Energy & Environmental Research Center (EERC)

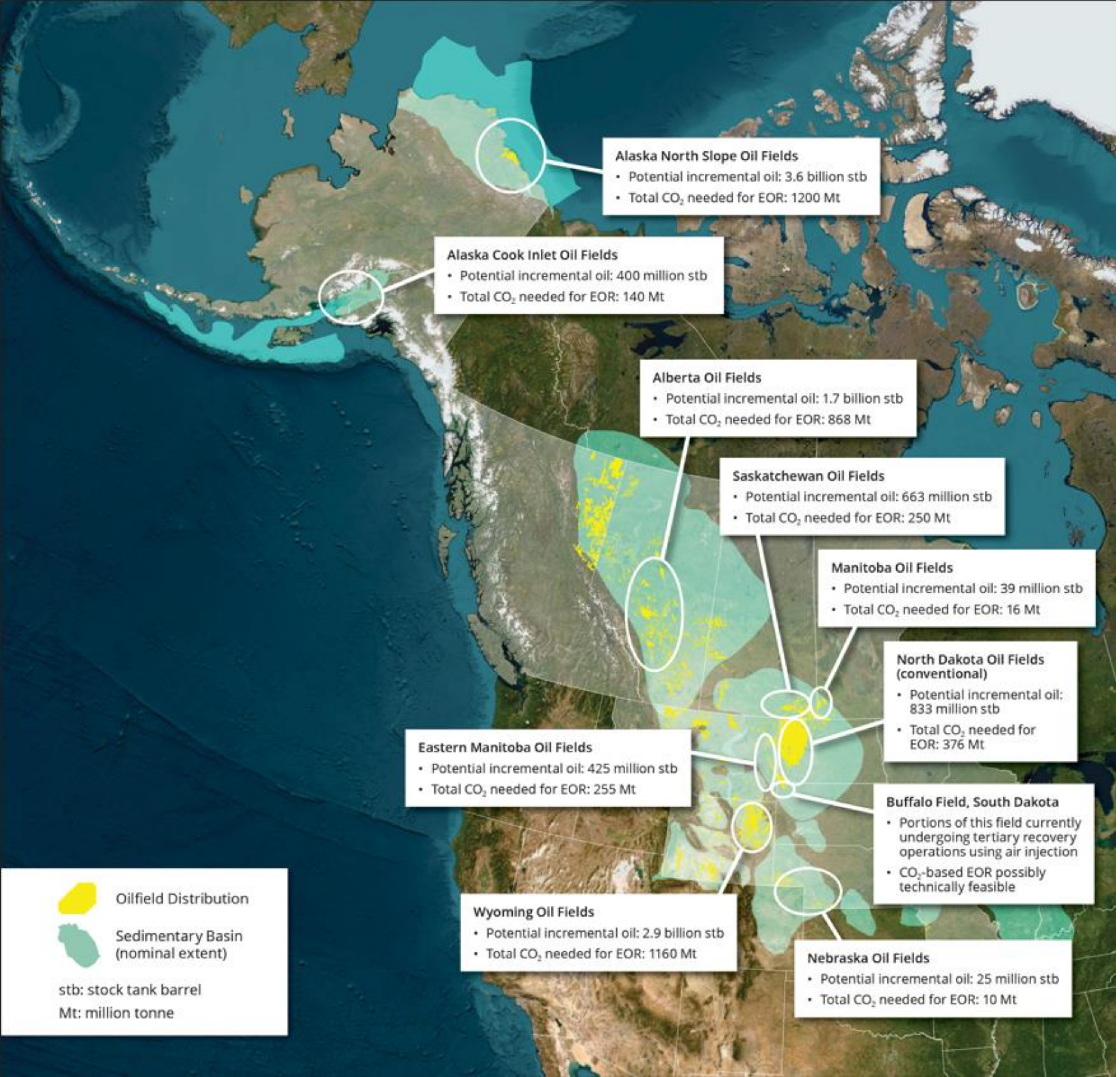
# SOURCE EMISSIONS

Regional Decarbonization Workshop – Alaska
Anchorage, Alaska
May 8, 2024

Jason D. Laumb
Director for Advanced Energy Initiatives

# OVERVIEW

- PCOR Partnership and University of Alaska Fairbanks – Institute of Northern Engineering
- PCOR Partnership region, $CO_2$ sources, and capture projects
- Characterization nature of Alaska $CO_2$ emissions
- Options for capturing/managing carbon and other considerations/challenges (impurities, power needed for capture, etc.)
- $CO_2$ concentration illustrations from various sources
- Special considerations related to Alaska sources compared to Lower 48 sources

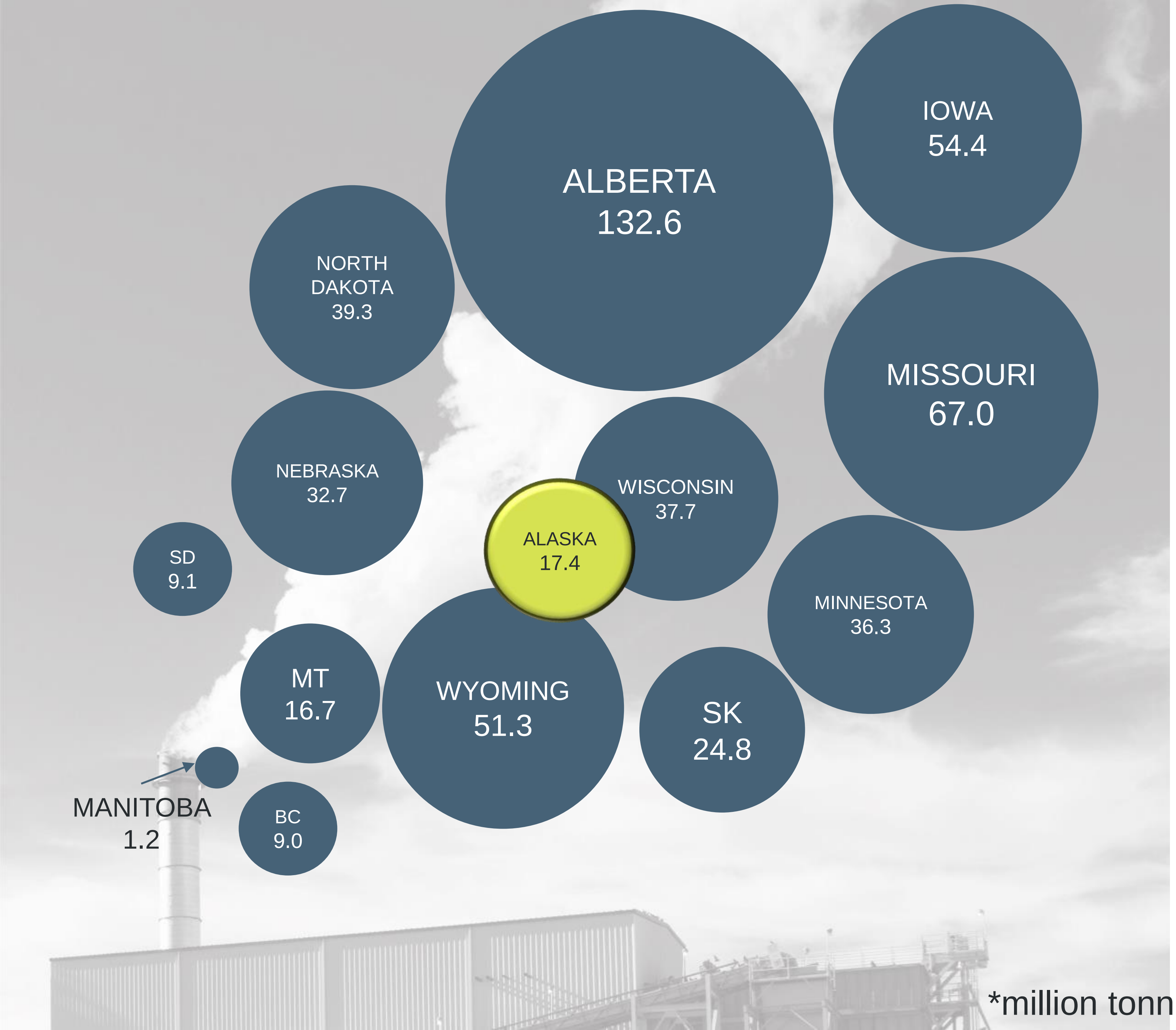


Alaska North Slope Oil Fields
• Potential incremental oil: 3.6 billion stb
• Total $CO_2$ needed for EOR: 1200 Mt
Alaska Cook Inlet Oil Fields
• Potential incremental oil: 400 million stb
• Total $CO_2$ needed for EOR: 140 Mt
Alberta Oil Fields
• Potential incremental oil: 1.7 billion stb
• Total $CO_2$ needed for EOR: 868 Mt
Saskatchewan Oil Fields
• Potential incremental oil: 663 million stb
• Total $CO_2$ needed for EOR: 250 Mt
Manitoba Oil Fields
• Potential incremental oil: 39 million stb
• Total $CO_2$ needed for EOR: 16 Mt
North Dakota Oil Fields (conventional)
• Potential incremental oil: 833 million stb
• Total $CO_2$ needed for EOR: 376 Mt
Eastern Manitoba Oil Fields
• Potential incremental oil: 425 million stb
• Total $CO_2$ needed for EOR: 255 Mt
Buffalo Field, South Dakota
• Portions of this field currently undergoing tertiary recovery operations using air injection
• $CO_2$-based EOR possibly technically feasible
Wyoming Oil Fields
• Potential incremental oil: 2.9 billion stb
• Total $CO_2$ needed for EOR: 1160 Mt
Nebraska Oil Fields
• Potential incremental oil: 25 million stb
• Total $CO_2$ needed for EOR: 10 Mt
Oilfield Distribution
Sedimentary Basin (nominal extent)
stb: stock tank barrel
Mt: million tonne

Received approval to pursue UIC Class VI primacy from EPA. Legislation under consideration addressing carbon storage licenses and leases on state land, unitization, and the establishment of a closure trust fund.
AK
Has adopted existing oil and gas regulations for $CO_2$ storage.
Has developed regulations for storage, pore space ownership, and long-term liability. Long-term liability is covered by the Post Closure Stewardship Fund to help cover the obligations assumed by Alberta after closure.
Has received UIC Class VI primacy approval.
Has legislation addressing pore space ownership. North Dakota takes over long-term liability of $CO_2$ storage with an established trust fund and per tonne fee.
Ministry of Natural Gas Development is developing a regulatory framework for CCS.
BC
AB
SK
MB
Has legislation addressing pore space ownership, long-term liability, and establishment of storage reservoir program fund. Implementation of this legislation is contingent upon application and approval of Class VI primacy.
MT
ND
MN
WI
SD
Has received UIC Class VI primacy approval.
Has legislation addressing pore space ownership; operator owns and is liable for stored $CO_2$. Established trust fund for long-term stewardship expenses.
WY
NE
IO
MO
Has legislation in place addressing pore space ownership; established a trust fund and per ton fee to cover long-term liability by the state.
No legislation in place, rules adopted, or under development.

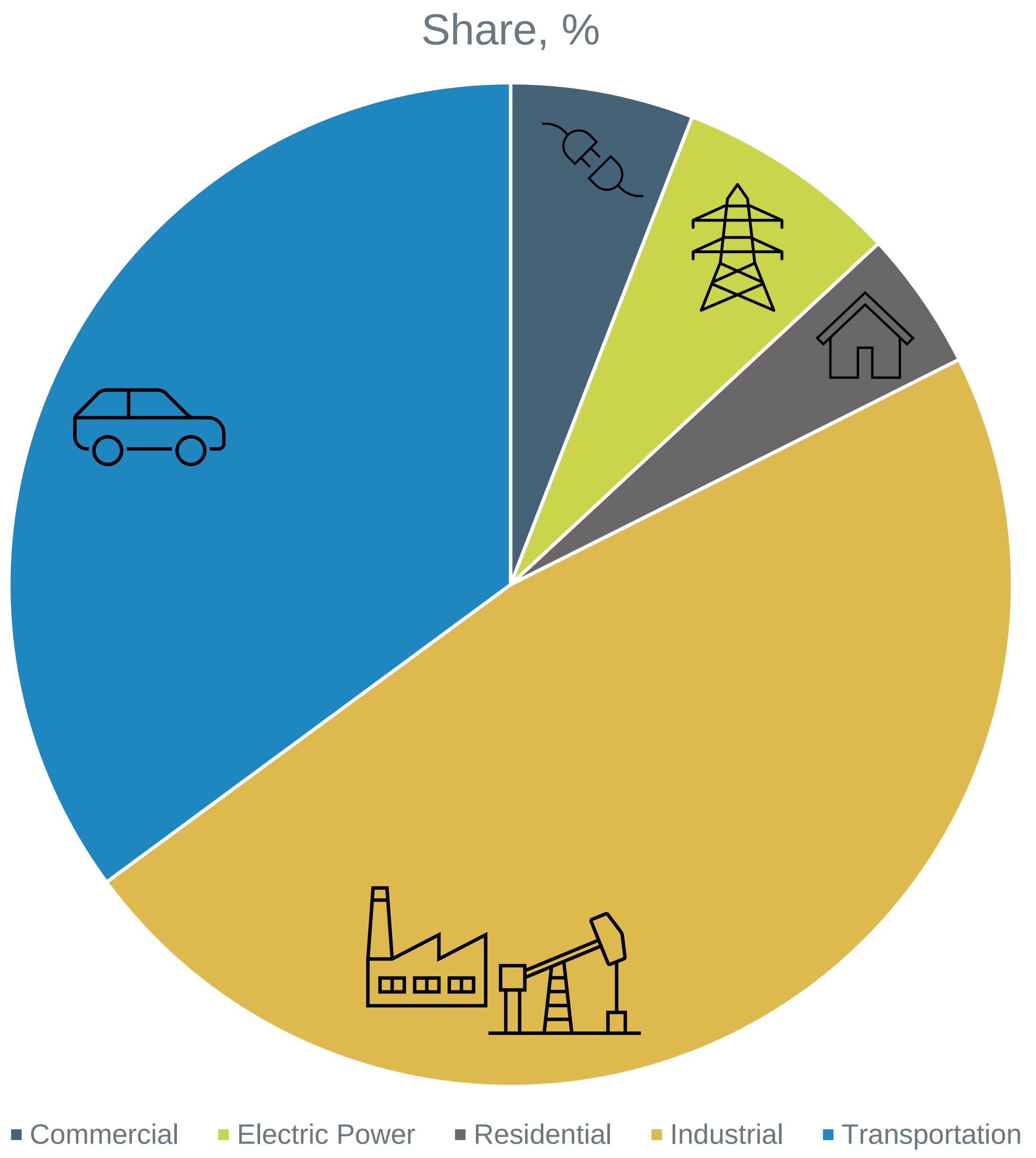

CANADA
UNITED STATES
MEXICO
Distribution of Sedimentary Basins Greater than 800 m Deep[28]
Sedimentary Basins

# ANNUAL $CO_2$ SOURCE EMISSIONS* IN THE PCOR PARTNERSHIP REGION

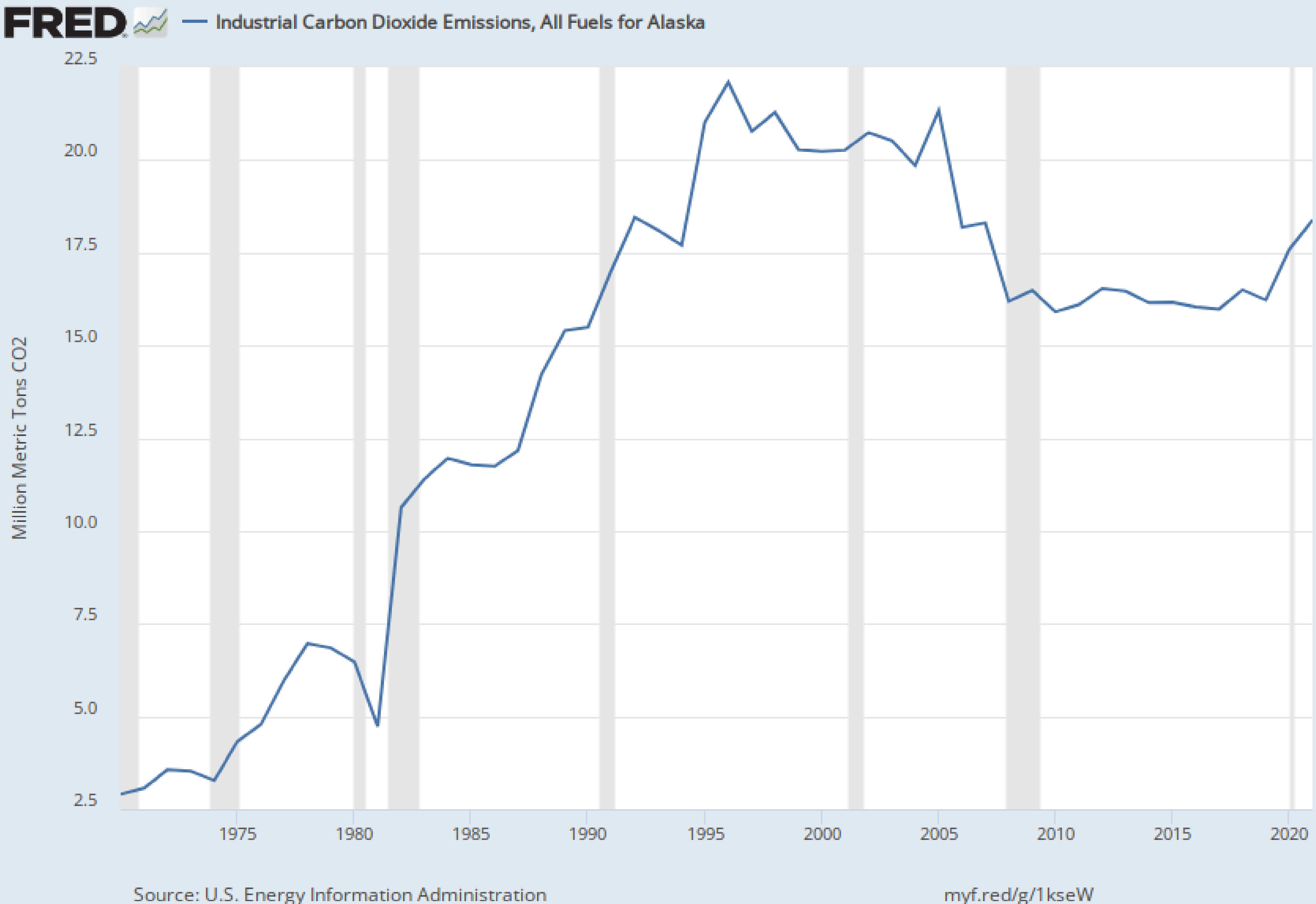


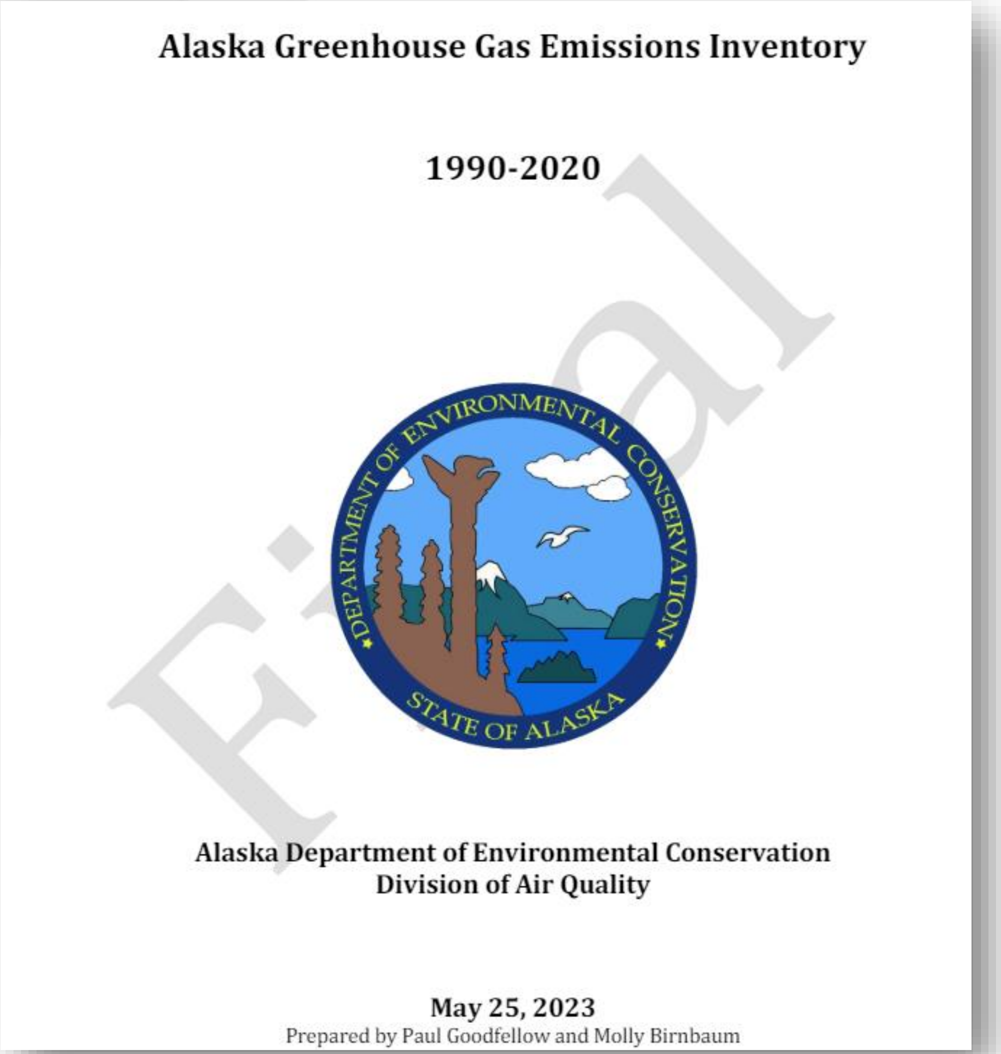

*million tonnes of $CO_2$/year

# ALASKA ENERGY-RELATED $CO_2$ EMISSIONS BY SECTOR




www.eia.gov


FRED
Industrial Carbon Dioxide Emissions, All Fuels for Alaska
Million Metric Tons CO2
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Source: U.S. Energy Information Administration
myf.red/g/1kseW


Alaska Greenhouse Gas Emissions Inventory

1990-2020

Final

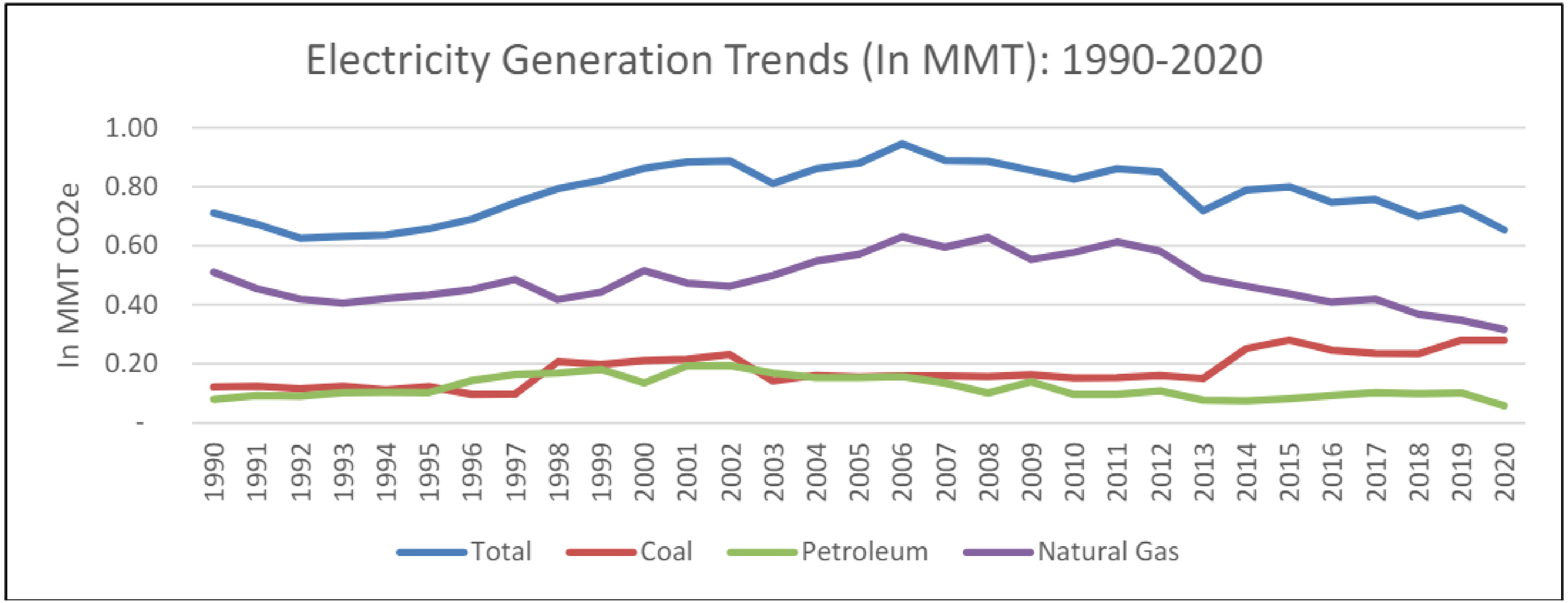
Alaska Department of Environmental Conservation
Division of Air Quality

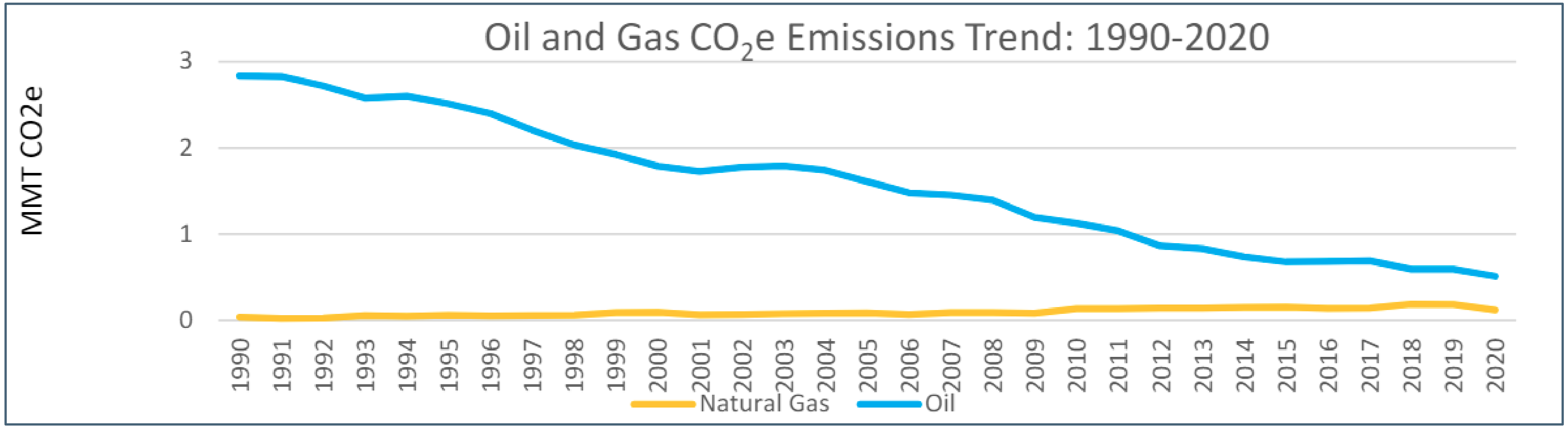
May 25, 2023
Prepared by Paul Goodfellow and Molly Birnbaum

- EIA rankings for Alaska (among states):
  - Total energy-related $CO_2$ emissions: 41*
  - Per capita emissions: 4
  - Total energy expenditures: 2
  - Total electrical generation: 49+
  - Total power generated by petroleum: 2
- Alaska GHG 2020 emissions:
  - 0.66% of nationwide GHG emissions

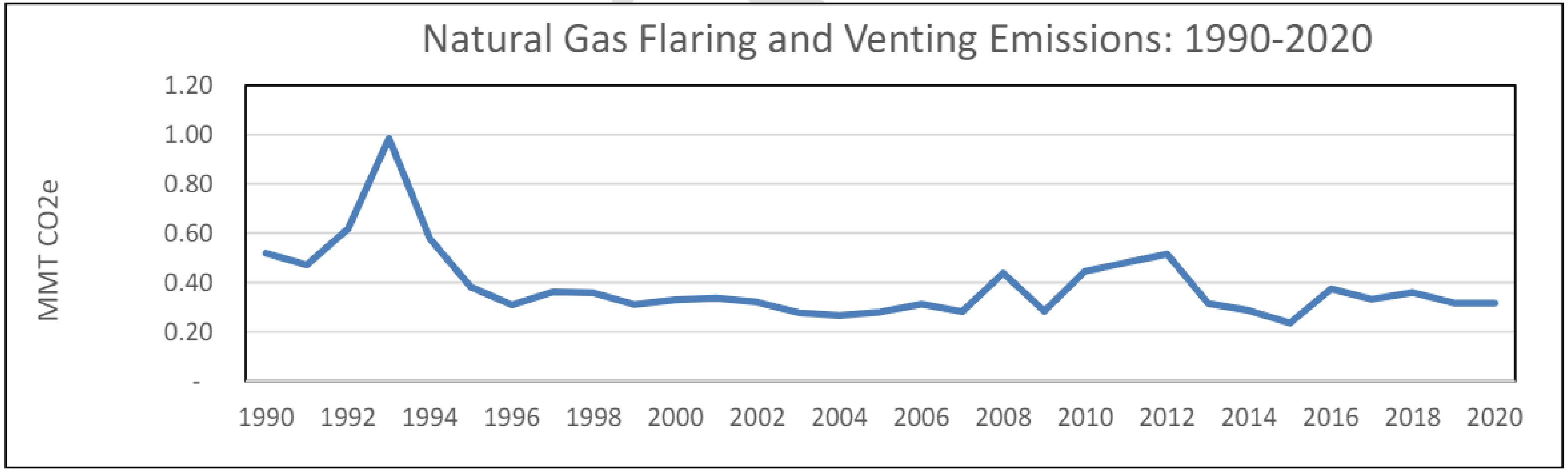
•[1990–2020 Greenhouse Gas Inventory Report (PDF)]

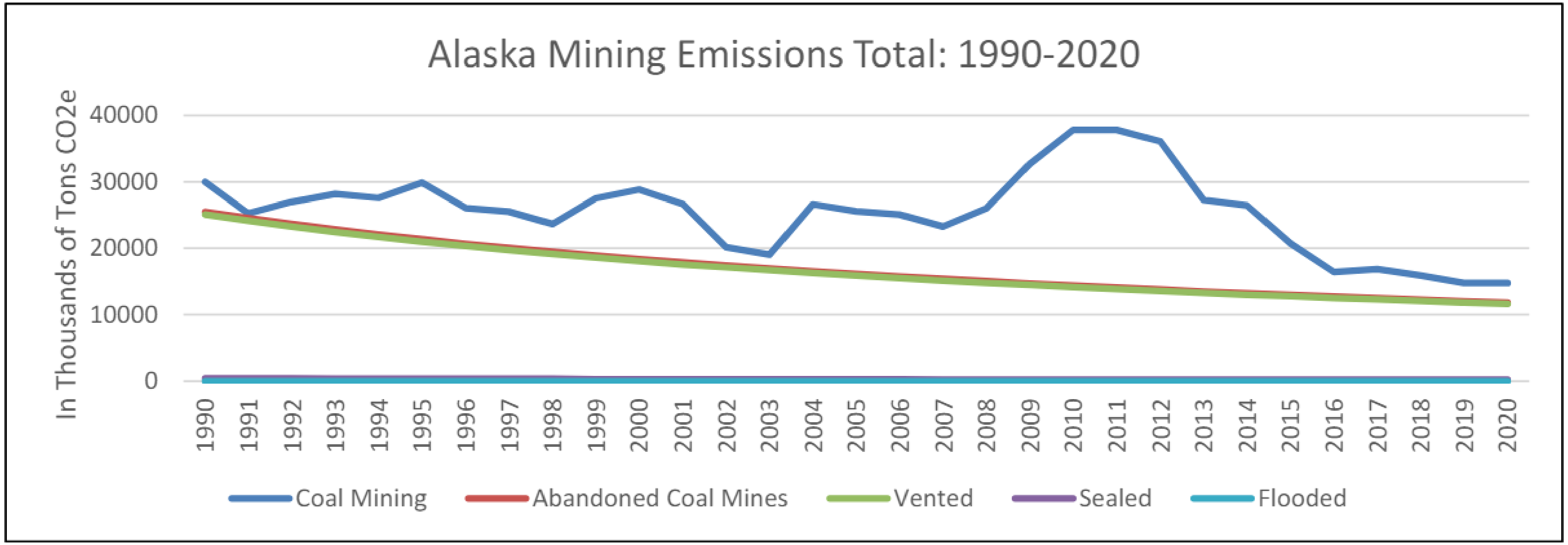
*2020
+2019



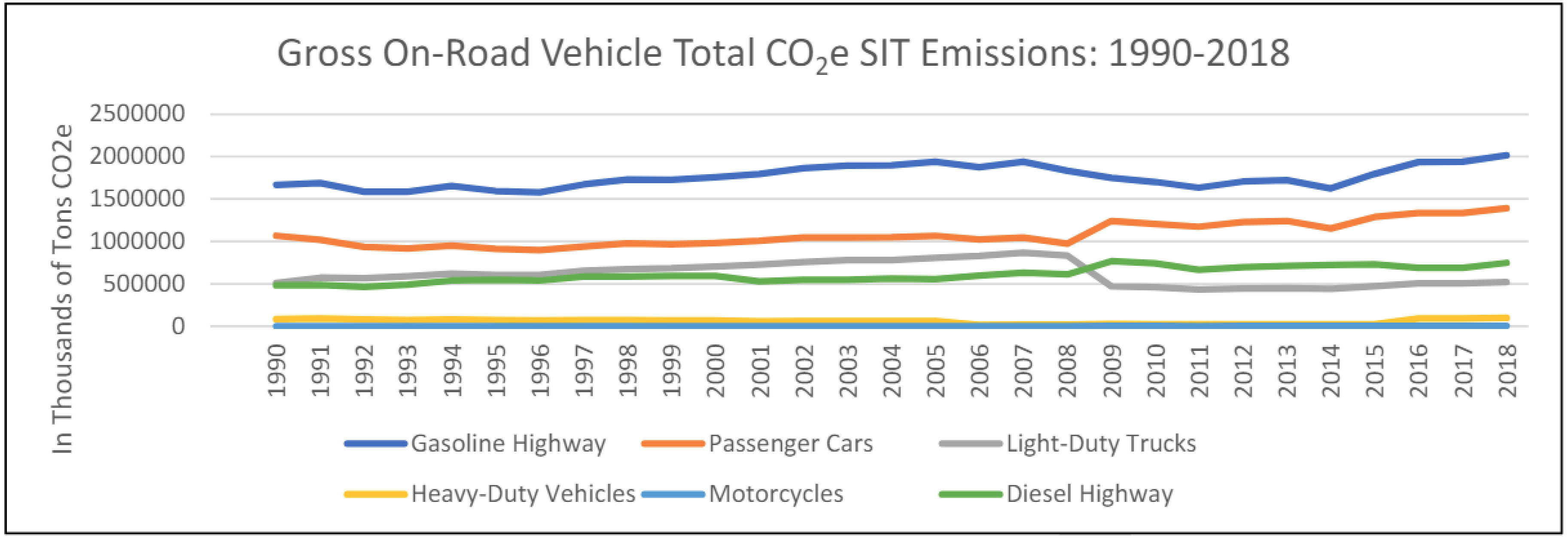



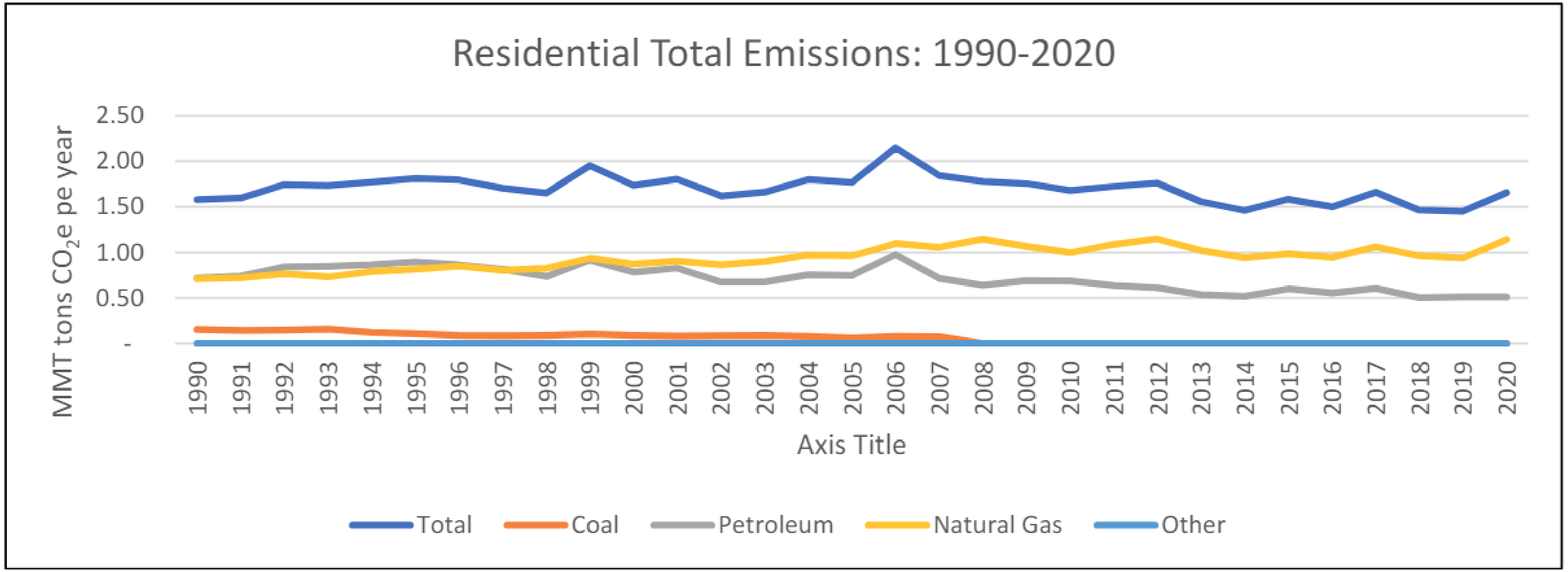

Alaska SIT – State GHG Inventory Tool




Alaska SIT – State GHG Inventory Tool

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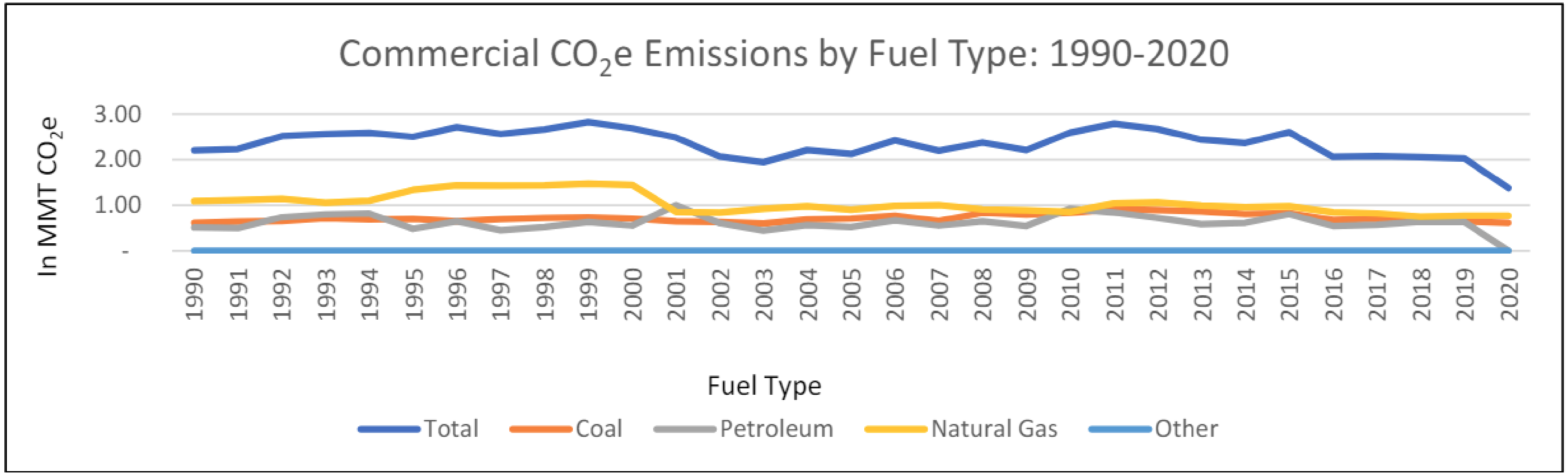


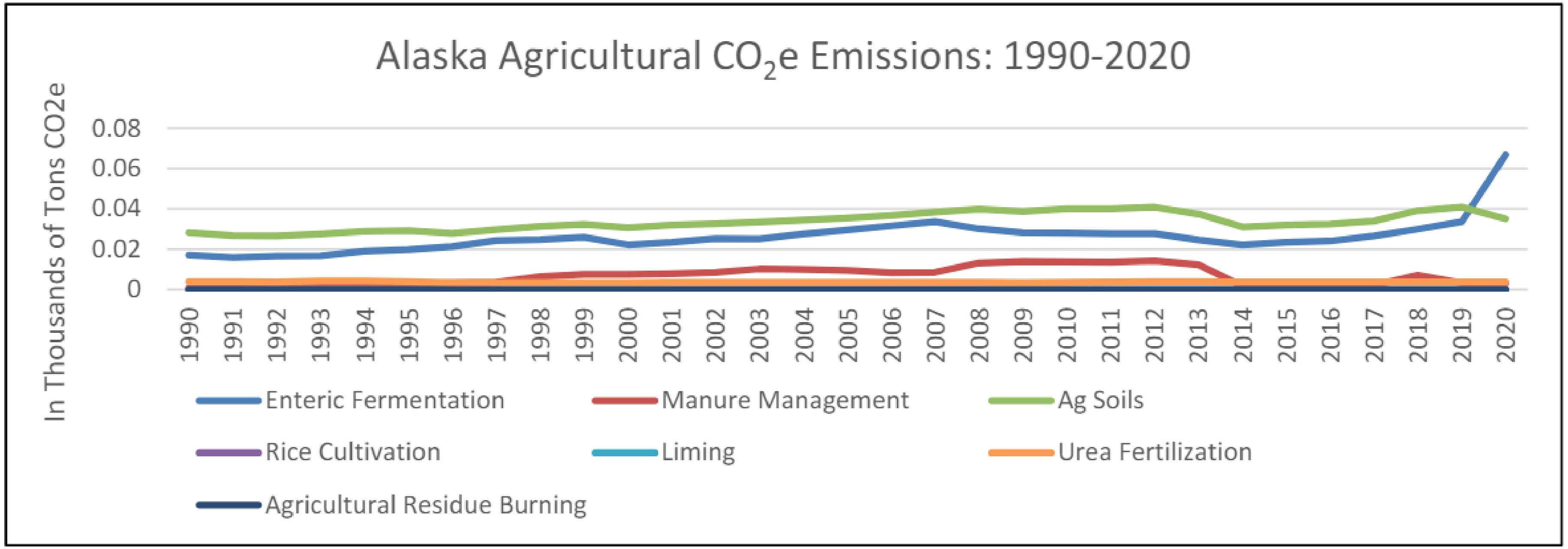


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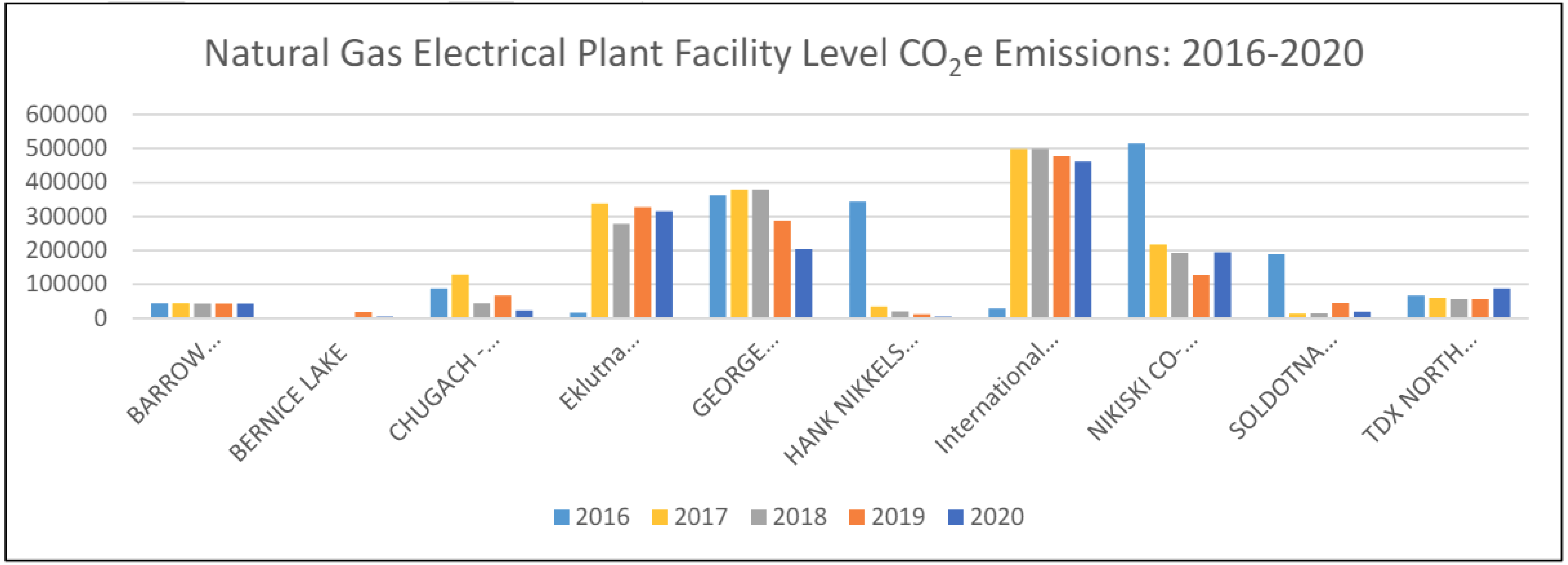
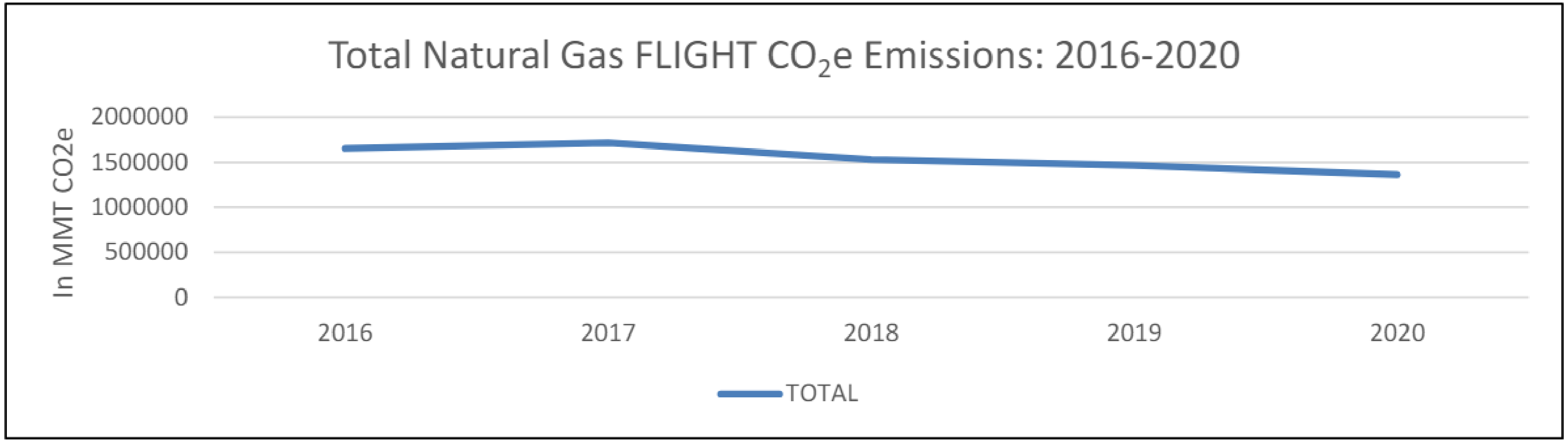
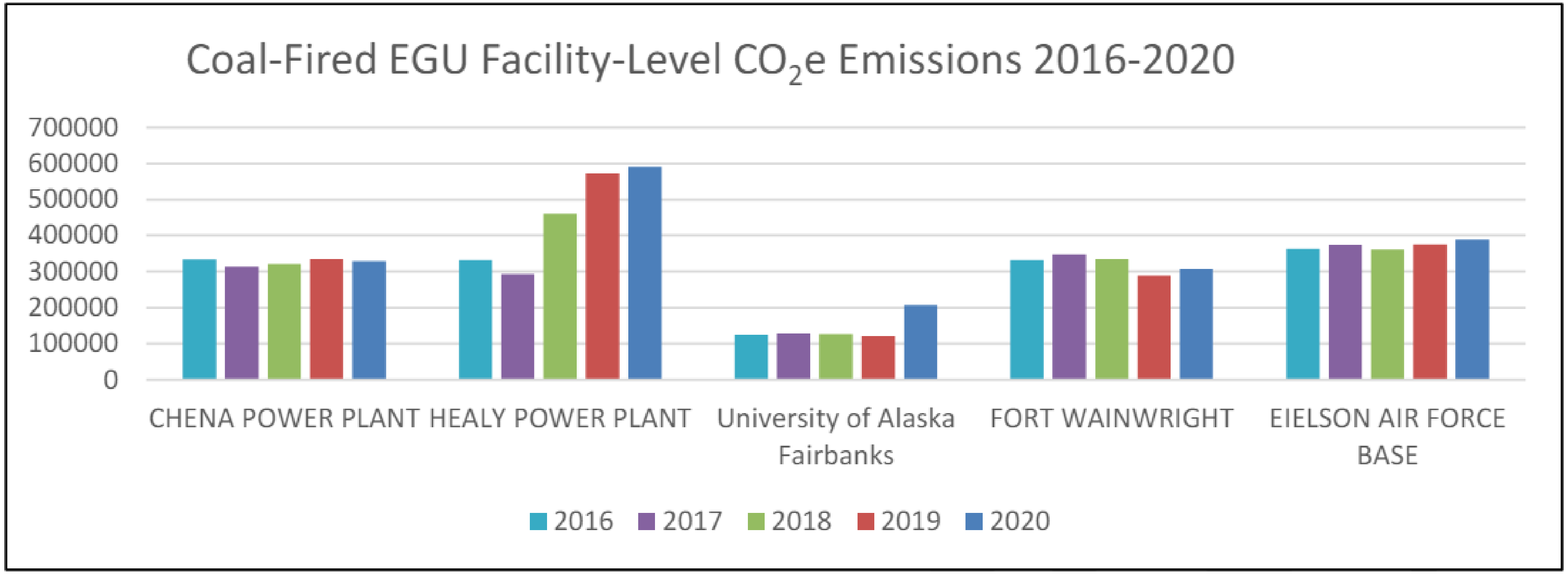
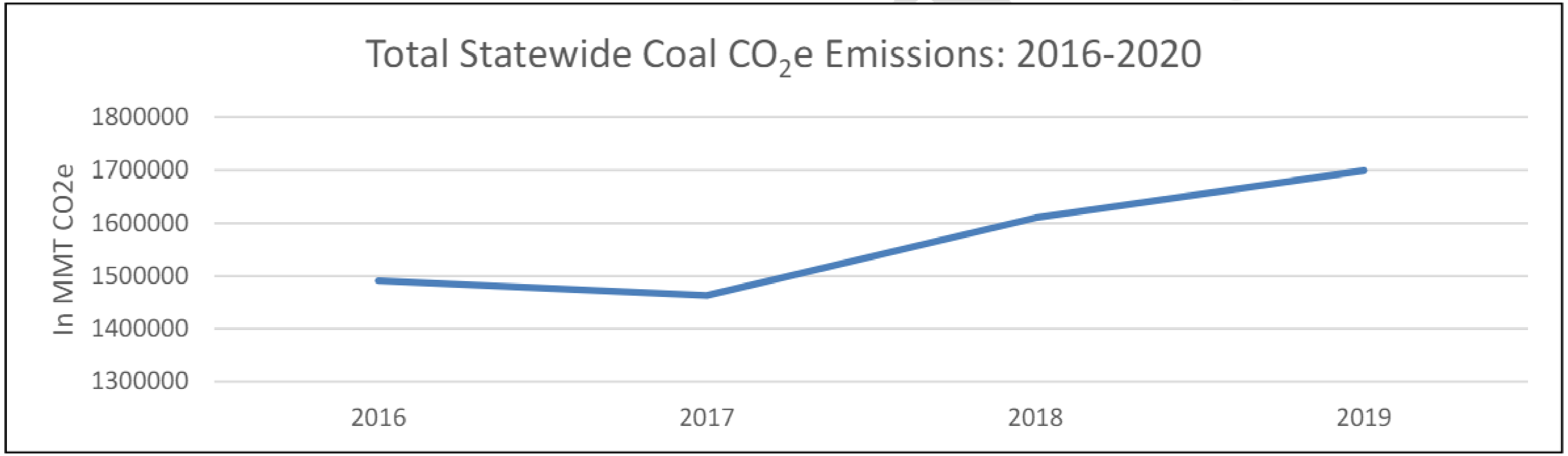



Alaska FLIGHT – EPA Facility Level Information on Greenhouse Gases Tool

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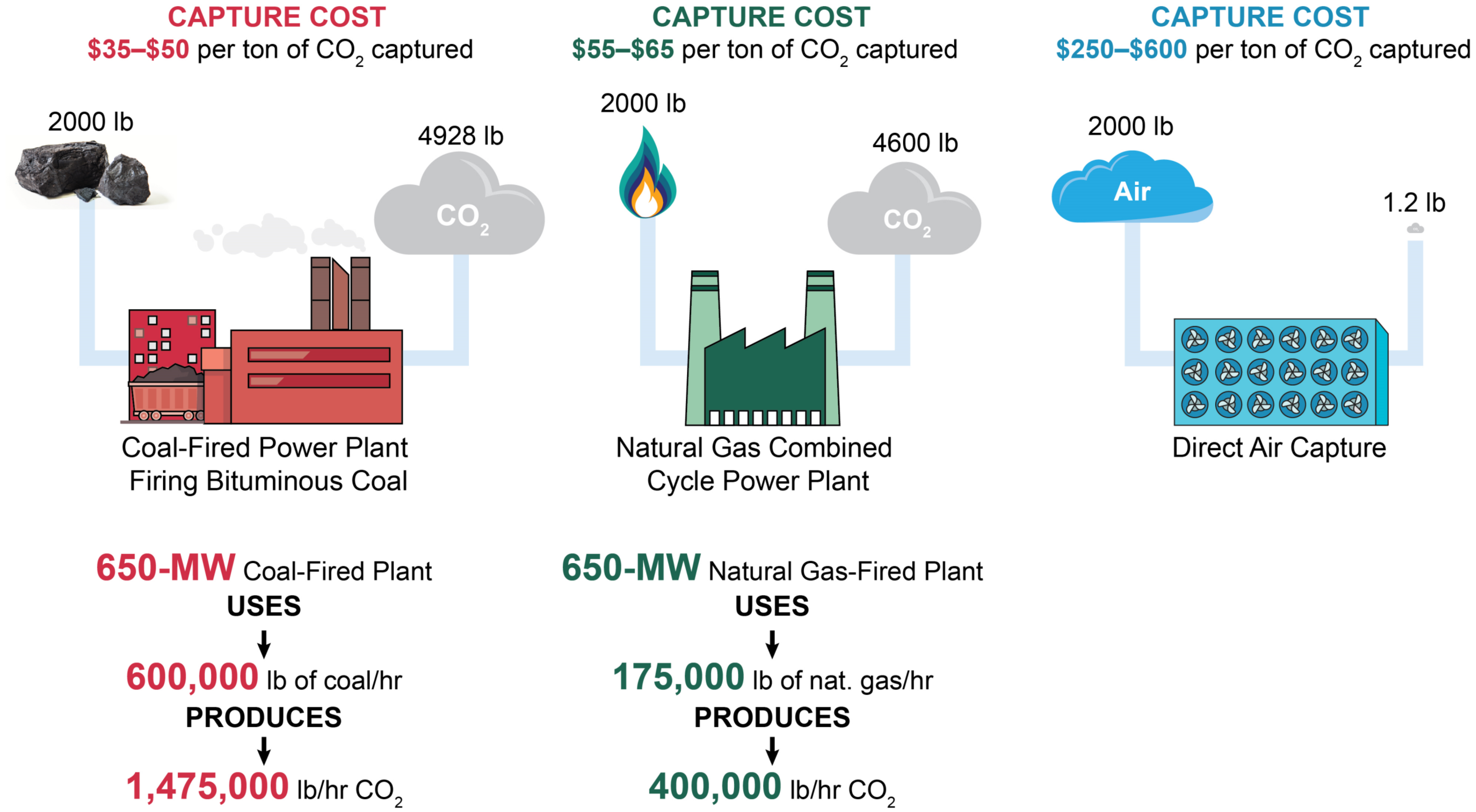
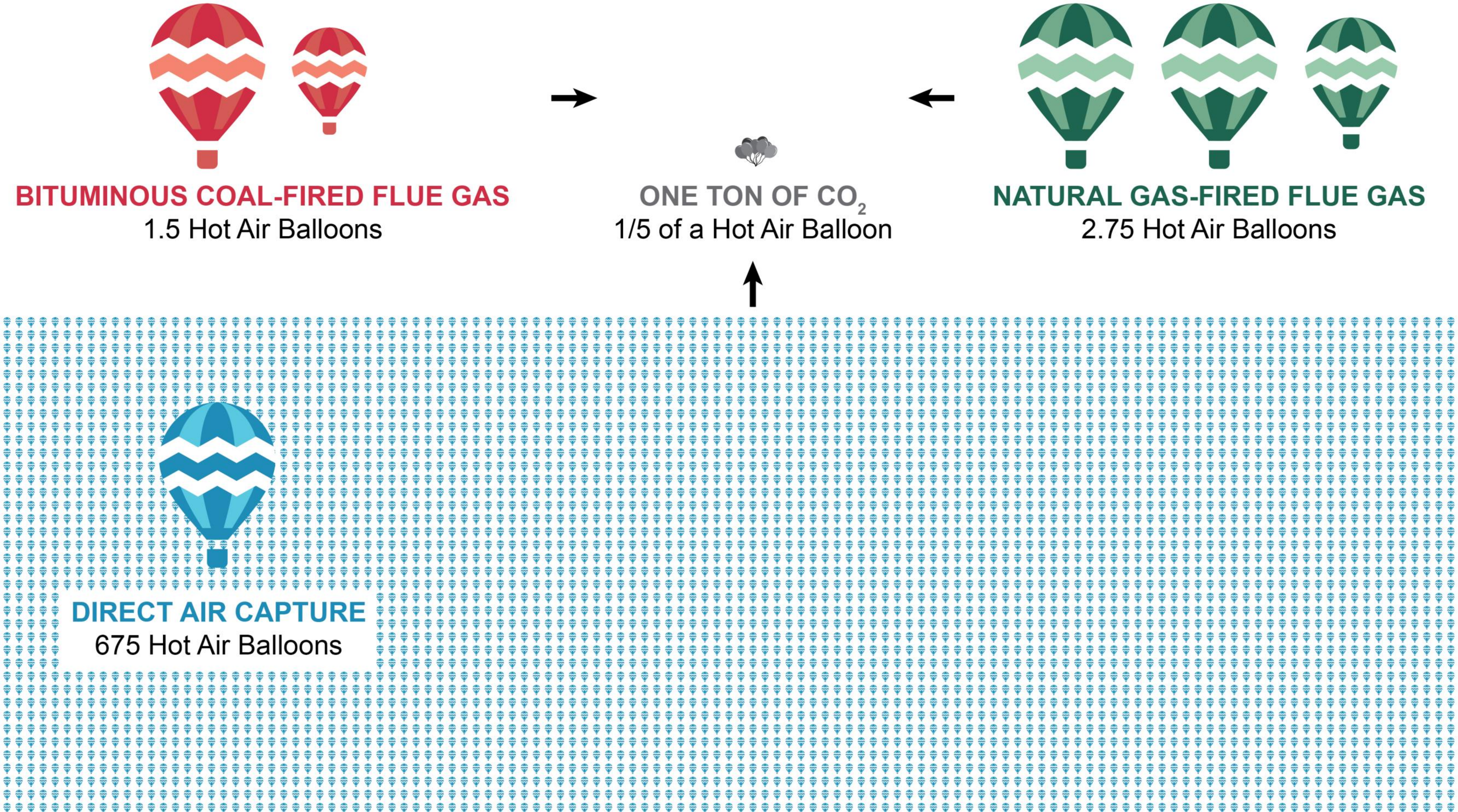

CAPTURE COST
$35–$50 per ton of $CO_2$ captured
2000 lb
4928 lb
$CO_2$
Coal-Fired Power Plant Firing Bituminous Coal
CAPTURE COST
$55–$65 per ton of $CO_2$ captured
2000 lb
4600 lb
$CO_2$
Natural Gas Combined Cycle Power Plant
CAPTURE COST
$250–$600 per ton of $CO_2$ captured
2000 lb
Air
1.2 lb
Direct Air Capture
650-MW Coal-Fired Plant
USES
600,000 lb of coal/hr
PRODUCES
1,475,000 lb/hr $CO_2$
650-MW Natural Gas-Fired Plant
USES
175,000 lb of nat. gas/hr
PRODUCES
400,000 lb/hr $CO_2$


BITUMINOUS COAL-FIRED FLUE GAS
1.5 Hot Air Balloons
ONE TON OF $CO_2$
1/5 of a Hot Air Balloon
NATURAL GAS-FIRED FLUE GAS
2.75 Hot Air Balloons
DIRECT AIR CAPTURE
675 Hot Air Balloons

# CHALLENGES

- Remoteness
  - Infrastructure
  - Construction
  - Transportation
  - Pipelines
- Impurities
  - Acid gases
  - Water
- Cost

NPS Photo / Kent Miller
*Denali tinged pink by alpenglow.*

# Alaska $CO_2$ Sources and Storage Potential



## North Slope

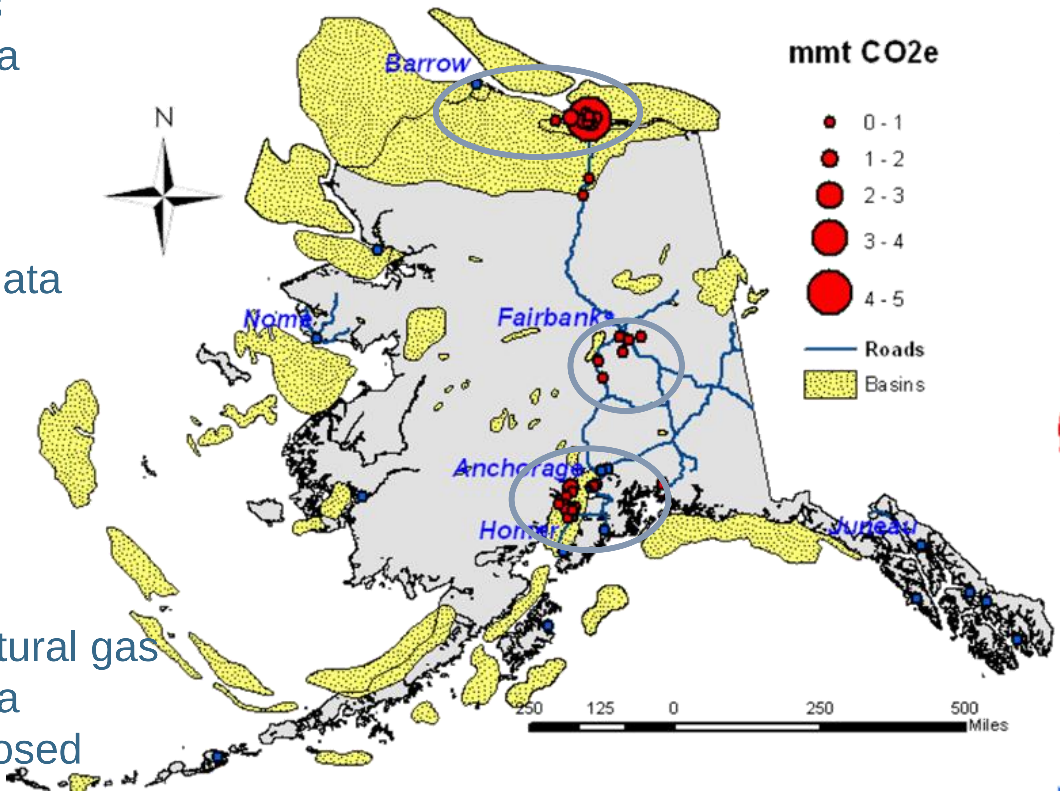
* Natural gas-fired
* Low-cost natural gas
* O&G subsurface data

## Interior

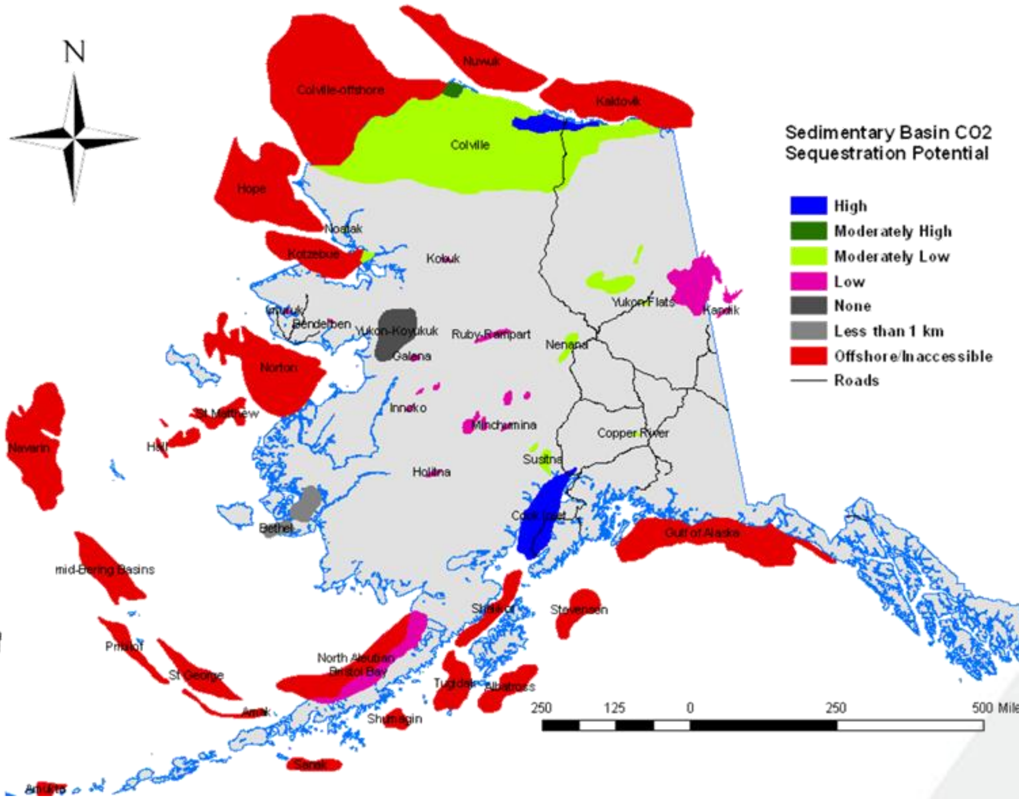
* Coal-fired
* Limited subsurface data
* Subsurface poorly understood, cap rock concerns

## Southcentral

* Natural gas-fired
* High cost, scarce natural gas
* O&G subsurface data
* ARCSS project proposed




$CO_2$ Stationary Sources (red) and Deep Sedimentary Basins (yellow)



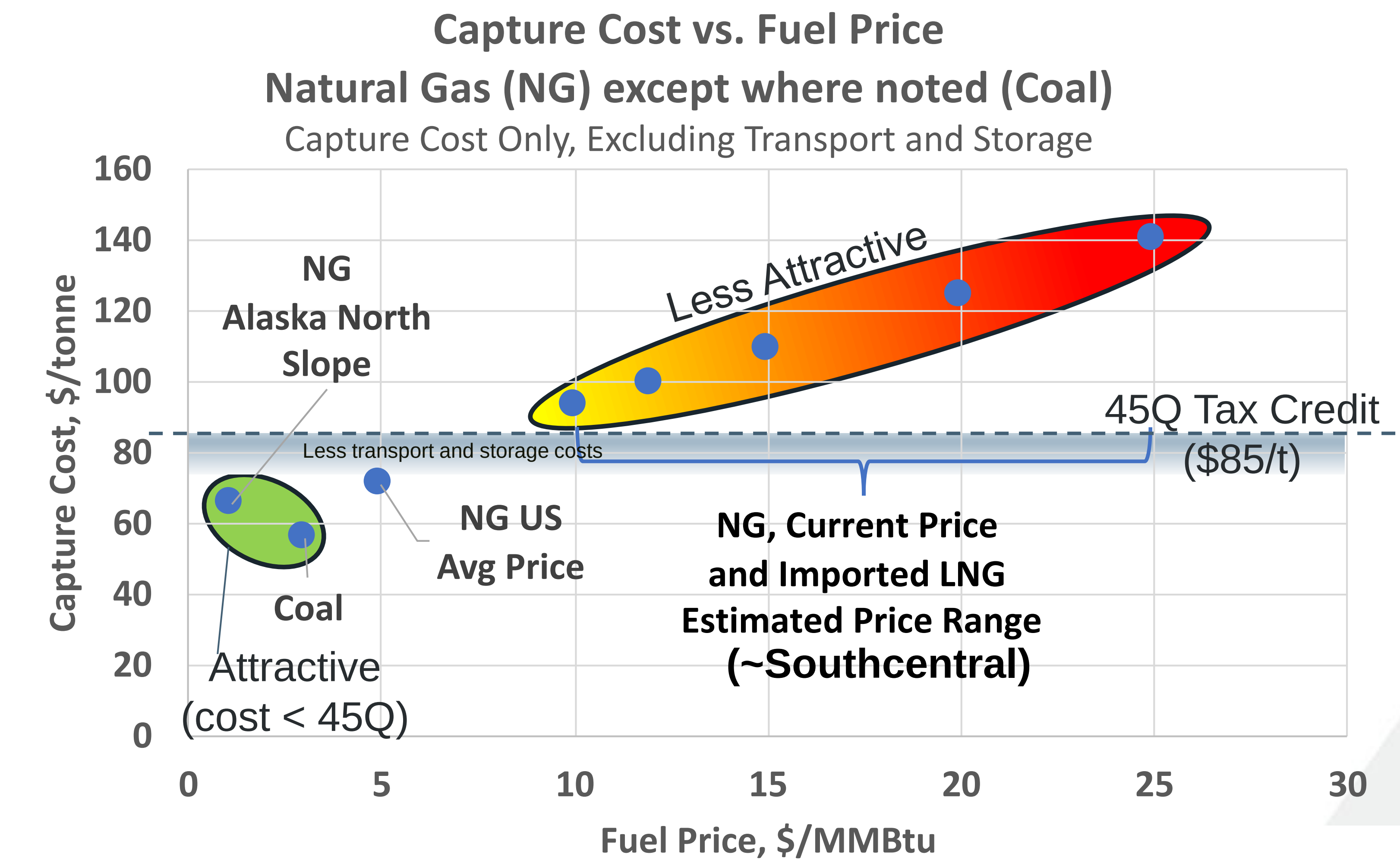

Sedimentary Basin Sequestration Potential (Shellenbaum and Clough, DNR, 2010)

# Alaska CCUS: $CO_2$ Capture Costs

Institute of Northern Engineering
University of Alaska Fairbanks

- **Alaska capture screening**
  - Using typical Lower 48 costs
  - Fuel price a key cost driver
  - Capture cost only, excluding transport and storage costs
- **With Lower 48 costs and 45Q**
  - Natural gas capture attractive on North Slope
  - Natural gas capture less attractive for southcentral
  - Coal capture looks attractive statewide
- **Further work should be done for attractive projects**

*Based on SPE paper 213051 Table 1, Paskvan et al. [1]*




[1] Cost methodology benchmarked against NETL, U.S. Department of Energy National Energy Technology Laboratory, 2015, "Cost and performance baseline for fossil energy plants volume 1a: Bituminous coal (PC) and natural gas to electricity" revision 3. July 6, 2015, DOE/NETL-2015/1723.

# CCUS Road Map: Opportunities and Needs



## North Slope

*Advantaged by low-cost natural gas*

- Natural gas-fired capture
- Direct air capture (DAC)
- **Subsurface data integration and site-specific data gathering needed**
- 40-year track record of successful $CO_2$ storage and use, ~15 TCF
- Major gas sales 2015 LNG plan sequestered $CO_2$ back in reservoir

## Interior

*Existing coal plant infrastructure*

- Coal-fired capture
- **Basic regional subsurface data gathering needed**

  **Address geotechnical concerns[1]**

## Southcentral

*Proximity to port, potential for import*

- Capture not attractive at natural gas plants or refineries due to gas supply shortage and high price
- Coal or hydrogen power with CCS can address natural gas shortage, food security, lower emissions
- Imported $CO_2$ storage (U.S. West Coast or Asia–Pacific)
- **Subsurface data integration and site-specific data gathering needed**

[1] ***Open Link***: Seismic Hazard Considerations for Carbon Sequestration in Alaska

- Coal is lowest-cost fuel ~ $4/MMBtu
  - $7–$10/MMBtu natural gas now
  - $20–$35/MMBtu diesel
  - Imported LNG $15–$25 /MMBtu [2]

- Coal supply local and abundant

- With CCS, coal $CO_2$ emissions:
  - Half to quarter that of natural gas
  - Half of wind power supported with natural gas power

- With CCS, biomass-coal net-negative

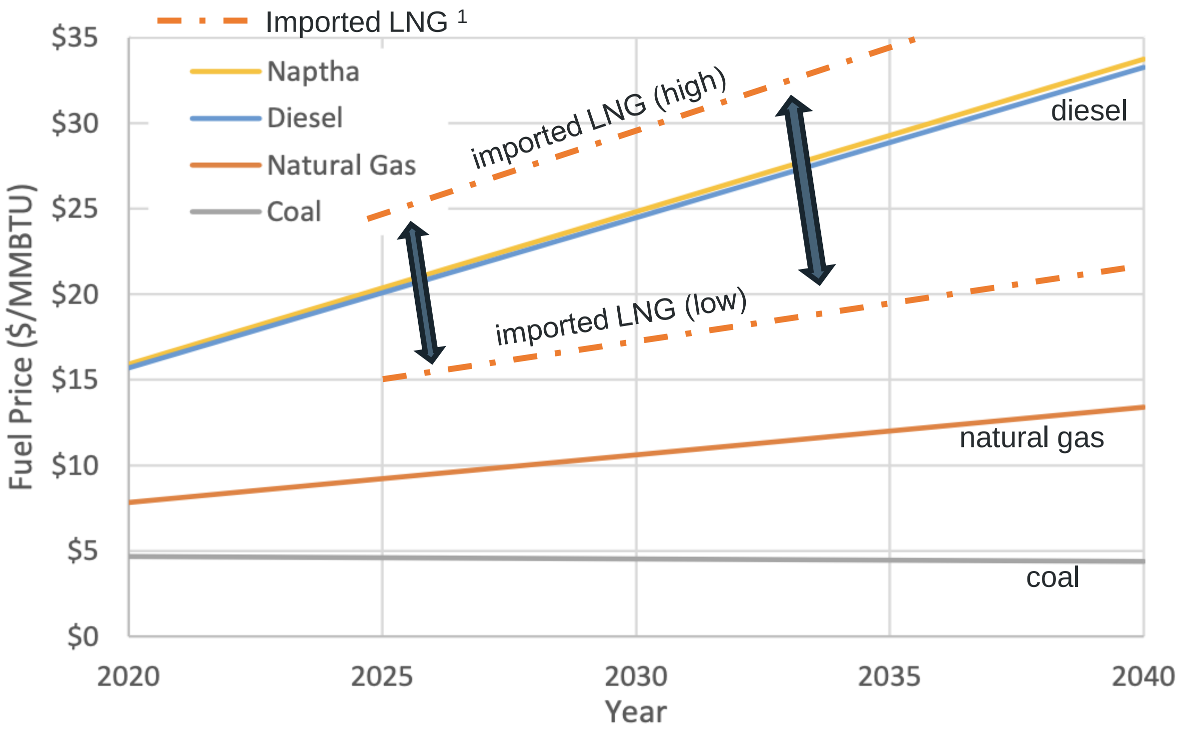



**Figure 5. Assumed fuel price trajectories (2020$)**

Fuel price forecasts from the Alaska Energy Authority, ref. *NREL Renewable Portfolio Standard Assessment for Alaska's Railbelt, 2022*, NREL/TP-5700-81698, https://www.nrel.gov/docs/fy22osti/81698.pdf.

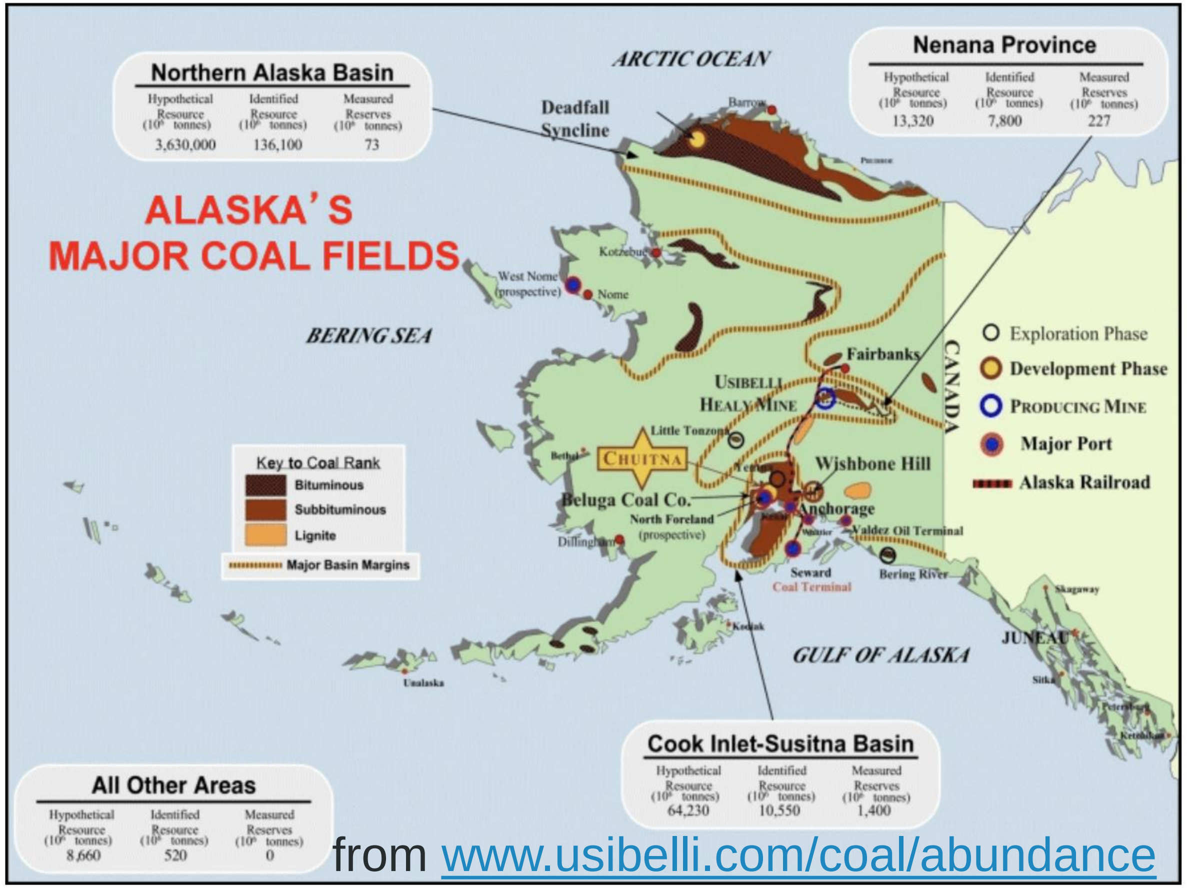
[1] Imported LNG price estimate from *"Cook Inlet Region Low Carbon Power 2024."*

- **CCS technology is proven and cost-effective**
  - EPA states CCS adequately demonstrated technology for certain natural gas- and coal-fired power generation.
  - Proposing CCS, low-GHG hydrogen co-fire, or other emission controls starting in 2030 as best systems of emissions reduction (BSER).
    - Federal Register 5/23/2023 vol.88 No.99 p.33291
    - See EPA's Fact Sheet on GHG Standards for Fossil Fuel-Fired Power Plants, Proposed Rule

- **Use of Alaska's abundant coal, oil, and natural gas resources may require CCS**
  - With CCS, coal and natural gas power plants across Alaska can provide reliable power.

**Coal is the most abundant fossil fuel in the U.S.**

**27% of the world's coal is in the U.S.**
**and half of all U.S. coal resources are found in Alaska**




from www.usibelli.com/coal/abundance

# ARCCS Project

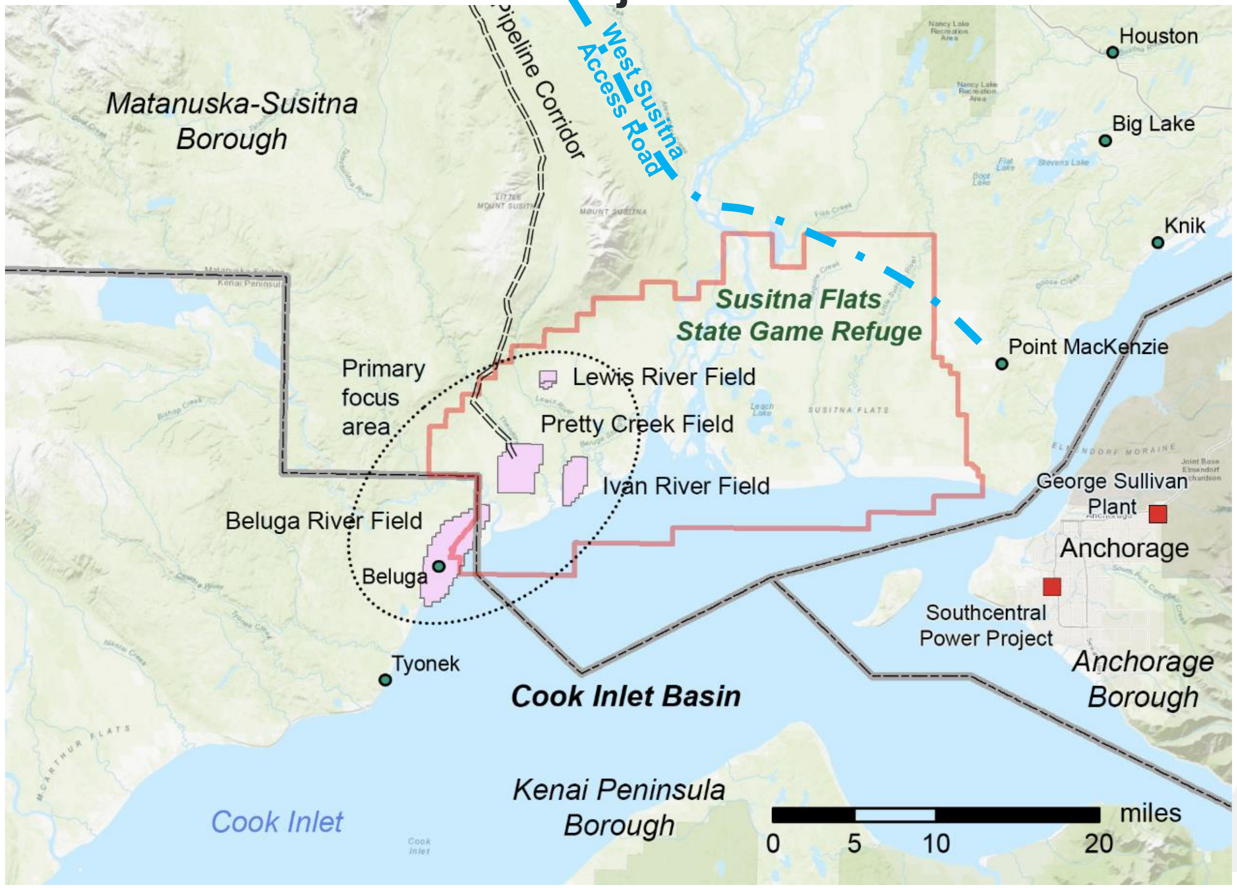
## Determine $CO_2$ Storage Volume Northern Cook Inlet



- Carbon storage capacity, proven through engineering and geoscience, is a key requirement for any CCS project.
- Beluga River Field has estimated 60+ years storage for 300-MW net biomass-coal power plant with CCS.
- Project evaluates aggregating $CO_2$ from Chugach Electric's two Anchorage natural gas power plants.
- DOE awarded $9 million to UAF November 2023, which cannot be accepted until matching funds are secured.
  - $2.2 million matching funds request included in UA budget, pending with AK Legislature.

ALSO NEED carbon storage volume assessments for 1) Interior AK and 2) Cook Inlet total storage capacity.

**Alaska Railbelt Carbon Capture and Storage (ARCCS) Project**



## BSER At-A-Glance

<table>
<tr><th colspan="4">FINAL CARBON POLLUTION STANDRADS FOR NEW AND EXISTING FOSSIL-FUEL FIRED ELEECTRICITY GENERATORS</th></tr>
<tr><th colspan="2">Existing 111(d) Steam Generators</th><th colspan="2">New Source and Reconstructed 111(b) Stationary Combustion Turbines</th></tr>
<tr><th>Coal-Fired Boilers</th><th>Natural Gas and Oil-Fired Boilers</th><th>Phase I<br>Date of promulgation or initial startup</th><th>Phase II<br>Beginning in Jan 1, 2032</th></tr>
<tr><td rowspan="2">Long-term subcategory: For units operating on or after January 1, 2039<br><br>BSER: CCS with 90 percent capture of $CO_2$ (88.4% reduction in emission rate lb/MWh-gross) by January 1, 2032</td><td rowspan="6">BSER: routine methods of operation and maintenance with associated degree of emission limitation:<br><br>Base load unit standard:<br>(annual capacity factors greater than 45%) 1,400 lb $CO_2$/MWh-gross<br><br>Intermediate load unit standard:<br>(annual capacity factors greater than 8% and less than or equal to 45%) 1,600 lb $CO_2$/MWh-gross.<br><br>Low load units:<br>(annual capacity factors less than 8%) a uniform fuels BSER and a presumptive input-based standard of 170 lb $CO_2$/MMBtu for oil-fired sources and a presumptive standard of 130 lb $CO_2$/MMBtu for natural gas-fired sources.<br><br>Compliance date of January 1, 2030</td><td colspan="2">Low Load Subcategory (Capacity Factor <20%)</td></tr>
<tr><td><u>BSER</u>: Use of lower emitting fuels (e.g., hydrogen, natural gas and distillate oil)<br><u>Standard</u>: less than 160 lb $CO_2$/MMBtu</td><td>EPA is not finalizing a Phase II BSER for low load units</td></tr>
<tr><td rowspan="2">Medium-term subcategory: For units operating on or after Jan. 1, 2032, and demonstrating that they plan to permanently cease operating before January 1, 2039<br><br>BSER: co-firing 40% (by heat input) natural gas with emission limitation of a 16% reduction in emission rate (lb $CO_2$/MWh-gross basis) by January 1, 2030</td><td colspan="2">Intermediate Load Subcategory (Capacity Factor 20% to 40%*)<br>*Source-specific upper bound threshold based on EGU design efficiency</td></tr>
<tr><td><u>BSER</u>: Highly efficient simple cycle technology with best operating and maintenance practices<br><u>Standard</u>: 1,170 lb $CO_2$/MWh-gross</td><td>EPA is not finalizing a Phase II BSER for intermediate load units</td></tr>
<tr><td rowspan="2">For units demonstrating that they plan to permanently cease operating before January 1, 2032<br><br>Units are exempt from the rule. Cease operations dates finalized in state plans for exemption purposes are federally enforceable.</td><td colspan="2">Base Load Subcategory (Capacity Factor >40%*)<br>*Operation above upper-bound threshold for Intermediate Subcategory</td></tr>
<tr><td><u>BSER</u>: Highly efficient combined cycle generation with the best operating and maintenance practices<br><u>Standard</u>: 800 lb $CO_2$/MWh-gross (EGUs with a base load rating of 2,000 MMBtu/h or more)<br><u>Standard</u>: 800 to 900 lb $CO_2$/MWh-gross (EGUs with a base load rating of less than 2,000 MMBtu/h)</td><td><u>BSER</u>: Continued highly efficient combined cycle generation with 90% CCS by Jan 1, 2032<br><u>Standard</u>: 100 lb $CO_2$/MWh-gross<br><br>EPA's standard of performance is technology neutral, affected sources may comply with it by co-firing hydrogen.</td></tr>
<tr><td colspan="4">For new and existing units installing control technologies, a 1-year extension is available in situations in which implementation delays are due to factors beyond the EGU owner/operator's control. For existing units with cease operations dates, a 1-year extension is available in situations in which the unit is needed for reliability through a reliability assurance mechanism, provided appropriate documentation is submitted.</td></tr>
<tr><td colspan="4">Major Modifications 111(b) Coal-fired Steam Generators: Standards of performance for coal-fired units that undertake a large modification (i.e., increases hourly emission rate by more than 10%) mirror the emission guidelines for existing coal-fired steam generators.</td></tr>
</table>

Interested parties can download a copy of the final rule from EPA's website at Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants

# ACKNOWLEDGMENT

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## DISCLAIMER

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# THANK YOU

Critical Challenges. Practical Solutions.