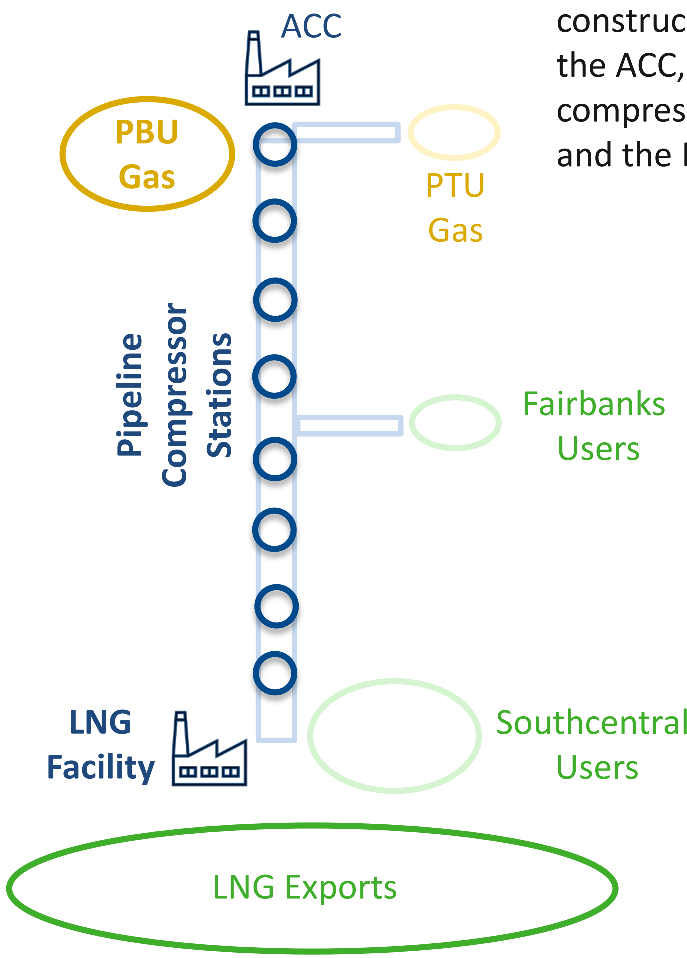
Phase 1: Gas to Alaskans

Gas is sourced from the Point Thomson Unit (PTU): Pre-build scope does not include Arctic Carbon Capture (ACC), pipeline compressor stations, or the LNG Facility.



Phase 2: LNG Exports

Full Alaska LNG Project scope is constructed, including the ACC, pipeline compressor stations, and the LNG Facility.



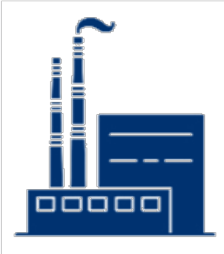
Positive Climate Impact

Alaska LNG can reduce GHG emissions by more than 77 million tonnes of CO_2 per year.

Alaska LNG can have one of the greatest GHG benefits of any project in the world.

Alaska LNG will have the same GHG impact as:

Eliminating

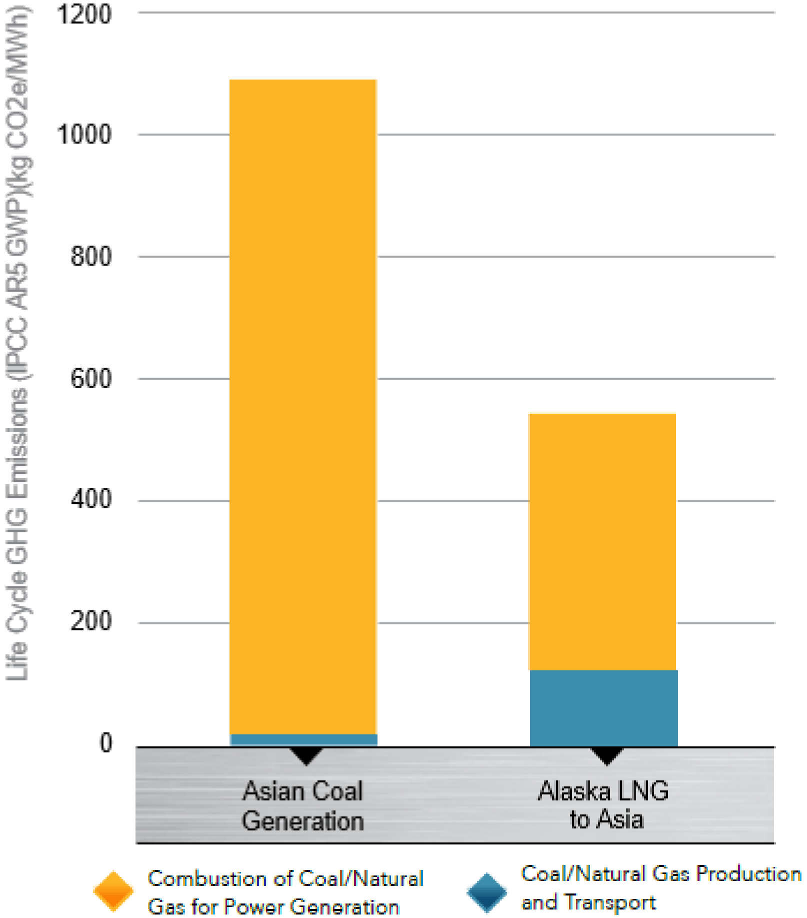


19 coal power plants

Constructing

16,0000 Wind Turbines

Lifecycle GHG Emissions for Natural Gas vs. Coal Power



Source: Greenhouse Gas Lifecycle Assessment: Alaska LNG Project

LNG Demand Forecast

ALASKA GASLINE DEVELOPMENT CORP.

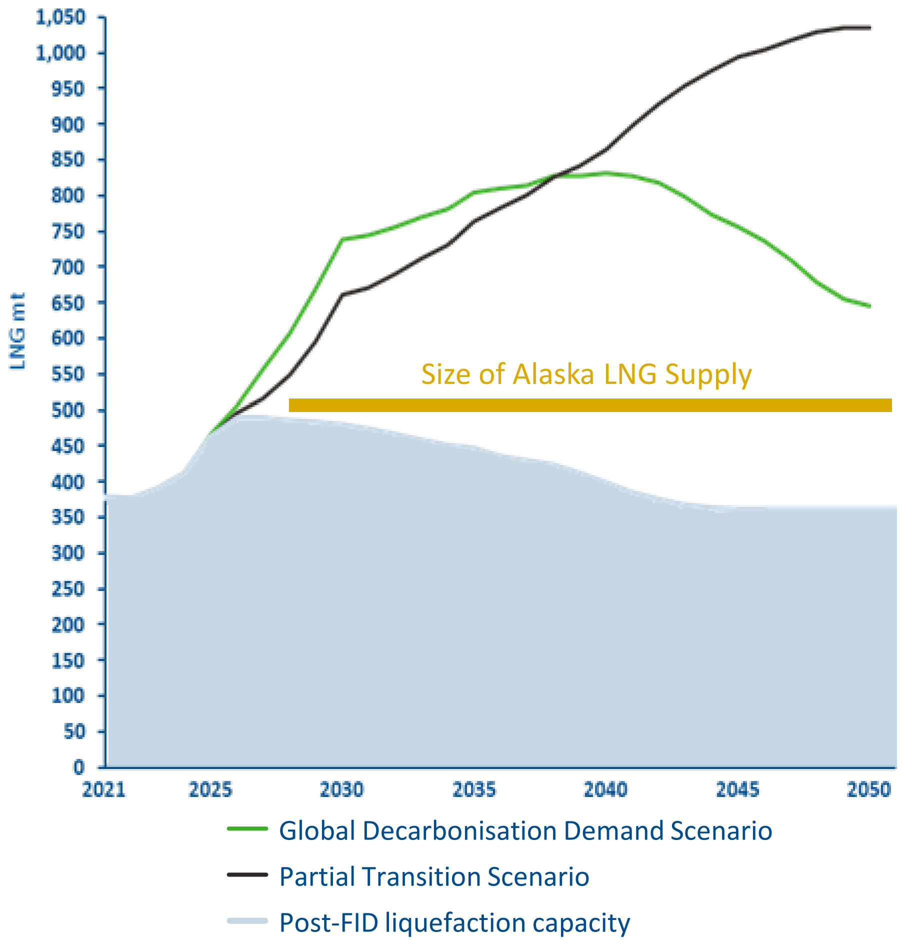
LNG Market is Still Growing

- Demand growth will outpace current and planned LNG capacity
- LNG growth expected as part of energy transition, as natural gas emits half the greenhouse gases as coal

Investors and Buyers want LNG

- New LNG projects expected to be sanctioned. Most new projects have some degree of energy transition planning
- Under both energy transition scenarios, LNG demand exceeds supply for the expected life of the Alaska LNG Project

Global LNG Supply/Demand Balance Forecast, 2021-2050



Source: Gas Strategies

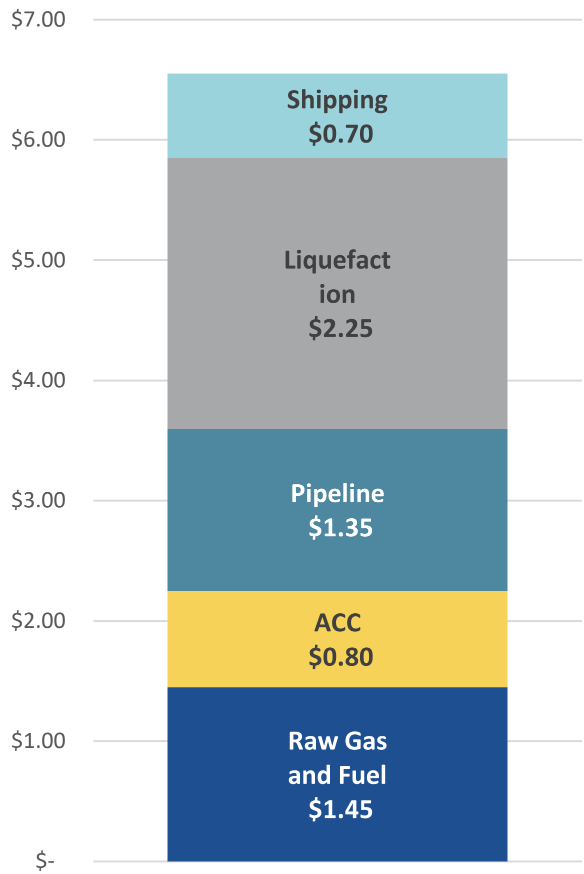
Strong Economics

Alaska LNG's Cost of Supply is Well Below Market Prices

- $6.55 cost of supply delivered to Asia is lower than competing market prices*
  - Brent Linked: $9.24 *($77 Brent x 12%)*
  - U.S. Gulf Coast: $7.30 *($2.30 Henry Hub + $5.00)*
  - JKM: $19.50 *(spot price)*
- LNG will be sold at market prices, providing for significant financial upside to Alaska LNG investors and the State of Alaska
- 2023 update to account for recent construction inflation, 45Q tax credits, and financial return expectation

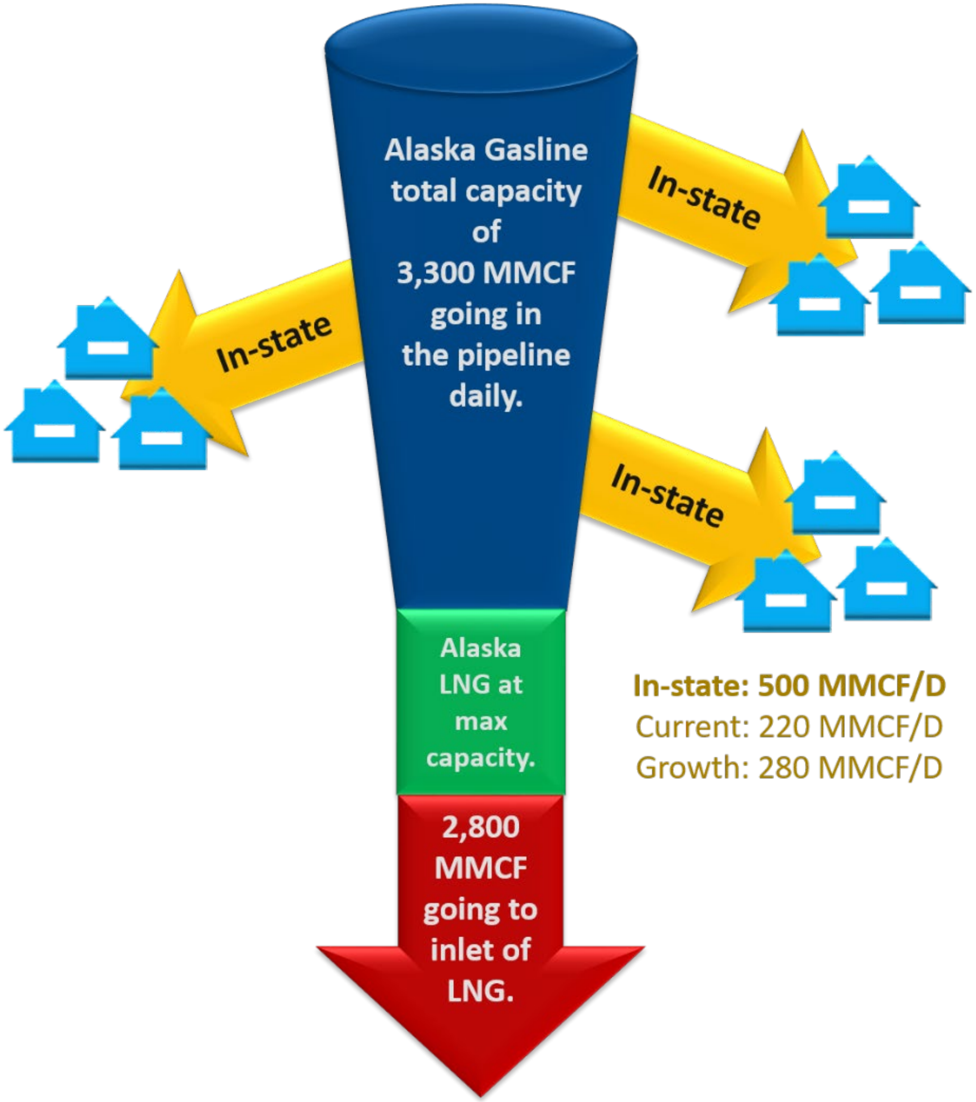
**As of June 8, 2023*

$6.55: Delivered Cost of Supply



Priority Supply for Alaskans

- Alaska LNG is designed to provide system capacity to ship natural gas to Alaskans
- The pipeline has 500 MMcfd of capacity in excess of the LNG Plant's needs
    - All 500 MMcfd is prioritized for Alaskans
    - Current Alaska natural gas demand is about 220 MMcfd
    - Allows for long-term Alaska natural gas demand growth



Lower Cost Energy for Alaskans

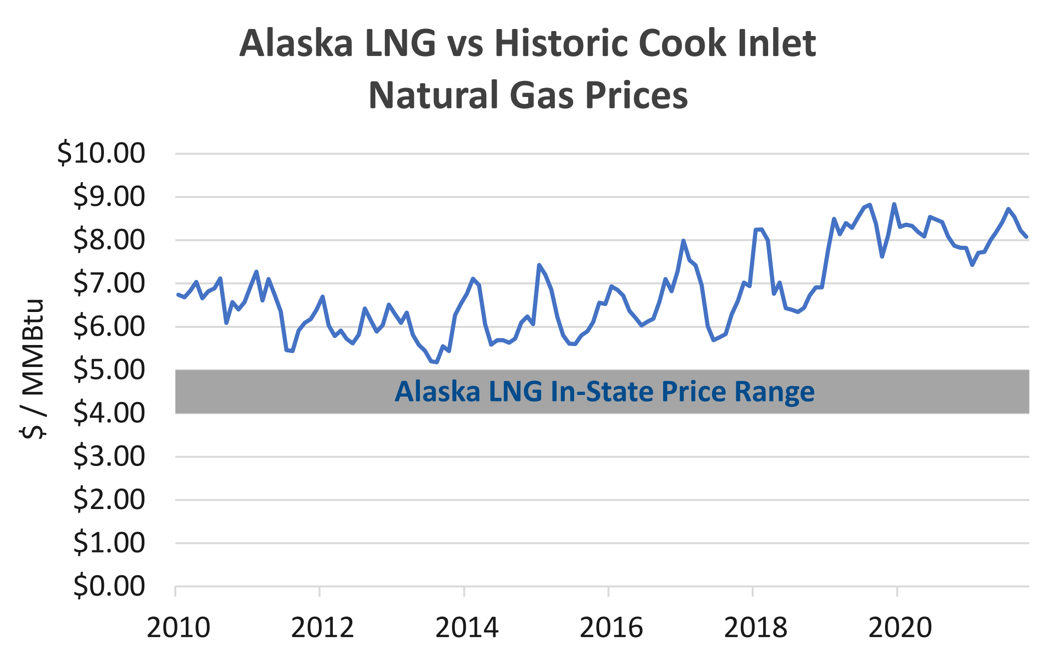
ALASKA GASLINE DEVELOPMENT CORP.

Low-Cost Gas for Alaskans

- The Alaska LNG in-state price is estimated to be between $4 - $5 per MMBtu
- Significant reduction from current prices, saving Alaskans hundreds of dollars per year*

Significant Energy Savings

- Southcentral households/businesses can save up to $1,000 in energy costs (more in the Interior)
- Communities without access to natural gas will benefit from Rural Energy Fund



Not all Alaskans use natural gas. This table converts the price of natural gas to other energy sources used in Alaska.

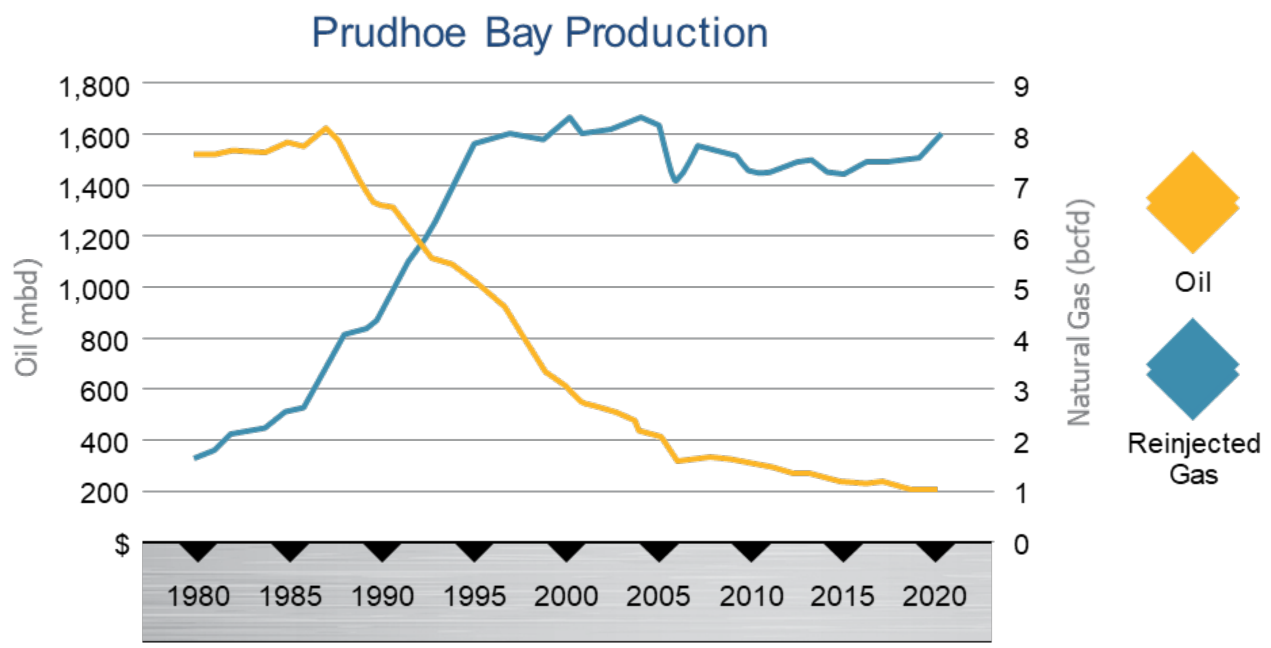
Natural Gas	Heating Oil	Electricity
$/MMBtu	*$/gal*	*$/kWh*
5.00	0.69	0.02
10.00	1.38	0.03
15.00	2.07	0.05
20.00	2.76	0.07
25.00	3.45	0.09
30.00	4.14	0.10

* Source: Energy Information Administration

Alaska Resource Use

ALASKA GASLINE DEVELOPMENT CORP.

Revenue from gas sales will offset declining oil revenues



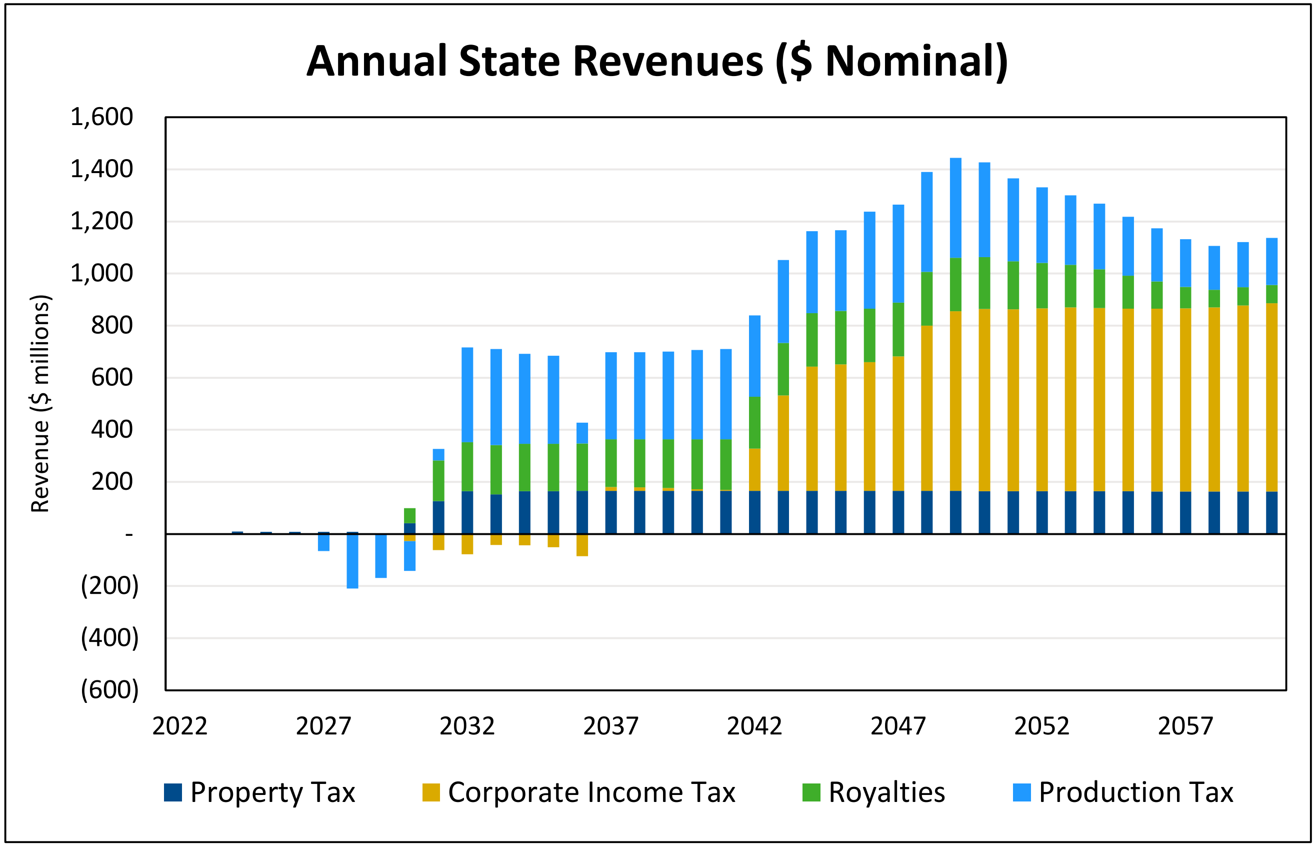
Project maximizes use of existing oil and gas infrastructure

- Upstream infrastructure and large-scale production facilities are already in place on the North Slope

Alaska LNG: New State Revenue

ALASKA GASLINE DEVELOPMENT CORP.

Significant revenue generated by Alaska LNG, even with no State of Alaska investment in construction.



State of Alaska Department of Revenue Analysis (April 2023)

**Does not include AGDC revenue from return on investment-to-date or future State investments.*

Alaska LNG Investment

ALASKA GASLINE DEVELOPMENT CORP.

- AGDC is seeking private investors to take Alaska LNG through Front-End Engineering and Design (FEED) and to a Final Investment Decision (FID)
- Goldman Sachs is under agreement to raise investment capital for Alaska LNG
- AGDC is targeting approximately $150M development capital to get to FID
  - 3rd Party FEED costs, project management, legal/commercial, 8 Star Alaska overhead
  - Investors will receive majority interest in 8 Star Alaska and Alaska LNG
- Capital Raise Process:
  - Goldman Sachs has set out a structured capital raise process and leading financial investment engagement
  - Goldman Sachs is only engaging with investors with the financial strength and expertise to advance the project

Alaska LNG CIM (Confidential Information Memorandum)

- Developed by Goldman Sachs
- Distributed to potential investors under confidentiality agreements
- Contains 60+ pages of detailed financial projections, commercial status, and investment terms

Alaska LNG Execution Strategy

AGDC's Role: Transition to Private Investors

- AGDC is seeking qualified partners and investors to advance Alaska LNG to FID
- AGDC created the project company 8 Star Alaska, LLC (8 Star) to function as the parent company of the project
- AGDC is transitioning Alaska LNG assets under 8 Star and is selling 75% equity ownership of the company to investors in exchange for taking the project to FID
- AGDC will retain a 25% carried interest in 8 Star

8 Star's Role: Manage Alaska LNG through FID

- 8 Star will be managed by private investors with AGDC being a minority owner
- 8 Star will be the project manager and retain oversight of all 3 aspects of the project through to FID
- 8 Star ownership is likely to consist of one "lead party" with other strategic partners owning minority stakes
- At FID, 8 Star will raise the construction capital for each of the three project subcomponents

Now → **After Investment**

Investment Highlights

ALASKA GASLINE DEVELOPMENT CORP.

1. **Significant Recent Tailwinds Driving Project Towards FID**
Combination of US government support, macroeconomic factors driving demand for LNG and long-term North Slope E&P operators underpins attractive outlook for Alaska LNG development

2. **Abundant Stranded Gas Reserves with no Commodity Linkage**
Significant volume of low-cost gas with no link to volatile commodity prices or need for fracking

3. **Proximity to Asia Reduces Cost of Supply and Transportation Bottlenecks**
Short shipping route, direct to Asian markets minimizing shipping (only 7-9 days)

4. **Most Economic North American LNG Project**
Delivered cost of supply is competitive with other pre-FID projects globally, targeting $6.50 per MMBtu delivered to Asia

5. **Offtake Agreement Flexibility Will Spur Contracting Momentum**
Low cost of supply and lack of commodity linkage enables pricing structure flexibility for offtakers

6. **In Discussions with World-Class Partners**
Group of IOCs, pipeline specialists, upstream operators, and LNG offtakers

7. **Significant Existing Value from Regulatory Approvals, Permitting and Due Diligence**
Major government approvals obtained including FERC Order, DOE export license, Corps of Engineers wetland permit, air permits for both major facilities, and lease / Right of Way agreements covering ~93% of the Project footprint

8. **Attractive Pre-FID Returns**
Significant project tailwinds towards FID with potential to unlock significant value for pre-FID equity

9. **Leading Low-Carbon LNG Profile**
Amongst the leading projects globally for low-carbon emissions, access to world-class potential Carbon Capture and Sequestration (CCS) and a ready opportunity to expand into hydrogen

10. **Local Support Incentivizing Project Development**
Alaska LNG has strong local support, Alaska Native land claims resolution, and commercial relationships with Alaska Native Corporations

Utility Supply Agreement

ALASKA GASLINE DEVELOPMENT CORP.

- AGDC offered agreements to Alaskan utilities that will ensure they receive gas supply on preferential terms from Alaska LNG.
- These agreements are with 8 Star Alaska, LLC and will bind future investors in Alaska LNG
- Key Terms
  - Alaska utilities will be provided natural gas from Alaska LNG on priority terms to supply residential, commercial, and small industrial customers
  - The price will be no higher than that paid by the LNG facility for natural gas supply (lowest cost possible)
  - In the event of an interruption, Alaska utilities will be prioritized over LNG exports
  - Ensure utility demand growth up to 500 MMcfd, over 2x growth
  - Ability to adjust take-or-pay commitments in response to changes in demand or new renewable sources of energy

Alaska Affordable Energy for Rural Alaska

ALASKA GASLINE DEVELOPMENT CORP.

- Required by Alaska Statute 37.05.610
- The purpose is to provide a source of funds for appropriation to develop infrastructure to deliver **energy** to areas of the state that do not have direct access to the Alaska LNG pipeline
- The Alaska Affordable Energy Fund is to receive an annual deposit of 20% of state royalty revenue after paying into the Permanent Fund

Gas Sales Agreement – Producers

ALASKA GASLINE DEVELOPMENT CORP.

- Investors have identified that gas supply terms are needed prior to investing development capital
- Securing these agreements is a top priority for AGDC
- Need for gas supply terms has been communicated to the Producers
  - DOR Commissioner Crum and DNR Commissioner Boyle joined meetings to stress the importance of the project to Alaska
  - Goldman Sachs joined meetings to communicate investors' views on the importance of gas supply
- AGDC has transmitted gas supply precedent agreements to Producers
  - 8 Star Alaska, LLC is the buyer in the agreements so it will be binding on future investors
  - Establishes, price, term, volume, and commitment to buy and sell gas
  - Fully-termed gas supply agreements will be negotiated by the private project developer prior to FID
  - Mixed level of engagement from the Producers

LNG Sales Agreements

ALASKA GASLINE DEVELOPMENT CORP.

- Active negotiations with multiple LNG offtakers/buyers are underway
  - Negotiations are fairly advanced with ongoing price discussions
  - Buyers include traditional Asian utility buyers, LNG traders, and oil and gas companies
  - All buyers are credit worthy and large-scale market participants
- Alaska LNG is uniquely able to offer a combination of prices
  - Brent-linked, Henry Hub, JKM, and fixed-price offering
  - 20-year term with an aggregate price floor that can cover system tolls and debt service
- Some buyers are considering “equity offtake” where they would invest in the project at FID in exchange for LNG supplied at cost
- In total, AGDC is currently in discussions for 125% of project capacity (25 MTPA)
- All conversations under confidentiality agreements

In Summary – Alaska LNG...

ALASKA GASLINE DEVELOPMENT CORP.

Increases Production:

- Provides infrastructure to get stranded gas to market
- Provides another 30+ years of North Slope production and increases condensate production
- Provides lower cost, clean-burning gas for Alaskans (no imports needed)
- Contributes to state revenue
- Provides bridge to ammonia and hydrogen production

Minimizes Impacts:

- Extensively scrutinized with multiple requirements to minimize impacts
- Maximizes use of existing infrastructure and resources
- Lowers global greenhouse gas emissions
- Uses existing corridors – TAPS, utility corridor, highway
- Regulated under strict U.S. and Alaska legal requirements

Energy Security – Alaska

ALASKA GASLINE DEVELOPMENT CORP.

- Cook Inlet gas supply is uncertain
- Utilities are evaluating potential alternative natural gas supplies
- Alaska LNG is the best option to replace Cook Inlet gas
  - Secure, low-cost supply for Alaskans
  - Alaska LNG will ensure priority natural gas supply for Alaskans

ANCHORAGE DAILY NEWS

Energy

Hilcorp warns Alaska utilities about uncertain Cook Inlet natural gas supplies

By Alex DeMarban
Updated: May 17, 2022
Published: May 17, 2022

Exhaust from the Southcentral Power Project in Anchorage is lit by the setting sun on Friday, Jan. 11, 2019. (Loren Holmes / ADN)

Officials with several Alaska utilities say they've been informed by Hilcorp that the company does not currently have enough natural gas reserves in Cook Inlet to provide for new gas contracts. Those contracts face renewal in the next two to 11 years.

Getting in Touch with AGDC

Contact Information

AGDC
http://www.agdc.us/
https://agdc.us/contact-agdc/

Alaska LNG
https://alaska-lng.com/
https://alaska-lng.com/contact-us/

Social Media
Twitter https://twitter.com/alaskalng
Facebook https://www.facebook.com/AKGaslineDevelopmentCorp
LinkedIn www.linkedin.com/in/alaska-gasline-development-corporation-607418245

Telephone
Phone: 907-330-6300
Toll Free: 1-855-277-4491

Post
3201 C Street, Suite 505
Anchorage, Alaska 99503

AGDC Common Acronyms

ACC	Arctic Carbon Capture
AFN	Alaska Federation of Natives
AGDC	Alaska Gasline Development Corporation
ANCSA	Alaska Native Claims Settlement Act
ANVCA	Alaska Native Village Corporation Association
AOGCC	Alaska Oil and Gas Conservation Commission
Bbl	Barrel
Bblsd	Barrels per Day
Bcf	Billion Cubic Feet
Bcfd	Billion Cubic Feet Per Day
BLM	Bureau of Land Management
CCS	Carbon Capture and Sequestration
CO2	Carbon Dioxide
CO2E	CO2 Equivalent
DOE	Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPC	Engineering, Procurement & Construction
FEED	Front End Engineering Design
FERC	Federal Energy Regulatory Commission

GTP	Gas Treatment Plant
HH	Henry Hub
Kbblsd	Thousand Barrels per Day
LNG	Liquefied Natural Gas
LOI	Letter of Intent
M3	Cubic Meters
MMBtu	Metric Million British Thermal Unit
MT	Metric Tons
MTPA	Million Tonnes Per Annum
NETL	National Energy Technology Laboratory
NPRA	National Petroluem Reserve Alaska
ROW	Right-Of-Way
TAPS	Trans-Alaska Pipeline System
Tbtu/yr	Trillion British Thermal Units per Year
Tcf	Trillion Cubic Feet
TPA	Tonne per Year

AGDC.us

ALASKA GASLINE DEVELOPMENT CORP.

ALASKA RURAL ENERGY: CHALLENGES & OPPORTUNITIES FOR REDUCING THE COST

Thursday, July 20, 2023, 11:00 AM – 1:00 PM

- Providing Electricity in Rural Alaska
- How is AVEC Doing?
- Standalone Rural Electric Utilities
- Challenges for Reducing Costs
- Intelligent Energy Systems

PROVIDING ELECTRICITY IN RURAL ALASKA

ALASKA ENERGY SECURITY TASK FORCE

JULY 20, 2023

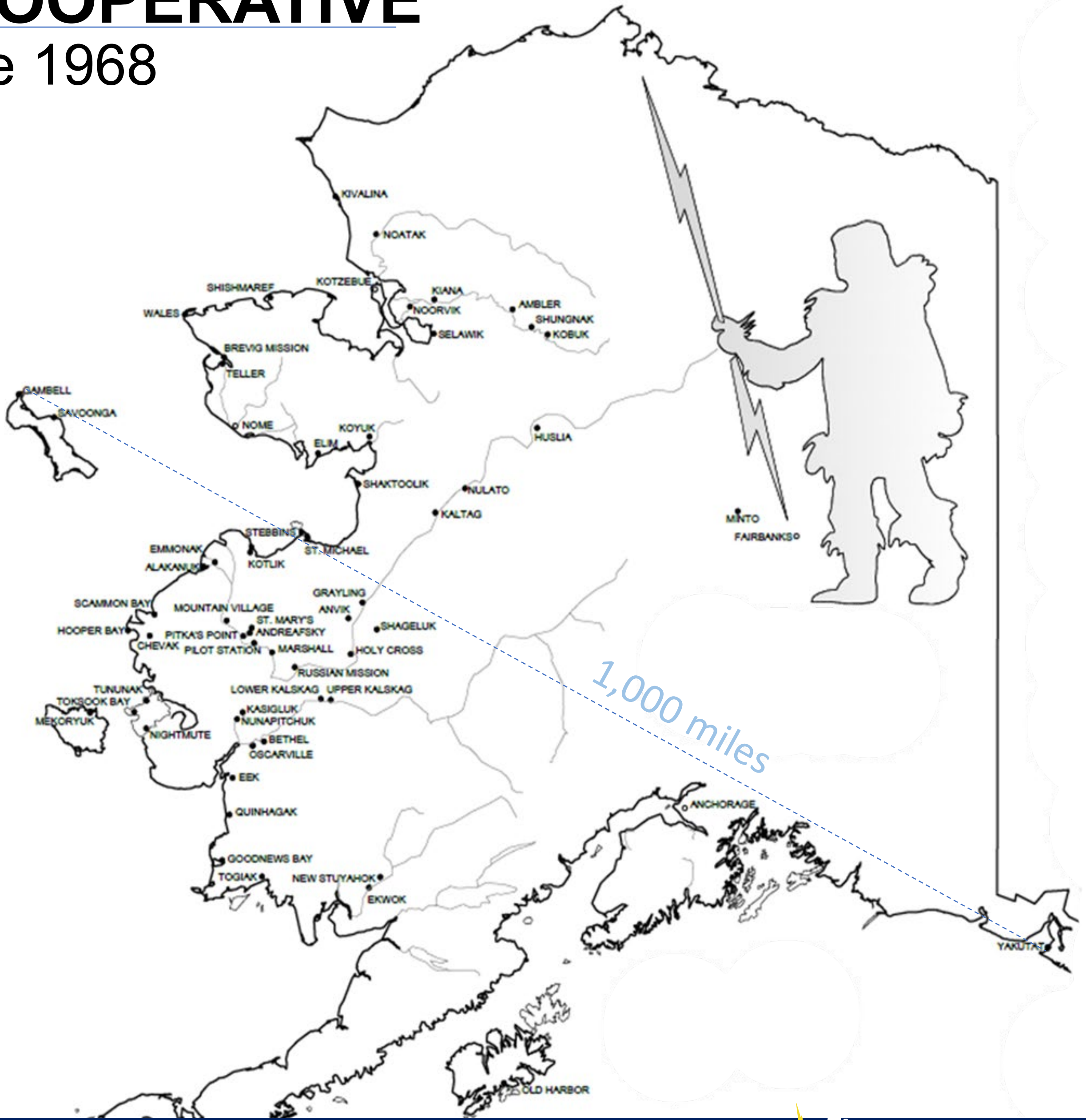
Kasigluk, AK

Alaska Village Electric Cooperative
Bill Stamm President & CEO

ALASKA VILLAGE ELECTRIC COOPERATIVE

Energizing Rural Alaska since 1968

- Nonprofit 501(c)12 -Electric Cooperative
- 8,300 Members, 11,500 Meters
- 58 Rural Communities, 31,000+ Residents
- 48 Power Plants, 160 Diesel Generators
- 9.1M Gallons of Diesel in 2022 ($35.3M)
- 515 miles of Distribution Lines, 4,752 Poles
- 12 Wind Sites, 32 Wind Turbines, Serving 20 Communities
- $60.7M Annual Revenue
- 2022 Total Electricity Sold 124.5 MWh







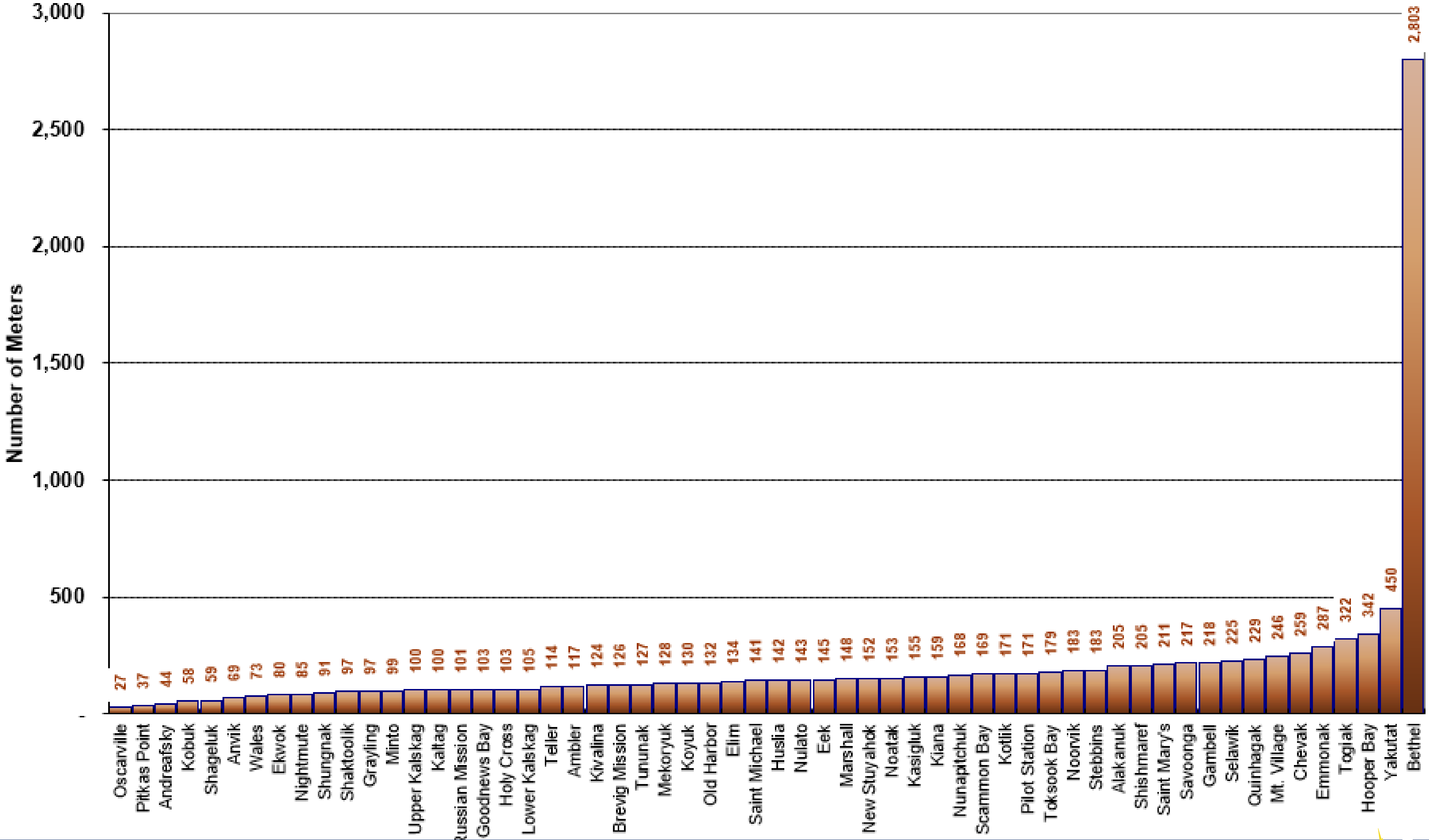




- 48 Full-time employees in Anchorage
- 24 Full-time travelling technicians
- 11 Full-time employees in Bethel
- 2 Full-time Operators in Yakutat
- 120 Part-time local Power Plant Operators

AVEC

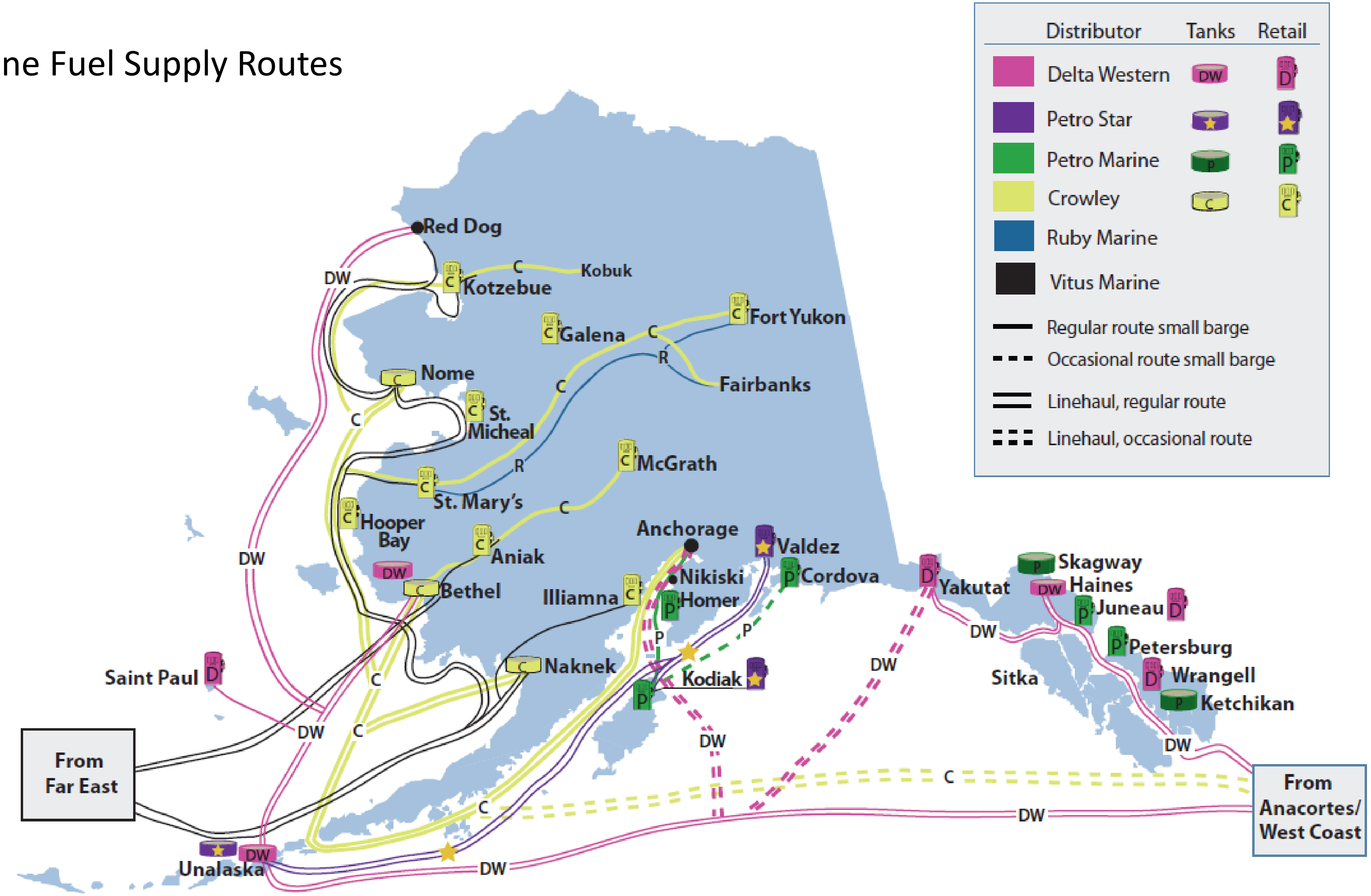
Relative "Size" of Community by Meter Count



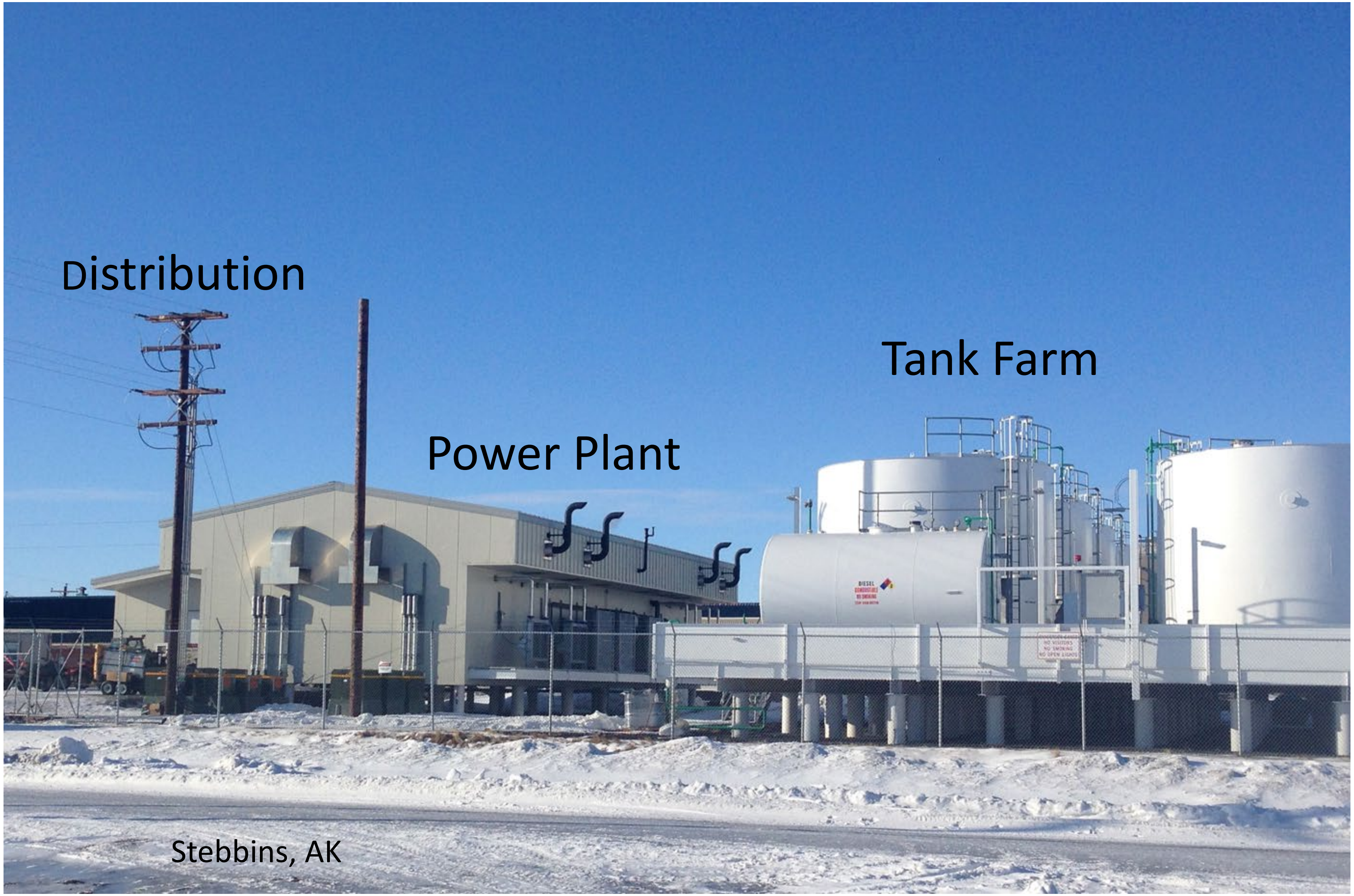
AVEC

Toksook Bay, AK

Marine Fuel Supply Routes



Components of Alaska Fuel Costs: An Analysis of the Market Factors and Characteristics that Influence Non-Railbelt Fuel Prices. 2010, Szymoniak, Fay, Villalobos-Melendez, Charon and Smith.


Distribution
Power Plant
Tank Farm
Stebbins, AK

Renewable Generation System-wide 2022

Net Wind Generation	4.5 MWh
Net Solar Generation*	0.2MWh
Total Renewable Gen	4.7MWh (5%)
Diesel Fuel Displaced (based on 13.7 kWH/gal)	343,000 gallons
Equivalent Cost of Diesel (based on $3.90/gal)	$1,338,000

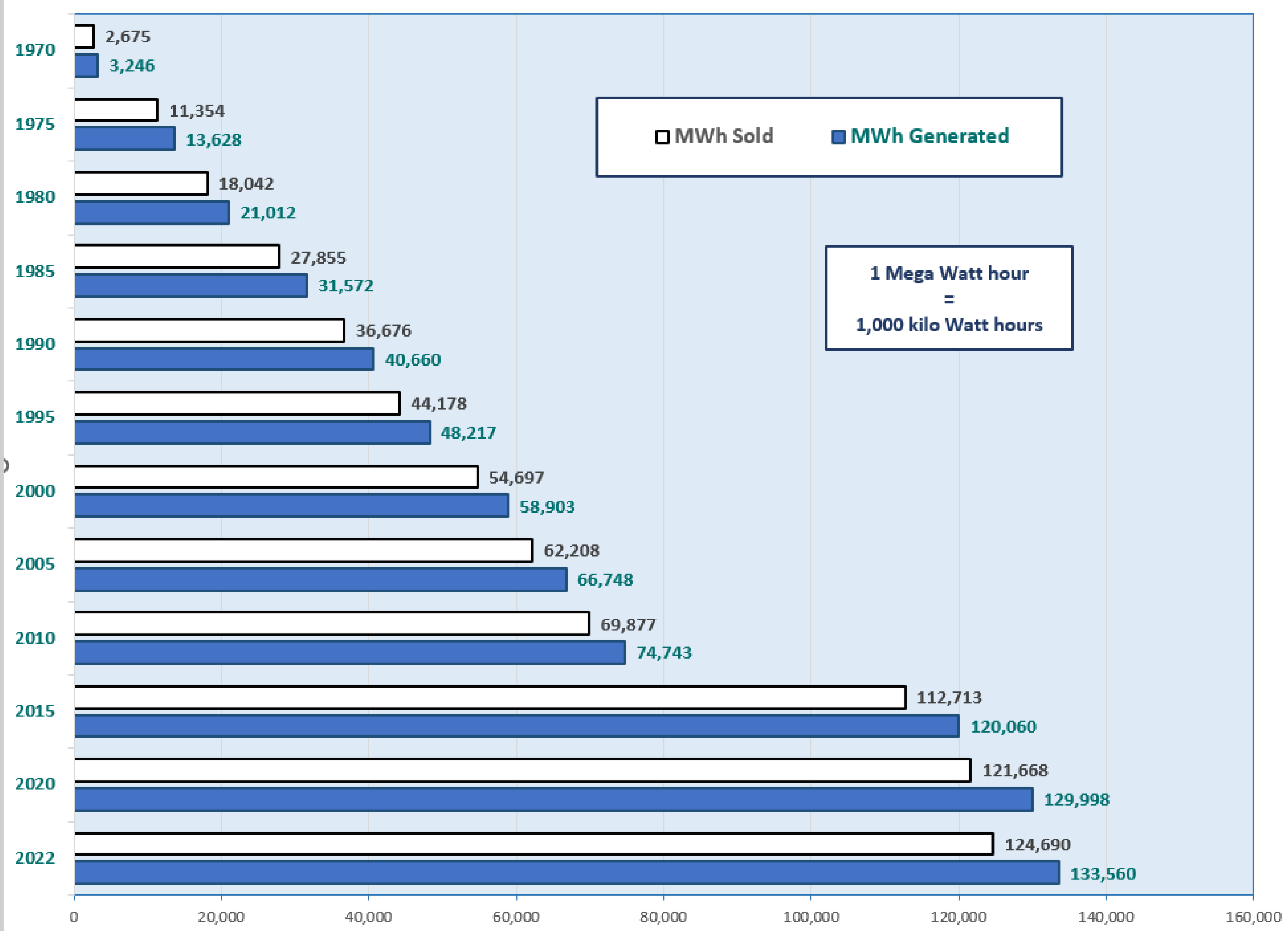
* Primarily due to Shungnak-Kobuk Solar IPP

Togiak

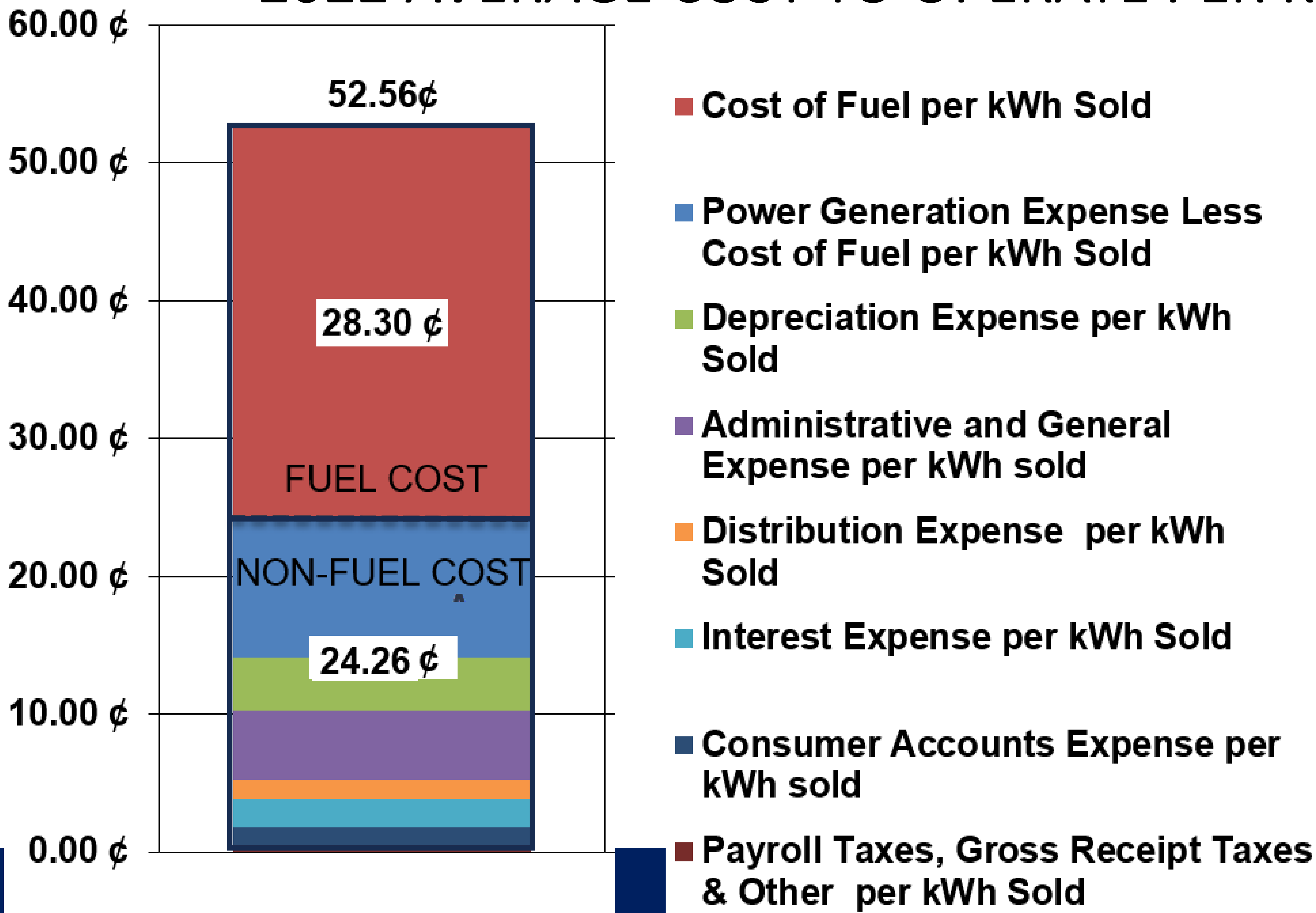
AVEC

POWER CONSUMPTION

- Steady load growth due to increased electrification and acquisitions since 1970
- Large step increase due to acquisition of Bethel in 2014
- Consistently low Line Loss, 6.6% in 2022
- Comparatively low power consumption for population size of 31,000 people.
  (< ½ of Juneau or Fairbanks)

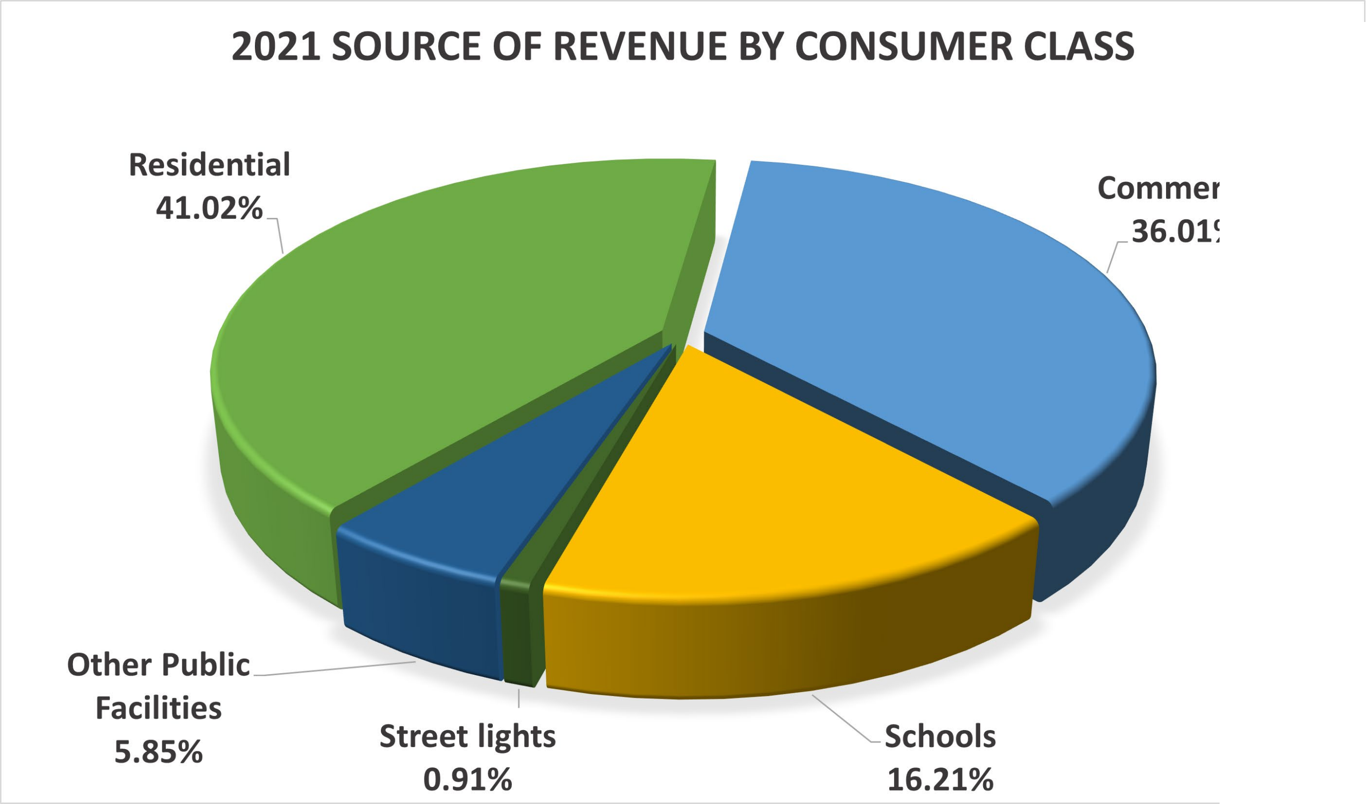


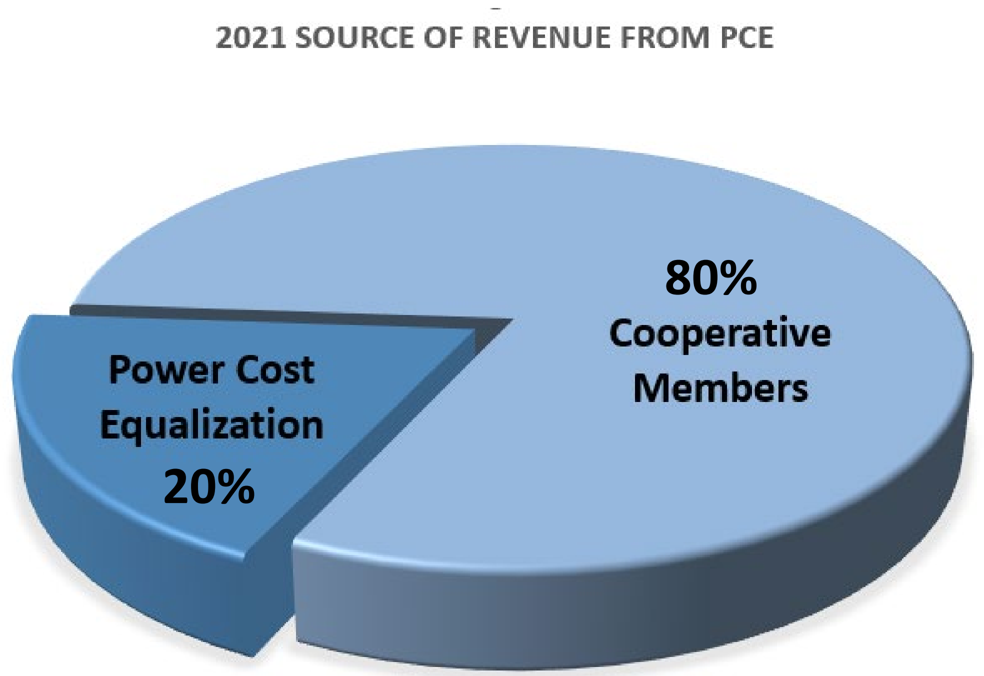
2022 AVERAGE COST TO OPERATE PER KWH SOLD



AVEC

Where the Money Comes From





Why is electricity expensive in rural Alaska?

- Small populations – AVEC's average village is ~400 people
- Small loads – AVEC's average village load is ~160 kW
- No economies of scale, minimal commercial and industrial loads

  (Expensive power = Less Development)
- Utilities are capital intensive; require lots of physical plant
- Isolated systems - reliability relies on self-redundancy
- Remote and difficult to access, limited infrastructure, equipment, resources
- Fuel is expensive – diesel delivery and storage cost often exceeds purchase cost
- Operations and maintenance is more expensive, freight, travel, lodging, it all adds up
- Availability of qualified personnel is limited, especially as complexity increases

AVEC strategies to reduce power cost

- Improve generation efficiency whenever possible
- Minimize distribution losses whenever possible
- Interconnect villages to improve economies of scale
- Welcome cost-effective new communities
- Add renewables and energy storage where economically feasible
- Capture and sell recovered heat, excess wind energy
- Promote energy education, workforce development, and economic opportunity

St. Mary's Family of Projects

- 900kW EWT Wind Turbine and Distribution Upgrades
- 20 Mile Intertie to Mt. Village
- 410,000-gallon Bulk Fuel Storage
- 3MW Power Plant
- GBS Energy Storage (2023)

Thank You,

AVEC

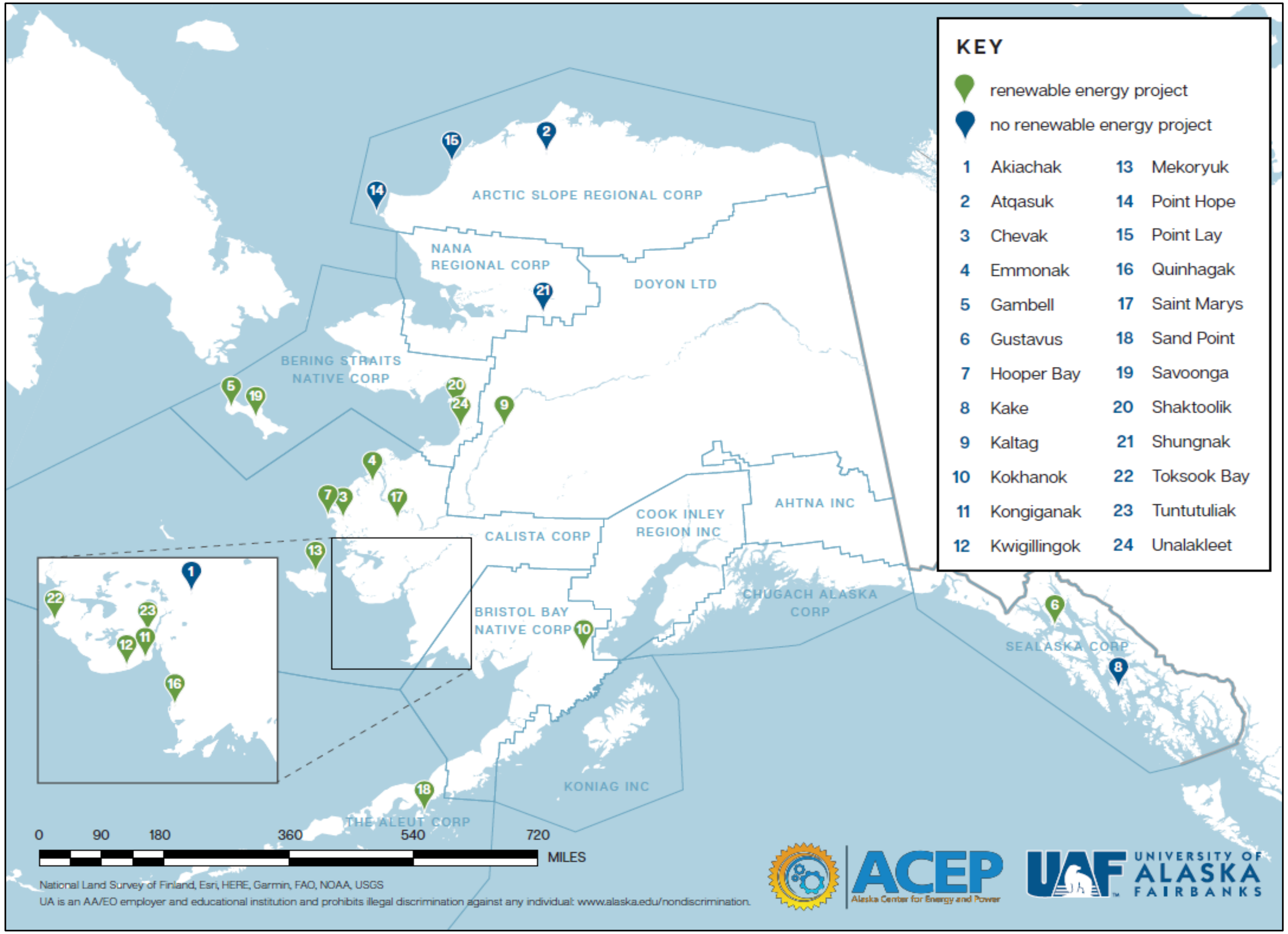
How is AVEC doing?

Bethel Census Area Communities (excluding Bethel)

11 AVEC Communities (median number of residents = 377)

14 Independent Communities (median number of residents = 441)

Pathways to Renewable Energy Development



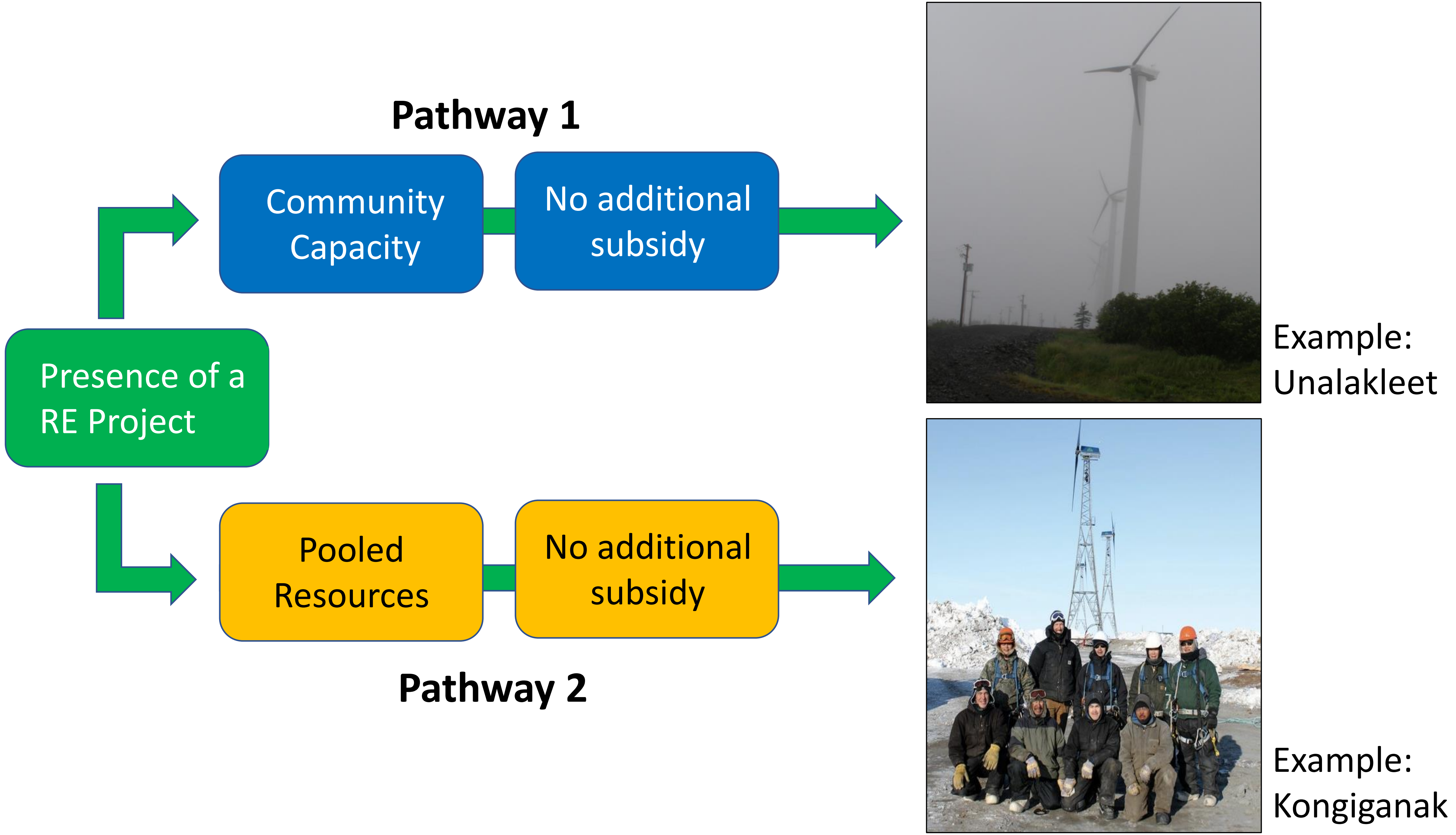
- 37 conditions/factors analyzed using qualitative comparative analysis
- 24 communities included in the analysis
- 3 explanatory factors: high capacity, pooling of resources, no additional subsidy beyond PCE

		Economic	Technological	Social	Political	Environmental	Infrastructural
Screening Criteria	Community is eligible for PCE subsidy	●		●	●		
	Community has economically viable renewable energy resource		●			●	●
	Community is not a regional hub but has >100 residents	●		●	●		
Utility Ownership	Utility ownership type (community or private)			●	●		●
	Membership in the Alaska Village Electric Cooperative				●		●
	The utility shares or pools resources across multiple communities	●		●	●	●	
	Partial or total postagestamp rate[a]	●					●
Power Costs	Fuel price paid by utility for diesel ($)	●					
	Annual total fuel costs	●					
	The average fuel cost per kilowatt hour ($/kWh)	●					
	The average nonfuel cost per kWh ($)	●					
	The cost to generate 1 kWh of electricity before subsidies[b]	●					
	The residential rate for 1 kWh (of electricity) after subsidies	●					
	The commercial rate for 1 kWh after subsidies	●					
Community Power Sales	Total annual electricity sales in kWh		●				●
	The average number of kWh sold to residential customers	●	●				
	Total annual residential electricity sales in kWh		●				●
	The number of the utility's residential customers			●	●		
	Industrial anchor tenant in community is purchasing electric from the local utility			●		●	●
Subsidy	Total PCE eligible kWh sold by the utility		●				●
	The non-PCE eligible kWh sold by the utility		●				●
	Percentage of total kWh sold that are not eligible for PCE		●				●
	The community has an additional subsidy (beyond the PCE)	●		●	●		
Community Capacity	The number of residents in the community			●	●		
	The number of community facilities eligible for PCE			●	●		●
	% of qualifying facilities (i.e., >20 % eligible for PCE subsidies)	●		●	●		
	The % of kWh claimed under the PCE program			●	●		
	The total number of PCE eligible kWh for a community			●	●		●
	Community capacity (as a fuzzy variable)	●		●	●		
Regional Government	The community is located in an organized borough			●	●		
	Total residents in the borough, including remote & non-remote communities			●	●		
	Total number of remote communities within borough			●	●		
	Total tax revenue collected by the borough in 2015	●		●	●		
	Median household income in area (borough)	●		●			
Poverty	Poverty levels (% of residents under the poverty line)	●		●	●		●
	Utility costs to average household income (ratio)	●		●	●		●
	Average household income in the community[c]	●		●			

[a] Whether the community has a partial or total postagestamp rate. Inside Passage Electric Cooperative (IPEC) communities have a total postage stamp rate, while Alaska Village Electric Cooperative communities only have a postage stamp rate for non-fuel costs.

[b] The cost to generate 1 kWh of electricity before utility and end-user subsidies have been applied.

[c] Based on census data [50].


Pathway 1
Community Capacity
No additional subsidy
Presence of a RE Project
Pooled Resources
No additional subsidy
Pathway 2
Example: Unalakleet
Example: Kongiganak

Analysis of AVEC's Performance

Statistically significant variables:

1) Delivered cost of fuel
2) Non-fuel costs
3) Line loss (kWhs of electricity produced but not sold)
4) Diesel efficiency
5) Non-PCE rate ($/kWh)
6) PCE rate ($/kWh)
7) Proportion of available PCE credits for qualifying community facilities used

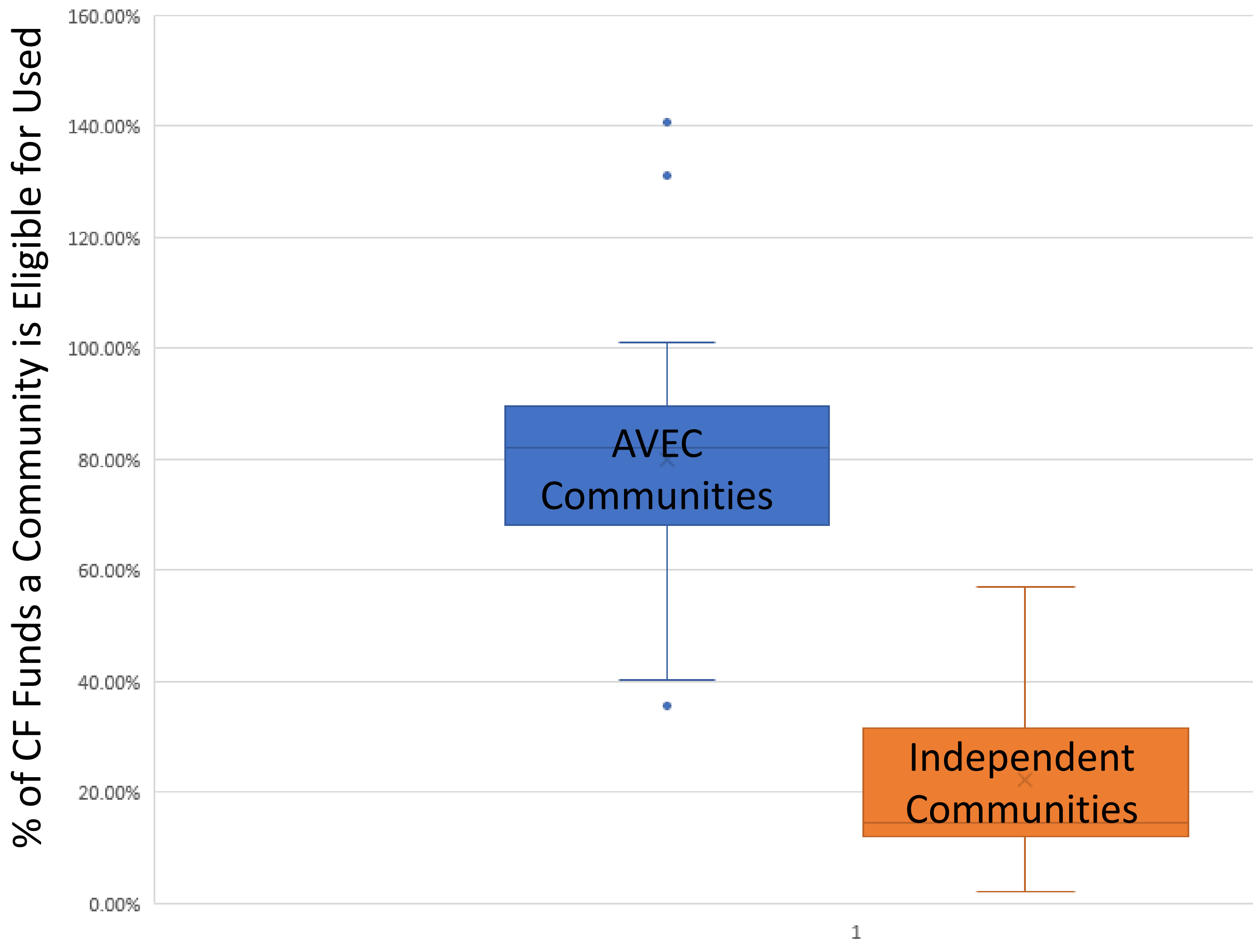
Variables – Statistically Significant

	AVEC (avg)	Independent (avg)	Difference
Line Loss (%)	4.49	8.78	4.29%
Fuel Cost ($/gal)	2.89	3.11	$0.22/gal
non-Fuel Cost ($/kWh)	0.21	0.27	$0.06/kWh
Fuel Efficiency (kW/gal)	13.4	11.97	1.43 kW/gal
Subsidized Rate ($/kWh)	0.25	0.32	$0.066/kWh
Unsubsidized Rate ($/kWh)	0.52	0.66	$0.14/kWh

PCE-Eligible Community Facilities

The PCE Program allows communities to apply a subsidy to power used by community facilities such as the washeteria, tribal hall, street lights or water/sewer treatment plant

The maximum allowable sales eligible for the PCE credit (70 kWhs/month/resident)



References (published)

Renewable Energy Integration in Alaska's Remote Islanded Microgrids: Economic Drivers, Technical Strategies, Technological Niche Development, and Policy Implications

by Holdmann, Wies, Vandermeer. Published in Proceedings of IEEE (2019):

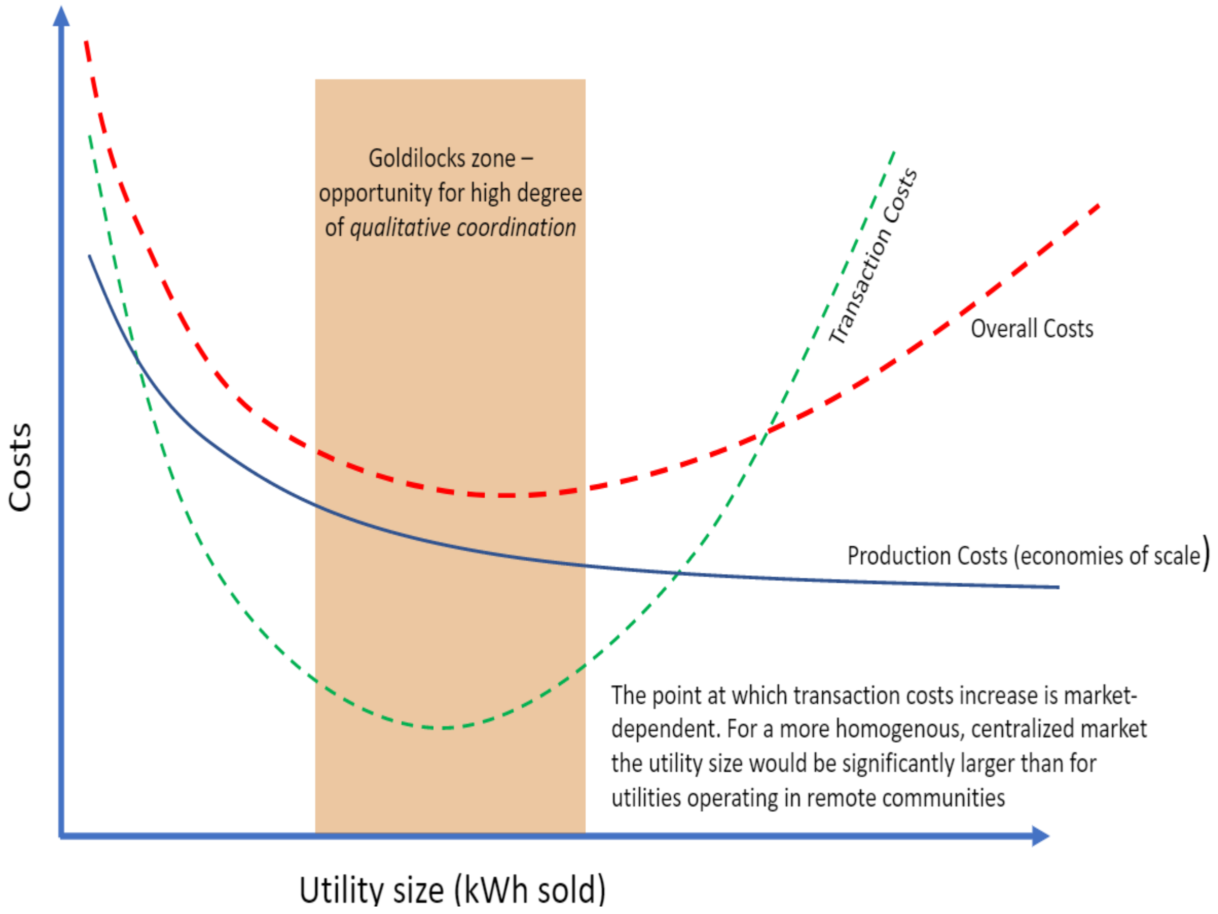
https://ieeexplore.ieee.org/document/8801901

Critical pathways to renewable energy transitions in remote Alaska communities: A comparative analysis

by Holdmann, Pride, Poelzer, Nobel, Walker. Published in Energy Research and Social Science (2022):
https://www.sciencedirect.com/science/article/abs/pii/S221462962200216X

References (to be published … soon)

- Case History of the Alaska Village Electric Cooperative
- Does Ownership Matter: Quantitative Analysis of AVEC's Performance
- Goldilocks Zone: Balancing Local Control Versus Economies of Scale in Remote Rural Electricity Utilities



Standalone Rural Electric Utilities

Municipalities and Tribes may choose to retain ownership/operation of the community electric utility because:

- The Council, with community input, gets to determine how the utility will make power and run the utility. Or…
- It creates local jobs, including board/council seats that pay stipends for attending meetings. Or…
- The Council can control customer rates and payment plans. Or…
- A utility can be a source of revenue. Or…
- AVEC said no.

Challenges	Solutions?
Personnel – Finding and Keeping: • Utility clerk, power plant operators, meter readers • Diesel mechanic, electrician, lineman, bookkeeper • Hybrid power plants require high level of training for complex controls and equipment integration/repairs	• Detailed Job Descriptions • On-site training and pay enough hours to do the job right • Compensation commensurate with performance – evaluate annually • Bring in student interns (14+ can work in office, 16+ in power plant) • Partnerships with nearby communities • Tribal Consortium/Borough/ANCSA Corp ("loose" coop) - Assistance that doesn't require giving up local control • Hire high end consultants/technicians to do complex services on hybrid systems
High Costs – Extremely Low Sales • Lime Village (pop. 6) (utility has 15 R, 6 CFs, 1 C, 1 F/S) $1.77/kWh - $.76	• Self-generation? Utility consist of a repairman and fuel sales?
Collections – hard to collect from family and friends	• Pre-Pay Metering – limited stock remaining reserved for existing installations. AMPY system no longer in production.
Board Members must navigate complicated issues	• Board training

Standalone Rural Electric Utilities

Several do an exceptional job under tough circumstances - mostly due to the good fortune of having a motivated and devoted staff – and good partners. It doesn't matter how many people are left; it matters who is left.

Creative Solutions

Chaninik Wind Group – villagers help each other install wind turbines, install dual meter bases, and repair equipment whenever possible.

NWAB Independent Power Producers/Community Solar – Tribe/Community owns renewable generation and sell kWhs to the utility. The kWhs become a fuel cost and eligible for PCE with each fuel report. The utility's customer and PCE rates don't change much if at all, but the IPP can use the revenue to repair/replace/increase renewable energy generation.

Nikolski (pop. 41 and growing) – Use Power Plant Operator Pairs (1 woman and 1 man). Man does the generator work while the woman documents everything on the plant log.

Started with TDX Power training 3 pairs. Those folks trained 2 more pairs.

They pay someone in Anchorage to do administrative work for utility as none of them want to do that job.

Standalone Rural Electric Utilities

POWER COST EQUALIZATION BUTTS HEADS WITH RENEWABLE ENERGY

ONE EXAMPLE:

Puvurnaq Power Company – Kongiganak, AK. According to Manager Rod Phillip, PPC has reduced imported diesel fuel for village heat and power by 50% since installing (5) 100 kW wind turbines and Electric Thermal Stoves (ETS) that utilize excess wind kWhs to produce heat for residential customers.

The RCA included those excess wind kWhs when calculating the utility's PCE rate. This caused a decrease in the PCE rate. They further reduced the PCE rate by deducting the revenue (which sells for $0.10/kWh) from the utility's expenses when calculating their PCE rate.

PPC's PCE rate was only reduced by $0.03 this time, which seems a small difference - $22.50 on 750 kWhs. But it will become more significant with the planned addition of more wind turbines, more ETS, and EV charging.

Reducing diesel should be incentivized, not penalized.

Standalone Rural Electric Utilities

Connie Fredenberg
Utility Management Assistance
907-444-6220
conniefredenberg@mtaonline.net

Working hard to work myself out of a job.

Alaska Rural Energy: Challenges & Opportunities for Reducing Costs

Northwest Arctic Borough & NANA Regional

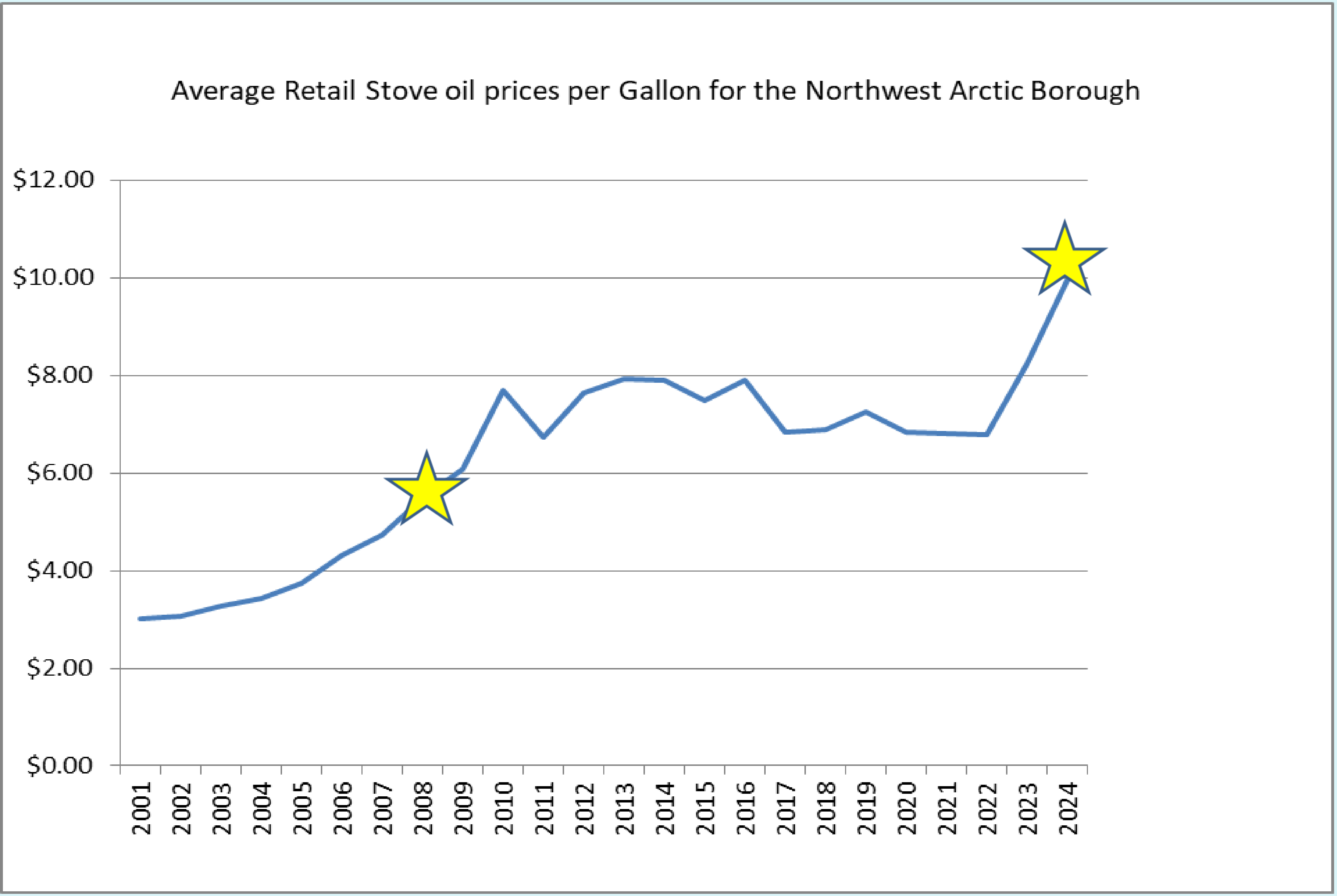
Public Private Partnerships & The case for Community – IPP's

Why are we here ?

Challenges

2008 Energy Summit

Brent Crude oil prices over time


Average Retail Stove oil prices per Gallon for the Northwest Arctic Borough
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

Fuel prices (tax included on retail) April. 2023 & FY24

Community	Gasoline $/G Retail	Stove oil $/G Retail	Sales Tax included	Util. & AVEC Cost $ Barge/Air FY2022- FY2023	NWABS Cost $ FY2023- FY2024
Kotzebue KIC and KEA	8.99	9.12	6%	3.71 KEA/ 3.20	4.54/4.7605
Kotzebue Vitus	7.99	7.57	6%		
Kotzebue Crowley	7.80	7.97	6%		
Ambler	14.42	14.42	3%	4.49 /11.50	6.07/6.2505
Kobuk	13.91	15.45	3%	N/A	6.07/6.2505
Shungnak	14.03	15.05	2%	5.45 / 11.50	6.07/6.2505
Kiana	7.98	7.73	3%	2.82/4.18	4.71/5.0005
Noorvik	7.21	6.18	4%	2.96/4.63	4.71/5.0005
Selawik	5.68	6.58	6.5%	2.854.52	4.71/5.0005
Buckland	7.65	7.66	6%	2.13-3.547	5.25/5.0005
Deering	5.50	5.20	3%	2.13-4.057	4.71/5.0005
Kivalina	6.52	6.52	2%	2.78/4.18	5.16/5.0005
Noatak	14.49	15.31	6%	8.10/10.75	7.24/10.96

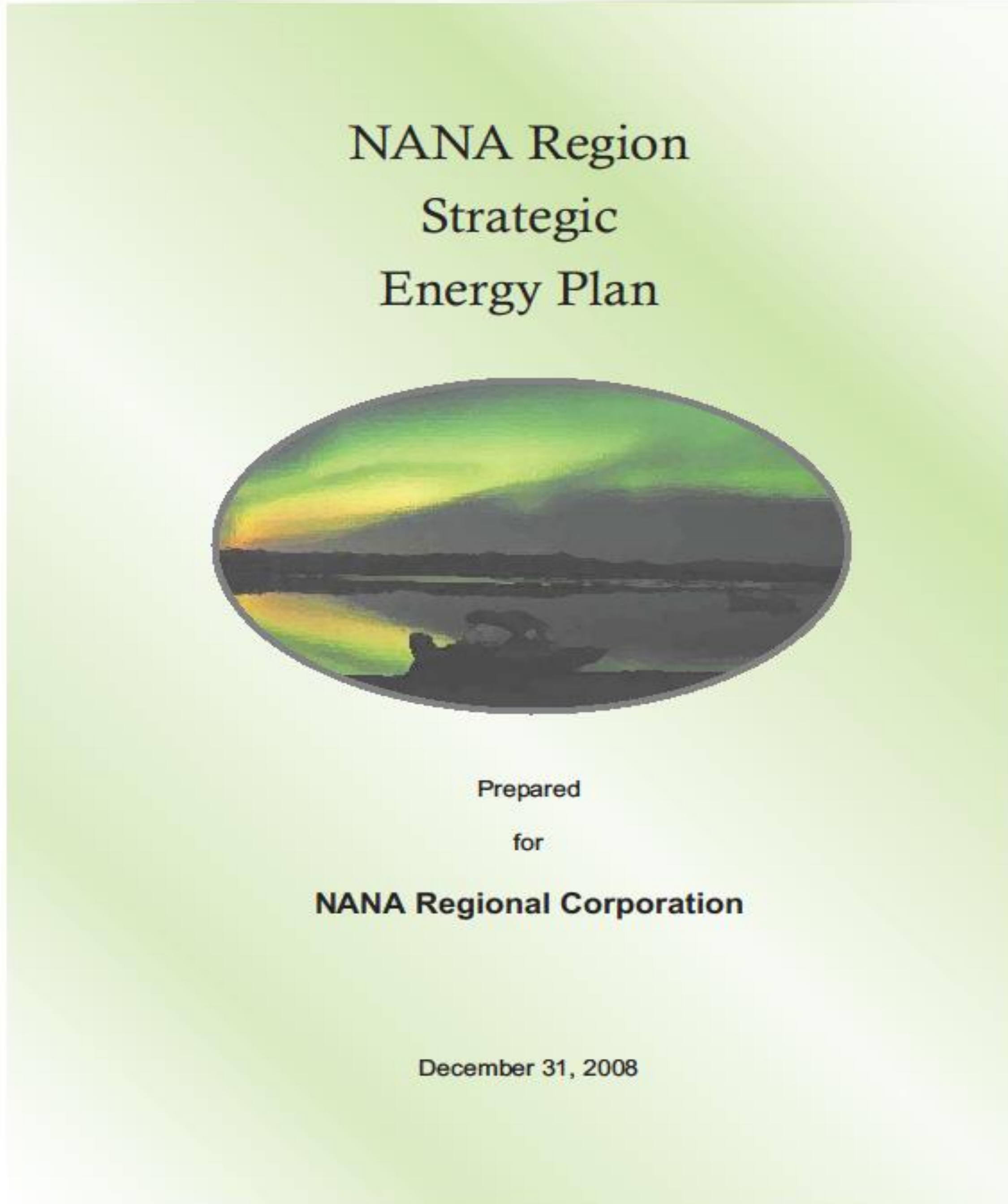
NAB Electric rates, Apr 6 2023

Community	1-750Kwh $/Kwh with PCE	Tax	1-750 Kwh Actual cost/Kwh with tax	0-750 $/Kwh No tax	750-up $/Kwh No tax	Utility Non firm power purchase rate $/Kwh 1/30/2023
Kotzebue KEA	0.2275	6%	0.24	0.3949	0.3918	N/A
Ambler AVEC	0.2651	3%	0.2731	0.8621	0.7566	0.3949
Kobuk AVEC	0.3348		0.3348	1.0988	0.9933	N/A
Shungnak AVEC	0.3348	2%	0.3414	1.0988	0.9933	0.6138
Kiana AVEC	0.2553		0.2647	0.6654	0.5599	0.2733
Noorvik AVEC	0.2545	4%	0.2647	0.6490	0.5435	0.2507
Selawik AVEC	0.2521	7%	0.2697	0.6027	0.4972	0.2053
Buckland BEC	0.2781		0.2781	0.4900	0.4900	0.2823
Deering IEC	0.4081		0.4081	0.6747	0.6747	0.3575
Kivalina AVEC	0.2535	2%	0.2586	0.6295	0.5240	0.2442
Noatak AVEC	0.3724	6%	0.3947	1.1364	1.0309	0.6682

2008

NANA Regional
11 communities

Kotzebue
Noorvik
Selawik
Kiana
Deering
Buckland
Noatak
Kivalina
Ambler
Shungnak
Kobuk



NANA Region
Strategic
Energy Plan

Prepared
for
NANA Regional Corporation

December 31, 2008

Northwest Arctic Energy Steering Committee

Co-Hosted & Sponsored by:

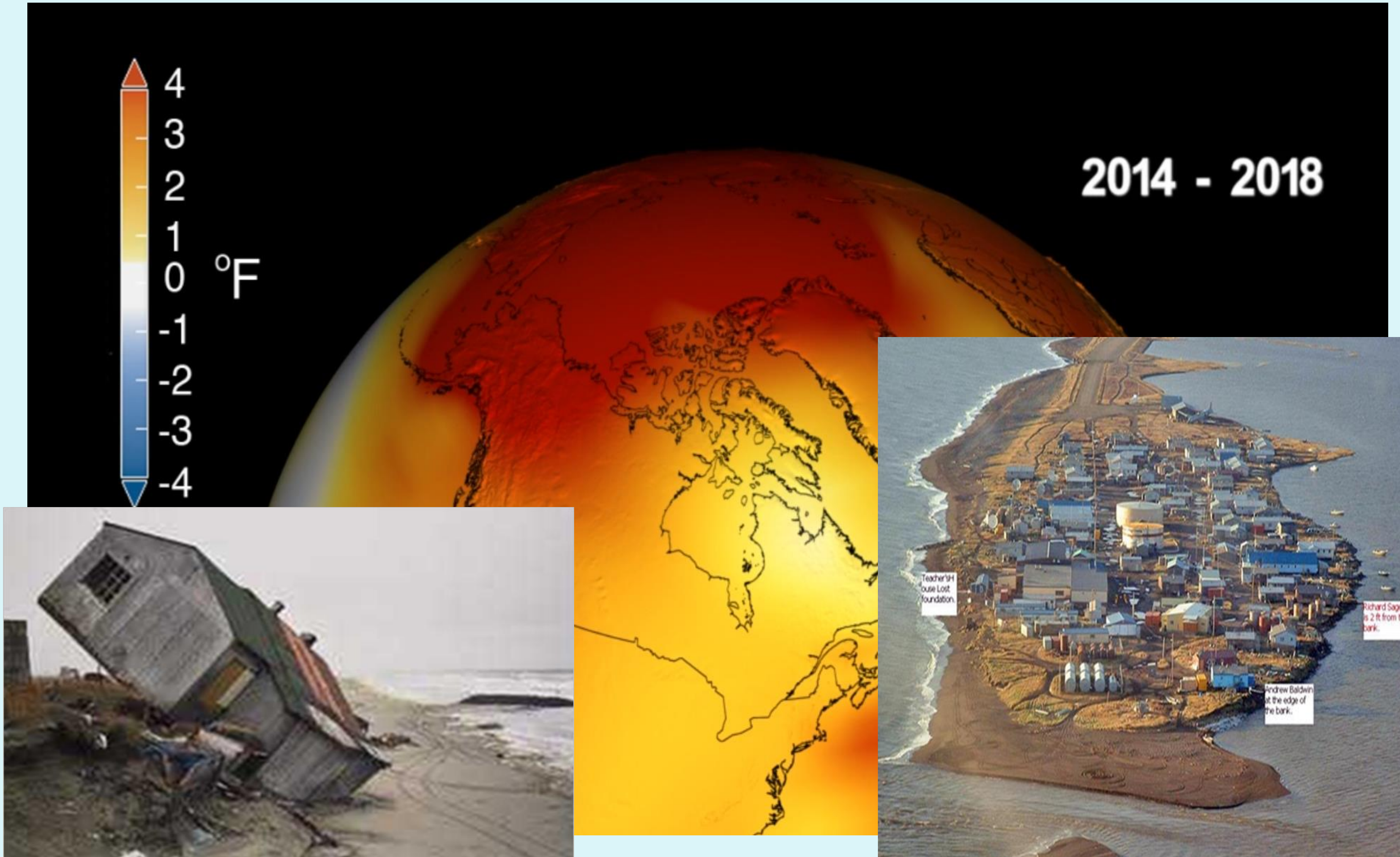
Northwest Arctic Borough – Energy Program

NANA Regional Corporation – Alternative & Village Energy Program

2009-2023

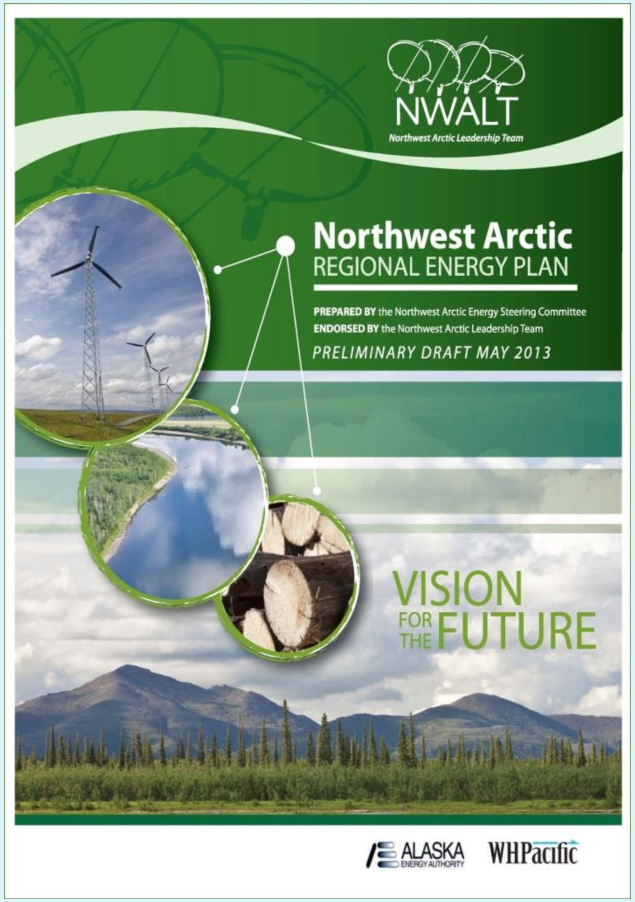
The Artic Warming up faster than the rest of the world

Climate Change Mitigation Plans was needed



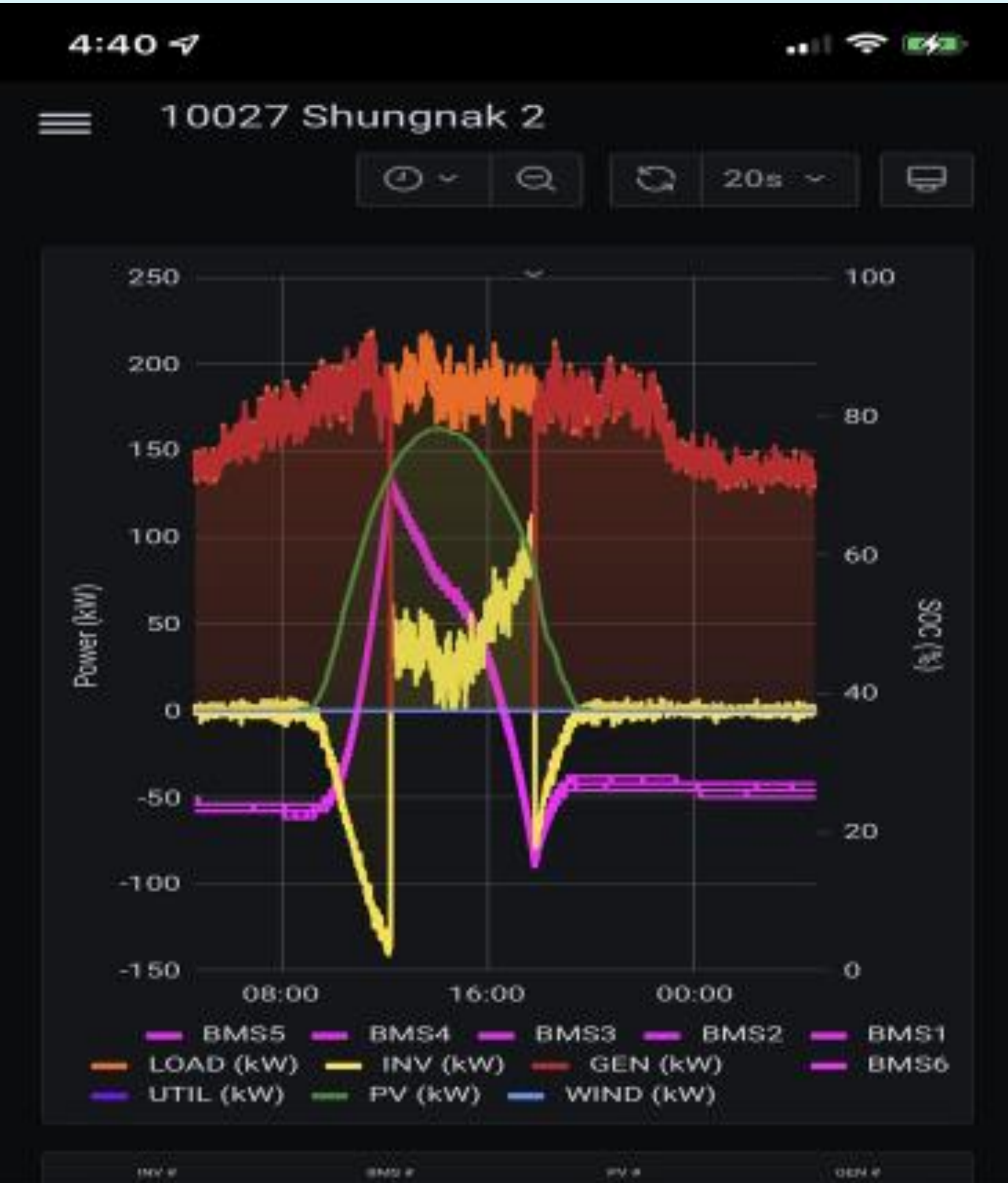
NANA-NAB Energy planning
Started in 2008-2009
Current version 2020
Available @Nwabor.org

The vision is for the Northwest Arctic region to be 50 percent reliant on regionally available energy sources, both renewable and non-renewable, for heating and generation purposes by the year 2050. And to combat rapid climate change due to greenhouse gas emissions like Co2, Methane and other harmful effects of fossil fuel usage.

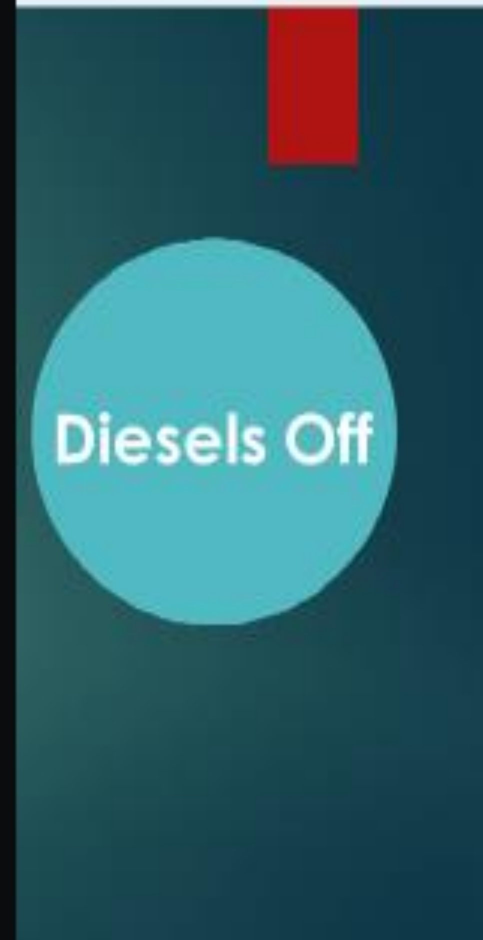


<u>The progression is planned as follows:</u>

10 percent decrease of imported diesel fuels by 2020
On track
25 percent decrease of imported diesel fuels by 2030
50 percent decrease of imported diesel fuels by 2050



To get there, we need to go;



Our Single Focus in 2008-2012

- To try to stabilize the cost of electricity by developing local energy resources as much as possible (Wind-Hydro) and possibly bring down cost/Kwh

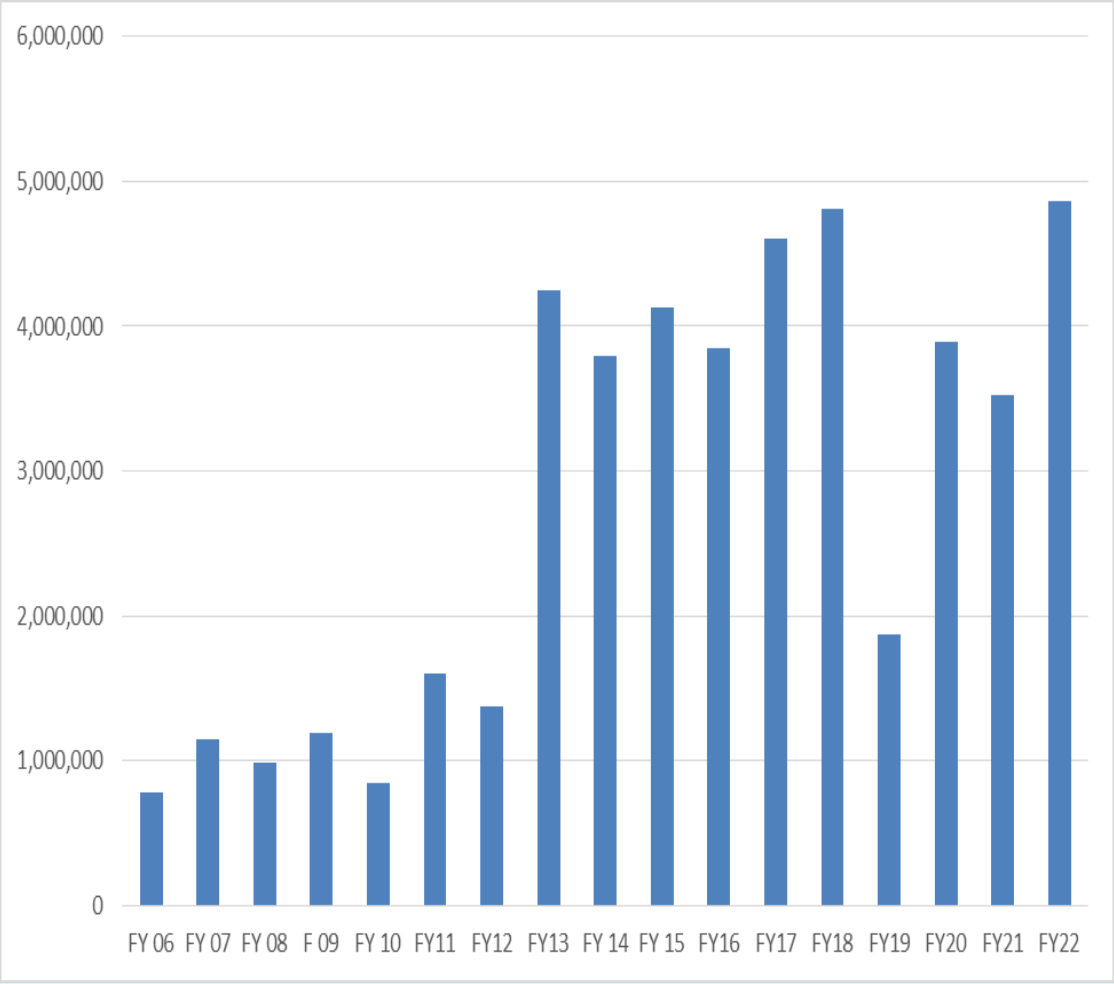
- Projects were funded and then implemented by Electric Utilities to offset the use of Diesel fuel.

- However, the cost to the Households $/Kwh, did not change in communities that receives PCE funding,
- Instead, as more Alternate Energy projects were built by grants, the allocation of PCE decreased to the communities.

2007-2012 Wind diesel projects

Wind projects and data

Kwh



	Total Kwh	Diesel Gallon saved	Value $ 3.75/Gallon
Selawik	1,158,985	82,785	$310,442.41
Buckland	1,105,121	78,937	$296,014.55
Deering	559,725	39,980	$149,926.34
Kotzebue	44,662,843	3,190,203	$11,963,261.52
Total	47,486,674	3,391,905	$12,719,644.82

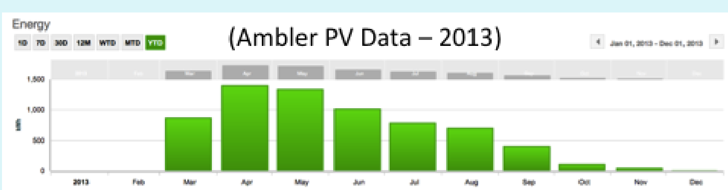
3.4 Mil Gallons of Diesel not needed

Independent Power producers shows up in Alaska
Fire Island

- September 2012
- The project started production in September 2012 and supplies approximately 2% of Chugach's retail load under a 25-year power purchase agreement with Cook Inlet Region Incorporated and its subsidiary Fire Island Wind LLC, who owns and operates the facility.

2012 NAB Synergy project over 10 Years has saved 50,000 Gallons

- Borough population: 7,810
- Electricity for village water / sewer plants
- Launched in Ambler, replicating across borough
- 10,000 kWh/year from 10 kW array
- Peak production April-July
- Long sunlight hours in summer + 30% reflection from snow-covered ground in spring

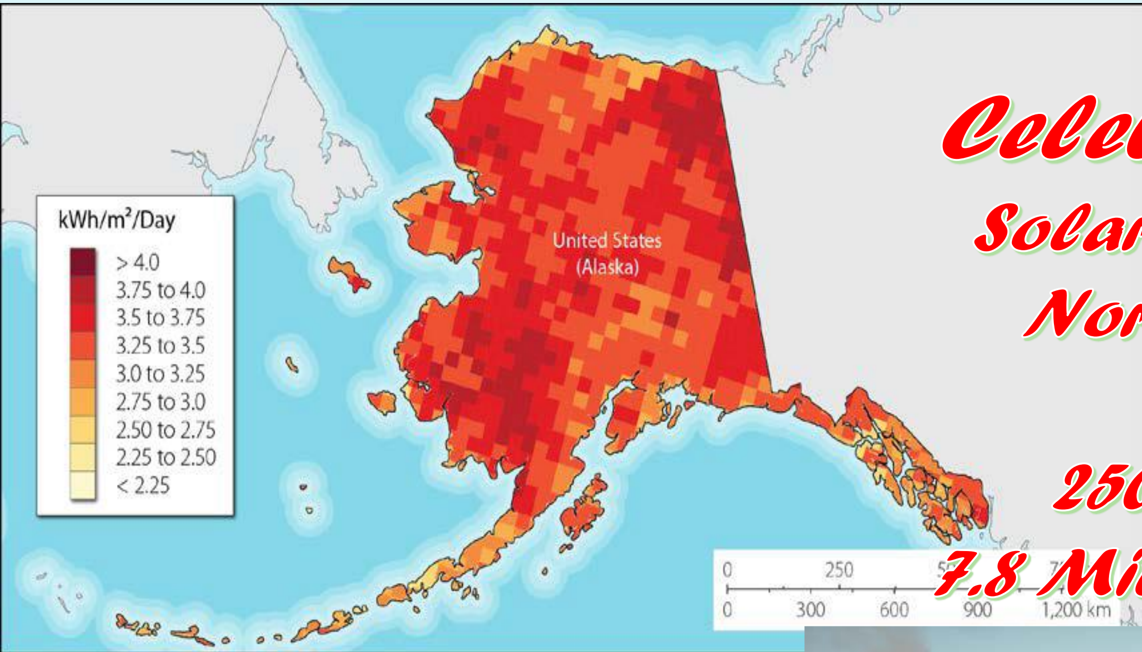


Powering water treatment facilities with renewable energy

Photos: Northwest Arctic Borough

2022

Celebrating 10 Years of
Solar PV development in the Northwest Arctic Borough
2013-2023
250,000 Gallons saved
7.8 Mil lb of CO2 not released



Approximate minimum value per year of behind the meter Solar projects at NAB Water plants due to PCE. Based on actual value for consumer.

	Installed Kw	Production Kwh	Value/Kwh	Value Per year
Ambler	8.4	8400	0.2547	$2,139.48
Kobuk	7.38	7380	0.2505	$1,848.69
Shungnak	7.5	7500	0.2555	$1,916.25
Noorvik	12	12000	0.2422	$2,906.40
Noatak	11.27	11270	0.2669	$3,007.96
Deering	11.13	11130	0.3575	$3,978.98
Kotzebue-1	10.53	10530	0.2180	$2,295.54
Kotzebue-2	10.53	10530	0.2180	$2,295.54
Selawik	9.72	9720	0.2478	$2,408.62
Kivalina	10.53	10530	0.2363	$2,488.24
Kiana	10.53	10530	0.2318	$2,440.85
Buckland	10.53	10530	0.2823	$2,972.62
Total	120.05	120,050		$30,699.17

Total Estimated savings per year

$ 30,699.17

However, the production is invisible to the utility, and no PCE is collected for it from AEA.

Value of utility size Solar arrays to the Households

Community	Installed Kw	Production Kwh	Behind meter PCE value / Kwh	Avoided Diesel rate $/Kwh	Value under IPP Management $/Kwh
Shungnak Ut	233	200,000	$51,100.00	0.5600	$ 112,00.00
Noatak Ut	275	250,000	$66,725.00	0.4868	$ 121,700.00
Noorvik Ut	23.4	23,400	$5,667.48	0.1685	$ 3,942.90
Deering Ut	48.5	48,500	$17,338.75	0.3500	$ 17,338.75
Buckland Ut	45.99	45,000	$12,703.50	0.2823	$ 12,703.50
Kotzebue Ut	966	920,000	$ 220,800.00	0.18	$ 165,600.00

July 2017
Noorvik 23 Kw Utility array 80 Mwh produced so far Saving 5,700 Gallons of Diesel so far

Nov 2018
Buckland & Deering Electric Utility Arrays 48.5 & 46 Kw 169 Mwh produced to date, saving 12,500 Gallons of Diesel so far

Courtesy
NANA

6/15/2020
Kotzebue Electric
Utility Array 576 Kw
Building out an additional 631Kw in 2023
822.47 Mwh produced to date,
saving 58,800 Gallons of Diesel

Courtesy
ANRI

9/26/2021
Shungnak-Kobuk IPP
233Kw/350Kwh Community Solar/Battery
273 Mwh produced to date,
Saving 19,500 Gallons of Diesel to date
And 818 Hours of Diesel off operation

Courtesy
ANRI

Transition to Village Independent Power Producers IPP's, 2020

- **So why develop Independent power producers**

- The Communities taking control of their Energy future, developing their local resources. This creates buy in and good relationships with the utility.

- Being able to sustain PCE support to the communities and stabilize energy cost.

- Better economics, Circular economy

- Funding collected pays for further development and local workforce expertise. The money stays in the community instead of sending the money to far off countries for oil.

Reasons for Regional approach to Alternate Energy Development

- *Regional* support to apply for and manage Energy grants, including access to Dept. of Energy and other funding.

- Economy of Scale and Increasing Efficiency
- (Small, single projects are too expensive).

- Develop Regional Energy infrastructure:
- Wind, Solar, Hydro, Interties, bulk fuel storage & direct Household involvement.

- Admin help for Independent power producers (IPP's) for PCE calculations, utility rates & billing.

- Job Creation - Workforce Development and Training/Capacity building.

- The Region speaking with one voice. Can advocate on behalf of PCE and State wide Energy Policy.

- This creates Energy Security and is needed to stop the increasing cost of Energy and hedge against fuel increases and supply disruptions.

The Shungnak Solar IPP Project

Shungnak-Kobuk 223.5 DC/200 AC Kw Solar/battery PV array.
Using 550pc Bifacial 405W panels

Blue Planet environmentally friendly LFP Battery.
Capable of holding the two communities for 2 Hours without Generators or Solar power.
Capacity 250Kw/352Kwh

Start of construction April 2021 completed Sep 2021.

Total project cost $ 2,363,215.11

Funded by USDA HECG @ $ 1,291,675.00
In-kind VIF and NAB funds $ 1,071,540.11

Shungnak-Kobuk Solar IPP example

- **A Grant opportunity from USDA HECG was secured by the 2 Tribes by allowing NAB to apply on behalf of the Communities.**
- **The communities are interconnected with a power line so the proposed Solar project benefits both.**
- **Through an MOA a working agreement is executed between the 2 tribes to become an IPP (independent power producer)**
- **A power purchase agreement is executed with the utility AVEC.**
- **AVEC pays for the Solar power and recover the cost partly from the PCE fund.**
- **Another MOA is executed with NAB for help with admin and investment of funds.**
- **An Energy fund is established for the communities.**
- **Funds dispersed for insurance and maintenance and eventual further build-out of the Solar array.**

Alaska Tribes Recognized with Sunny Award for Equitable Community Solar

Congratulations! The DOE Solar Energy Technologies Office awarded a Sunny Awards Grand Prize to the Shungnak-Kobuk Community Solar Battery Independent Power Producer project, in Shungnak, Alaska.

This solar and battery project led by the Shungnak and Kobuk tribes in the Northwest Arctic Borough region aims to stabilize the cost of electricity and allow the communities to take charge of their energy future. The Shungnak project also received the 2022 Microgrid Project of the Year from *Solar Builder* magazine.

Following suit: Among current Office of Indian Energy projects, the Northwest Arctic Burrough 2021 Project with the Native Village of Noatak is emulating the Shungnak project and is making progress on a high-penetration distributed solar-battery hybrid system.

A Loud Shout-out to all Partners; USDA, Shungnak IRA, Kobuk IRA, NAB, NANA, AVEC, TECK, ANRI, AGETO, Blue Planet, Deerstone, Daylight services, Launch Alaska & others that contributed to the success of the project

Shungnak-Kobuk IPP Yearly financials FY22

Estimated Gross Annual Revenue	$120,000.00
Insurance	$3,771.32
Electric	$1,958.05
Ageto service fee	$3,242.28
Tribe Employee	$8,683.44
Fuel	$3,150.00
Total Estimated Expenses	$20,805.09
Estimated Net Income	$99,194.91
Estimated Administrative Fee (10% Annual Net)	$9,919.49
Annual Income Less Admin Fee	$89,275.51

The Noatak Solar IPP Project 2023

Noatak 280.6 DC/250Kw AC Kw Solar/battery PV array phase 1.
Using 432 pc Canadian solar Bifacial 650 W panels
Expansion to 380.6 Kw available for phase 2.

Kronus/Pylontech LFP Battery 438.5 Kwh
Capable of holding the to communities for 2 Hours
without Generators or Solar power.

Construction Sep 2022 to July 2023.

Total project cost $ 2,946,886.00
Funded by DOE Tribal grant @ $ 2,008,765.00
Denali Commission $ 134,079.00
Teck (Red Dog) $ 100,000.00
NANA VEI and inkind $ 309,998.00
In-kind VIF and NAB funds $ 394,123.00

The Selawik Solar IPP and REPOP

Selawik 130kw DC/100Kw AC Kw Solar/battery PV array phase 1.
Using 200 pc Canadian solar Bifacial 650 W panels
Expansion to 500 Kw available for phase 2.

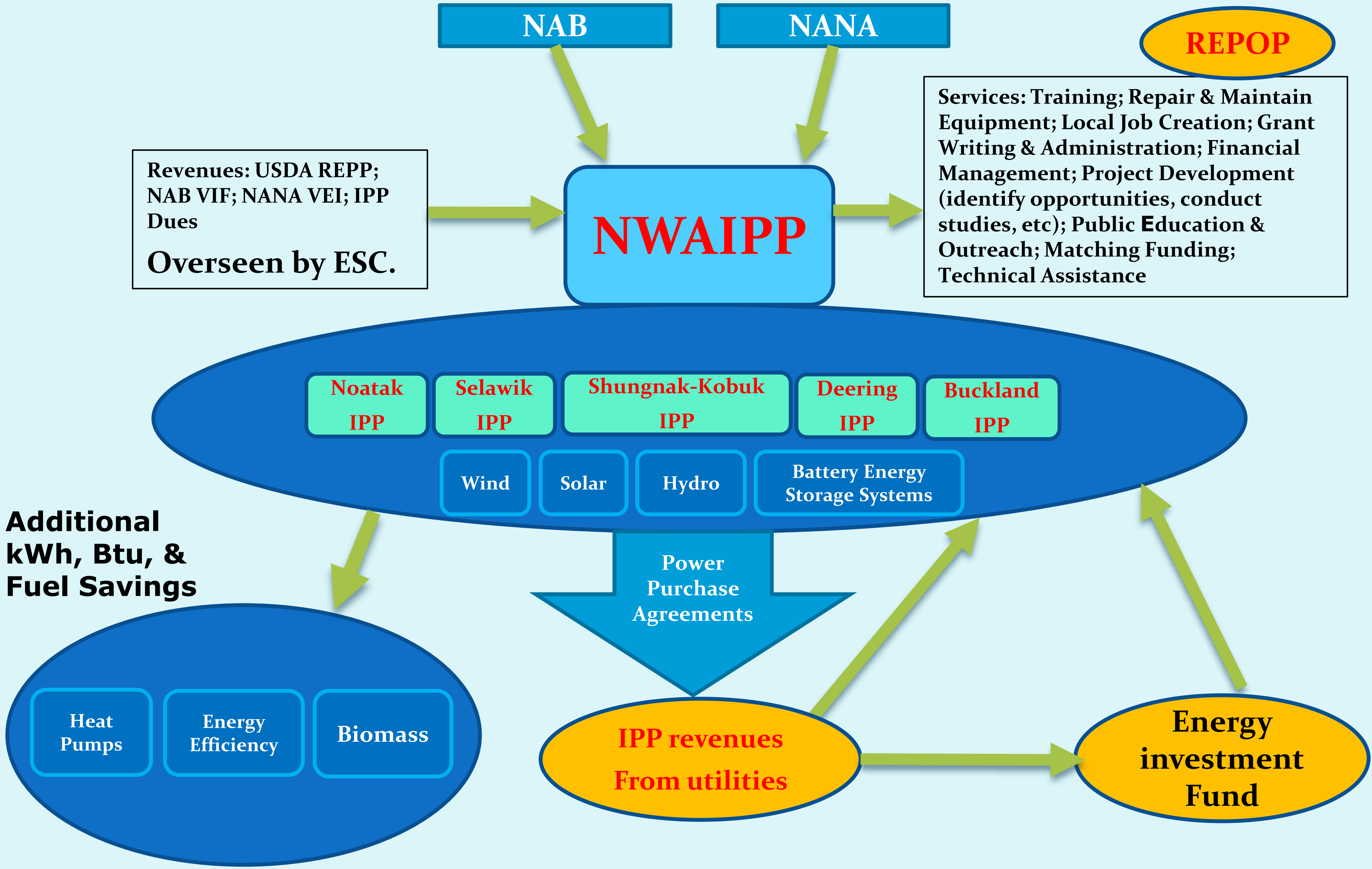
Blue Planet LFP Battery, 1 Mw
Capable of holding the to community for 4 Hours
without Generators or Solar power.

Start of construction Sep 2023 completion by July 2024.
Total project cost $3,611,190.00
Funded by USDA REPP @ $1,998,820.00
AEA REF 14 $ 250,000.00
AVEC $ 100,000.00
Teck (Red Dog) $ 100,000.00
NANA VEI and inkind $ 130,000.00
In-kind VIF and other NAB funds $ 1,032,370

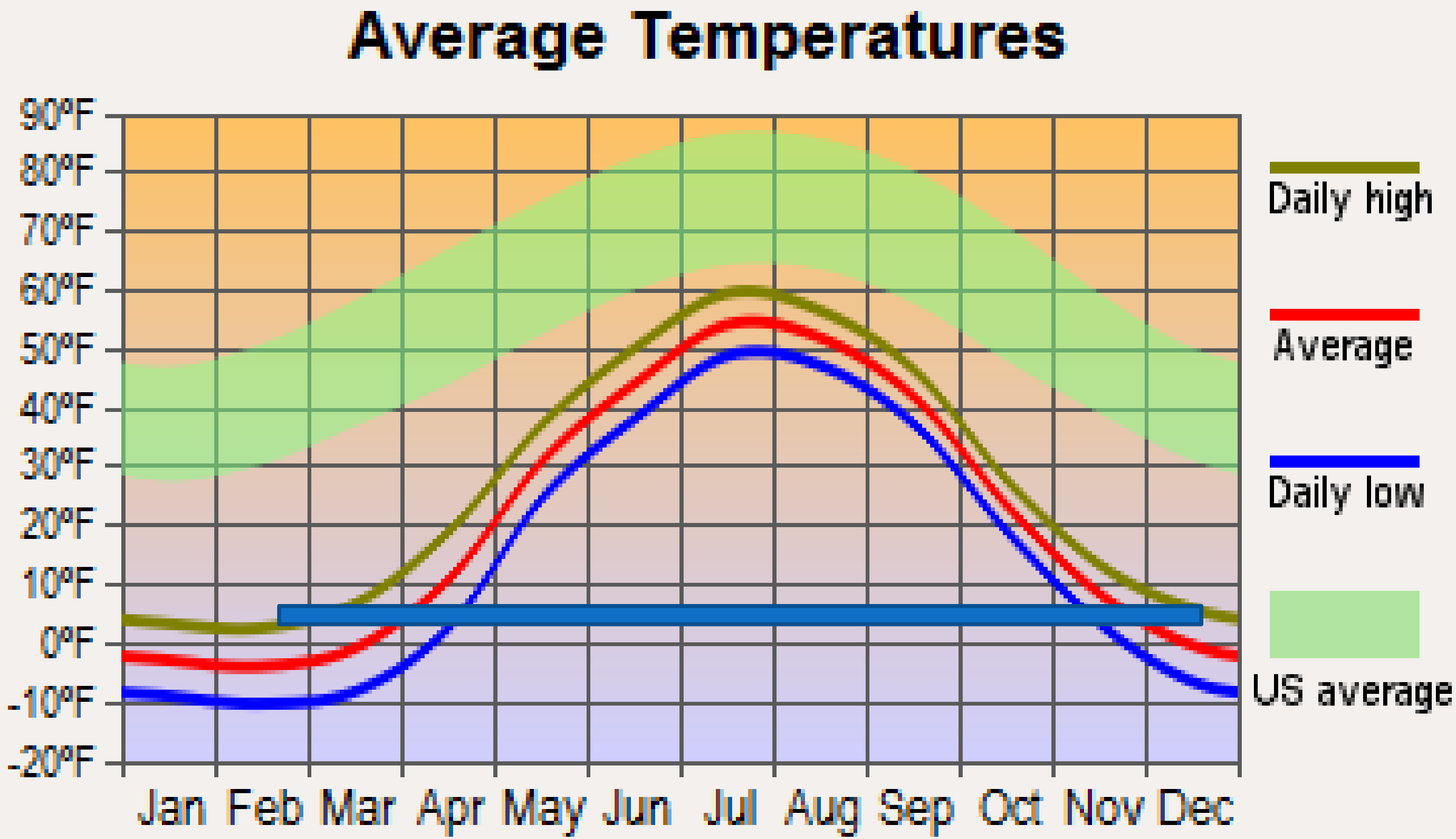
5 Year plan
Solar IPP's full build out

Community	Total			Total
	Solar PV	BESS	Combined	Diesel offset
	kW	MW	MWh/year	Gallons/year
Ambler	400	1	360	25,714
Buckland	450	1	405	28,929
Deering	250	0.5	225	16,071
Kiana	400	1	360	25,714
Kivalina	450	1	405	28,929
Noatak	550	1	495	35,357
Noorvik	550	1	495	35,357
Selawik	500	1	450	32,143
Shungnak-Kobuk	500	1	450	32,143
TOTALS	4,050	8.5	3,645	260,357

Regional IPP Organizational Structure

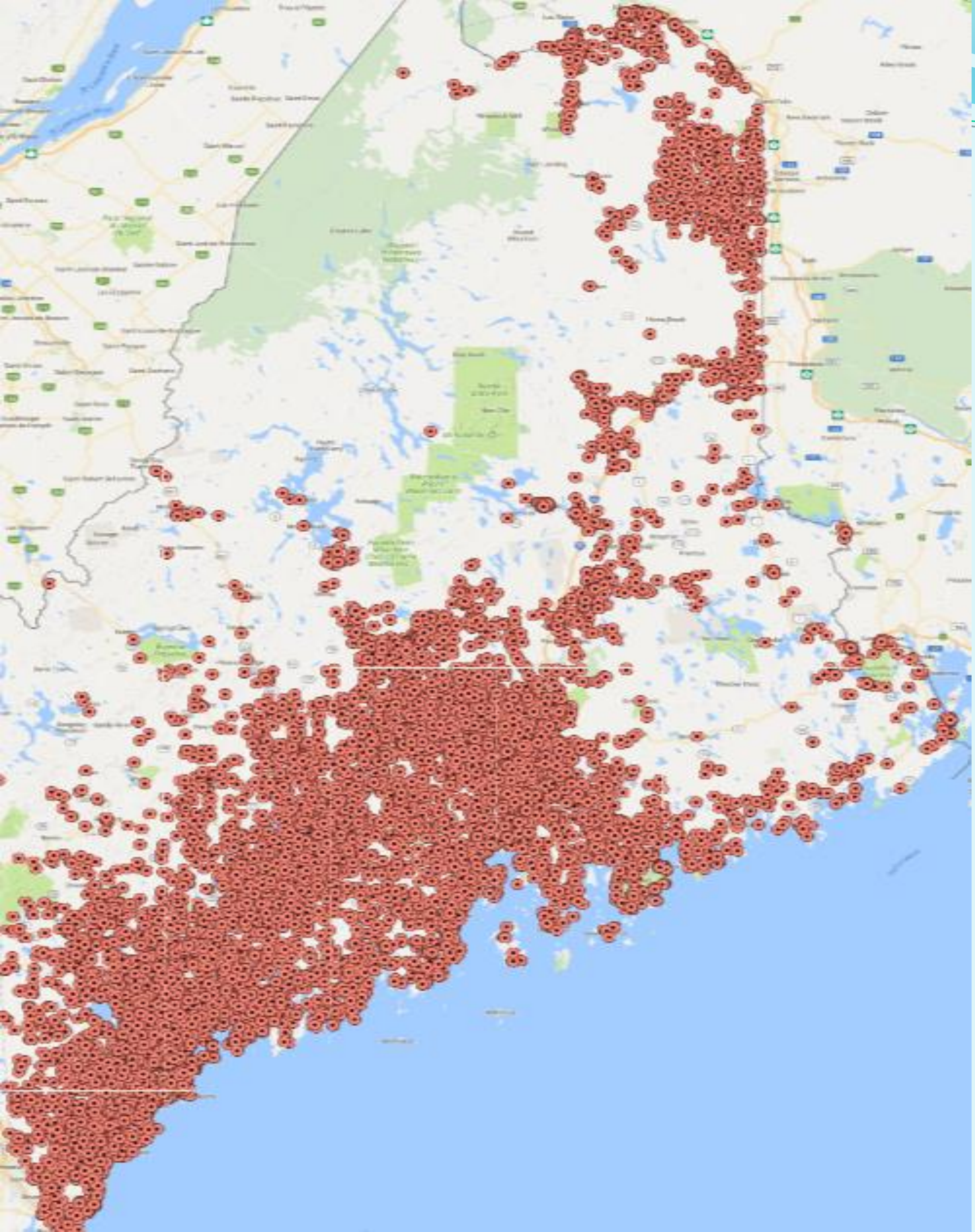


2016-17 Harvest season for Solar PV Is the same as for Heat pumps



Heat-pump COP level for Diesel displacement if cost of Electric-Diesel and cost of Heating fuel is the same

Break Even COP for Diesel displacement			
			COP
Toyostove:			2.43
Boiler:			2.42
Furnace, Standard Fan:			2.4
Furnace, Efficient ECM Fan			2.33



Map showing 17,500 ductless heat pump installations in the first 3.5 years.

Installation density correlates directly with population.

Very popular in far northern areas where systems are reported to continue to provide heat even at -27F.

Courtesy Efficiency Maine

Heat pump advantages

- **Low-cost heat** – The cost of heating with a heat pump is similar to heating with natural gas or wood. This is typically half the cost of heating with oil, kerosene, electric baseboard or propane to compare heating costs of different heating systems.

- **Low-cost air conditioning** – Today's best heat pumps are twice as efficient as typical air conditioners.

- **Comfort** – With advances in controls, heat pumps can maintain very constant temperatures.

- **Safety** – Because heat pumps are electrically powered, there is no risk of combustion gas leaks.

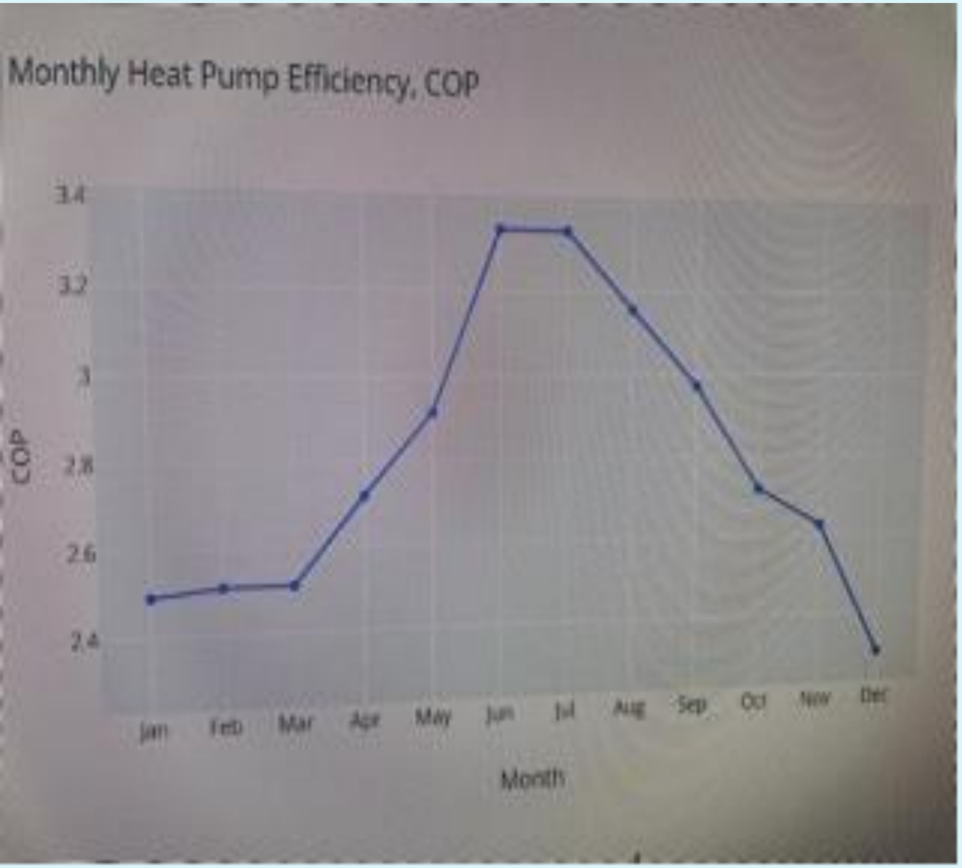
- **Air quality** – Heat pumps filter air as they heat/cool/dehumidify it.

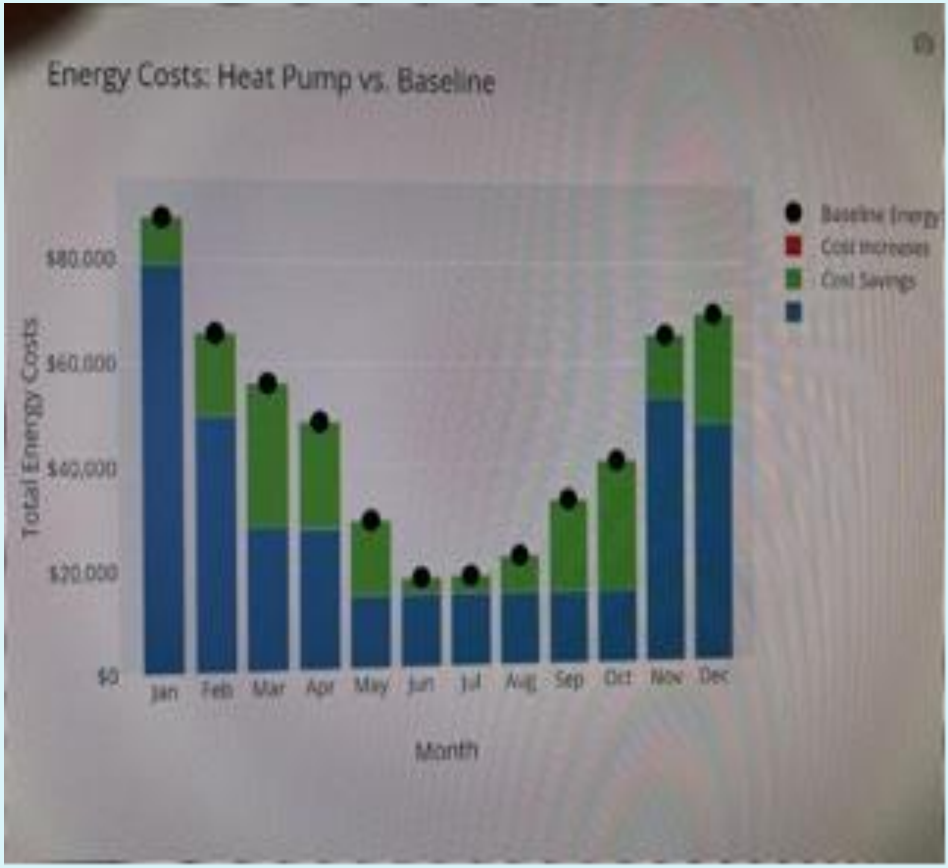
- **No CO_2 emissions** – Cleaner environment and resilience to Global Warming.

13 Air to Air Heat-pump installations Pilot Project- CIAP Funded 2017-18. Panasonic MHP MXZ4C36NA2-U1

Cooling tent for Meat

COP curve and cost savings According to Heat-pump Calc.





All Alaska Online Calculator

Thank you to our sponsors:

NORTHWEST ARCTIC BOROUGH

Homer Electric Association, Inc.
A Touchstone Energy Cooperative

ALASKA ENERGY AUTHORITY

Alaska Housing FINANCE CORPORATION

NANA

FOR THE COASTAL AND INLAND PEOPLES
INCORPORATED SEPTEMBER 16, 1974

AP&T

AVEC
ALASKA VILLAGE ELECTRIC COOPERATIVE

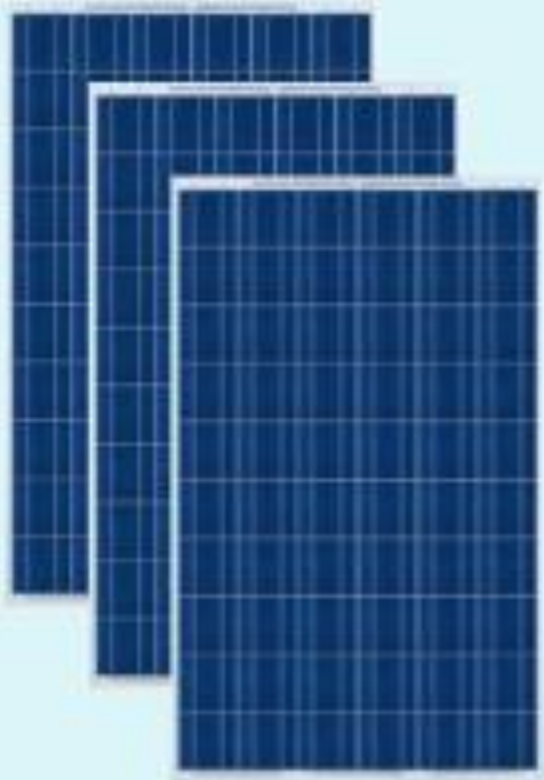
Web access @ https://heatpump.cf/

The Calculator has been updated with the latest Fuel and electric rates and additional new Heat-pump models

Here are some results from Ambler average size House

Heat-pump; Low temp. Mitzubishi HI-Heat single zone 38,000 BTU
Annual Heating Fuel Savings: 463 gallon of #1 Oil
Annual saving: $ 2,500/year @ $ 12.36/G Fuel cost
Savings over 14 Year life: $ 35,065

DC4812VRF Solar/DC Mini split Air Conditioner/heater



Pilot Energy Efficiency Project for Ambler

12,000-38,000 BTU 48V DC Heat Pump VRF Dynamic Capacity Compressor 100% DC - No Inverter with AC backup

65 Households out of 68 Completed in Ambler July 2021.

1 Kw of Solar for every Household

Data to be collected 2021-2022

Ambler VPSO Building & House installations.

The Energy Steering Committee
15 Years and Going 2009-2023

Goals and lessons learned

- **Make a sustained effort, realize that changes comes slowly with understanding of new ways and operation.**

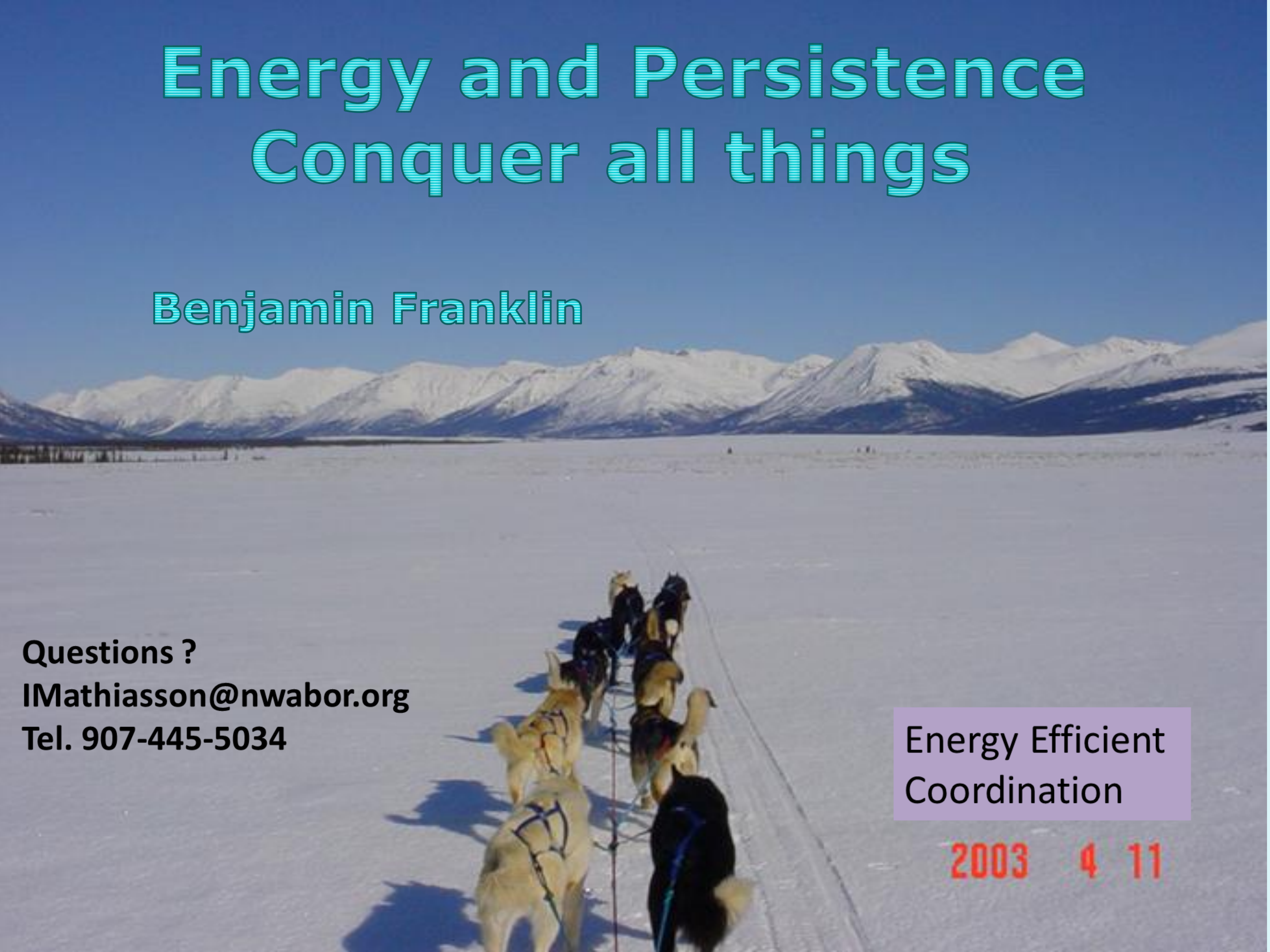
- **Continue to work with the Regional Energy Plan**
- **It is the "Vision" for the future, from the people for the people.**

- **Make sure the document gets updated periodically as it is a "Dynamic" living document and needs to be able to "Adapt" to changes when new thinking and resources comes along.**
- **Hopefully it will never be completed.**

Energy Policy

- **Do we develop Energy resources for short time profits ?**

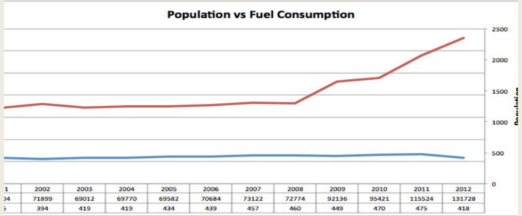
- **Or do we develop Local Energy resources that can sustain the Region for the foreseeable future and create a cleaner environment for our Children ?**


Energy and Persistence
Conquer all things
Benjamin Franklin
Questions ?
IMathiasson@nwabor.org
Tel. 907-445-5034
Energy Efficient
Coordination
2003 4 11

Intelligent Energy Systems: Anchorage, Alaska

Things can’t stay the same

Must invest to maintain quality of life

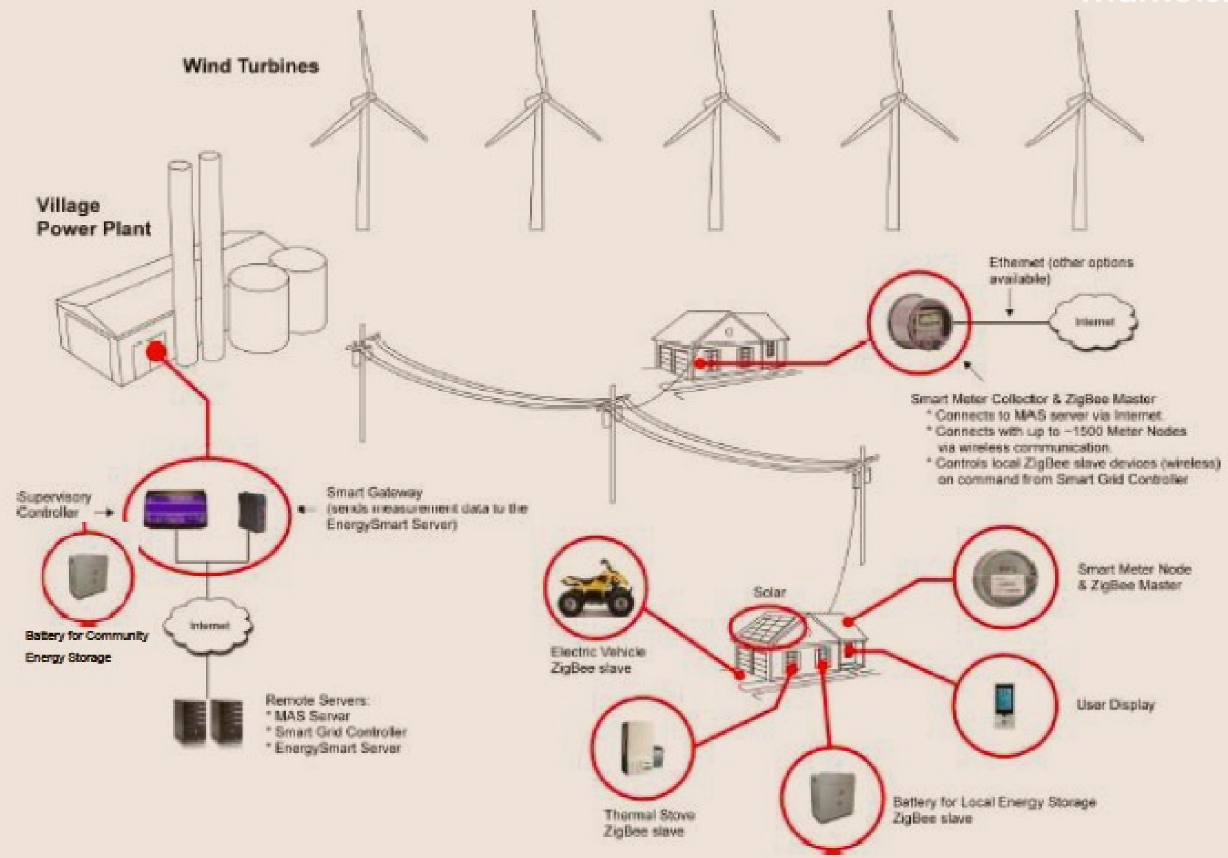


Intelligent Energy Systems, LLC

Hypothesis

- Renewable based microgrids Common
- Deployments will accelerate, number, scope, size
- Progress here has impacts

Markets:



Hallucination

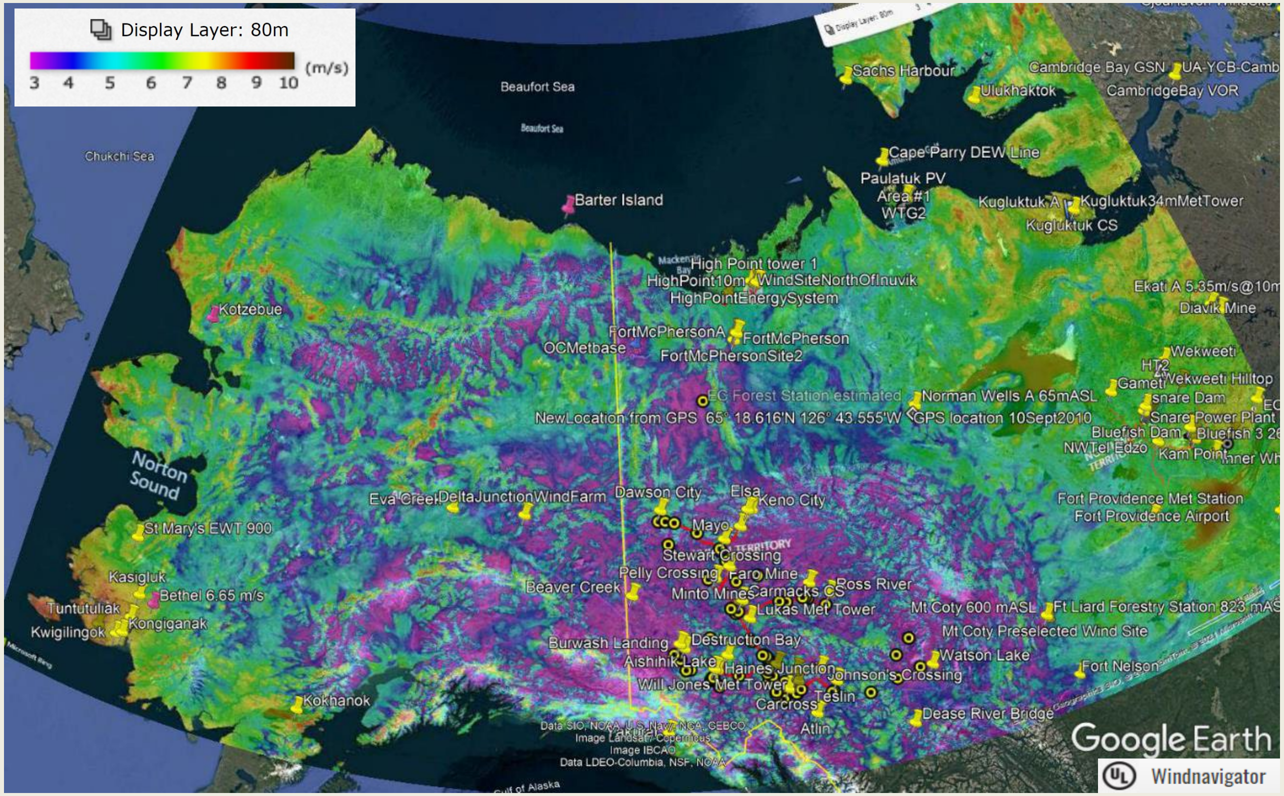
2003 =Reduce Diesel

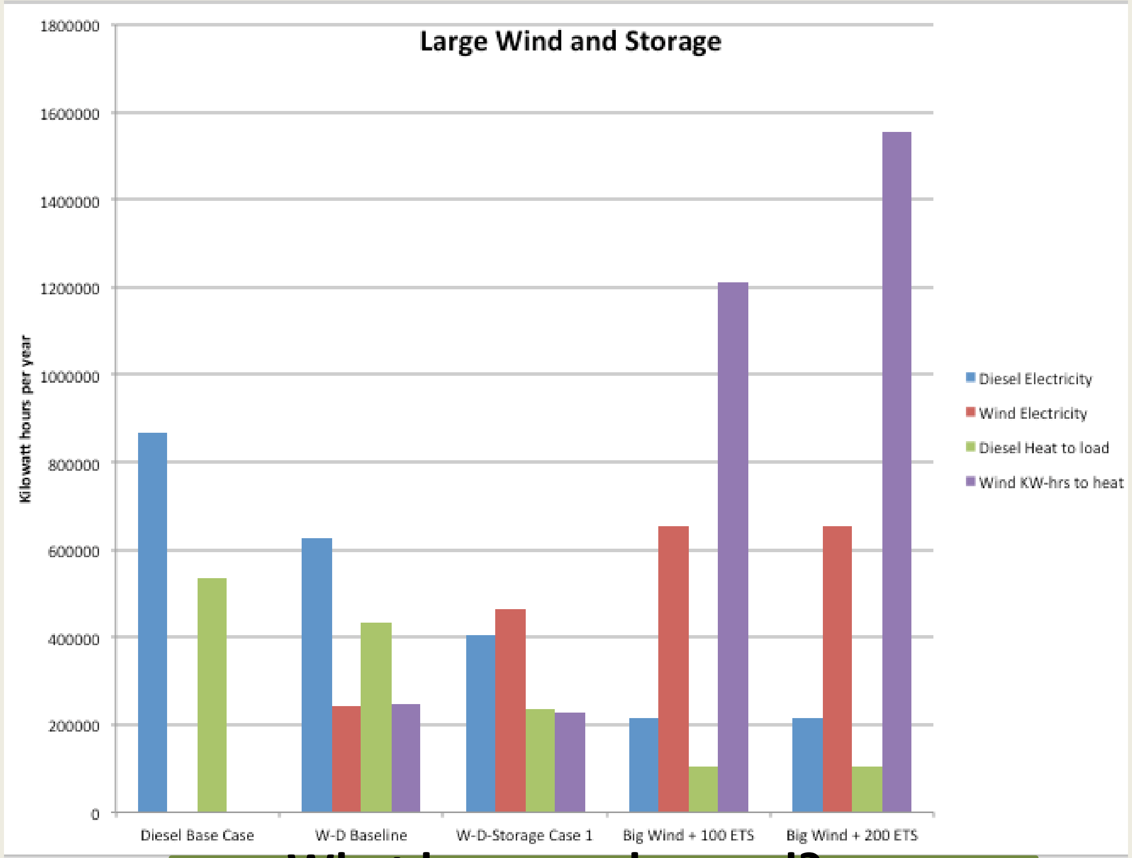
- Control/integration?
- Wind turbines?
- Wind Heat?
- Distribution ?
- Capacity?
- Funding?

2023 **(100% Clean, secure, resilient, cross sector)**

- **Internet**
- **Energy Storage**
- **Heat**
- **Solar PV**
- **EV's**
- **Biz models**
- **Water**
- **Hydrogen**

Why Wind


Display Layer: 80m
3 4 5 6 7 8 9 10 (m/s)
Beaufort Sea
Chukchi Sea
Norton Sound
Sachs Harbour
Ulukhaktok
Cambridge Bay GSN
CambridgeBay VOR
Cape Parry DEW Line
Paulatuk PV Area #1 WTG2
Kugluktuk34mMetTower
Kugluktuk CS
Barter Island
High Point tower 1
HighPoint10m
WindSiteNorthOfInuvik
HighPointEnergySystem
Kotzebue
FortMcPhersonA
FortMcPherson
FortMcPhersonSite2
OCMetbase
Ekati A 5.35m/s@10m
Diavik Mine
Wekweeti
Wekweeti Hilltop
Snare Dam
Snare Power Plant
Bluefish Dam
NWTel Edzo
Kam Point
Norman Wells A 65mASL
NewLocation from GPS 65° 18.616'N 126° 43.555'W GPS location 10Sept2010
Eva Creek
DeltaJunctionWindFarm
Dawson City
Elsa
Keno City
Mayo
Fort Providence Met Station
Fort Providence Airport
St Mary's EWT 900
Stewart Crossing
Pelly Crossing
Faro Mine
Ross River
Kasigluk
Bethel 6.65 m/s
Beaver Creek
Minto Mines
Carmacks CS
Lukas Met Tower
Mt Coty 600 mASL
Ft Liard Forestry Station 823 mASL
Tuntutuliak
Kwigilingok
Kongiganak
Mt Coty Preselected Wind Site
Burwash Landing
Destruction Bay
Aishihik Lake
Haines Junction
Watson Lake
Johnson's Crossing
Will Jones Met Tower
Teslin
Carcross
Fort Nelson
Kokhanok
Dease River Bridge
Atlin
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Image IBCAO
Data LDEO-Columbia, NSF, NOAA
Gulf of Alaska
Google Earth
Windnavigator



What have we learned?

Coherent Technology

- A family of appliances working together

Meaningful Projects/Jobs

Not just install a few solar panels

Learn by doing
And innovating

Lower Costs

- Increase deployment
- Expand Scope
- Grow Scale

Progress:

- Define state of the art
- Invest in reducing risk
- Generate a history of investment performance

ies

Lessons:

Don’t always assume, Remove roadblocks, Pull goalie

GLOBAL TRENDS AND GRID OF THE FUTURE

Thursday, July 27, 2023, 11:00 AM – 1:00 PM

- Energy Transformation: South Australia as a Case Study
- Opportunities for Electric Load Growth in Alaska
- Insights into the Icelandic Energy Market

Sandia National Laboratories

Energy Transformation:

It Can Happen Faster Than You Think!

South Australia as a Case Study

Abraham Ellis | June 27, 2023

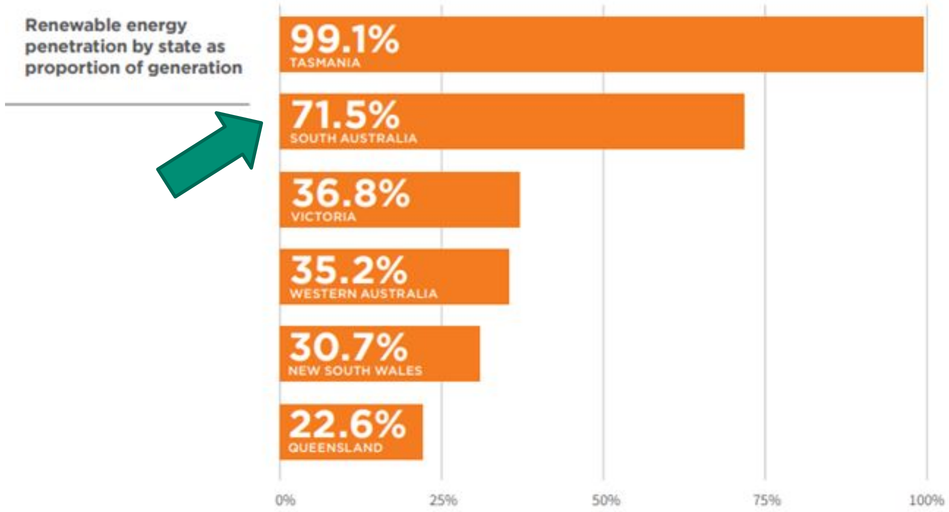
Abstract

- The case study describes the ongoing rapid energy transition in South Australia.
- Many of the illustrations were compiled from presentations given at the 2022 IRED conference in Adelaide, accessible here: https://research.csiro.au/ired2022/

- Alaska is charting its own path to energy transformation that reflects unique challenges and opportunities

Province of South Australia

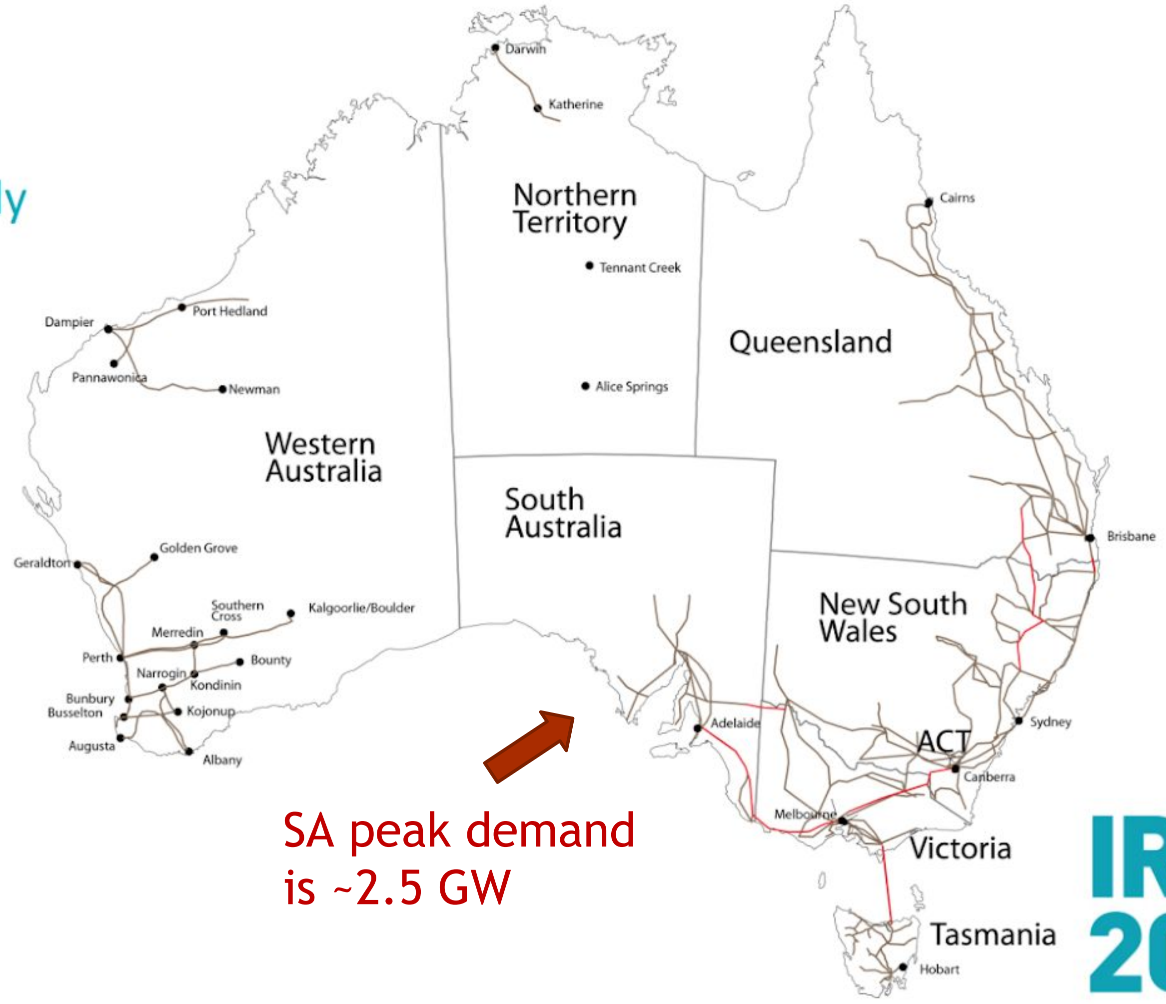
- ❖ Area is ~57% of the size of Alaska AK
- ❖ 1.8 million in 2020 (**2.5X** that of AK), highly concentrated in Adelaide (77%)
- ❖ Latitude: 26° to 38° S (Anchorage at ~61° N)
- ❖ Leads states in renewable energy generation
- ❖ State Target: 100% RE by 2030



Source: https://assets.cleanenergycouncil.org.au/documents/Clean-Energy-Australia-Report-2023.pdf

Australia's Electric Systems

- Eastern interconnection (NEM)
  - 56 GW of electricity generation capacity
  - 15 - 35 GW demand
  - 5 minute generation dispatch, Energy-Only market, since 1998
  - Security constrained economic dispatch, with co-optimised energy and ancillary services
- WEM for SWIS
  - 5.8GW of electricity generation capacity
  - comprises a wholesale electricity trading component and a capacity component.
- Significant increase in wind, solar and battery connections. (NEM: 15GW small solar, 7GW wind, 4GW large solar)

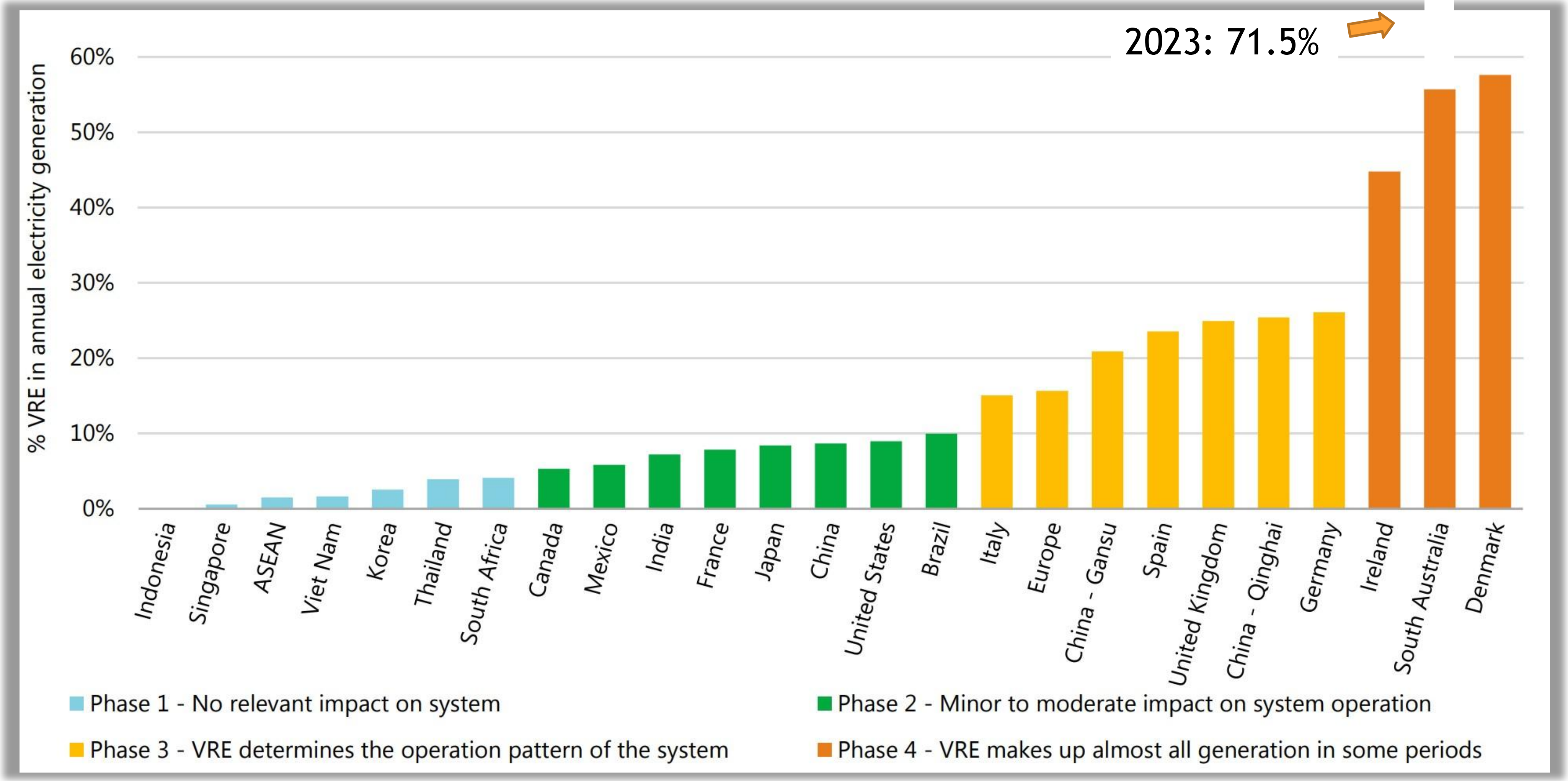


SA peak demand is ~2.5 GW

IRED 2022
9TH INTERNATIONAL CONFERENCE INTEGRATION OF RENEWABLE & DISTRIBUTED ENERGY RESOURCES

Source: CSIRO, John Hard, IRED 2022, 9th International Conference Integration or Renewable & Distributed Energy Resources

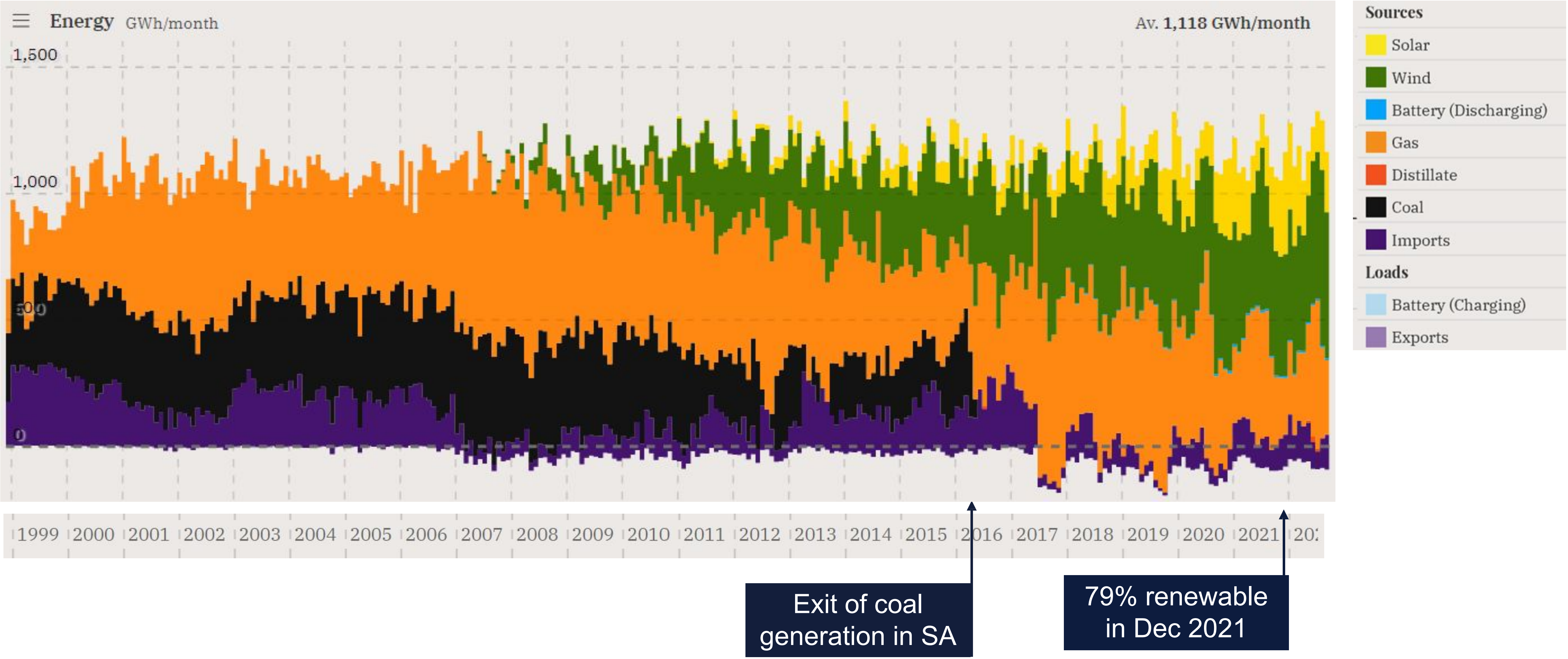
Pushing the limits on VRE penetration



Source: IEA, Secure Energy Transitions in the Power Sector, 2021. Note China = The People's Republic of China

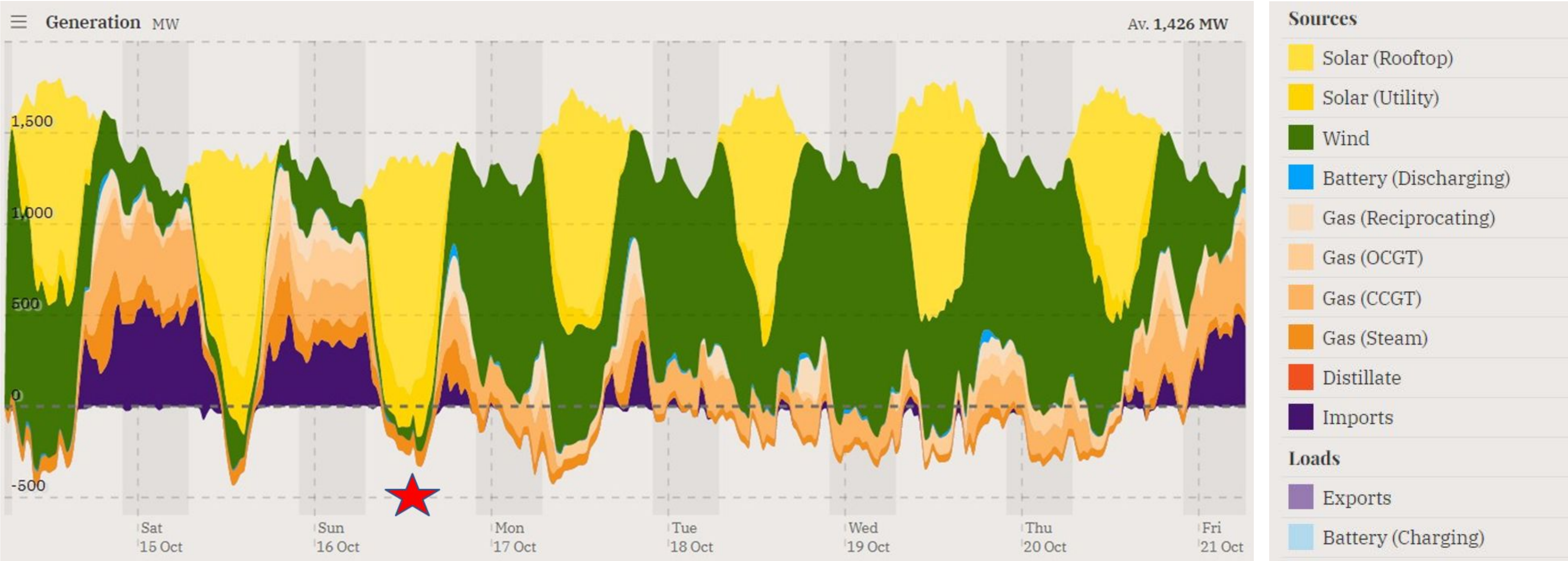
What can we learn from SA's experience?

It can happen fast!



Source: www.opennem.org.au

Dealt with difficult operational challenges

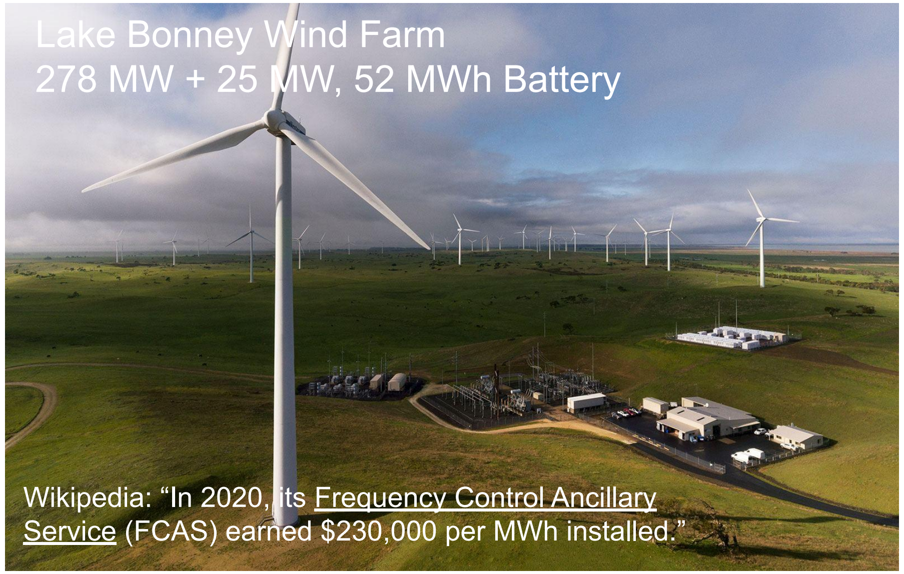


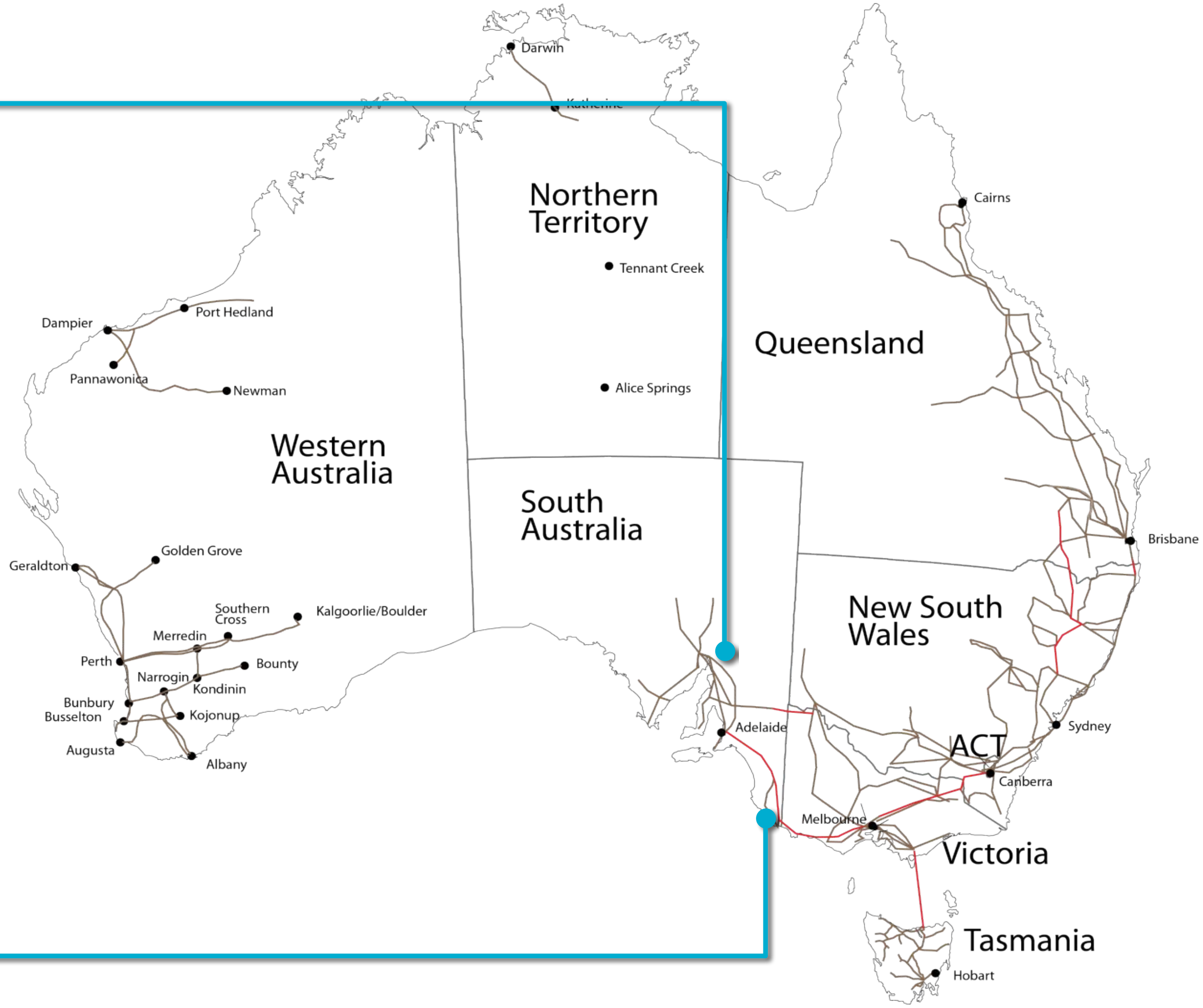
Sunday 16 Oct 2022

- New minimum operational state demand record of 100MW (after rooftop solar), lowering last year's record by 4MW
- New solar PV generation record of 116.7% of state demand, beating last year's record of 110%
- 76.2% renewable energy generation for the week (note the record of 88.3%, 17 –23 January 2022)

Source: www.opennem.org.au

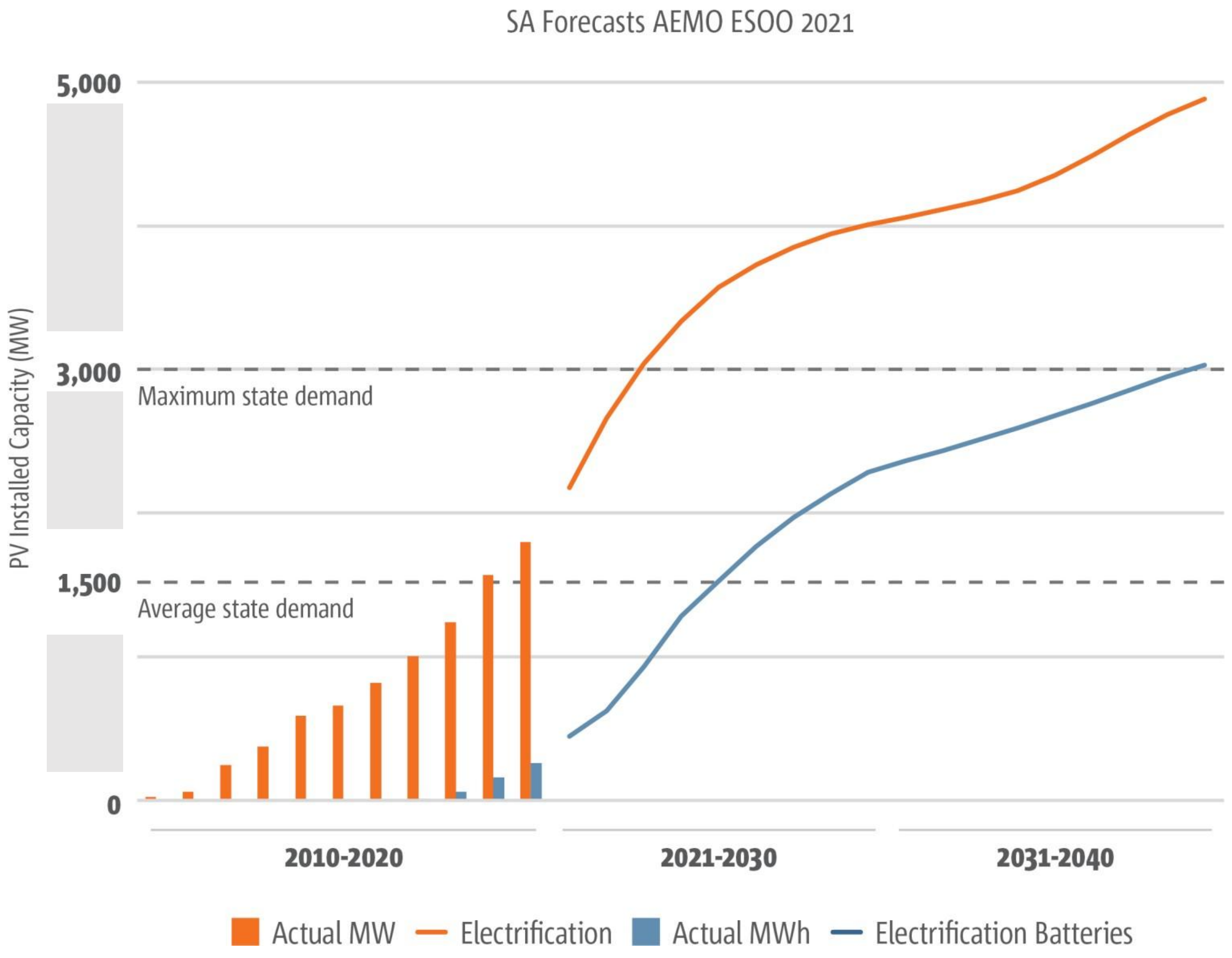
Incentivized flexibility by wind/solar & storage

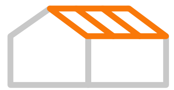




Source: IRED 2022, 9th International Conference Integration or Renewable & Distributed Energy Resources

… and also promoted grid-friendly DER!



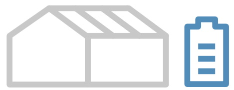


~300,000 Rooftop solar systems

>1 in 3 customers, world's highest

State's largest generator

Record growth continues

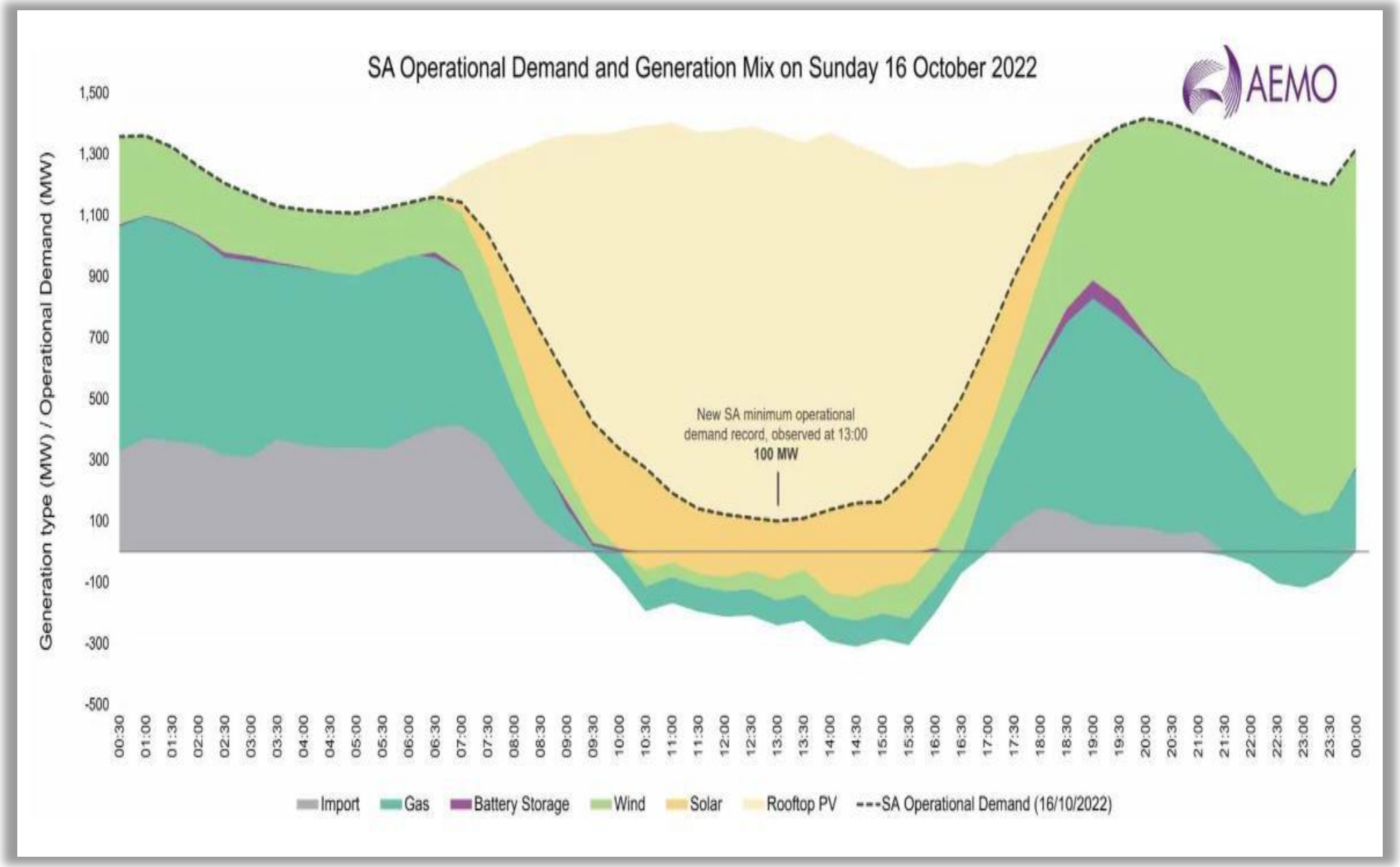


~30,000 Home batteries

9 Virtual Power Plants operating in SA

Source: SAPN

Supply flexibility is critical for security/reliability



Source: SAPN

It sure helps to have strong connections!


Source: Neoen


Source: SMA


Source: ElectraNet


Source: Wärtsilä

Technology innovation has been key…

SA as a test bed for leading edge concepts

- Grid scale batteries
- Home batteries & VPPs
- Synchronous condensers
- Fast gas

Adapted from: Richard Day, Government of South Australia

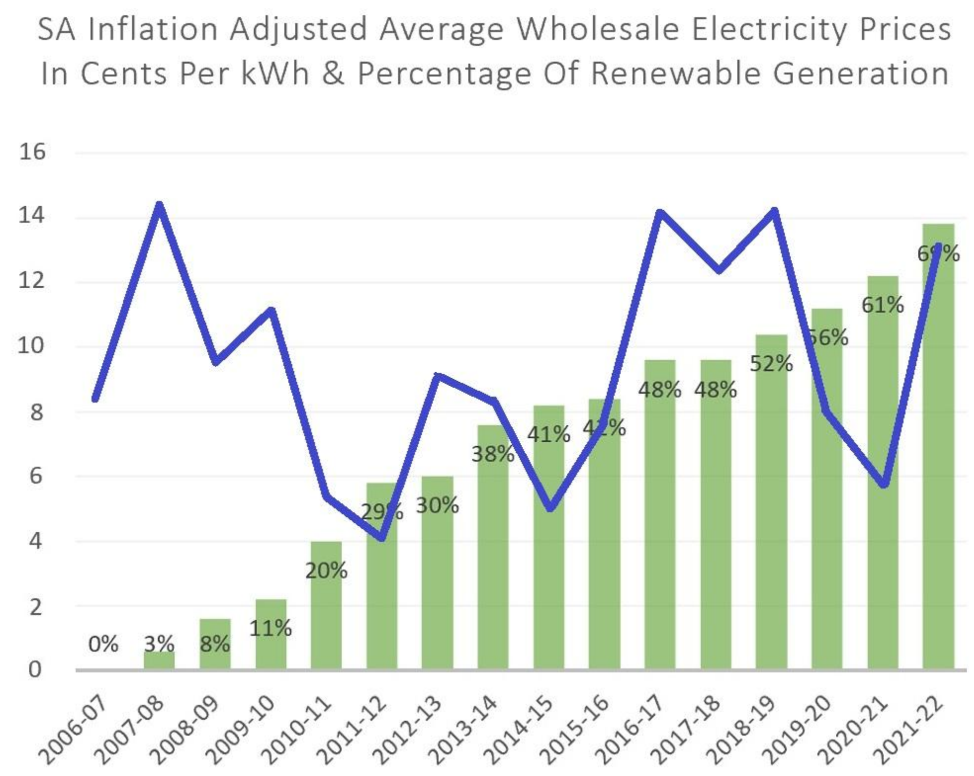
The institutional foundations are also critical

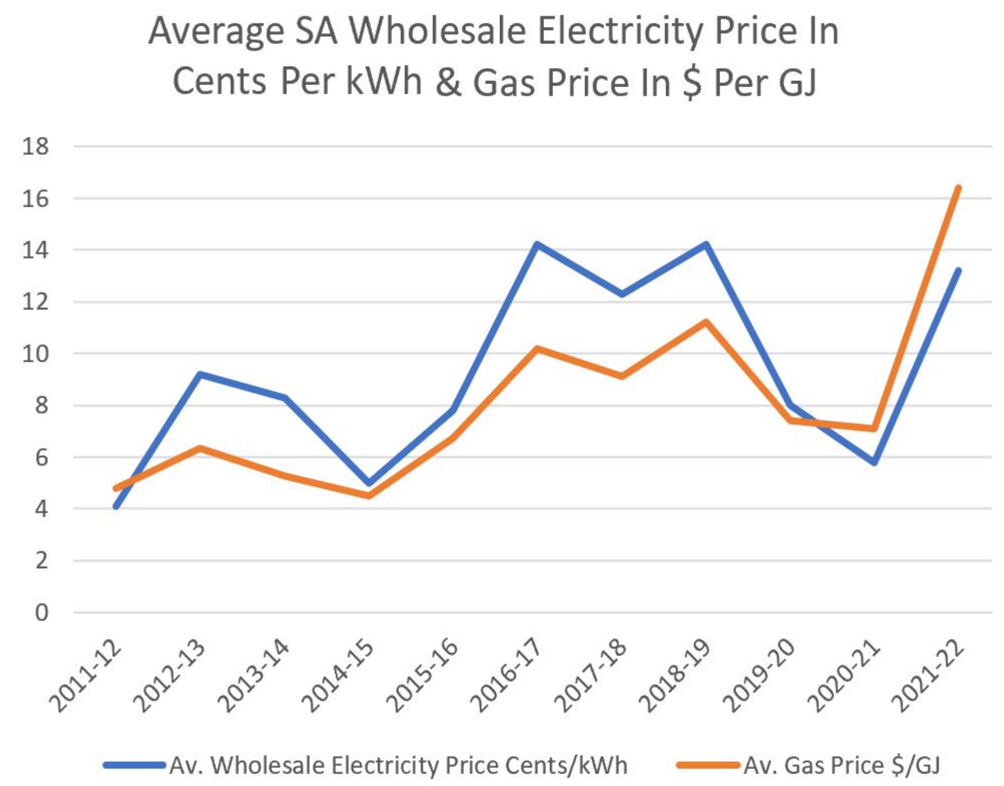
Decisive, well-functioning, innovation-friendly Policy, Regulatory & Market Constructs

Source: Luke Robinson. A/Group Manager Modeling & Engineering

Is RE increasing electricity costs?

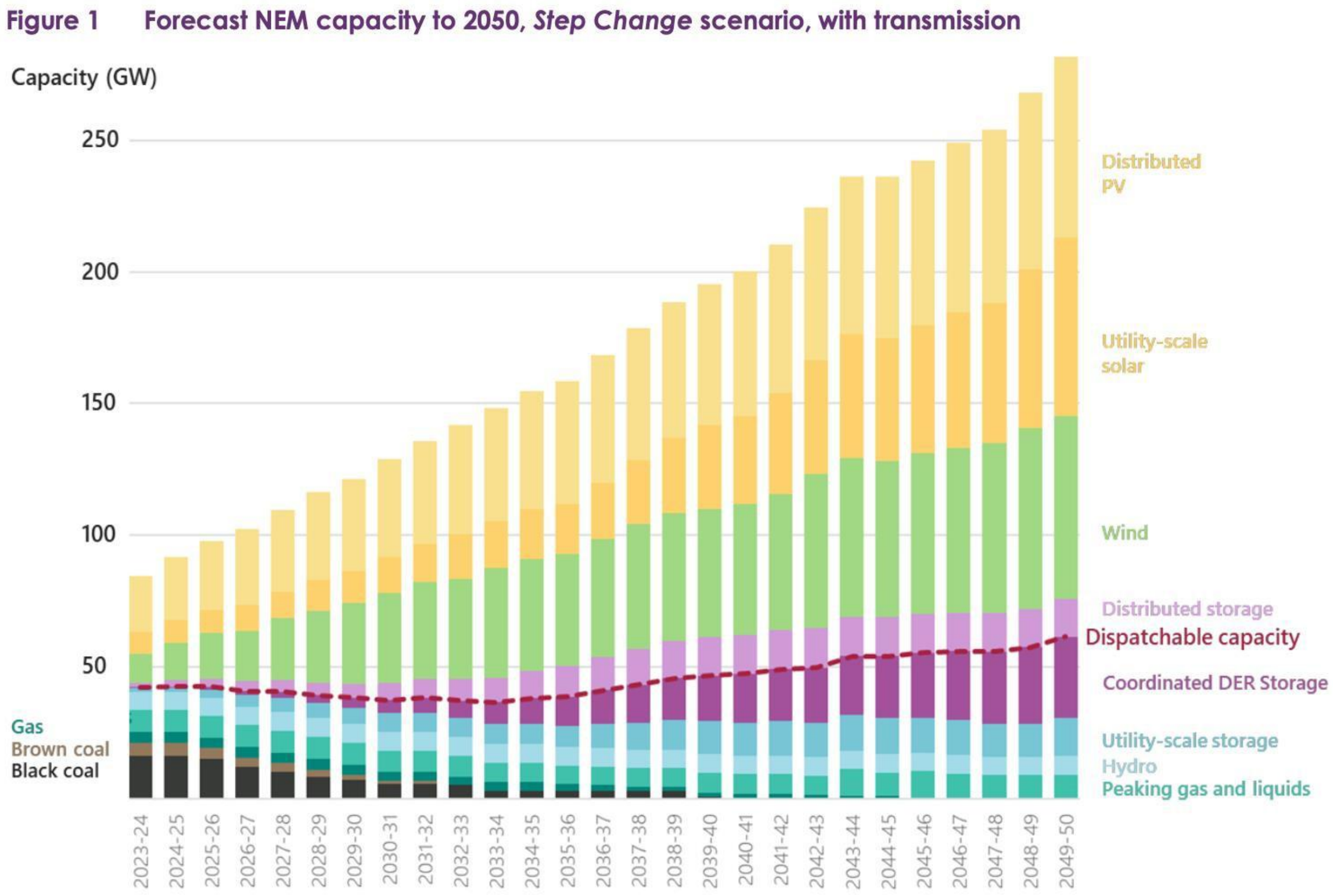
It’s complicated… Wholesale electricity prices are driven more by the cost of natural gas.





Source: https://www.solarquotes.com.au/blog/cheap-renewables-expensive-electricity/

What's next? More RE (mainly solar) and storage



AEMO ISP (2050):

- **5x** Distributed Solar
- **9x** Large Scale Solar
- **30x** Storage
- **2x** Electricity usage

!

Source: IRED 2022, 9th International Conference Integration or Renewable & Distributed Energy Resources

2X electricity usage by 2050.

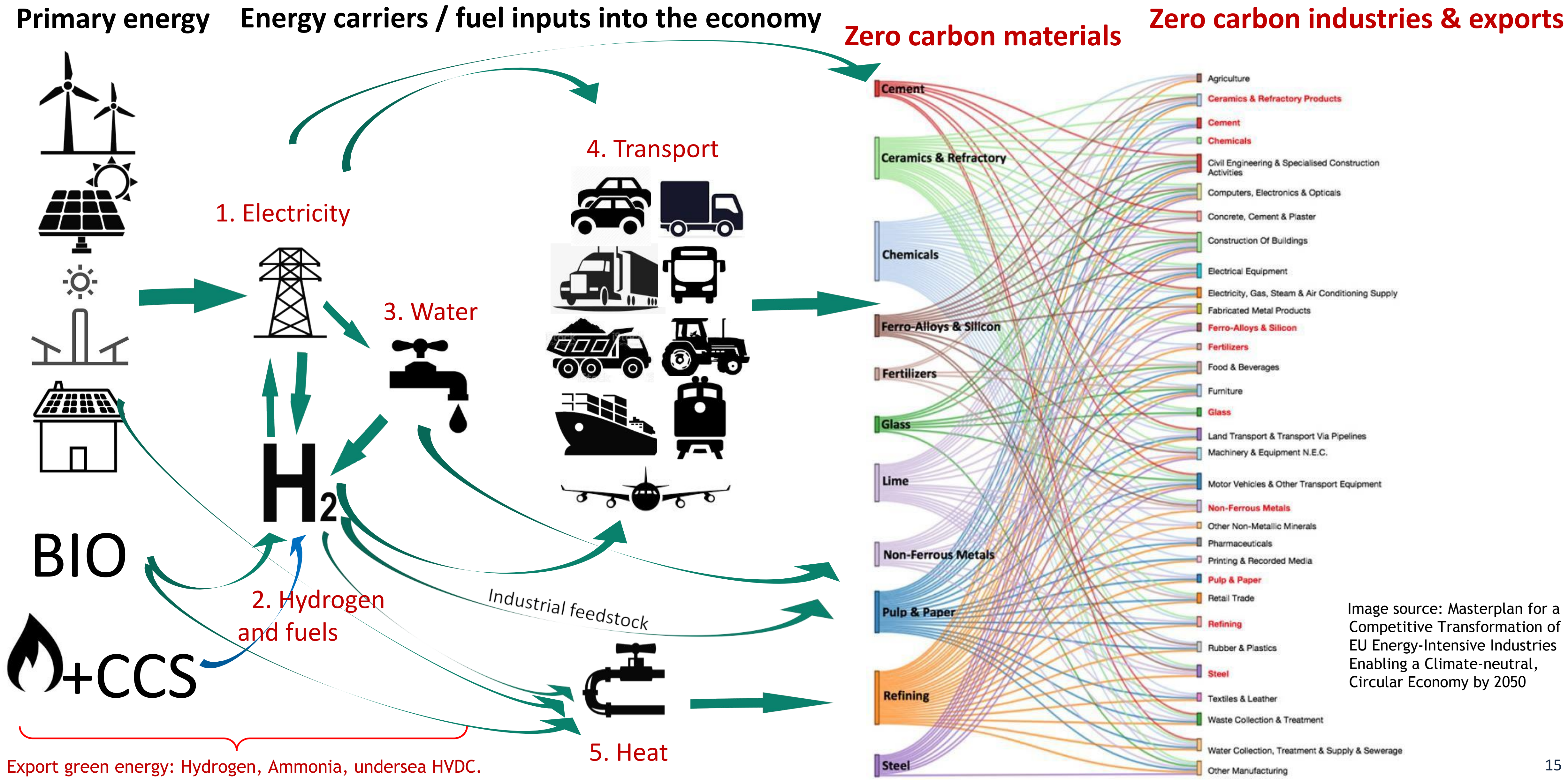


Image source: Masterplan for a Competitive Transformation of EU Energy-Intensive Industries Enabling a Climate-neutral, Circular Economy by 2050

Looking out for Consumers

"For the changes that we see as necessary to become reality, requires **a kind of grand bargain** between consumers and those who run the system."

"Consumers care most about affordability."

"Least cost also means unlocking the potential of the demand side."

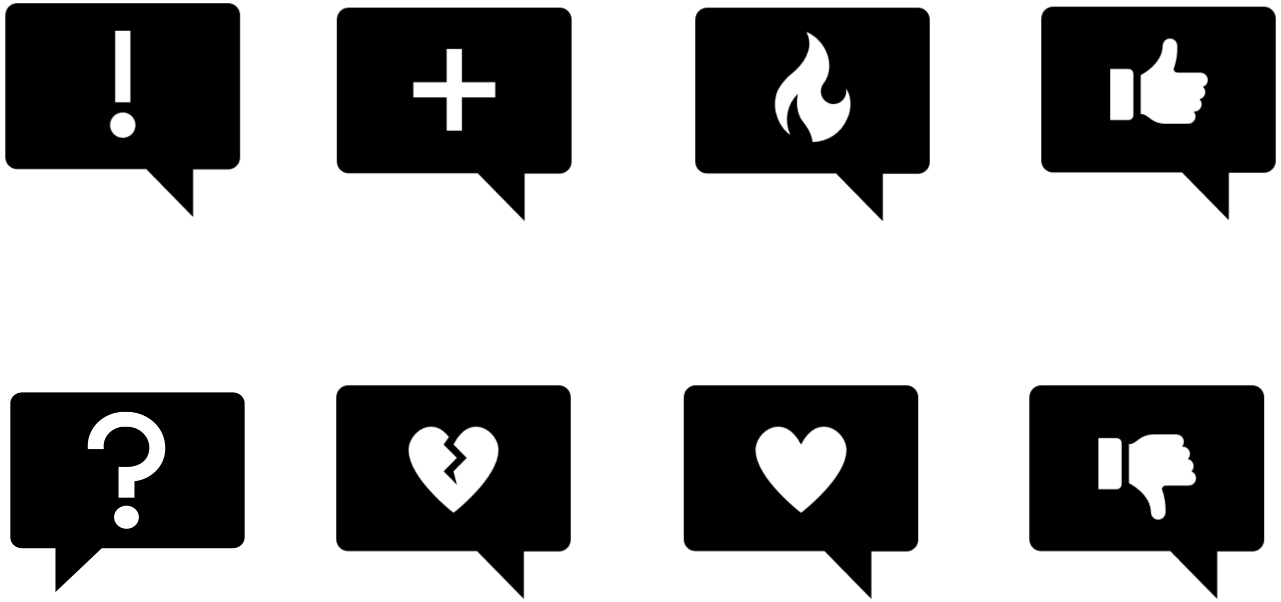
"Energy inclusion is essential to our energy transformation… The first thing is nobody gets left behind."

"Delivering a transition with affordability for all requires optimizing consumer participation."

"And participation? Well, that requires trust."

Credit: Lynn Galagher, "The Role of Consumers in the Energy Transformation"
Presentation at the IRED 2022 conference, Adelaide, Australia, October 2022

Discussion



Contact:

Abraham Ellis

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Sandia National Laboratories

aellis@sandia.gov

UNCLASSIFIED UNLIMITED RELEASE

Sandia National Laboratories

Exceptional service in the national interest

Opportunities for electric load growth in Alaska

Andrea Mammoli

Principal Member of the Technical Staff

Renewable and Distributed Systems Integration

ALASKA ENERGY SECURITY TASK FORCE MEETING

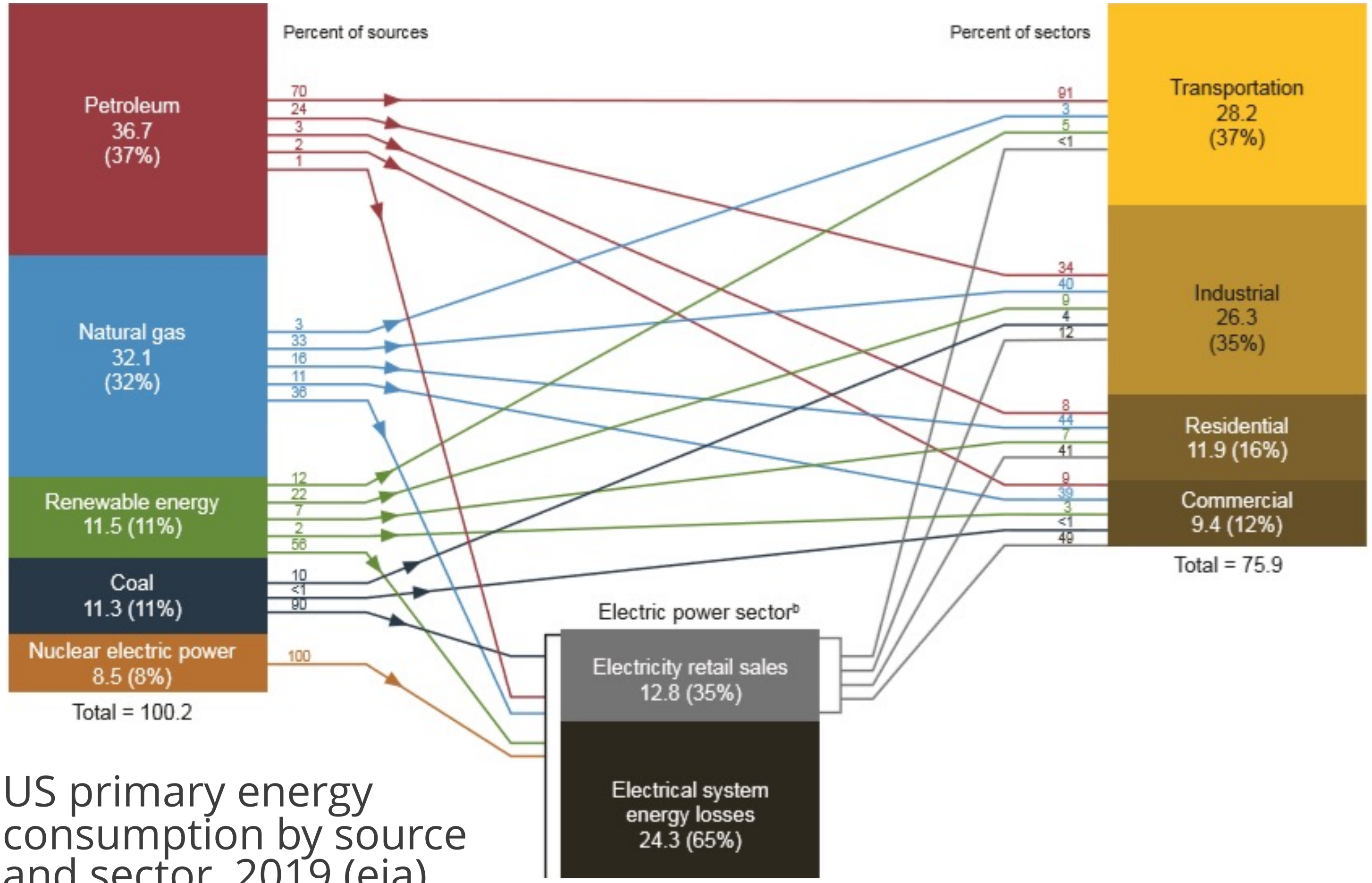
SAND2023-07070PE

July 27, 2023

U.S. DEPARTMENT OF ENERGY NNSA

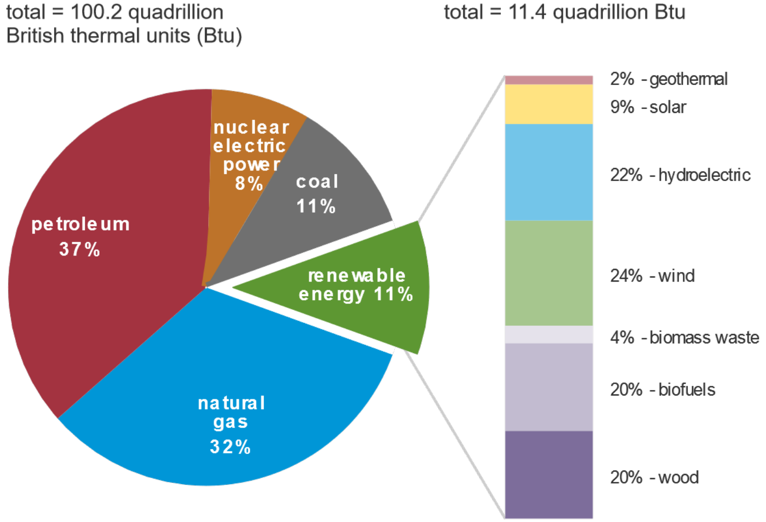
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

The rapidly evolving context

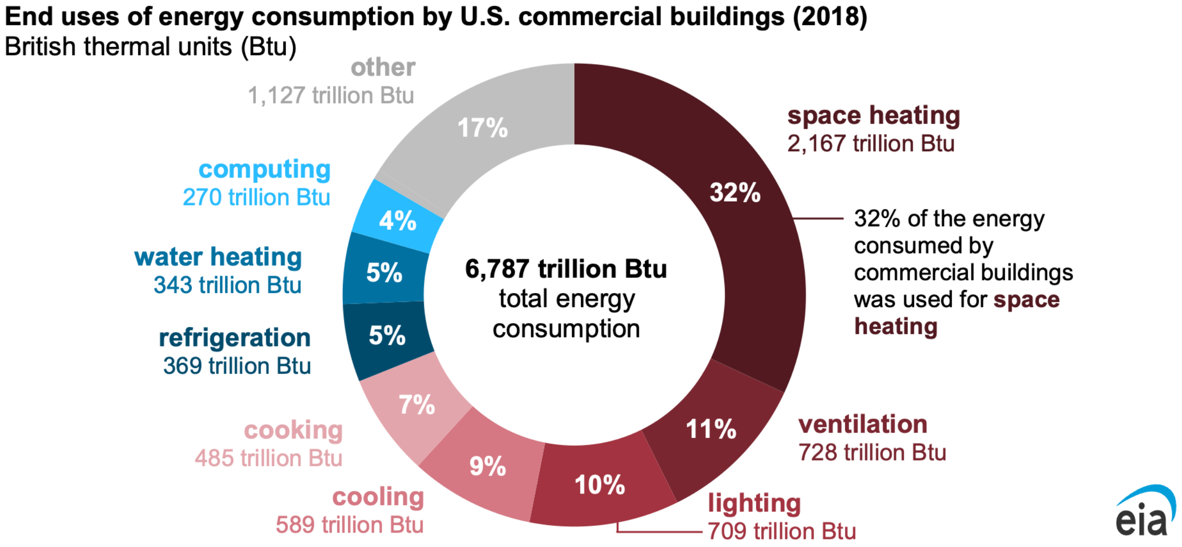


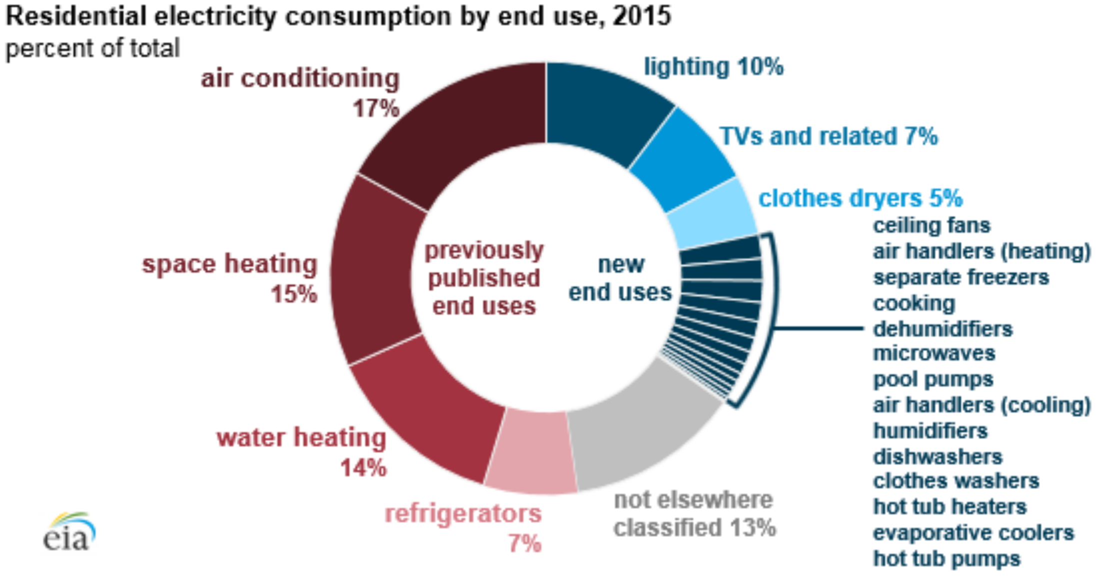
US primary energy consumption by source and sector, 2019 (eia)

US primary energy consumption by source, 2019 (eia)



What buildings do with their energy





Heating is the elephant in the conference room. CBECS has all the gory details.

Heating stuff is the elephant in the living room too. Cooling stuff is a slightly smaller elephant. RECS has the entire story.

What buildings do with their energy in Alaska

Figure 34: Total non-residential energy end-use consumption in MMBTU/yr, Climate Zones 6, 7 and 8.

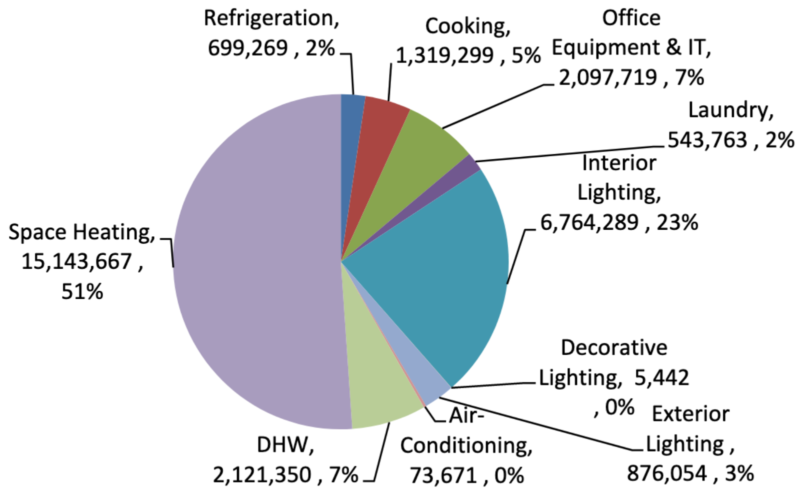
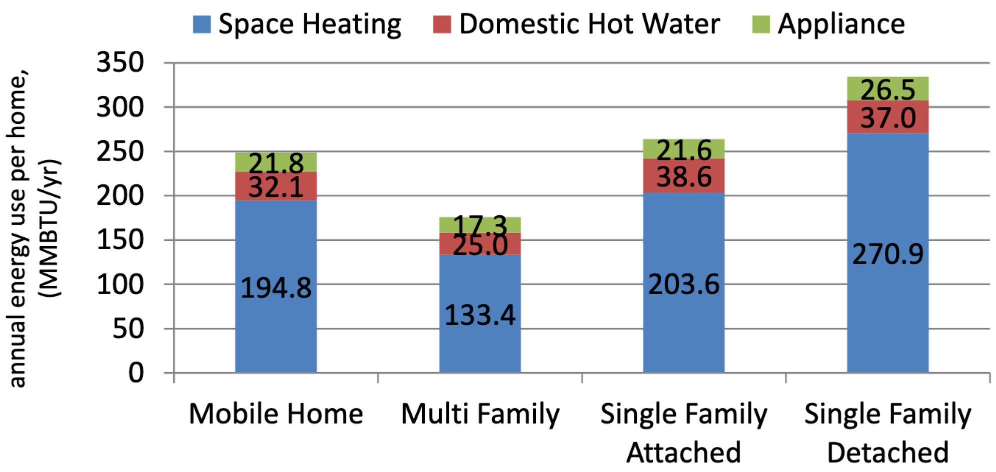


Figure 6: Total energy use per home for major energy uses by residence type (pop wt, MMBTU)

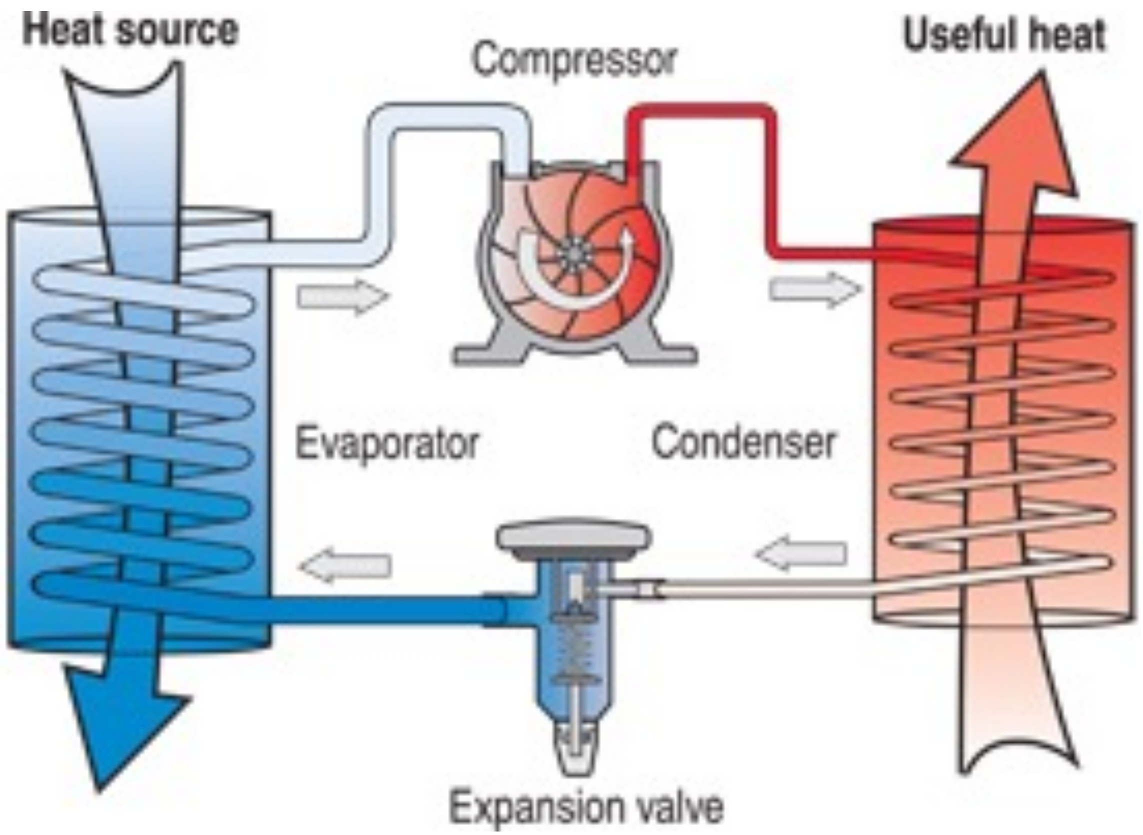


Space and water heating heating are even bigger elephants in AK conference rooms

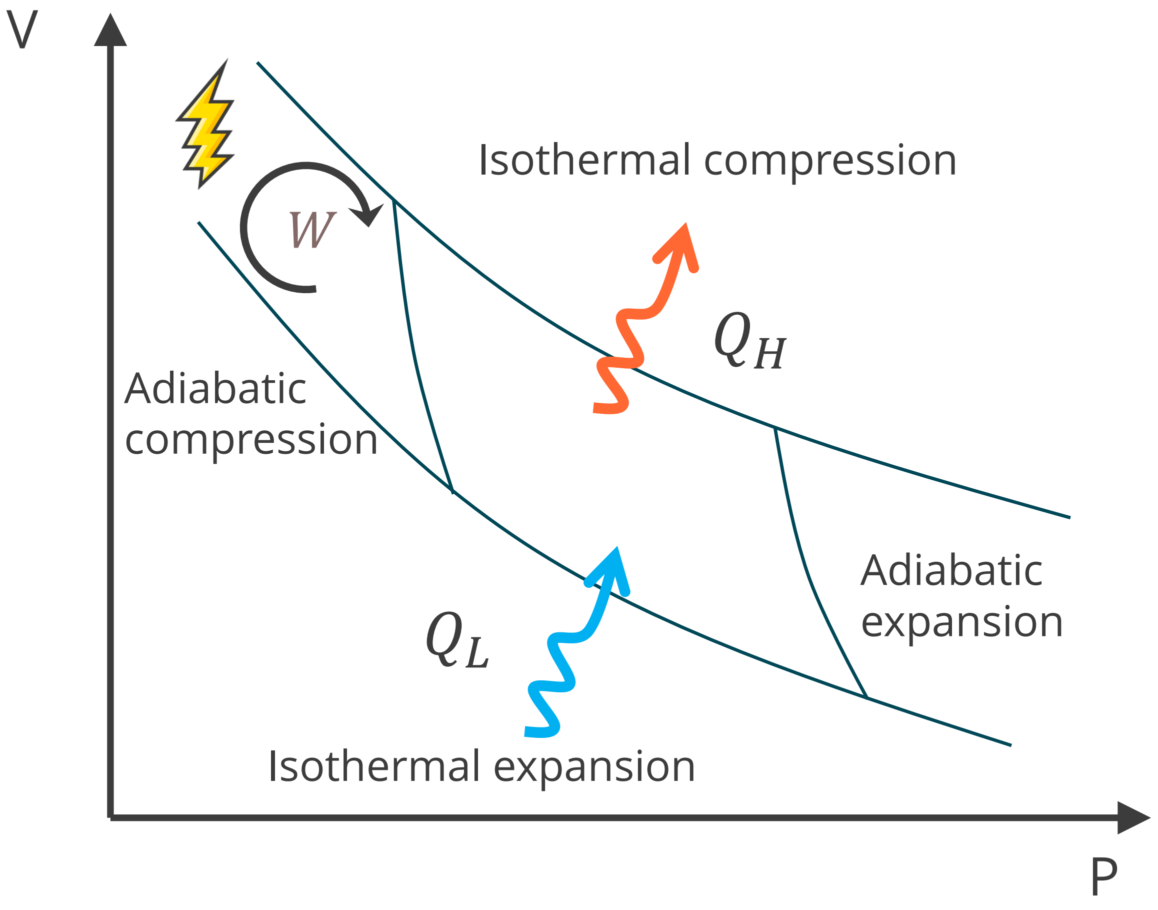
Heating space and water is *by far* the biggest Alaskan home energy user

Source: Alaska Energy Authority End Use Study: 2012

Heat pumps 101



In the weeds – the Carnot efficiency

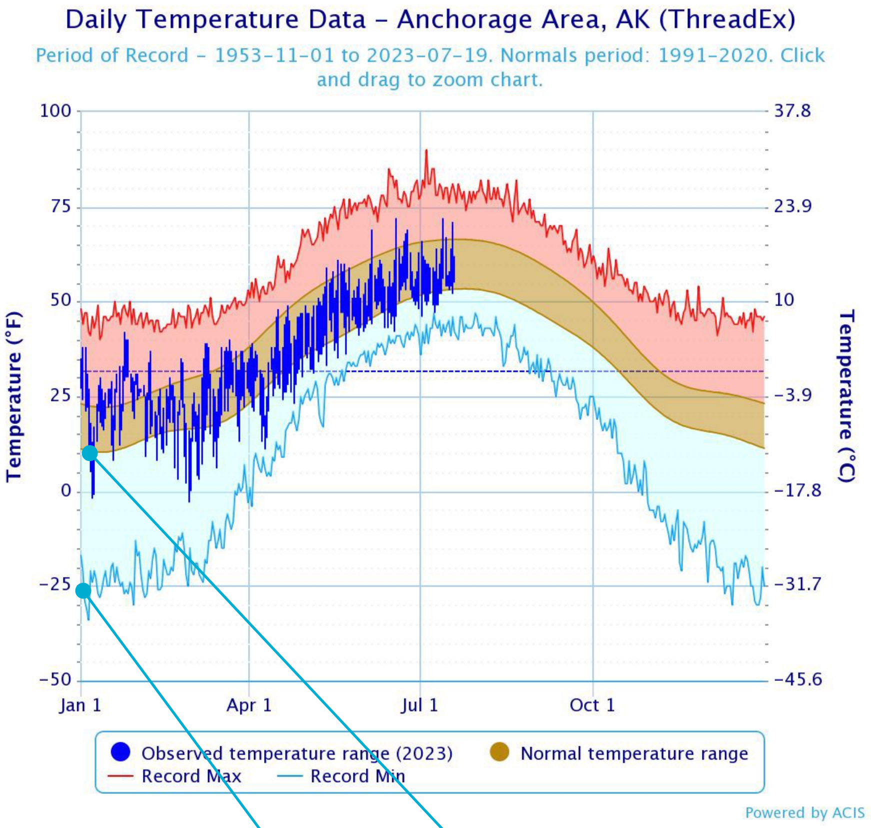


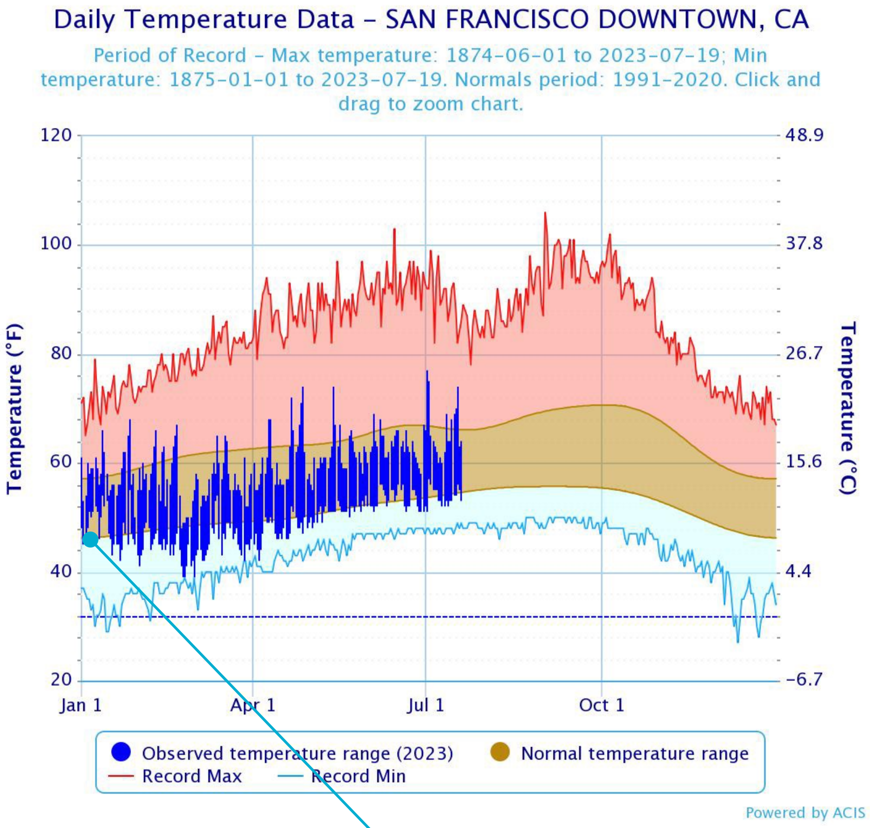
$$COP = \frac{Q_H}{W} = \frac{T_H}{T_H - T_L}$$

The COP, or Coefficient of Performance, is the ratio of amount of heat delivered to a space Q_H and the amount of work done by the compressor W, usually provided by electricity

Can heat pumps work in Alaska (at least in theory)?

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION





COP=8.97

COP=5.57

COP=22.05

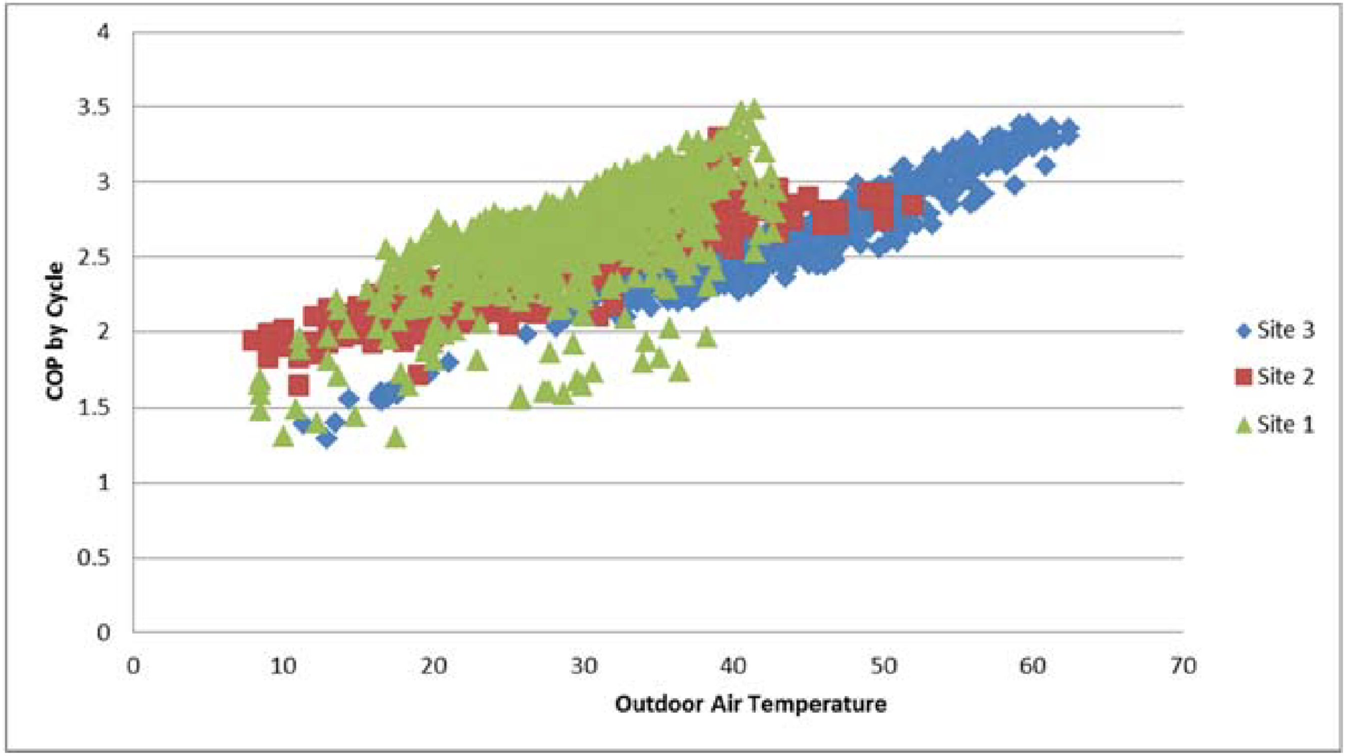
Note: these are ideal COPs!

How practical heat pumps compare to ideal ones

- A Carnot heat pump operates at equilibrium – meaning it transfers no power
- Real, practical heat pumps have much lower COP because:
  - Need temperature gradient to transfer heat, hence higher T_H and lower T_L
  - Compressor not 100% efficient
  - Motor not 100% efficient
  - Fans
  - Defrost cycles
  - Etc.

"But I heard heat pumps don't work in cold climates"

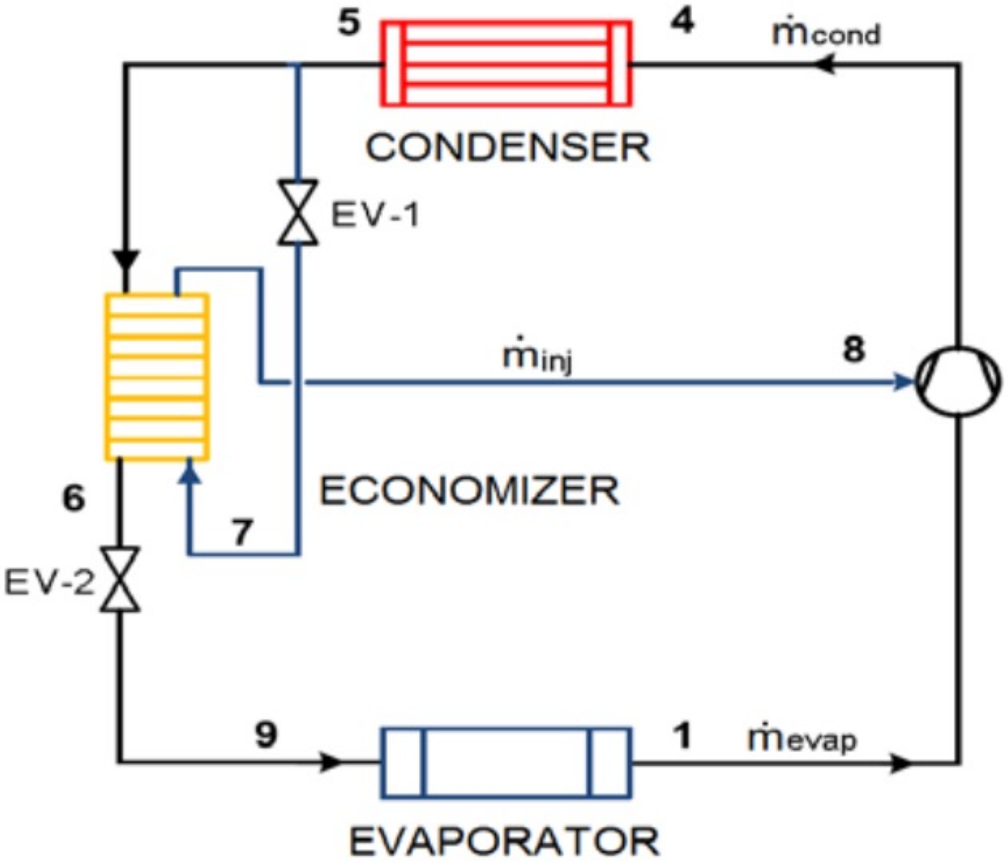
- There is some truth to this statement: the COP and capacity of a heat pump decreases as outside temperature drops
- However, recent advances have improved cold-climate performance substantially
- But are they good enough for Alaska conditions?



Schoenbauer, Ben, Nicole Kessler, David Bohac, and Marty Kushler. "Field assessment of cold climate air source heat pumps." In *ACEEE Summer Study on Energy Efficiency in Buildings*. 2016.

Recent improvements in ccASHP technology

- Cold-climate Air Source Heat Pumps take advantage of:
  - Refrigerants with lower boiling point
  - Variable speed compressor
  - Vapor injection
- Modern ccASHPs can function effectively at temperatures down to 0ºF



Tello Oquendo, Fernando M., Emilio Navarro-Peris, and José Gonzálvez-Maciá. "A Methodology for Characterization of Vapor-injection Compressors." (2016). Purdue e-pubs.

How does an installer know what to select?

NEEP'S COLD CLIMATE AIR SOURCE

Heat Pump List

VIEW DETAIL

[redacted]

AHRI #: **201754461**
Singlezone Ducted, Compact Ducted
Central Air Conditioning Heat Pump (HP)
14,300 Max Btu/h **@5°F**
29,400 Rated Btu/h **@47°F**
24,400 Rated Btu/h **@95°F**
COP @5°F: **2.33**
HSPF: **10.8**
Outdoor Unit Model #: **PUZ-A24NHA7*****
Indoor Model #: **PEAD-A24AA***

VIEW DETAIL

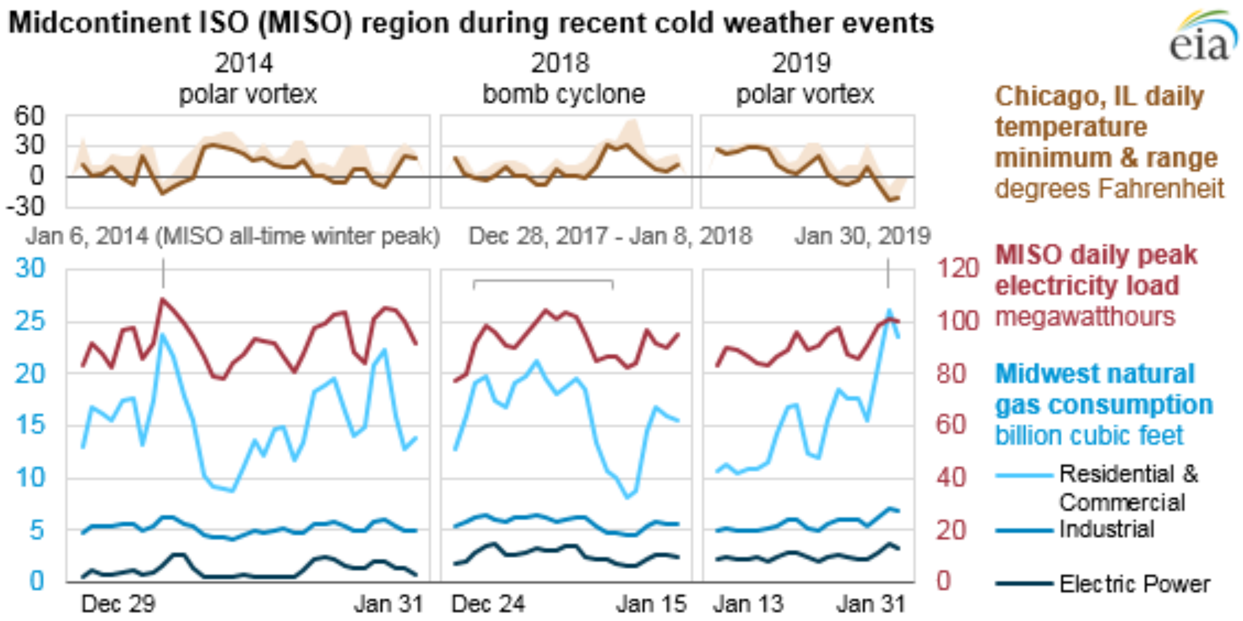
AHRI #: **201754463**
Singlezone Ducted, Centrally Ducted
Central Air Conditioning Heat Pump (HP)
14,500 Max Btu/h **@5°F**
28,000 Rated Btu/h **@47°F**
24,000 Rated Btu/h **@95°F**
COP @5°F: **2.24**
HSPF: **9.3**
Outdoor Unit Model #: **PUZ-A24NHA7*****
Indoor Model #: **PVA-A24AA***

VIEW DETAIL

AHRI #: **201754460**
Singlezone Non-Ducted, Ceiling Placement
Central Air Conditioning Heat Pump (HP)
14,900 Max Btu/h **@5°F**
28,000 Rated Btu/h **@47°F**
24,000 Rated Btu/h **@95°F**
COP @5°F: **2.3**
HSPF: **10.8**
Outdoor Unit Model #: **PUZ-A24NHA7*****
Indoor Model #: **PCA-A24KA***

Potential problem with widespread HP adoption

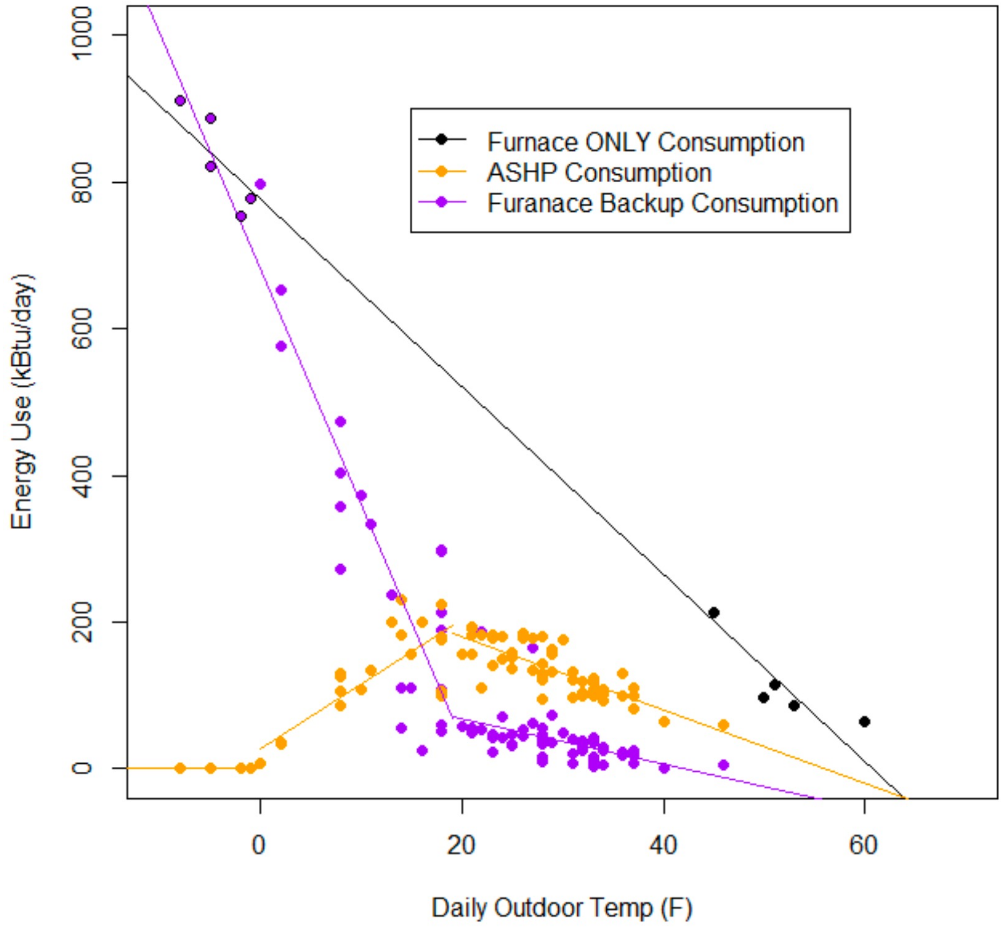
- On very cold days, ASHP may not have sufficient capacity to heat the space
- No problem, backup resistance heater comes on and provides necessary heat!
- This could place an excessive strain on the electric grid



eia Independent Statistics and Analysis
U.S. Energy Information Administration

Solution 1: dual fuel heat pumps

- Several manufacturers offer integrated gas / ccASHP system
- Existing furnace systems can be run in parallel with new ccASHP
- The transition between gas and ccASHP operation is adjusted to suit user requirements



Schoenbauer, Ben, Nicole Kessler, David Bohac, and Marty Kushler. "Field assessment of cold climate air source heat pumps." In *ACEEE Summer Study on Energy Efficiency in Buildings*. 2016.

Solution 2: better building envelope

- Passivhaus principles:
  - Highly insulated walls
  - High-performance windows
  - Minimize thermal bridges
  - Minimize infiltration
  - heat recovery ventilation
  - Thermal storage
  - Radiant heat
- Retrofitting to passivhaus standard can be expensive
- What is a reasonable compromise?

What's wrong with this picture?

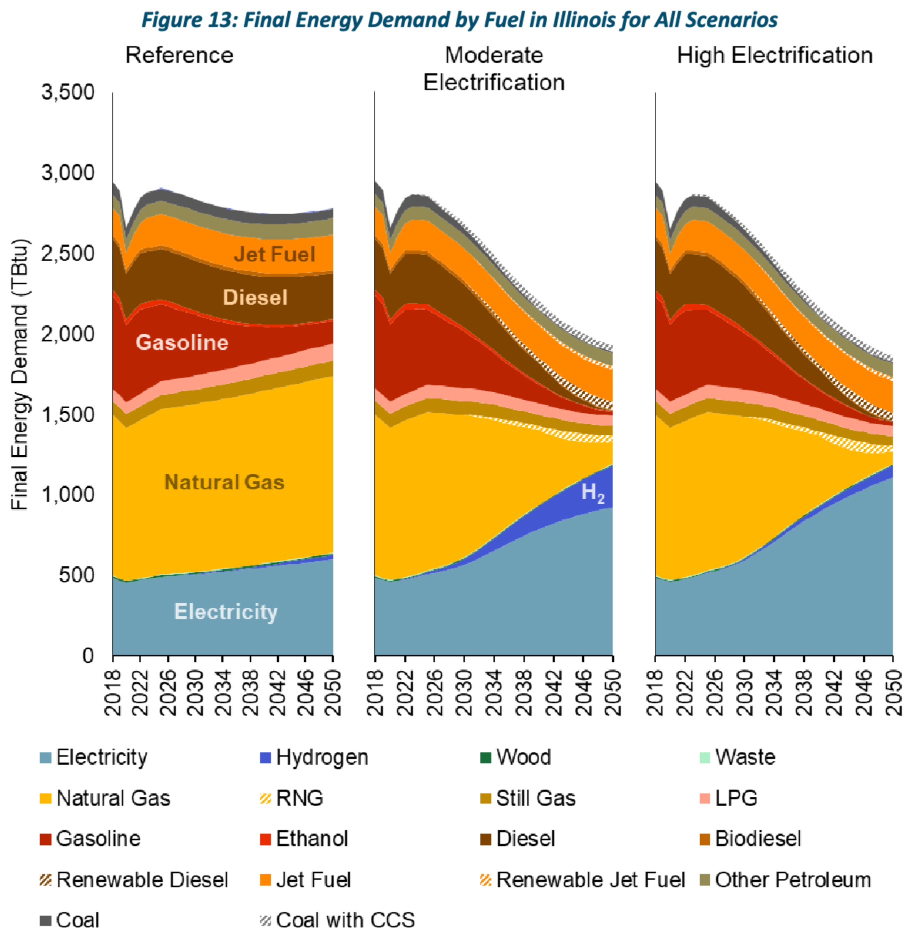
Solution 3: geothermal heat pump

- Ground temperatures are generally constant even during cold parts of the year
- Alaska conditions are more challenging, depending on location
- Higher upfront cost are offset by energy savings in the long run
- Another option: heat exchange with ocean or other water bodies – as in the case of the Prince William Sound Science Center in Cordova, under construction now

Installation work on the ground source heat pump loop for Juneau airport, 2012

Back of the envelope calculation for heating buildings

- 1.41M metric tons of CO_2 equivalent for heating and cooking in 2020
- This corresponds to 0.512M metric tons of natural gas burned
- Assuming efficiency of 70% for a typical furnace / boiler, this corresponds to 20M GJ of heat
- Assuming an average COP of 2, this is equivalent to 2.78M MWh of electricity
- Chugach 2021 retail sales were 1.92M MWh
- Detailed study under way at ACEP



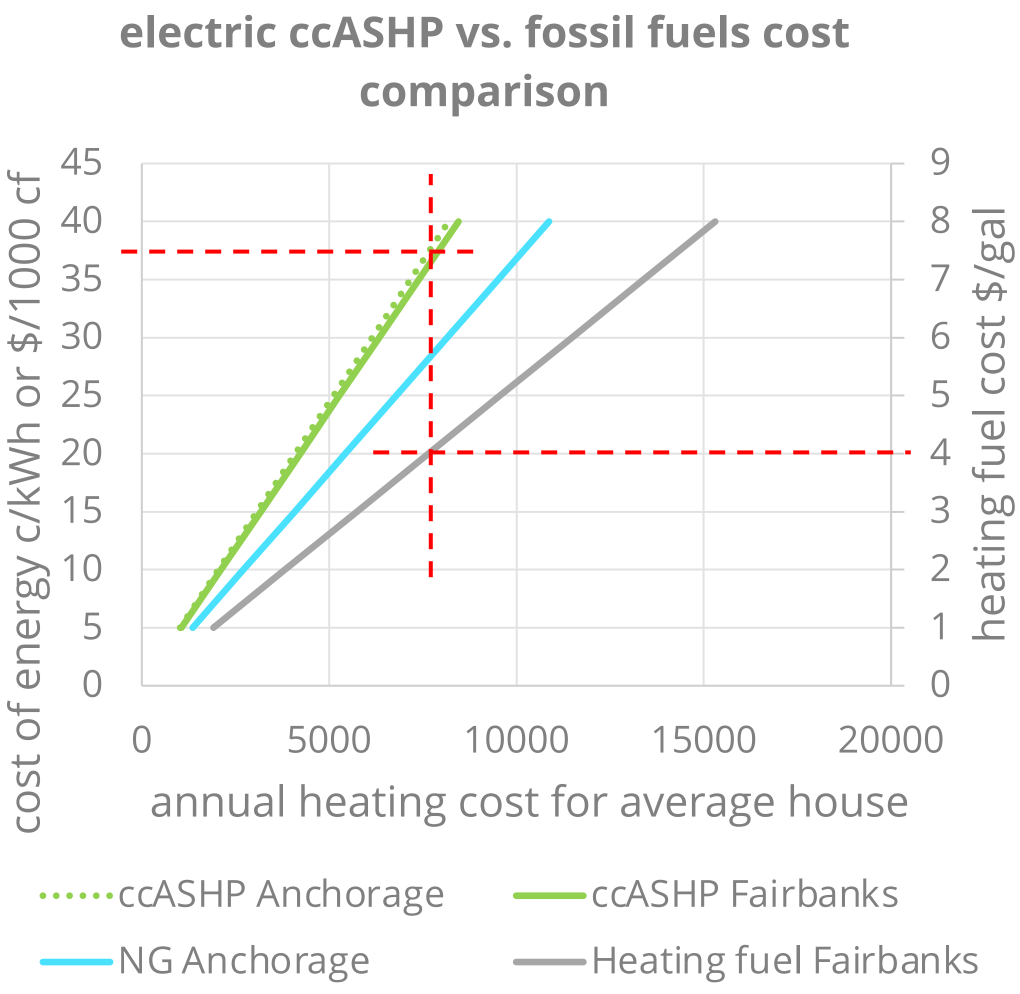
Illinois Decarbonization Study
Climate and Equitable Jobs Act and Net Zero by 2050, Energy+Environmental Economics 2022

What are the economics?

- The cost of installing a ccASHP can be from $6k to $35K in Alaska. There are rebates but these are capped and this is still a major investment
- The cost of retrofitting a house to Passivhaus standard can be 30% of the value of the house. For the “average” Anchorage house (median cost $410K in 2023), this is about $123K, not exactly pocket change, and about twice the cost of the average major remodel
- The average monthly heating cost in Alaska is $291, with a 7-month heating season
- So, does an energy retrofit make sense? What can be done to change this?

How much does it cost to run heating?

- The COP of a heat pump changes with temperature, so the cost of a unit of heat varies throughout the cooling season
- The published Heating Seasonal Performance Factor is a measure of the "average" performance of a heat pump over a heating season and can be used to get seasonal cost
- On the other hand, NG and Heating Fuel cost per unit heat is constant



Recap so far

- Buildings use about 40% of total primary energy production in the US, but 17% in Alaska, due to large industrial energy consumption. However, 77% of all electricity sales go to commercial and residential buildings.
- Heating is the largest residential energy user in Alaska, between 76% and 83%
- Heating is also the largest commercial building energy user in Alaska, at 58% for space and water heating combined
- Most of the heat is from burning fuels, so there is an opportunity for decarbonizing heating – but how?
- Much of the decarbonization could be in the form of heat pumps
- Cold climate heat pumps have improved substantially in recent years
- The Alaska climate still poses challenges, but solutions exist
- Deep electrification of building heating could produce almost 150% electric load growth in Anchorage

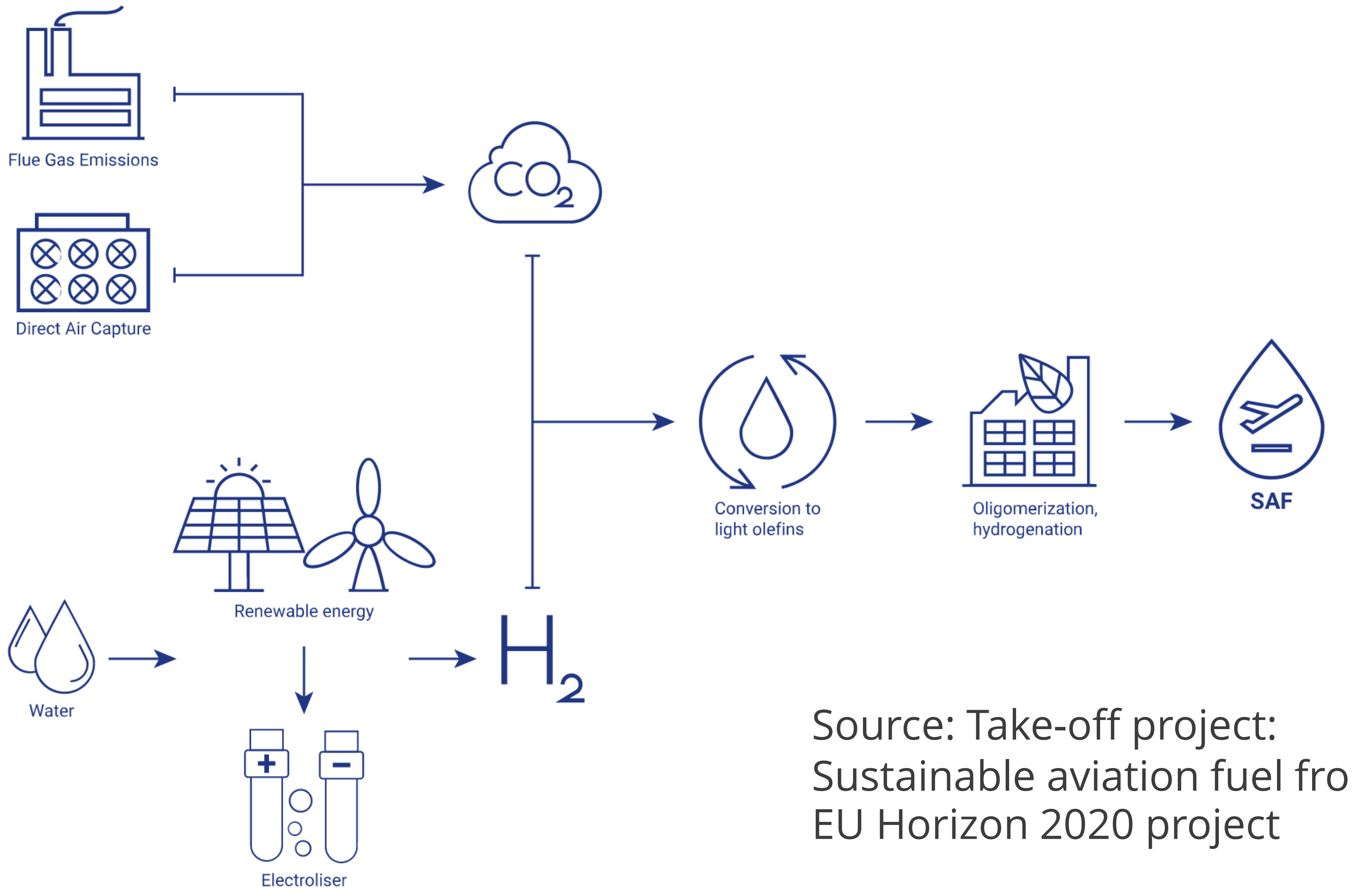
Electrification of the chemicals industry

- The chemicals industry is responsible for 37% of all industrial emissions in the US (EPA 2021)
- Petrochemicals are organic chemicals made primarily using oil, gas and coal
- Petrochemicals are used in a wide variety of consumer products ranging from pharmaceuticals to shampoo to plastic bottles
- There is vast potential to shift the source of carbon from fossil to CO_2 contained in flue gases or even the atmosphere

Sustainable aviation fuel

- Aviation is developing drop-in solutions for existing fleet and infrastructure
- Feedstocks:
  - Waste oil / fats
  - Municipal waste
  - Non-food biomass
  - Synthetic route via DAC and H_2
- SAF is carbon neutral because carbon released in combustion is derived from carbon absorbed from atmosphere
- But – currently only 0.1% of total fuel used in aviation industry is SAF (IEA)
- ANC uses almost 2M gal of jet fuel per day!

One route to production at scale



Source: Take-off project:
Sustainable aviation fuel from CO2.
EU Horizon 2020 project

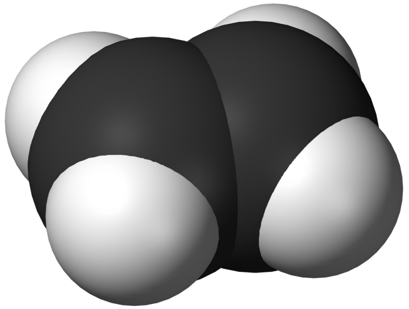
How far are we from chemicals by electrolysis?

- 175 million tons of ethylene are produced per year* (this is one of the highest production chemicals)
- All the renewable energy produced in 2022 (8,500TWh) would not be enough to electrify ethylene production alone (energy need estimated at ~12,000TWh*)
- Is this good news or bad news?

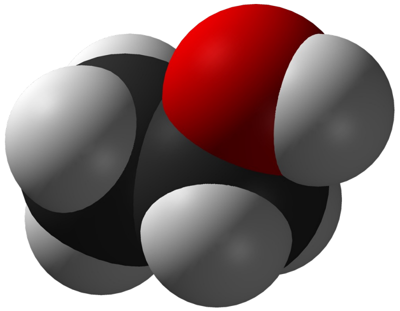
* Source: Xia, Rong, Sean Overa, and Feng Jiao. "Emerging electrochemical processes to decarbonize the chemical industry." *JACS Au* 2, no. 5 (2022): 1054-1070.

Emerging trends

- Electrification of the production of high-carbon-footprint commodity chemicals such as ammonia, nitric acid, ethylene, urea is key to meeting emissions goals
- Production of commodity chemicals by electrolysis to date has not been adopted due to high cost of electricity and lack of technology to allow production at scale
- The cost of renewable electricity, particularly solar PV, continues to drop, from an average of 5c/kWh today to a target of 2c/kWh in 2030 (DOE)
- Rapid progress is being made on suitable catalysts / reactors
- The global petrochemicals market is projected to grow from $582.4 billion in 2021 to $888.3 billion in 2028 (Fortune Business Insights 2022)
- Ammonia and other nitrogen compounds hold similar potential



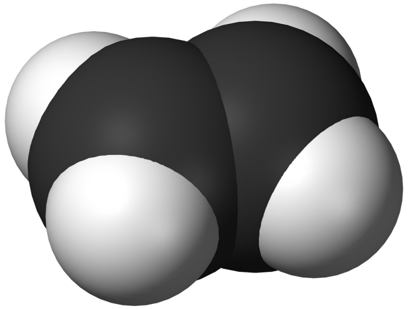
Ethylene molecule



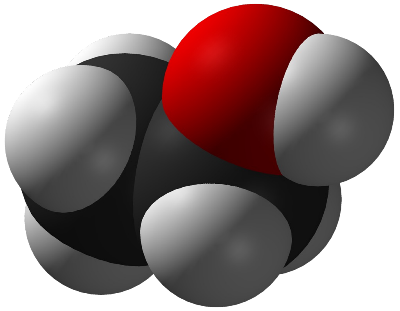
Ethanol molecule

Opportunities for Alaska

- Massive increase in solar, wind, hydro (and nuclear?) generation needed to meet decarbonization targets
- There is potential for large curtailment of solar or wind during certain parts of the year
- Curtailed energy can be absorbed by synthetic fuels or chemicals manufacturing
- Modular, non-steady-state production routes are also being investigated by many
- Hydro power can also play a major role
- Fills a need for aviation and maritime transportation
- TEA needed to establish economic viability of a new type of seasonal industry



Ethylene molecule



Ethanol molecule

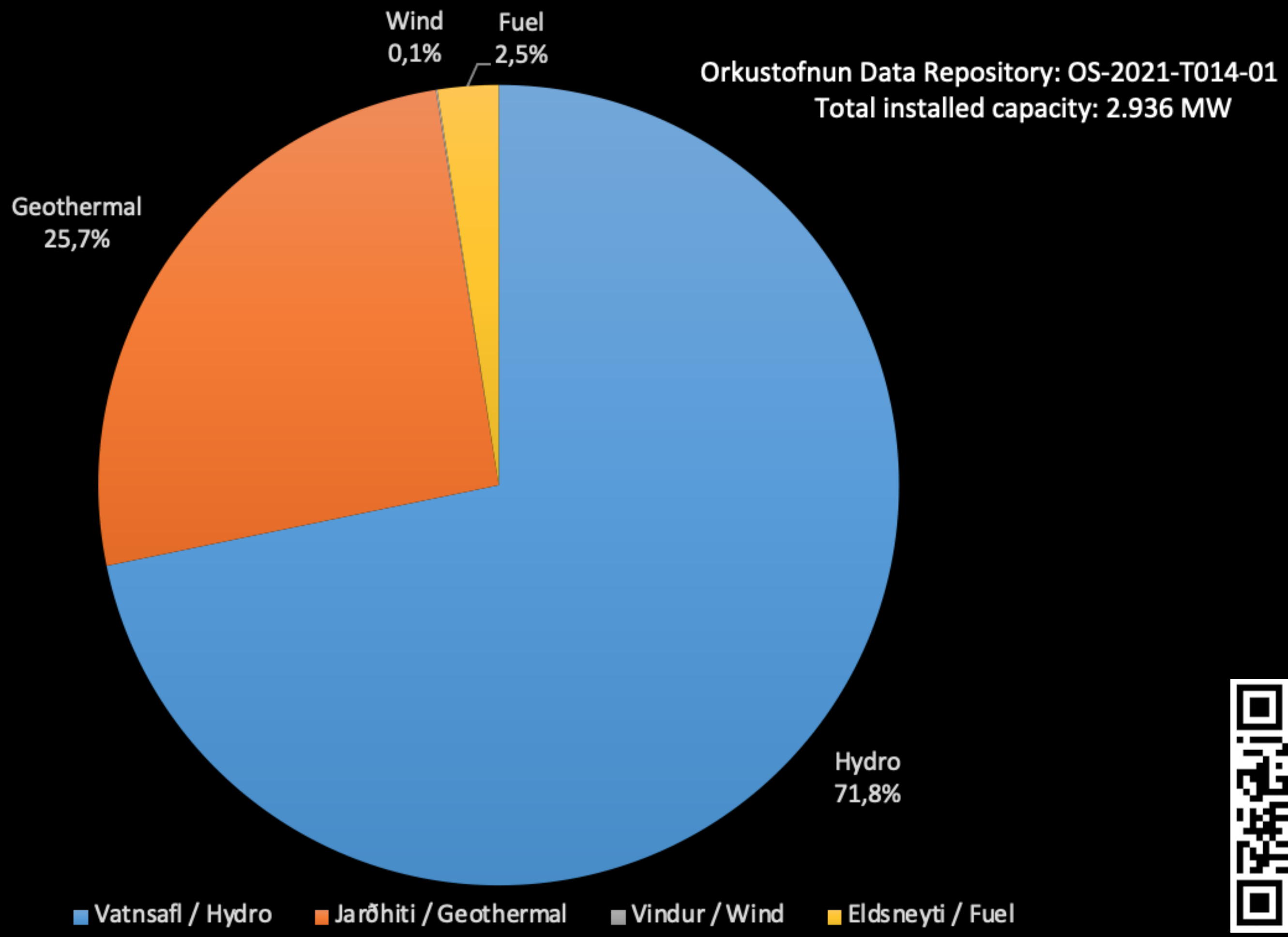
Questions?

Insights into the Icelandic Energy Market

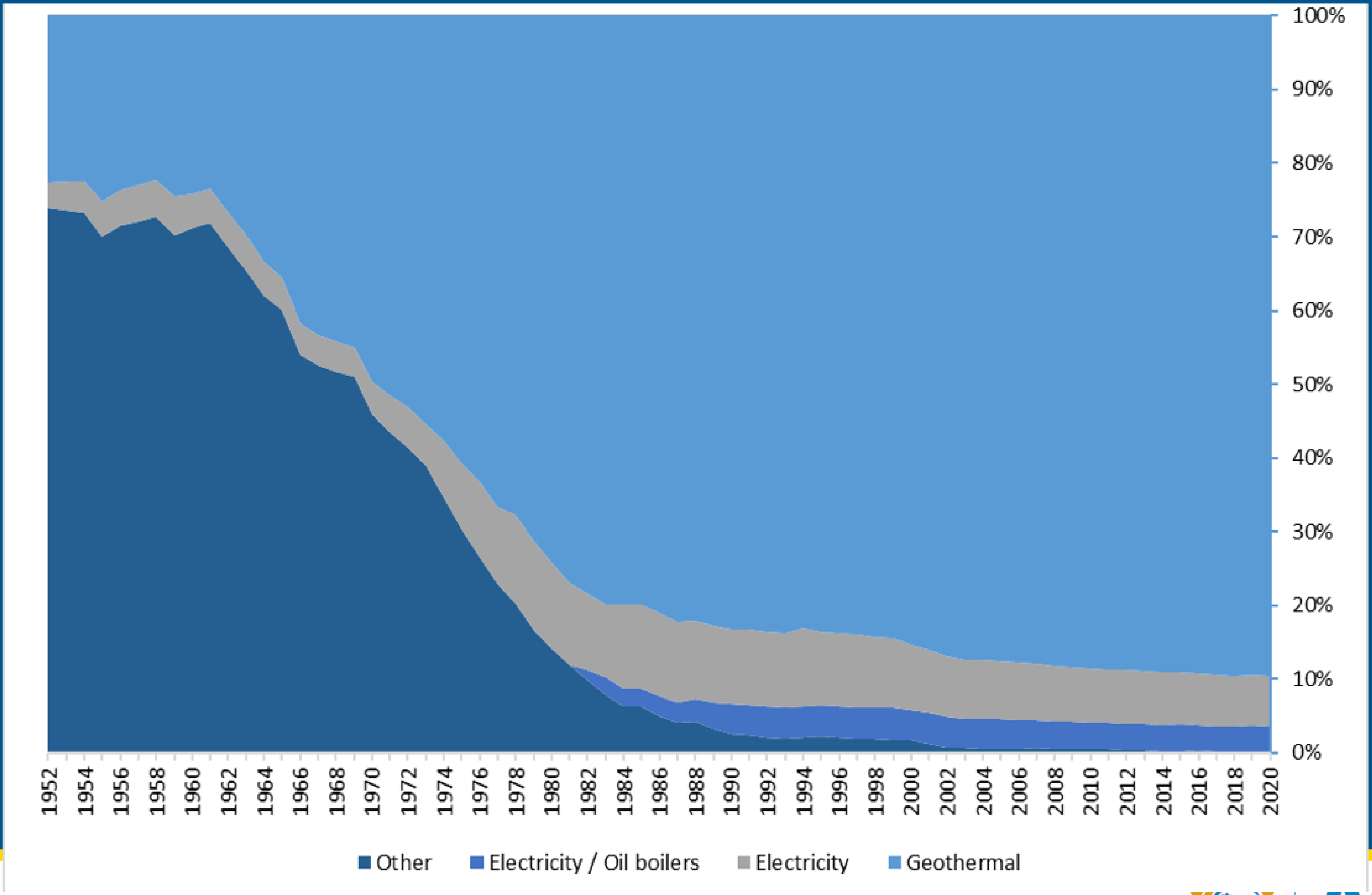
Gwen Holdmann & Erlingur Gudleifsson
Alaska Center for Energy and Power


Welcome to the land
of renewable energy

Installed Capacity by Source (2020)



Space Heating by Energy Source – Iceland 1952-2020

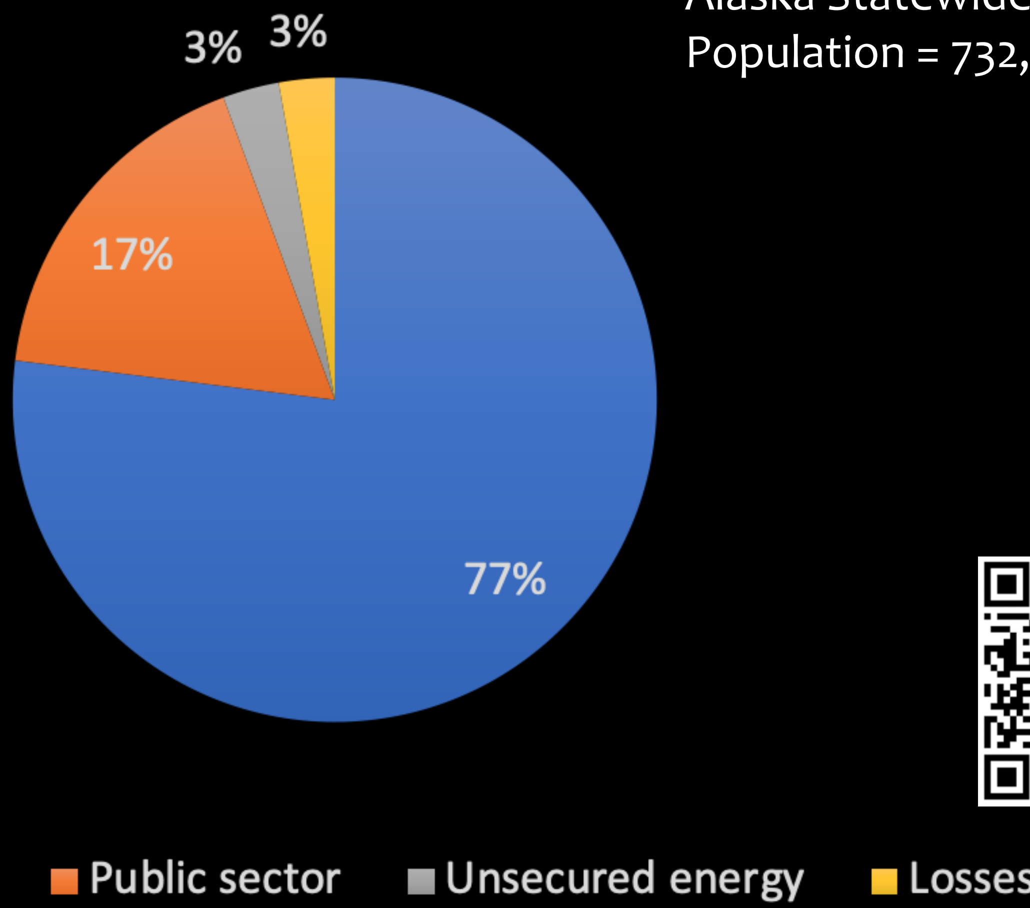


ACEP Alaska Center for Energy and Power

Iceland Electricity Sales/Production

Iceland Total Production 19.8 GWh
Population = 372,000

Alaska Statewide 6.5 GWh
Population = 732,000



ACEP
Alaska Center for Energy and Power


LEAH

Ring Grid/Railbelt Grid Comparison

	Installed capacity	Annual sales	Length	Per capita sales
	[MW]	[GWh]	miles	[MWh/capita]
Railbelt Grid	2,000	4,400	~650	845 MWh/capita
Ring Grid	2,900	19,100	~2000	51.6 MWh/capita

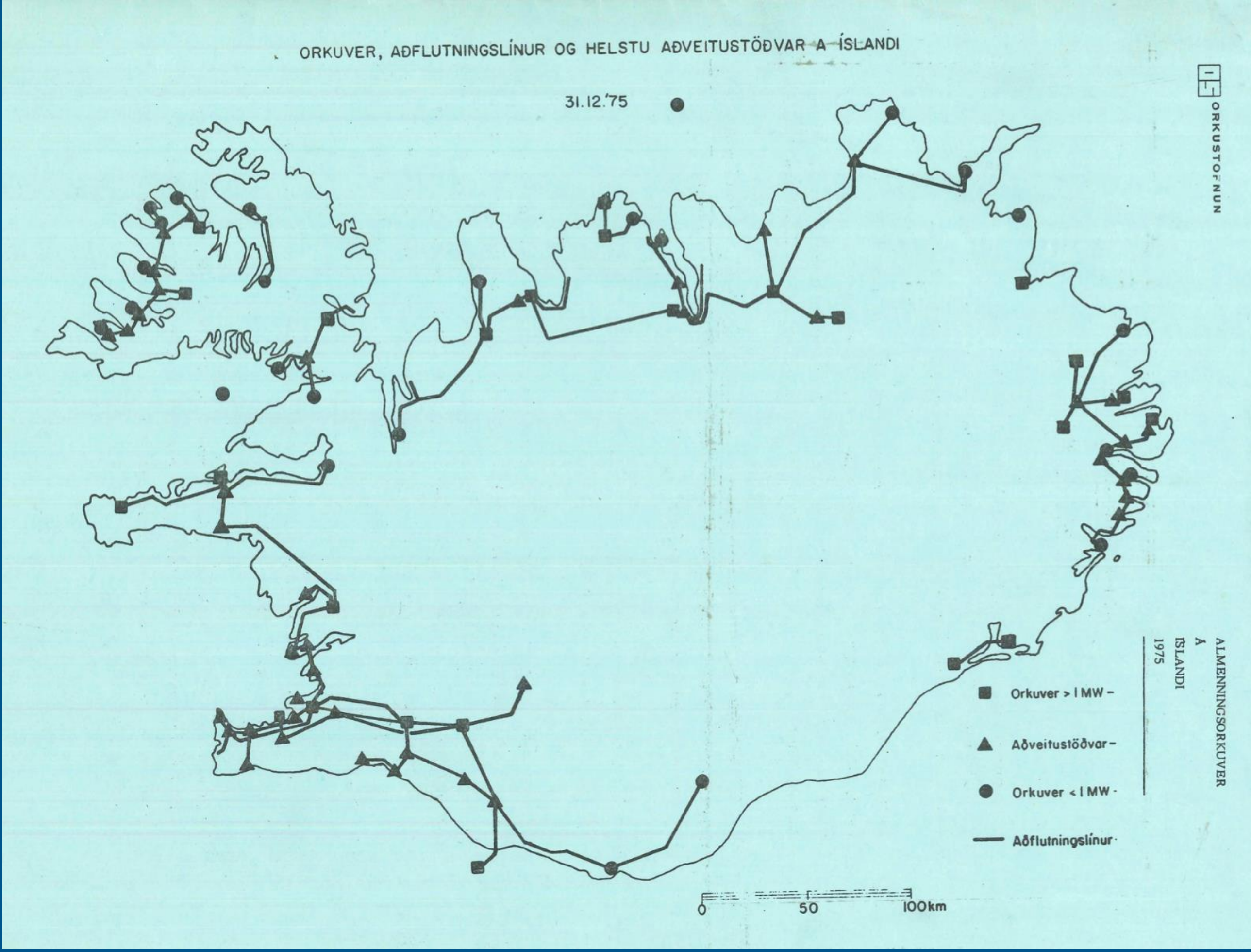
ACEP
Alaska Center for Energy and Power

Ring Grid/Railbelt Grid Comparison

	Installed capacity	Annual sales	Length	Per capita sales
	[MW]	[GWh]	miles	[kWh/year]
Railbelt Grid	2,000	4,400	650	845 kWh/yr
Ring Grid	2,900	19,100	2000	51,620 kWh/yr

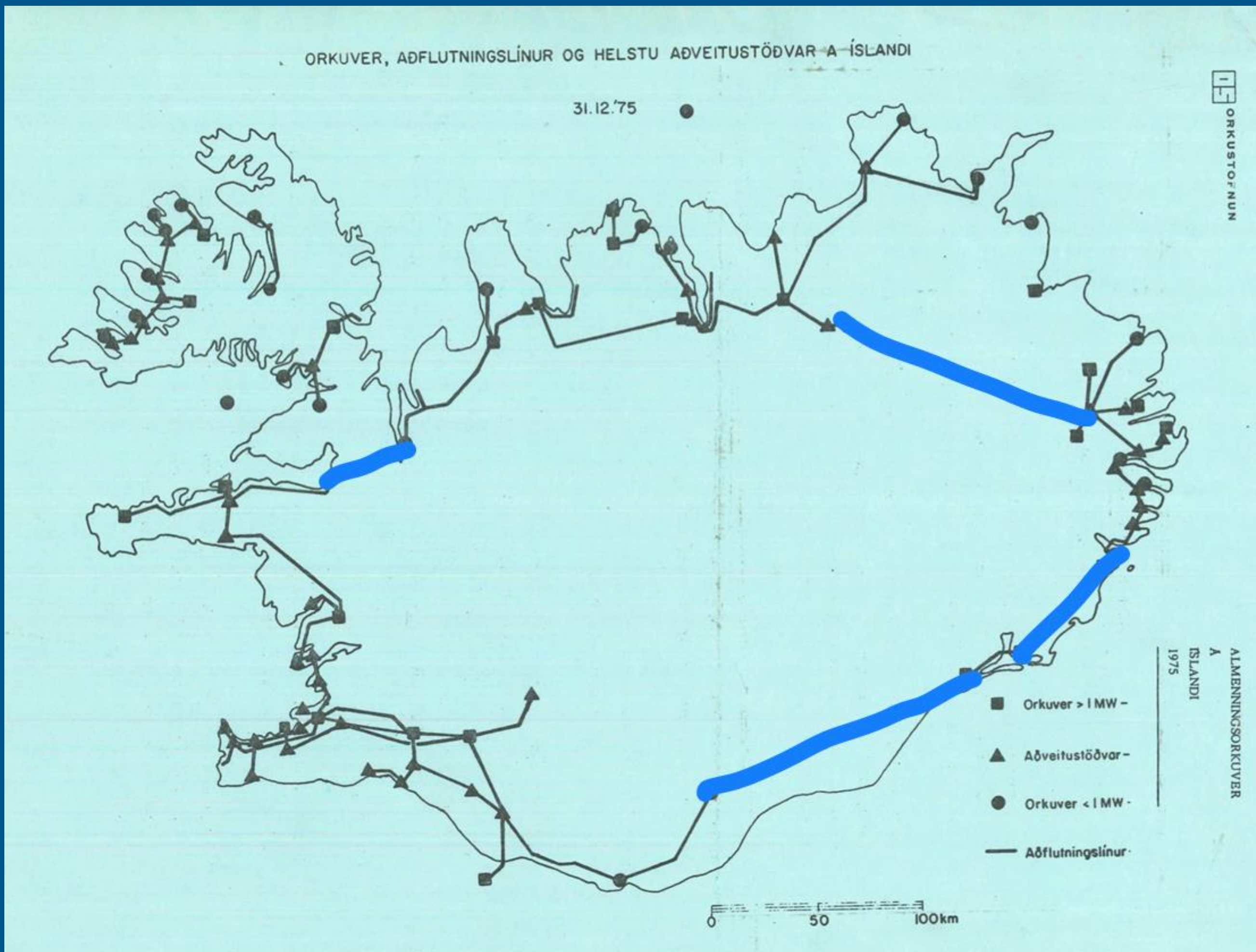
On a per capita basis, Iceland produces and sells 6 times more electricity than the Railbelt grid

"Closing the Gap"



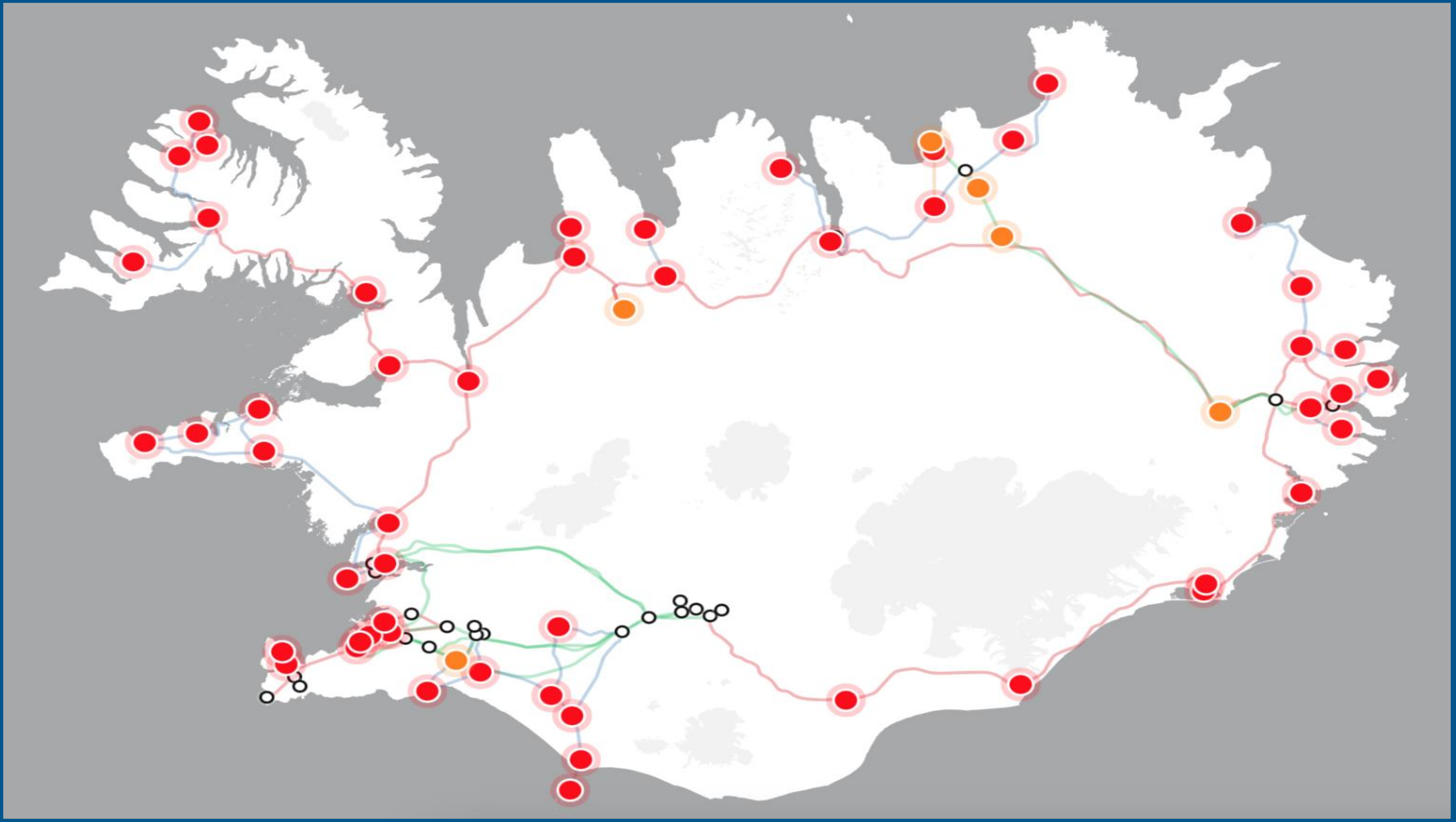
Iceland circa 1975 had 4 independent non-interconnected generation "regions"

“Closing the Gap”



Transmission interconnections completed in 1984

TSO Grid and Generation Stations (2023)



Alaska Center for Energy and Power

Unbundling G&T Assets

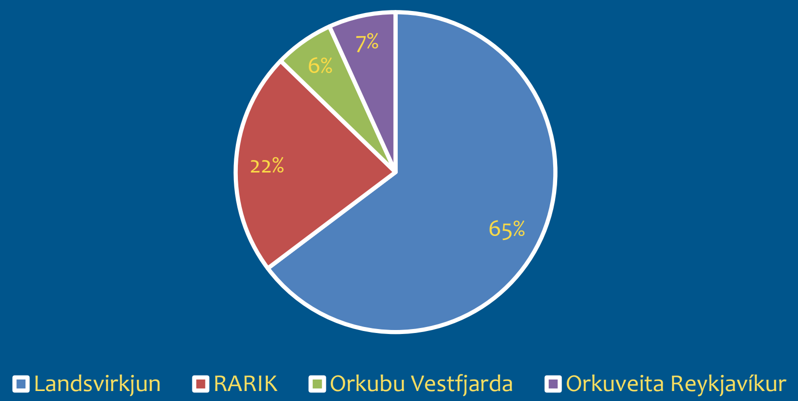
Required by EU Policy – 3 stages over a decade

EFTA

Landsvirkjun

LANDSNET

Landsnet shareholders 2007



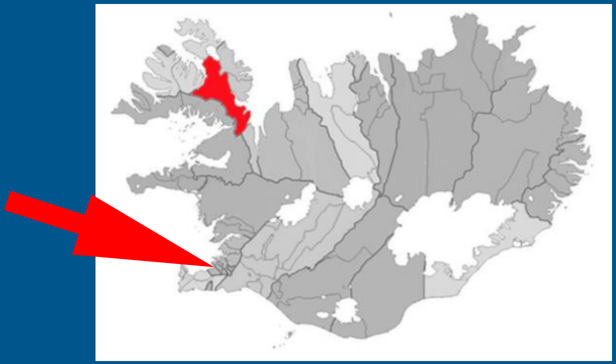
Transmission assets primarily owned by Icelandic state (through Landsnet);

maintains generation and distribution ownership diversity

Consumer Energy Price Structure (Iceland)

	Energy price (general)	Energy price (general)	Energy price (heating)	Energy price (heating)	Heating discount
	kr/kWh	*cents/kWh*	*kr/kWh*	*cents/kWh*	%
Straumlind	6,98	**4,99**	6,25	**4,46**	10,5%
N1 Rafmagn	6,98	**4,99**	6,25	**4,46**	10,5%
Orkubú Vestfjarða	7,50	**5,36**	6,72	**4,80**	10,4%
Orka Heimilanna	7,30	**5,21**	6,54	**4,67**	10,4%
Fallorka	8,67	**6,19**	7,56	**5,40**	12,8%
Orkusalan	9,16	**6,54**	7,68	**5,49**	16,2%
HS Orka	9,24	**6,60**	7,79	**5,56**	15,7%
Orka náttúrunnar	9,18	**6,56**	8,04	**5,74**	12,4%

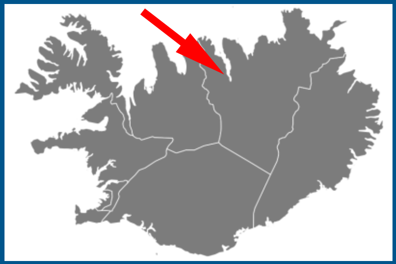
Consumer Pricing – bottom line



		Example 1	Example 2
Energy unit price	cent/kWh	4,02	4,02
VAT		0,97	0,97
Total	cent/kWh	4,99	4,99
Wheeling cost	cent/kWh	10,78	4,66
Equalizing fee	cent/kWh	0,29	0,29
Gov. subsidy	cent/kWh	-3,93	
VAT		1,71	1,19
Total	cent/kWh	8,86	6,14
Total cost	cent/kWh	13,84	11,12
	ISK/kWh	19,38	15,57

Example 1 = rural area; Example 2 = urban area

Electrical prices: Industrial Customer



Small commercial example: Construction company; 150-200 MWh annual sales

Electricity bill brake down

Usage	Qty	Unit	Unit price	Unit	Total (USD)	VAT	Total w. VAT (USD)
Energy (general)	14.114	kWh	4,99	cent/kWh	704,79	24%	873,94
Total usage	14.114	kWh			704,79		873,94

Transmission

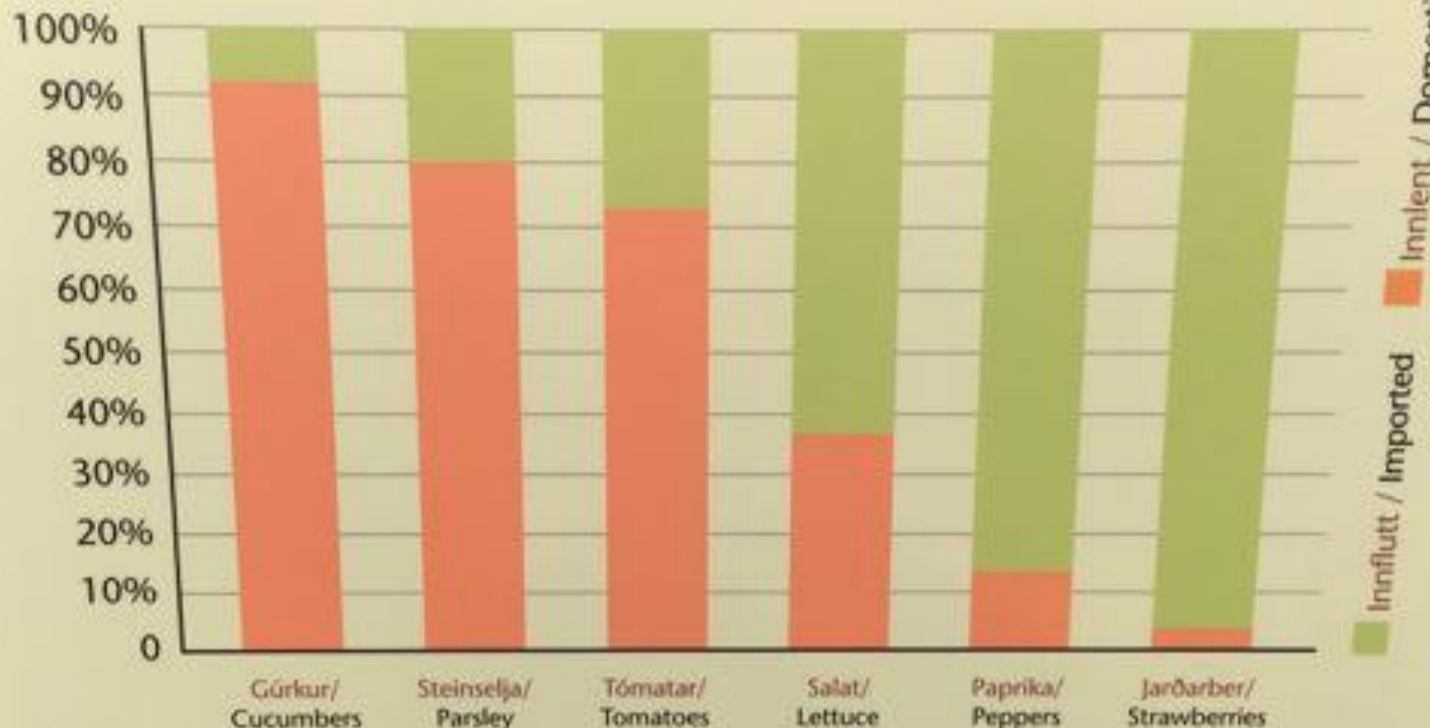
Usage	Qty	Unit	Unit price	Unit	Total (USD)	VAT	Total w. VAT (USD)
Connection fee (general)	31	Days	2,32	USD/day	71,93	24%	89,20
Transmission (general)	14.114	kWh	4,51	cent/kWh	636,14	24%	788,81
Equalizing fee	14.114	kWh	0,29	cent/kWh	41,33	24%	51,25
Total usage					749,41		929,26

To be payed per month (USD)	1.803,21

Average price (cent/kWh)	12,78


FRIÐHEIMAR
Velkomin

Hlutdeild innlendrar framleiðslu í framboði á Íslandi 2010
Participation of domestic production available in Iceland 2010



Megnið af þeim gúrkum sem íslenskir neytendur leggja sér til munns er innlend framleiðsla, eða rúm 90%. Um 75% af tómötum á markaðnum er innlend framleiðsla en einungis lítið brot af jarðarberjunum.

Most of the cucumbers consumed in Iceland are domestic, or about 90%. About 75% of tomatoes on the Icelandic market are domestic produce, but only a small fraction of strawberries.

cers

surface

Framleið
innar og
við innflu

Productio
Agreemen
local produ

Large commercial:

- Located in Reykjavik
- Steel Fabrication and Construction
- ~1200 MWh annual sales

Electricity bill brake down

Usage	Qty	Unit	Unit price	Unit	Total (USD)	VAT	Total w. VAT (USD)
Energy (general)	100.013	kWh	3,52	cent/kWh	3523,46	24%	4.369,10
Total usage	100.013	kWh			3523,46		4.369,10

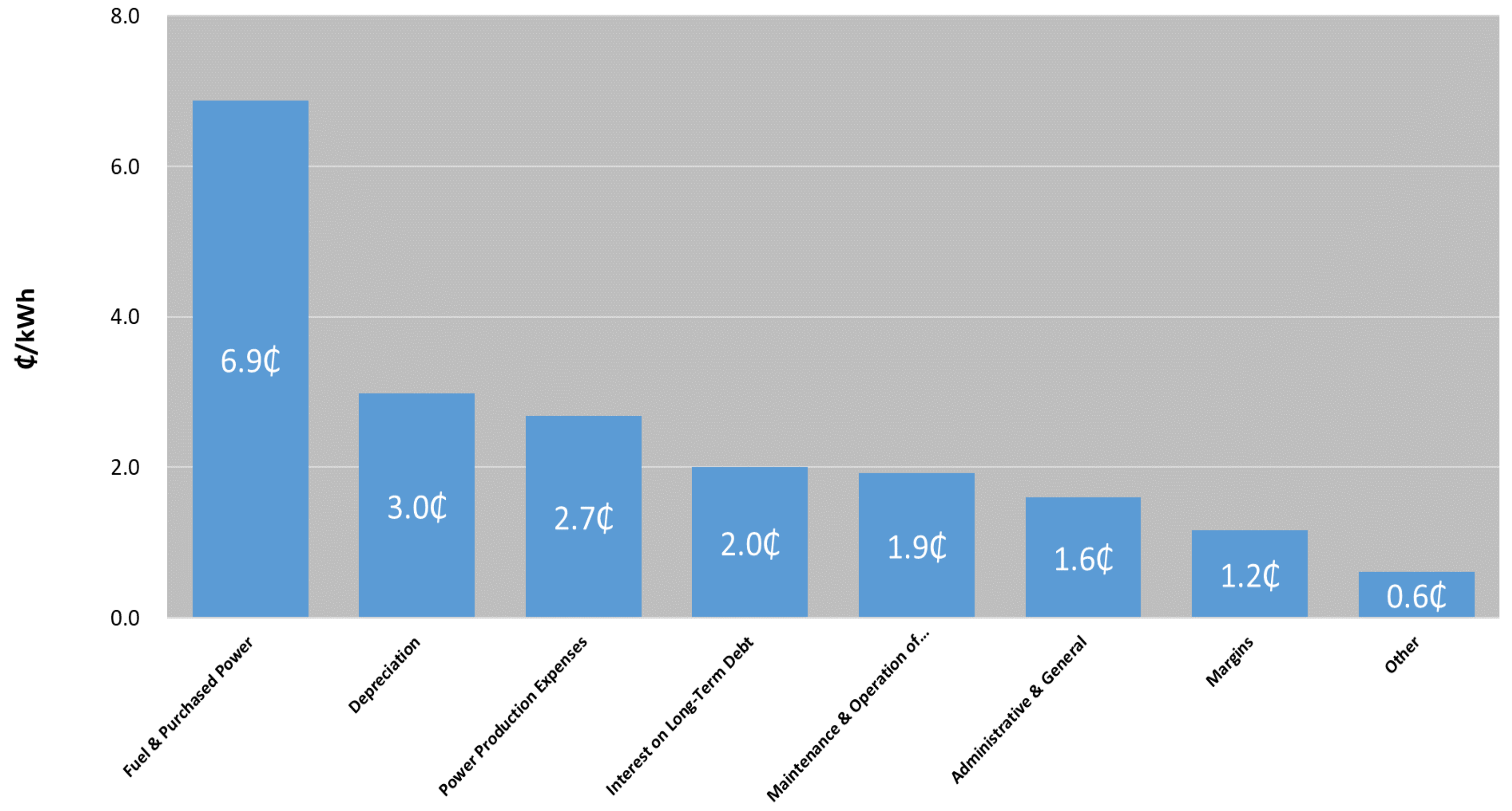
Transmission

Usage	Qty	Unit	Unit price	Unit	Total (USD)	VAT	Total w. VAT (USD)
Connection fee (general)	28	Days	2,32	USD/day	64,97	24%	80,57
TSO fee	100.013	kWh	0,62	cent/kWh	623,37	24%	772,98
DSO fee	100.013	kWh	1,16	cent/kWh	1.159,80	24%	1.438,15
Equalizing fee	100.013	kWh	0,29	cent/kWh	292,90	24%	363,19
Total usage					2.141,03		2.654,88

To be payed per month (USD)	7.023,97

Average price (cent/kWh)	7,02

Railbelt Utilities Cost per kWh (2021)



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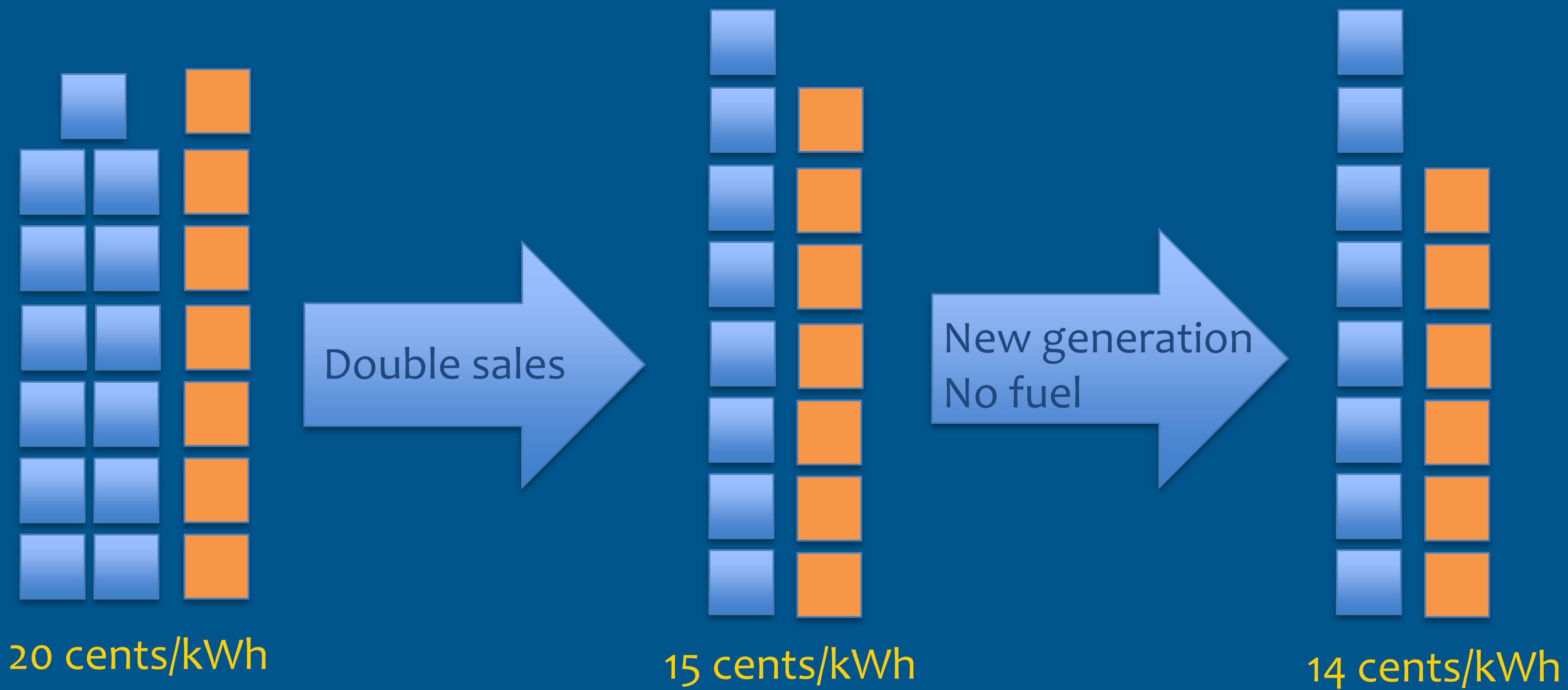
Economies of scale

Many caveats here!!!!



"Cheaper by the dozen" - https://www.uaf.edu/acep-blog/cheaper-by-the-dozen-reducing-alaskas-electricity-costs.php

Iceland's Policies (high level)

- Commitment to energy independence
- Industry partnerships to build up infrastructure
- Investment in transmission
- Subsidies for high-cost regions (heat and power)
- Iceland drilling fund – loan fund to reduce risk
- Iceland energy plan – selecting projects
- Hesitancy to develop intertie
- Investment in knowledge economy

Overseas Activities of Geothermal Companies

Thank you!

Gwen Holdmann
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Alaska Center for Energy and Power

RAILBELT HYDROPOWER DEVELOPMENT & FINANCING: LESSONS LEARNED FROM THE PAST, OPPORTUNITIES FOR THE FUTURE

Thursday, August 3, 2023, 11:00 AM – 1:00 PM

- Small Hydropower in Southcentral Alaska
- Bradley Lake Operations and Governance
- Railbelt Hydropower: Current and Upcoming Projects
- Susitna-Watana Hydro

Small Hydropower in Southcentral Alaska

Governor's Energy Security Task Force Symposium
August 3, 2023

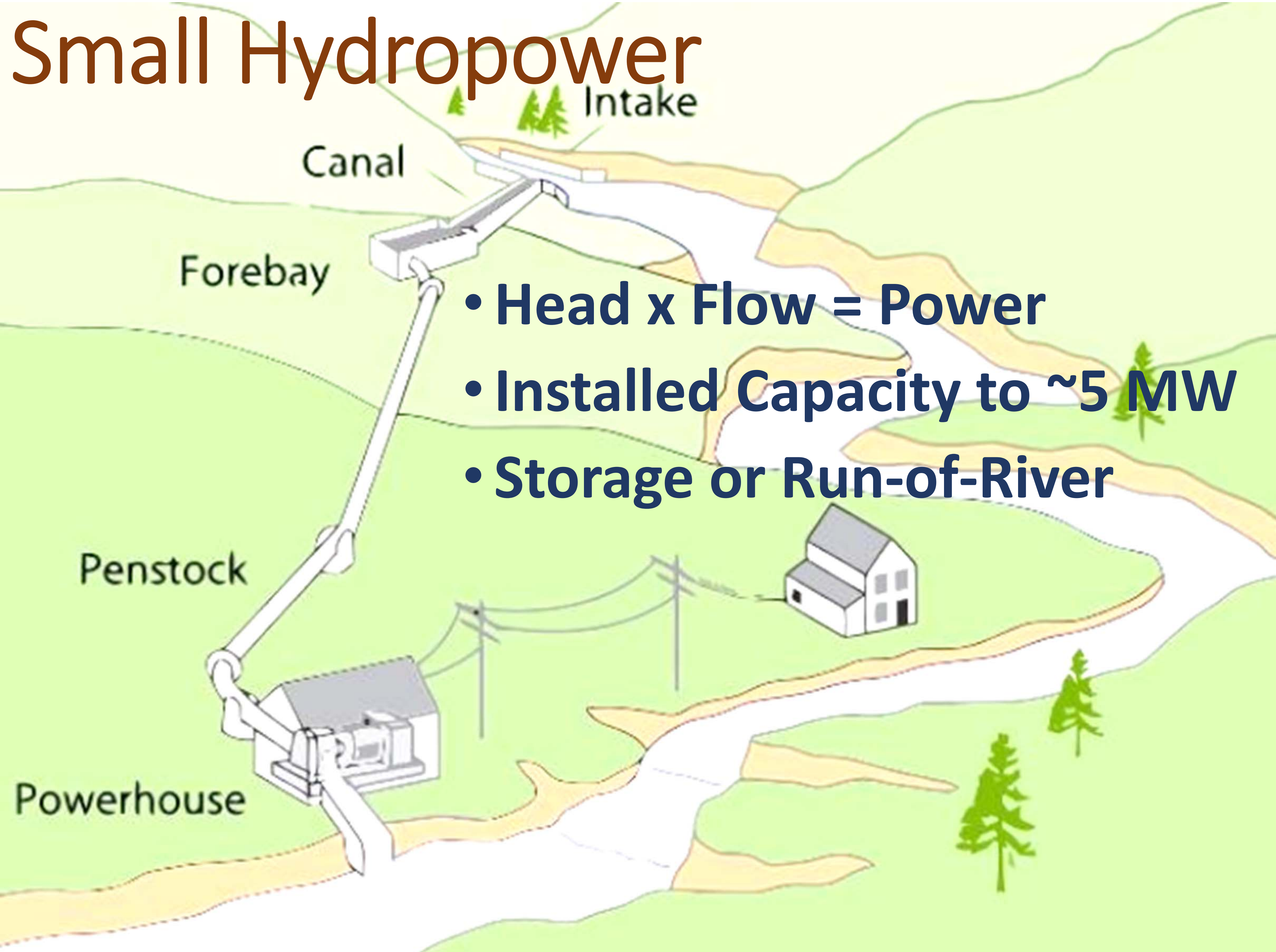
Joel Groves, P.E.

Polarconsult Alaska, Inc.

Presentation Outline

- **What is hydropower?**
- **Small Hydro History in Southcentral**
- **What is the resource potential?**
- **How might we build this?**

Small Hydropower



- **Head x Flow = Power**
- **Installed Capacity to ~5 MW**
- **Storage or Run-of-River**

Big Storage Hydro

Bradley Lake
Homer, Alaska
120 MW

Small Storage Hydro

Chuniisax Creek
Atka, Alaska
270 kW

Big ROR Hydro

Forest Kerr Project
British Columbia, Canada
195 MW

Small ROR Hydro

Juniper Creek
Eagle River, Alaska
300 kW

2. Small Hydro History

Early generation in Southcentral

- Canneries – 1910s
- Mines (Hatcher Pass, etc.) 1910s – 1950s
- Communities (Seward, Valdez, others…)
- Eklutna River (2 MW, 1920s)

…Hydro History & Lessons

Hydro Independent Power Producers (IPPs)

- 1991 – 100 kW McRoberts Creek ($0.04 / kWh)
- 2013 – 1.1 MW South Fork ($0.07 / kWh)
- 2021 – 300 kW Juniper Creek ($0.07 to 0.08 / kWh)
- No government subsidies!
- Short lead (2 to 50 years)!
- Unique circumstances – not commercially replicable
- Intriguing potential…

→ OLD HYDRO IS THE CHEAPEST POWER THERE IS.

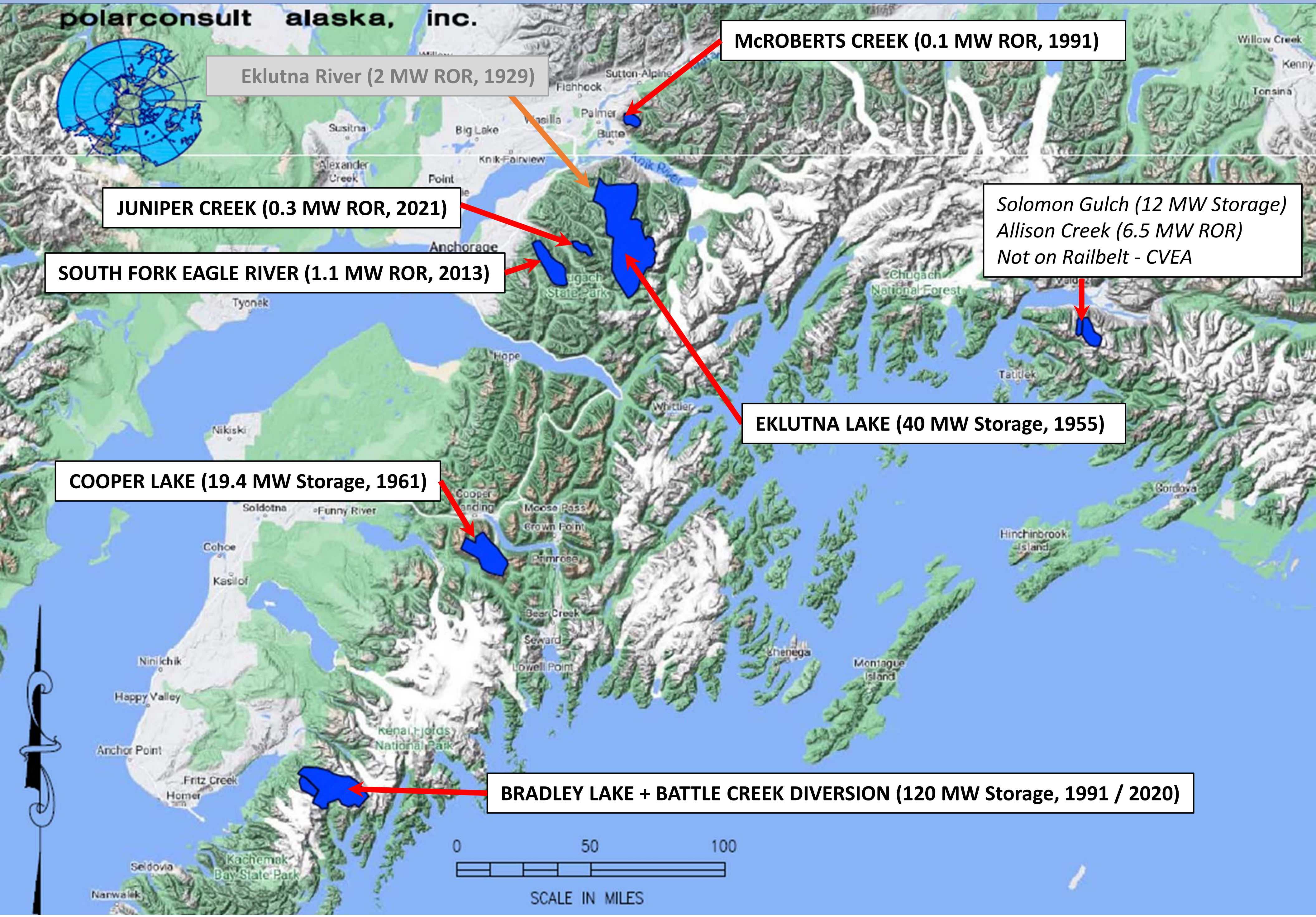
→ IPP SMALL HYDRO IS ON THE CUSP OF COMM. VIABILITY.

3. Small Hydro Resource Potential

How much are we talking about?

Existing Grid-tied Hydropower in SCAK

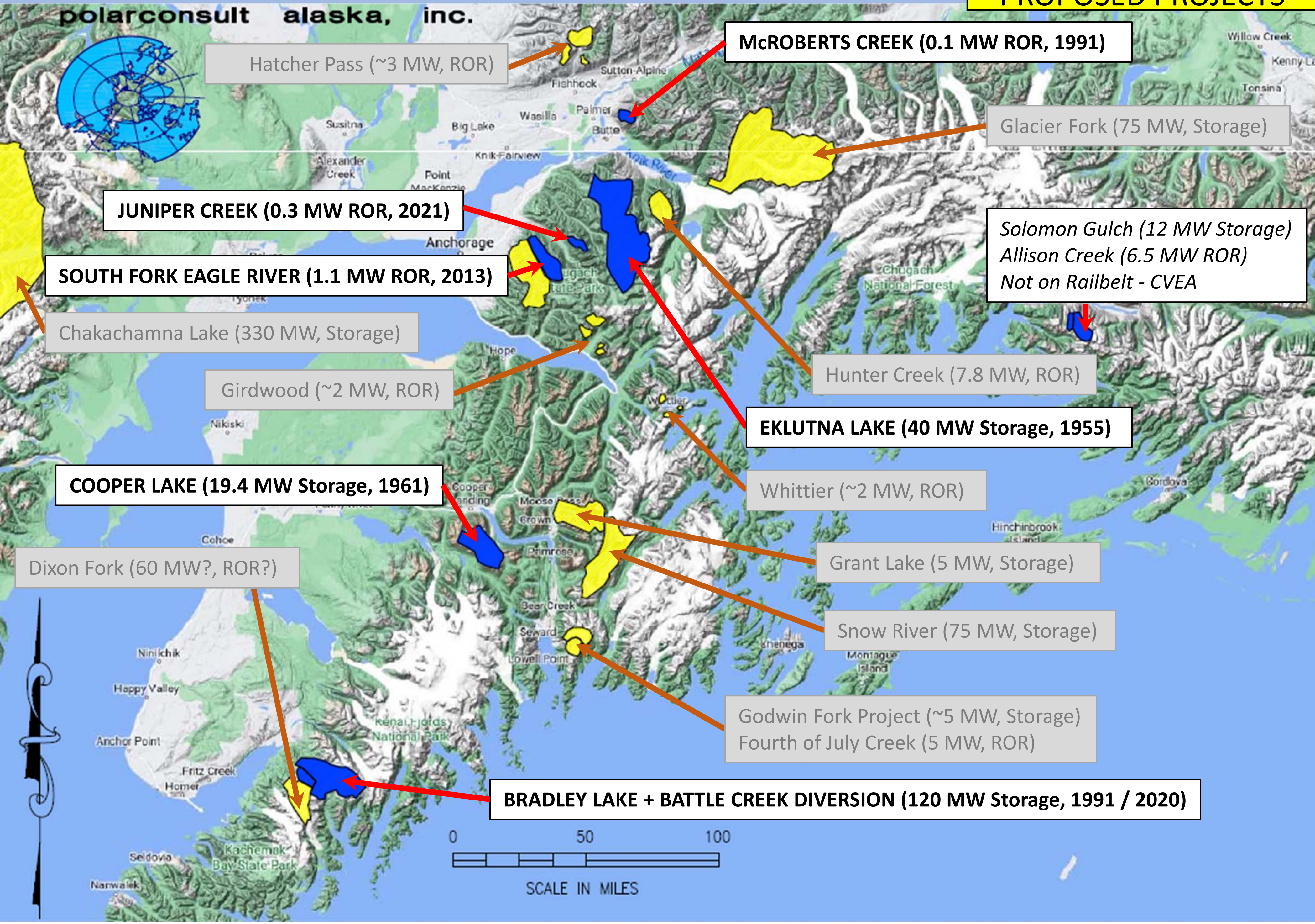
EXISTING PROJECTS



Existing / Proposed Grid-tied Hydropower

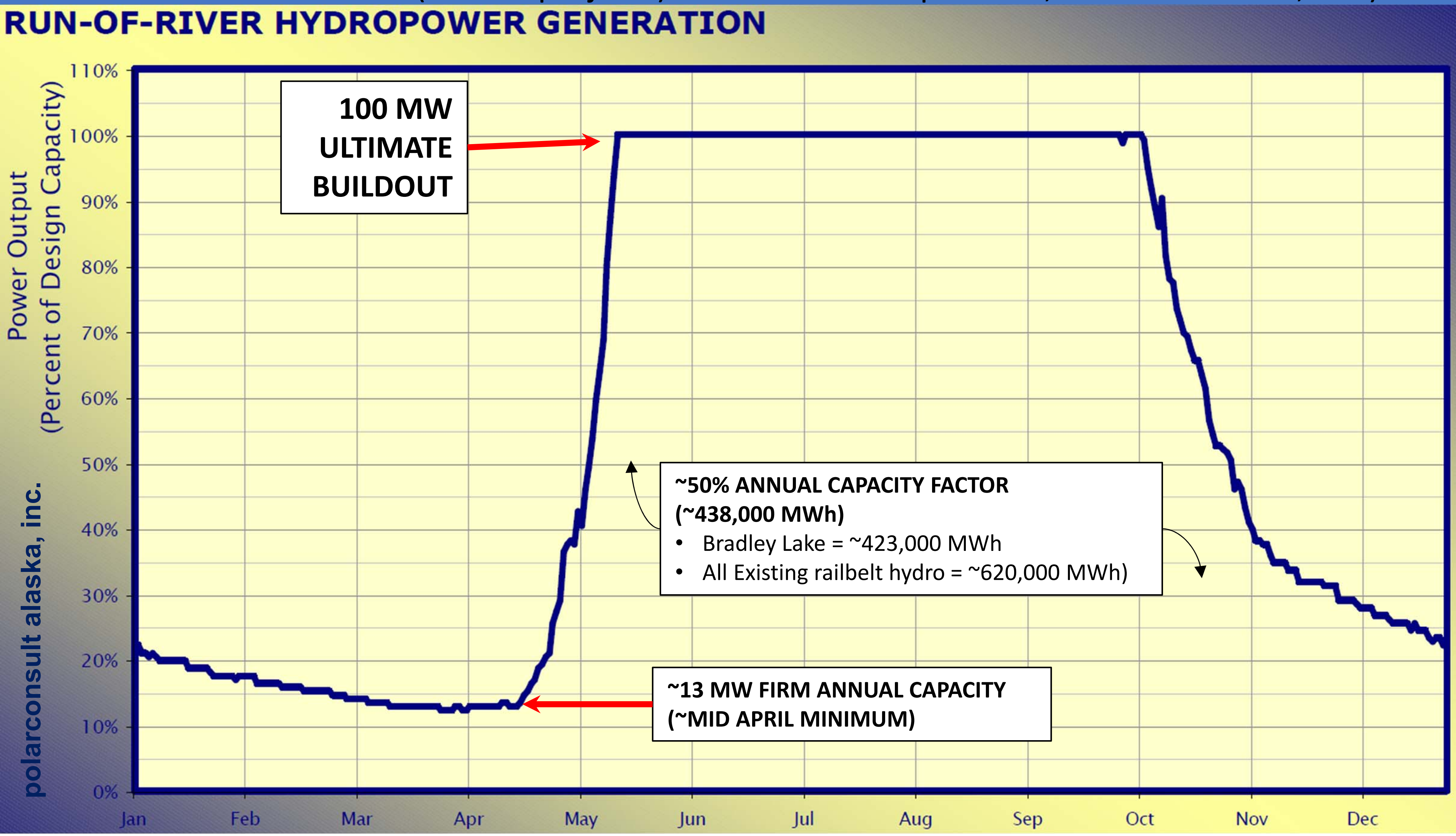
EXISTING PROJECTS

PROPOSED PROJECTS

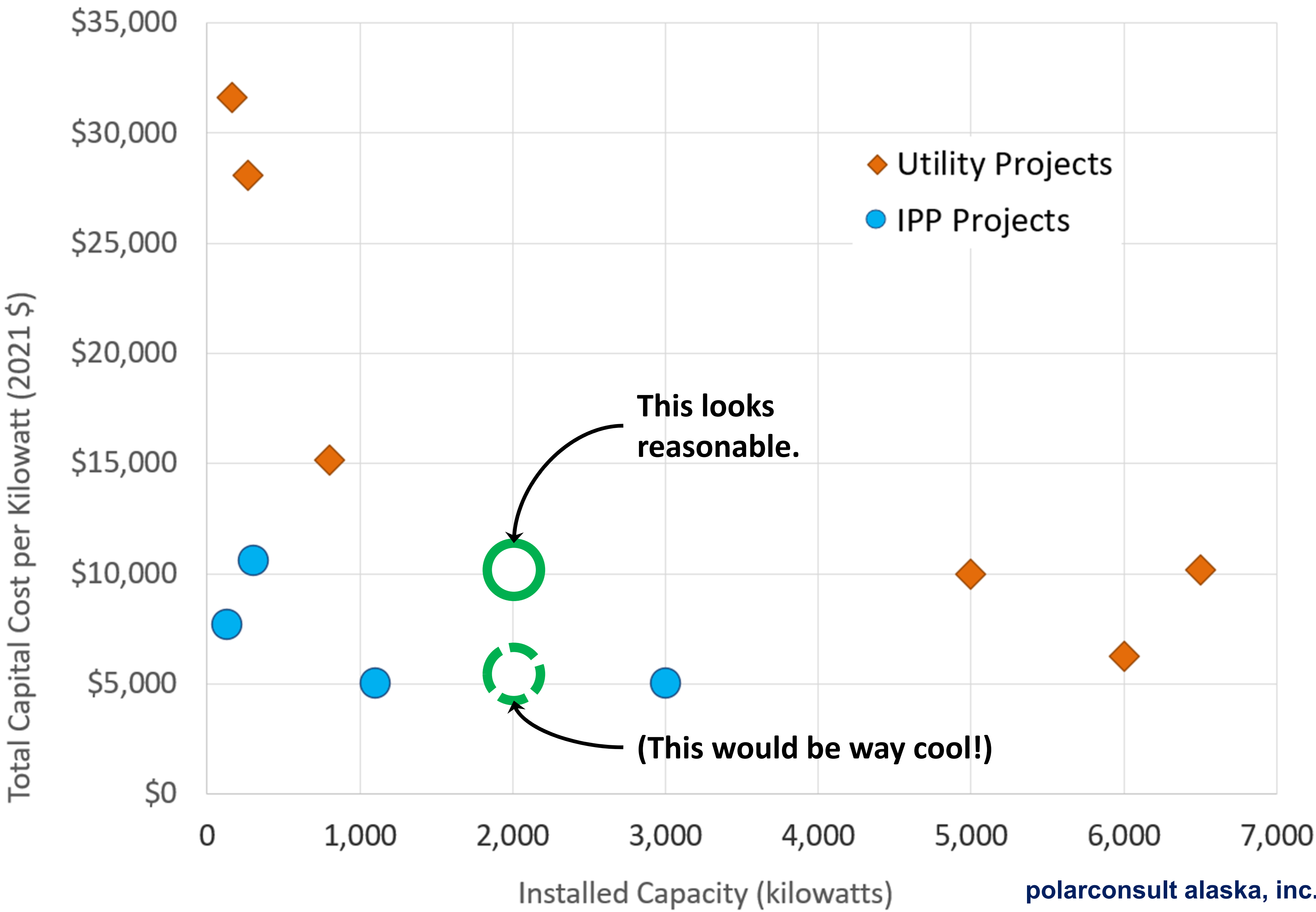


SOUTHCENTRAL SMALL HYDRO RESOURCE POTENTIAL

- 100 MW small hydro capacity is achievable
- Roughly equal to 2nd Bradley Lake Project
- Environmentally sustainable
- Distributed Generation (~40-60 projects)
- Recreational Enhancements
- Grid Resiliency Benefits
- Distributed Risk (development, operation, natural disaster, etc.)



COST?



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What's the Bottom Line?

- $500M to $1B Capex over many years
- 40 to 60 individual, independent Projects
- Project commissioning 2-5 years after commitment
- 100 MW Cumulative Capacity
- 438,000 MWh annually (~10% Railbelt Demand)
- ~25 MW firm capacity at peak load (Dec / Jan)
- ~15 MW minimum firm capacity (April / May)

→ 100 MW capacity is probably conservative
→ More progress needed before fine-tuning

4. Barriers to Small Hydro on the Railbelt

Three new projects totaling 1.5 MW in 30 years is not a solution.

Small Hydro Barriers

- **Regulatory Reform**

→Permit Agencies need binding, uniformly applied decision deadlines

→Reform to state land authorization processes

- **Market Reform**

→Utilities recognize full value of hydro projects

→De-monopolize (monopsonize) energy market


Thanks for Listening!
Questions?
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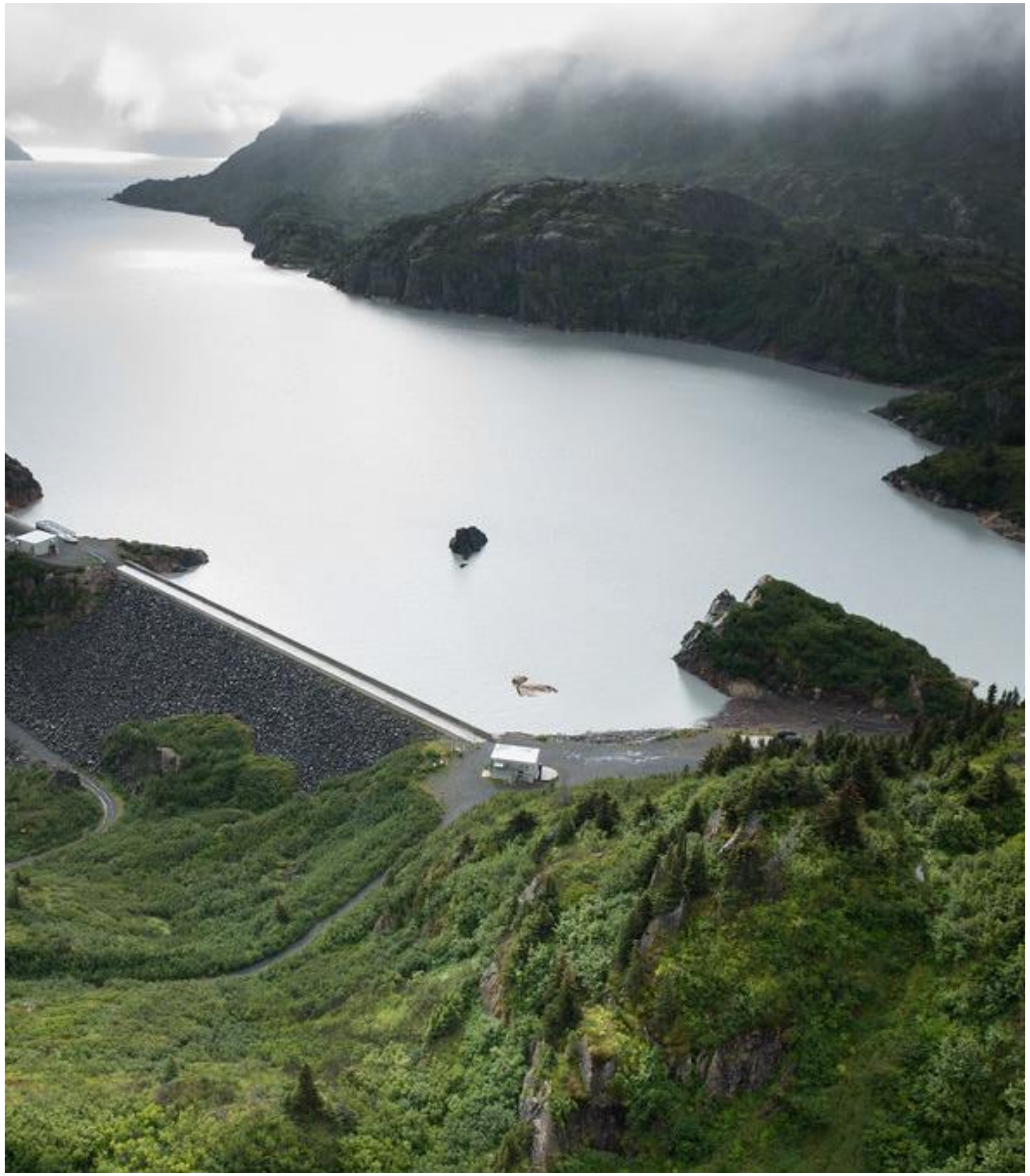
Bradley Lake Operations and Governance



The Bradley Lake Hydroelectric Project

- Net 120 MVA hydroelectric project
  - Limited to 90MW during normal operation due to transmission constraints
- Vertical shaft high-head Pelton Turbine
  - 1100 feet of head pressure
- Lake and Penstock
  - 125-foot dam
  - 3.5 Mile tunnel mostly rock and in some cases steel lined
  - 11 feet in diameter
  - ~ 400 GWH annual energy
- Transmission assets
  - Static VAR Compensators- Soldotna and Cooper Landing
  - Transmission lines -Bradley to Bradley Junction and Soldotna to Quartz Creek,
  - Batteries- Southern, Central, and Northern Regions
- Due to tunnel pressure constraints, the project exhibits a very slow response rate to underfrequency events
  - Zero to full output; theoretical response is 90 sec, but is more typically measured in minutes
- However, when considering divider performance (excluding batteries), it is the fastest responding machine in the Railbelt to overfrequency events
  - Full out put to zero in ~2 seconds

Contractual Framework

The Bradley Lake Hydroelectric Project (the Project) is organized through a single primary agreement

- The Agreement for the Sale and Purchase of Electric Power (Power Sales Agreement (PSA))
- Includes Power revenue bond resolutions

  The Project was 50% State funded and 50 % Bond funded, with a mechanism to pay the State back for its funding after paying off the Projects bonds at zero interest

Two secondary agreements forming "a paper intertie"

- The Amendment to Agreement for Sale of Transmission Capability (the Capability Agreement)
  - Terms and conditions for the pledge of the Homer transmission system for Project use
- The Agreement for the Wheeling of Electric Power and for Related Services (the Services Agreement)
  - Terms and conditions for the pledge of the Chugach transmission system for Project use

And several sub-agreements governing system operations, field operations, maintenance, and control

Key stakeholders include utilities, and the State via AEA (Alaska Energy Authority)

- The Project and the related transmission agreements are exempt from RCA regulation under AS 42.05.431 (c) (1)

The PSA requires the creation of the Project Management Committee (BPMC) and tasks the committee with

- creating rules of procedure (bylaws)
- And, subject to AEA approval, delegates operations and maintenance responsibility to the BPMC

Roles and Responsibilities

Utilities: known as the "Participants" and are power purchasers via a "take or pay" contract (the PSA) and are members of the BPMC

State via AEA: As owner of the Project provides oversight and support for the Project's operations and is a member of the BPMC

The BPMC is made up of the participants and AEA

- Responsible for Improvement, Operations and Maintenance of the Project
- Decisions are made based on majority plus 50% of load voting mechanism
- AEA has a unique role, most topics require the affirmative vote of AEA

Public: Project meetings are open to the public and subject to AS 44.62.310 - AS 44.62.312.meetings act.

Power Delivery and Transmission

- The Services and Capability agreements formed a back stop “paper intertie” to deliver Project power to the participants
  - It became apparent that lack of funding for interties might delay or kill the project
- The Capability Agreement outlines the performance and operational aspects of the Project's utilization of the HEA system to transmit Project power from Bradley Junction to Quartz Creek (formerly Soldotna).
  - This includes the capacity purchase terms for the Bradley Junction to Soldotna 115 Line, which was constructed and is owned by HEA. The participants contributed funds based on their Project shares, and in return, they obtained proportional capability rights.
- The Services Agreement outlines the performance and operational aspects of the Project's utilization of the HEA system to transmit Project power from Quartz Creek (formerly Soldotna) to various delivery points north of Quartz creek.
  - Includes calculation of firm and non firm wheeling with a 15 year phase in, capped at 90% of the Chugach fully allocated rate less the Beluga Point Mackenzie costs
  - Names Chugach as the Project dispatcher subject to review of performance by the BPMC
- AEA is not signatory to either of these agreements

Energy Pricing

- The Project's energy is priced based on cost and energy generated during the year
  - Budgeted in advance with a true-up mechanism

ALASKA ENERGY AUTHORITY

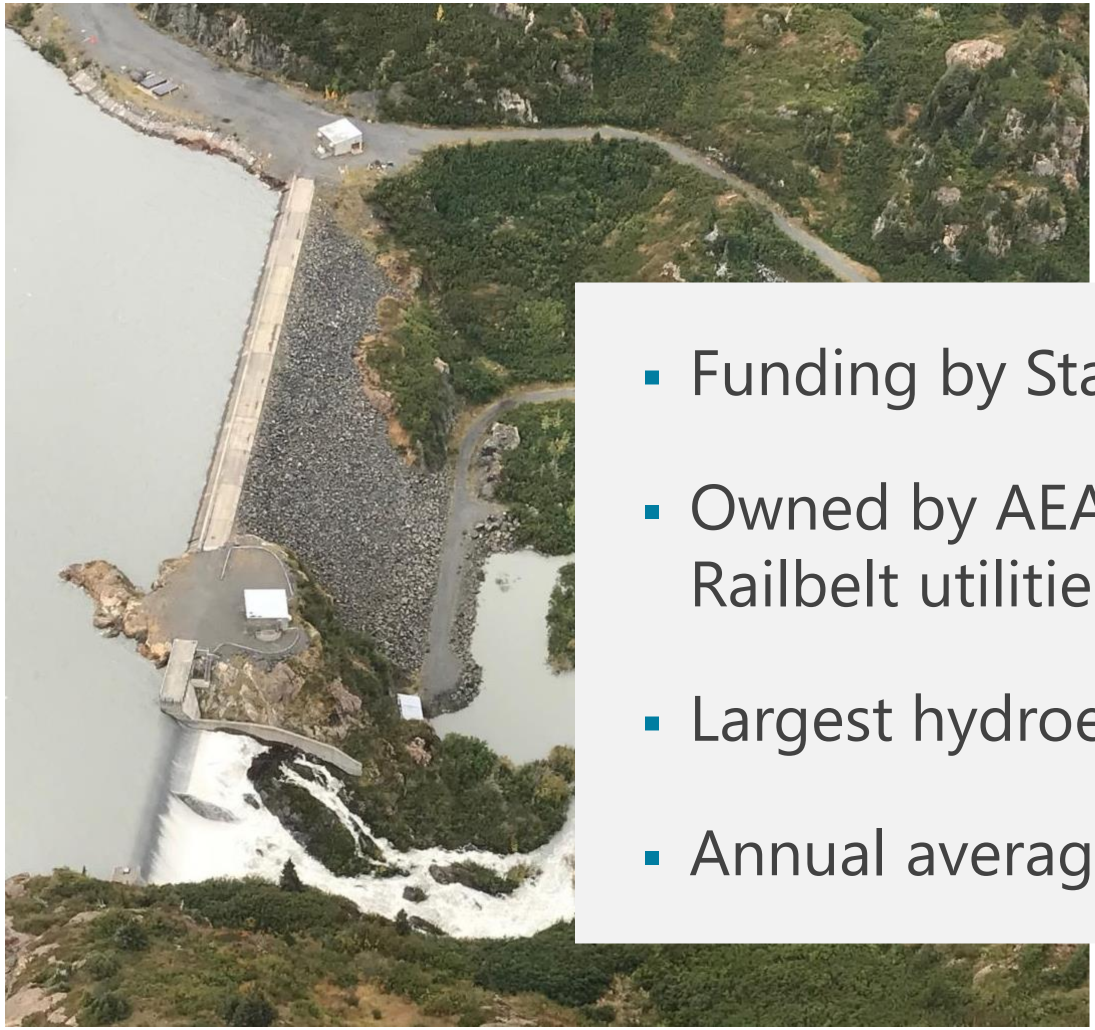
RAILBELT HYDROPOWER: CURRENT & UPCOMING PROJECTS

Bryan Carey, PE
Director, Owned Assets

Alaska Energy Task Force
Energy Symposium
August 3, 2023

ALASKA ENERGY AUTHORITY

Bradley Lake Hydroelectric Project



Alaska's largest source of renewable energy, the 120-megawatt facility generates about 10% of the total annual power used by Railbelt electric utilities at some of the lowest-cost to more than 550,000 Alaskans.

- Funding by State of Alaska and Railbelt utilities
- Owned by AEA and managed to maximum extent by Railbelt utilities
- Largest hydroelectric Project in Alaska
- Annual average energy 400,000 MWh — and increasing

Battle Creek Project

- Located 2 miles southwest of Bradley Lake and serves Railbelt
- Completed in 2020
- Funding by State of Alaska and Railbelt utilities
- Diversion of upper Battle Creek to Bradley Lake by two-mile pipe
- Annual energy ~37,000 MWh
- Low-cost energy

Battle Creek Project Schedule

- 2010-2013: Studies
- 2015: Submit license amendment to Federal Energy Regulatory Commission (FERC)
- 2016: Environmental Assessment
- 2016: Receive license amendment
- 2017: Financing and bid project
- 2018-2020: Construction

Dixon Glacier

Dixon Diversion Project

- AEA is investigating generating energy from the outflow of Dixon Glacier five miles southwest of the Bradley Lake Hydroelectric Project.
- The Dixon Diversion Project would be largest renewable energy project in Alaska since Bradley Lake was completed in 1991.

Dixon Diversion Project

- Drainage area is ~20 square miles.
- Watershed receives more than 100 inches precipitation per year (106,000 ac-ft/yr).
- Ice melt average 94,500 ac-ft/yr.
- ~200,000 ac-ft/yr.

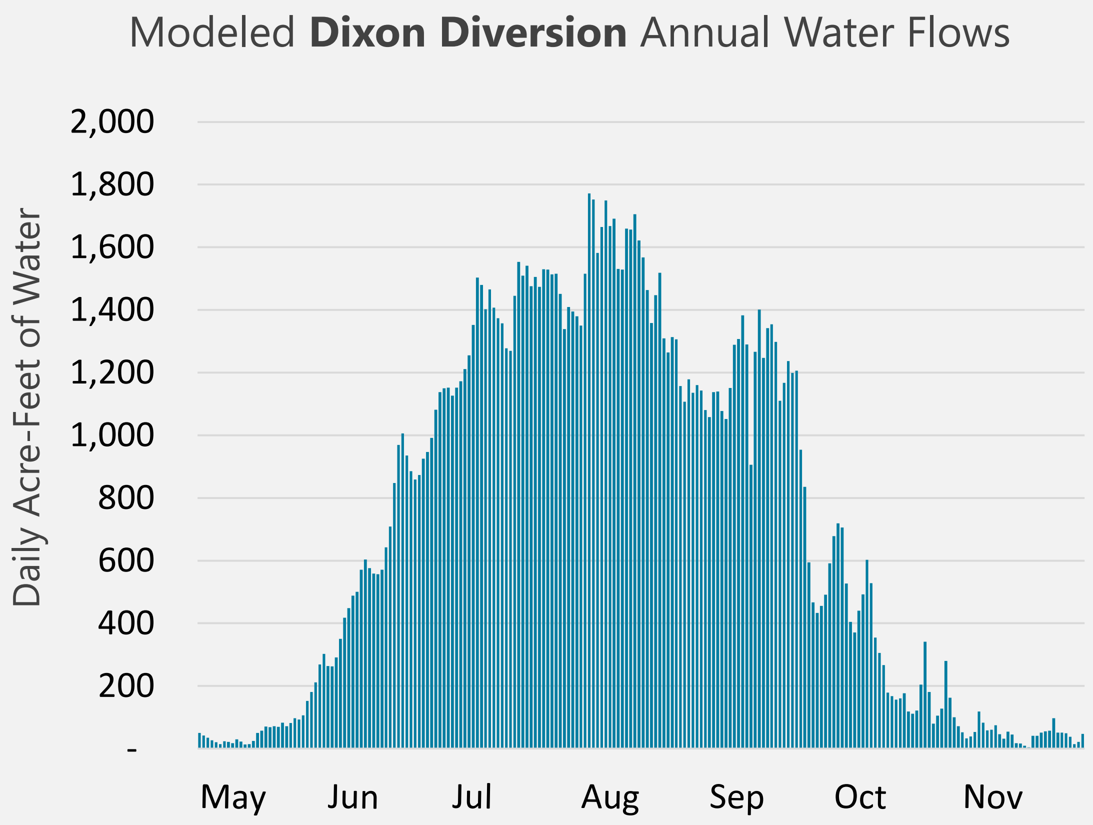
Diversion to Bradley Lake

- 4.7 mile tunnel from intake to Bradley Lake
- Water goes through Bradley Lake powerhouse
- Raise Bradley spillway/dam to capture seasonal flow and allow for additional water storage for winter
- Entire project on State land

Energy Generation Comparison

Project	**MWh/yr**
Bradley Lake Hydro	~400,000 MWh/yr
Dixon Diversion	***~160,000 MWh/yr***
Fire Island Wind	~49,000 MWh/yr
Battle Creek Diversion	~37,000 MWh/yr
Net Metered Solar	~3,500 MWh/yr

Source: This comparison slide is courtesy of Chugach Electric Association.



Dixon Diversion Value

- Dixon Diversion provides:
  - Energy (more water)
  - Higher capacity factor (from 37% to 53%), but no increase of maximum capacity (no new turbine)
  - Increased long-duration energy storage (higher dam)
  - Low-cost, long-duration energy storage
- A new turbine/generator could be added at Bradley Lake power plant in the future

Dixon Diversion Next Steps

- Verify energy (2023)
  - Discharge measurements
  - Water Quality measures
- Optimism facilities and revise cost (2023)
  - Need for road
  - Geologic Site Review
- Consultation (2024)
- Studies (2024)

Dixon Diversion Schedule

ALASKA ENERGY AUTHORITY

2022

April
File Amendment

June
Agency/Public Meeting Homer

Fall
Agency Study Requests

2023-2025

Studies

2026-2027

Federal Energy Regulatory Commission Amendment

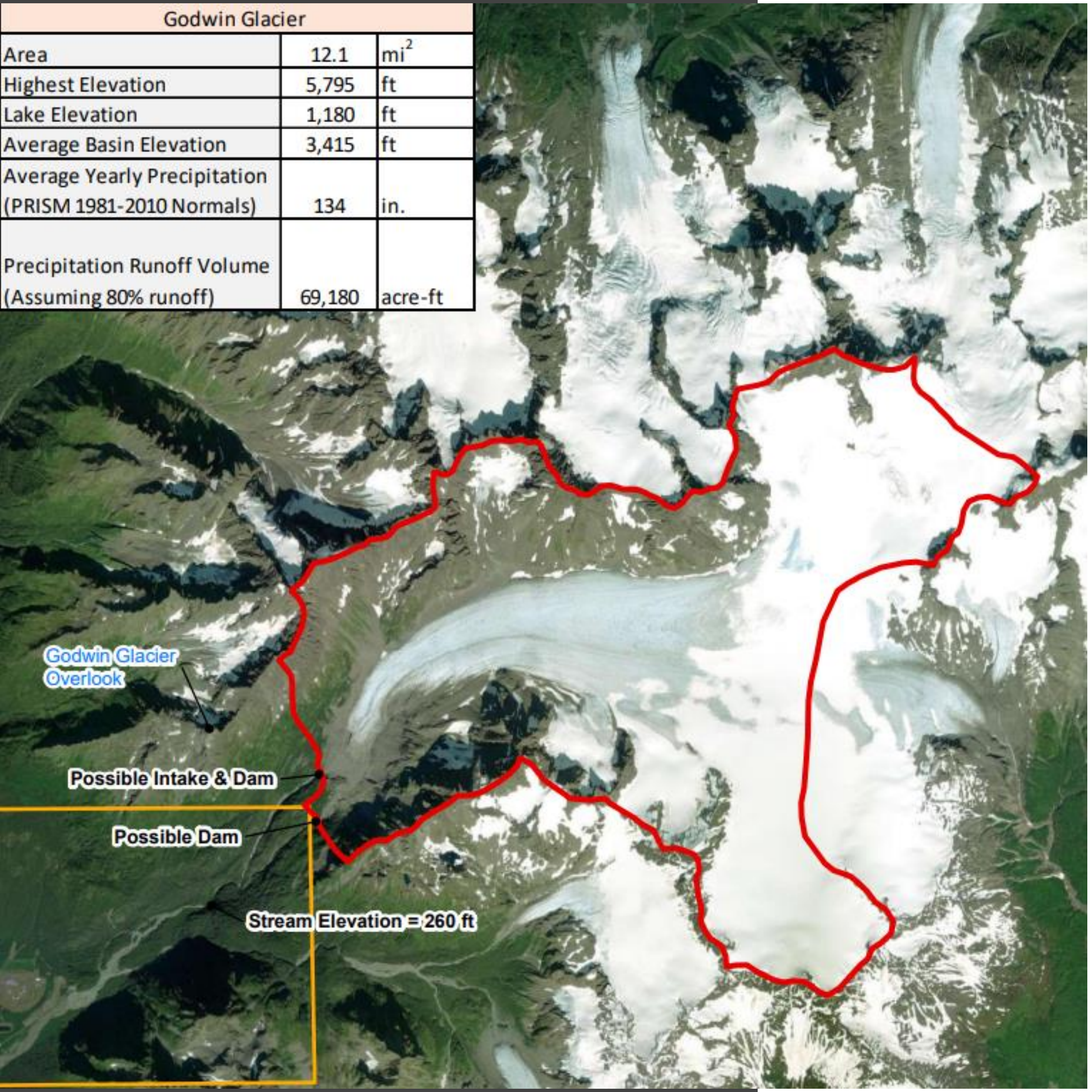
2028

Bid

2028-2032

Construction

ALASKA ENERGY AUTHORITY

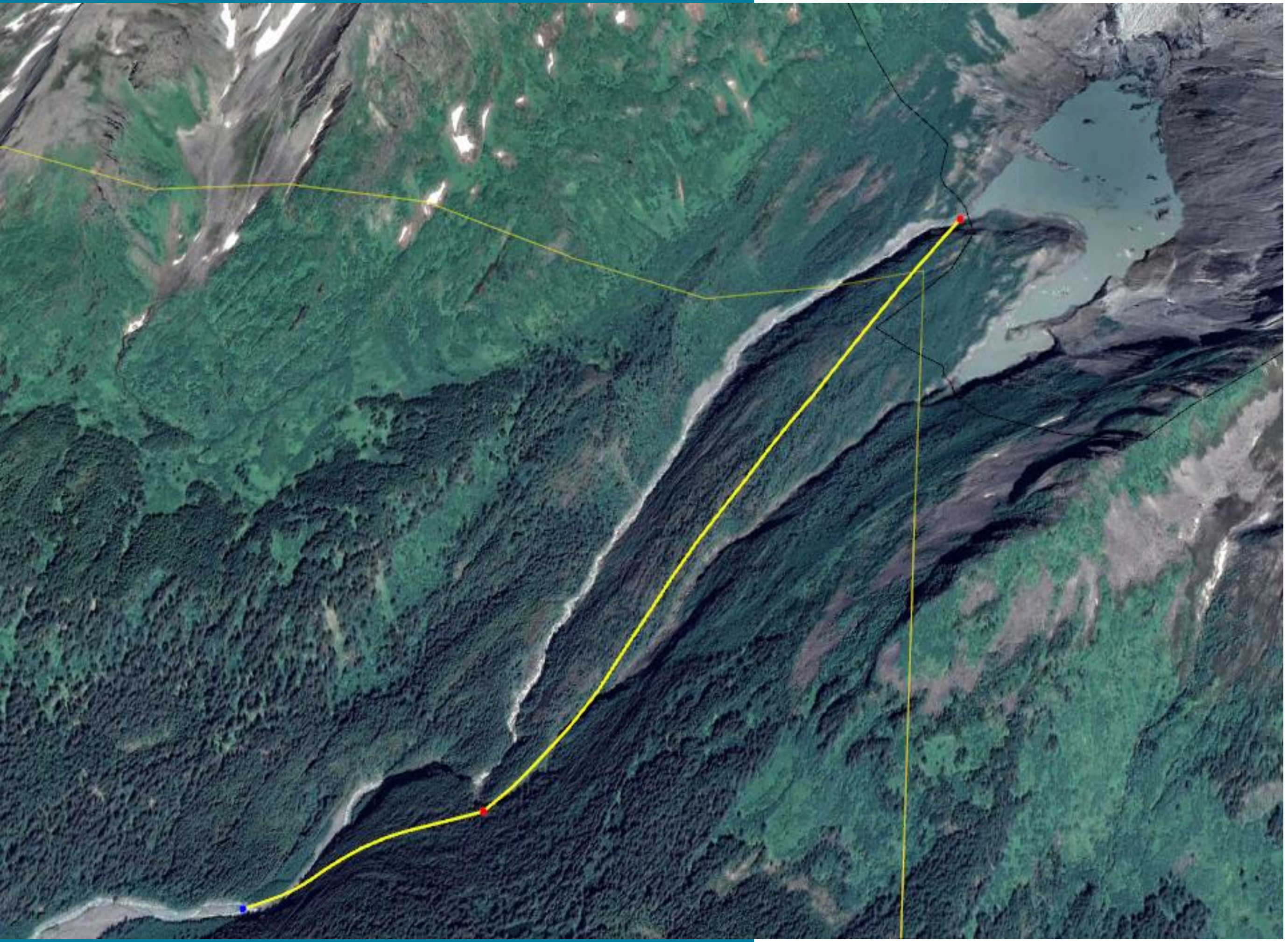


Godwin Glacier		
Area	12.1	mi^2
Highest Elevation	5,795	ft
Lake Elevation	1,180	ft
Average Basin Elevation	3,415	ft
Average Yearly Precipitation (PRISM 1981-2010 Normals)	134	in.
Precipitation Runoff Volume (Assuming 80% runoff)	69,180	acre-ft

Godwin Hydropower Project

- If average ice melt 10 feet/year then an additional 77,000 ac-ft above annual precipitation for coming decades
- Power plant less than 2 miles from roads and 115 kVA lines
- Port to bring in equipment and materials

Godwin Hydropower Project



- River drop ~920 feet over 1.5 miles.
- Intake downstream of lake has entire project on State land (likely non-FERC). Intake at lake provides regulating ability.
- Chugach Electric Association performing feasibility work.
- Could be online ~ 10 years.

AEA provides **energy solutions** to meet the unique needs of Alaska's rural and urban communities.

Alaska Energy Authority

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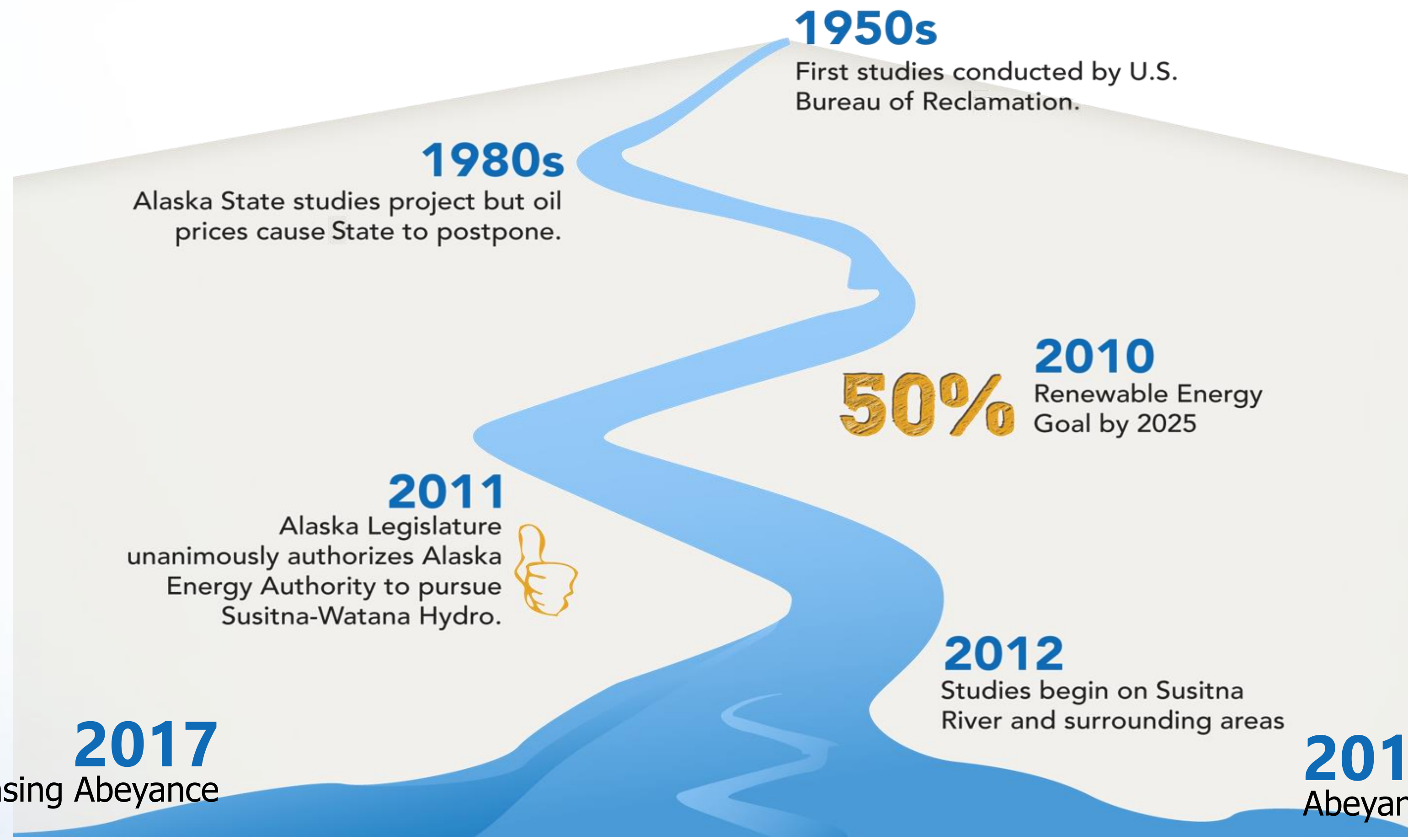
SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Susitna-WatanaHydro.org

Governor's Task Force Meeting
August 3, 2023

Susitna Hydro: History



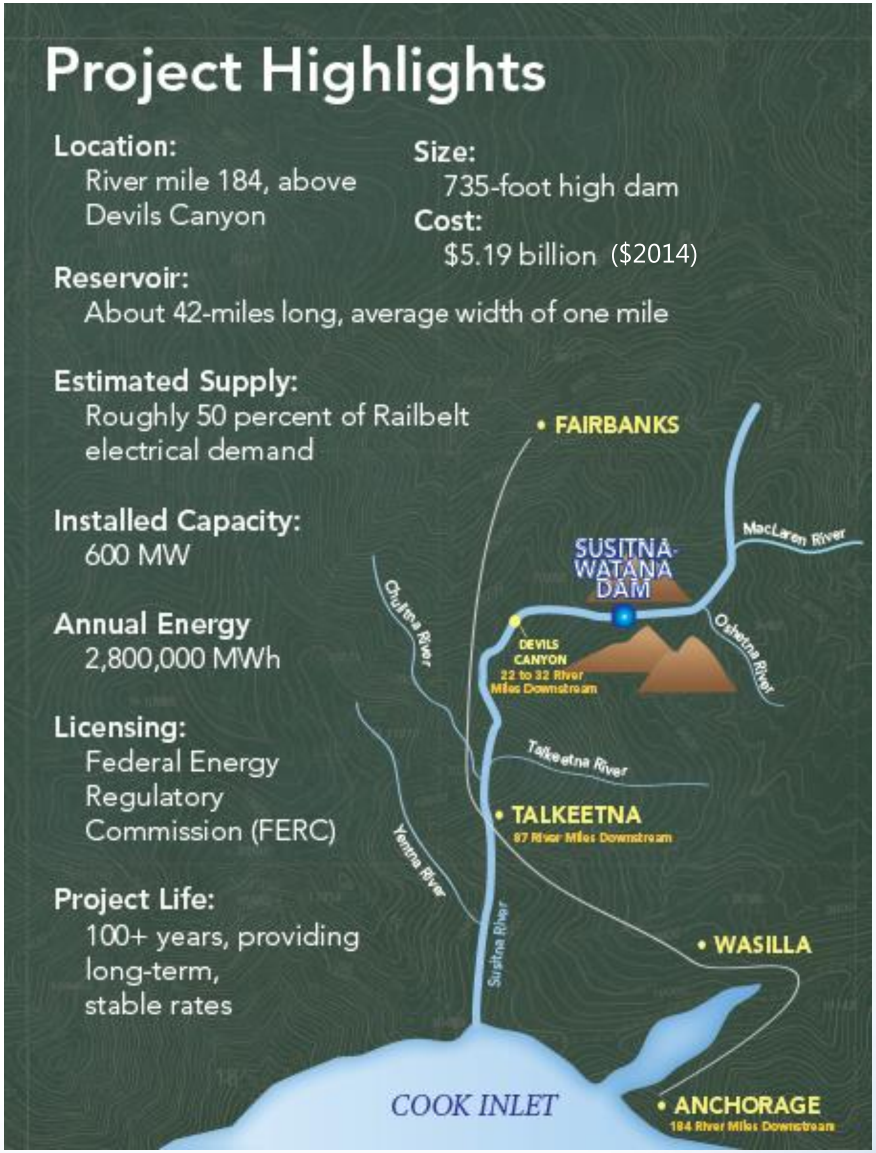
SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Why Susitna-Watana Hydro

- Serves ~80% of state's population
- 1,000 jobs during peak construction
- Stable electricity rates for 100+ years
- Long-term diversification
- Clean, reliable energy source
- Promotes integration of variable power sources
- Reduce CO_2 emissions by more than 100 million tons annually (equivalent to 250,000 cars)

Project Highlights

- Susitna-River Mile 184
- 87 River Miles from Talkeetna
- 22-32 River Miles upstream from Devils Canyon
- ~50 percent of Railbelt's Energy Demand

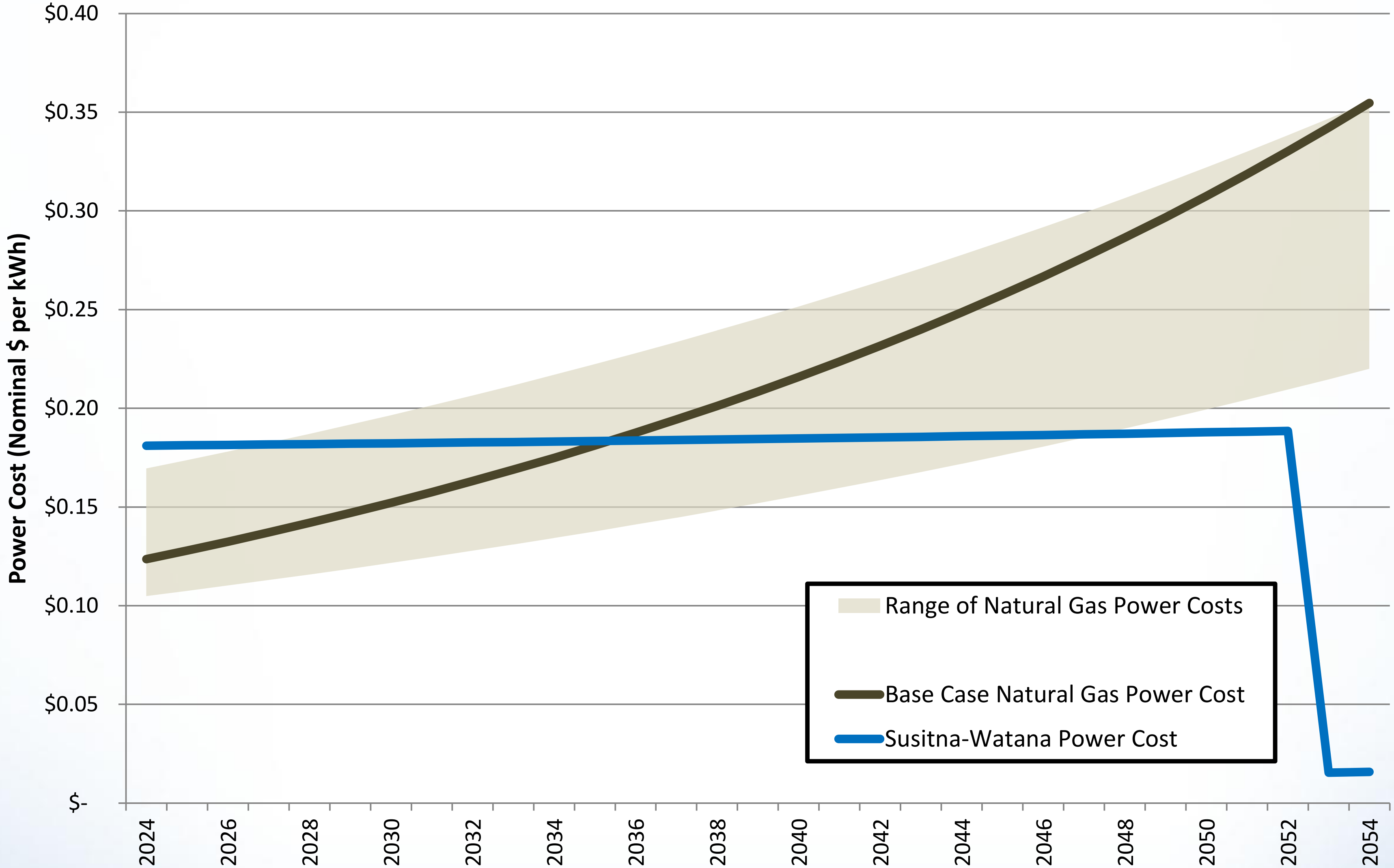


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Next Steps

- Governor and legislature would need to re-initiate FERC licensing process, restart process with FERC
- Collaborate with Alaska Native land owners and utilities
- Update construction cost and financing approach
- Conduct public engagement
- File license application

Susitna-Watana vs. Natural Gas Power Costs



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Key Takeaways

- Susitna-Watana Hydroelectric Project can significantly reduce future power cost uncertainty
- Potential to be competitive with natural gas in the early years, lower cost over long term
- More than doubles Alaska's renewable energy
- Enhances Alaska energy security
- Allows for other renewables generation sources

ALASKA ENERGY STATISTICS & ECONOMICS

Thursday, August 17, 2023, 11:00 AM – 1:00 PM

- *Alaska Energy Data: The Good, the Bad, the Missing*
- *Alaska Comprehensive Economic Development (CEDS) Strategy*
- *CEDS Energy-Specific Goals and Objectives*

Alaska Energy Data:
The Good, the Bad, the Missing

Available in the internet at:

Created by:
Neil McMahon, DOWL
Funding Provided by:
University of Alaska Fairbanks, Alaska Center for Energy and Power
Published:
June 2023

Main Sources of Data:

Alaska Energy Authority
Power Cost Equalization Program Data , Calendar Year 2021
http://www.akenergyauthority.org/
AEA - Various Infrastructure datasets

Energy Information Administration
EIA final data files from survey forms 860, 861 and 923.
http://www.eia.gov/electricity/data/eia860/index.html
http://www.eia.gov/electricity/data/eia923/
http://www.eia.gov/electricity/data/eia861/index.html

Content:

Installed Capacity (MW) of utilities & operators by AEA Energy Region, 2021

AEA Energy Region	Fossil Fuel Turbines	Reciprocating Internal Combustion Engine	Hydroelectric	Wind	Solar	Storage	Region Total	Percent of Statewide Total
Aleutians	0	56	2	1	0	0	59	2%
Bering Straits	0	33	0	3	0	0	37	1%
Bristol Bay	0	40	1	0	0	0	42	1%
Copper River/Chugach	5	30	26	0	0	1	62	2%
Kodiak	0	39	34	9	0	5	87	3%
Lower Yukon-Kuskokwim	0	60	0	6	0	1	67	2%
North Slope	43	33	0	0	0	0	75	2%
Northwest Arctic	0	24	0	4	1	2	31	1%
Railbelt	1,589	234	191	45	2	90	2,150	68%
Southeast	113	156	234	0	0	1	503	16%
Yukon-Koyukuk/Upper Tanana	0	27	0	0	0	0	27	1%
Total	**1,750**	**732**	**488**	**68**	**3**	**100**	**3,141**	**100%**

Source: Aggregated from Table 2.1a

ACEP Energy Symposium
August 17, 2023

prepared by Steve Colt, Research Professor
sgcolt@alaska.edu

ACEP Alaska Center for Energy and Power

UNIVERSITY OF ALASKA FAIRBANKS

Outline

- Focus on “meso-scale” data corresponding to our day-to-day economic realities
  - Building, utility, community, regional scales
  - Monthly, annual time periods
- *Alaska Energy Statistics* – views from the trenches
- What about Heat?
- What about Transport?
- A few final thoughts

Prepare to be bored….or fascinated

AK Energy Statistics:
A View from the Trenches

Mini Case Study 1: Southeast Diesel Generation

What’s wrong with this picture?

Net Generation by Fuel Type by Operators/Utilities (MWh) by AEA Energy Regions, 2014						
AEA Energy Region	Oil	Gas	Coal	Hydro	Wind	Solar
Aleutians	102,128	0	0	2,498	1,695	0
Bering Straits	48,287	0	0	0	3,205	0
Bristol Bay	52,816	0	0	3,908	14	0
Copper River/Chugach	42,095	0	0	74,580	0	0
Kodiak	2,019	0	0	134,174	23,323	0
Lower Yukon-Kuskokwim	59,020	0	0	0	3,912	0
North Slope	29,378	130,548	0	0	0	0
Northwest Arctic	31,297	0	0	0	4,673	0
Railbelt	325,635	3,213,640	558,292	547,735	124,092	0
Southeast	-243,316	0	0	774,201	0	0
Yukon-Koyukuk/Upper Tanana	35,028	0	0	0	0	9
Total	**484,387**	**3,344,188**	**558,292**	**1,537,096**	**160,914**	**9**

What's wrong with this picture?

Net Generation by Fuel Type by Operators/Utilities (MWh) by AEA Energy Regions, 2014						
AEA Energy Region	**Oil**	**Gas**	**Coal**	**Hydro**	**Wind**	**Solar**
Aleutians	102,128	0	0	2,498	1,695	0
Bering Straits	48,287	0	0	0	3,205	0
Bristol Bay	52,816	0	0	3,908	14	0
Copper River/Chugach	42,095	0	0	74,580	0	0
Kodiak	2,019	0	0	134,174	23,323	0
Lower Yukon-Kuskokwim	59,020	0	0	0	3,912	0
North Slope	29,378	130,548	0	0	0	0
Northwest Arctic	31,297	0	0	0	4,673	0
Railbelt	325,635	3,213,640	558,292	547,735	124,092	0
Southeast	-243,316	0	0	774,201	0	0
Yukon-Koyukuk/Upper Tanana	35,028	0	0	0	0	9
Total	**484,387**	**3,344,188**	**558,292**	**1,537,096**	**160,914**	**9**

Energy Stats T2.3c

Utility Name	Plant Name	Intertie Name	Energy Region	Fuel Type	Prime Mover	Net Generation MWh
Ketchikan Public Utilities	S W Bailey	SEAPA_grid	Southeast	DFO	IC	-262901.99
Metlakatla Power & Light	Centennial	Metlakatla_grid	Southeast	DFO	IC	-39
Alaska Power & Telephone Compan	Thorne Bay Plant	Prince of Wales Is._grid	Southeast	DFO	IC	-24
Alaska Power & Telephone Compan	Viking	Prince of Wales Is._grid	Southeast	DFO	IC	-15

EIA 923 data:

		Electricity Net Generation (MWh)											
Plant Nan	Operator Name	Netgen Januar	Netgen Februa	Netgen March	Netgen April	Netgen May	Netgen June	Netgen July	Netgen Augus	Netgen Septemb	Netgen Octobe	Netgen Novemb	Netgen Decemb
Swan Lake	Ketchikan Public Utilities	6,081	5,488	4,965	5,322	4,653	4,321	4,086	5,081	7,857	5,721	5,891	6,723
Ketchikan	Ketchikan Public Utilities	2,245	2,026	1,832	1,964	1,717	1,595	1,508	1,875	2,900	2,112	2,174	2,481
S W Bailey	Ketchikan Public Utilities	-27,254	-25,859	-25,243	-23,718	-20,026	-11,936	-21,102	-16,978	-19,975	-26,406	-19,301	-25,105
Beaver Falls	Ketchikan Public Utilities	4,181	3,774	3,414	3,659	3,199	2,971	2,809	3,493	5,402	3,934	4,050	4,622
Silvis	Ketchikan Public Utilities	1,261	1,138	1,029	1,103	965	896	847	1,053	1,629	1,186	1,221	1,394

EIA 923 instructions

Independent Statistics & Analysis
U.S. Energy Information Administration

Form·EIA-923·¶
POWER·PLANT·OPERATIONS·
REPORT·INSTRUCTIONS

Year:··2013¶
Form·Approva
Approval·Expi
Burden:··2.7·H

aved to this PC

Net·Generation:··Enter·the·net·generation·(gross·generation·minus·the·parasitic·station·load,·i.e.·station·use).····If·the·monthly·station·service·load·exceeded·the·monthly·gross·electrical·generation,·report·negative·net·generation·with·a·minus·sign.··Do·not·use·parentheses.·For·each·month,·enter·that·amount·in·MWh.···

EIA 923 form

Generation Table		
Nuclear Unit Code	Gross Generation (MWh)	Net Generation (MWh)

https://www.eia.gov/survey/#eia-923

Another View from the Trenches

Mini Case Study 2: Northwest Arctic Renewables

What’s wrong with this picture?

Operators/Utilities Net Generation by Fuel Type (MWh), 2021									
Plant Name	Intertie Nam	Energy Region	Oil	Gas	Coal	Hydr	Wind	Solar
Deering	Deering_grid	Northwest Arctic	679	0	0	0	61	43
Ambler	Ambler_grid	Northwest Arctic	1,331	0	0	0	0	0
Kivalina	Kivalina_grid	Northwest Arctic	1,874	0	0	0	0	0
Kiana	Kiana_grid	Northwest Arctic	1,715	0	0	0	0	0
Noatak	Noatak_grid	Northwest Arctic	1,853	0	0	0	0	0
Shungnak	Shungnak_grid	Northwest Arctic	1,634	0	0	0	16	0
Noorvik	Noorvik_grid	Northwest Arctic	1,963	0	0	0	13	0
Buckland	Buckland_grid	Northwest Arctic	1695.8	0	0	0	239.392	0
Selawik	Selawik_grid	Northwest Arctic	2,860	0	0	0	0	0
Kotzebue	Kotzebue_grid	Northwest Arctic	18343.458	0	0	0	2583.924	594.163

Hint

Photo: USDOE

Again, What’s wrong with this picture?

Operators/Utilities Net Generation by Fuel Type (MWh), 2021								
Plant Name	Intertie Nam	Energy Region	Oil	Gas	Coal	Hydr	Wind	Solar
Deering	Deering_grid	Northwest Arctic	679	0	0	0	61	43
Ambler	Ambler_grid	Northwest Arctic	1,331	0	0	0	0	0
Kivalina	Kivalina_grid	Northwest Arctic	1,874	0	0	0	0	0
Kiana	Kiana_grid	Northwest Arctic	1,715	0	0	0	0	0
Noatak	Noatak_grid	Northwest Arctic	1,853	0	0	0	0	0
Shungnak	Shungnak_grid	Northwest Arctic	1,634	0	0	0	16	0
Noorvik	Noorvik_grid	Northwest Arctic	1,963	0	0	0	13	0
Buckland	Buckland_grid	Northwest Arctic	1695.8	0	0	0	239.392	0
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What's wrong with this picture?

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Kivalina	Kivalina_grid	Northwest Arctic	1,874	0	0	0	0	0
Kiana	Kiana_grid	Northwest Arctic	1,715	0	0	0	0	0
Noatak	Noatak_grid	Northwest Arctic	1,853	0	0	0	0	0
Shungnak	Shungnak_grid	Northwest Arctic	1,634	0	0	0	16	0
Noorvik	Noorvik_grid	Northwest Arctic	1,963	0	0	0	13	0
Buckland	Buckland_grid	Northwest Arctic	1695.8	0	0	0	239.392	0
Selawik	Selawik_grid	Northwest Arctic	2,860	0	0	0	0	0
Kotzebue	Kotzebue_grid	Northwest Arctic	18343.458	0	0	0	2583.924	594.163

Look at installed capacity

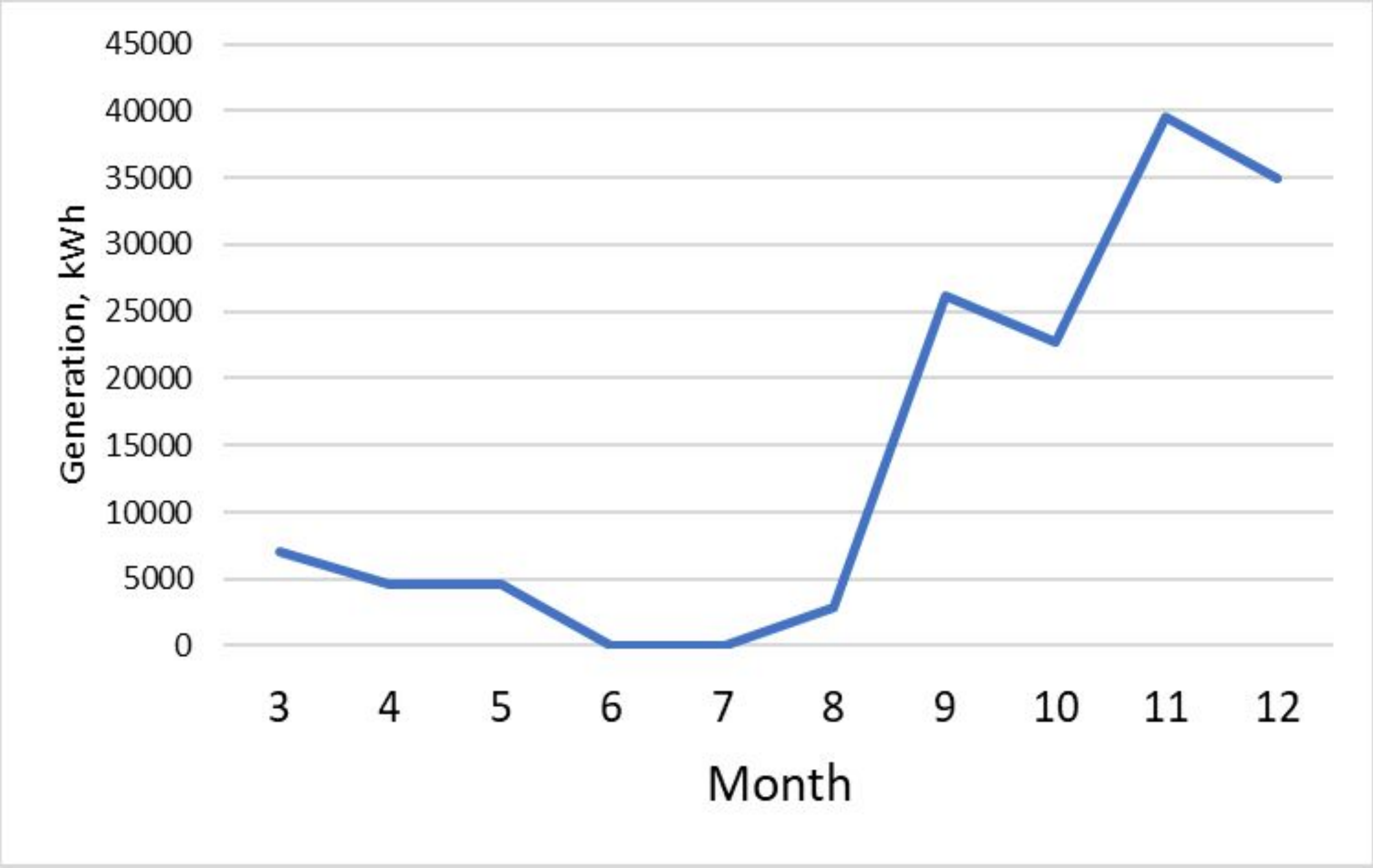
Installed Capacity by Prime Mover by Plant (MW), 2021						
Plant Name	Total Capacit	Fossil Fuel Turbine	Internal Combu	Hydroelec tric	Wind Turbin	Solar P
Ambler	1.1	0	1.1	0	0	0
Buckland	1.675	0	1.152	0	0.2	0.046
Deering	0.7955	0	0.37	0	0.1	0.0485
Kiana	1.2	0	1.2	0	0	0
Kivalina	1.1	0	1.1	0	0	0
Kotzebue	17.1	0	11.8	0	3.3	0.8
Noatak	1.252	0	1.252	0	0	0
Noorvik	1.649	0	1.626	0	0	0.023
Selawik	2.51	0	2.25	0	0.26	0
Kobuk	0.18	0	0.18	0	0	0
Shungnak	1.959	0	1.5	0	0	0.224

Look at source data: PCE monthly from AEA

Community	Fiscal Year	Fiscal Month	Fuel Used Gallons	Diesel kWh Generated	Hydro kWh Generate	Other 1 kWh Type	Other 1 kWh Generated
Shungnak PCE	2021	1	7303	94002	0		0
Shungnak PCE	2021	2	8330	112699	0		0
Shungnak PCE	2021	3	9035	124409	0		0
Shungnak PCE	2021	4	9839	138106	0		0
Shungnak PCE	2021	5	12696	157918	0		0
Shungnak PCE	2021	6	12641	151974	0		0
Shungnak PCE	2021	7	12819	160909	0		0
Shungnak PCE	2021	8	13648	176437	0		0
Shungnak PCE	2021	9	12484	166480	0		0
Shungnak PCE	2021	10	11732	146645	0		0
Shungnak PCE	2021	11	8049	108751	0		0
Shungnak PCE	2021	12	9075	97146	0		0
Shungnak PCE	2022	1	7444	108869	0		0
Shungnak PCE	2022	2	9691	118978	0		0
Shungnak PCE	2022	3	8968	111507	0	WIND	6976
Shungnak PCE	2022	4	9481	125223	0	WIND	4659
Shungnak PCE	2022	5	14523	125223	0	WIND	4659
Shungnak PCE	2022	6	27862	187520	0	WIND	8
Shungnak PCE	2022	7	12088	166939	0	WIND	39
Shungnak PCE	2022	8	14448	205579	0	WIND	2904
Shungnak PCE	2022	9	11006	136300	0	WIND	26128
Shungnak PCE	2022	10	9565	118552	0	WIND	22682
Shungnak PCE	2022	11	6786	87048	0	WIND	39492
Shungnak PCE	2022	12	5393	64116	0	WIND	34886

Granular data to t
rescue?

Community	Fiscal Year	Fiscal Month	Fuel Used Gallons	Diesel kWh Generated	Hydro kWh Generated	Other 1 kWh Type	Other 1 kWh Generated
Shungnak PCE	2021	1	7303	94002	0		0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							6976
							4659
							4659
							8
							39
							2904
							26128
							22682
							39492
Shungnak PCE	2022	12	5393	64116	0	WIND	34886



Granular data to the rescue!!

This is SOLAR.

Community	Fiscal Year	Fiscal Month	Fuel Used Gallons	Diesel kWh Generated	Hydro kWh Generate	Other 1 kWh Type	Other 1 kWh Generated
Shungnak PCE	2021	1	7303	94002	0		0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
							6976
							4659
							4659
							8
							39
							2904
							26128
							22682
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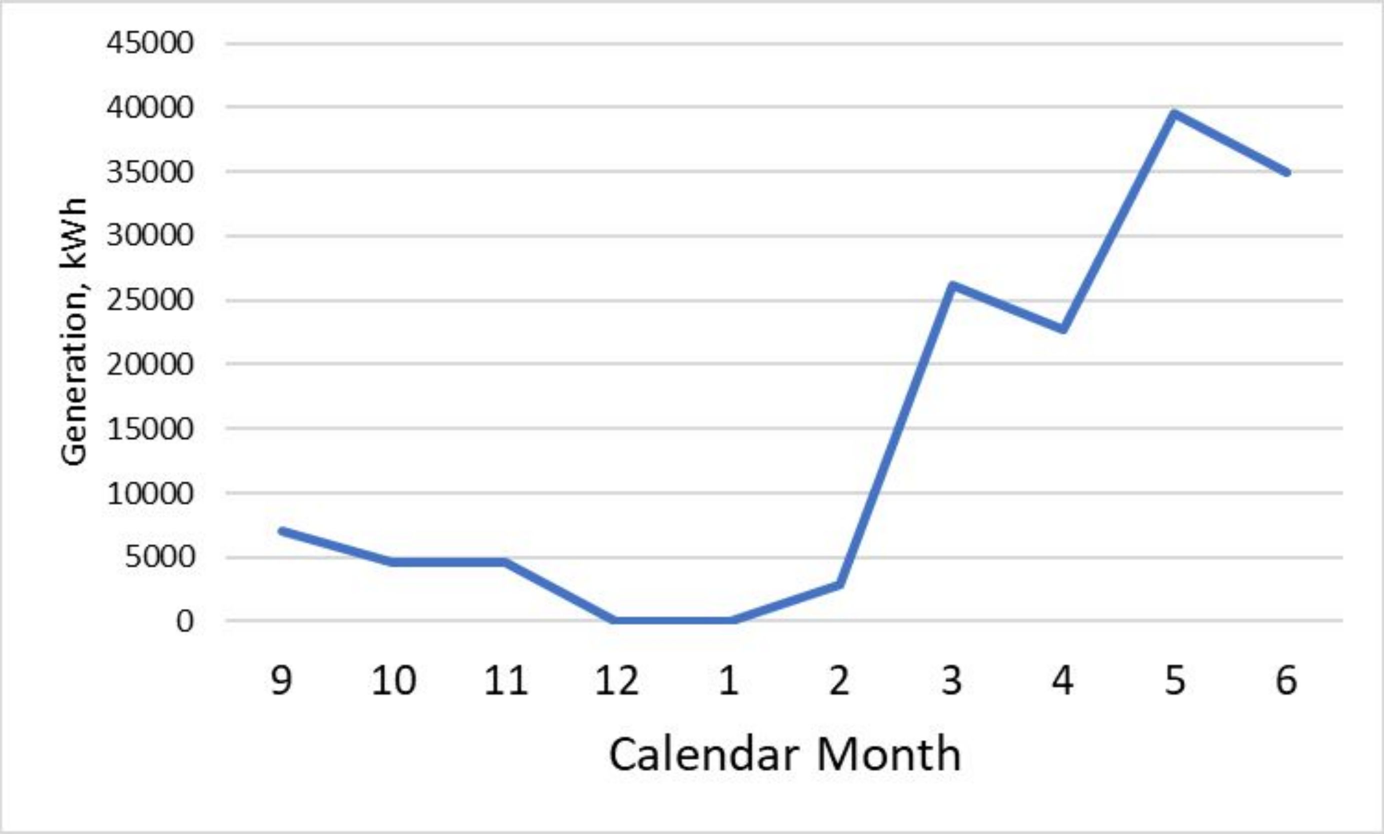
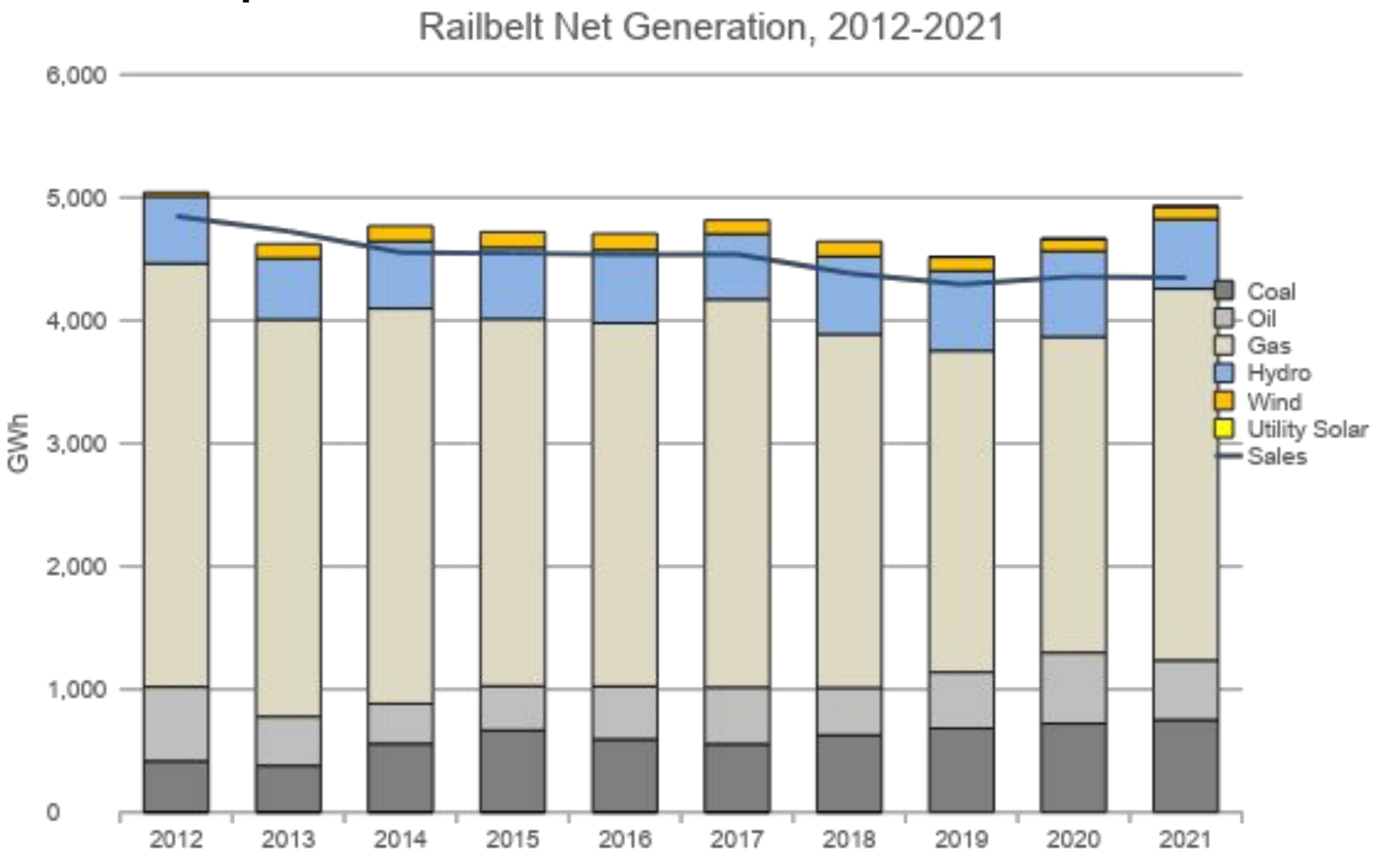


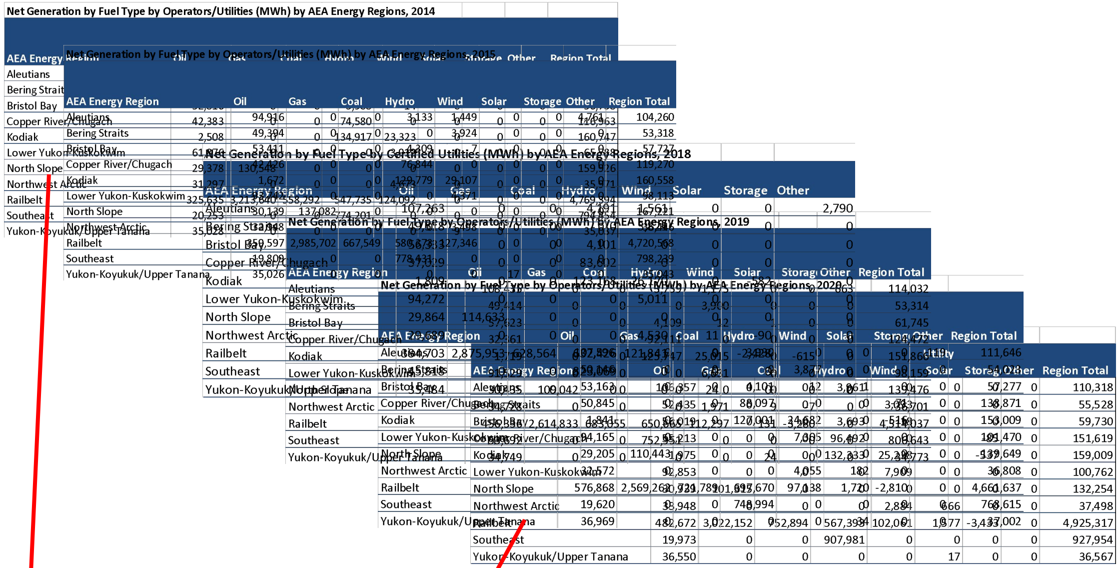
View from the Trenches

Trends vs snapshots

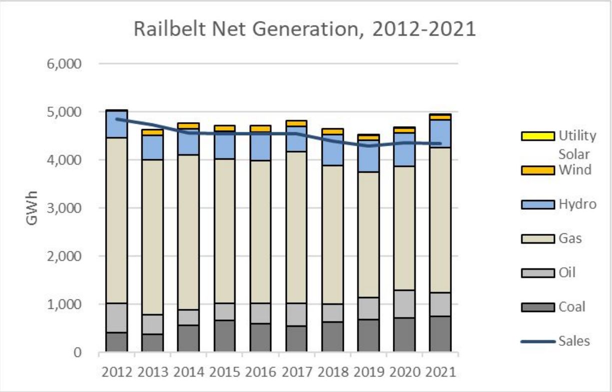
Trends vs Snapshots



Trends can be tedious to compile



Year	ACEP Energy Region	Oil	Gas	Coal	Hydro	Wind	Utility Solar	Storage	Other	Total	Sales
		Net Generation, GWh (compiled from above, divided by 1000, pasted as values)									
2012	Railbelt	603	3,444	417	546	32	0	0	0	5,043	4,848
2013	Railbelt	400	3,230	379	498	117	0	0	0	4,624	4,726
2014	Railbelt	326	3,214	558	548	124	0	0	0	4,769	4,554
2015	Railbelt	360	2,986	668	580	127	0	0	0	4,721	4,545
2016	Railbelt	431	2,954	594	594	134	0	(2)	0	4,705	4,537
2017	Railbelt	460	3,157	556	532	112	0	(3)	0	4,814	4,539
2018	Railbelt	385	2,876	629	632	122	0	(2)	0	4,641	4,384
2019	Railbelt	456	2,615	683	651	112	0	(3)	0	4,514	4,294
2020	Railbelt	577	2,569	722	698	97	2	(3)	0	4,662	4,356
2021	Railbelt	483	3,022	753	567	102	2	(3)	0	4,925	4,349



The Alaska Energy Data Gateway automates this process…at least somewhat. (AEDG is not maintained.)

AEDG

Data Search | 1: Start | 2: Select Dataset | 3: Filter Data | 4: View/Download | Help/

Net Ger
AEA En
Aleutiar
Bering S
Bristol B
Copper
Kodiak
Lower Y
North S
Northw
Railbelt
Southea
Yukon-k

Alaska Energy Statistics Table 2.3b - Certified Utilities Net Generation by Fuel Type (MWh)

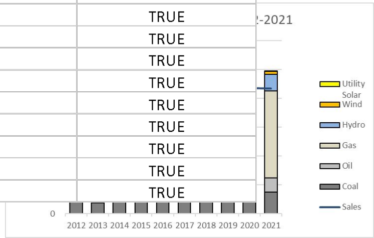
Information about electric net generation by fuel source and fuel use of c

Alaska Energy Statistics 1960-2011 Final Report (PDF) *Dataset revised A*

Download Dataset

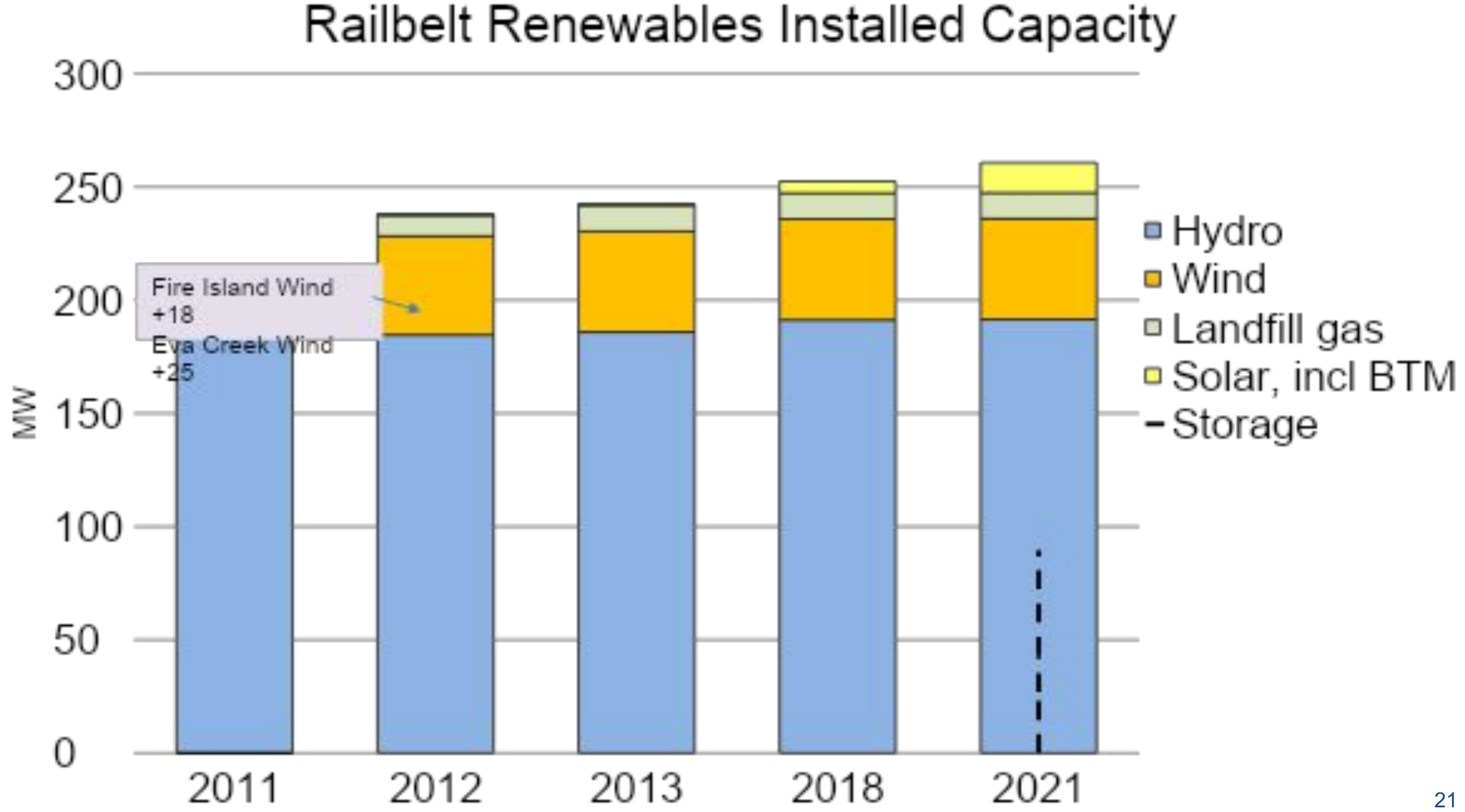
Southeast	19,973	0	0
Yukon-Koyukuk/Upper Tanana	36,550	0	0

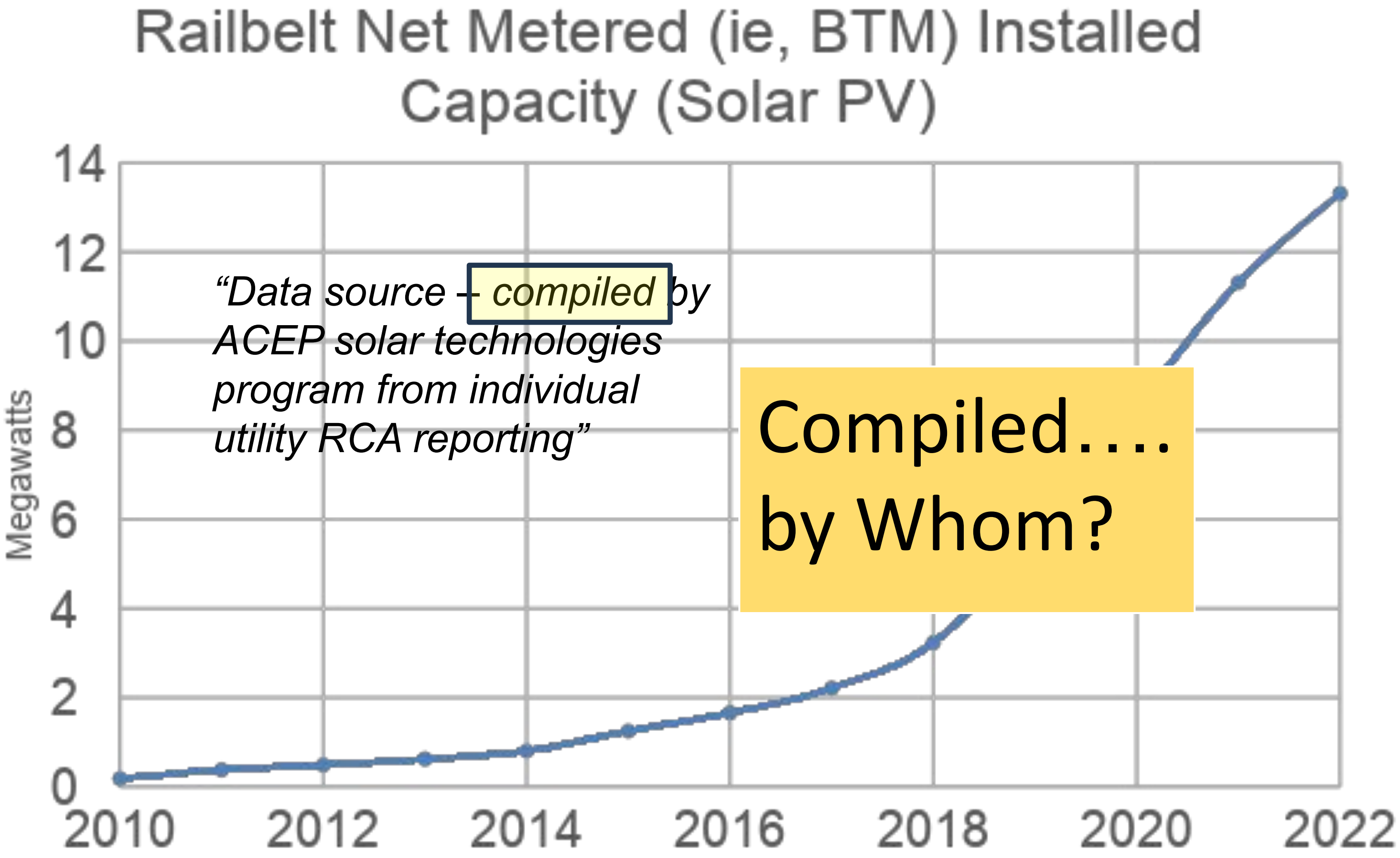
year	utility__name	utility__regulatory_status__name	utility__certificate
2008	Anchorage Municipal Light & Power	Regulated	TRUE
2008	Anchorage Municipal Light & Power	Regulated	TRUE
2008	Anchorage Municipal Light & Power	Regulated	TRUE
2008	Aurora Energy LLC Chena	Regulated	TRUE
2008	Chugach Electric Assn Inc	Regulated	TRUE
2008	Chugach Electric Assn Inc	Regulated	TRUE
2008	Chugach Electric Assn Inc	Regulated	TRUE
2008	Chugach Electric Assn Inc	Regulated	TRUE
2008	Golden Valley Elec Assn Inc	Regulated	TRUE
2008	Golden Valley Elec Assn Inc	Regulated	TRUE
2008	Golden Valley Elec Assn Inc	Regulated	TRUE
2008	Golden Valley Elec Assn Inc	Regulated	TRUE
2008	Homer Electric Assn Inc	Regulated	TRUE
2008	Homer Electric Assn Inc	Regulated	TRUE
2008	Homer Electric Assn Inc	Regulated	TRUE
2009	Anchorage Municipal Light & Power	Regulated	TRUE
2009	Anchorage Municipal Light & Power	Regulated	TRUE
2009	Anchorage Municipal Light & Power	Regulated	TRUE



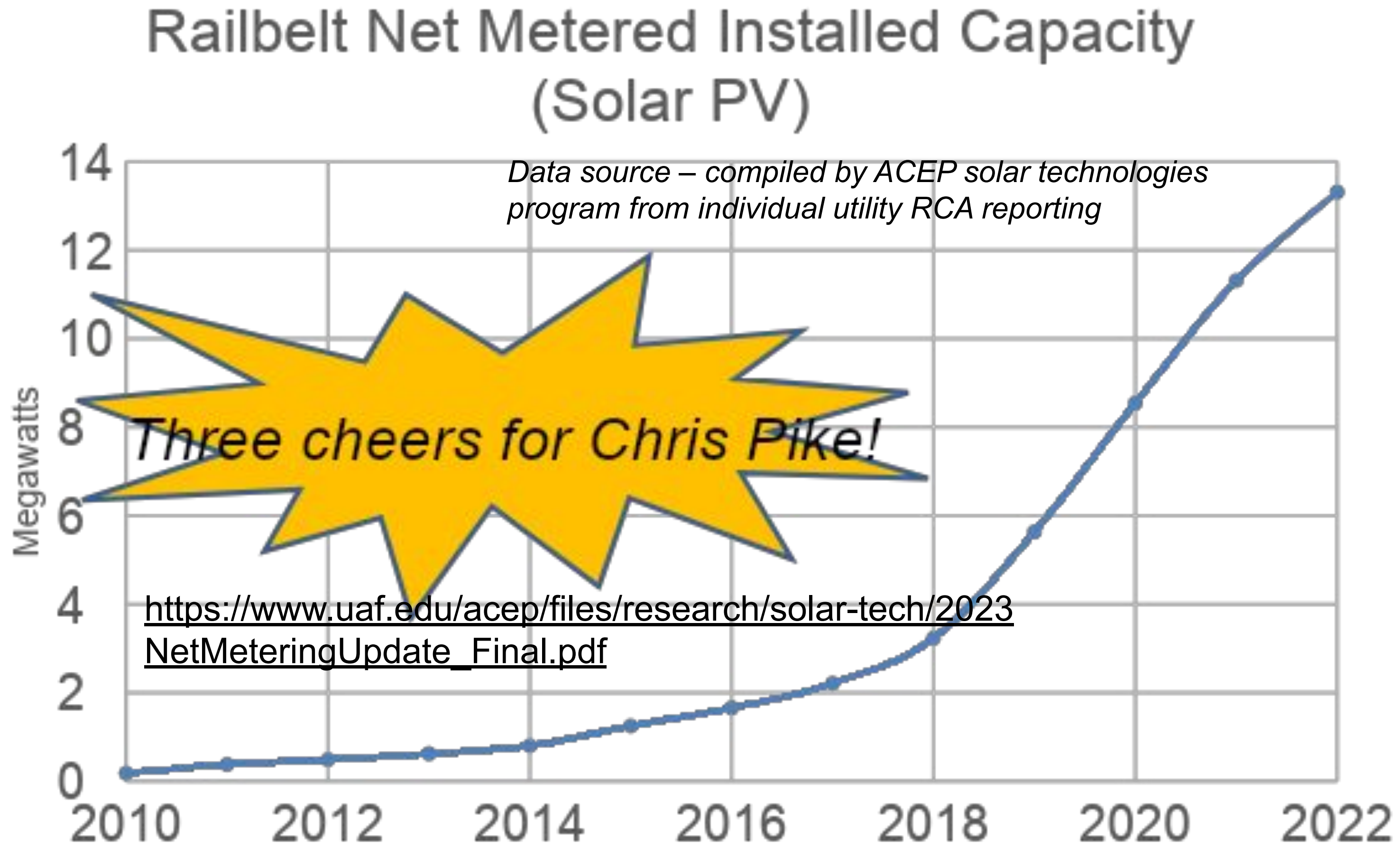
Bonus view from the Trenches

Where’s Rooftop Solar?

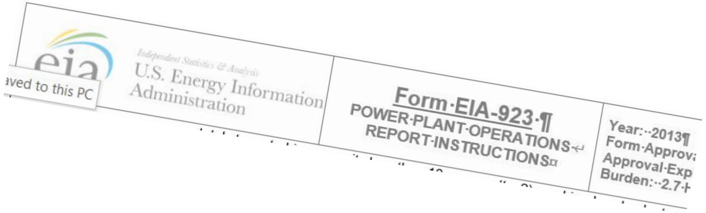

Railbelt Renewables Installed Capacity
300
250
200
150
100
50
0
MW
2011
2012
2013
2018
2021
Fire Island Wind +18
Eva Creek Wind +25
Hydro
Wind
Landfill gas
Solar, incl BTM
Storage



Railbelt Net Metered (ie, BTM) Installed Capacity (Solar PV)
Megawatts
14
12
10
8
6
4
2
0
2010
2012
2014
2016
2018
2020
2022
"Data source – compiled by ACEP solar technologies program from individual utility RCA reporting"
Compiled….
by Whom?


Railbelt Net Metered Installed Capacity
(Solar PV)
Data source – compiled by ACEP solar technologies
program from individual utility RCA reporting
Three cheers for Chris Pike!
https://www.uaf.edu/acep/files/research/solar-tech/2023
NetMeteringUpdate_Final.pdf
Megawatts
14
12
10
8
6
4
2
0
2010
2012
2014
2016
2018
2020
2022

Possible Takeaways



- Much potentially useful energy data comes from fallible people.
- Unreliable/uncleaned data is worse than no data. GIGO.
- Clean, timely, consistent data requires sustained human effort.
- Who is / should be accountable for spotting glitches and cleaning data?
  - Not obvious – recall that the mighty EIA did not catch SW Bailey Plant kWh vs MWh – a 1000-fold error
  - How can “peer review” be used to ensure data quality
- No good substitute for people developing and sustaining relationships with key energy data sources and the raw data therefrom. (Three cheers for P. Haldane!)

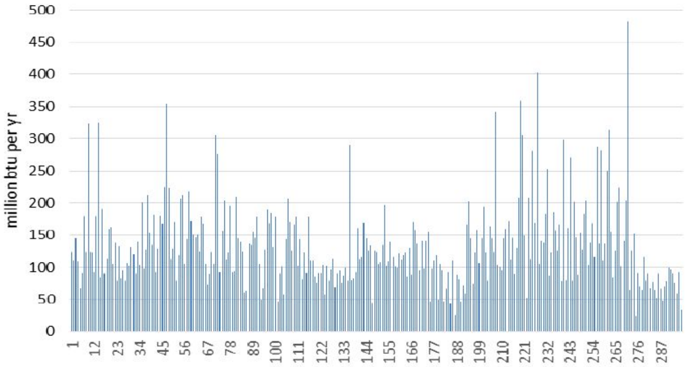
WHAT ABOUT HEAT?

Heat: *The Good……*

- ARIS* data is now publicly available!

Three cheers for AHFC!

- Big sample, data at individual building level
  - *There is no "typical house" or "typical household"*



source: Alaska Retrofiit Information System; Alaska Energy Authority & WH Pacific, Alaska End Use Study (2012)

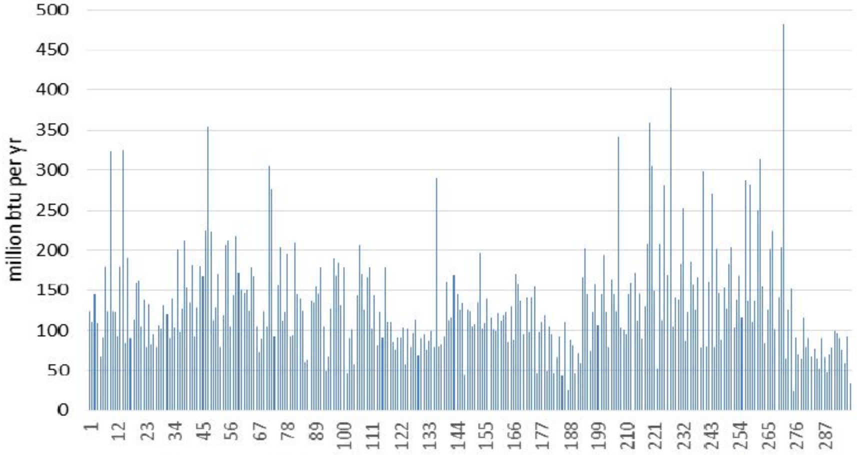
*Alaska Retrofit Information System

From: http://hdl.handle.net/11122/9564

Heat: *The "Bad"...*

- ARIS energy consumption "data" is mostly modeled estimates
  - *There has been little to zero groundtruthing of these* estimates

Figure 6. Variation in modeled heating fuel usage among 297 individual houses in the study area



source: Alaska Retrofiit Information System; Alaska Energy Authority & WH Pacific, Alaska End Use Study (2012)

From: http://hdl.handle.net/11122/9564

Heat: *The Missing*

We have almost zero measured fuel oil consumption data.

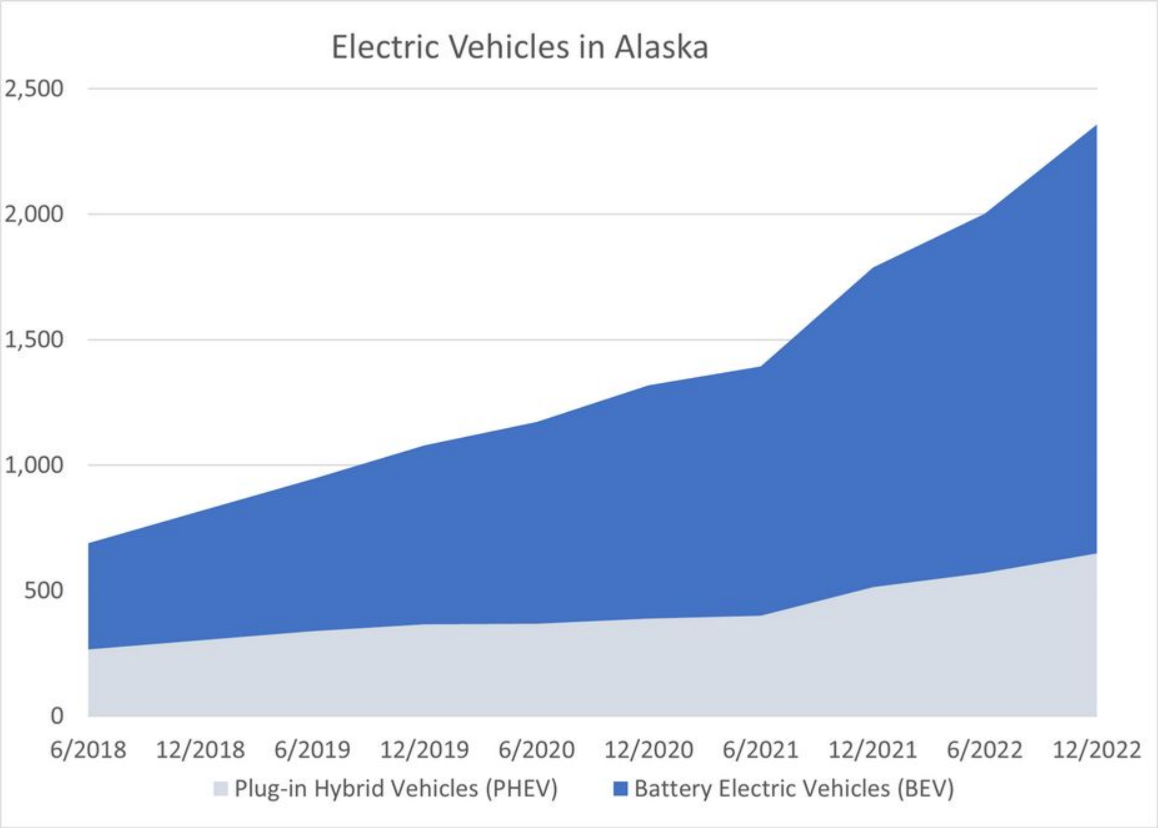
"we're working on it!" at ACEP, but it is slow going

We have almost zero publicly available fuel use data from fuel tax (exemption) data collected by DOR

For decades, we had no publicly available demographic data from the PFD application dataset….but now we do!

WHAT ABOUT TRANSPORTATION?

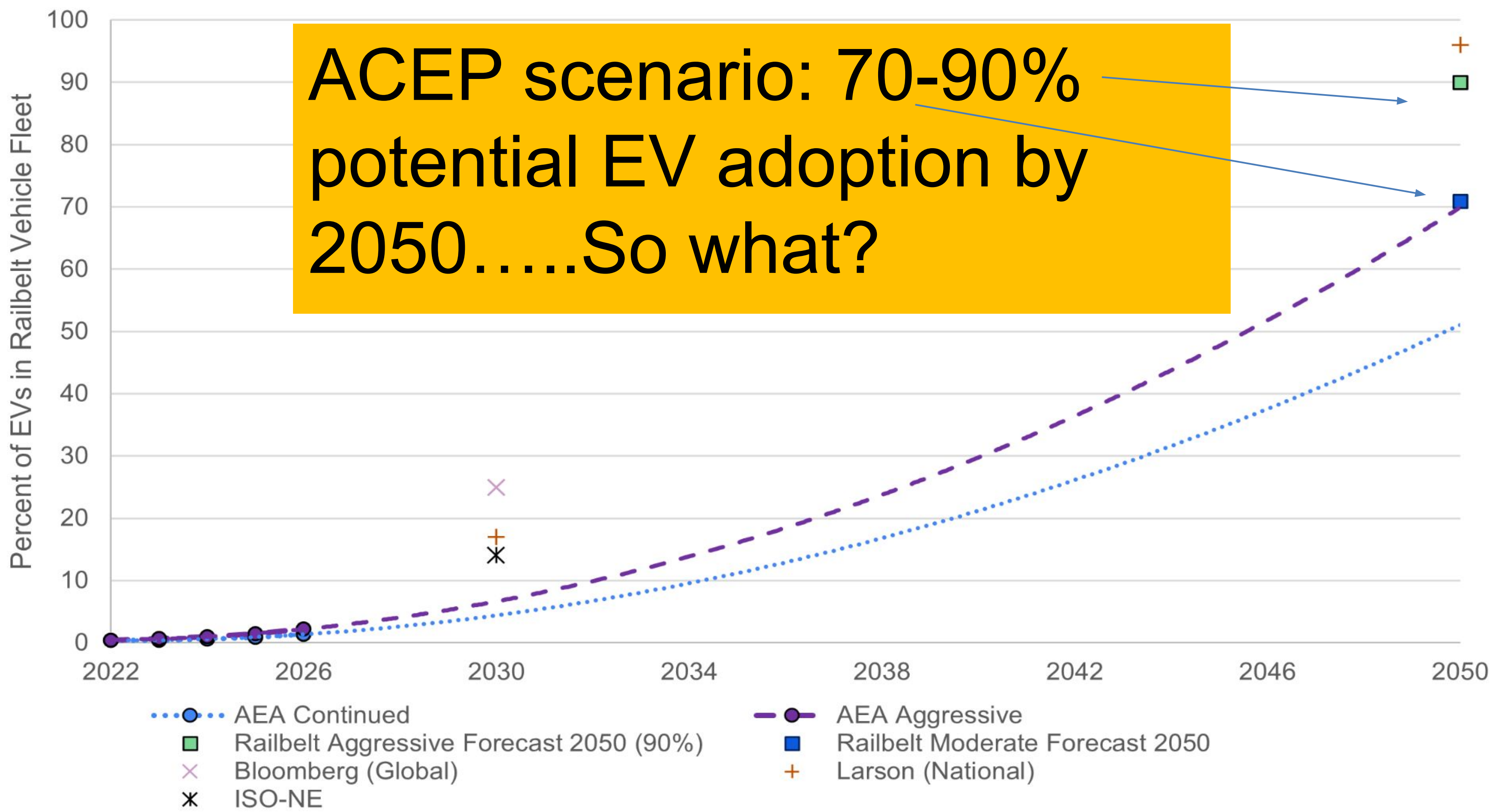
Q: Where did this chart come from?



A: The good folks at Chugach Electric

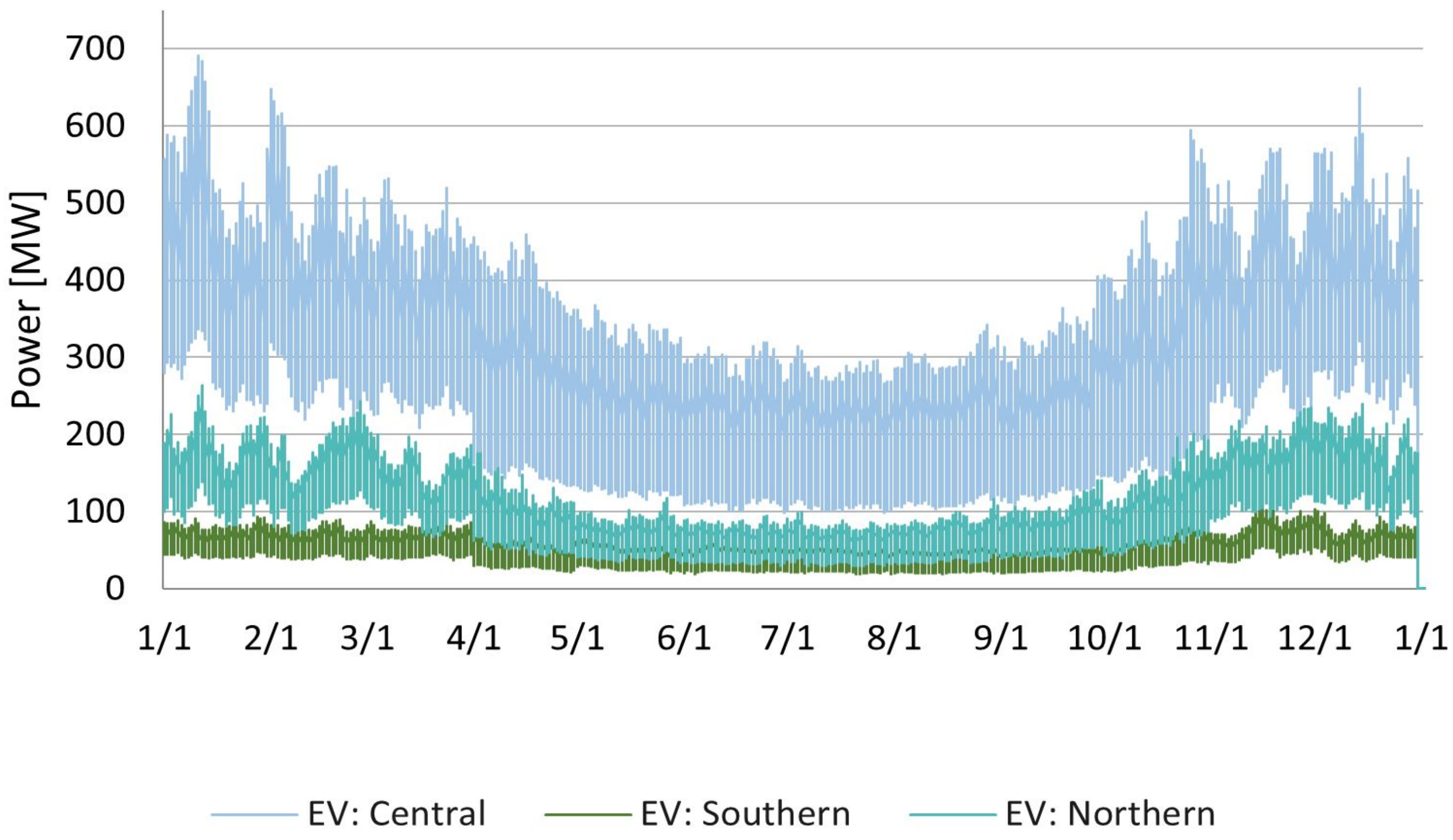
Final view from the Trenches

How might EV and Heat Pump load increase total Railbelt electricity demand?

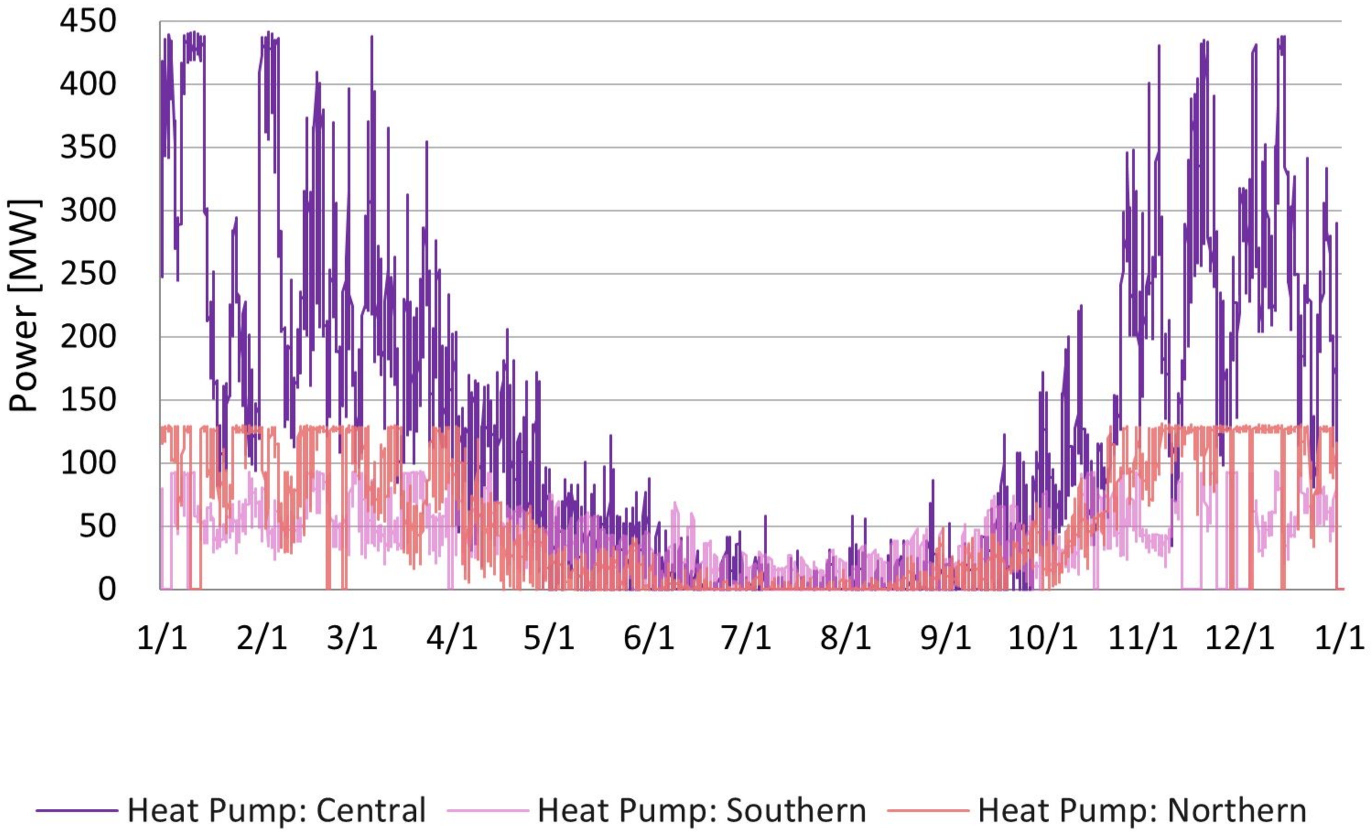


Cicilio et al. *Energies,* forthcoming. This slide from author.

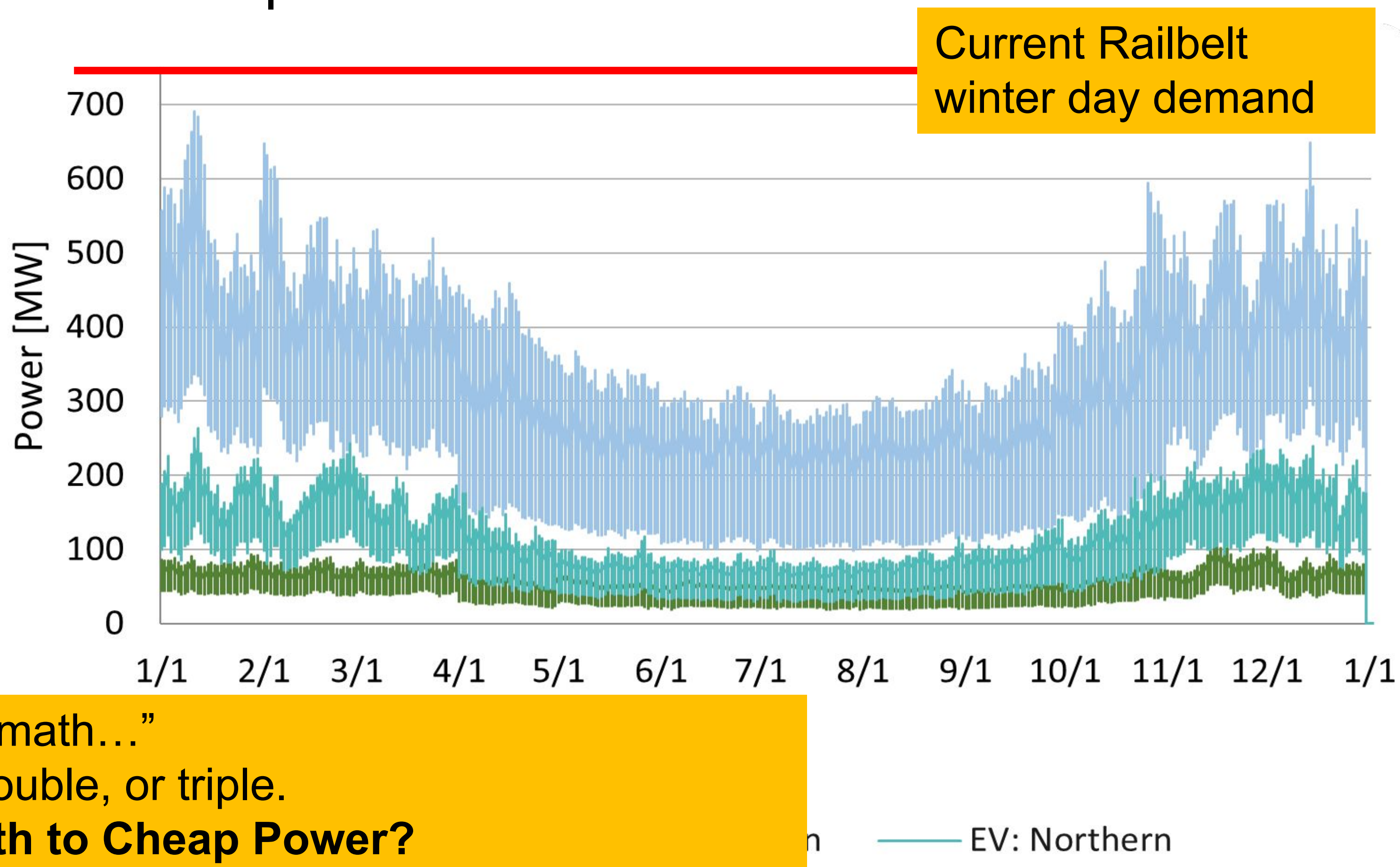
With 90% EV adoption in 2050…..



With 90% Heat Pump adoption in 2050…..



With 90% EV adoption in 2050…..



"You do the math…"
Load may double, or triple.
The Path to Cheap Power?

Final thoughts and a question

- This slide deck was messy because energy data is inherently messy
  - *Only people, applying sustained effort, can clean up messy energy data and make it accessible in useful formats*
- Our understanding of Alaska's energy picture is messy because much data is not collected
  - *Only people, working together and trusting one another, can collect, compile, and clean the heat and transportation data that will dominate policy choices during the next 20 years*
- GIGO
  - Bad raw data in □ [cleaning?] □ ??bad ??better ??good data out
  - Bad data in □ bad policy out
    - No data in □ ???
  - Bad policy in □ ???
- Is energy data a **useful byproduct** of program admin, or a **primary outcome**?
  - Can we live with data served up one pdf at a time?

Thank you for caring about energy data!

Questions/Discussion

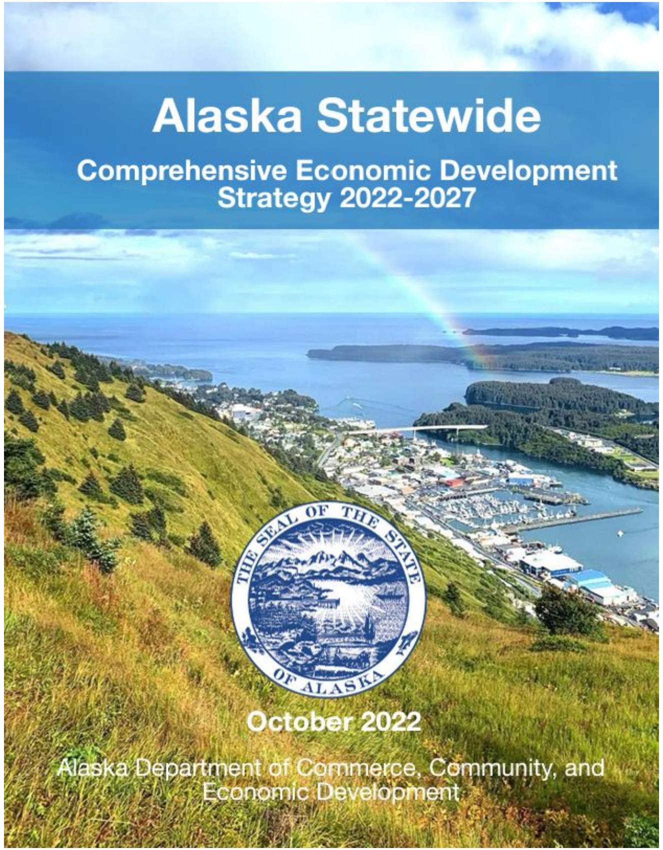
Alaska Comprehensive Economic Development Strategy (CEDS)

University of Alaska Center for Economic Development
for
Alaska Department of Commerce, Community, and Economic Development

Center *for* Economic Development
UAA Business Enterprise Institute

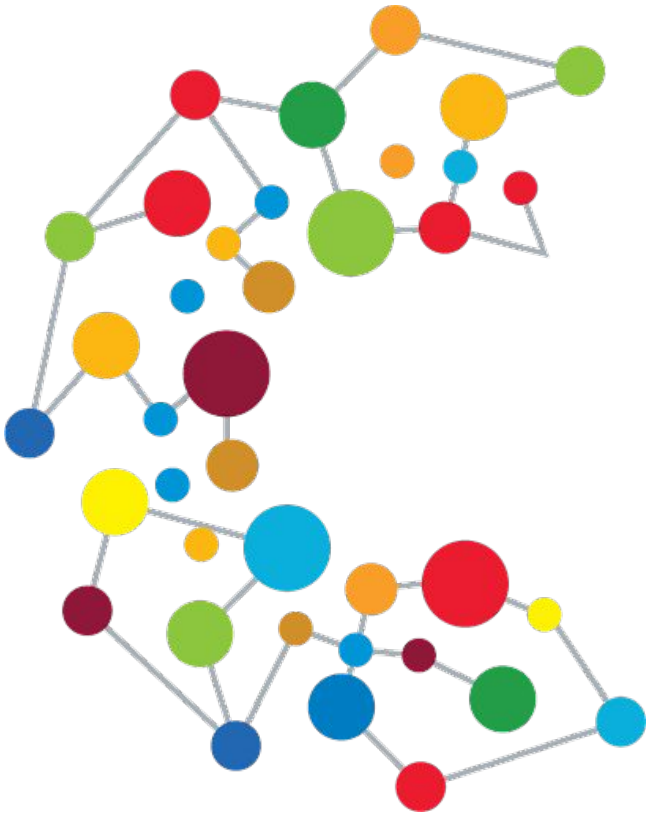
What is a CEDS?

- A **strategic plan** for economic development of a locality, region, or state
- Requires a **public process**
- Necessary for some **federal funds**
- Valid for **5 years**, updated annually (2022-2027)
- Must be approved by the **Economic Development Administration** (EDA)

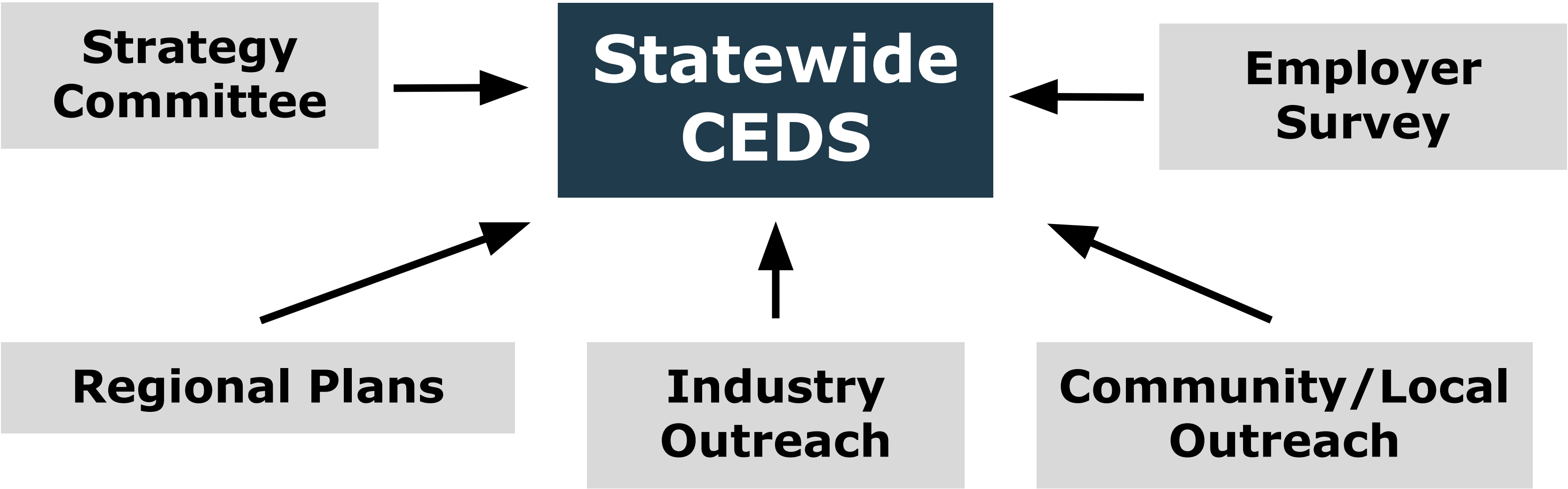


Why have a statewide CEDS?

- Most industries **span multiple regions**
- Many **infrastructure needs are statewide** (i.e. broadband)
- Serve **regions without a CEDS**
- Promote **statewide growth and recovery**
- Attract **strategic federal investments**

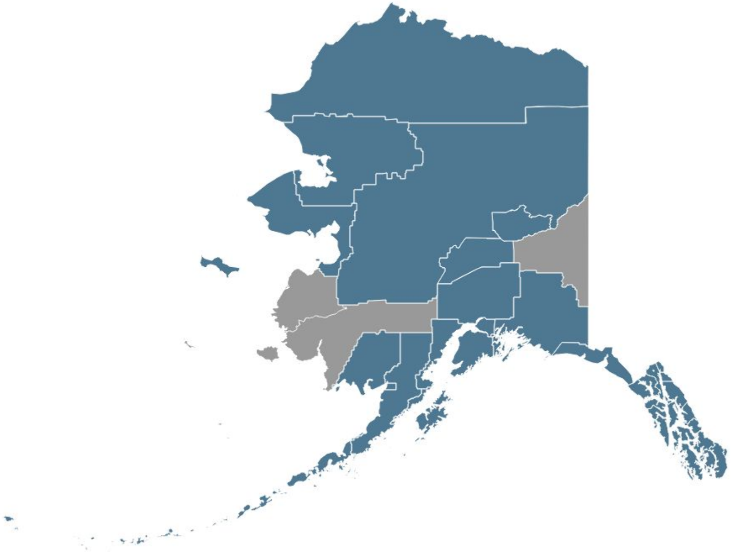


A robust public process



CEDS outreach included

- **Strategy Committee** meetings (50+ members)
- 32 **listening sessions**: all parts of Alaska
- 25 **key informant interviews**
  - Industry associations
  - Government leaders
- **Employer survey**: 200+ responses



Alaska’s economic position, condensed

Challenges

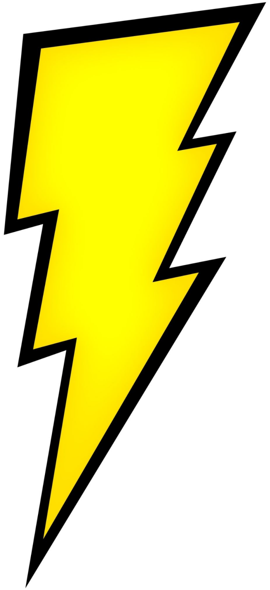
- Recession, stagnation, slow recovery
- Declining oil and gas production
- Workforce shortages
- High operating costs
- Regulatory hurdles to development

Opportunities

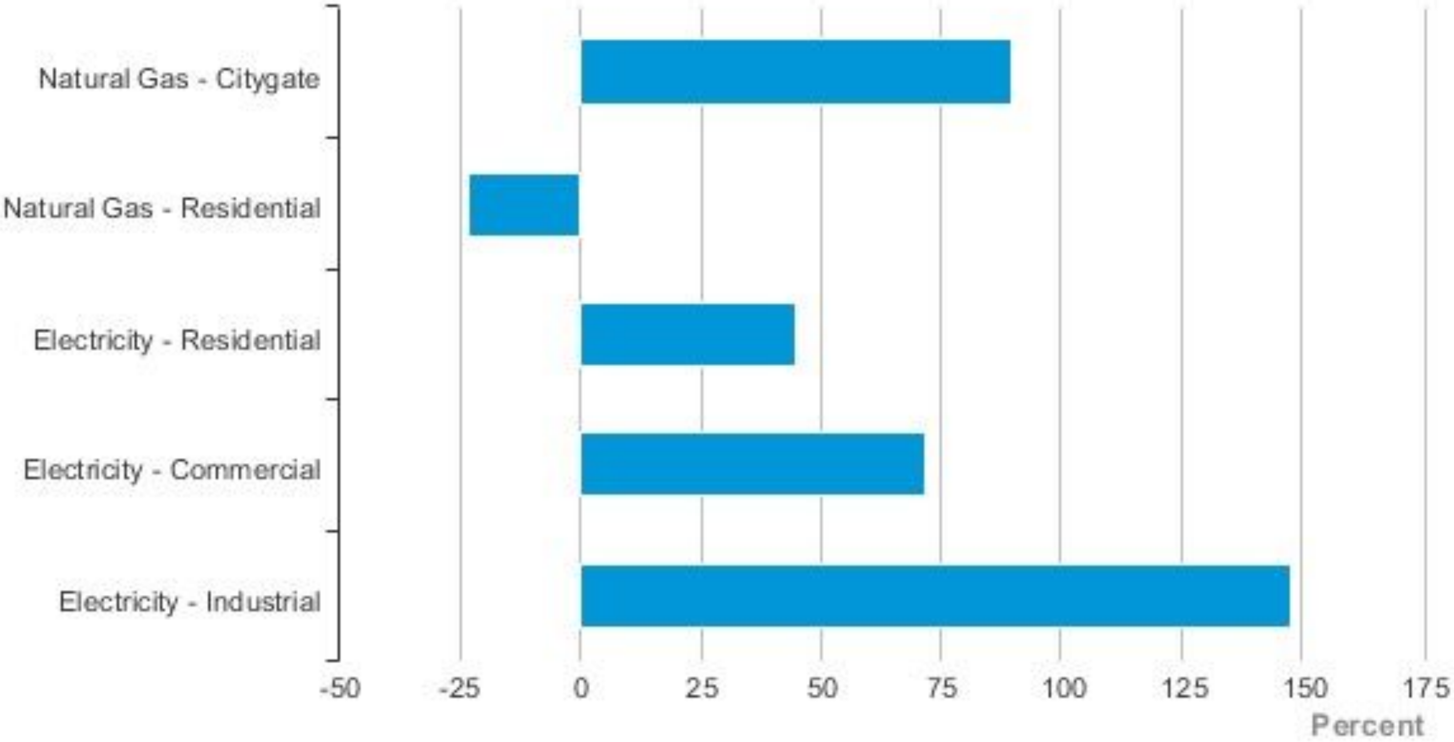
- Resource development opportunities
- Emerging sectors: energy, mariculture, aerospace, marine services, etc
- Geographic position: Arctic and Pacific Rim
- Federal infrastructure investment

Energy's multifaceted role in Alaska's economy

1. We are a major **producer** of energy, via oil and gas
2. High energy **costs** are a significant economic constraint
3. Energy **innovation** is a potential source of economic opportunity
4. Supply of energy is a **resilience challenge**



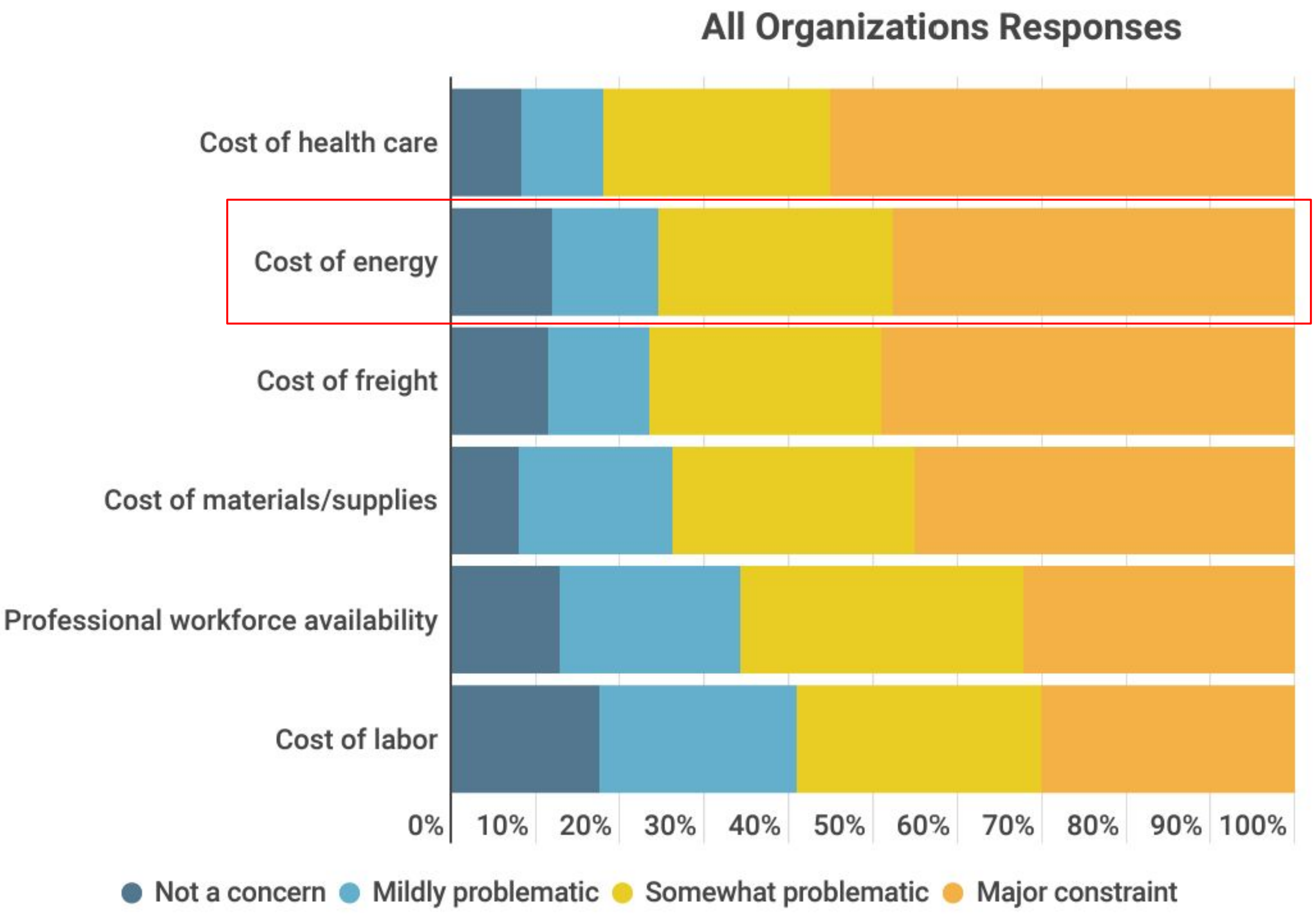
Alaska Price Differences from U.S. Average, Most Recent Monthly



eia

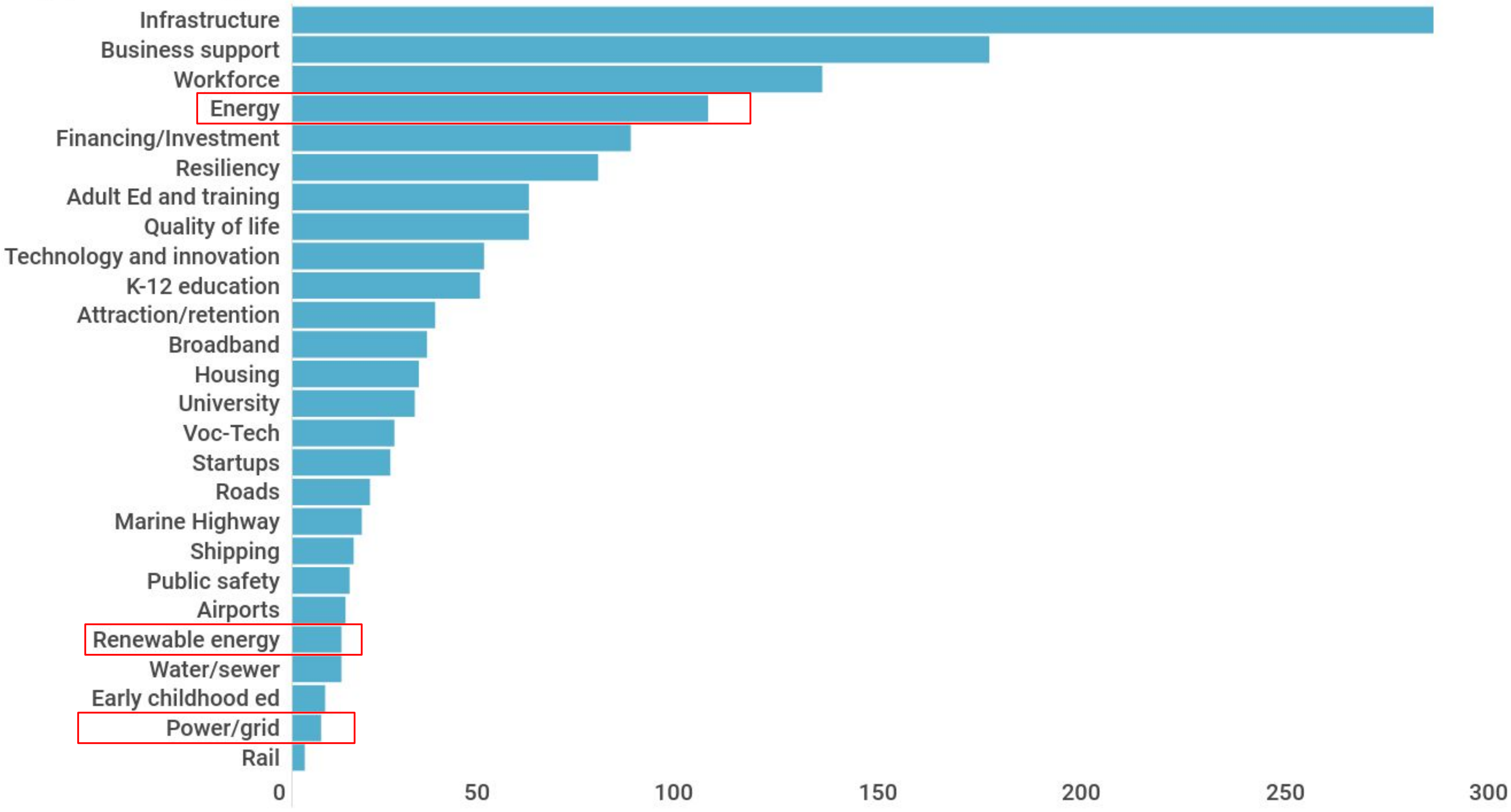
Source: Energy Information Administration, Petroleum Marketing Monthly; Natural Gas Monthly; Electric Power Monthly

What Barriers do Respondents See for their Organizations?



All types of organizations found the cost of doing business (healthcare, energy, freight, materials/supplies, and labor) to be a constraint for their organization.

Types of goals mentioned in AK CEDS documents



Most frequently mentioned in listening sessions

- Workforce shortages and gaps
- Housing availability and affordability
- Energy costs
- Availability of child care

Major CEDS Goals

1. Strengthen Alaska's **Economic Engines**
2. Cultivate and Grow **Emerging Sectors**
3. Support Alaska **Businesses** and the **Entrepreneurial** Ecosystem
4. Build and Update **Economic Foundations**
5. Develop Alaska's **Workforce** and Human Capital
6. Build a **Resilient** State Economy

Goal 1: Strengthen Alaska's Economic Engines


Goal 2: Cultivate and Grow Emerging Sectors


Goal 3: A Strong Business Climate & Entrepreneurial Ecosystem
[redacted]

Goal 4: Build & Update Economic Foundations

Valdez

Photo by Jeremy Talbott


Goal 5: Develop Alaska's
Workforce & Human Capital

Goal 6: Build a Resilient Economy

Resiliency refers to the ability of an economy to avoid, withstand, or mitigate the effects of negative external events such as natural disasters, commodity price instability, or downturns. Recent years in Alaska have witnessed oil price swings, fisheries disasters, floods, earthquakes, severe storms, wildfires, food supply chain interruptions, power outages, coastal and riverine erosion, cyber-attacks, and the COVID-19 pandemic. Some of these are associated with climate change. The CEDS includes both proactive and responsive measures to plan for and reduce negative impacts.

Center *for* Economic Development
UAA Business Enterprise Institute

Thank You!

UNIVERSITY *of* ALASKA
Many Traditions One Alaska

THE STATE of ALASKA
GOVERNOR MIKE DUNLEAVY

Department of Commerce, Community, and Economic Development

Alaska Statewide Comprehensive Economic Development Strategy (CEDS) 2022-2027

Energy-Specific Goals & Objectives

Laura Vaught
Project Manager

Energy Security Task Force
Energy Symposium Series
August 17, 2023

Background

- Alaska Statewide CEDS 5-year update was funded by an Economic Development Administration (EDA) Statewide Planning Grant, one-time American Rescue Plan Act (ARPA) funding intended to fund economic development initiatives to help states recover from the pandemic.
- Existing 2017-2022 CEDS was due to expire in September 2022.

Project Team

The State of Alaska was ultimately responsible for the CEDS creation and adoption.

Contracted by the State of Alaska, UACED led research, meeting facilitation, and CEDS development.

Strategy Committe e

Approximately 50 community and industry leaders critiqued, vetted, and contributed ideas to steer the CEDS.

Regional EDOs

Regional economic development organizations and partners guided outreach sessions in their regions.

Roles & Responsibilities

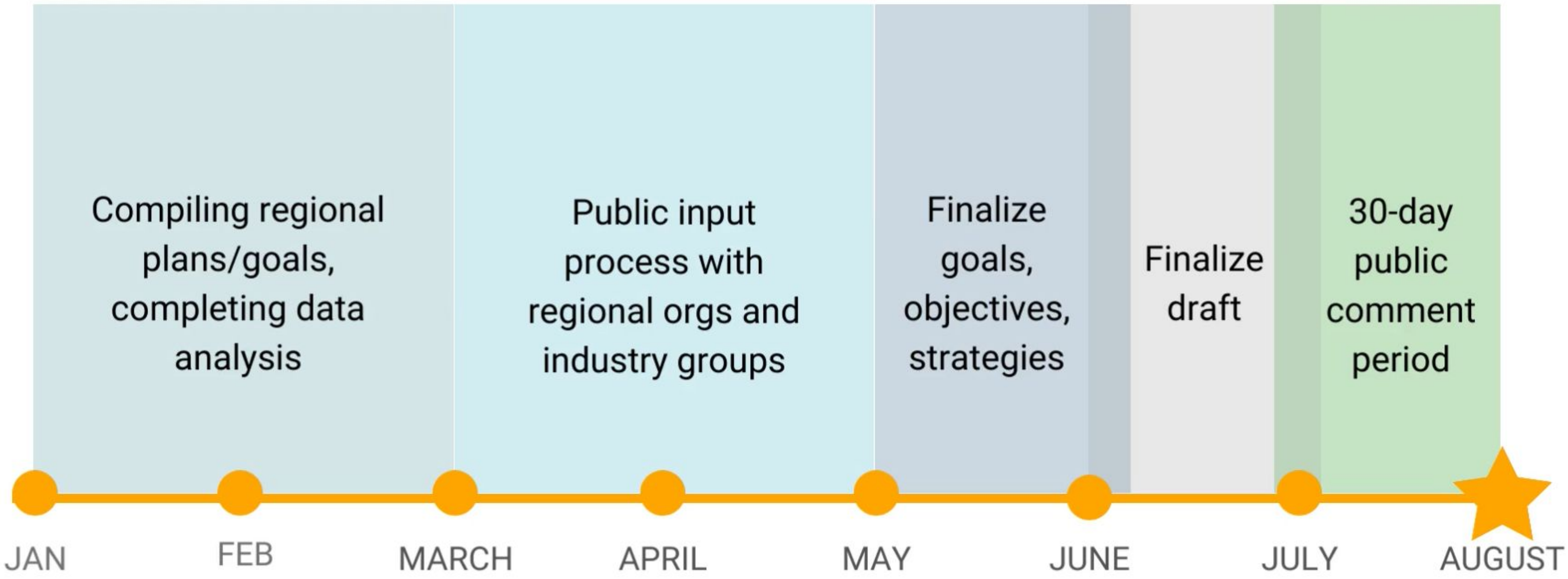
State of Alaska – DCCED and Governor's Office

- Managed grant that funded this effort. Ensured compliance with project scope.
- Composed CEDS Strategy Committee.
- Coordinated with economic development organizations to conduct regional outreach.
- Identified communities and industries critical for inclusion in engagement sessions.
- Reviewed, approved, and published final Statewide CEDS Report.

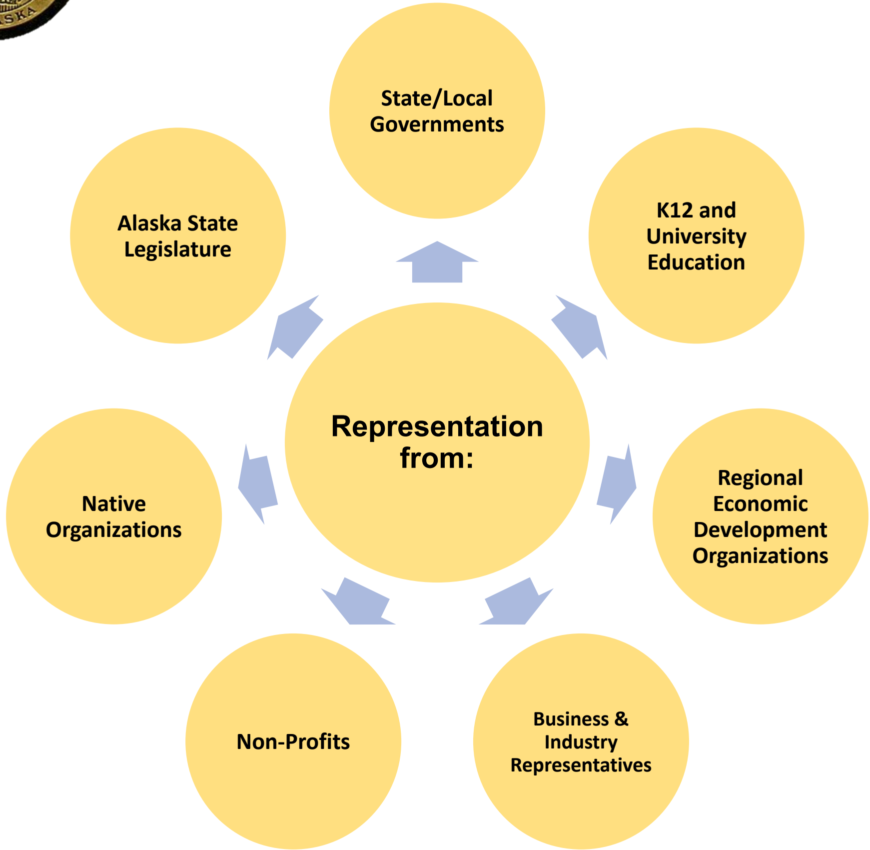
University of Alaska Center for Economic Development

- Compiled regional CEDS information.
- Researched and updated economic, demographic, and geographic data.
- Facilitated Strategy Committee meetings and regional and industry engagement sessions.
- Processed and refined objectives and action items identified through public engagement.
- Prepared draft Report. Incorporated public comment and graphic design into final Statewide CEDS Report.

Timeline of 2022 CEDS Update Process



CEDS Strategy Committee



Areas of Expertise:

- Aerospace
- Agriculture
- Banking
- Business Development
- Energy
- Housing
- Intellectual Property
- Manufacturing
- Resource Development
- Seafood
- Telecommunications
- Tourism
- Transportation
- Workforce

Regional Outreach

Alaska Regional Development Organizations (ARDORs)

- Anchorage Economic Development Corporation
- Copper Valley Development Association
- Fairbanks North Star Borough Economic Development Commission
- Kawerak, Inc.
- Kenai Peninsula Economic Development District
- Northwest Arctic Borough Economic Development Council
- Prince William Sound Economic Development District
- Southeast Conference
- Southwest Alaska Municipal Conference

CEDS Goals

Goal 1: Strengthen Alaska's Economic Engines

Goal 2: Cultivate and Grow Emerging Sectors

Goal 3: A Strong Business Climate & Entrepreneurial Ecosystem

Goal 4: Build & Update Economic Foundations

Goal 5: Develop Alaska's Workforce & Human Capital

Goal 6: Build a Resilient Economy

CEDS Objectives

Strengthen Economic Engines

- [ ] 1.1: Regulatory
- [x] 1.2: Oil & Gas
- [ ] 1.3: Stranded Resources
- [ ] 1.4: Mining
- [x] 1.5: Alternative Energy
- [ ] 1.6: Military
- [x] 1.7: Timber
- [ ] 1.8: Air Cargo
- [ ] 1.9: Seafood
- [ ] 1.10: Tourism

Cultivate and Grow Emerging Sectors

- [ ] 2.1: Mariculture
- [ ] 2.2: Aerospace
- [ ] 2.3: Agriculture
- [ ] 2.4: Maritime
- [ ] 2.5: Manufacturing
- [ ] 2.6: Minerals
- [x] 2.7: Sustainable Energy

A Strong Business Climate & Entrepreneurial Ecosystem

- [x] 3.1: University
- [ ] 3.2: Training
- [ ] 3.3: Start-Ups
- [ ] 3.4: Access to Capital
- [ ] 3.5: Technical Expertise
- [ ] 3.6: Inclusivity
- [ ] 3.7: Regulatory
- [ ] 3.8: Entrepreneurs
- [ ] 3.9: Promote Alaska

Build and Update Economic Foundations

- [ ] 4.1: Broadband
- [ ] 4.2: Ferries
- [ ] 4.3: Air
- [ ] 4.4: Housing
- [ ] 4.5: Marine Infrastructure
- [x] 4.6: Affordable Energy
- [ ] 4.7: Affordable Health Care
- [ ] 4.8: Transportation Infrastructure
- [ ] 4.9: Recreation

Develop Alaska's Workforce and Human Capital

- [ ] 5.1: Workforce Coordination
- [ ] 5.2: Education
- [ ] 5.3: Workforce Attraction
- [ ] 5.4: Remote Workers
- [ ] 5.5: Childcare
- [ ] 5.6: WIOA
- [ ] 5.7: Infrastructure Bill Preparedness
- [ ] 5.8: Planning
- [x] 5.9: Alternative Energy Workforce
- [ ] 5.10: Regulatory

Build a Resilient Economy

- [ ] 6.1: Resiliency Planning
- [x] 6.2: Resilience Capacity
- [x] 6.3: Resilient Infrastructure
- [ ] 6.4: Rural Resilience

Objective 1.2: Develop Alaska's North Slope natural gas and heavy oil for in-state and export markets.

Action Item

Attract private co-investment to build a natural gas pipeline and liquefaction facilities for export to the Lower 48 and abroad.

Potential Lead Entity:

AGDC

Potential Partners:

Governor's Office

Action Item

Where economically feasible, build infrastructure to supply natural gas to Alaska communities to reduce greenhouse gas emissions and energy costs.

Potential Partners:

AGDC

Gas utilities

Local governments

Action Item

Support research, pilot testing, development, and production of North Slope heavy oil using existing infrastructure.

Potential Lead Entity:

Governor's Office

Potential Partners:

Oil and gas producers

University of Alaska

Department of Natural Resources

Objective 1.5: Develop alternative, low emission uses for existing natural resources.

Action Item

Pursue public and private investment to utilize North Slope natural gas to produce hydrogen fuel.

Potential Partners:

Governor's Office

AGDC

Action Item

Continue R&D in the utilization of natural gas to produce hydrogen for world markets.

Potential Lead Entity:

UAF

Potential Partners:

Governor's Office

AGDC

Action Item

Explore alternative uses for coal, such as gasification and hydrogen production.

Potential Partners:

University of Alaska

Mining companies

Action Item

Pursue carbon capture and sequestration to make existing resources cleaner.

Action Item

Develop and implement Hydrogen Roadmap for Alaska.

Potential Lead Entity:

UAF

Potential Partners:

Governor's Office

AGDC

University of Alaska Center for Economic Development

ACEP

Objective 1.7: Revitalize Alaska's forest products industry.

Action Item

Support access to other resources and uses in National Forests, such as hydroelectric development.

Potential Partners:

Southeast Conference

Division of Forestry

National Forest Service

DCCED

Governor's Office

Action Item

Encourage utilization of local timber to meet in-state lumber and biomass needs, including from beetle-killed spruce.

Potential Partners:

Division of Forestry

ARDORs

Economic Development Organizations

DCCED

Governor's Office

Objective 2.7: Develop Alaska as a global center of clean, sustainable energy innovation to attract and grow innovative firms.

Action Item
Adopt a clean energy portfolio standard that targets 80% clean energy while simultaneously reducing energy costs for users in the Railbelt by 2040.

Potential Lead Entity:
Governor's Office

Potential Partners:
REAP

Action Item
Deploy next generation renewable energy solutions throughout rural Alaska as legacy systems reach end of useful life, accounting for maintenance and training costs.

Potential Lead Entity:
AEA

Potential Partners:
ACEP
Launch Alaska
Alaska Power Association

Action Item
Execute pilot and demonstration projects for energy technology through entities such as AEA, Launch Alaska, and the National Laboratories.

Potential Lead Entity:
AEA

Potential Partners:
ACEP
Launch Alaska

Action Item
Deploy clean energy sources such as geothermal, tidal, and microreactors.

Potential Lead Entity:
AEA

Potential Partners:
ACEP
Launch Alaska

Action Item
Conduct and implement a statewide strategic plan for energy development.

Potential Lead Entity:
AEA

Potential Partners:
ACEP
Launch Alaska
REAP
Alaska Power Association

Action Item
Conduct a study on state level energy incentives programs across the U.S. with a goal of expanding energy incentive programs in Alaska.

Potential Lead Entity:
AEA

Potential Partners:
State of Alaska
Launch Alaska

Action Item
Support the establishment of an Alaska Hydrogen Hub and an Alaska Carbon Capture, Utilization and Storage (CCUS) Hub.

Potential Lead Entity:
Governor's Office

Potential Partners:
AEA
Governor's Office
Congressional delegation

Objective 3.1: Utilize the assets of the University of Alaska System to grow knowledge-economy firms in Alaska.

Action Item

Align university research with the R&D needs of Economic Engines and Emerging Sectors, especially in energy, Arctic technologies, resource development, ocean sciences, health care technologies, biosciences, and aerospace.

Potential Lead Entity:

University of Alaska

Potential Partners:

UAA Business Enterprise Institute

UAF Center ICE

UA intellectual property offices

Alaska Blue Economy Center

UAF ACUASI

Objective 4.6: Reduce the cost of energy for industrial and residential use through any realistic means throughout the state.

Action Item
Build natural gas infrastructure to increase the supply of natural gas to the Interior, leveraging public and private investment.

Potential Lead Entity: AGDC

Potential Partners: FNSB, Interior Gas Utility, AIDEA

Action Item
Where feasible, install renewable energy systems such as wind, tidal, geothermal, and solar to reduce power costs in rural areas.

Potential Lead Entity: AEA

Potential Partners: Electric utilities, Local governments, Tribal governments, ACEP

Action Item
Use industrial access roads and bulk purchasing power to supply low-cost fuel to rural communities located near natural resource development sites.

Potential Lead Entity: AIDEA

Potential Partners: Local governments, Tribal governments, Alaska Native Corporations

Action Item
Expand transmission lines to connect outlying communities to the Railbelt (or other regional) grids wherever a cost-benefit analysis indicates a positive value.

Potential Lead Entity: AEA

Potential Partners: Local governments, Tribal governments, Electric utilities

Action Item
Utilize federal infrastructure funds to retrofit commercial and industrial buildings for greater efficiency.

Potential Partners: AEA, AHFC, DCCED

Action Item
Build new, and upgrade existing hydroelectric facilities to provide low cost, low emissions power.

Potential Partners: AEA, Electric utilities, Local governments, Tribal governments

Action Item
Fully implement Commercial Property Assessed Clean Energy (CPACE) financing to help commercial building owners increase energy efficiency and reduce costs at the local government level.

Potential Partners: AEA, Local governments, Commercial lenders

Action Item
Establish a green bank to finance energy efficiency projects in partnership with the private sector.

Potential Partners: AEA, AIDEA, Commercial lenders, Local governments, REAP

Action Item
Increase the reimbursement for Power Cost Equalization (PCE) from 500 kWh to 750 kWh.

Potential Lead Entity: AEA

Potential Partners: Governor's Office, State Legislature

Action Item
Upgrade Railbelt transmission lines to increase transmission capacity, per announced $200 million capital plan.

Potential Lead Entity: AEA

Potential Partners: Electric utilities

Objective 5.9: Prepare the Alaska workforce for job opportunities in low and no emissions energy technologies, such as electric vehicles, renewable energy systems, and other

Action Item

Obtain federal grants under the IIJA to train mechanics and maintenance workers on electric and hydrogen vehicles.

Potential Partners:

University of Alaska
Training providers
Unions
Employers
K-12 system
Industry associations

Objective 6.2: Leverage Economic Engines and Emerging Sectors to promote the resiliency to supply chain disruptions, natural disasters, and external shocks.

Action Item

Develop in-state timber resources for construction lumber and biomass energy.

Potential Partners:

Division of Forestry

Southeast Conference

Southeast Sustainable Partnership

Private sawmills

Action Item

Utilize natural gas resources for power and heating needs.

Potential Partners:

AIDEA

Electric utilities

Gas utilities

Action Item

Incorporate decarbonization, climate change, and the energy transition into economic development efforts.

Potential Partners:

ARDORs

Economic Development Organizations

DCCED

Governor's Office

Tribal governments

Local governments

Objective 6.3: Build new, and upgrade existing, infrastructure capable of withstanding resiliency shocks such as natural disasters.

Action Item

Ensure power reliability for certain forms of infrastructure, such as ports and airports, which require an uninterrupted supply.

Potential Partners:

Local governments

Electric utilities

AEA

Action Item

Invest in redundancy for transmission lines and broadband fiber when feasible to continue service during interruption.

Potential Partners:

Alaska Broadband Office

AEA

Electric utilities

Telecommunications companies

Action Item

Upgrade rural energy infrastructure such as power houses and bulk fuel farms.

Potential Lead Entity:

AEA

Potential Partners:

Denali Commission

Rural electric utilities

Action Item

Deploy clean energy systems to reduce dependence on diesel fuel, including renewable and micronuclear sources.

Potential Lead Entity:

AEA

Potential Partners:

U.S. Department of Energy

Electric utilities

Find the Statewide CEDS Online

DCCED homepage – www.commerce.alaska.gov

DCCED COVID-19 Relief Information & Programs

DCCED's COVID-19 Business Relief Programs website is intended to provide information on COVID-19 economic relief programs available to businesses at the State and Federal levels.

The AK-ARPA Business Relief Program application period is closed.

The Alaska Seafood Processors Pandemic Response Relief Program application period is closed and awards have been made.

Highlights

Governor's Food Security & Independence Task Force

Approximately 95% of the food Alaskans purchase is imported. Governor Dunleavy has put together this task force to address Alaska's food security and independence. Visit our Food Security & Independence Task Force page for more information.

Alaska SBIR/STTR Grant Program

State grant funds are available for businesses with a currently active Federal Small Business Innovation Research (SBIR) or Small Business Technology Transfer (STTR) award. For more information, visit our Alaska SBIR/STTR Grant Program page.

Community Development Quota (CDQ) Program

The CDQ Program is administered through NOAA's National Marine Fisheries Service. For more information on the State of Alaska's 2022 CDQ Decennial Review, visit our Community Development Quota (CDQ) Program page.

2022-2027 Statewide CEDS

The Final 2022-2027 Statewide Comprehensive Economic Development Strategy (CEDS) is now available.

Alaska SBIR/STTR Grant

PROJECTS

- Food Security Task Force
- 2022-2027 Statewide CEDS

DIVISION LINKS

- Commissioner's Office
- Administrative Services
- Banking and Securities
- Community and Regional Affairs
- Corporations, Business and Professional Licensing
- Insurance
- Investments

CORPORATE AGENCIES

- Alaska Energy Authority
- Alaska Industrial Development and Export Authority
- Alaska Gasline Development Corp.
- Alaska Railroad Corporation
- Alaska Seafood Marketing Institute
- Alaska Oil and Gas Conservation Commission
- Alcohol & Marijuana Control Office
- Alaska Broadband Office
- Regulatory Commission of Alaska

State of Alaska / Commerce / Statewide Comprehensive Economic Development Strategy

STATEWIDE COMPREHENSIVE ECONOMIC DEVELOPMENT STRATEGY

2022-2027

The Department of Commerce, Community, and Economic Development (DCCED) published a 5-year Statewide Comprehensive Economic Development Strategy (CEDS) in October 2022. Funded by the Economic Development Administration, this economic development strategy leveraged a locally based, regionally driven, state connected planning process. The 2022-2027 Statewide CEDS identifies the current state of the economy, addresses strategies to improve Alaska's economic resilience, and provides a roadmap for future economic growth.

DCCED partnered with the University of Alaska Center for Economic Development (UACED) to perform the background research, facilitate the public process, and draft the document, with the Alaska Development Team within the Governor's Office providing high-level direction and guidance. Public outreach for the CEDS took place between January and June 2022 and involved a wide range of stakeholders - local and regional leadership, industry and business representation, Tribal representation, learning institutions, and regional economic development organizations, including Alaska Regional Development Organizations (ARDORs). A Strategy Committee made up of state leaders from business, government, and the nonprofit sector provided strategic guidance throughout the CEDS development.

Many regions throughout Alaska have a CEDS or some version of a regional economic development strategy. The Statewide CEDS is not meant to replace any regional strategies; instead, it provides a coordinated, high-level economic strategy for the entire state. Most of the state's industries span more than one region, as do its foundational gaps like affordable housing. In these cases, collaborative statewide strategies are necessary to make progress. Although developed by state government, the Alaska Statewide CEDS is designed to be used broadly by anyone working to strengthen the Alaska economy.

Click each link below for access to the 2022-2027 Statewide CEDS Report as well as supplemental Appendices A-H:

- 2022-2027 Alaska Statewide CEDS Report
- Appendix A: Goals and Objectives Matrix
- Appendix B: Economic Summary Background
- Appendix C: Economic Engines
- Appendix D: Emerging Sectors
- Appendix E: SWOT Analysis
- Appendix F: Survey Results
- Appendix G: Review of CEDS Across Alaska
- Appendix H: Evaluation Framework Sources

DIVISION LINKS

- Commissioner's Office
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CORPORATE AGENCIES

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- Alaska Railroad Corporation
- Alaska Seafood Marketing Institute
- Alaska Oil and Gas Conservation Commission
- Alcohol & Marijuana Control Office
- Alaska Broadband Office
- Regulatory Commission of Alaska

Thank You

Laura Vaught

Project Manager

Laura.Vaught@alaska.gov

(907) 269-7387

TRANSMISSION AND SHORTAGE: BUILDING A MORE RESILIENT GRID

Thursday, August 24, 2023, 11:00 AM – 1:00 PM

- *Energy Storage Options and Selection Considerations*
- *Beneficial and Equitable Electrification*
- *Tidal Power in Alaska*

Sandia National Laboratories

Exceptional service in the national interest

Energy Storage Options & Selection Considerations

Sandia National Laboratories

AESTF Energy Symposium

Presenter: Luke McLaughlin, Ph.D.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

OUTLINE

Energy Storage

- Importance
- Promising Technologies
- Modeling
- Influence of Key System Parameters

Summary

Energy Storage

Importance

Promising Technologies

Modeling

Energy Storage

Energy Storage (LDES) needed to achieve full decarbonization

"…energy storage is not a luxury, but a necessity…" – Jeremy Twitchell of PPNL

Long Duration Energy Storage (LDES)

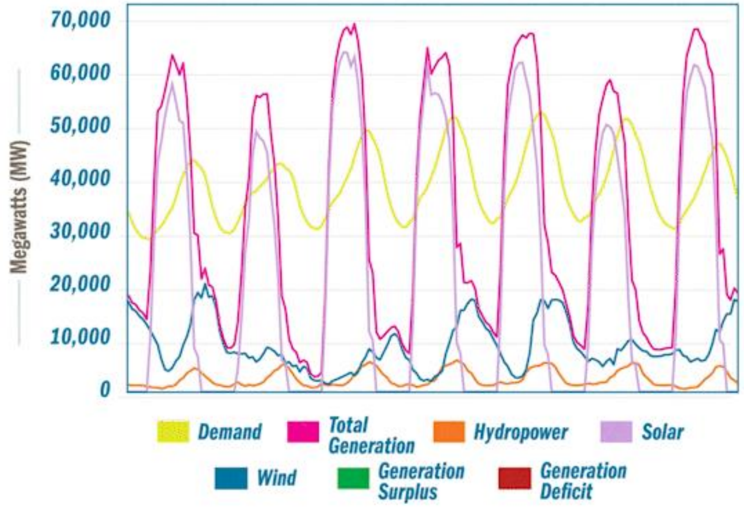
- 8+ hrs (approximate duration)
- Dispatchable at maximum deficit

85-140 TWh LDES needed by 2040 to enable global net zero goals

- LDES Council Report: A path towards full grid decarbonization with 24/7 clean Power Purchase Agreements

Cost Reduction of LDES systems necessary

Importance



Courtesy of PNNL

Courtesy of DOE

Energy Storage

Commercially Available Technologies

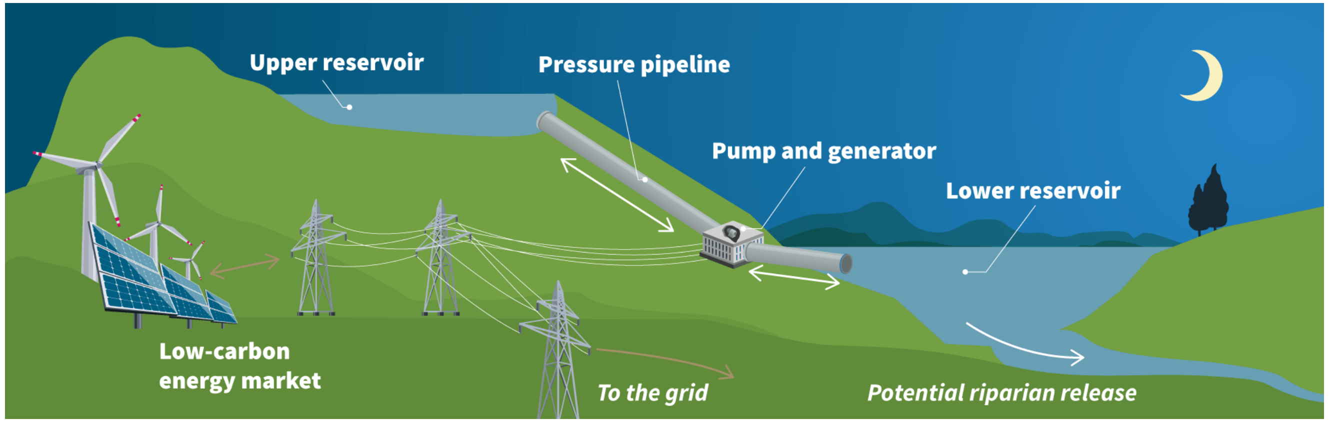
- Lithium-ion (Li-ion) Iron Phosphate (LFP)
- Lithium-ion Nickel Manganese Cobalt (NMC)
- Lead Acid
- Vanadium Redox Flow (VRF)
- Zinc-based
- Compressed Air Energy Storage (CAES)
- Pumped Storage Hydropower (PSH)
- Thermal Energy Storage (TES)
- Gravity Energy Storage
- Hydrogen

Technology solutions are scenario specific

Promising Technologies

https://electrek.co

https://www.renewablethermal.org



https://www.advisian.com

Energy Storage

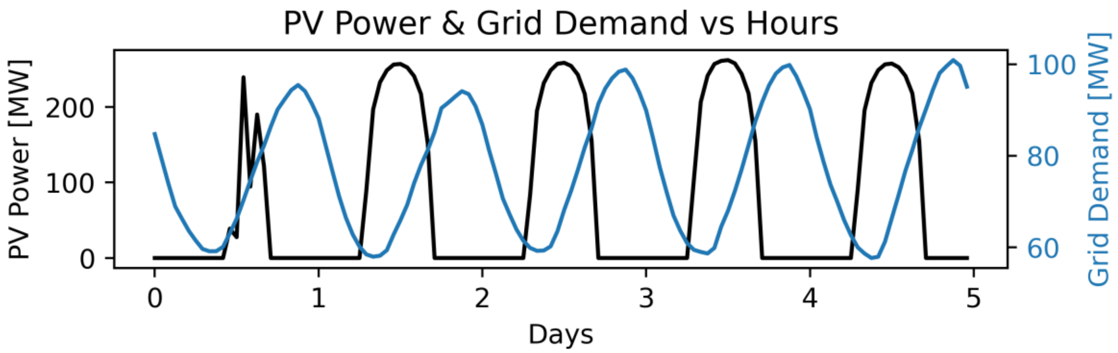
8760 Modeling

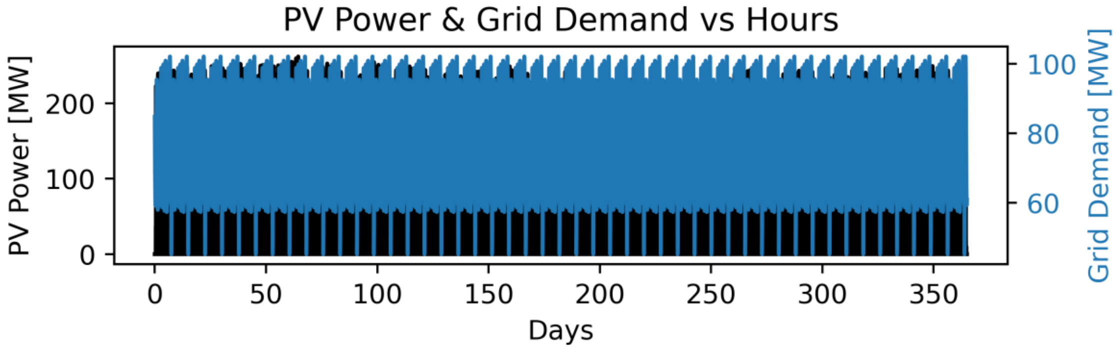
- Models energy storage system (ESS) using hourly data over a year
- Utilizes hourly grid demand and energy availability data
- Assesses system performance in dynamic environment

SNL 8760 Modeling

- Compare ESS within the same setting
- Assesses Impacts of:
  - Power purchase agreement
  - Energy available for charging
  - System efficiency

Modeling





Fixed Parameter	Value	Units
Peak grid demand/discharge	100	MW
Operational life	30	Years
Loan percentage	50	%
Interest rate	8	%
Base Electricity Price	0.05	$/kWh

Energy Storage

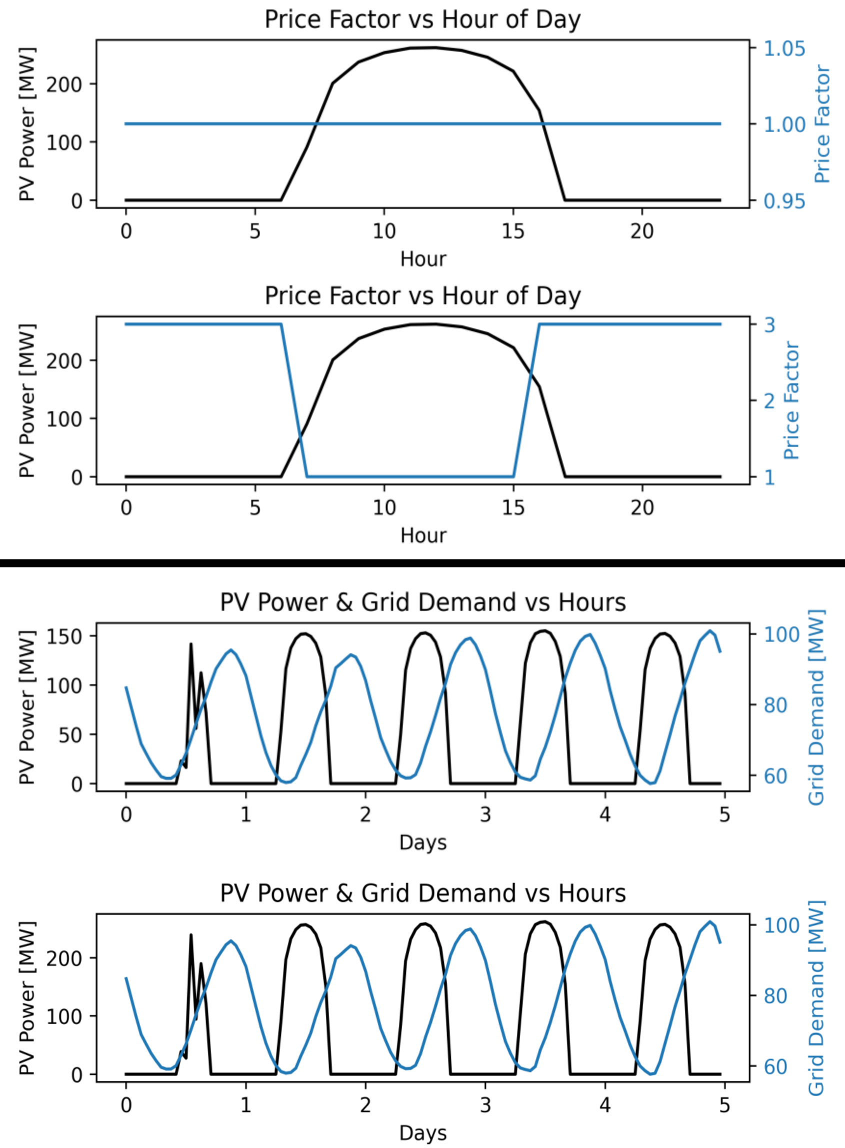
Model assesses standalone ESS

Excess PV energy for charging

Varied Model Parameters

- **Electricity Pricing**
  - Flat
  - Hypothetical “100% RE” Scenario
- **Power available for charging**
  - 100 MW max charge
  - 200 MW max charge
- **System Efficiency**
  - TES system RTE
  - 35-60 %

Modeling



Energy Storage

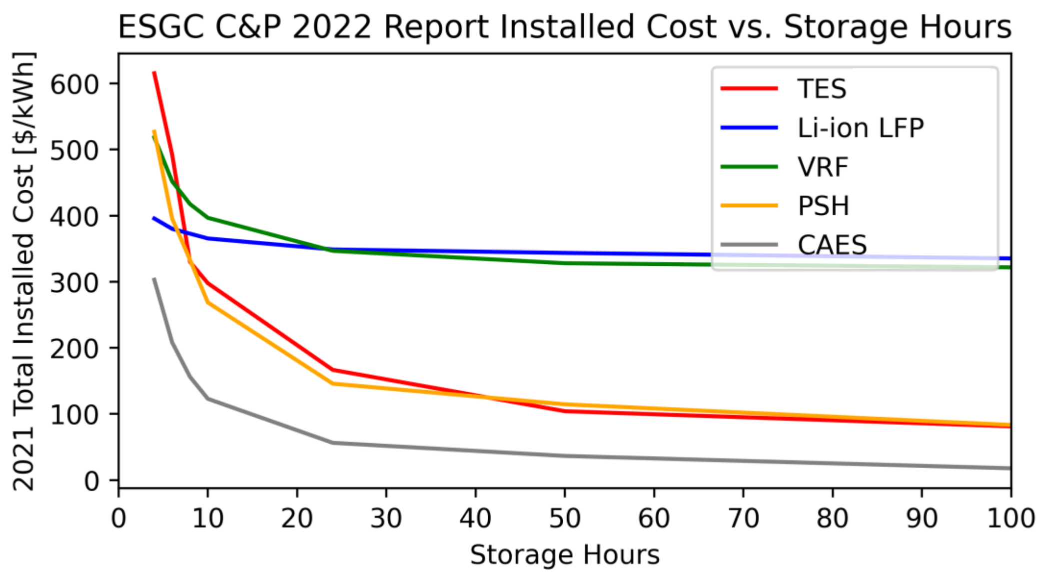
Systems Analyzed

- Li-ion LFP
- Vanadium Redox Flow (VRF)
- Pumped Storage Hydropower (PSH)
- Compressed Air Energy Storage – Caverns (CAES)
- Thermal Energy Storage (TES)

ESGC Cost & Performance 2022 Report used as basis for analysis

- Installed Cost
- RTE
- Lifespan
- O&M Cost

Modeling



ESS	Life Time [years]	RTE [%]	O&M [$/kW-yr]
PSH	59.9	79.9	28.19
Vanadium Redox Flow	11.9	65.5	12.08
Li-ion LFP	16.0	82.5	9.87
CAES	59.9	51.9	16.11
Thermal	33.9	51.7	32.31

Energy Storage

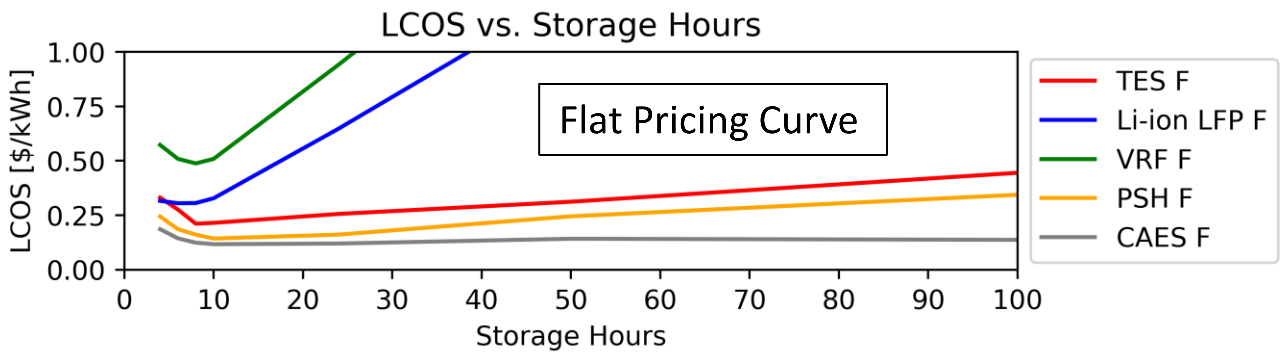
$$LCOS = \frac{\sum_1^n (CAPEX + O\&M + I - Net\ Profit)}{\sum_1^n E_{out}}$$

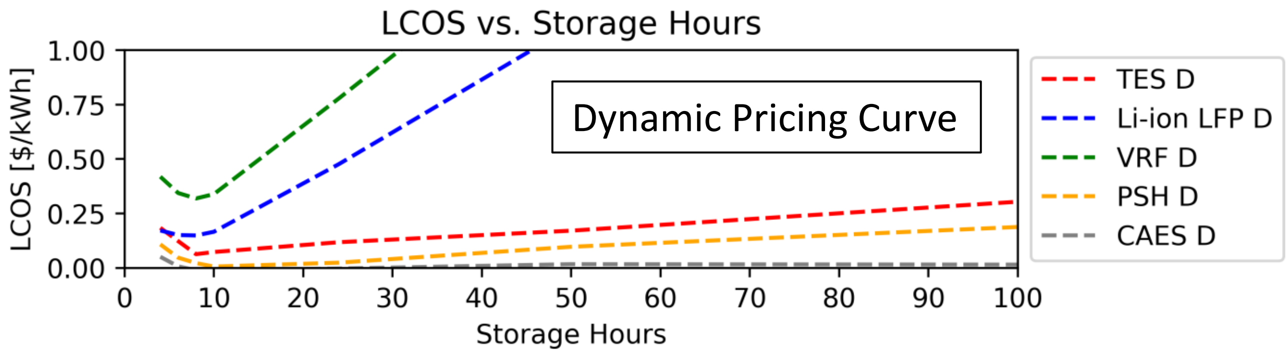
200 MW Charge General Trends

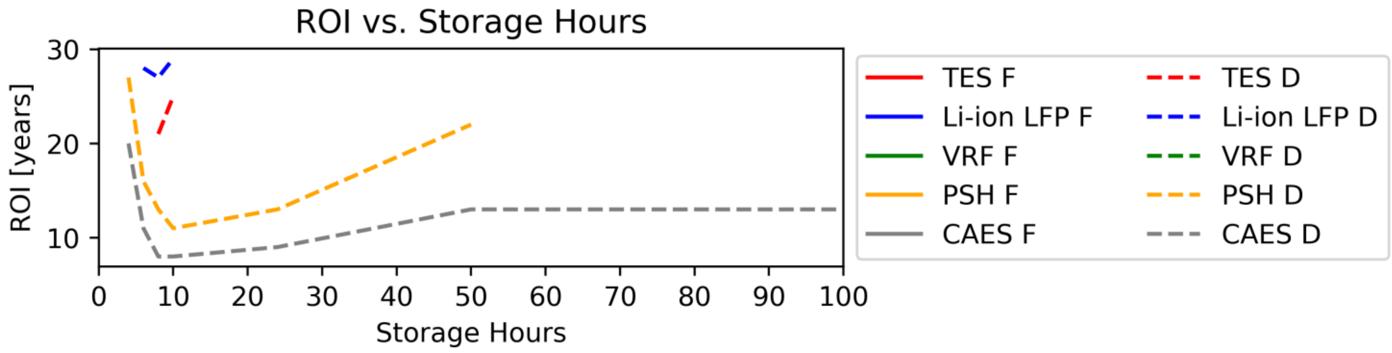
- CAES & PSH lowest LCOS
- TES lowest LCOS 8+ hours without geographical constraint
- Li-ion LFP lowest LCOS 4 hours without geographical constraint

Influence of Electricity Pricing

- Buying "low" and selling "high" reduces system cost via increased Net Profit of electricity sold
- Enables return on investment (ROI)





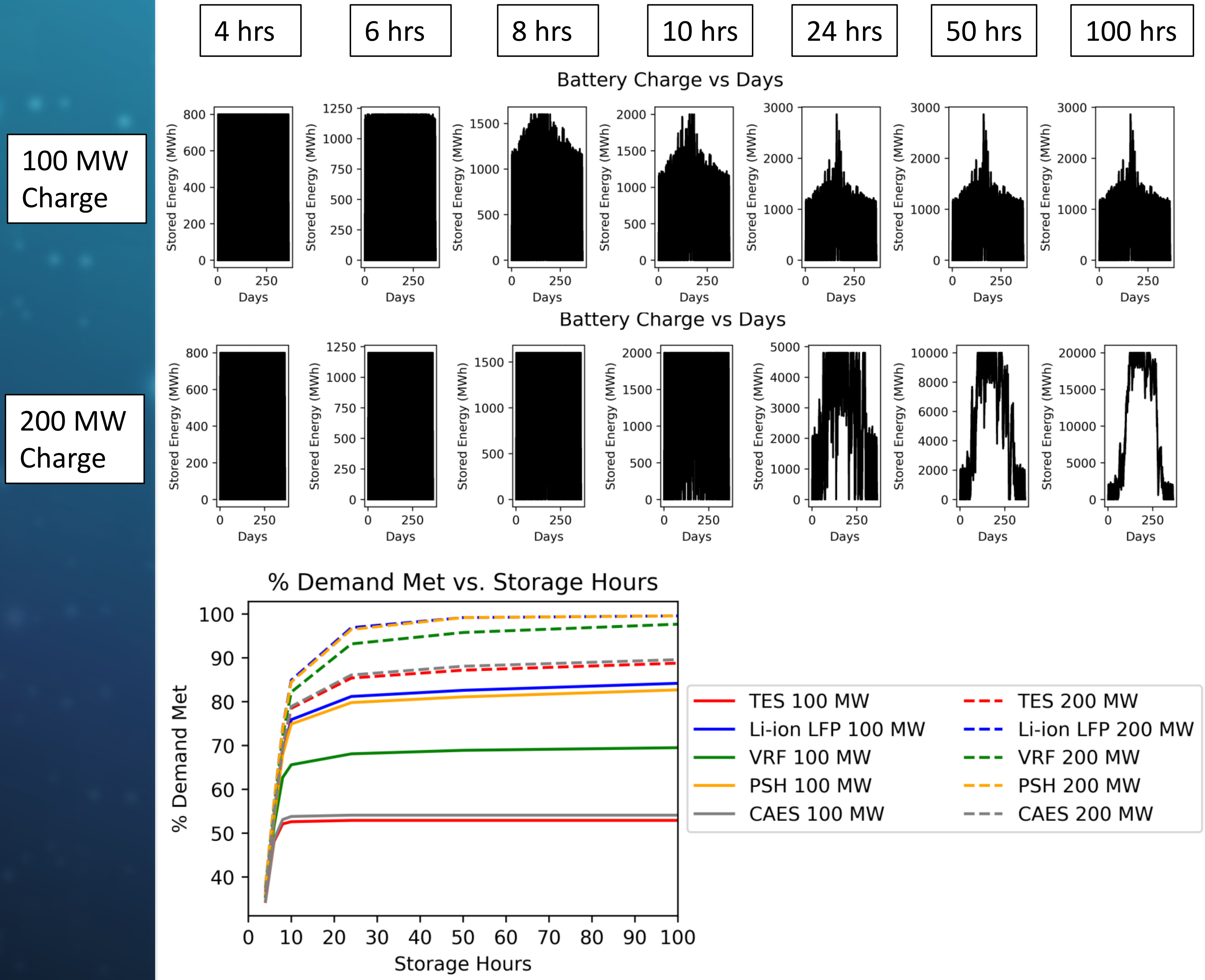


Energy Storage

Influence of Available Charging Energy

- Increased storage duration requires sufficient power to charge
- Increased charging power increases % demand met by system

$$\%_{demand} = \frac{E_{out,ESS}}{E_{grid\ demand}}$$

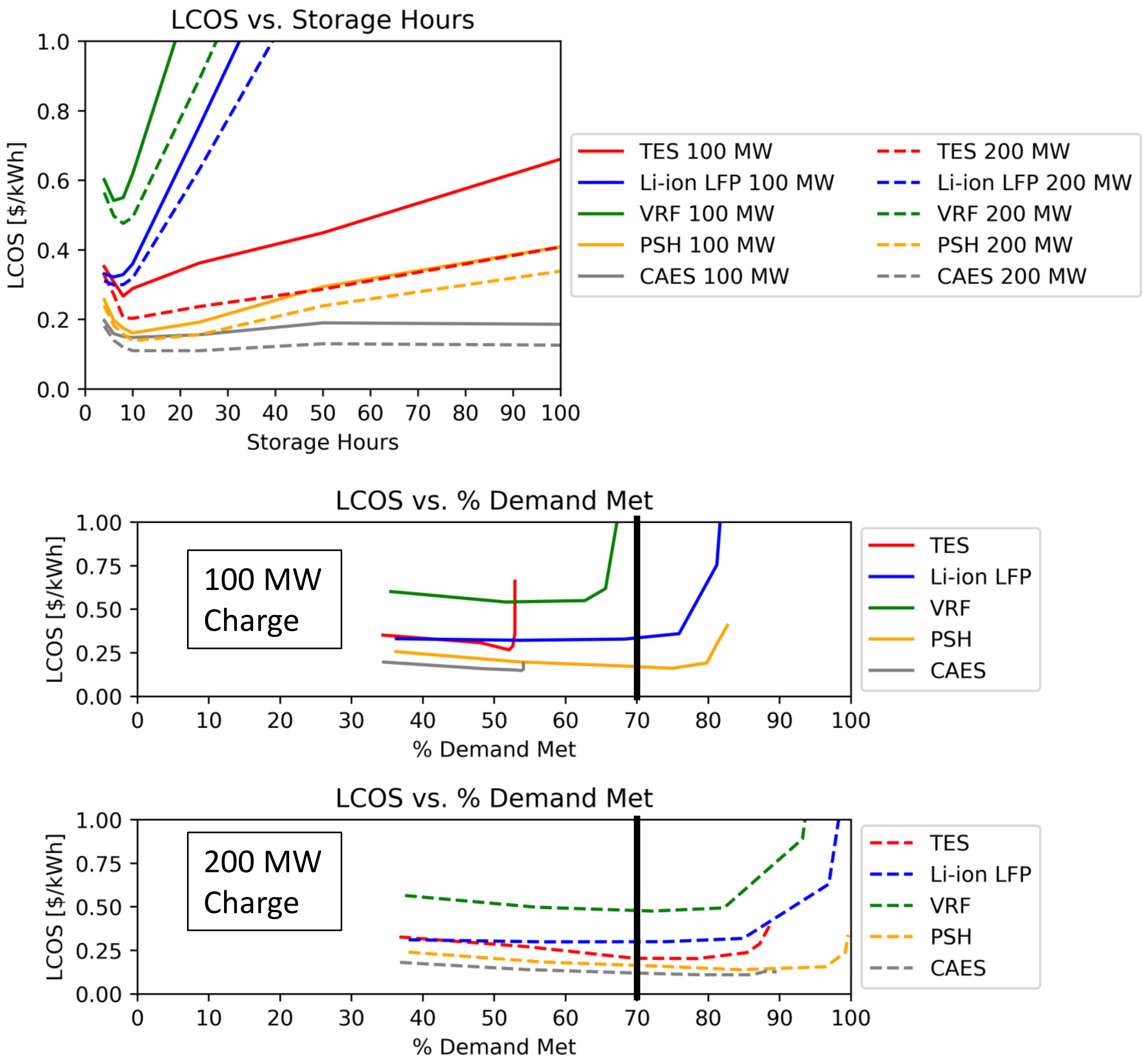


Energy Storage

Influence of Available Charging Energy

- Increased battery utilization decreases system cost

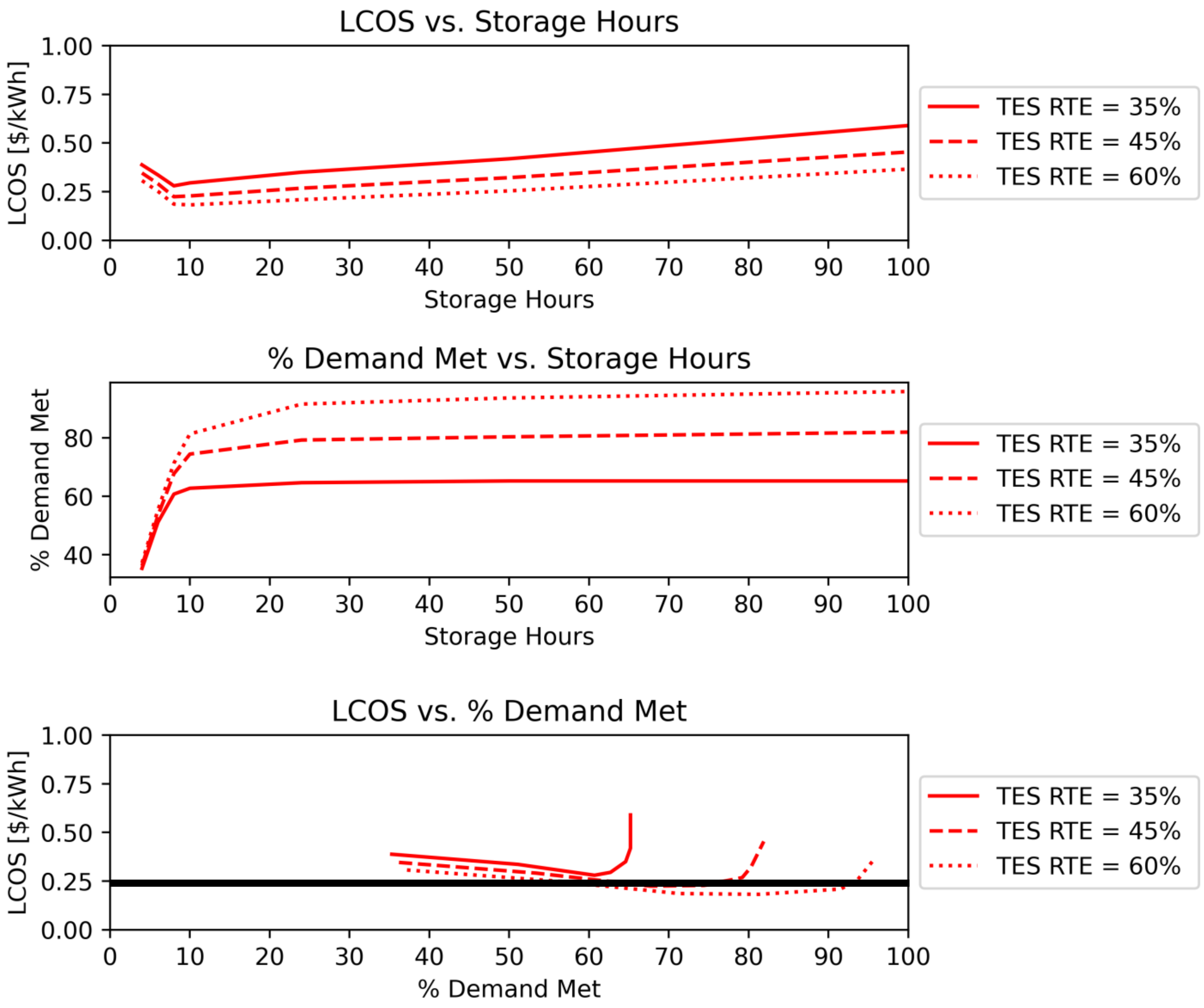
- Lowest cost solution may not meet % met demand requirement



Energy Storage

Influence of Round Trip Efficiency

- Increased ESS RTE reduces LCOS
- Increased ESS RTE increases % demand met for specific scenario
- Higher % demand met for same LCOS



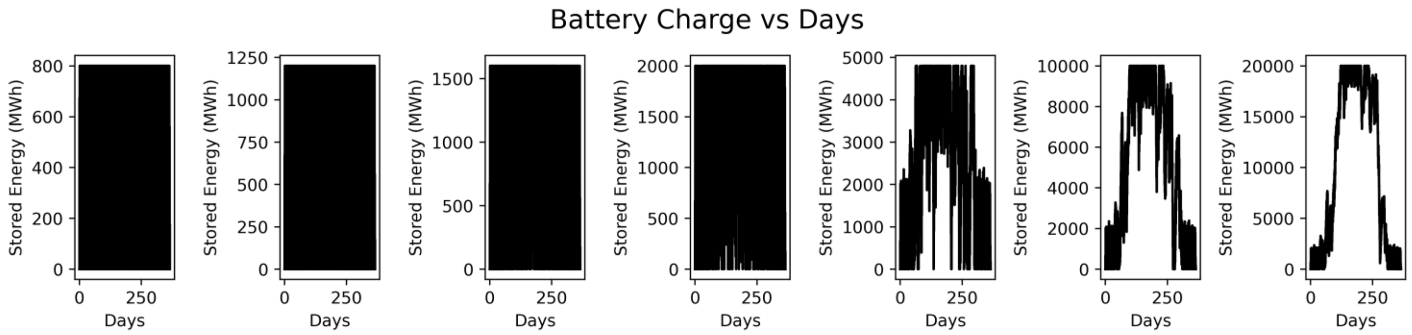
Summary

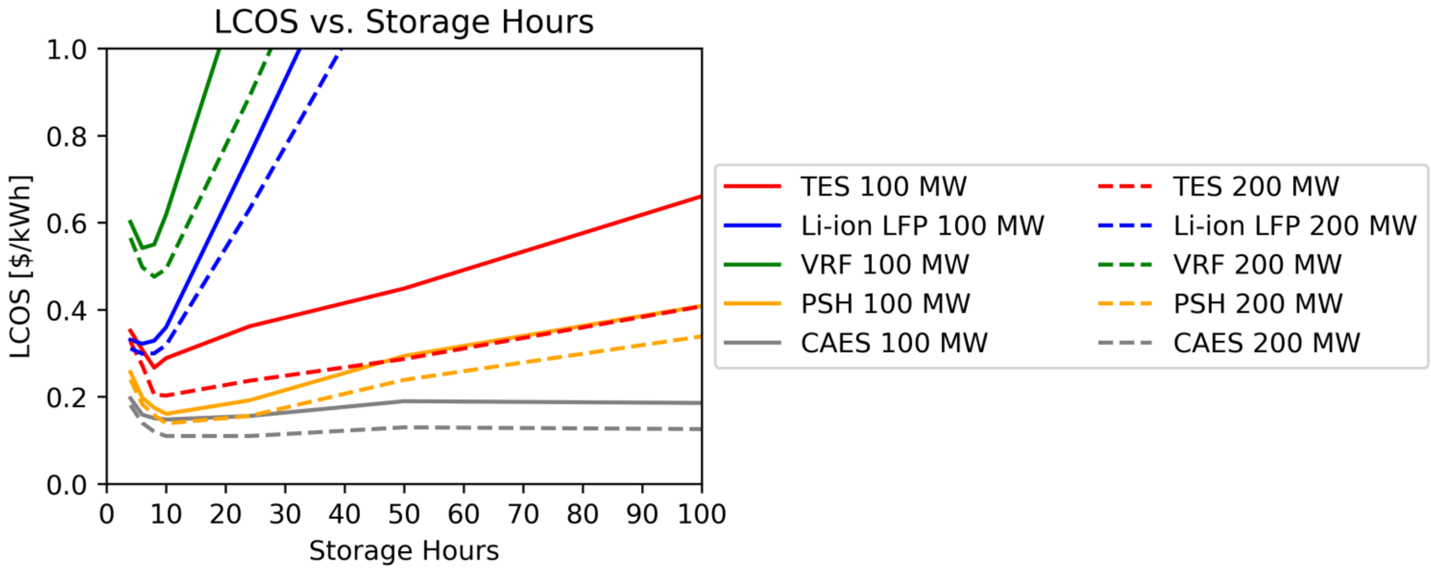
Summary

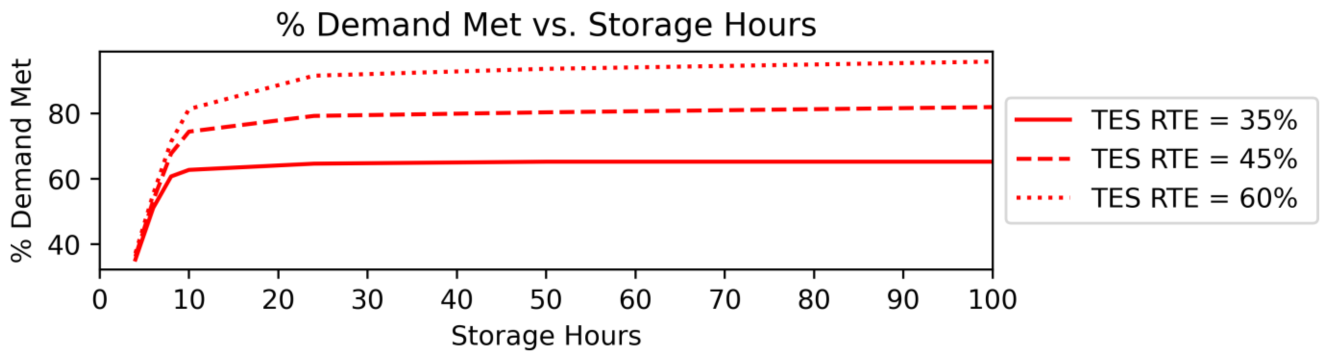
ESS selection is scenario specific

Key ESS selection considerations:

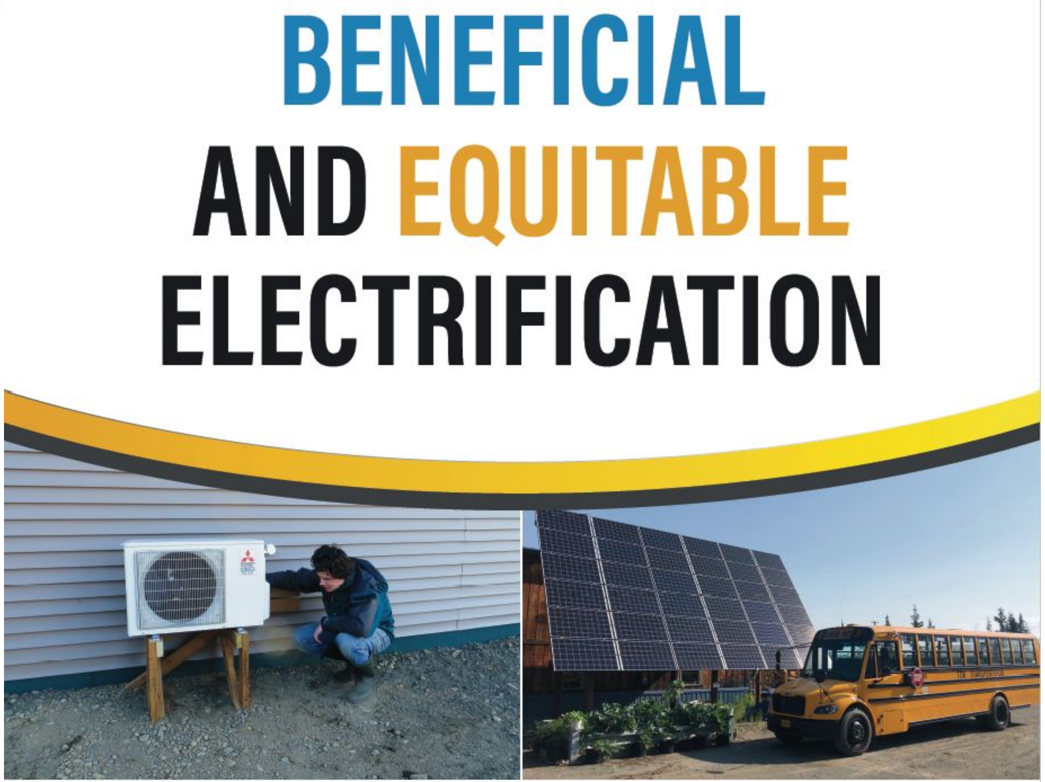
- Power purchase agreement
- Grid demand
- Available energy for charging
- System RTE
- % demand met requirement
- LCOS requirement/ROI requirement







Questions?



Office of Naval Research Science & Technology

ACEP Alaska Center for Energy and Power

acep.uaf.edu

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The ARCTIC program is an initiative supported by the Office of Naval Research (ONR) Award # N00014-18-S-B001.

UAF UNIVERSITY OF ALASKA FAIRBANKS

Harnessing local, sustainable, and cost-effective energy resources to electrify energy loads such as transportation and heating.

Behavioral and Socio-Economic Adoption Factors

Microgrids and Cold Regions

Outreach and Engagement

Costs and Performance

projects and reports at:
https://acep.uaf.edu/projects-(collection)/bee.aspx

ACEP
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The ARCTIC program is an initiative supported by the Office of Naval Research (ONR) Award # N00014-18-S-B001.

UNIVERSITY OF ALASKA FAIRBANKS

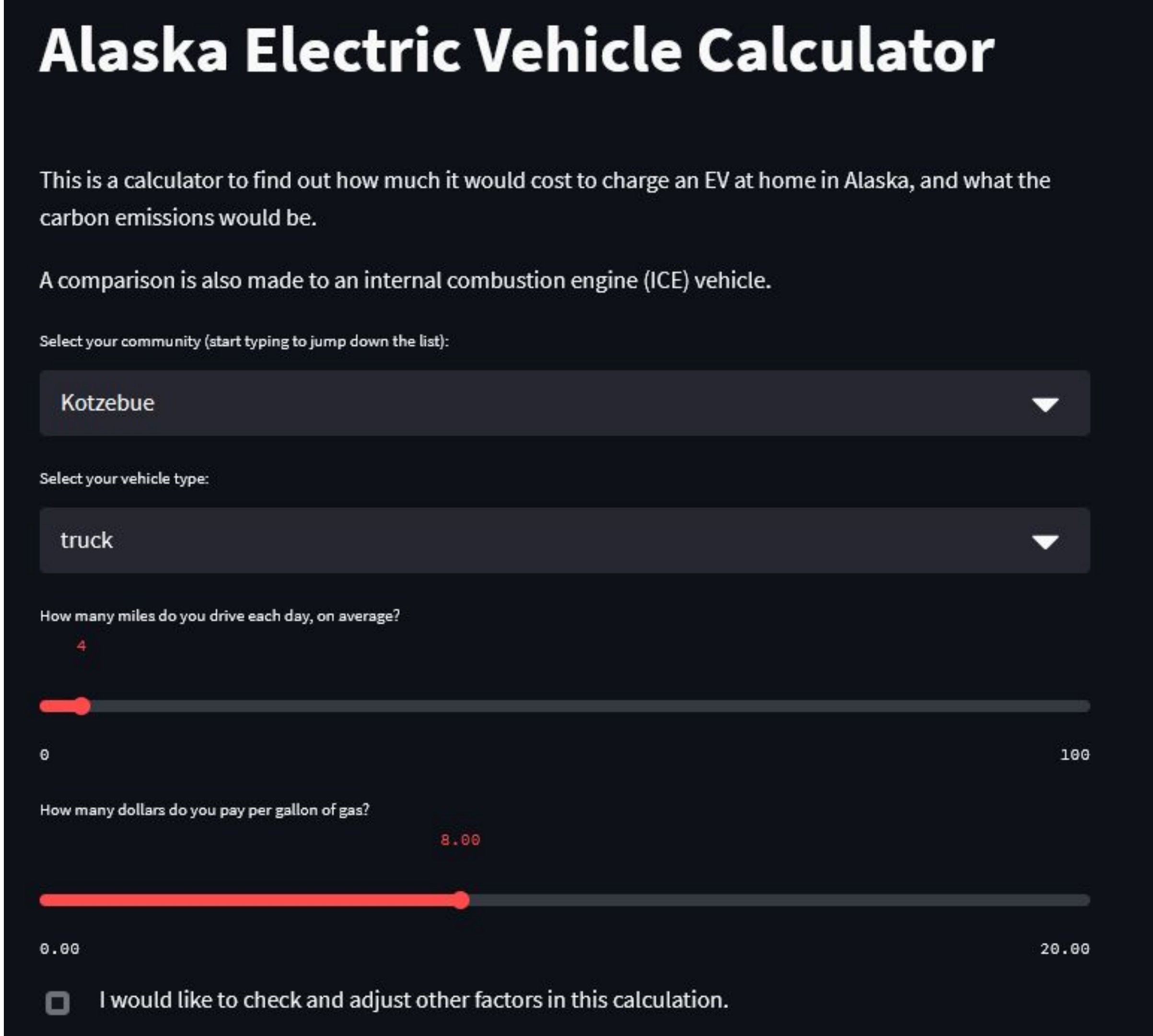
Tinyurl.com/AKEVCalc

User Input

- Community
- Vehicle type
- Daily mileage
- Price of gas

Advanced:

- Utility info (rate/emissions)
- Vehicle efficiency
- Home solar
- Block heater use and idling for gas vehicle
- Garage/temperature
- Weekend mileage



Output

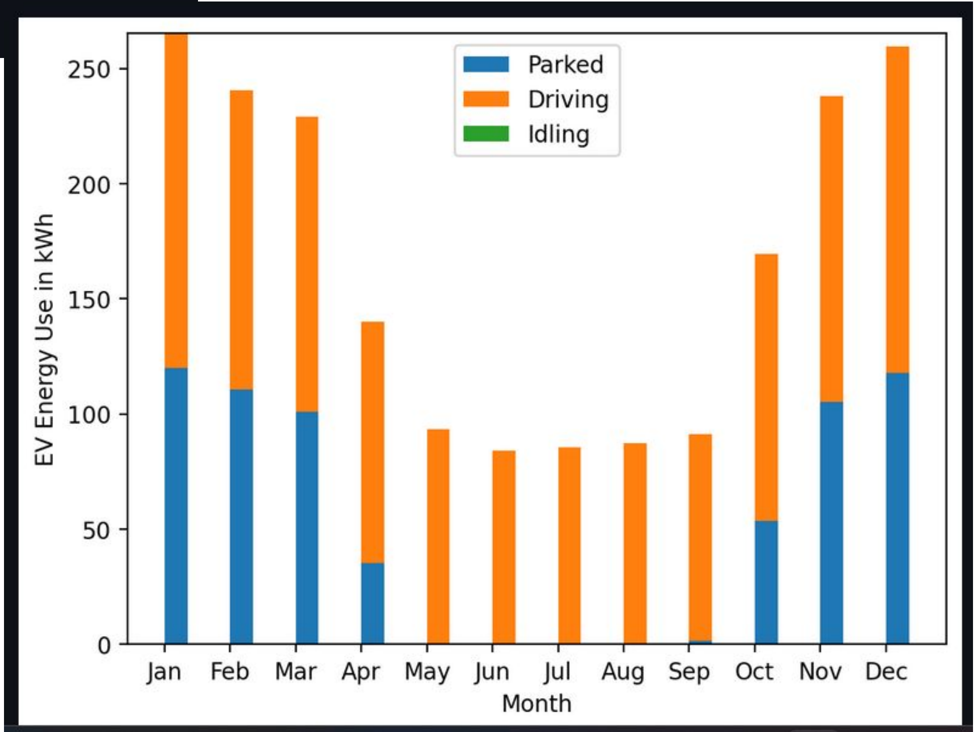
Total cost of Electric Vehicle fuel per year = $ `397.0`

Total cost of Internal Combustion Engine (gas) fuel per year = $ `646.0`

Total kg CO2 emissions of Electric Vehicle per year = `683.0`

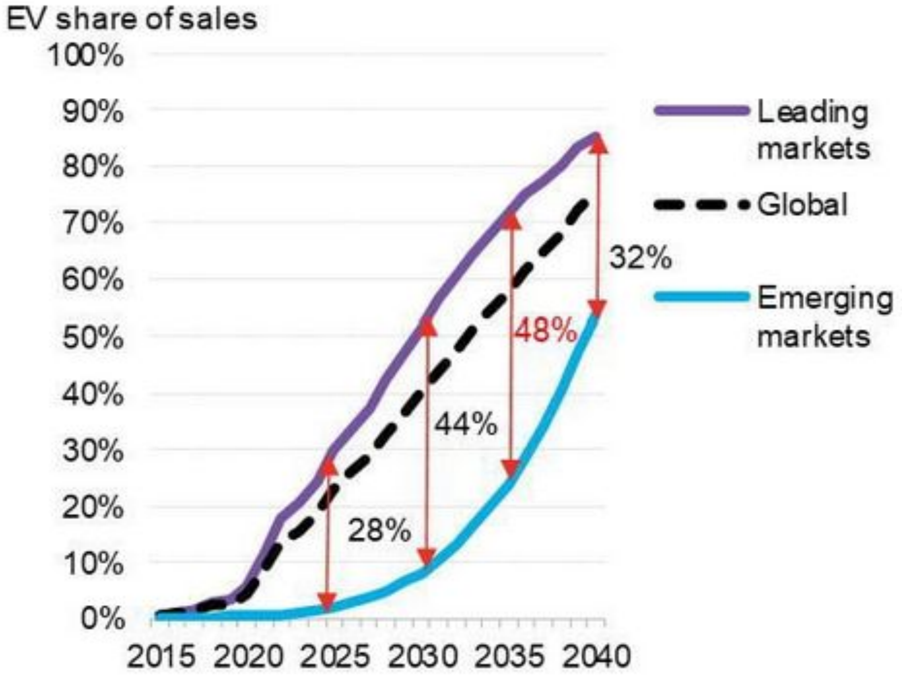
Total kg CO2 emissions of Internal Combustion Engine per year = `1428.0`

- Cost comparison
- Climate emissions comparison
- Monthly electricity use for EV

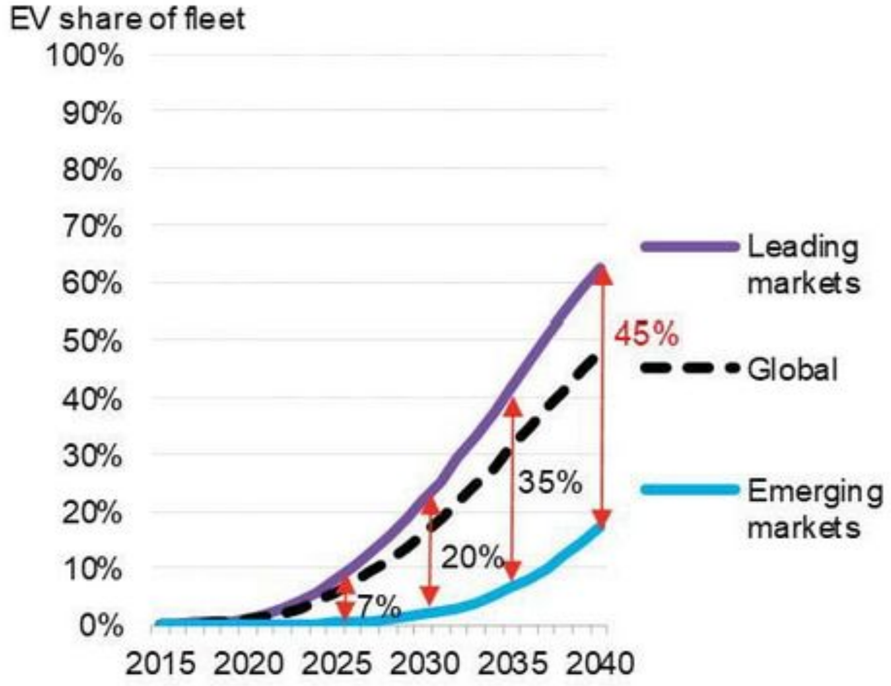


Opportunity?

Passenger EV share of sales – Economic Transition Scenario



Passenger EV share of fleet – Economic Transition Scenario

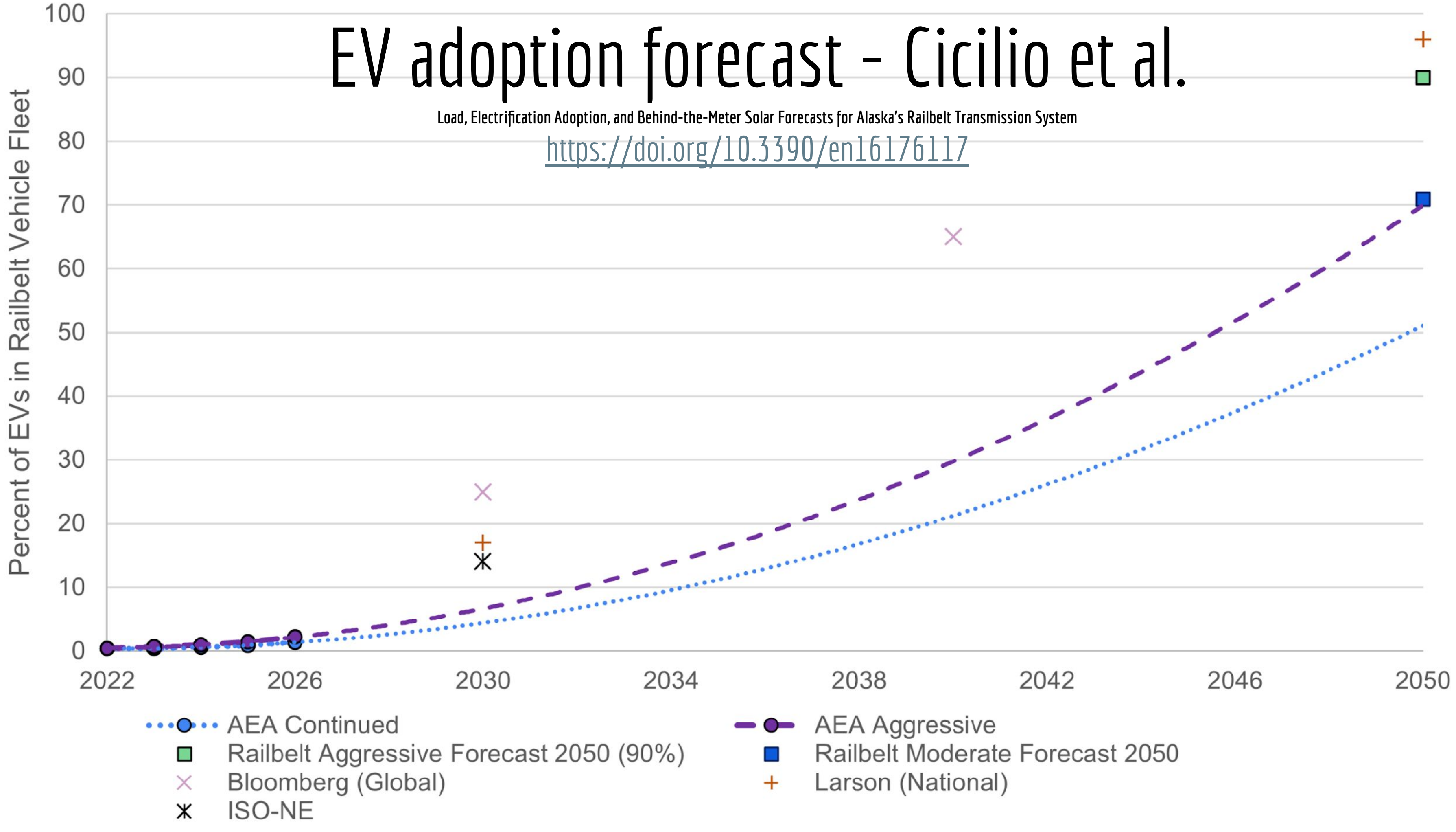


Source: BNEF. Note: EV includes battery electric, plug–in hybrid and fuel cell vehicles.

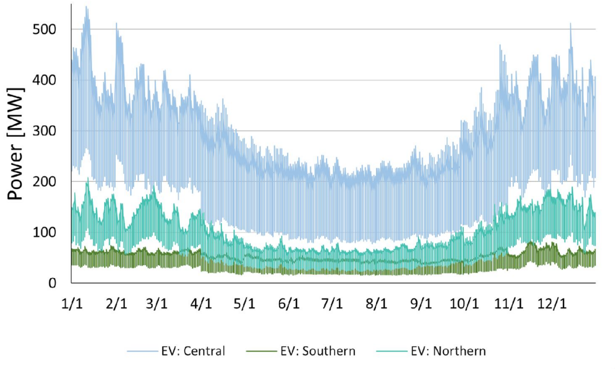
EV adoption forecast - Cicilio et al.

Load, Electrification Adoption, and Behind-the-Meter Solar Forecasts for Alaska's Railbelt Transmission System

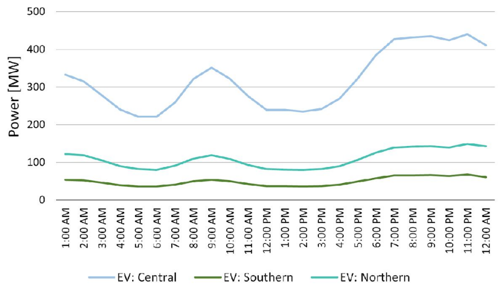
https://doi.org/10.3390/en16176117



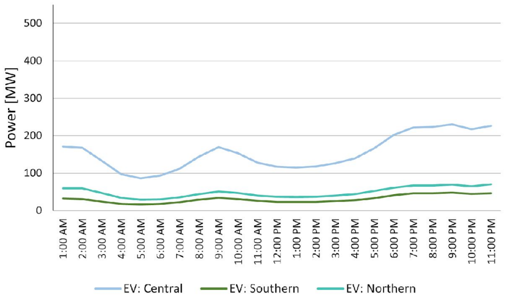
2050 EV load forecast - Cicilio et al.



(**a**) Year 2050.

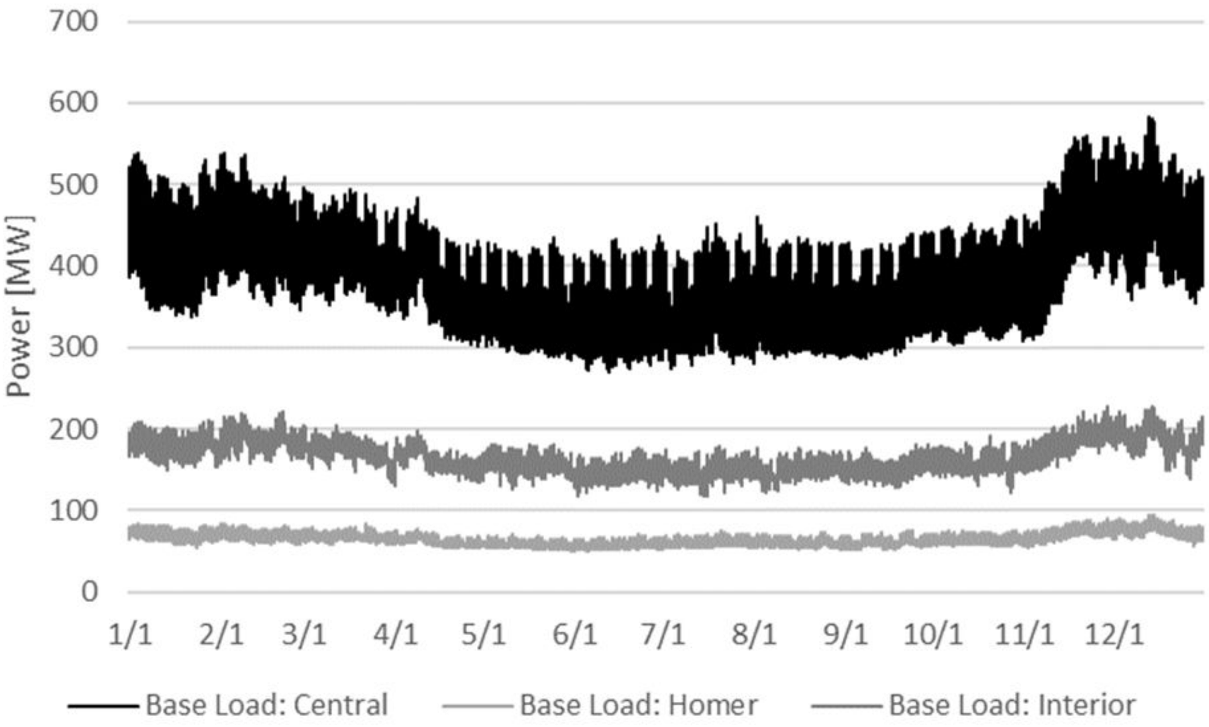


(**b**) 1 January 2050.



(**c**) 1 June 2050.

2050 Baseline Load Forecast - Cicilio et al.

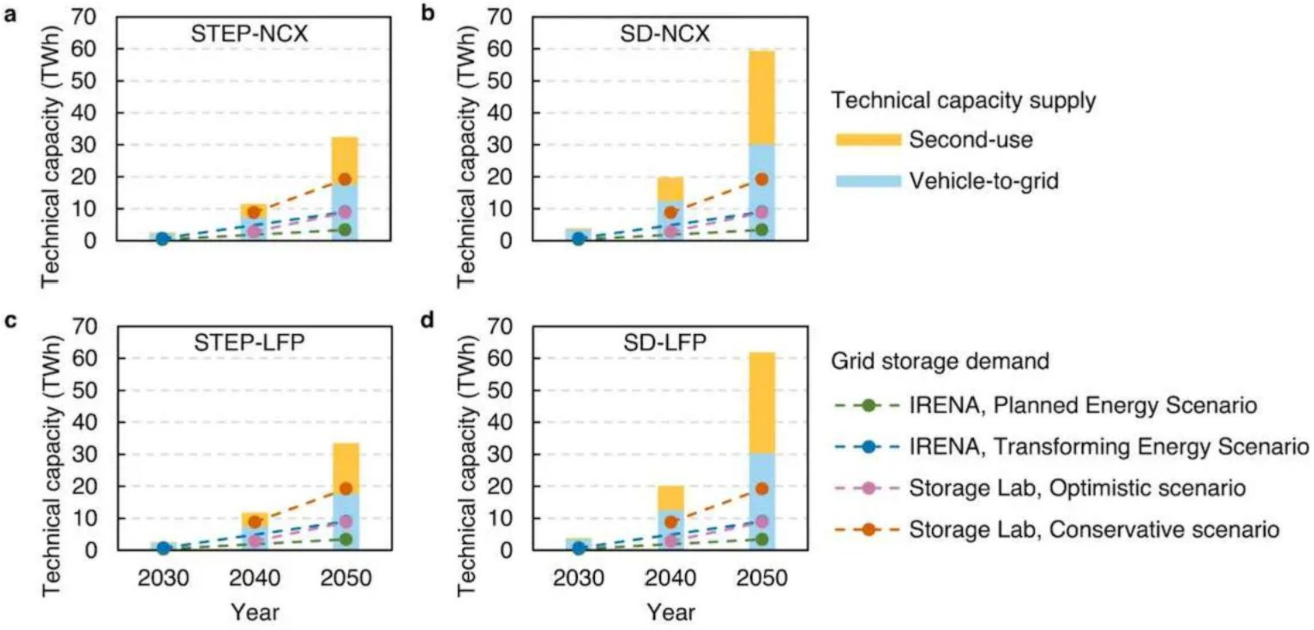


EVs could satisfy global short-term grid storage by 2030

Xu et al – Nature Communications 1/17/23

Fig. 2: Total technical capacity for EV batteries and comparison to grid storage demand.

From: Electric vehicle batteries alone could satisfy short-term grid storage demand by as early as 2030

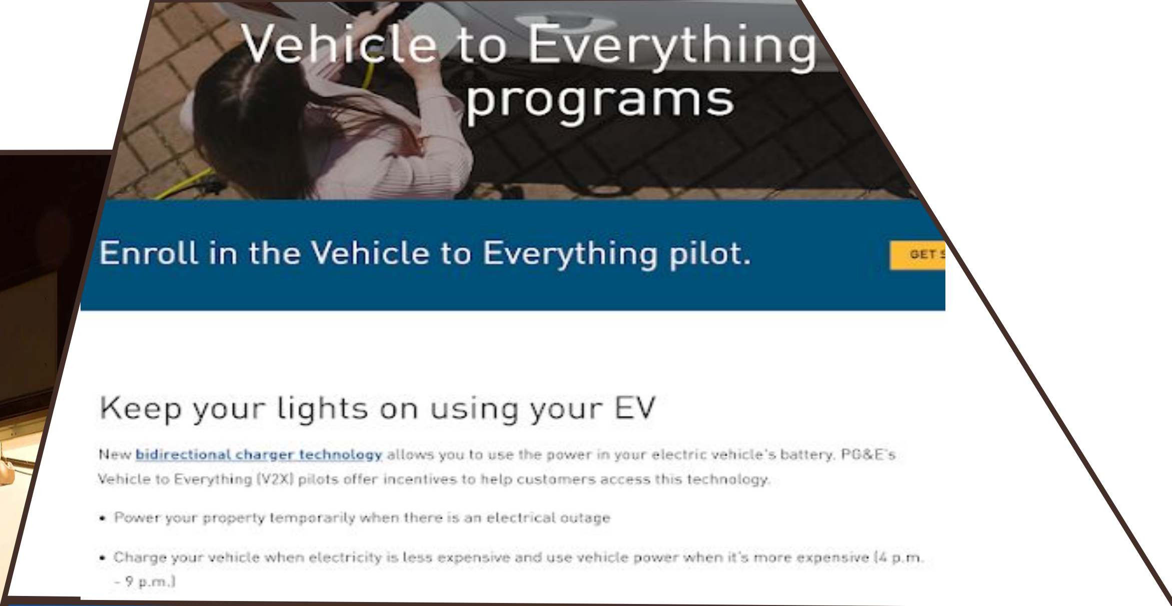


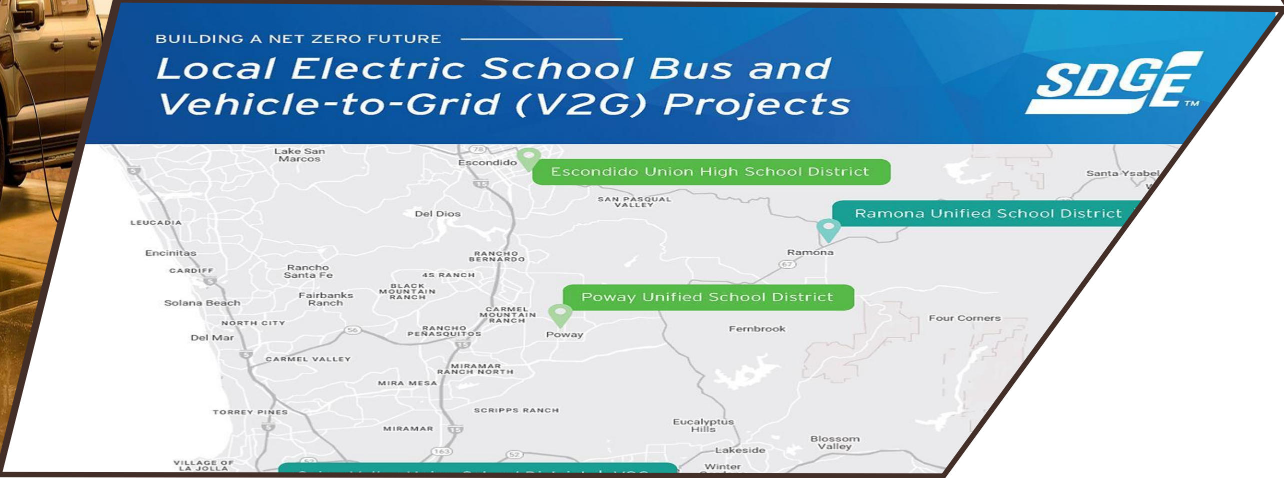
a STEP-NCX scenario. **b** SD-NCX scenario. **c** STEP-LFP scenario. **d** SD-LFP scenario (see details in Supplementary Table 1). IRENA = International Renewable Energy Agency.

CEC EV Use Case
Grid BESS vs. EVs

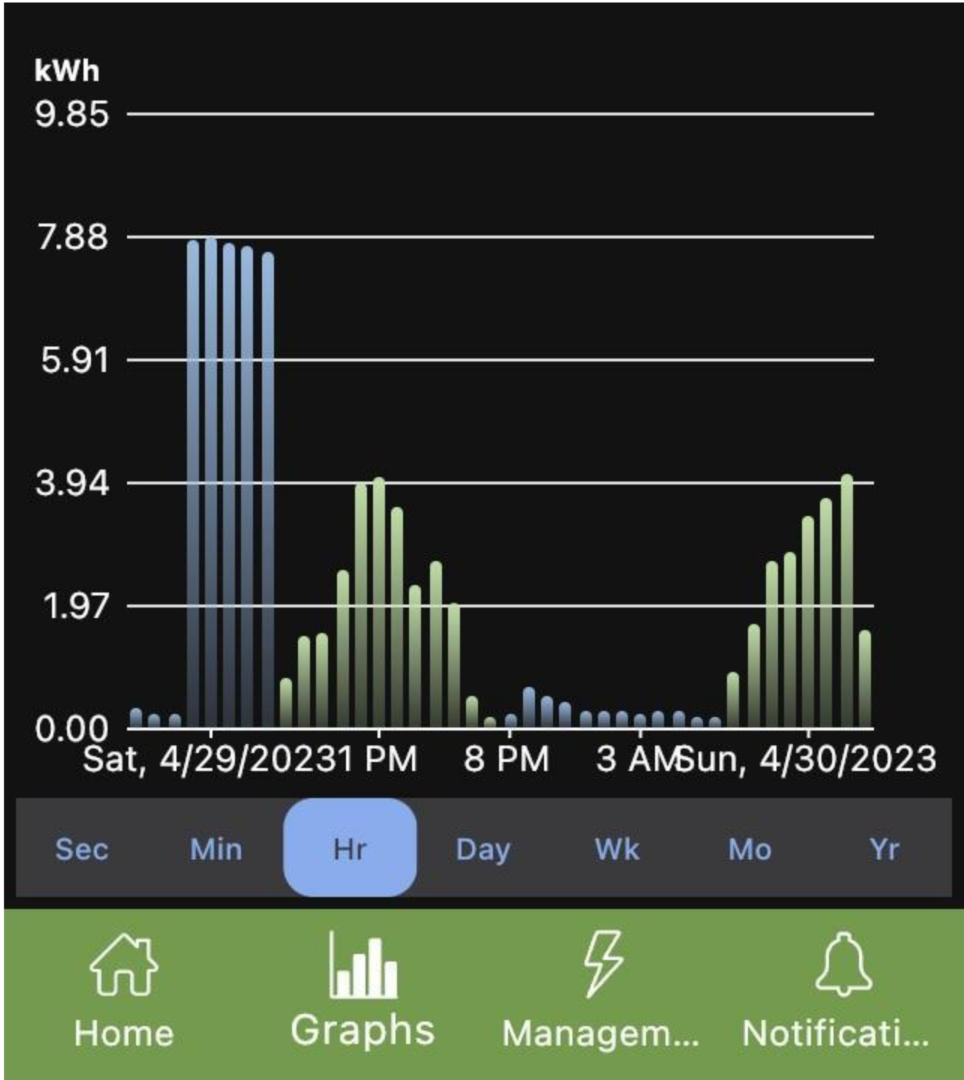
- CEC BESS COST: $2,000,000
- 1MW, 1 MWh Storage
- Equivalent 52 ‘20 Nissan Leaf Cost
- 52 Nissan Leafs = 3.2 MWh Storage
- Can Balance CEC Grid with 16 Leafs
- Can Balance localized microgrids
- Substantial Customer Benefits:
    - Free Car
    - Free Electricity
    - Energy Security
    - Reduces other’s electric bills
    - Portability (take your microgrid anywhere)

The path to get there:





even managed charging could produce a lot of the benefits of storage…



GREEN MOUNTAIN POWER

GMP & You ▾ My Account ▾ Ou

NEW! EV Charging Rates

Charge up and save with a rate just for EV drivers! Call us to sign up and start charging for less.

Rate 72

GMP partners with you and manages the charging for you during peaks. We alert you to energy peaks (about 5-7 per month, they last a few hours and usually start around 5pm or 6pm). By not charging during peaks, you will save money. You can opt out, and still charge during a peak, and you will pay more. Off peak charging is $0.14274/kWh, which on average is like paying $1.03 per gallon. If you charge during a peak, it is $0.73388/kWh.

Twitter: The US Census musing on the load-balancing benefits of timed EV charging - in 1912.

station circuits. It is only natural, therefore, that throughout the country an effort has been made to develop this new class of business and build up the vehicle "load." The opportunity thus offered is enormous. At the meeting of the Illinois Electrical Association in 1912 it was stated by Mr. George Jones that if half the horses in use in Chicago were replaced by electric vehicles, the central station load created would amount to 94,000,000 kilowatt hours per annum As such vehicles are usually charged late at night, when the ordinary demand for current is small, no additional investment in central station apparatus would be necessary, and this "off peak" business would improve the general load factor about 13 per cent.

National Museum of American History


https://dssg2023heatpump.shinyapps.io/VisApp/
Heat Pumps in
UNIVERSITY of WASHINGTON
eScience Institute
DATA SCIENCE FOR SOCIAL GOOD
GitHub
Motivation
Statewide Adoption
Borough Potential
Frequently Asked Questions
An Interactive Visualization Tool to Explore Heat Pump Adoption in Alaska
Why Study Heat Pumps?
Navigating the Dashboard

Projected Heat Pump Adoption Rates

Toggle between current heat pump estimates, moderate projections (5% of households), and aggressive projections (15% of households)

Current | 5% | 15%

Show absolute or relative numbers?

Absolute | Relative

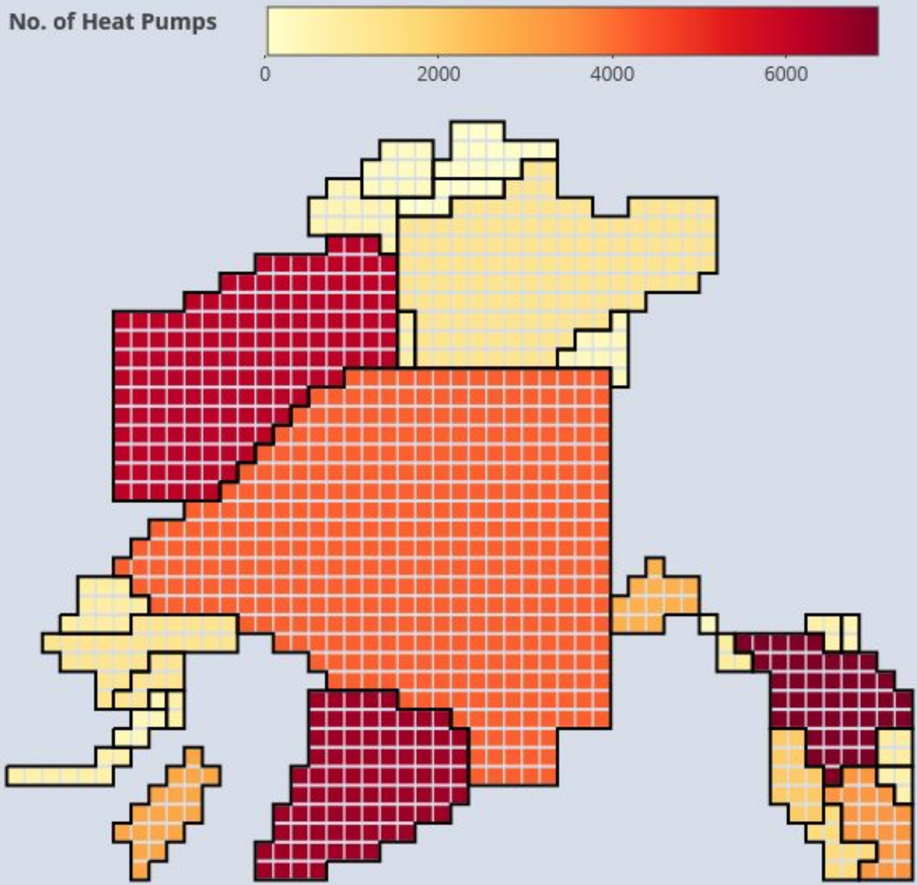
97.1 %

of Heat Days Covered

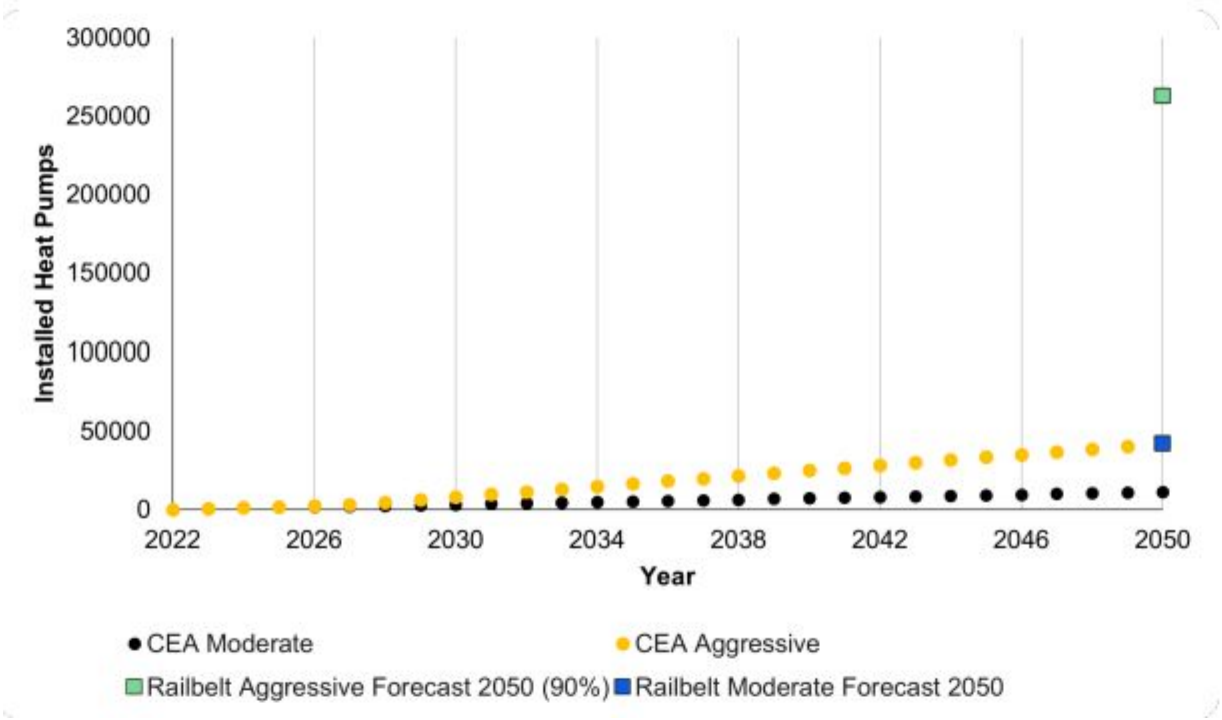
169.8

Millions of $ Saved

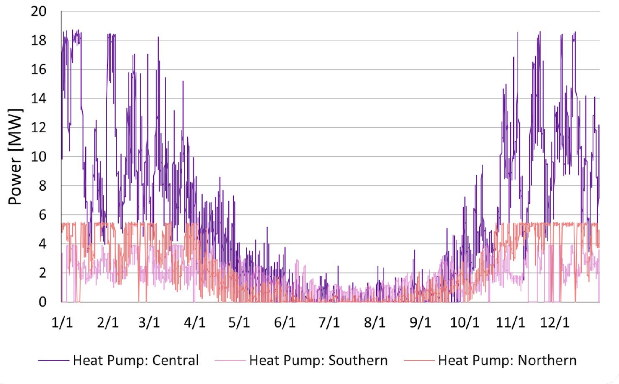
Number of Heat Pumps Installed by Borough



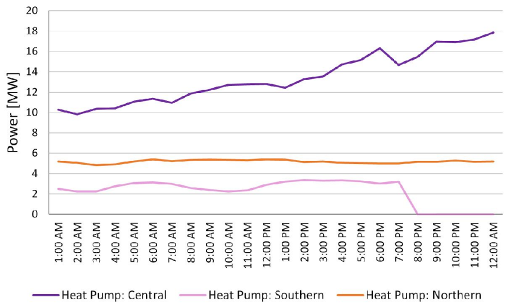
Heat pump adoption forecast - Cicilio et al.



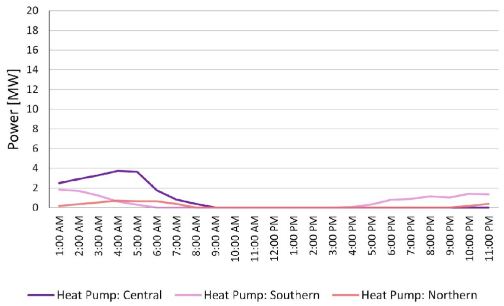
2050 Heat pump load forecast - Cicilio et al.



(**a**) Year 2050.

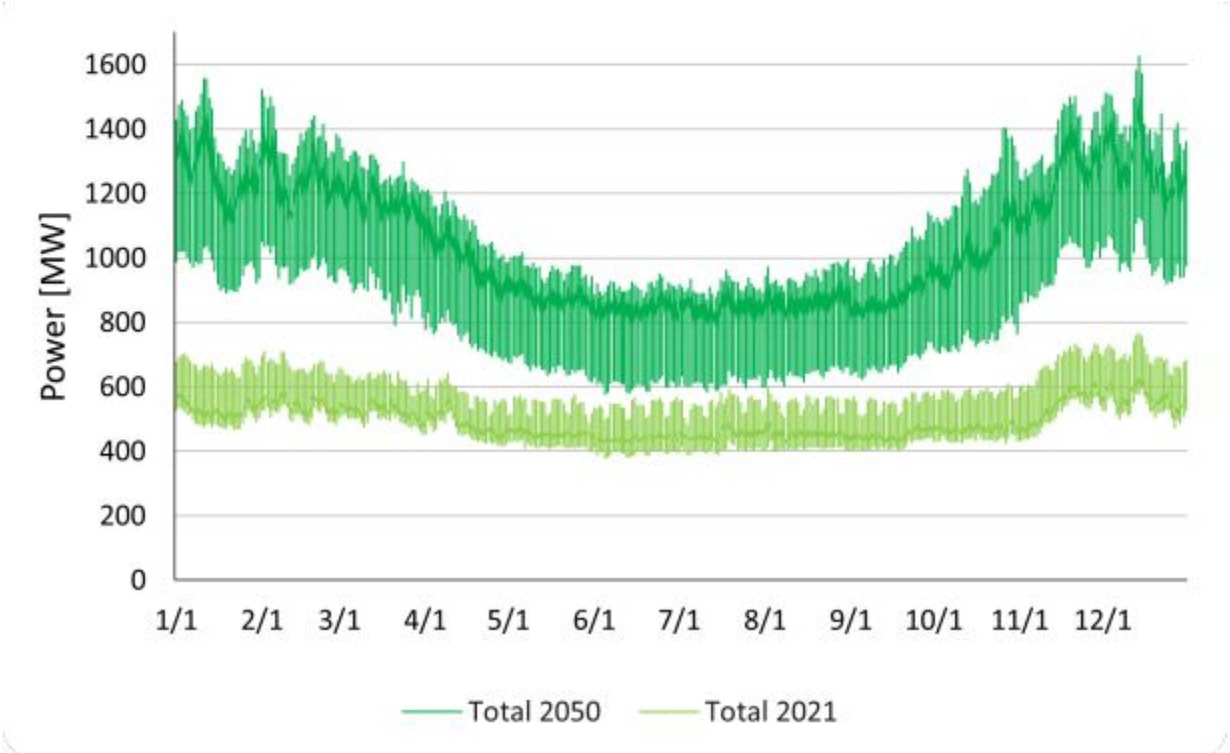


(**b**) 1 January 2050.

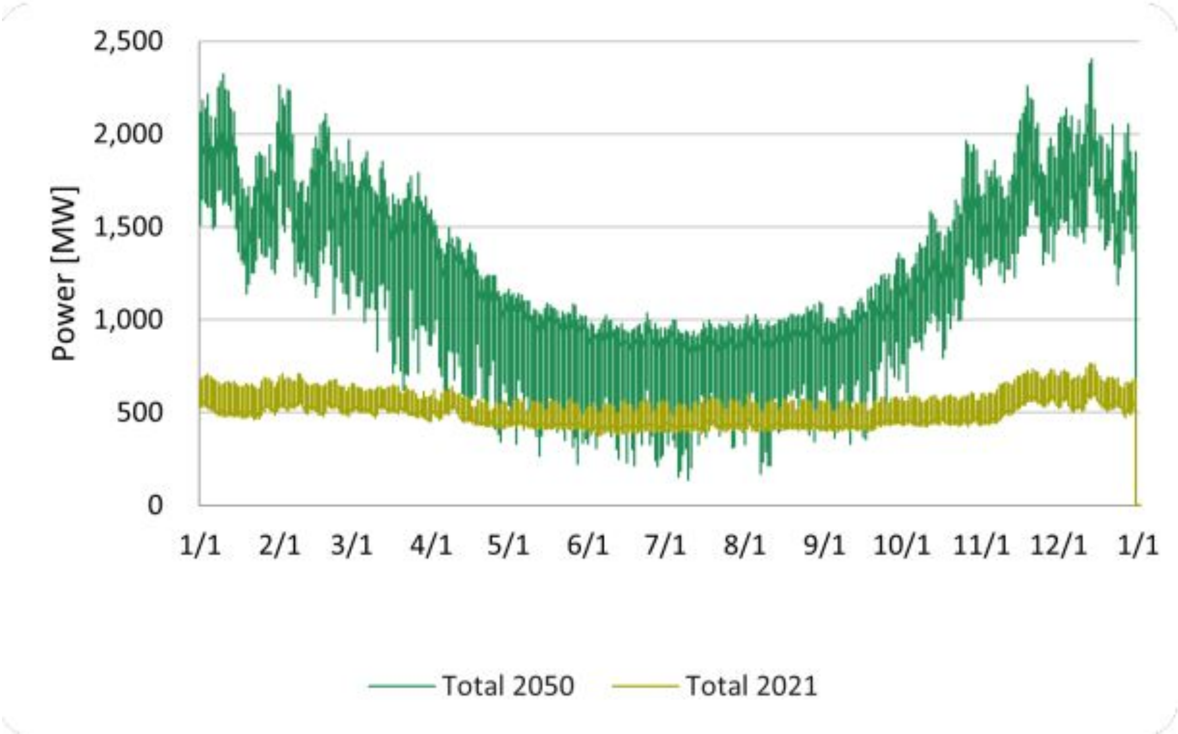


(**c**) 1 June 2050.

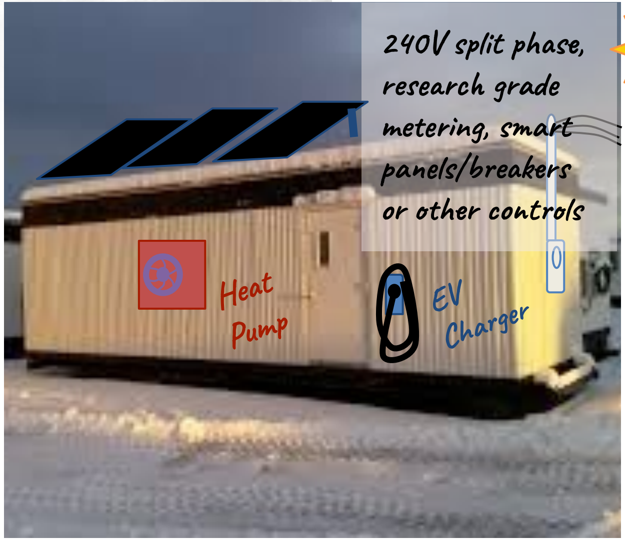
2050 load forecast (moderate) - Cicilio et al.

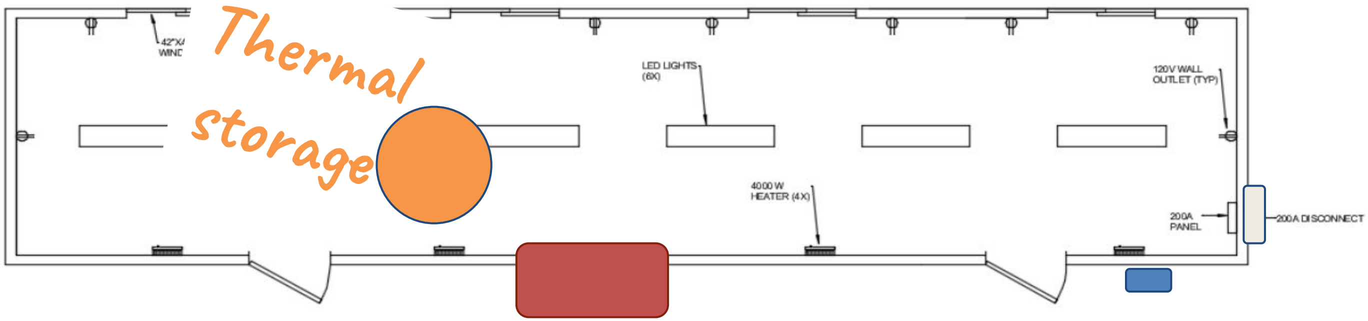


2050 load forecast (High adoption) - Cicilio et al.



Beneficial and Equitable Electrification Home InnoVation Experiment (BEEHIVE)





Questions?

Michelle Wilber

mmwilber@alaska.edu

Tidal Power in Alaska

Ben Loeffler, Alaska Center for Energy and Power at UAF
bhloeffler@alaska.edu

PMEC Pacific Marine Energy Center

University of Alaska Fairbanks

Oregon State University

University of Washington

Outline

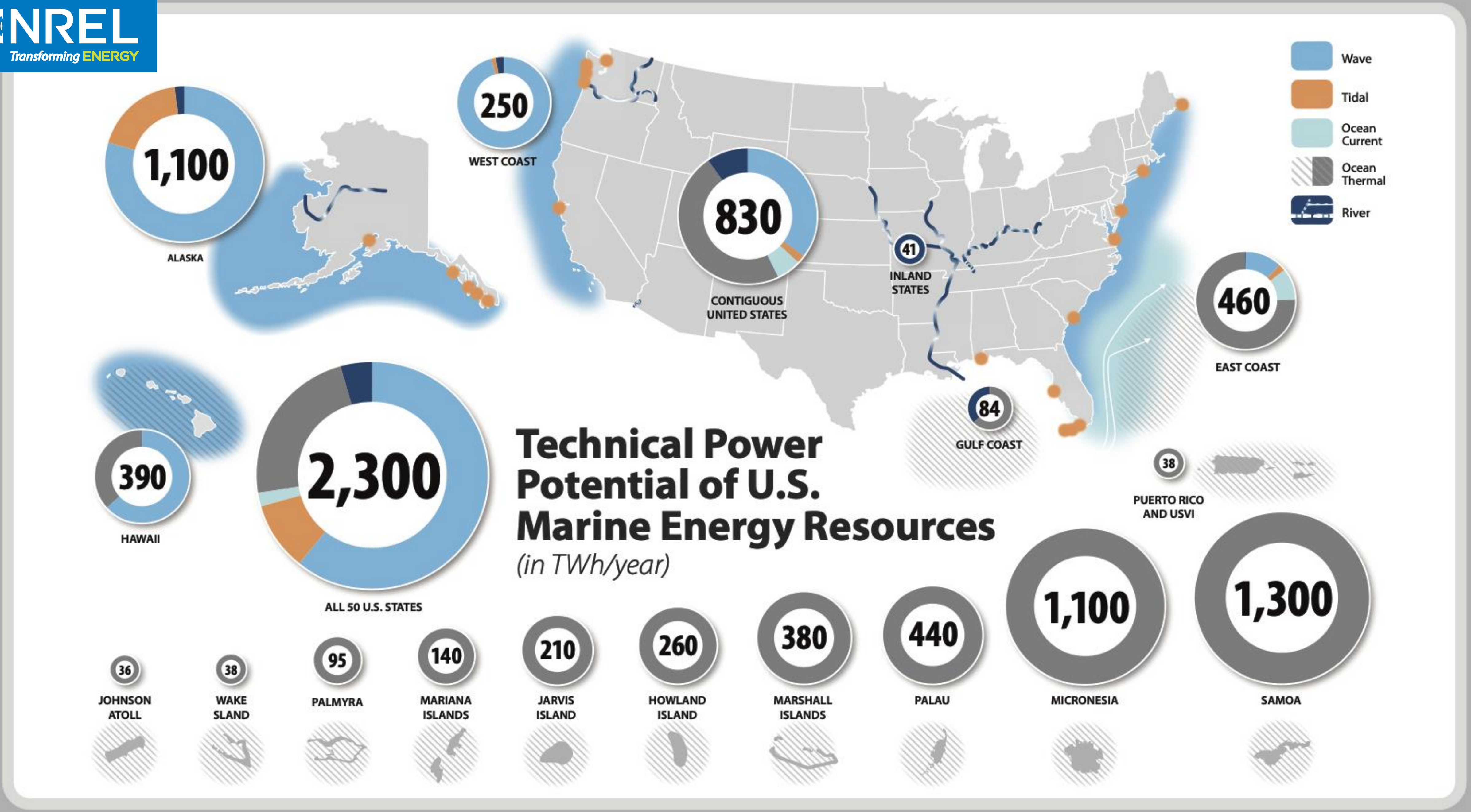
- Alaska Marine Energy Overview
- Cook Inlet Tidal Focus
- Tidal technology overview
- NREL and PNNL Work
- ACEP/UAF Work (PMEC)
- Cook Inlet Tidal Energy Working Group
- Activities/opportunities

Tidal Space – DOE Research Efforts Intro

Levi Kilcher

Zhaoqing Yang

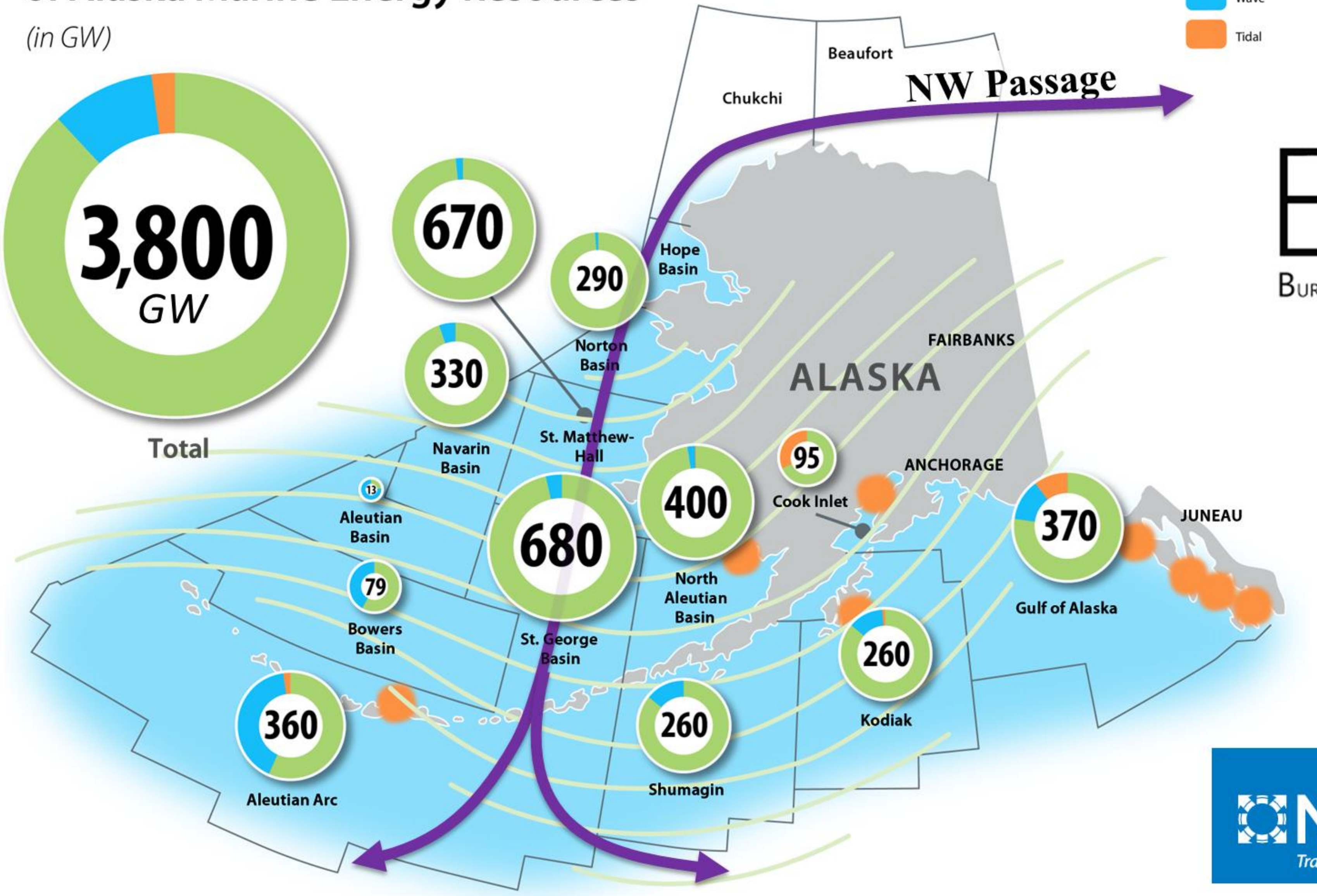
Ben Loeffler



Kilcher, Fogarty, Lawson. 2021. *Marine Energy in the United States: An Overview of Opportunities*. NREL/TP-5700/78773.

Technical Power Potential of Alaska Marine Energy Resources

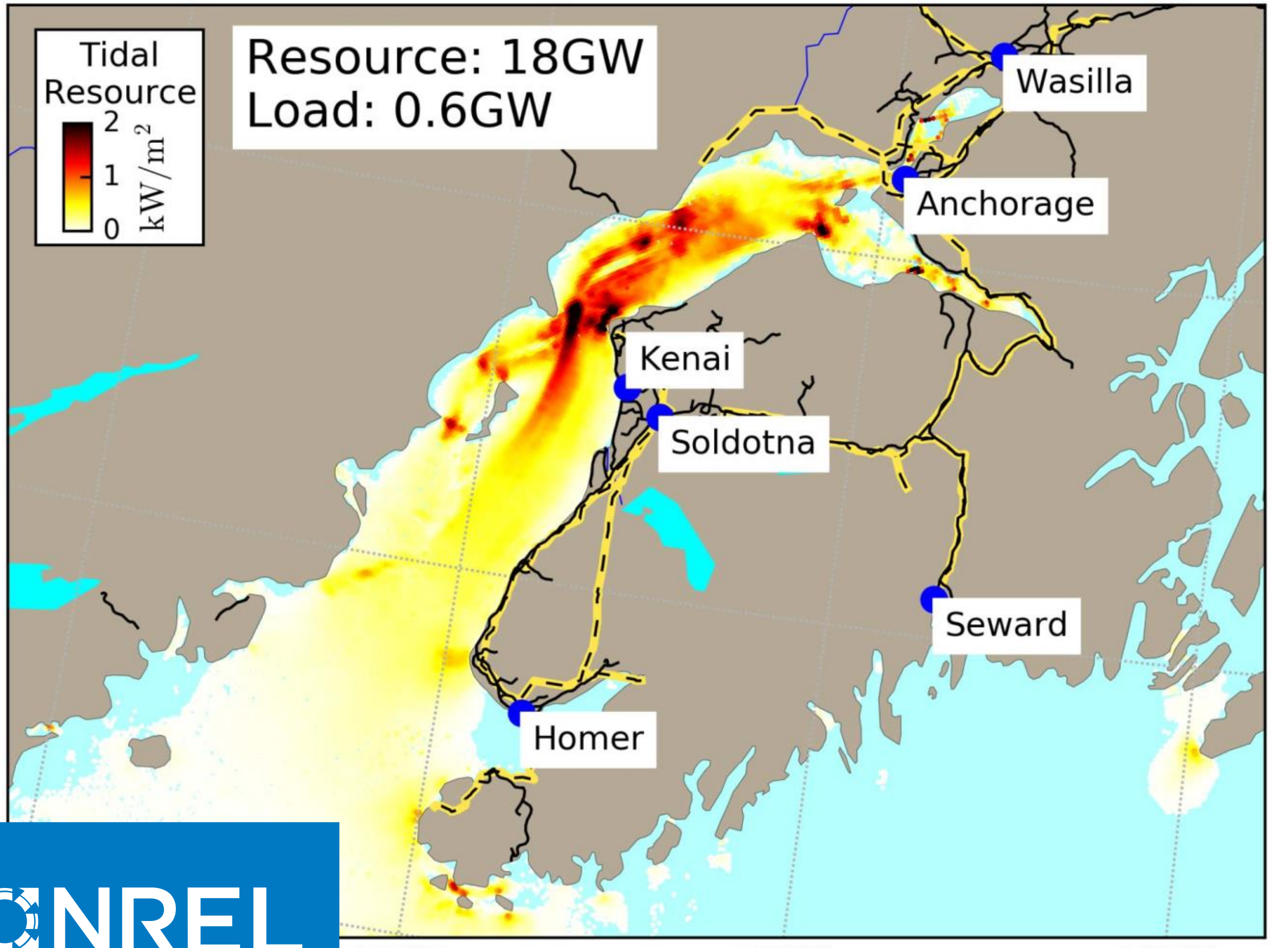
(in GW)



BOEM Bureau of Ocean Energy Management

NREL Transforming ENERGY

Cook Inlet Tidal Energy

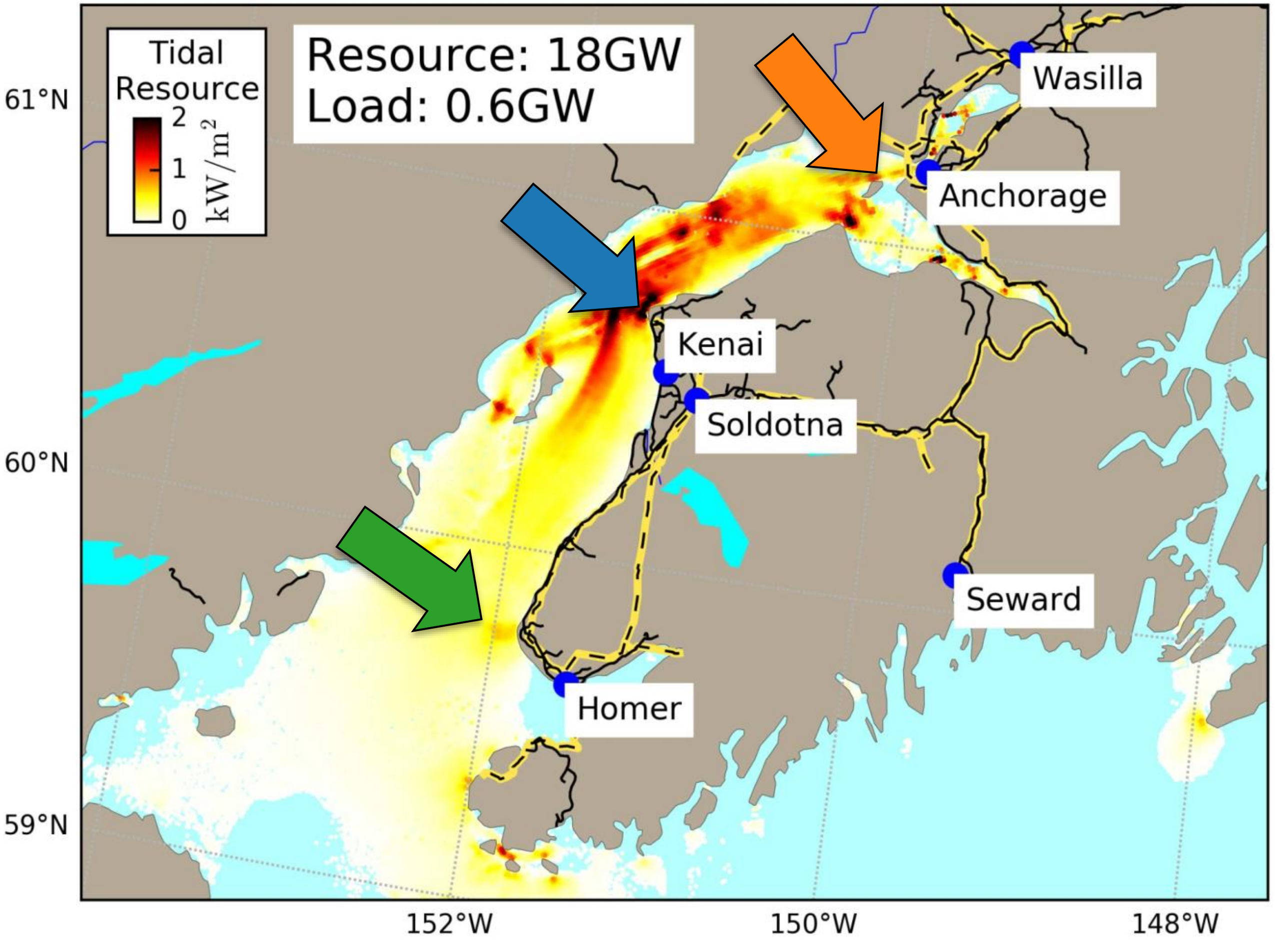


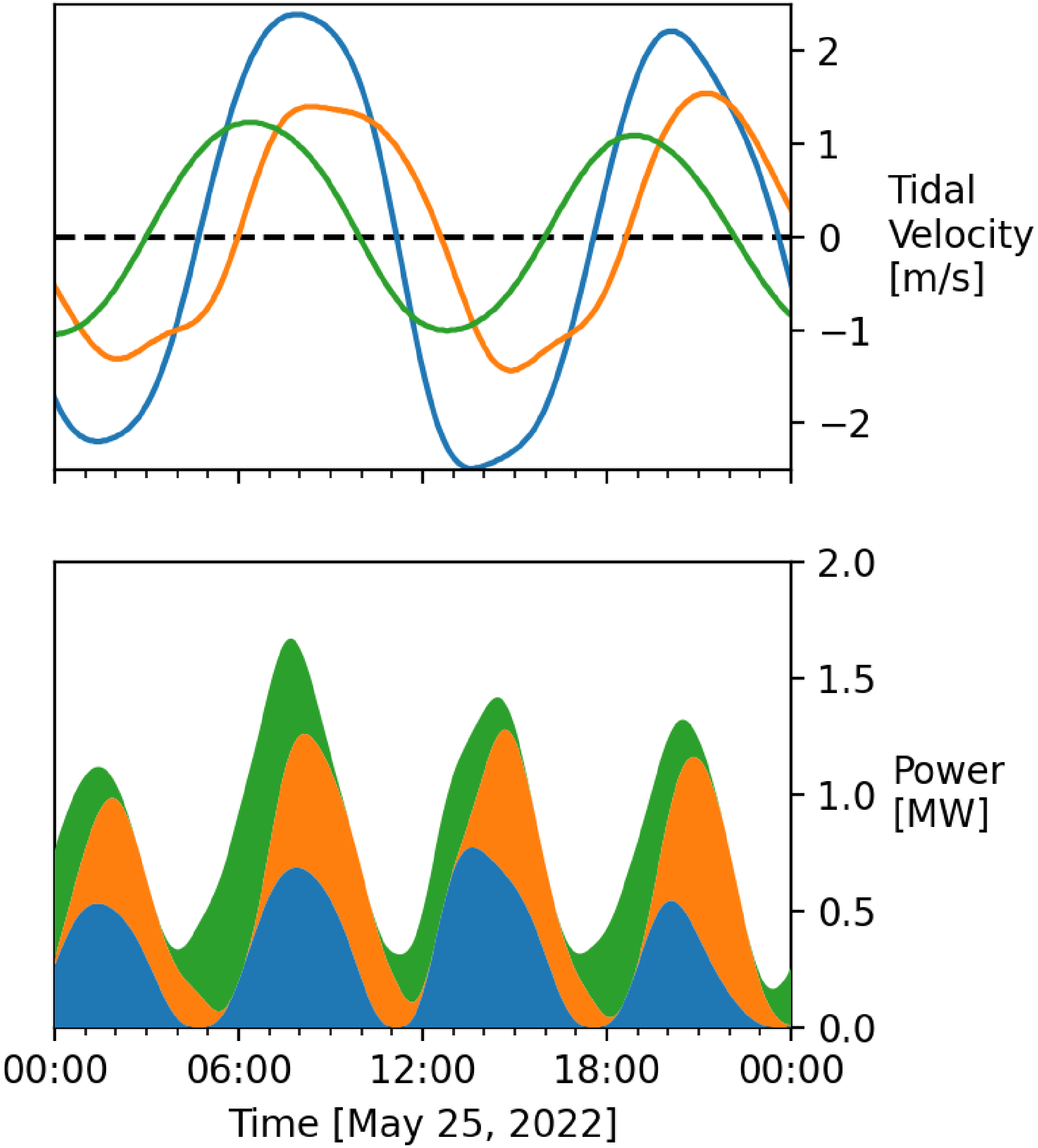
- 18 GW Resource: ~30x Railbelt load
- Infrastructure – platforms, shoreside
- 'Blue Economy' expected to double to $3T by 2030
- What will Alaska's role be?

Photo by Bureau of Safety and Environmental Enforcement

NREL Transforming ENERGY

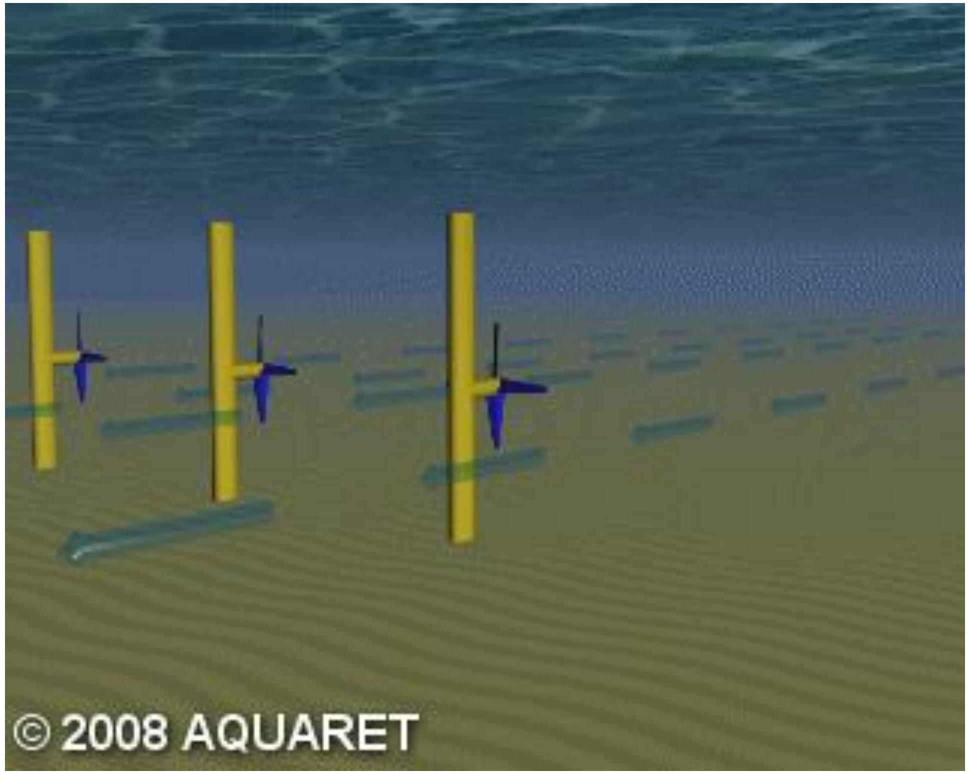
Tidal Energy is Predictable

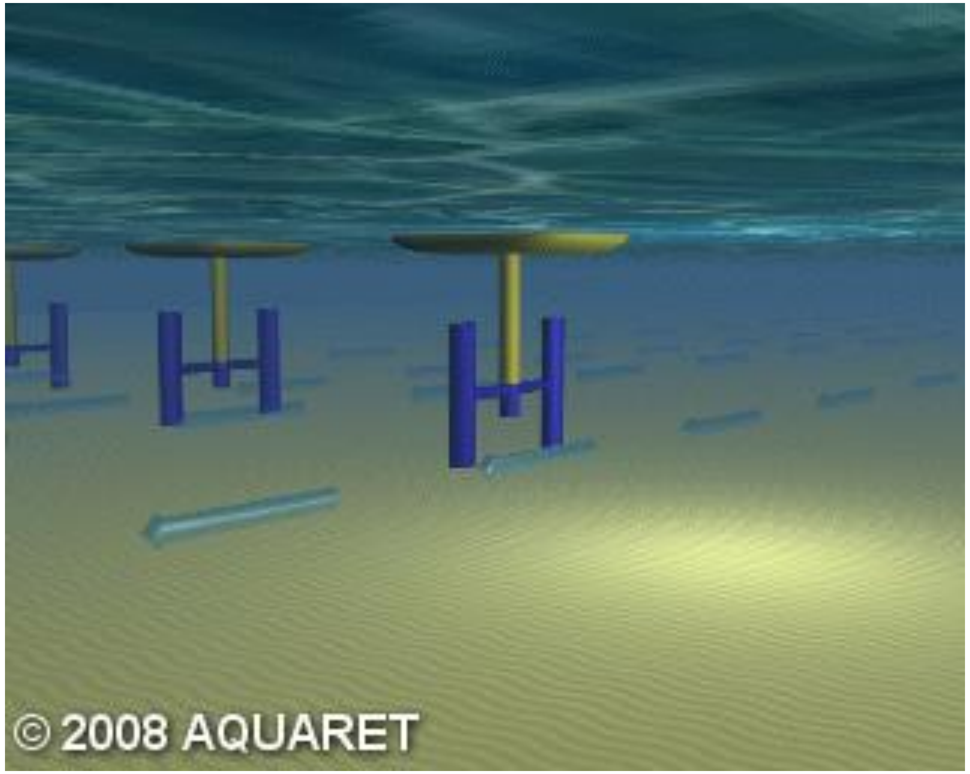




NREL Transforming ENERGY
Homer Electric Association, Inc.
A Touchstone Energy® Cooperative

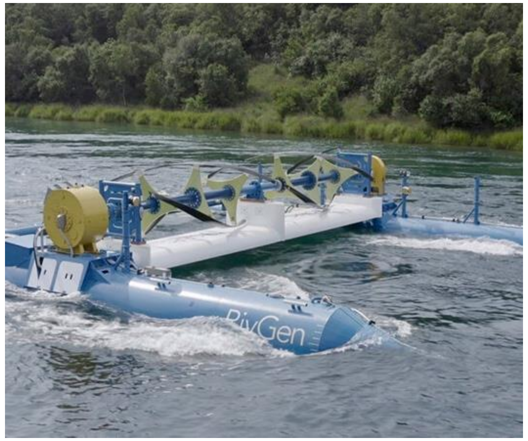
Current Energy Converter Types (Tidal or Riverine)

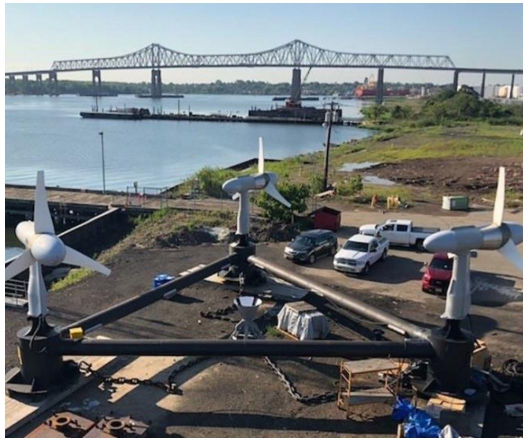




Tidal Energy Technology

- Utility MW-scale technology convergence on axial flow
- MW-scale demonstration projects in EU: e.g. Meygen - Scotland, 8 MW in 2017
- Many kW-scale demonstration projects in the US and around the world
- **<u>Commercial pilot projects needed to prove viability of technologies</u>**







National Labs and Universities

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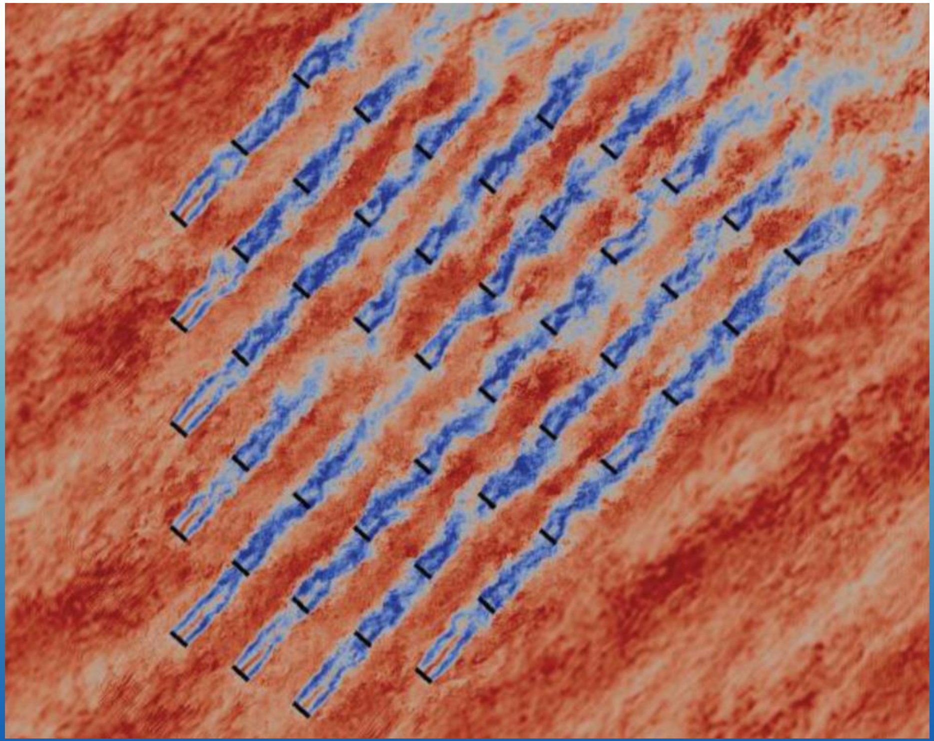
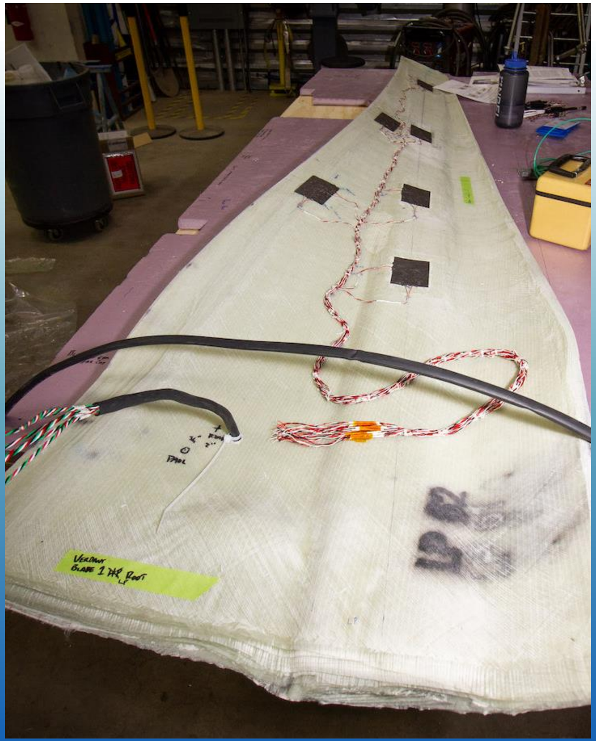
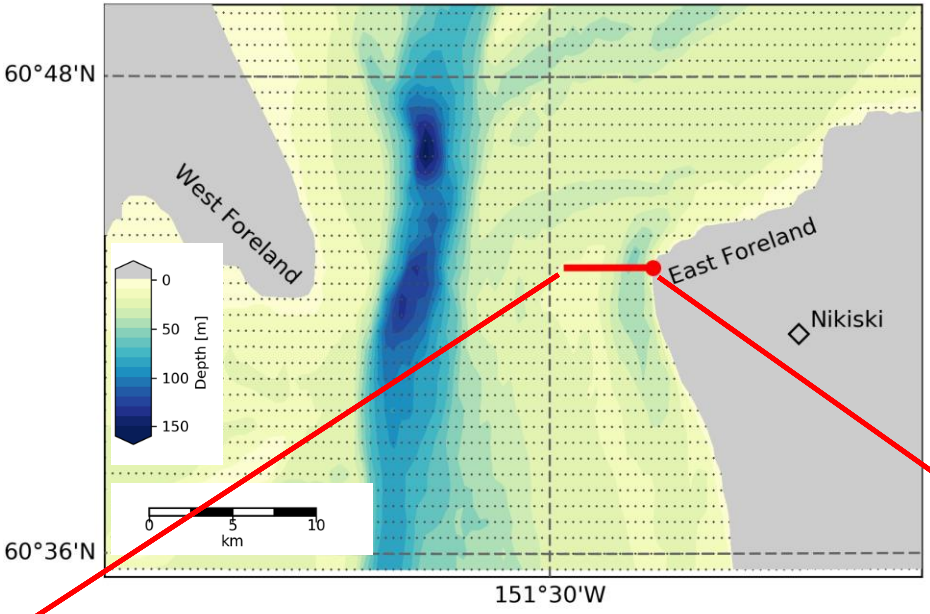
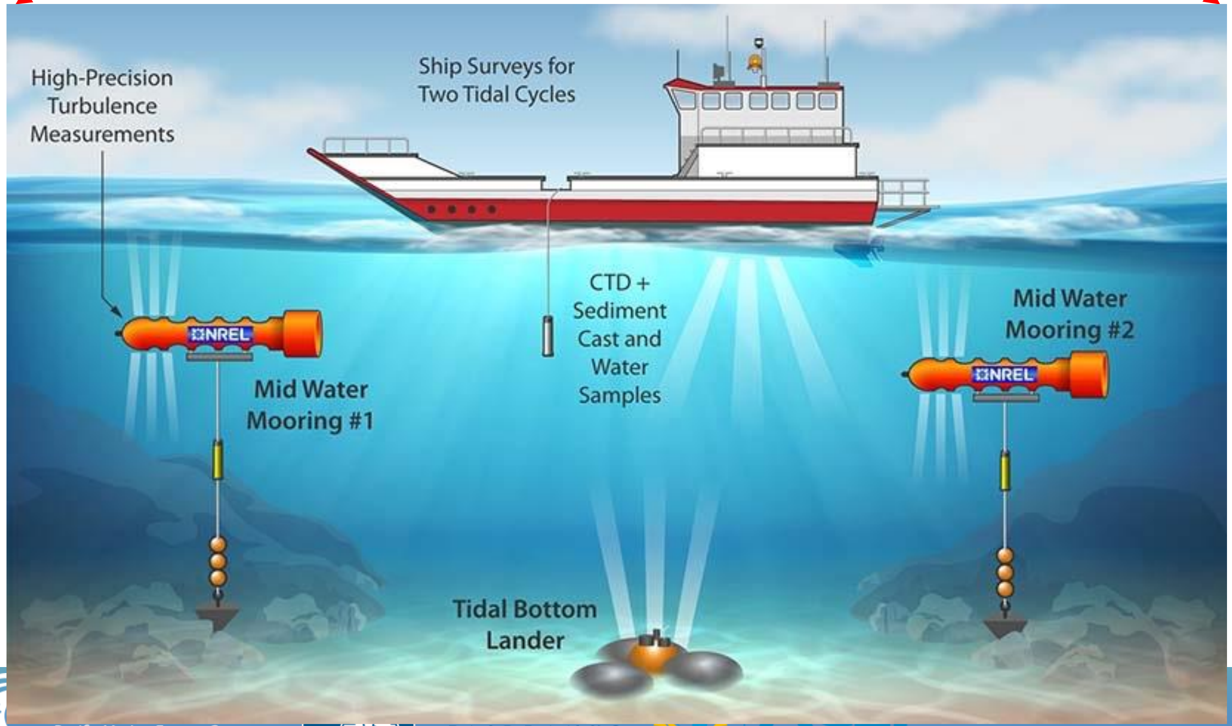




NREL
Transforming ENERGY





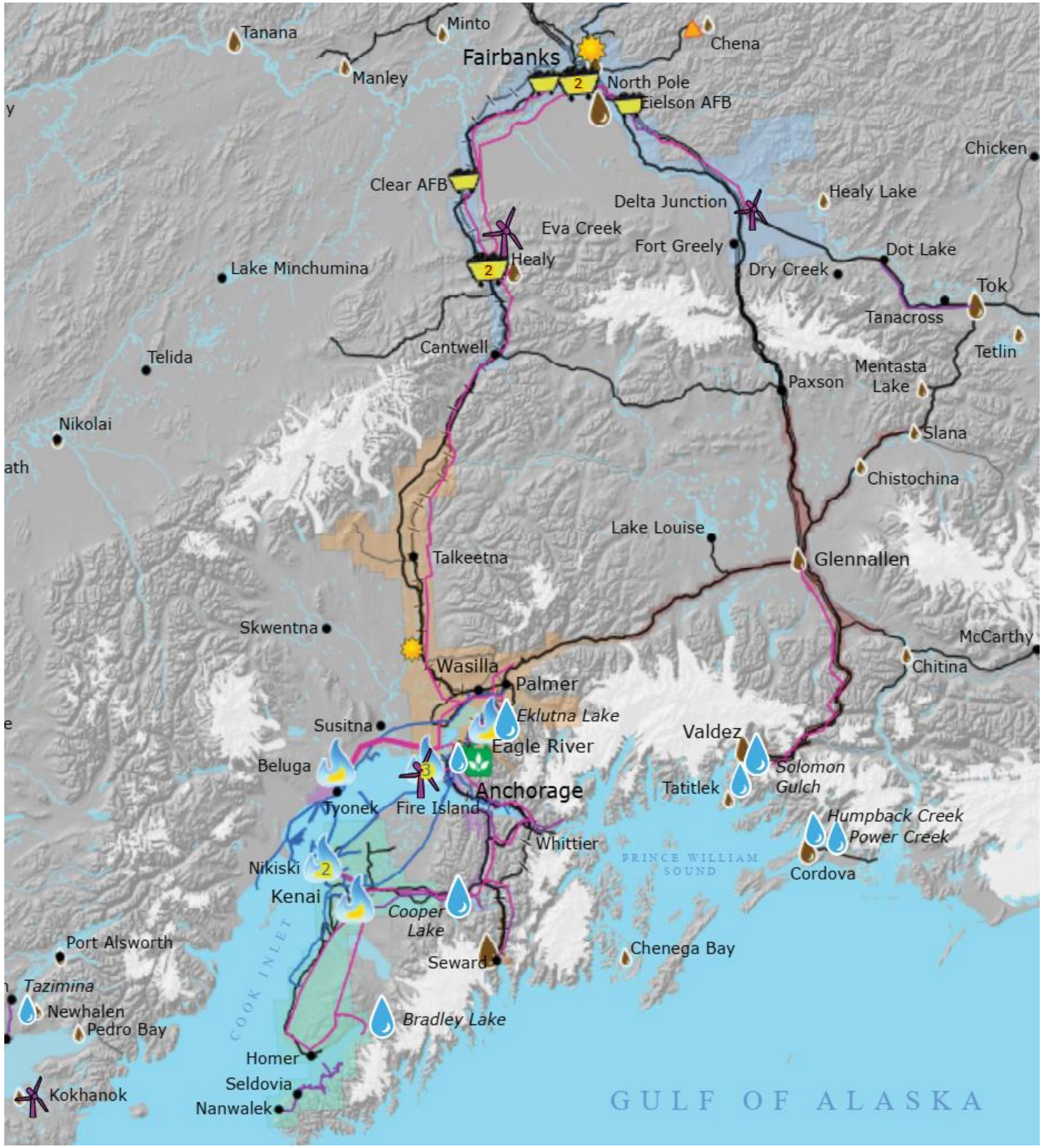
U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

NREL Transforming ENERGY

Alaska "Railbelt"

- Homer to Fairbanks
- 70% of AK population
- ~600MW average load
  - ***42% natural gas***
  - 28% hydro
  - 27% coal & petroleum
  - 3% renewables
- Space heating
  - Fuel Oil
  - Wood
  - Natural Gas
  - ASHP (coastal)



https://alaskarenewableenergy.org/initiatives/renewable-energy-atlas/

Cook Inlet Tidal Energy - Context

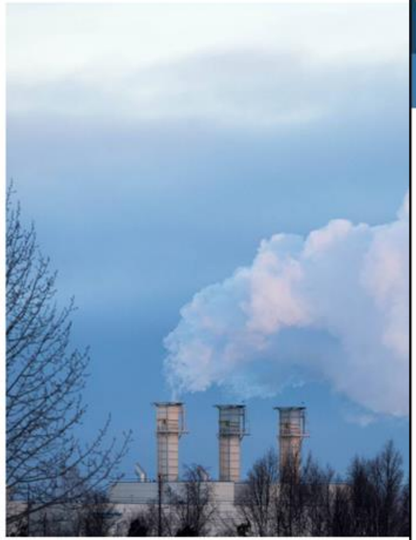
Motivations

- Declining gas reserves
- Immense and predictable tidal resource
  - Tech reaching MW scale
  - FERC permits being issued
- RPS scenarios
  - “it’s time for Alaskans to consider where we want to be 20 years from now”
- Global interest in Hydrogen, carbon-free fuels

Sections ☰ ANCHORAGE DAILY NEWS 2022 Election • Alaska News • Politics • Opinions • T

Hilcorp warns Alaska utilities about uncertain Cook Inlet natural gas supplies

By Alex DeMarban
Updated: May 17, 2022
Published: May 17, 2022



Exhaust from the Southcentral Power Project in Anc… 2019. (Loren Holmes / ADN)

Office of Governor
MIKE DUNLEAVY

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Governor Dunleavy Introduces Legislation Setting Renewable Energy Standards Benchmarks will prepare Railbelt for energy independence

February 4, 2022

Today, Governor Mike Dunleavy introduced his second bill from a package of energy legislation intended to promote energy independence, long-term cost reductions, and competitive markets in both urban and rural Alaska.

House Bill 301 and Senate Bill 179 will allow Alaska to join 30 states and two territories in creating a renewable portfolio standard in the Railbelt. A key element of the governor’s RPS is a

Cook Inlet Tidal Energy - Context

- Alternatives
  - North Slope Gas Pipeline
  - LNG import terminal
  - Traditional Hydroelectric
  - Advanced Nuclear
- Factors
  - Economics
  - Integration and Storage
  - Environmental Impact


MILITARY NEWS

FAIRBANKS Daily News-Miner

SEEK NATURAL GAS PIPELINE HERE

Mistake Made In Identifying Dead Youth!

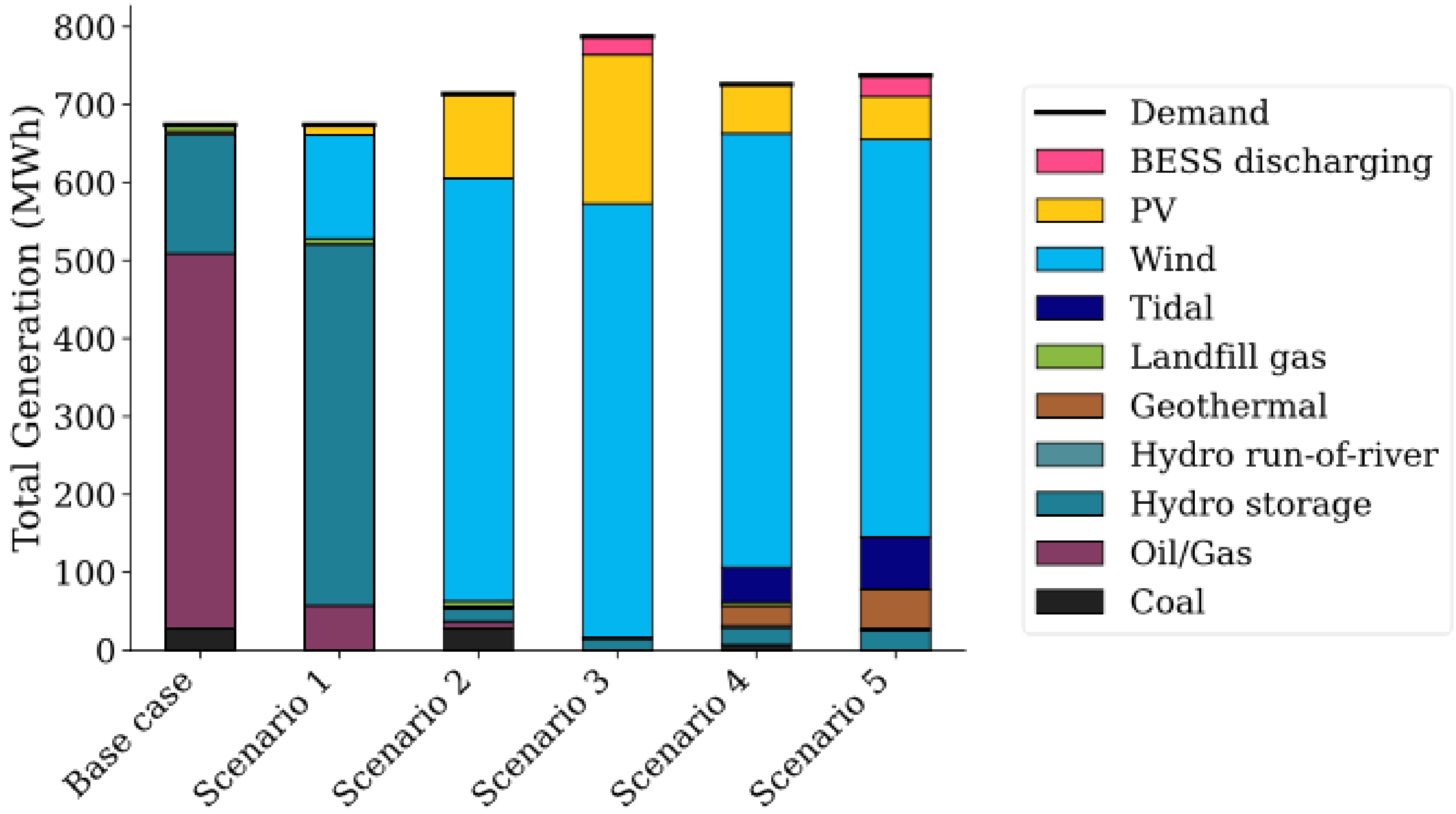
Arctic Resource Could Slash Living Costs, Bring Industry

Renewable Portfolio Standard Assessment for Alaska's Railbelt

Multiple pathways to achieving an 80% RPS

Balancing supply and demand under major outage conditions with appropriate system engineering

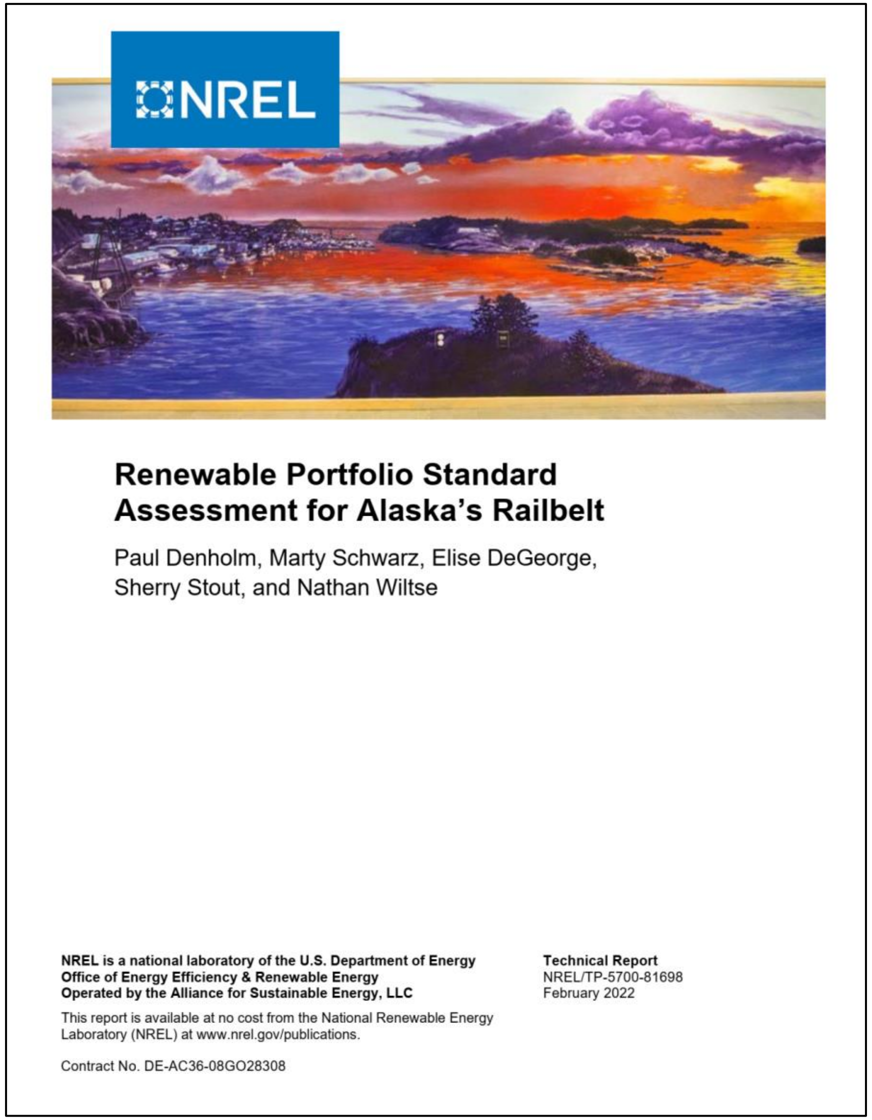
UAF working with OSU on Grid Integration Modeling



https://www.nrel.gov/docs/fy22osti/81698.pdf

Tidal Energy Progression

1. Tidal R&D, platform power
2. Tidal to electric utilities (RPS)
3. Tidal to synthetic fuels (export market)
    1. “Hydrogen Hub”
    2. Ammonia, Methanol, etc to export markets and rural Alaska
    3. AK heating and transportation
4. Tidal, synthetic fuels and carbon sequestration
    1. Natural gas export, CO2 import
    2. Synthetic fuel decarb and sequester


NREL

Renewable Portfolio Standard Assessment for Alaska’s Railbelt

Paul Denholm, Marty Schwarz, Elise DeGeorge, Sherry Stout, and Nathan Wiltse

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5700-81698
February 2022

Cook Inlet Tidal - Roadmap Development

Topic Area	Date	Presenters	Participants
Working Group Intro	December 5	Levi Kilcher, NREL	30
Data Needs & Gaps	January 23	Katie Petersen, NREL	31
Permitting & Regulatory	February 13	Julianna Potter, Aleut Jonathan Colby, Streamwise	45
Global Tidal Energy Projects	March 27	Jonathan Colby, Streamwise	29
Tidal Array Modeling	April 12	Zhaoqing Yang, PNNL	18
Project Costs & Economics	May 18	Elena Baca, NREL	28

Participants include tidal tech developers, tidal project developers, electric utilities, user groups, state and federal regulatory agencies, university researchers, national lab researchers

Data Needs & Gaps - Feedback

WORKING GROUP HIGHLIGHT

Multiple development phases require different kinds of data and level of resolution. Key data needs now are for pre-demonstration phase

Resource data:
-Still need to validate data
-Have most of the resource data for pre-demo phase

Site data:
-Data gaps are bathy/sediment/ice/seafloor
-Private data on bathy, seafloor comp may exist

Environmental data:
-Salmon & belugas – major concerns; check with recreational & subsistence fishers too
-Review FERC dockets for enviro assessments

Socioeconomic data:
-Social license data thru lit review
-Funding for sustained stakeholder engagement?

Workforce development & engagement:
-NREL workforce dev program, engage with SeaGrant fellows
-Classroom outreach w/ STEM educators

Device design & performance:
-Would it be possible to have a generic testing facility? Single site presents some challenges wrt timing & suitability to different types of tech.

Economics:
-Cost of integration should be included.
-2nd Phase Renewable Portfolio Standard for the Railbelt is underway.

WORKING GROUP HIGHLIGHT

Key Regulatory Agencies

FEDERAL

Lead Agency dependent on scope and location

FERC
- Federal Power Act
- Energy Policy Act

USACE
- Rivers and Harbors Act Section 10
- Clean Water Act Section 404

BOEM
- OCS Lands Act
- Energy Policy Act

EPA
- Clean Water Act
- APDES/NPDES

FAA
- Determination of No Hazard to Air Navigation

NMFS
- Endangered Species Act
- Marine Mammal Protection Act
- Magnuson-Stevens Act

USCBP
- Jones Act (Merchant Marine Act of 1920)

USCG
- Notice to Mariners
- Movement Regulations
- Private Aids to Navigation

USFWS
- ESA
- MMPA
- Fish and Wildlife Coordination Act
- Migratory Bird Treaty Act

STATE

ADNR, DMLW/DOG
- Land Use Authorization
- Right of Way/Easement
- Tidelands Lease

ADEC, DOW
- Clean Water Act
- Section 401 Cert.
- APDES/NPDES
- *Domestic wastewater / Drinking water*

ADNR, SHPO
- National Historic Preservation Act Section 106

ADFG
- Title 16, Fish Habitat
- Public Safety
- Title 5, Special Area Permit

- Pre-Application Meetings are critical
- Engage with agencies early and often

LOCAL

Native Corp.
- Land Use Authorization
- Letter of Non-Objection

KPB/KRC
- Multi-Agency Permit
- Floodplain Permit
- Vegetation Management

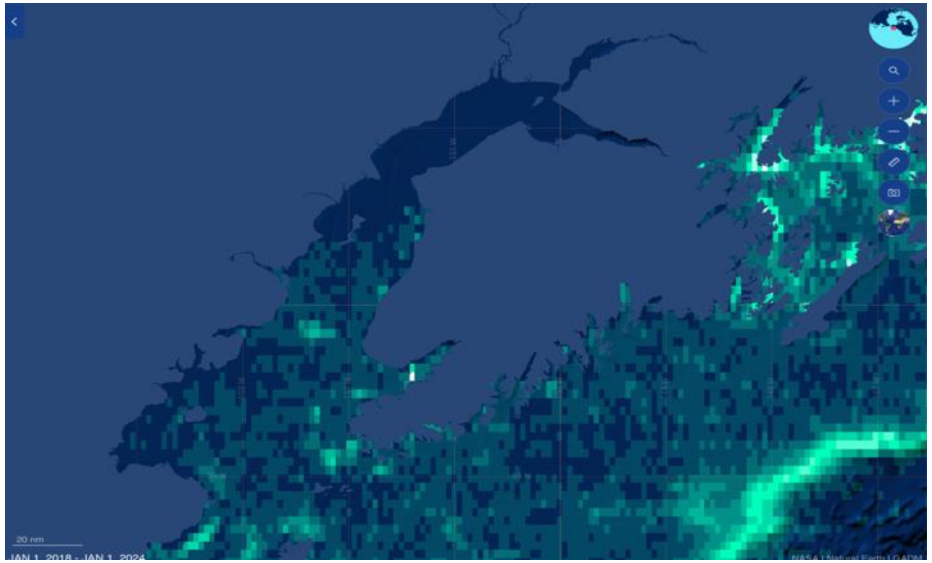
Group Discussion:

1) What other Agencies should be included?
→ PLEASE PROVIDE THESE IN THE CHAT.

2) What strategies have been successful in your experience?

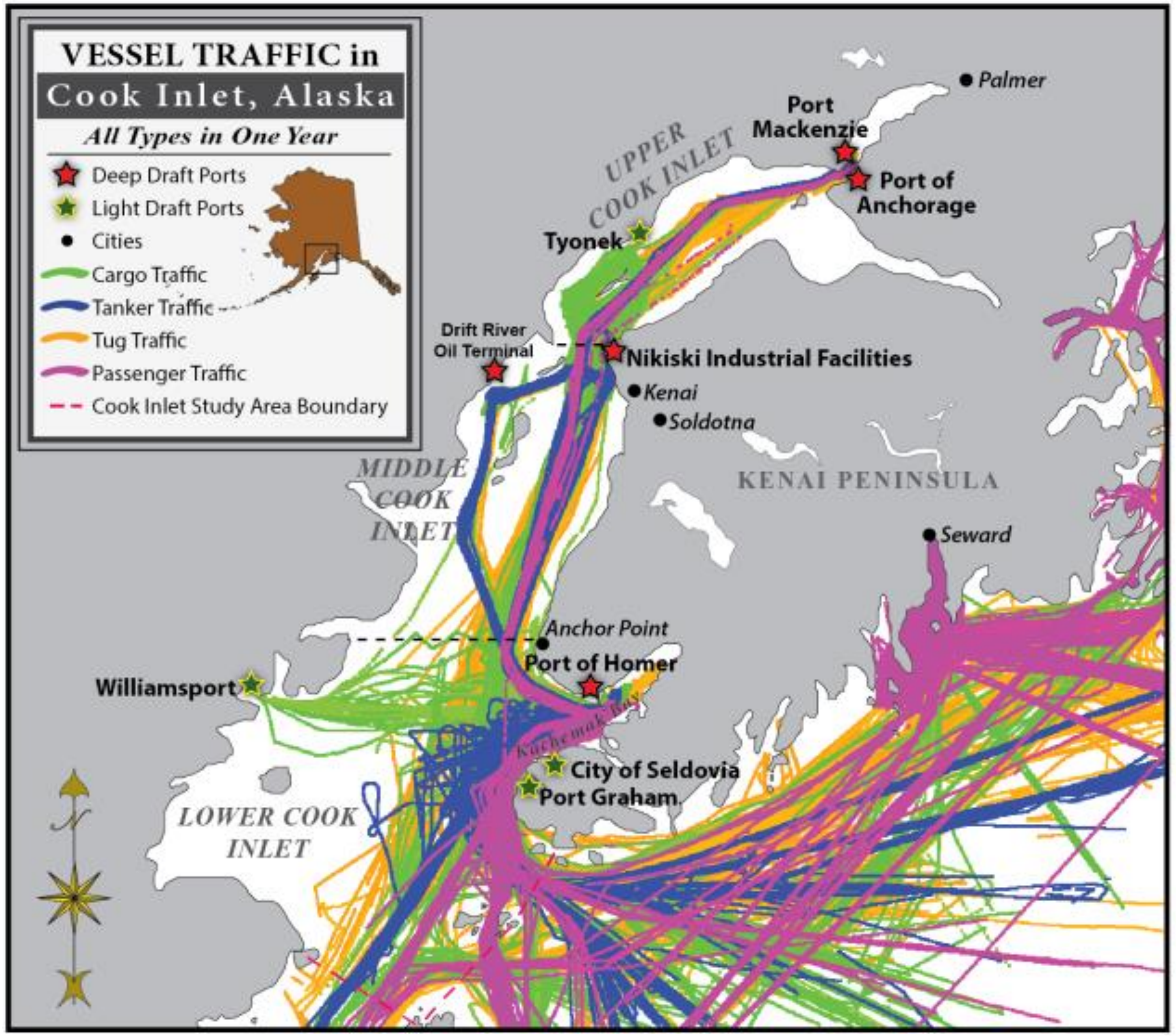
WORKING GROUP HIGHLIGHT

Considerations



Global Fishing Watch


Boats on Cook Inlet, 1898 – Alaska Digital Archives



Cape International, 2012

WORKING GROUP HIGHLIGHT

Marine Mammals

Marine Mammal Protection Act (MMPA)

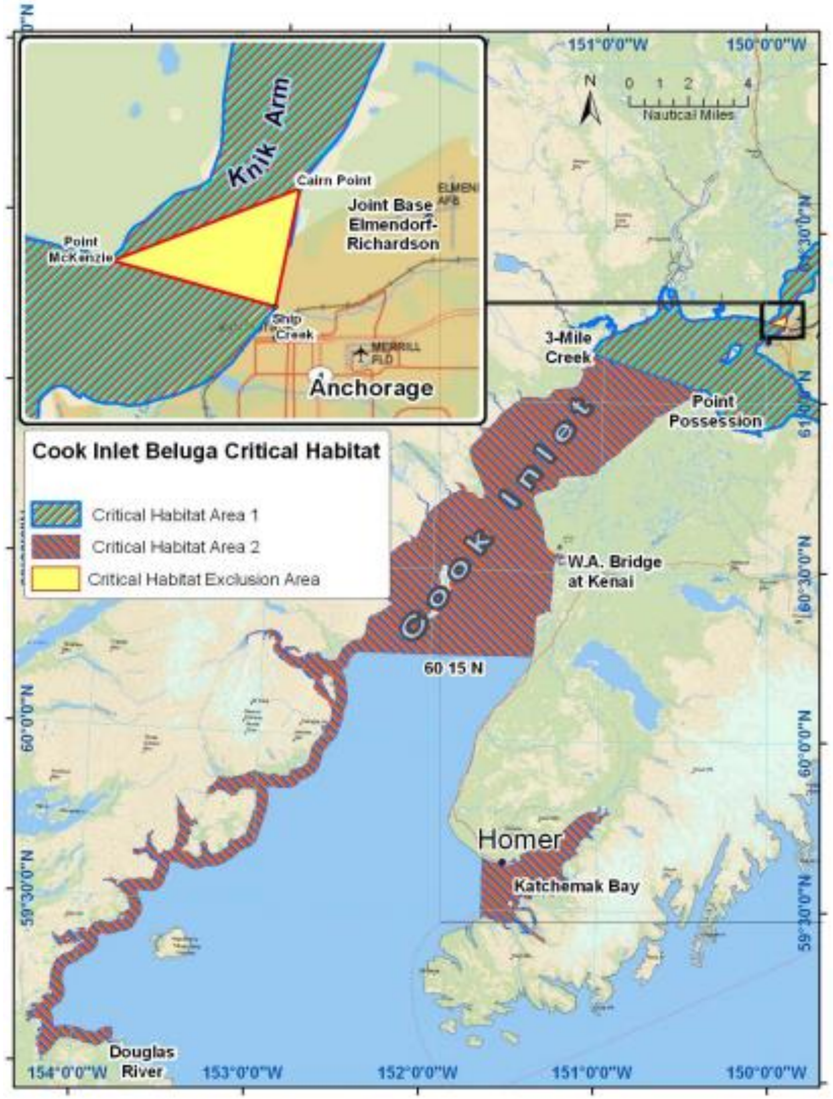
- 13 species in middle Cook Inlet

Endangered Species Act (ESA)

- 5 species in Cook Inlet
- Cook Inlet DPS Beluga Whales are the most endangered population in the U.S.
- Population estimates of Beluga Whales in Cook Inlet have declined since the 1970s

Marine Mammals	Injury (Level A) Threshold		Disturbance (Level B) Threshold	
	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive
Low-Frequency (LF) Cetaceans	219 dB L_{pk} 183 dB SEL	199 dB SEL	160 dB rms	120 dB rms
Mid-Frequency (MF) Cetaceans	230 dB L_{pk} 185 dB SEL	198 dB SEL	160 dB rms	120 dB rms
High-Frequency (HF) Cetaceans	202 dB L_{pk} 155 dB SEL	173 dB SEL	160 dB rms	120 dB rms
Phocid Pinnipeds	218 dB L_{pk} 185 dB SEL	201 dB SEL	160 dB rms	120 dB rms
Otariid Pinnipeds	232 dB L_{pk} 203 dB SEL	219 dB SEL	160 dB rms	120 dB rms

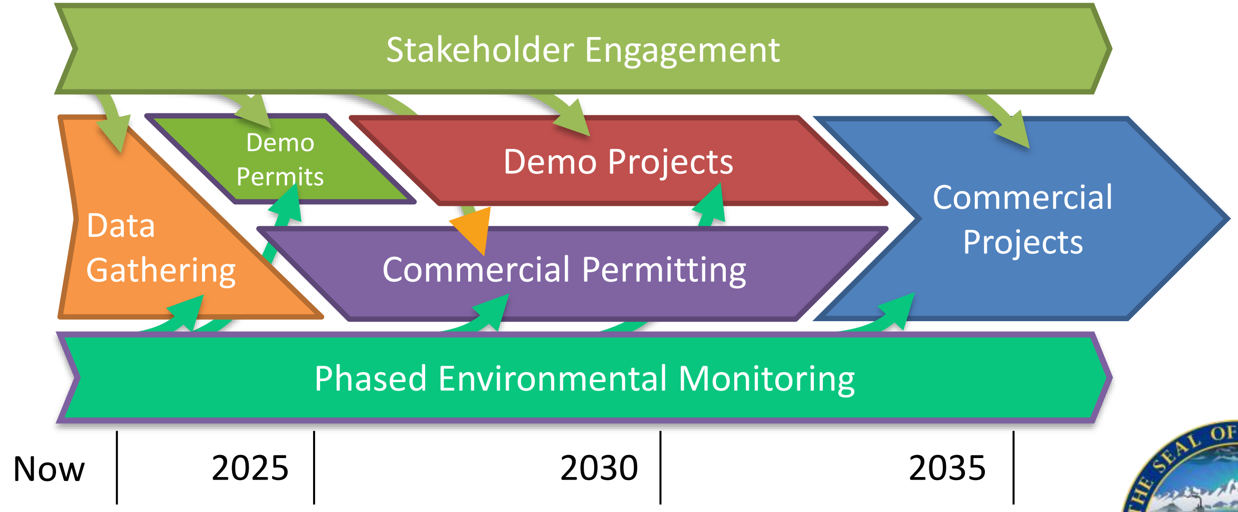
NOAA Technical Guidance, 2018

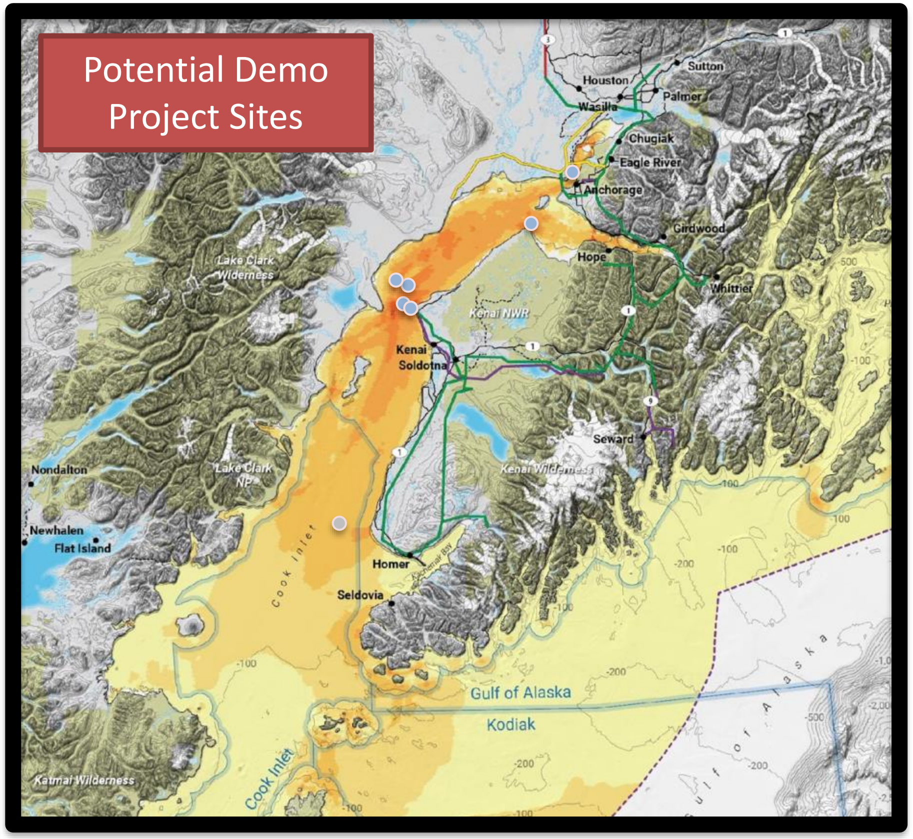


NOAA Fisheries Website

Cook Inlet Tidal Energy Roadmap

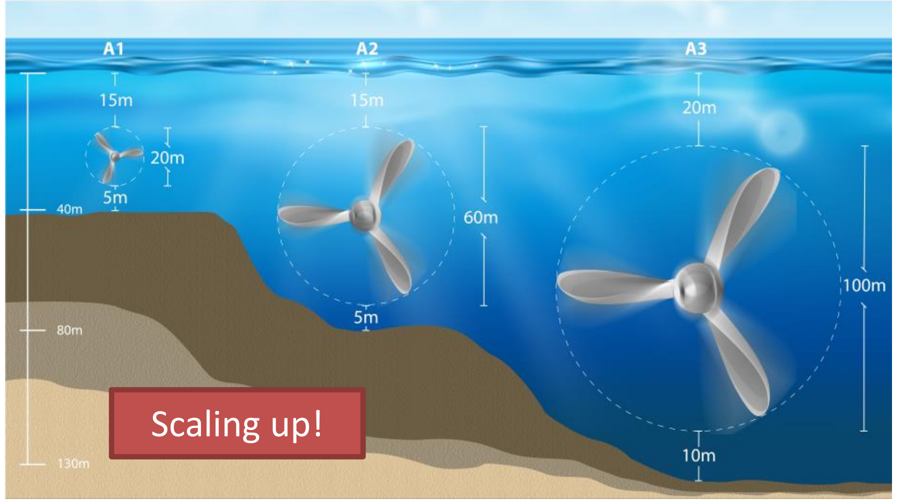
100MW by 2035





Demonstration projects are critical to proving technology, reducing cost, environmental monitoring, scaling up, and technology down-select.

Research & development is critical to meeting these objectives and making informed decisions.



Policy & Permitting Recommendations

- Identify and Fill Regulatory Data Gaps
- Support Adaptive Management Approaches
- R&D Investment
  - Direct technology development
  - Skilled workforce development

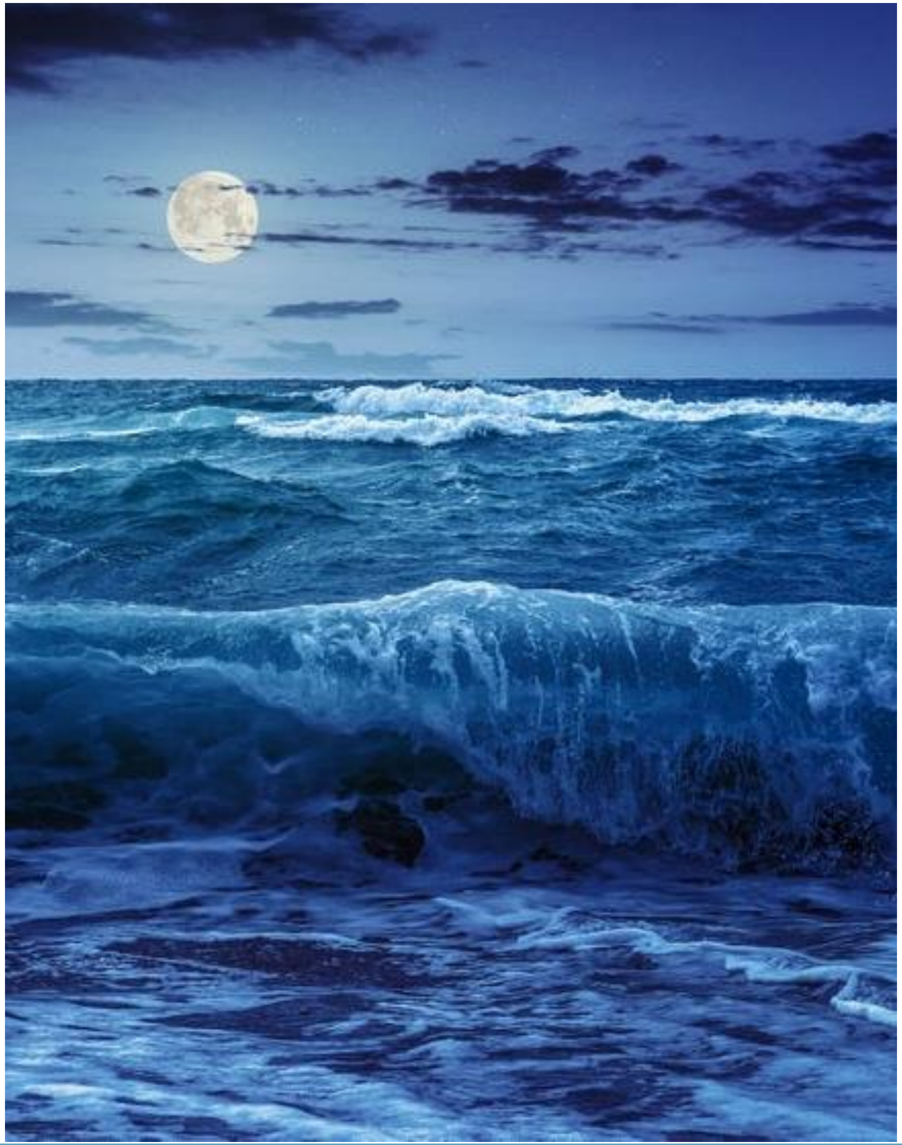
$35M for Tidal and Current Energy Systems

DOE's WPTO - $35M funding from the Bipartisan Infrastructure Law

FOA Objectives and Goals

- Goal – 1-5MW pre-commercial tidal demonstration site
  - Build upon state clean energy strategies with local partners.
  - Attract competitive tidal and current energy developers for technology site integration.
  - Improve tidal and current energy research and development.
  - Build site infrastructure and supply chains with increased participation at the state level, including local agency, tribal, and university research involvement.
  - Establish a working business model covering site development to commercial scale.

- Multiple proposals included Cook Inlet
- Award decisions expected this November

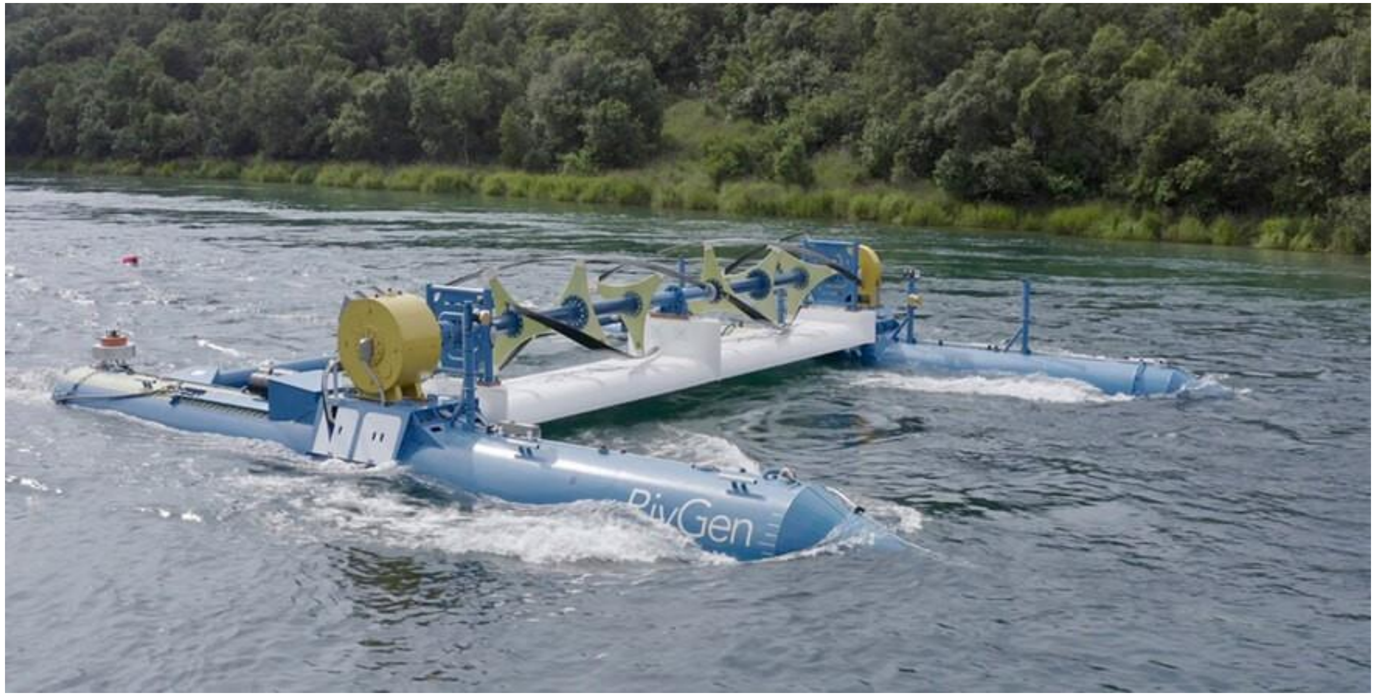


Summary

- Resource is immense and predictable (storage requirements reduced)
- Alaska waters are challenging
- Technology is pre-commercial
- Environmental impacts not fully understood
- Variety of potential offtakes (electricity, hydrogen, ammonia, etc)

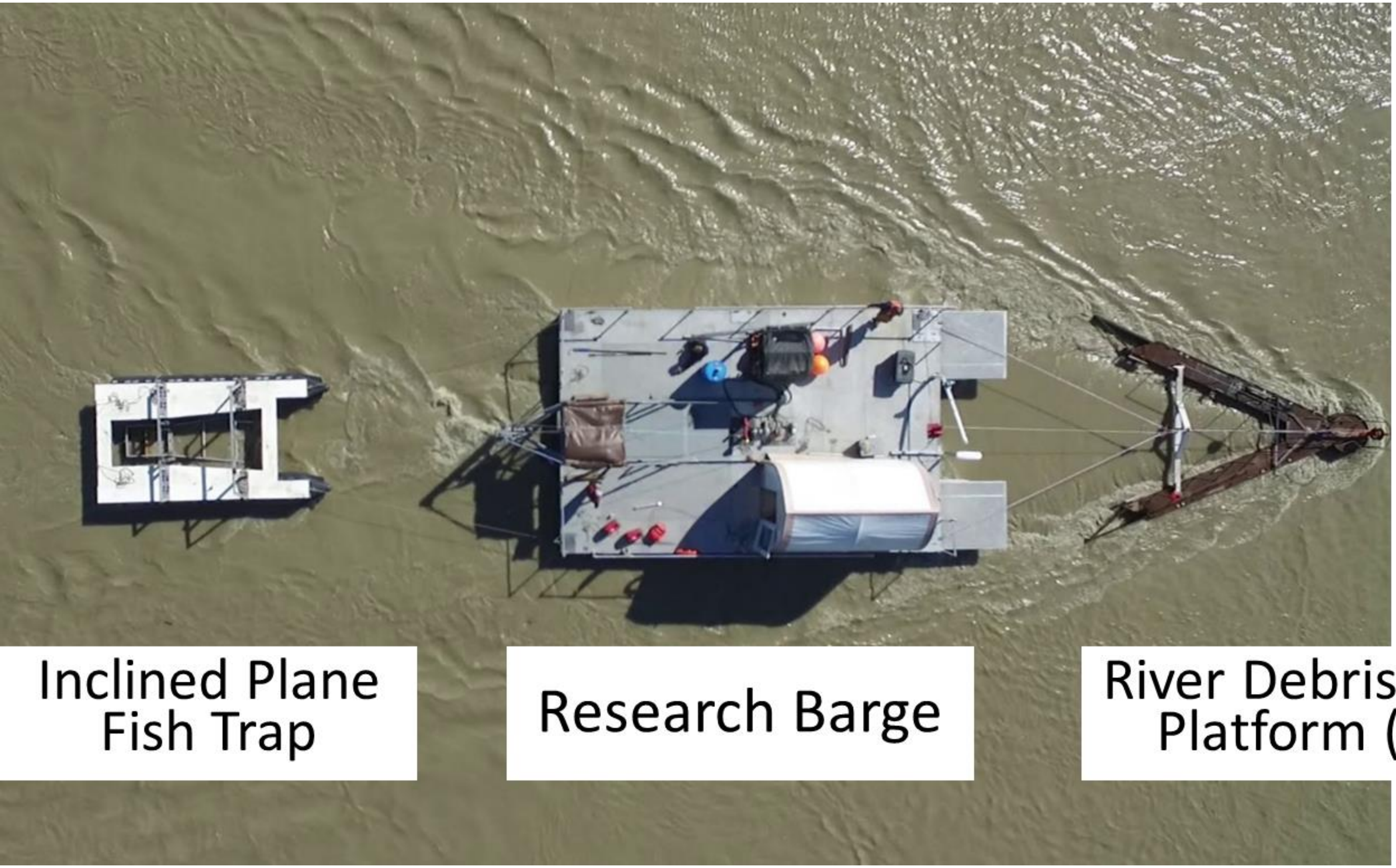
Alaska MHK History

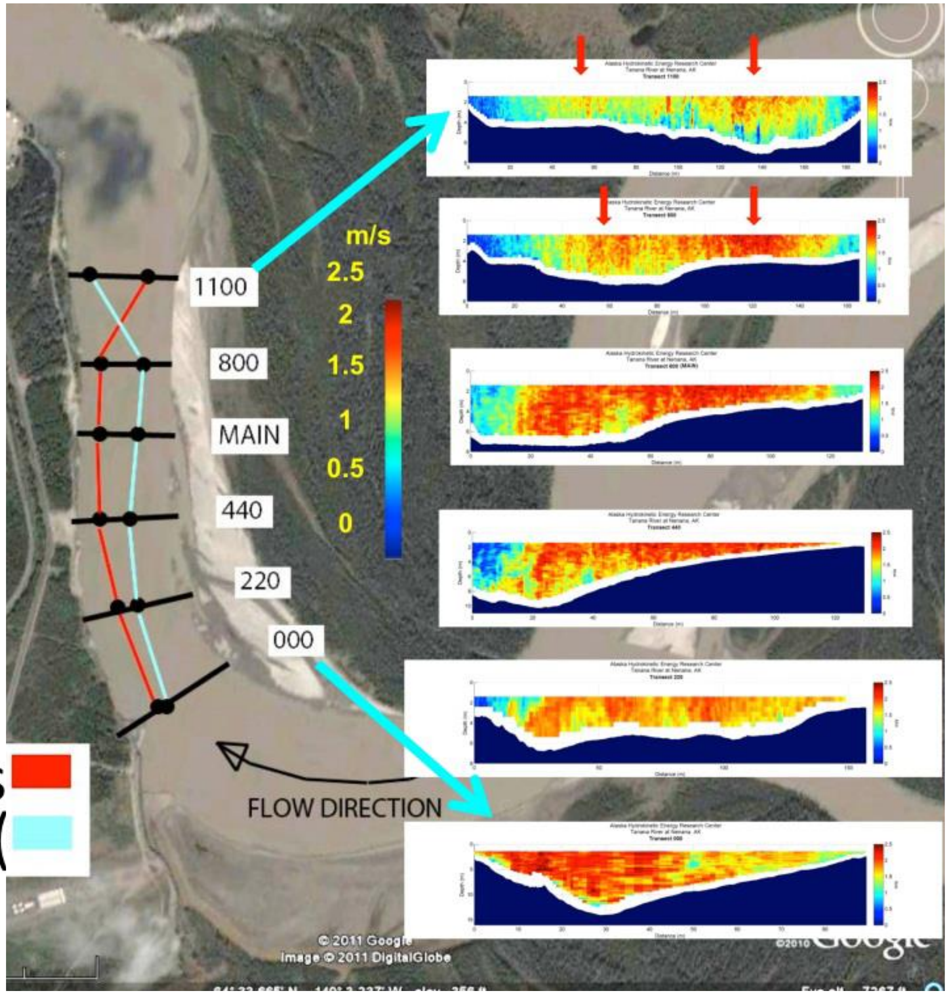
Debris accumulation on surface turbine. Ruby, AK 2013



ORPC RivGen, prior to submersion. Igiugig, AK 2020

Tanana River Test Site





Data Collection

- Simrad EK60 Split Beam Sonar
- Reson 7125 Multibeam Sonar
- Trimble GPS
- ADCP and ADV – 3D velocity
- Campbell Scientific Dataloggers
  - CR1000
  - CR6
- DC voltage and current transducers
- Load Cells

Hydrokinetic Experience

Hydrokinetic Experience

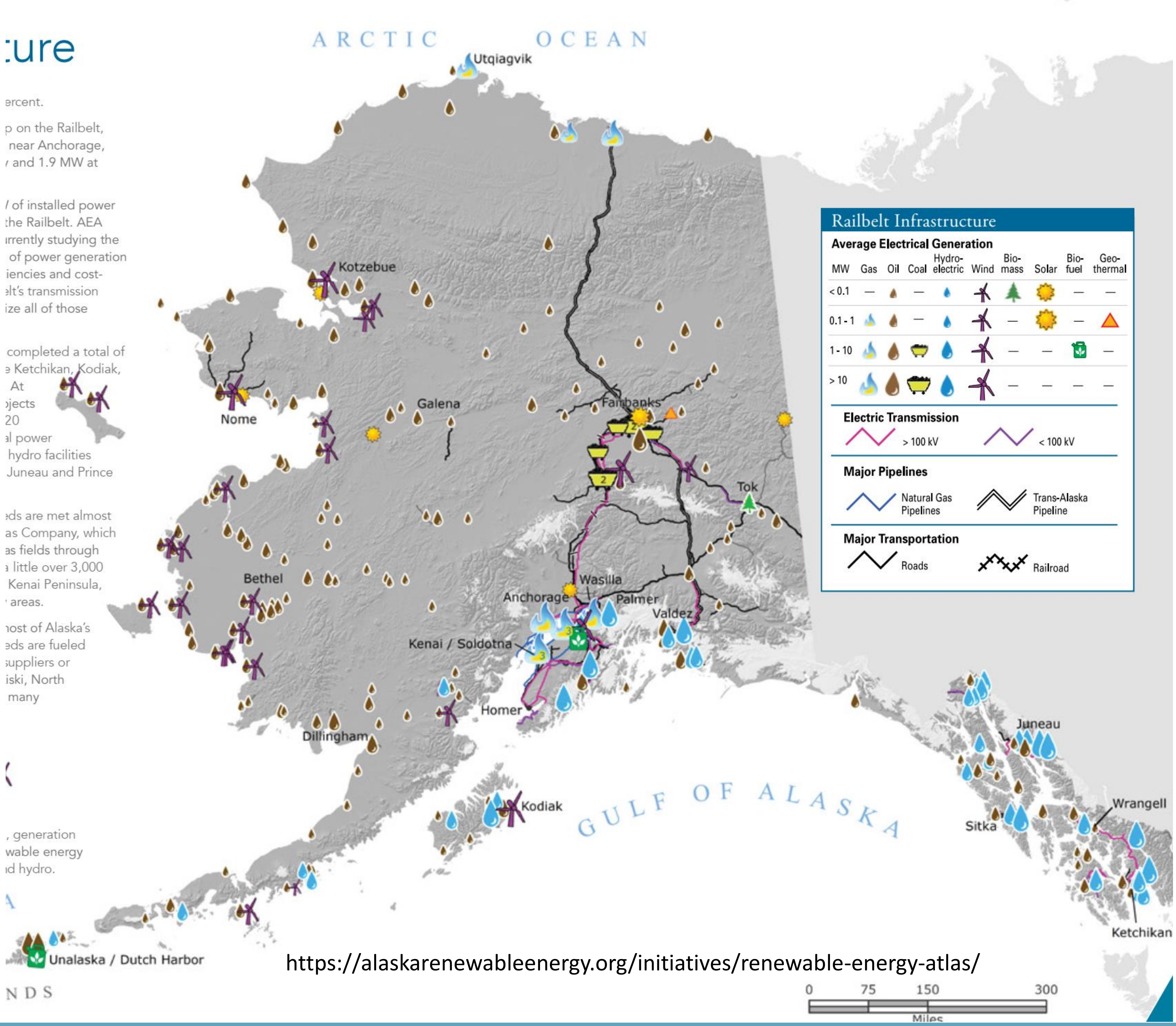
Alaska Energy Leadership

- State Level
  - Office of Energy Innovation
  - Alaska Energy Security Task Force
  - Alaska Energy Independence Fund (proposed)
  - Alaska Sustainable Energy Conference
- Federal Level
  - DOE Arctic Energy Office
  - National Lab Research Programs focused on Arctic
  - DOE Water Power Technologies Office
    - R&D in Alaska
    - National Marine Energy Centers

Alaska Energy Infrastructure

- 730,000 residents
- Railbelt Grid
- Remote Microgrids

www.alaska.org

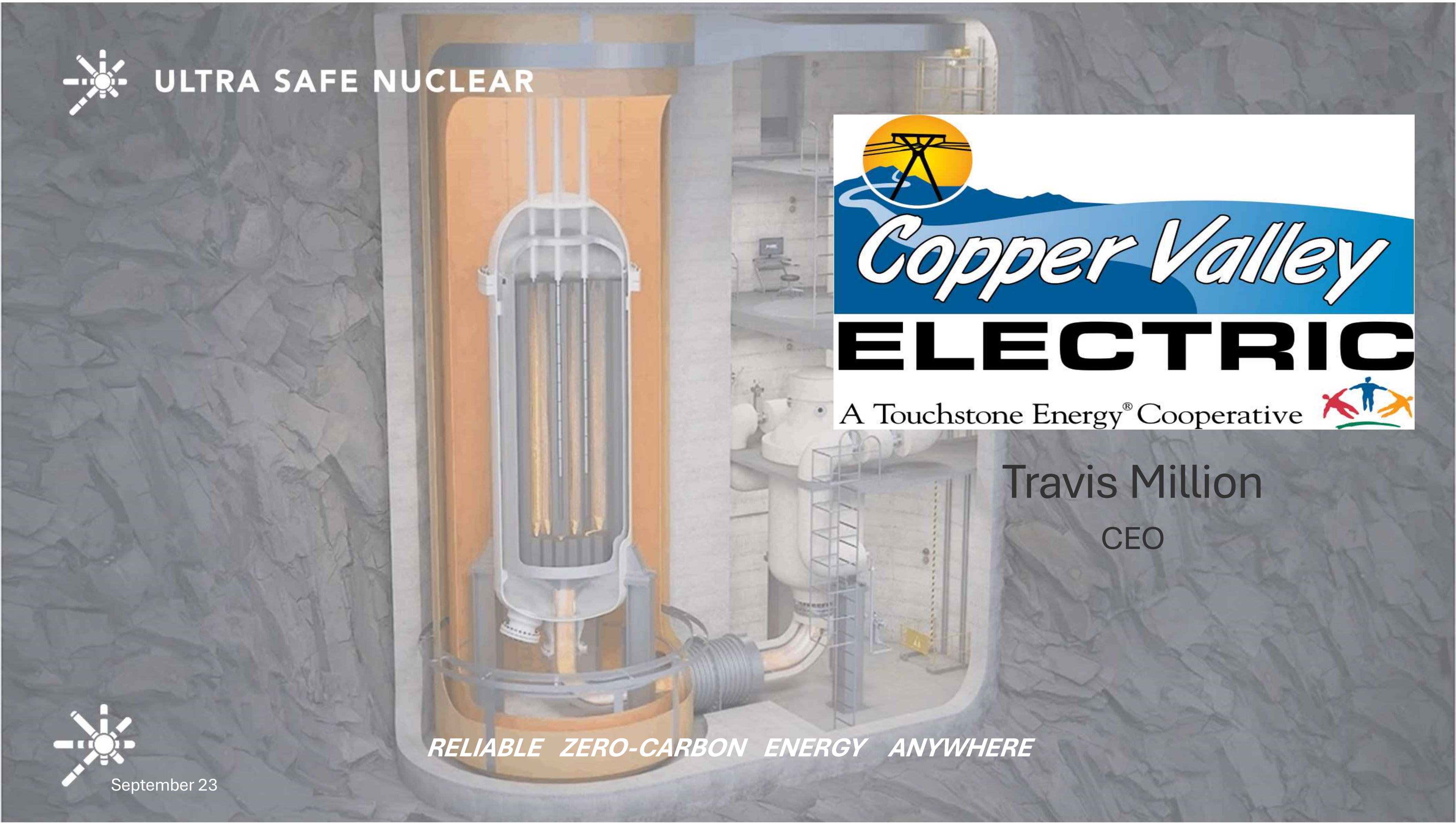


https://alaskarenewableenergy.org/initiatives/renewable-energy-atlas/

EMERGING TECHNOLOGIES AND OPPORTUNITIES FOR ALASKA: SMALL SCALE NUCLEAR

Thursday, August 31, 2023, 11:00 AM – 1:00 PM

- *Copper Valley Electric Association*
- *Nuclear Energy: State of Micro Reactors*
- *Small Nuclear Power: An Option for Alaska?*

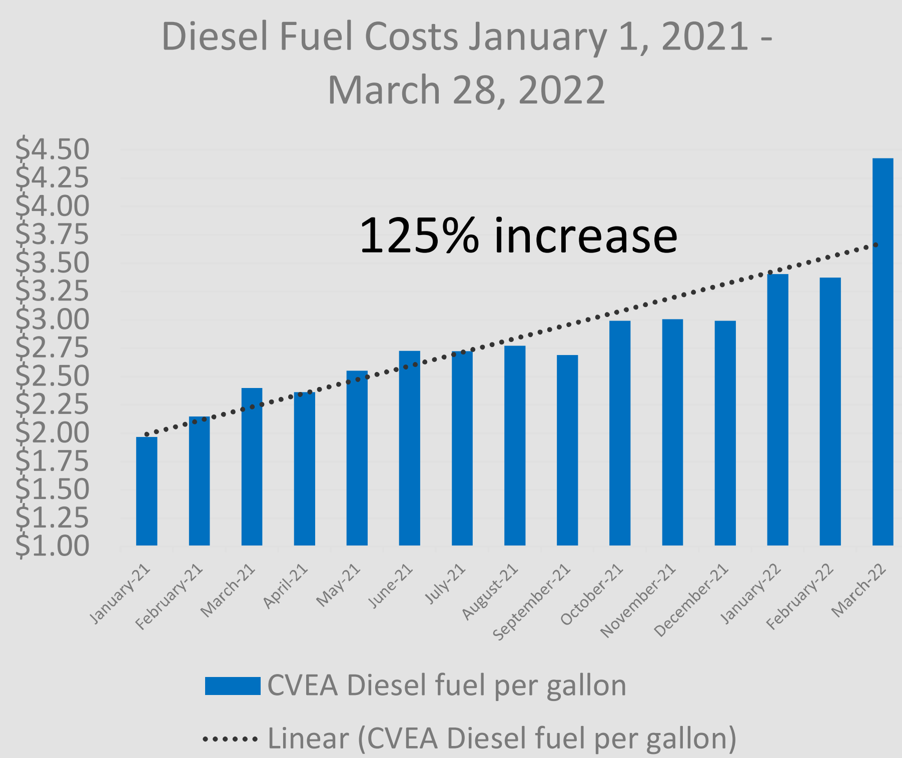

ULTRA SAFE NUCLEAR
Copper Valley
ELECTRIC
A Touchstone Energy® Cooperative
Travis Million
CEO
RELIABLE ZERO-CARBON ENERGY ANYWHERE
September 23

Agenda

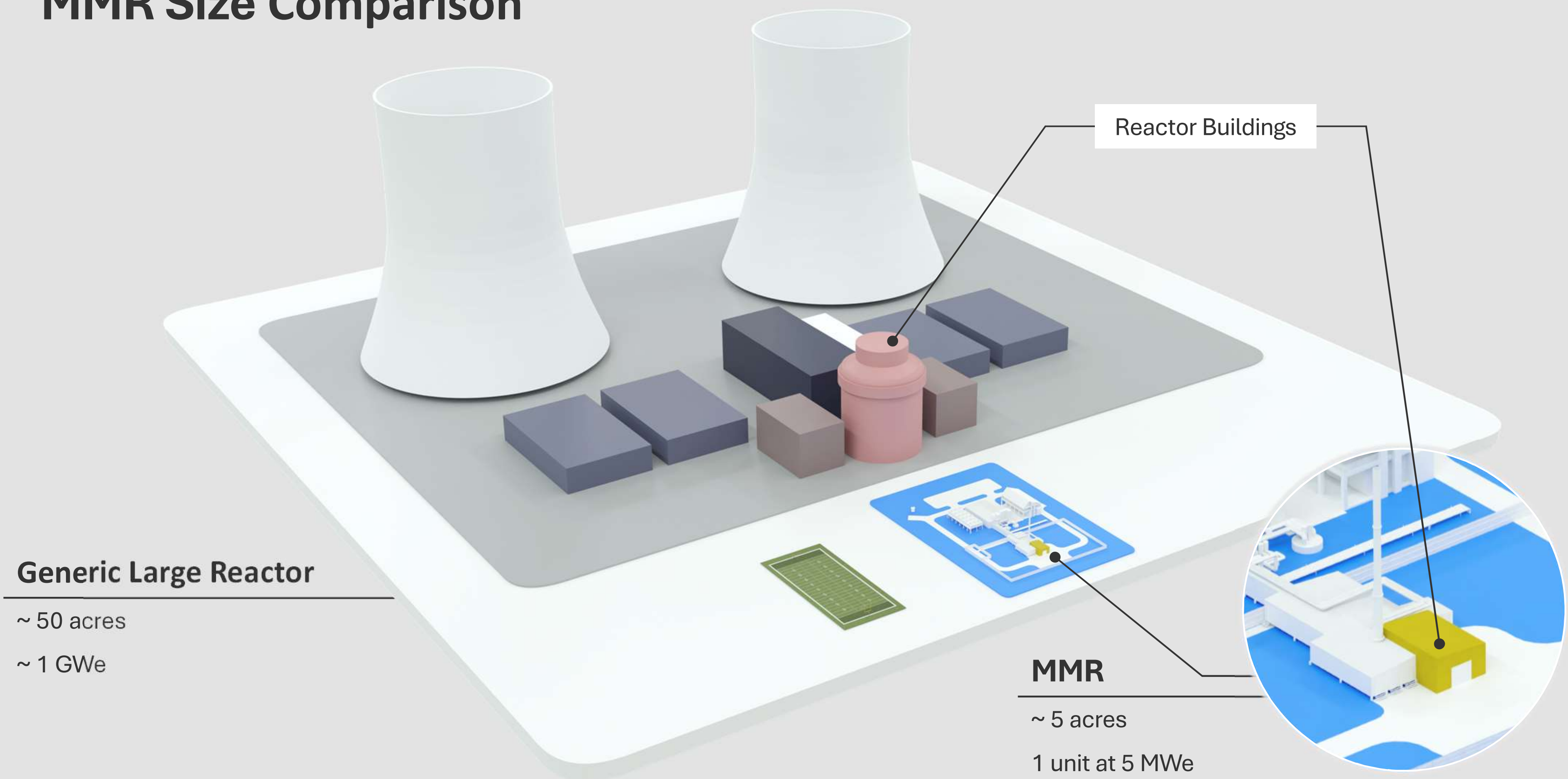
- Overview
- Feasibility Study Results
- Next Steps

Why Nuclear for Copper Valley

- Board Strategic Plan
  - Develop a plan to reduce use of diesel fuel
- Increasing, fluctuating winter energy costs
- Reduction in emissions from fossil fuel power plants
- Lack of solutions for winter energy
  - Wind, Solar, Geothermal, Biomass, Hydro, Intertie, etc.

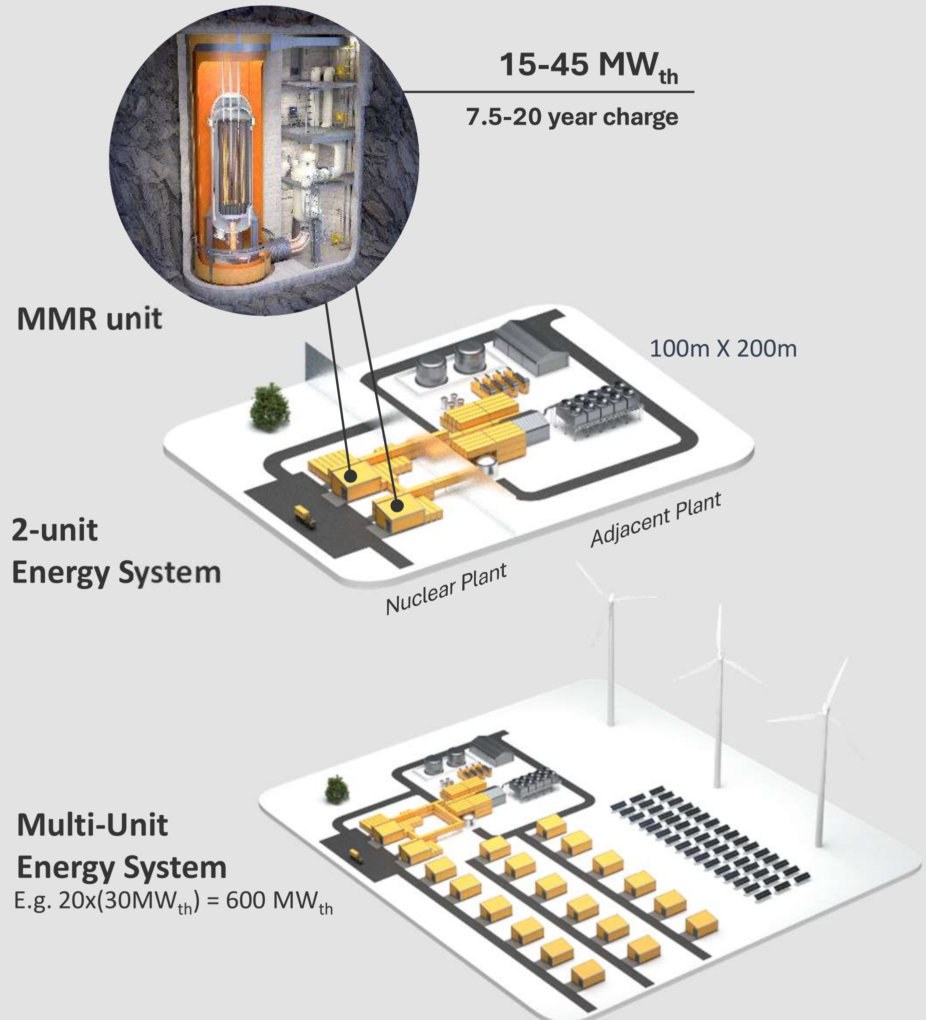


MMR Size Comparison



Micro Modular Reactor MMR™ Energy Systems Overview

- **Scalable and Flexible**
  - Standardized factory-produced units – commercial off-the-shelf parts (COTS)
  - Mass-production drives steep cost reductions
  - Projects scalable with multiple units
  - Flexible configurations to serve any customer
  - Energy cost visibility
- **Easy to Assemble**
  - 85% of construction costs in factory
  - Units are tested in approved factory before delivery
  - Modules are transported and assembled on site
  - Walk away AND walk back safe
- **Easy to decommission**
  - No environmental contamination
  - No fuel storage on site
  - Site is returned to green field after operations
  - Waste forever contained in FCM
- **Competitive Advantage**
  - Proprietary patented MMR and FCM technology
  - Vertical integration with strong regulatory barriers



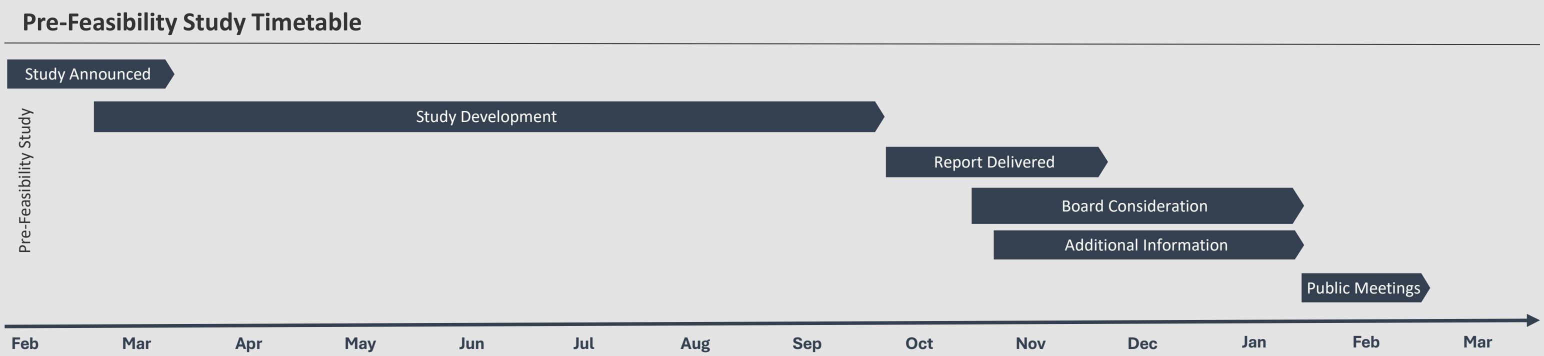
Pre-Feasibility Study Scope & Purpose

Questions the pre-feasibility study is intended to answer

- Is there anything that would prevent siting an MMR here?
- What are the preferred sites and their characteristics?
- What are the cost parameters and decision points?
- What are the benefits, concerns, and issues for the community?
- What operating specifics might apply in locating an MMR here?

CVEA, Ultra Safe Nuclear, contracted a local engineering firm for the study that knows the area utilities, power grid, customers and community factors well.

Pre-Feasibility Study Process Overview



Milestones

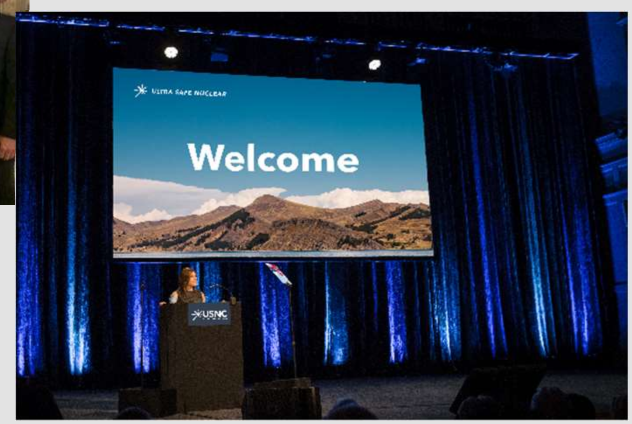
- Collaboration on Pre-Feasibility Study announced February 2, 2022
- Contracted with Alaska engineering firm (EPS) familiar with generation and power grid
- Study delivered to CVEA October 2022
- Internal economic analysis performed December 2022
- Board review and consideration October 2022 & January 2023

Stakeholder Engagement

Engagement Timetable

Beyond Public Acceptance

- Participatory approach and space
- Diverse perspectives and values
- Opportunity for creative solutions

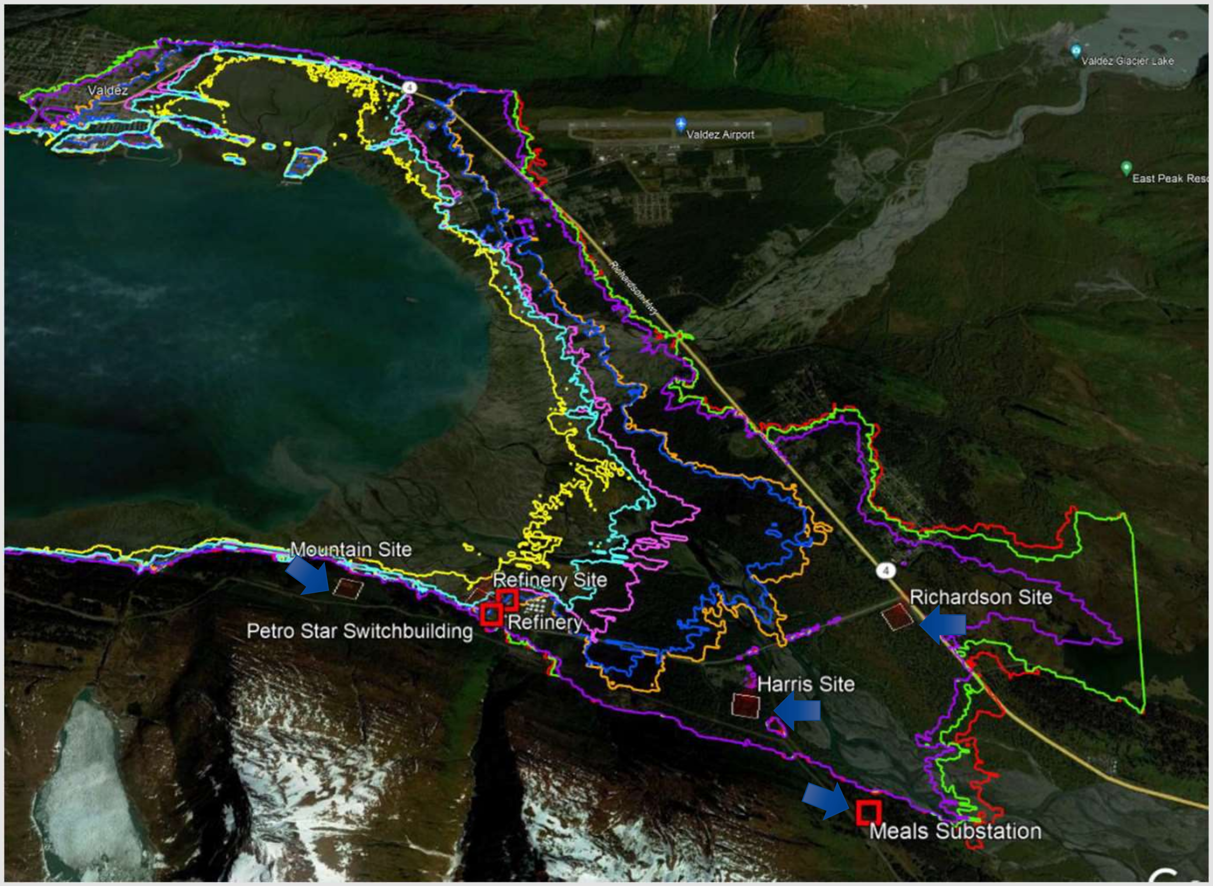


Stakeholder Engagement

- Outreach conducted primarily in Copper Valley basin and Valdez with local elected officials, Native Alaskan Communities, NGO's, industry and any interested public
- Preliminary conversations didn't show any significant opposition to siting an MMR in the CVEA service territory and generally very supportive
- Concerns expressed were primarily on issues of safety, environmental impacts and waste disposal
- Strong desire expressed by all to remain engaged in these conversations as the feasibility study progresses to a decision

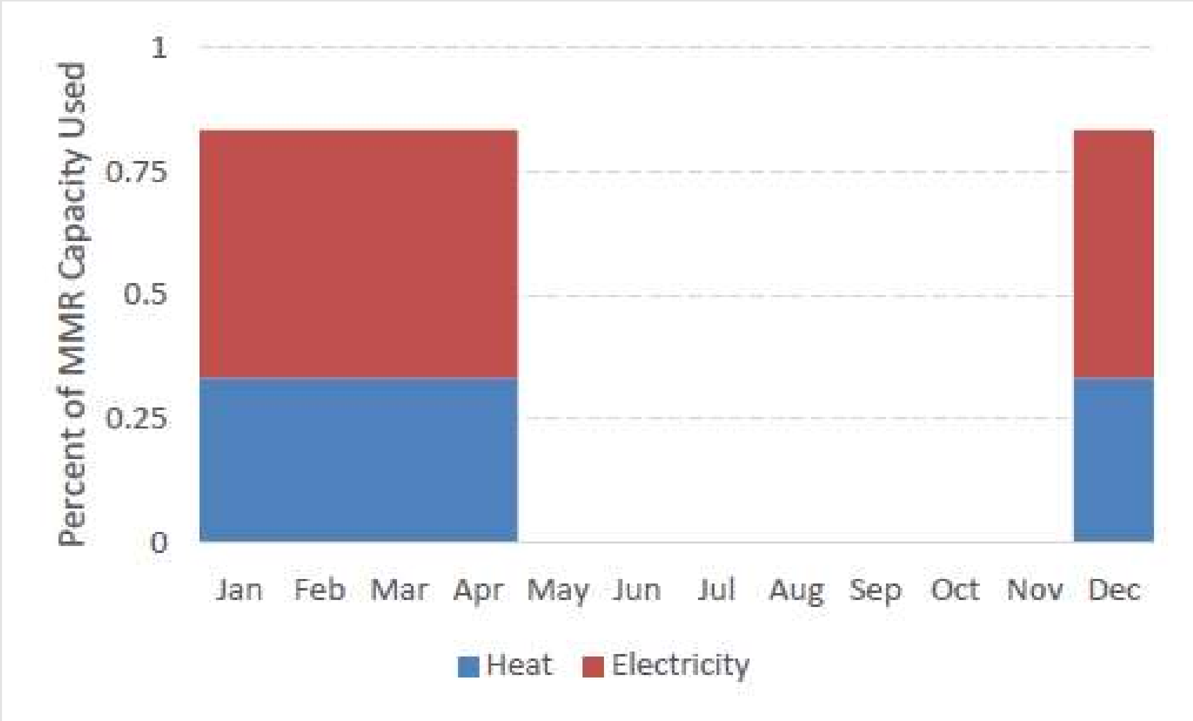
Locations

- Valdez
  - Richardson
  - Harris
  - Mountain
  - Meals
- Glennallen
  - Near existing transmission substation



FINANCIALS

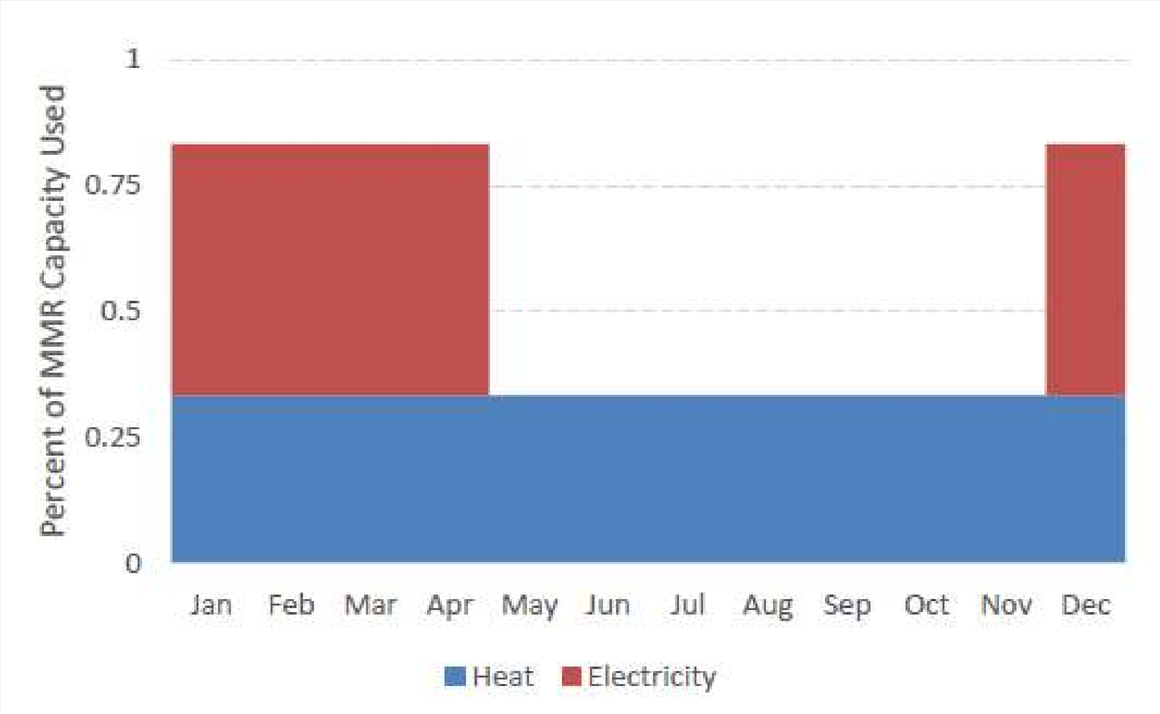
Electric only doesn't work economically



Current

FINANCIALS

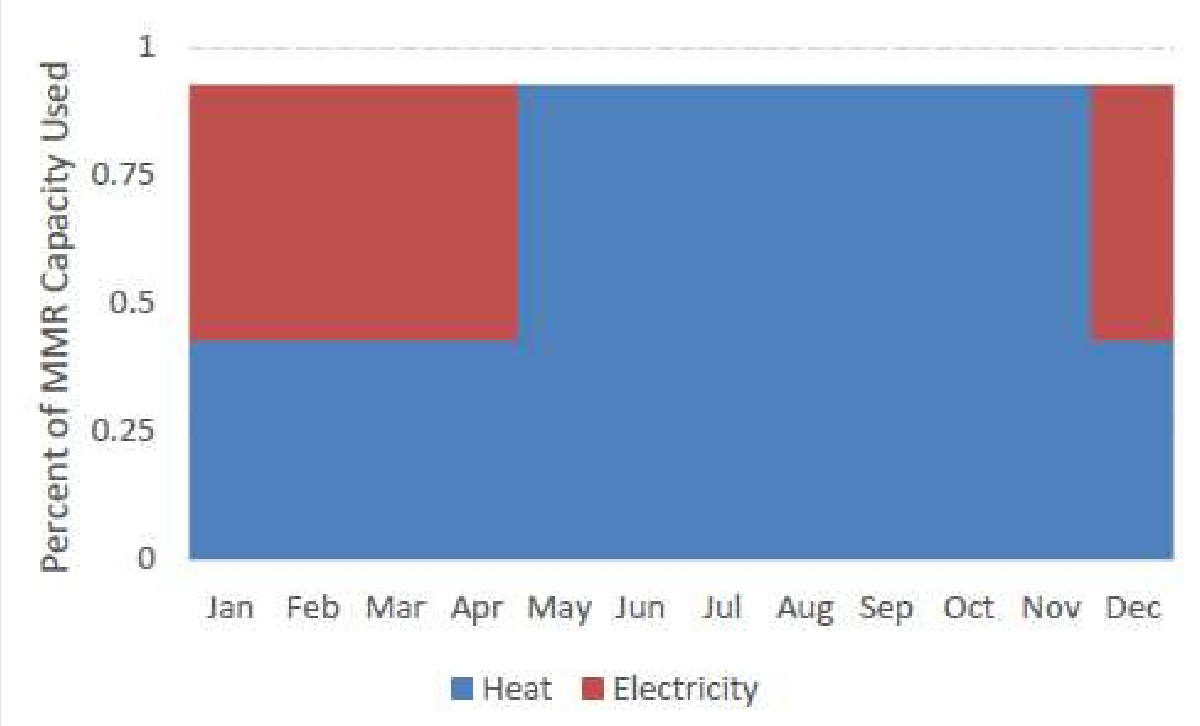
Using MMR to replace Cogen as it is currently operating is difficult economically



Year-round current rate

FINANCIALS

Year-round heat sales used in economic analysis



Maximized

Conclusions

Suitable site locations

Easily integrated into current system

Public acceptance appears positive and will continue to engage broadly

Potentially economically viable

- High risk for CVEA members to own
- Evaluated PPA with USNC

Conclusions

- With proper education many are supportive
- MMR could work in many Alaskan communities
- Could be economical
  - High-capacity factor
  - Heat off taker
  - Economy of scale

QUESTIONS

Nuclear Energy: State of Micro Reactors

Alaska Energy Security Task Force

August 31, 2023

Marc Nichol
Executive Director, New Nuclear

NUCLEAR ENERGY INSTITUTE

Micro Reactor Technology

Designed to replace Diesel Generators

Oklo Aurora
1.5 MWe

Ultra Safe Nuclear Corporation
5 MWe

Westinghouse eVinci
5 MWe

BWXT BANR
17 MWe

- Very small size
  - Site as small as 0.1 acres, building ~size of a house
  - Reactor is road shippable, minimal site work
- Resilience – withstand, mitigate or quickly recover from
  - Extreme natural events
  - Man-made physical and cyber threats
- Operations
  - Automatic operations, island mode and black-start
  - Flexible – hybrid energy and renewables integration

Other Designs (not all inclusive)

- General Atomics
- HolosGen
- Hydromine
- NuGen
- NuScale
- Radiant
- X-energy

System Benefits of Advanced Reactors

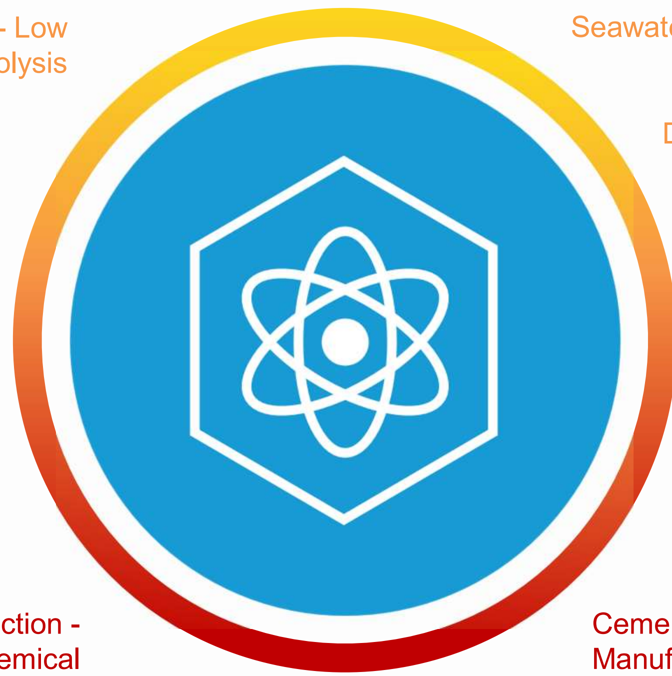
NEI

Long term price stability	• Low fuel and operating costs
Reliable dispatchable generation	• 24/7, 365 days per year, years between refueling (Capacity factors >92%)
Integration with renewables and storage	• Paired with heat storage and able to quickly change power
Efficient use of transmission	• Land utilization <0.1 acre/TWh (Wind =1,125 acre/TWh; Solar 144 acre/TWh)
Environmentally friendly	• Zero-carbon emissions, one of lowest total carbon footprints • Many SMRs are being designed with ability for dry air cooling
Black-start and operate independent from the grid	• Resilience for mission critical activities • Protect against natural phenomena, cyber threats and EMP

Source: SMR Start, *SMRs in Integrated Resource Planning*

Gateway to Heat Markets

Process Heat Temperature Needs

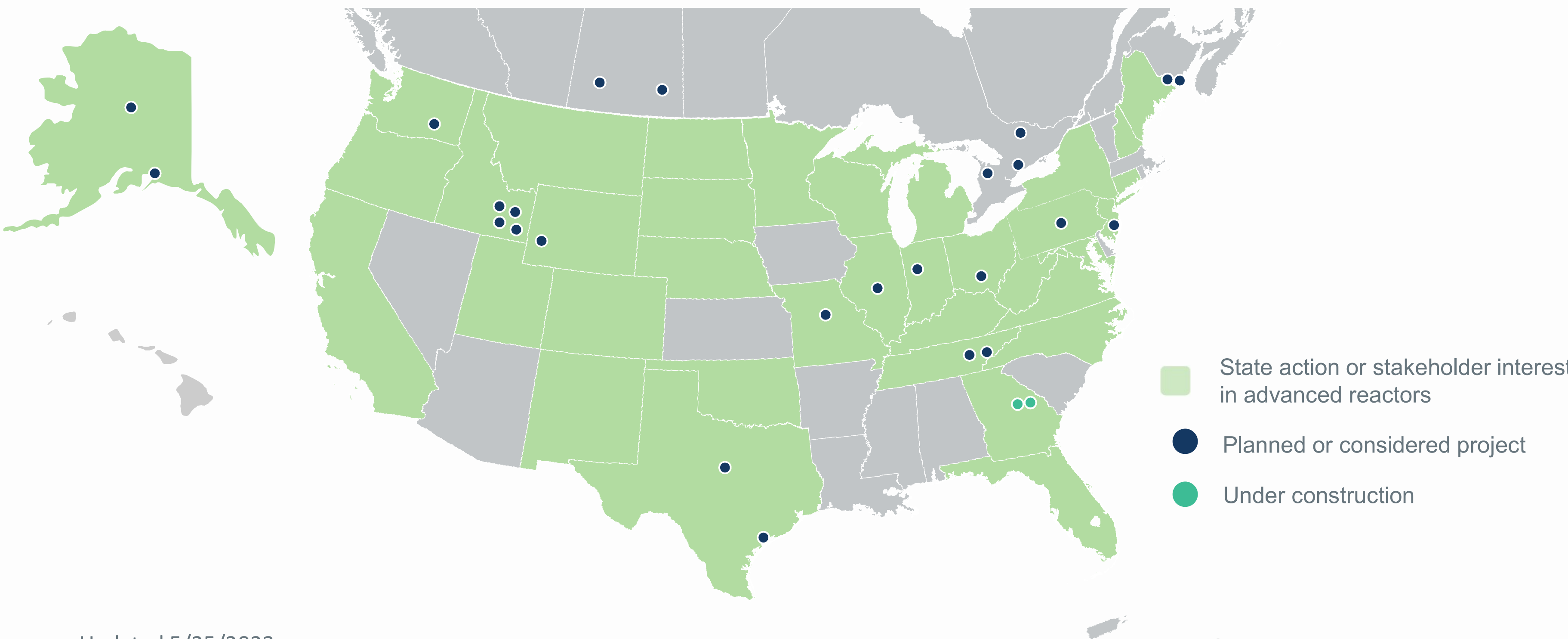


Source: Nuclear Cogeneration, civil nuclear energy in a low-carbon future, The Royal Society, October 2020

Market Opportunities

Advanced Nuclear Deployment Plans

Projects in planning or under consideration in U.S. and Canada >20; Globally >30



Updated 5/25/2023

Advanced Reactor Deployment Plans

Micro-reactors and low scale test reactors

Updated 5/25/2023

Developer	Utility / User	Location	Size	Target Online
Oklo	Oklo	Idaho, USA	15 MWe	2026
	Oklo	Ohio, USA	2 @ 15 MWe	2028
	Compass Mining	TBD	TBD (150 MWe total)	TBD
Ultra Safe Nuclear	Global First / OPG	CRL, Canada	5 MWe	2025
	University of Illinois	Illinois, USA	5 MWe	2027
	Copper Valley (CVEA)	Alaska, USA	5 MWe	TBD
Westinghouse	Sask Research Council	West Canada	5 MWe	2027
	Bruce Power	ON, Canada	5 MWe	2027
	Penn State University	USA	5 MWe	2027
Radiant	TBA	Idaho, USA	1.2 MWe	2026
TBD	Eielson AFB	Alaska, USA	1 – 10 MWe	2027
BWXT	DoD SCO	Idaho, USA	1.5 MWe	2024
Kairos Power	Kairos	TN, USA	35 MWth	2026
Natura	Abilene Christian University	TX, USA	1 MWth	2025
TBD	Univ. of Missouri	MO, USA	TBD	TBD

Advanced Reactor Licensing Progress

Approved	Under Review	Pre-Application
1. NuScale Power	1. Abiline Christian University	1. GEH BWR X-300
	2. Kairos Power	2. General Atomics
	3. NuScale (power uprate)	3. Holtec SMR-160
		4. Kairos Power
		5. Oklo
		6. TerraPower Natrium
		7. TerraPower MCFR
		8. Terrestrial
		9. Univ. of Illinois U-C
		10. X-energy
		11. Westinghouse

Micro-Reactor

Resource Planning

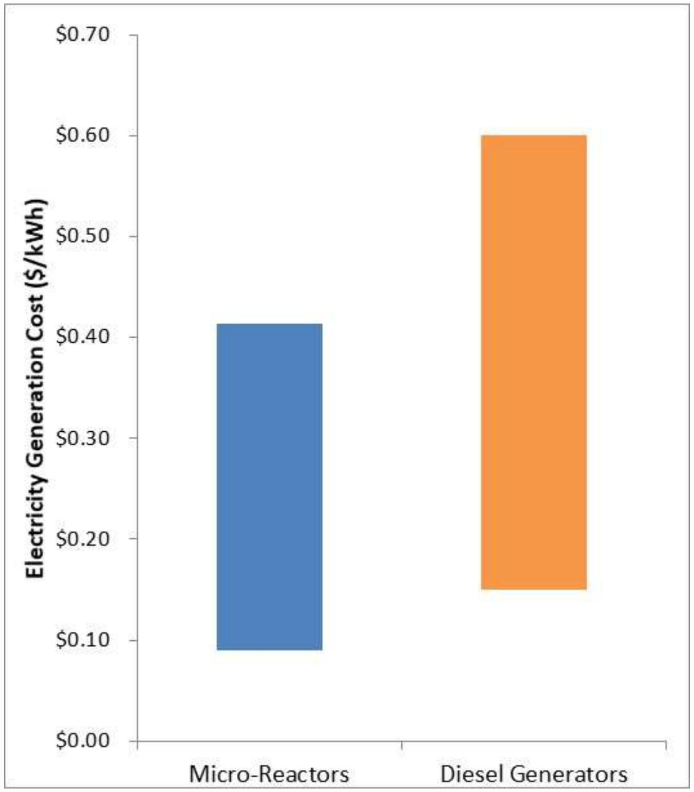
Benefits	Considerations	Planning Options
• Fuel diversity • Carbon-free • Flexible/dispatchable • Resilience/reliability • Renewables integration • Repower retired fossil sites	• Schedule • Cost • Risks • Environmental • Economic benefits	• Monitoring • Planning • Evaluating sites • Licensing • Project initiation

http://smrstart.org/wp-content/uploads/2020/02/SMR-Start-Public-SMRs-in-IRPs-APPROVED-2020-02-28.pdf

Cost Comparison

Full cost of micro-reactor vs only diesel fuel cost

- Diesel generator costs
  - Primarily fuel costs
  - Fuel from $2.86/gallon to $4.89/gallon
- Micro-reactor costs
  - Include used fuel disposal and decommissioning
  - 10 year fuel life
  - 40 year plant life
  - 95% capacity factor



NEI: *Cost Competitiveness of Micro-Reactors for Remote Markets*, April 2019

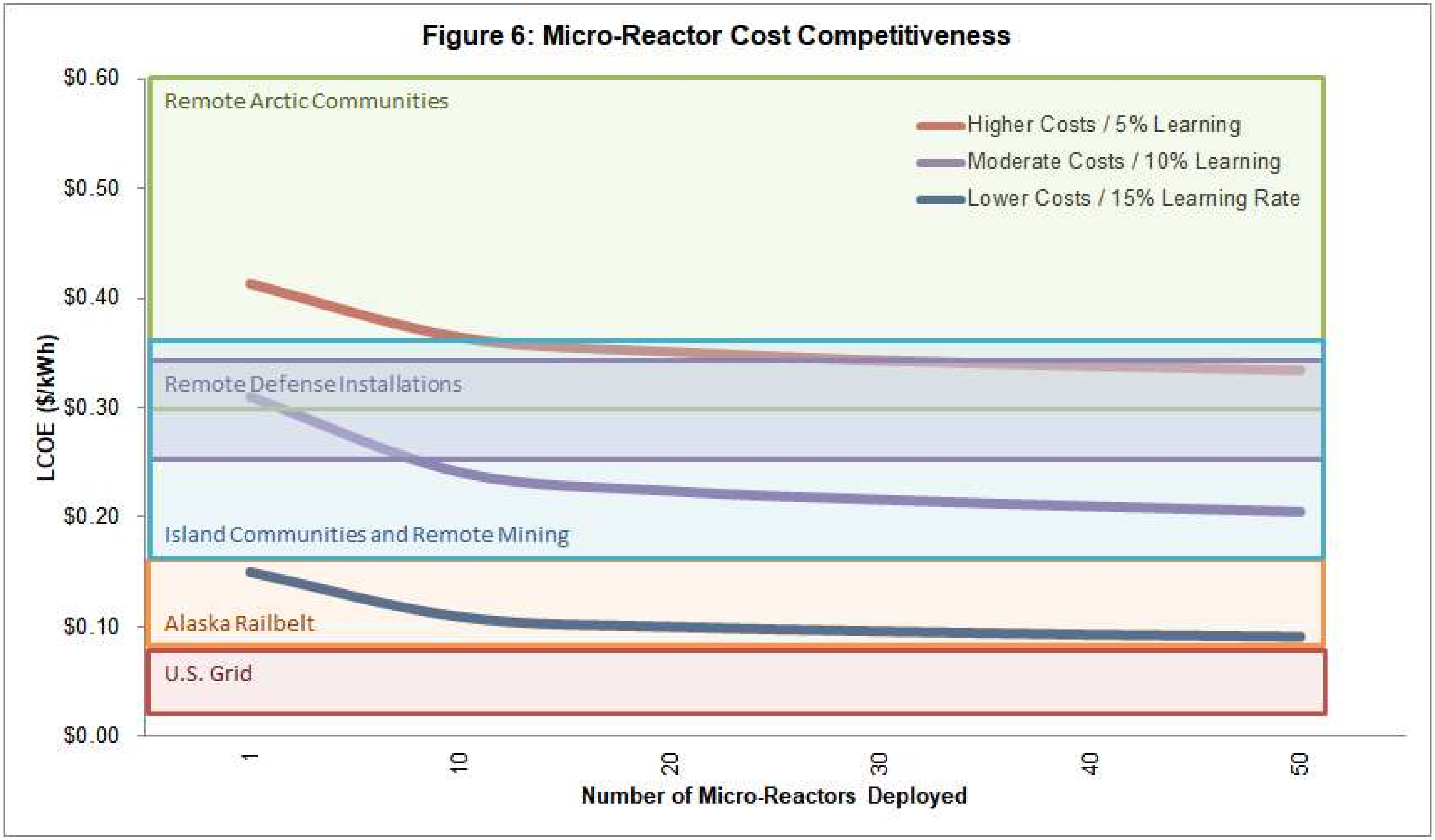


Figure 6: Micro-Reactor Cost Competitiveness
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
LCOE ($/kWh)
Remote Arctic Communities
Higher Costs / 5% Learning
Moderate Costs / 10% Learning
Lower Costs / 15% Learning Rate
Remote Defense Installations
Island Communities and Remote Mining
Alaska Railbelt
U.S. Grid
1
10
20
30
40
50
Number of Micro-Reactors Deployed

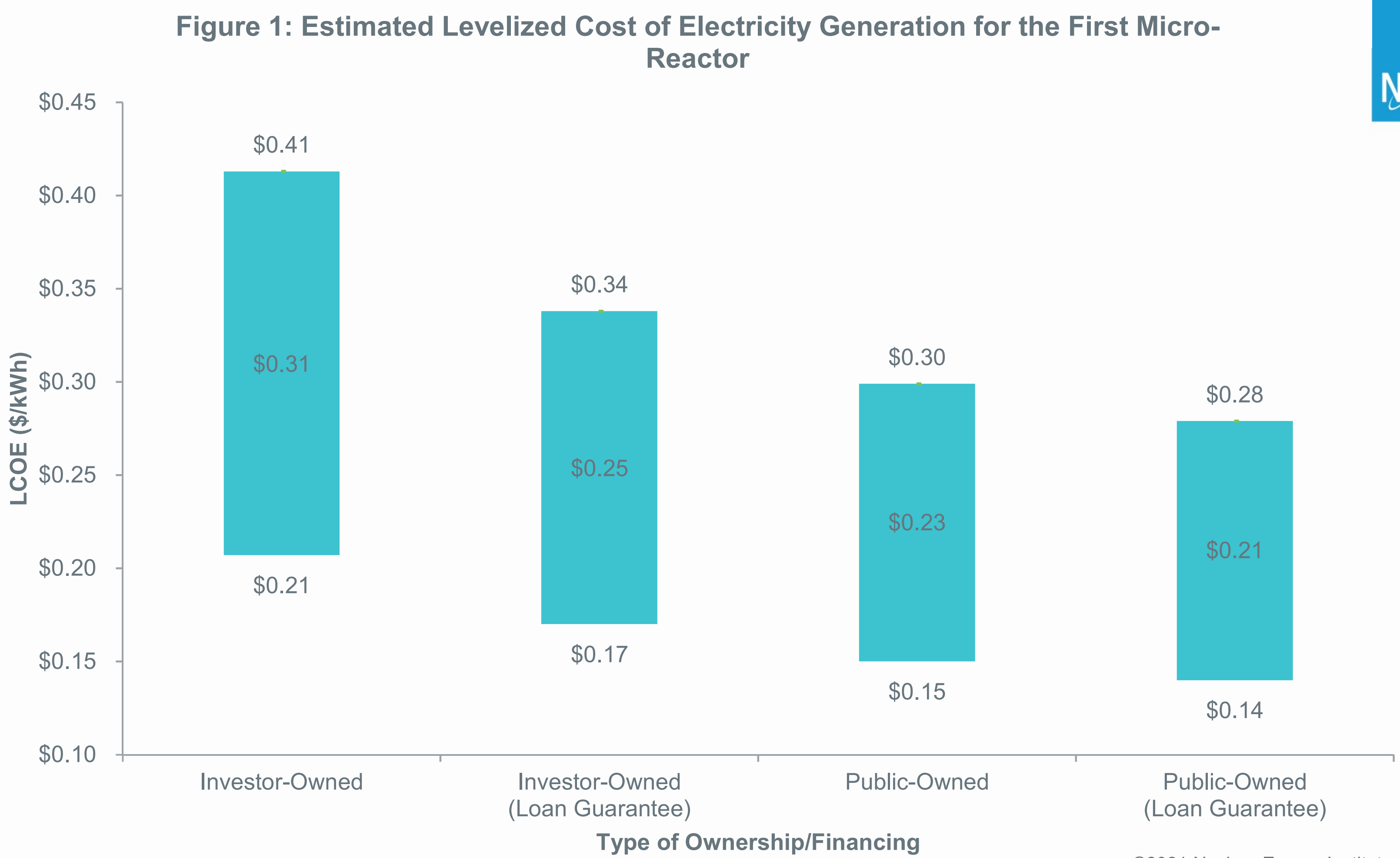


Figure 1: Estimated Levelized Cost of Electricity Generation for the First Micro-Reactor
LCOE ($/kWh)
$0.45
$0.40
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.41
$0.31
$0.21
$0.34
$0.25
$0.17
$0.30
$0.23
$0.15
$0.28
$0.21
$0.14
Investor-Owned
Investor-Owned (Loan Guarantee)
Public-Owned
Public-Owned (Loan Guarantee)
Type of Ownership/Financing

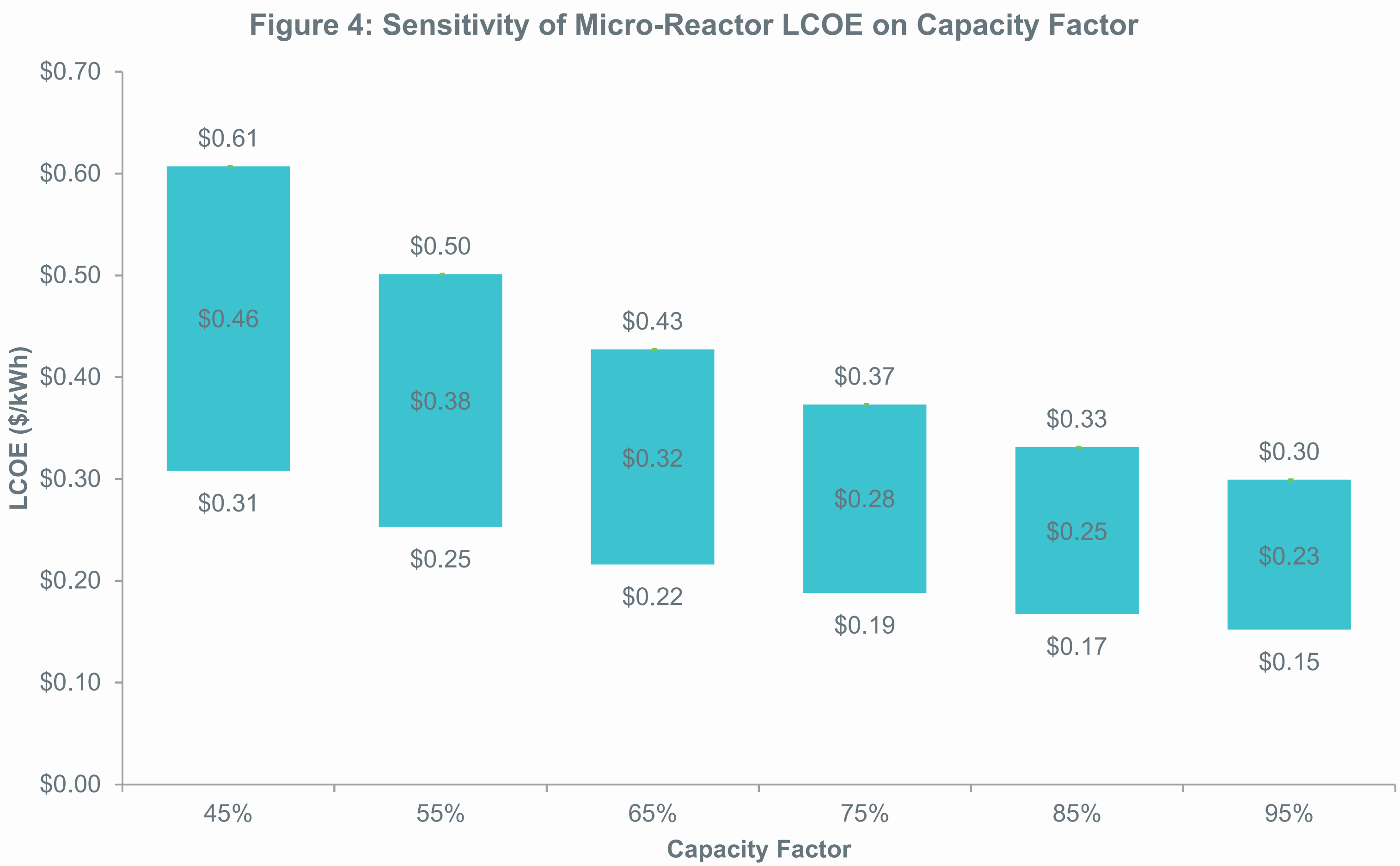


Figure 4: Sensitivity of Micro-Reactor LCOE on Capacity Factor
LCOE ($/kWh)
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
$0.61
$0.46
$0.31
$0.50
$0.38
$0.25
$0.43
$0.32
$0.22
$0.37
$0.28
$0.19
$0.33
$0.25
$0.17
$0.30
$0.23
$0.15
45%
55%
65%
75%
85%
95%
Capacity Factor

Financing Micro-Reactors

Capital Costs of 5 MWe plant = $50M to $100M*

- Conventional business model
  - Local utility finances capital costs
  - Financing typically by debt at low rates, amortized
- New business models
  - Developer owns and operates plant, uses a Power Purchase Agreement
  - Local utility does not finance capital costs, only pays for power
- Similarities and differences
  - In both: customers only pay as levelized cost of capital
  - New business model: developer bears bulk of financial risk of project

*Derived from NEI *Cost Competitiveness of Micro-Reactors for Remote Markets*, April 2019
https://nei.org/resources/reports-briefs/cost-competitiveness-micro-reactors-remote-markets

Micro-Reactor Workforce

Target <10 employees to power rural areas

Technology enablers	NRC considering for micro-reactors
Safety and simplicity in design	Minimal worker training and qualifications
Automatic operations	Operators allowed additional duties (e.g., maintenance, administrative)
Remote operations	No operator needed on site
Security by design	No armed security guards needed

- Hub areas: population sizes that can supply workers
  - Direct use of electricity and heat with existing grid and district heating
- Spoke areas: population sizes that cannot supply workers
  - Electric transmission from hub region (if close by); OR
  - Use hydrogen or ammonia from hub region (low-cost due to economics of micro-reactors and short transport distances)

Lowest System Cost Achieved by Enabling Large Scale New Nuclear Deployment

Lowest Cost System

Nuclear is 43% of generation (>300 GW of new nuclear)

Wind and solar are 50%

Energy System with Nuclear Constrained

Wind and Solar are 77% of generation

Nuclear is 13% (>60 GW of new nuclear)

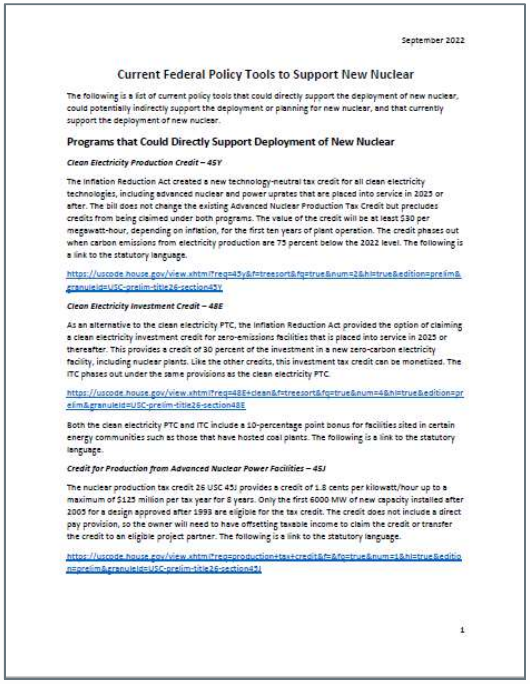
Increased cost to customers of $449 Billion

Both scenarios are successful in reducing electricity grid GHG emissions by over 95% by 2050 and reducing the economy-wide GHG emissions by over 60%

Source: Vibrant Clean Energy: https://www.vibrantcleanenergy.com/media/reports/

Strong Federal Support for Advanced Reactors

- DOE funding 12 different designs, >$5B over 7 years
- Infrastructure Bill
  - $2.5B funding for two demonstration projects
- Inflation Reduction Act
  - PTC: At least $30/MWh for 10 years
  - ITC: 30% of investment
  - Both can be monetized, include 10% bonus for siting in certain energy communities
  - Loan Guarantees – up to $40B in expanded authority
  - HALEU Fuel - $700M
- CHIPS Act
  - Financial assistance to States, Tribes, local governments and Universities


September 2022

Current Federal Policy Tools to Support New Nuclear

The following is a list of current policy tools that could directly support the deployment of new nuclear, could potentially indirectly support the deployment or planning for new nuclear, and that currently support the deployment of new nuclear.

Programs that Could Directly Support Deployment of New Nuclear

Clean Electricity Production Credit – 45Y

The Inflation Reduction Act created a new technology-neutral tax credit for all clean electricity technologies, including advanced nuclear and power uprates that are placed into service in 2025 or after. The bill does not change the existing Advanced Nuclear Production Tax Credit but precludes credits from being claimed under both programs. The value of the credit will be at least $30 per megawatt-hour, depending on inflation, for the first ten years of plant operation. The credit phases out when carbon emissions from electricity production are 75 percent below the 2022 level. The following is a link to the statutory language.

https://uscode.house.gov/view.xhtml?req=45y&f=treesort&fq=true&num=2&hl=true&edition=prelim&granuleId=USC-prelim-title26-section45Y

Clean Electricity Investment Credit – 48E

As an alternative to the clean electricity PTC, the Inflation Reduction Act provided the option of claiming a clean electricity investment credit for zero-emissions facilities that is placed into service in 2025 or thereafter. This provides a credit of 30 percent of the investment in a new zero-carbon electricity facility, including nuclear plants. Like the other credits, this investment tax credit can be monetized. The ITC phases out under the same provisions as the clean electricity PTC.

https://uscode.house.gov/view.xhtml?req=48E+clean&f=treesort&fq=true&num=4&hl=true&edition=prelim&granuleId=USC-prelim-title26-section48E

Both the clean electricity PTC and ITC include a 10-percentage point bonus for facilities sited in certain energy communities such as those that have hosted coal plants. The following is a link to the statutory language.

Credit for Production from Advanced Nuclear Power Facilities – 45J

The nuclear production tax credit 26 USC 45J provides a credit of 1.8 cents per kilowatt/hour up to a maximum of $125 million per tax year for 8 years. Only the first 6000 MW of new capacity installed after 2005 for a design approved after 1993 are eligible for the tax credit. The credit does not include a direct pay provision, so the owner will need to have offsetting taxable income to claim the credit or transfer the credit to an eligible project partner. The following is a link to the statutory language.

https://uscode.house.gov/view.xhtml?req=production+tax+credit&f=&fq=true&num=1&hl=true&edition=prelim&granuleId=USC-prelim-title26-section45J

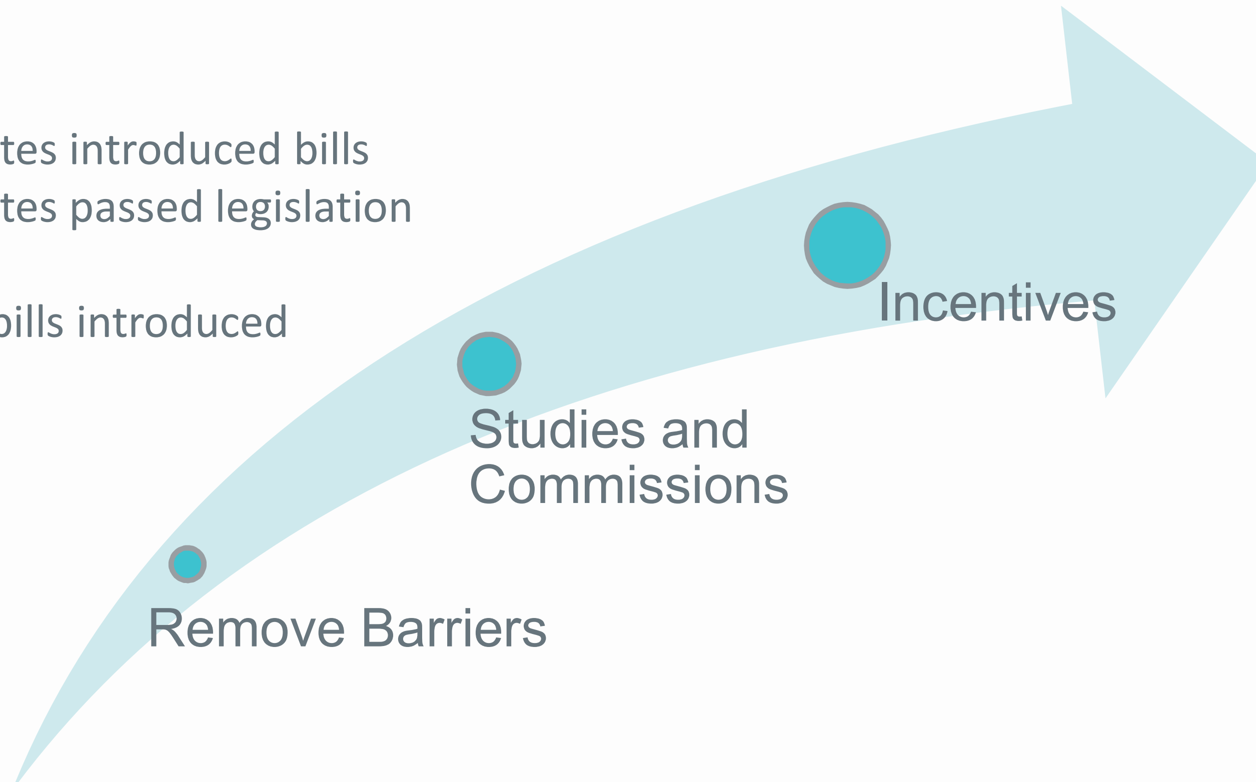
1

Current Federal Policies: https://www.nei.org/CorporateSite/media/filefolder/advantages/Current-Policy-Tools-to-Support-New-Nuclear.pdf

State Action for Advance Reactors

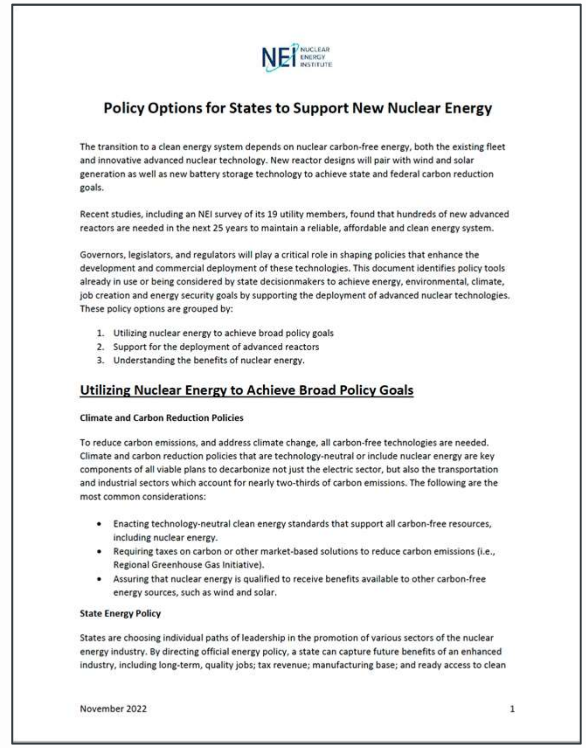
2022
- 19 States introduced bills
- 11 States passed legislation

2023
- 100+ bills introduced



State Options to Support Advanced Reactors

- Feasibility Studies
- Reducing Barriers
- Tax incentives (e.g., property)
- Advanced cost recovery
- Workforce and infrastructure



NEI NUCLEAR ENERGY INSTITUTE

Policy Options for States to Support New Nuclear Energy

The transition to a clean energy system depends on nuclear carbon-free energy, both the existing fleet and innovative advanced nuclear technology. New reactor designs will pair with wind and solar generation as well as new battery storage technology to achieve state and federal carbon reduction goals.

Recent studies, including an NEI survey of its 19 utility members, found that hundreds of new advanced reactors are needed in the next 25 years to maintain a reliable, affordable and clean energy system.

Governors, legislators, and regulators will play a critical role in shaping policies that enhance the development and commercial deployment of these technologies. This document identifies policy tools already in use or being considered by state decisionmakers to achieve energy, environmental, climate, job creation and energy security goals by supporting the deployment of advanced nuclear technologies. These policy options are grouped by:

1. Utilizing nuclear energy to achieve broad policy goals
2. Support for the deployment of advanced reactors
3. Understanding the benefits of nuclear energy.

Utilizing Nuclear Energy to Achieve Broad Policy Goals

Climate and Carbon Reduction Policies

To reduce carbon emissions, and address climate change, all carbon-free technologies are needed. Climate and carbon reduction policies that are technology-neutral or include nuclear energy are key components of all viable plans to decarbonize not just the electric sector, but also the transportation and industrial sectors which account for nearly two-thirds of carbon emissions. The following are the most common considerations:

- Enacting technology-neutral clean energy standards that support all carbon-free resources, including nuclear energy.
- Requiring taxes on carbon or other market-based solutions to reduce carbon emissions (i.e., Regional Greenhouse Gas Initiative).
- Assuring that nuclear energy is qualified to receive benefits available to other carbon-free energy sources, such as wind and solar.

State Energy Policy

States are choosing individual paths of leadership in the promotion of various sectors of the nuclear energy industry. By directing official energy policy, a state can capture future benefits of an enhanced industry, including long-term, quality jobs; tax revenue; manufacturing base; and ready access to clean

November 2022 1

State Policy Options: https://www.nei.org/resources/reports-briefs/policy-options-for-states-to-support-new-nuclear

QUESTIONS?

By Third Way, GENSLER

Small Scale Nuclear Power
an option for Alaska?

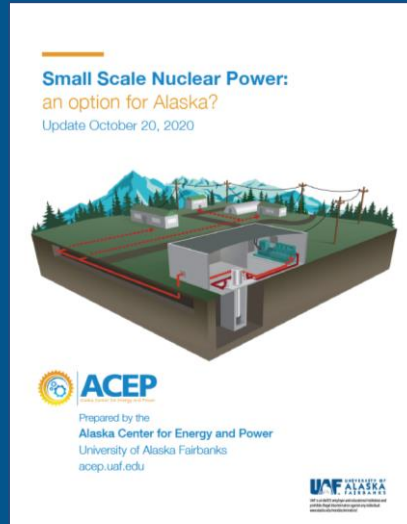
Gwen Holdmann,
Alaska Center for Energy and Power, University of Alaska Fairbanks

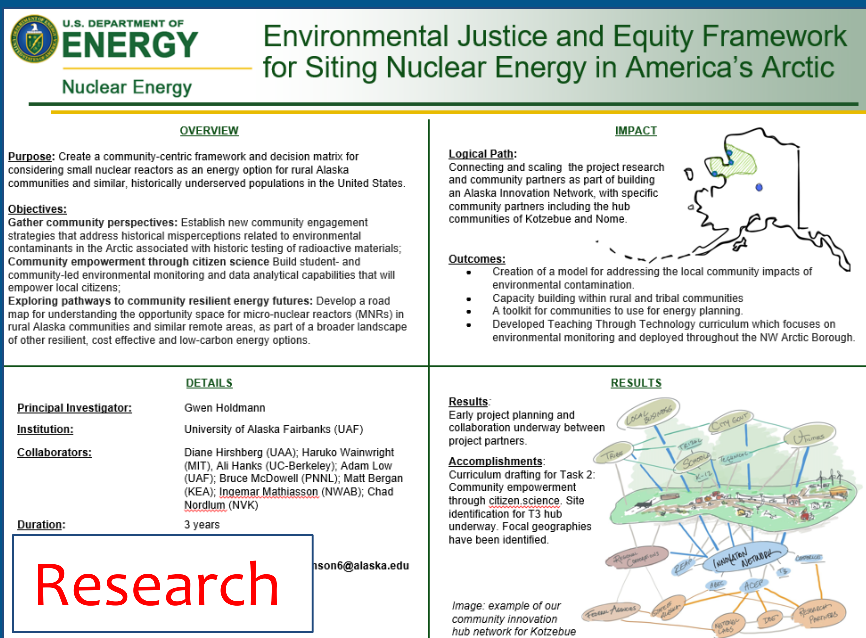
Presentation Agenda

PART 1: Context/intro

PART 2: Alaska Perceptions

PART 3: Alaska "Strategy" around nuclear energy





U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Environmental Justice and Equity Framework for Siting Nuclear Energy in America's Arctic

OVERVIEW

Purpose: Create a community-centric framework and decision matrix for considering small nuclear reactors as an energy option for rural Alaska communities and similar, historically underserved populations in the United States.

Objectives:
Gather community perspectives: Establish new community engagement strategies that address historical misperceptions related to environmental contaminants in the Arctic associated with historic testing of radioactive materials;
Community empowerment through citizen science Build student- and community-led environmental monitoring and data analytical capabilities that will empower local citizens;
Exploring pathways to community resilient energy futures: Develop a road map for understanding the opportunity space for micro-nuclear reactors (MNRs) in rural Alaska communities and similar remote areas, as part of a broader landscape of other resilient, cost effective and low-carbon energy options.

IMPACT

Logical Path:
Connecting and scaling the project research and community partners as part of building an Alaska Innovation Network, with specific community partners including the hub communities of Kotzebue and Nome.

Outcomes:
- Creation of a model for addressing the local community impacts of environmental contamination.
- Capacity building within rural and tribal communities
- A toolkit for communities to use for energy planning.
- Developed Teaching Through Technology curriculum which focuses on environmental monitoring and deployed throughout the NW Arctic Borough.

DETAILS

Principal Investigator:	Gwen Holdmann
Institution:	University of Alaska Fairbanks (UAF)
Collaborators:	Diane Hirshberg (UAA); Haruko Wainwright (MIT), Ali Hanks (UC-Berkeley); Adam Low (UAF); Bruce McDowell (PNNL); Matt Bergan (KEA); Ingemar Mathiasson (NWAB); Chad Nordlum (NVK)
Duration:	3 years

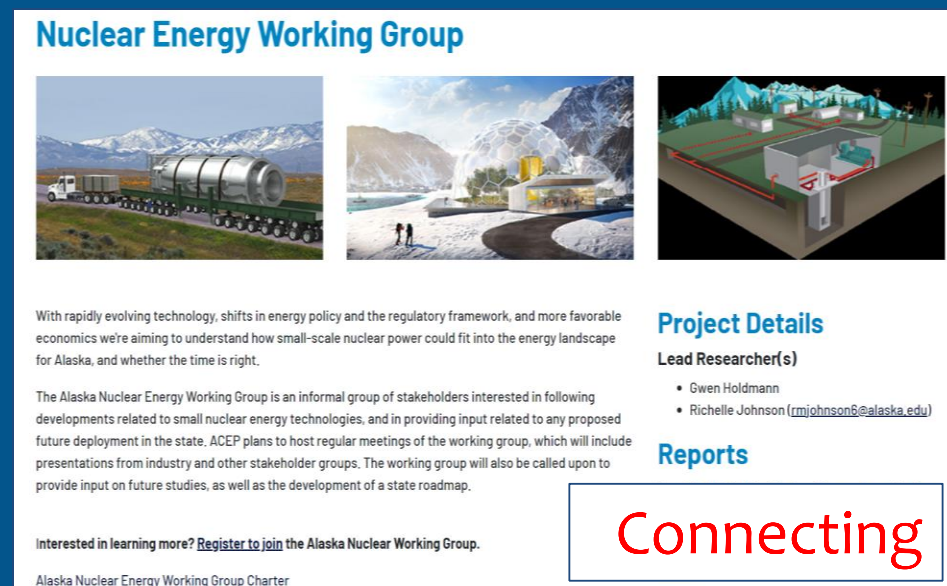
...nson6@alaska.edu

RESULTS

Results:
Early project planning and collaboration underway between project partners.

Accomplishments:
Curriculum drafting for Task 2: Community empowerment through citizen.science. Site identification for T3 hub underway. Focal geographies have been identified.

Image: example of our community innovation hub network for Kotzebue



Nuclear Energy Working Group

With rapidly evolving technology, shifts in energy policy and the regulatory framework, and more favorable economics we're aiming to understand how small-scale nuclear power could fit into the energy landscape for Alaska, and whether the time is right.

The Alaska Nuclear Energy Working Group is an informal group of stakeholders interested in following developments related to small nuclear energy technologies, and in providing input related to any proposed future deployment in the state. ACEP plans to host regular meetings of the working group, which will include presentations from industry and other stakeholder groups. The working group will also be called upon to provide input on future studies, as well as the development of a state roadmap.

Interested in learning more? Register to join the Alaska Nuclear Working Group.

Alaska Nuclear Energy Working Group Charter

Project Details

Lead Researcher(s)

- Gwen Holdmann
- Richelle Johnson (rmjohnson6@alaska.edu)

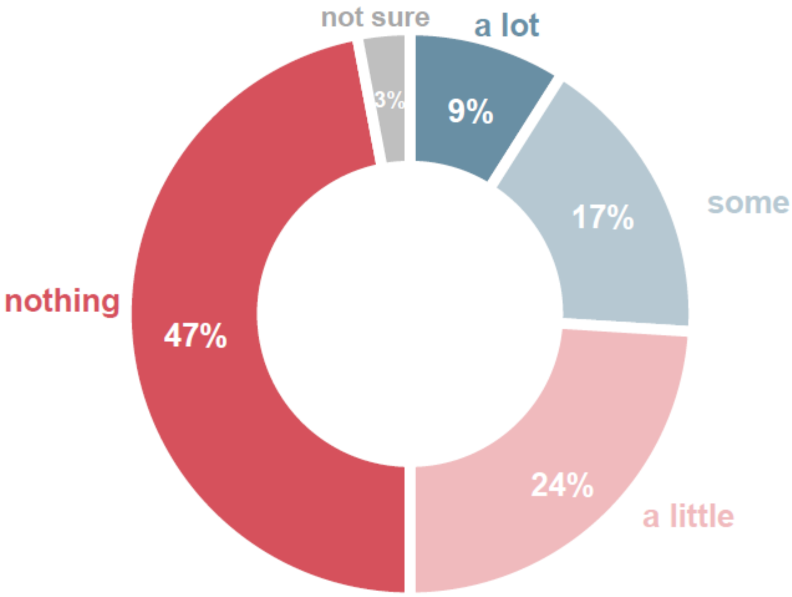
Reports

S360 Poll (Perception on Nuclear)

- Multi-modal survey 700 registered voters, oversample Fairbanks (172)
- Weighted to accurately represent Alaska's electorate
- Completed by phone May 23-June 4th
- Margin of error 4% (7.5% for Fairbanks)

When it comes to microreactors, there is a large information gap across subgroups.

Amount heard about nuclear microreactors*

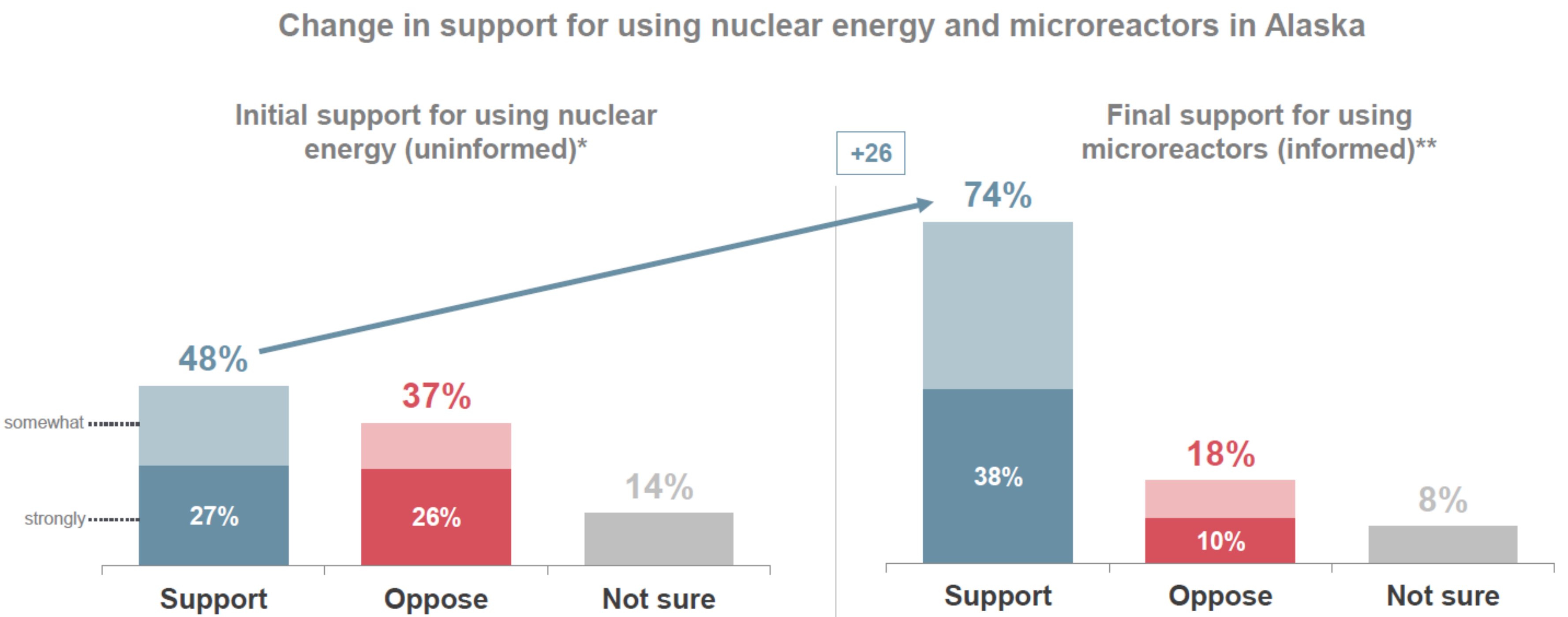


	total heard a lot/some
Anchorage	29
Fairbanks	32
Kenai	21
Matsu	23
Southeast	16
Rural*	23
Age 18-49	27
Age 50+	24
Democrat	28
Independent	28
Republican	24
Live comfortably	33
Struggling to get by	21

*Small sample size

*How much, if anything, have you heard about a new type of nuclear technology called advanced microreactors?

With little to go on, support for nuclear is tepid … after more information is provided, support grows considerably

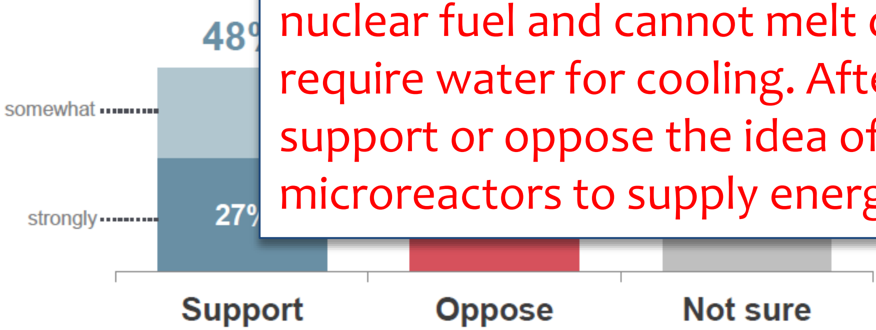


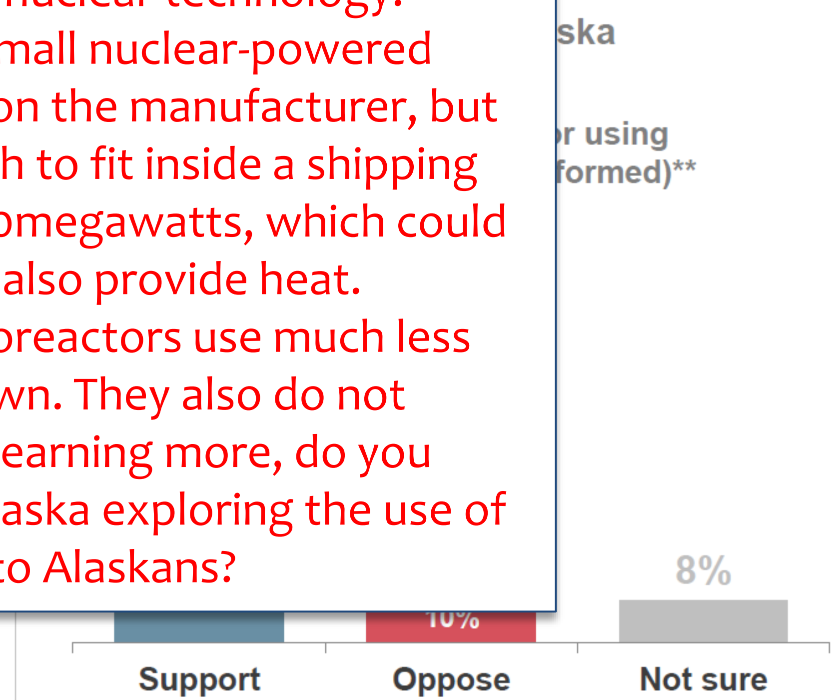
*Based on what you know right now, do you support or oppose the idea of using nuclear energy in Alaska?
**A nuclear microreactor is a small nuclear reactor that is much smaller than conventional nuclear technology. Microreactors are essentially a small nuclear-powered battery. They vary in size based on the manufacturer, but in general would be small enough to fit inside a shipping container and produce around 10 megawatts, which could power around 7,000 homes and also provide heat. Because of their small size, microreactors use much less nuclear fuel and cannot melt down. They also do not require water for cooling. After learning more, do you support or oppose the idea of Alaska exploring the use of microreactors to supply energy to Alaskans?

ACEP Alaska Center for Energy and Power

With little to go on, support for nuclear is tepid … after more information is provided, support grows considerably

**A nuclear microreactor is a small nuclear reactor that is much smaller than conventional nuclear technology. Microreactors are essentially a small nuclear-powered battery. They vary in size based on the manufacturer, but in general would be small enough to fit inside a shipping container and produce around 10megawatts, which could power around 7,000 homes and also provide heat. Because of their small size, microreactors use much less nuclear fuel and cannot melt down. They also do not require water for cooling. After learning more, do you support or oppose the idea of Alaska exploring the use of microreactors to supply energy to Alaskans?





*Based on what you know right now, do you support or oppose the idea of using nuclear energy in Alaska?
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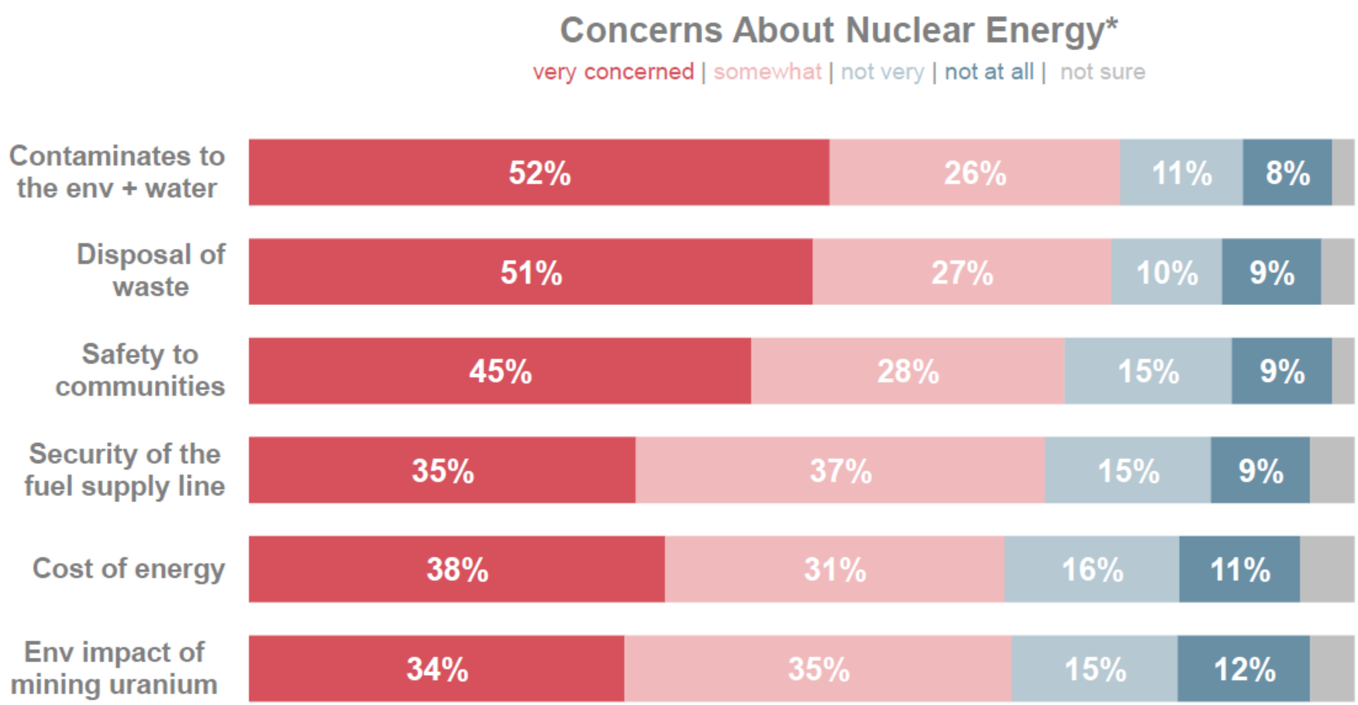
Information changes perceptions

Change in support for using nuclear energy and microreactors in Alaska

Support	Initial	Final	Δ
Total	48	74	+26
Anchorage	50	76	+26
Fairbanks	59	76	+17
Kenai	54	75	+21
Matsu	49	77	+28
Southeast	36	62	+26
Rural*	29	61	+32
Age 18-49	53	78	+25
Age 50+	42	68	+26
Democrat	42	76	+34
Independent	51	80	+29
Republican	56	72	+16

Support	Initial	Final	Δ
Total	48	74	+26
White	53	77	+24
POC	39	68	+29
Live comfortably	57	79	+22
Struggling to get by	43	72	+29
Affordable energy bills	52	74	+22
Unaffordable energy bills	41	72	+31
Heard of microreactors	71	80	+9
Haven't heard	41	72	+31

Voter concerns center on environmental contaminants and waste disposal



Concerned	Not concerned
79%	19%
78%	19%
73%	25%
72%	23%
69%	26%
69%	27%

*How concerned are you about the following things when it comes to nuclear energy?

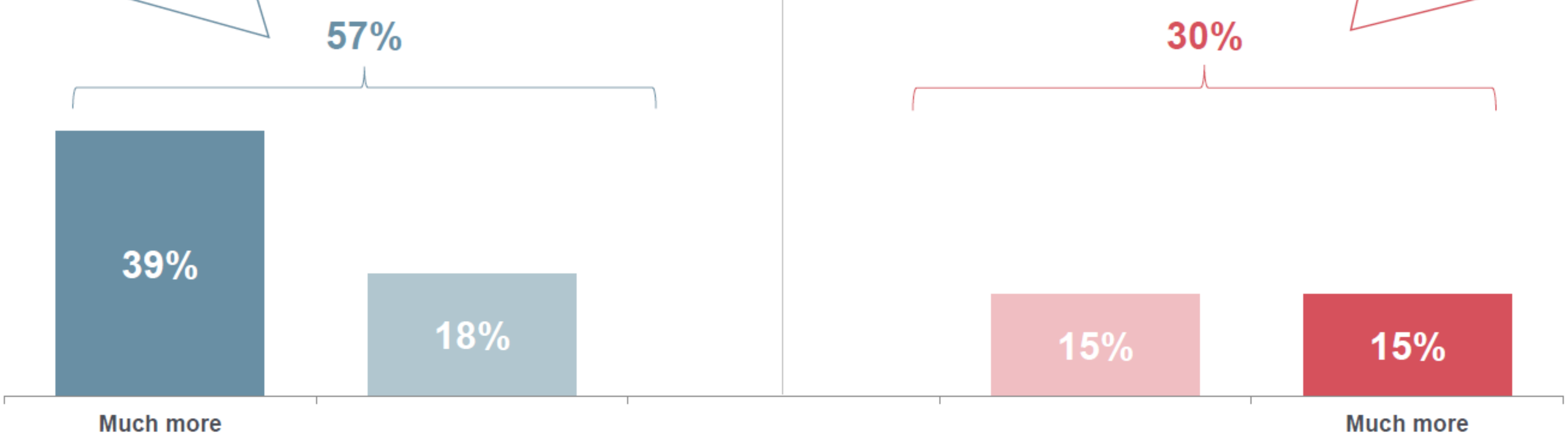
ACEP
Alaska Center for Energy and Power

Messaging

Messaging on microreactors as a safe, reliable piece of Alaska's approach to clean energy and addressing climate change stands up well to criticisms of the technology.

Alaska **should explore developing nuclear microreactors** as a diversified part of the state's energy supply mix. **Nuclear energy is a clean energy option** that will reduce greenhouse gas emissions and **mitigate climate change**. Technological advancements have made it possible to use safe microreactors that can provide a **consistent and steady supply of cleaner, lower-cost energy to Alaskans**.

Nuclear power plants are **an unproven technology** that **poses safety risks** to the people and environment around them. Additionally, nuclear power plants are **expensive to build and operate**. Nuclear energy is not an efficient use of the state's resources, which are better spent on the other issues facing Alaska right now.



*Please indicate which statement comes closer to your own view, even if neither is exactly right.

Perceptions are largely non-partisan

Top statement by key subgroup

	Alaska should explore developing microreactors…	Nuclear power plants are an unproven technology	Net "Should explore"
Total	57	30	+27
Heard of microreactors	73	18	+55
Haven't heard	53	33	+20
Always supportive	87	10	+77
Move to support	47	37	+10
Always opposed	14	73	-59
Democrat	58	22	+36
Independent	61	31	+30
Republican	56	36	+20

ACEP Alaska Center for Energy and Power

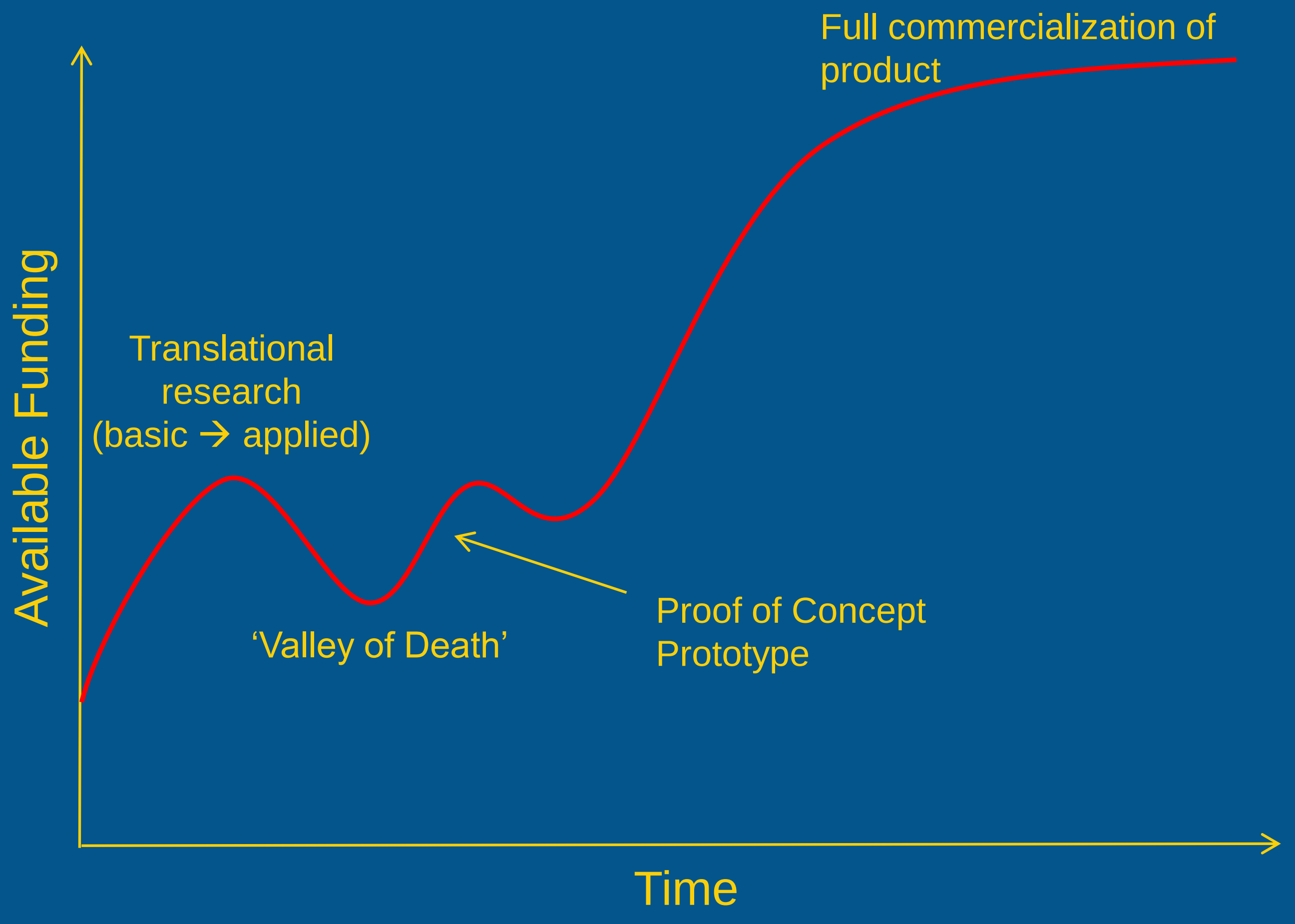
Alaska Strategy: *factors to consider*

- SB 194 – local control of siting authority for small reactors (<50 MW)
- Alaska is a near-ideal early adopter market (high cost of energy, heat + power)
- Interest from vendors
- Risk associated with being an early adopter (economic, technological, public perception, etc)
- Opportunity for state/federal partnership
- Passive or active decision making

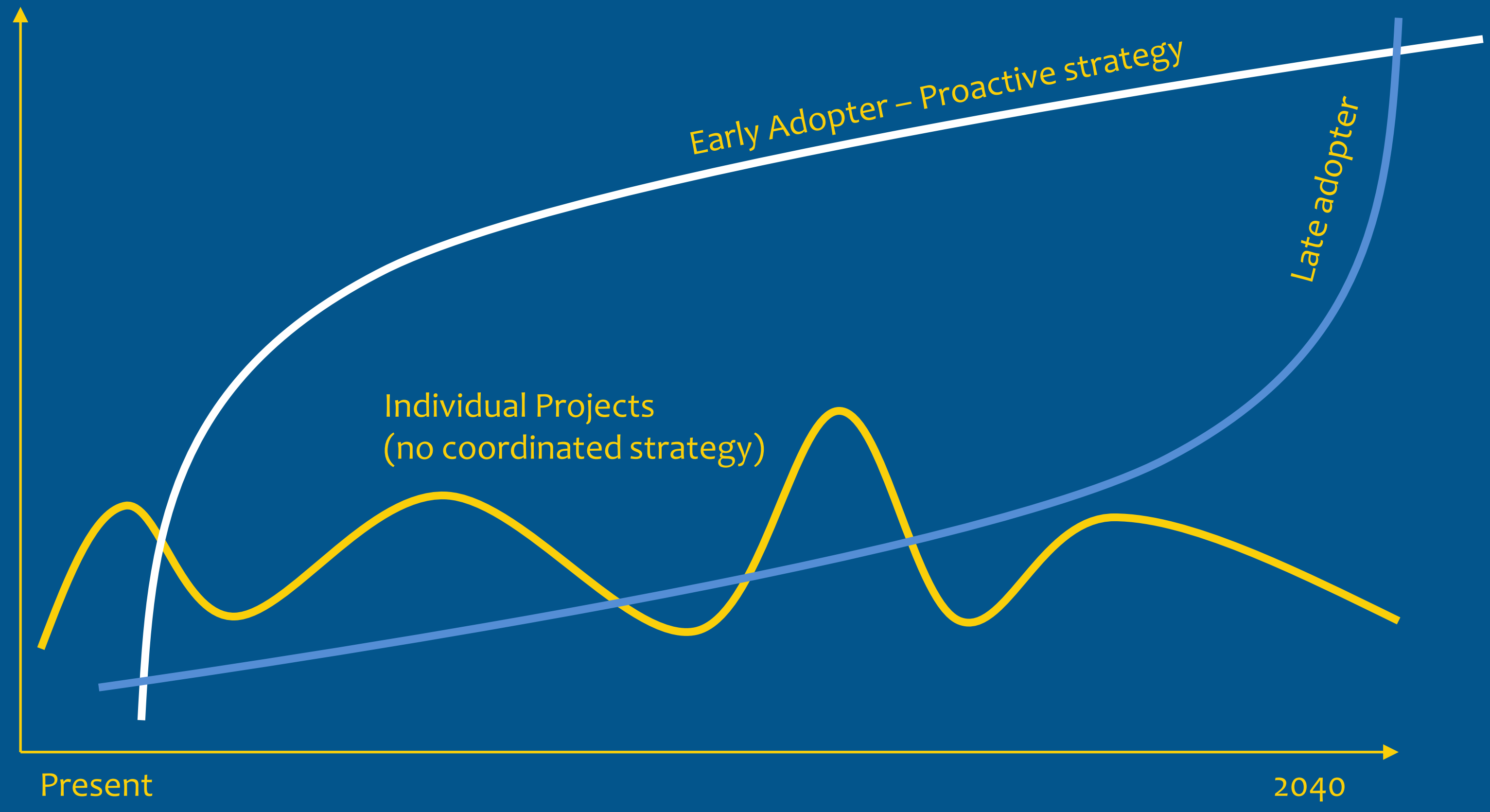
Weighing Risk versus Reward for Pilot Projects

GVEA BESS (above);
Healy Clean Coal Project (right)

Valley of Death
Bridge to Financeability



Alaska Pathways



Issues/considerations

- Public is not well informed
- Utilities (most) are taking a passive approach
- Traditional approaches to procurement and project development may not be optimal for early projects (RFS versus RFP)
- Announcement TODAY! Re: Eielson AFB reactor
- Lack of coordination – opportunity for Task Force

Why I am interested in small reactors:

- *Baseload heat and power*
- *Compliment to variable renewables*
- *Carbon free*
- *Safer, Reduced risk of environmental contamination*
- *Competitive Pricing?*
- *Better long-term certainty of energy costs*
- *Possible complement to existing AK resource mix*

Thank you!

Gwen Holdmann
Alaska Center for Energy and Power
University of Alaska Fairbanks
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RPS AND CLEAN ENERGY STANDARDS: NATIONAL POLICY COMPARISONS

Thursday, September 7, 2023, 11:00 AM – 1:00 PM

- *Renewable Energy Standards and Clean Energy Standard Overview*

Renewable Energy Standards and Clean Energy Standards Overview

Jenny Sumner
Modeling & Analysis Group Manager
September 7, 2023

RPS and CES Overview

Renewable Portfolio Standard (RPS) Overview

- An RPS is a public policy tool requiring a certain amount of renewable electricity relative to the entire electricity supply.
- RPSs are an enforceable form of renewable energy targets (vs. a renewable “goal”)
- RPS policies are all unique: different motivations, target types, and technology approaches exist
- An RPS can set a share of energy demand (e.g. 20% of electricity supply) or a fixed amount of energy production or consumption (e.g. GW or GWh)

Source: Jenny Heeter, Bethany Speer, and Mark B. Glick. International Best Practices for Renewable Portfolio Standard (RPS) Policies. 2019. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72798. https://www.nrel.gov/docs/fy19osti72798.pdf.

Key RPS Design Elements

- Typically set as a production target (in MWh)
- Typically established on an annual basis with an end-year target
- Provide a list of eligible technologies
- Determine whether renewable imports are eligible
- Establish a compliance and enforcement structure

Table 2. Examples of Key Components of an RPS

Key Component	Example
Target	20% renewable electricity by 2050
Interim schedule	5% renewable electricity by 2020, 10% by 2030, 15% by 2040
Eligible resources	All solar photovoltaics, wind, biomass, and hydropower facilities less than 10 MW that began commercial operation on or after July 1, 2019
Compliance entities	All load-serving electricity companies with more than 50,000 customers
Regulatory entity	Public Utilities Commission
Penalties for noncompliance	$50/MWh

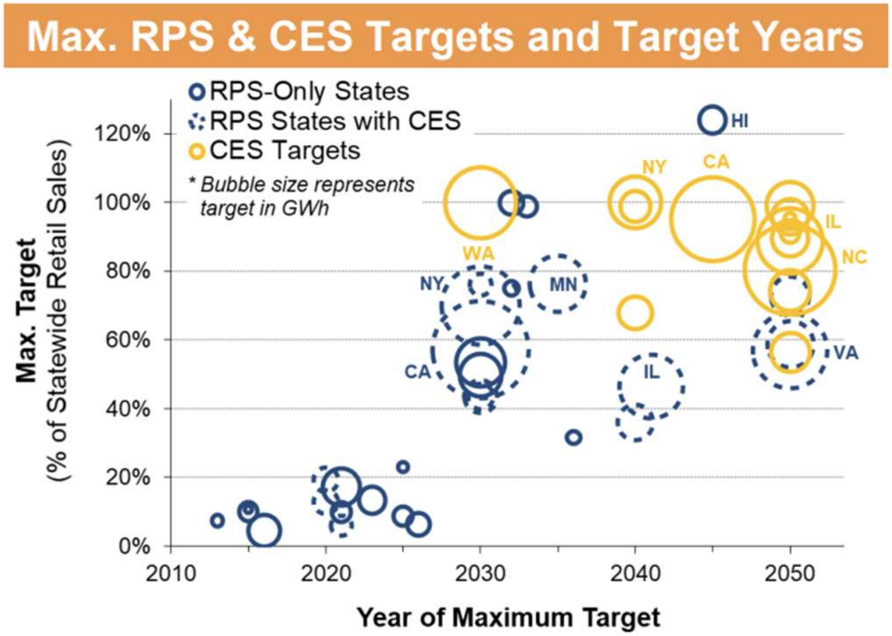
Source: Jenny Heeter, Bethany Speer, and Mark B. Glick. International Best Practices for Renewable Portfolio Standard (RPS) Policies. 2019. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72798. https://www.nrel.gov/docs/fy19osti72798.pdf.

Clean Electricity Standards (CES) Overview

- A CES is similar to an RPS, but the includes a broader set of eligible resources
- Many states have not yet defined the implementation or enforcement mechanism for their CES policy
- CES adoption has accelerated in recent years, and states typically adopt a “100%” CES

Key CES Design Elements

- CES adoption is typically in combination with an RPS
- CESs typically focus on longer-term (2040-2050) targets
- CESs include higher percentage targets (80-100%) than RPSs



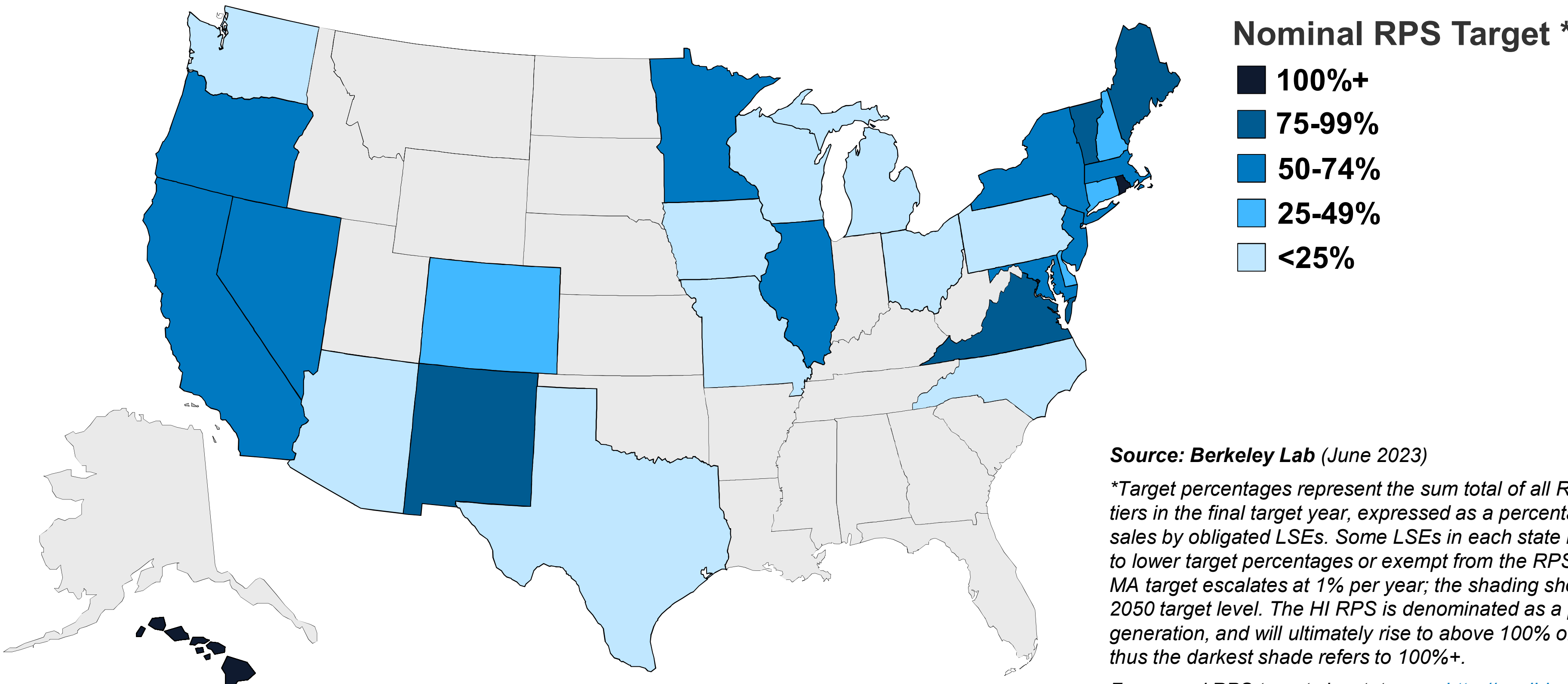
Notes: The figure shows each state's maximum RPS and CES percentage target and the associated year when that target must be reached. Targets are shown here as the percentage of total statewide retail sales, which may differ from nominal targets if those apply to only a subset of LSEs in a state. The RPS target for HI is denominated as a percent of total statewide generation, and thus is greater than 100% of retail sales. Bubble sizes represents the target in GWh terms; in the case of the CES targets, bubble sizes reflects only the incremental GWh above and beyond the RPS.

Source: https://eta-publications.lbl.gov/sites/default/files/lbnl_rps_ces_status_report_2023_edition.pdf

RPS and CES Policy Adoption

RPS Policies Exist in 29 States and DC

Apply to 58% of total U.S. retail electricity sales

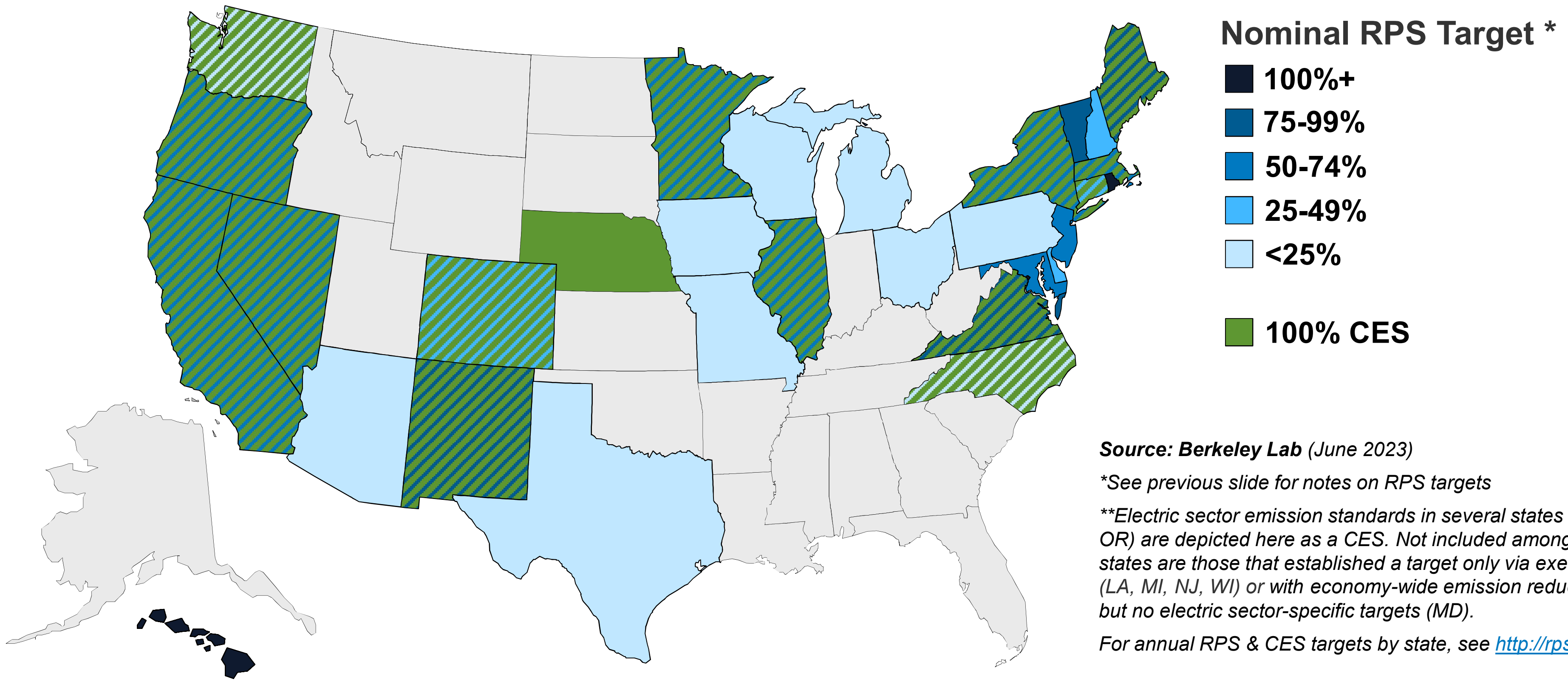


***Source: Berkeley Lab** (June 2023)*

**Target percentages represent the sum total of all RPS resource tiers in the final target year, expressed as a percentage of retail sales by obligated LSEs. Some LSEs in each state may be subject to lower target percentages or exempt from the RPS altogether. The MA target escalates at 1% per year; the shading shown reflects the 2050 target level. The HI RPS is denominated as a percent of generation, and will ultimately rise to above 100% of retail sales; thus the darkest shade refers to 100%+.*

For annual RPS targets by state, see http://rps.lbl.gov

15 States Have Established a Broader 100% CES **
Typically in combination with an RPS



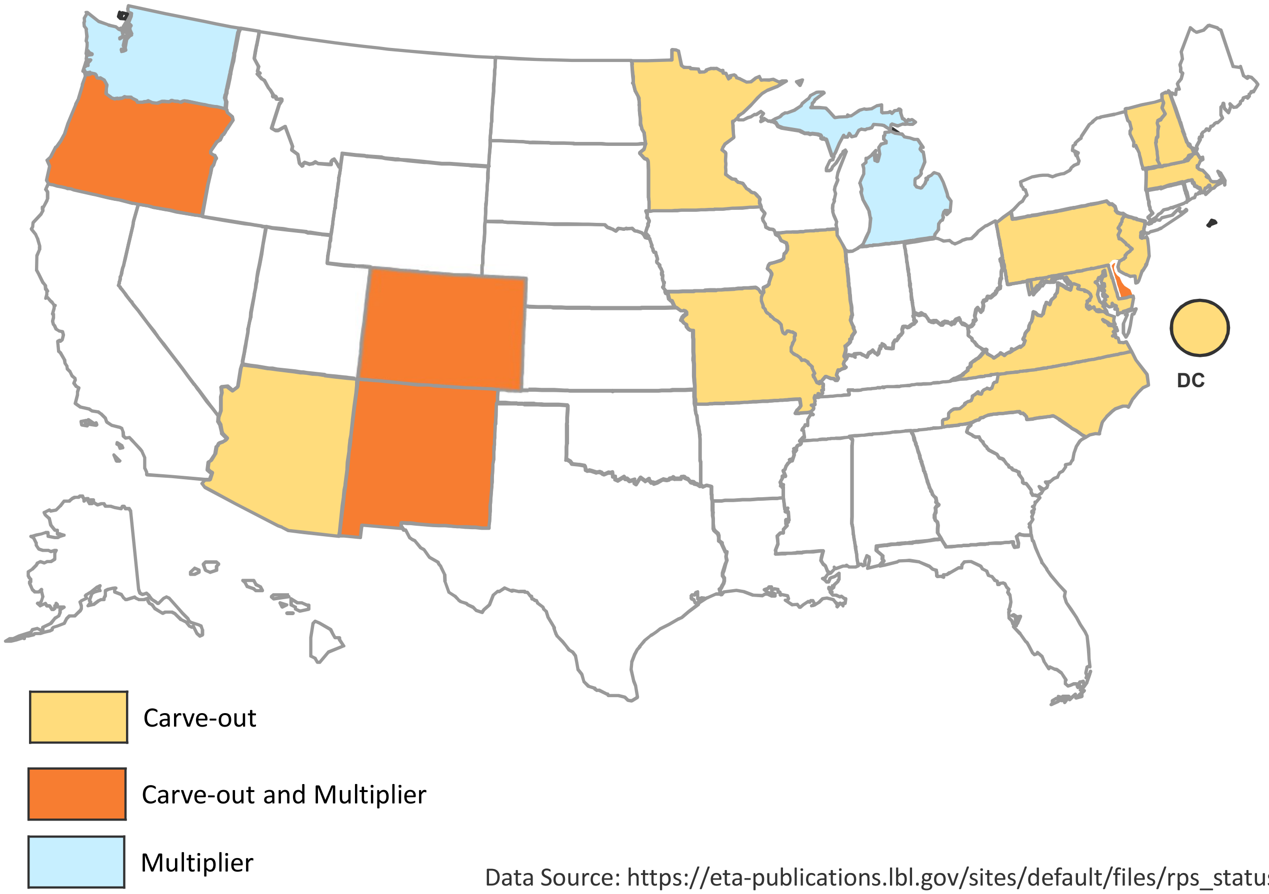
***Source: Berkeley Lab** (June 2023)*

**See previous slide for notes on RPS targets*

***Electric sector emission standards in several states (CO, NC, NV, OR) are depicted here as a CES. Not included among the CES states are those that established a target only via executive order (LA, MI, NJ, WI) or with economy-wide emission reduction targets but no electric sector-specific targets (MD).*

For annual RPS & CES targets by state, see http://rps.lbl.gov

Solar or Distributed Generation (DG) Carve-outs and Credit Multipliers



- 16 states + D.C. have solar or DG carve-outs, sometimes combined with credit multipliers
- 3 other states only have credit multipliers

Data Source: https://eta-publications.lbl.gov/sites/default/files/rps_status_update-2021_early_release.pdf

RPS and CES Resources

- NREL RPS basics: https://www.nrel.gov/analysis/rps.html
- LBNL Status and Trends in RPSs and CESs: https://emp.lbl.gov/projects/renewables-portfolio/
- Clean Energy States Alliance 100% Clean Energy Collaborative: https://www.cesa.org/projects/100-clean-energy-collaborative/

Thank you

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