ALASKAN CCUS FAQs

This document answers frequently asked questions (FAQs) about carbon dioxide capture, transport, use, and storage. Questions are grouped into the following categories:

- G General CCUS
- T Carbon Dioxide Transportation
- S Carbon Dioxide Geologic Storage
- U What CCUS work is UAF doing?
- A What is the ARCCS Project?
- F Feasibility Study for a West Susitna Plant with Carbon Capture

For more information, see our website https://ine.uaf.edu/carbon/

General CCUS

QG1. What is Carbon Dioxide (CO2)?

Carbon Dioxide, or CO_2, is a non-flammable, non-explosive, naturally occurring gas. It is exhaled by humans every time you breathe; it is used in hundreds of products including soda, dry ice and fire extinguishers; and is a necessary component of plant growth. It's the bubbles in your beer.

QG2. What happens if CO2 leaks? Does CO2 explode?

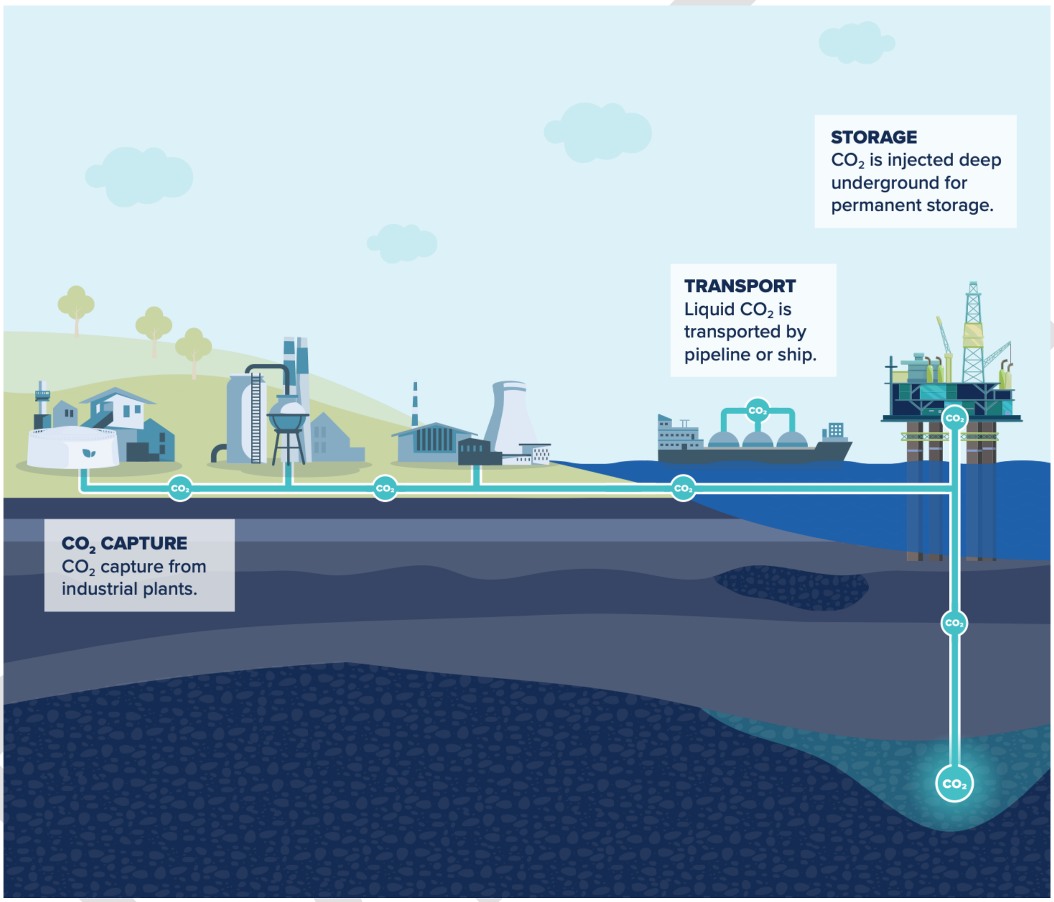
CO_2 is not flammable or explosive. In the unlikely occurrence CO_2 escapes from a pipeline or through the surface, it will become dry ice or go back to a gaseous state. While prolonged exposure to high concentrations of CO_2 can cause breathing difficulty, the gas typically quickly evaporates into the air and requires little to no clean-up. In the event of a leak, pipeline systems are designed to automatically shut down, ceasing all operations until the cause is determined and repaired. Underground storage sites are monitored and in the unlikely event of a leak, wells are remediated, and operating practices are modified to prevent future leaks.

QG3. Why do we call it carbon capture, CCS, or CCUS?

Carbon capture is the act of separating CO_2 molecules from the exhaust or flue gas of an industrial facility such as a power plant or ethanol plant, this is known as point source capture (PSC). Carbon capture can also be removing CO_2 directly from the atmosphere, which is known as Direct Air Capture (DAC).

In Carbon dioxide Capture with Storage or Sequestration (CCS), captured CO_2 is injected deep underground (nearly a mile or more) within porous and permeable rock beds, covered by cap rock. With Storage or Sequestration, captured carbon dioxide is permanently removed from the atmosphere.

In CCUS, the captured carbon dioxide is beneficially Used or Utilized. Uses can include enhanced oil recovery (EOR), medical, carbonating beverages, enhance crop growth in a greenhouse, and other industrial uses.

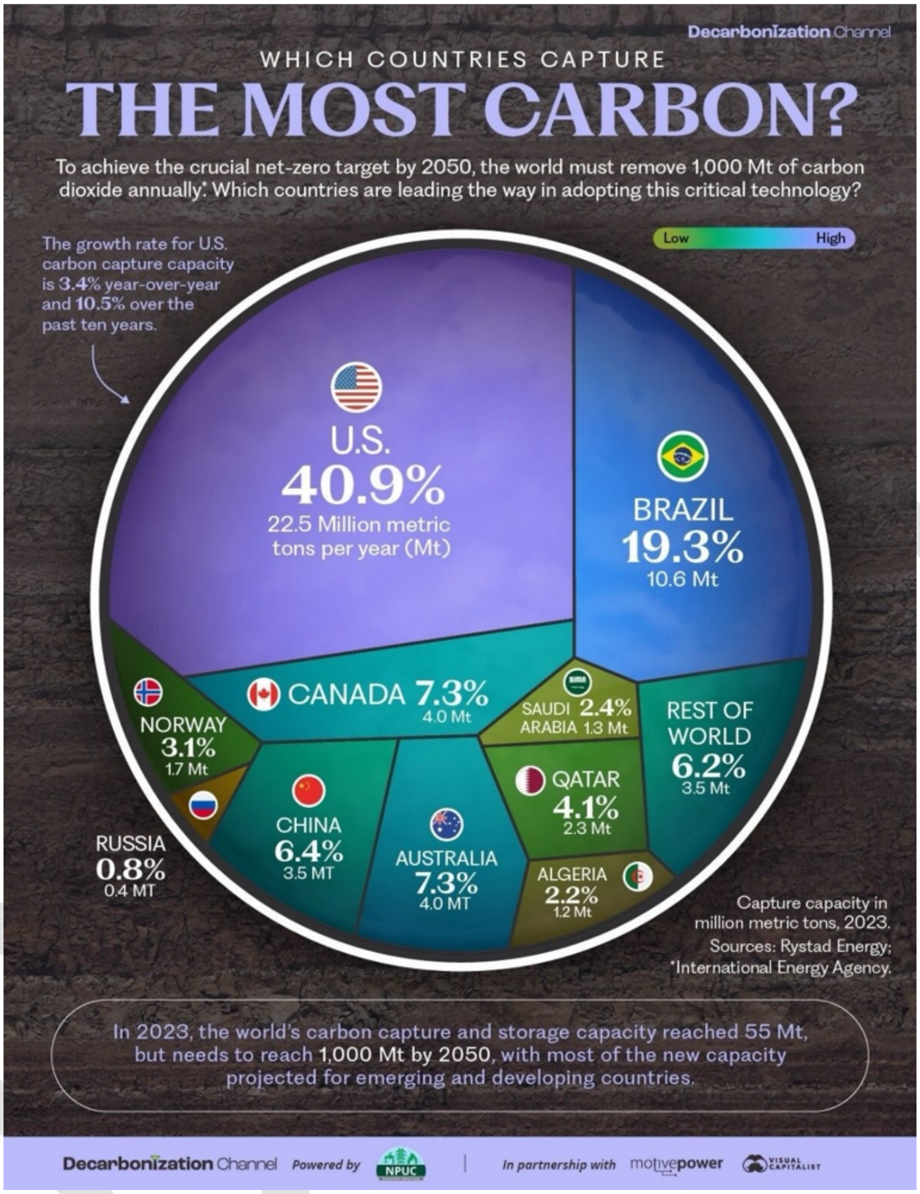


From the Global CCS Institute, CCS 101

QG4. Are there successful CCUS projects in Alaska or elsewhere?

Yes, in Alaska, natural gas processing in Prudhoe Bay has concentrated carbon dioxide from the natural gas (12.5% CO_2 naturally) to around 20% CO_2 for the miscible gas enhanced oil recovery project. Miscible gas is 20% CO_2 with 80% rich hydrocarbon gases including ethane, propane, and butane. The Prudhoe Bay miscible gas project has increase oil recovery from the field by over 500 million barrels of oil—using existing injectors and producing wells and improving overall field recovery.

The following chart summarizes carbon capture capacity globally in 2023, with 55 million tonnes per year (MMTPA) combined:

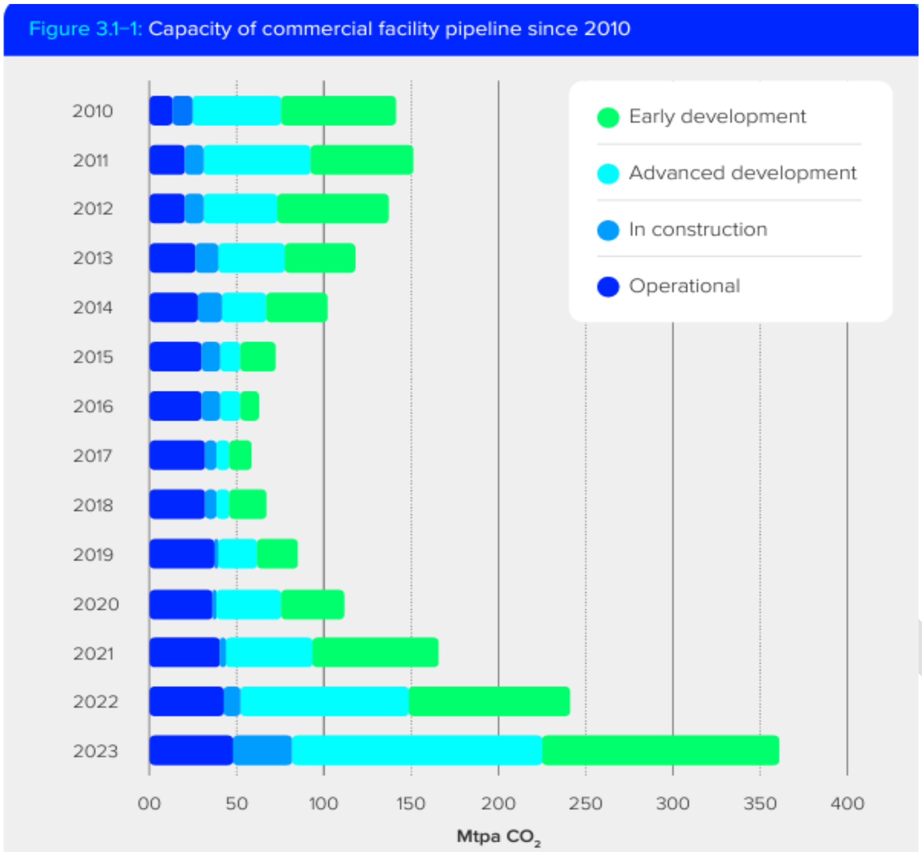


From the Decarbonization Channel

The following figure from the Global CCS Institute's 2023 annual report shows commercial facility capacity as of 2023. Investments continue to grow CCS capacity. Key changes from 2022 to 2023:

The CO_2 capture capacity of all CCS facilities under development has grown to 361 million tonnes per annum (MMTPA) – 48% growth in one year.

198 new facilities added to the development pipeline: currently 41 projects in operation, 26 under construction, plus 325 in advanced and early development.



From the Global CCS Institute, 2023 Annual Report

In North America for example, about 2.5 million tonnes per year is being captured in North Dakota and shipped to Canada for enhanced oil recovery and/or sequestration for about 25 years. CCUS Projects include:

- In North Dakota, there are three active carbon capture projects, 2 ethanol and one coal plant.
- In Alberta, Canada, the Boundary Dam #3 coal-fired electrical power plant has captured about 7 million tonnes of carbon dioxide.
- In Texas, the Petro Nova plant has restarted and is meeting its performance targets, supplying CO_2 to the Hilcorp to enhance oil recovery.
- There are two coal-fired power plants operating with carbon capture in China.
- The Milton R Young power plant has its permits and plans to begin acquiring equipment, constructing, and starting operations. This is known as Project Tundra.

QG5. Why should we do carbon capture? How is it good for Alaska?

Carbon capture allows projects to move forward aligned with Policies of Federal, State, and Local governments and with their own corporate goals. For example, by lowering a company's CO_2 footprint.

For example, we are discussing a new biomass and coal-fired power plant in Southcentral Alaska for the Railbelt. This firm power supply, which could help strengthen the Railbelt system resilience, would probably not be an option for consideration without CCS.

Capturing carbon dioxide earns tax credits of $85 per tonne CO2 sequestered. If the CCS costs are less than the tax credits, electricity costs with CCS are lower than the cost of electricity without CCS. This is the expectation for the Minnkota Power Cooperative that is supporting Project Tundra on the Milton R. Young Power Plant in North Dakota. This Co-Op expects that CCS will improve the economics and viability of their power plant.

States are also implementing carbon management policies, in addition to Federal Regulations and EPA rules. Washington, Oregon, and California have all put caps on their refinery gasoline carbon intensity. Crude oil suppliers, including Alaskan companies, now must demonstrate how much carbon dioxide is generated from producing and shipping their crude oil, and lower carbon intensity crude oil is more valuable in those markets.

Carbon capture and storage is one way that companies can reduce the carbon intensity of their products, which will make them more attractive to West Coast refineries.

QG6. What CCUS-related projects are underway in Alaska?

Alaska CCUS activities include the following (as-of 1Q2025):

Regulatory

- AOGCC seeking Class VI injection well primacy from EPA (SB48, May 2023)
- DNR issued carbon storage leasing regulations (HB50, July 2024)

Federal DOE Funded Awards

- DNR has a $1MM carbon storage public information sharing geologic database project underway. Public outreach partners to discuss CCUS include UAF-ACEP and ARE.
- UAF-INE is leading an $11MM Alaska Railbelt Carbon Capture and Sequestration (ARCCS) CarbonSAFE Phase II storage assessment with EERC and ARI. ARCCS evaluates CCS from a new biomass-coal power plant and two existing natural gas CEA power plants in Anchorage.
- ASRC Energy Services (AES), Santos, and Repsol have a $3MM Direct Air Capture Pre-Feasibility Study ongoing with US DOE.
- AES and Santos: $62MM North to the Future CCS Hub CarbonSAFE Phase III subsurface site characterization and permitting for potential North Slope project site.

Additional Studies

- US DOE & Japan METI announced a cross-border CCS import to Alaska feasibility study, with Phase I focused on transportation feasibility.
- Hilcorp, Sumitomo, and K Line signed joint study agreement for CCS feasibility of imports from Japan to Alaska for sequestration.

QG7. What industries use carbon capture?

Carbon capture is being applied in manufacturing plants for cement, iron, steel, chemicals, and ethanol, in natural gas processing, oil refining, and power and heat generation.

There is also growing interest in direct air capture, with projects underway including the CarbFix project in Iceland that captures carbon dioxide (CO_2) from power plants and stores it as rock underground.

QG8. Does Carbon Capture or CCUS Actually Work Technically?

Yes, underground CO_2 injection first began more than 50 years ago in western Texas. By 2023, the world's carbon capture and storage capacity reached 55 million tonnes per annum (MMTPA). In 2023 alone, 198 new carbon capture commercial facilities were added to the development pipeline, which would grow global CCS capacity to 361 MMTPA. Major investors are putting money on the line to design and build new CCS projects. Most of the new capacity is projected for emerging and developing countries.

This US EPA site provides key information regarding the supply, uses, underground injection, and geologic sequestration of carbon dioxide (CO_2) in the United States: https://www.epa.gov/ghgreporting/supply-underground-injection-and-geologic-sequestration-carbon-dioxide.

In Alaska, carbon capture technology is used to process the entire produced gas stream in Prudhoe Bay since 1986. The Central Gas Facility separates carbon dioxide from the natural gas stream (12.5% CO_2) and manufactures miscible injection gas (20% CO_2) for enhanced oil recovery. The Prudhoe Miscible Gas Injection Project has increased field recovery by over 500 million barrels of oil.

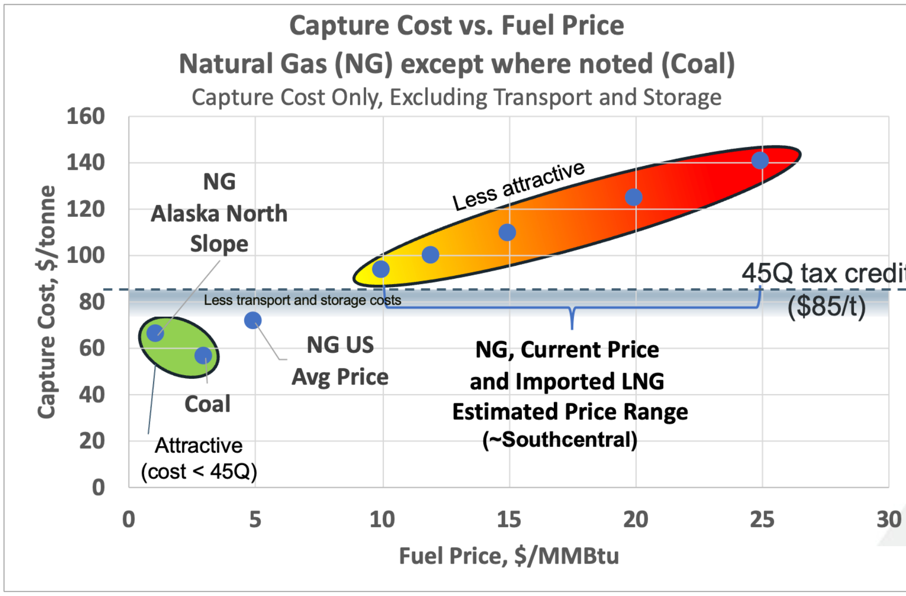
QG9. Is CCUS economically feasible?

It depends. Like any business, there is a wide range of project costs for CCUS. Generally, capture costs are higher for carbon dioxide sources with lower concentration and lower pressure. Some projects are commercially viable today using existing technology and costs. Other projects may not strictly be economically attractive, but may move forward if a business decides that carbon dioxide capture makes sense for other reasons. Economics of projects may change over time with new technologies and applications.

Carbon dioxide capture from ethanol manufacturing typically has a low cost, ~ $20/tonne CO_2, so they have been early adopters.

Coal-fired plants capture costs have been estimated in the range of $50 to $65/tonne. The only dot on the following figure that is coal is at ~ $4/MMBtu and $60/tonne capture cost.

Costs for natural gas capture, as shown in the following figure, increases with increasing fuel price. While it may be more cost-competitive in the Lower 48 (less than $85/tonne 45Q credit), it becomes less attractive at Southcentral Alaska's higher fuel prices, especially for imported LNG (at least $16/MMBtu per Enstar's John Sims).



From SPE 213051 Table 1, Paskvan et. al.

Direct air capture costs have been estimated in the $150 to $600 per tonne range using current technologies, but this is an area of intense research and costs are expected to decrease with new technologies.

In addition to capture costs, transportation and storage costs need to be included in project economics.

QG10. Is CCUS legal?

Yes, the Alaska Legislature passed the Carbon Storage Bill, HB50, in April 2024. The Governor signed it into law July 2024. This creates a comprehensive framework for carbon storage in Alaska. In February 2025, regulations developed by the Alaska DNR took effect for carbon storage.

CO_2 injection, also known as Class VI injection, is currently regulated by the EPA. The AOGCC (Alaska Oil and Gas Conservation Commission) is pursuing Class VI injection well primacy from EPA, as authorized in May 2023 by SB48.

The Governor, Legislature, and State Agencies including the DNR and AOGCC are actively working to enable carbon capture and storage in Alaska.

QG11. Will carbon capture reduce the carbon dioxide in the air and kill all the plants or make them difficult to grow?

No. Most facilities are installed at single point sources, for example at a power or ethanol plant. These capture carbon dioxide rather than allowing it to be emitted into the air and further increase its concentration in the atmosphere.

There are 860 billion tonnes (or gigatonnes, GT) of carbon dioxide in the atmosphere, at a concentration of around 400 parts per million. The planned carbon capture equipment capacity is thousands of times smaller than the carbon dioxide volume in the air. This equipment reduces future emissions but will not reduce the air's carbon dioxide concentration below favorable levels for plant growth.

Direct air capture is being tested in pilot facilities which remove carbon dioxide directly from the air. Carbon dioxide air concentrations currently reach around 419 parts per million (ppm) in 2023, significantly higher than the pre-industrial level of roughly 280 ppm; this data is primarily sourced from measurements taken at the Mauna Loa Observatory in Hawaii.

QG12. CCUS is expensive. Who is making you do it?

In Alaska today, carbon capture and CCUS are not required as they are for some operations in other States.

There is a 45Q tax credit, first made available in 2008, which has since been increased in dollar value to $85/tonne CO_2 sequestered and expanded to apply to more applications of carbon capture, use, and sequestration. It is currently available for projects that initiate onsite construction by December 31, 2032. This is one reason some may wish to do CCUS.

Carbon dioxide management also gives **competitive advantages**:

- Improves investments
- Increases opportunities
- Lowers carbon intensity of products.
- Creates marketable products and enhances customer brand loyalty.
    - For example, many airlines are selling CO2 emissions offsets that make people feel better about their traveling.
    - Making a product that is carbon neutral makes it more sellable.
- Enables some investors in the free market to express a preference for, and fund, low carbon dioxide intensity energy and other products.

QG13. Why is CCS Necessary?

Without CCS, global atmospheric levels of carbon dioxide have increased from pre-industrial levels of 280 ppm to 430 ppm currently, largely from fossil fuel emissions.

Governments, NGOs, corporations, and individuals are making choices about whether managing carbon dioxide concentrations in the atmosphere is necessary. CCS will be particularly vital for hard-to-abate sectors like cement and steel production, where no other viable solutions currently exist, and for removing CO2 already in the atmosphere.

To reduce carbon dioxide emissions, the Intergovernmental Panel on Climate Change has estimated the cost for clean energy security globally to more than double without CCS. Adding CCS to existing plants is lower cost than total replacement.

In Alaska, installing CCS may be necessary to attract new investments and to create options to decarbonize activities vital to the State's economy including power generation, refineries, and oil and gas production.

Carbon Dioxide Transportation

QT1. Is transportation of carbon dioxide in pipelines safe?

Underground CO_2 injection first began more than 50 years ago in western Texas. Decades of data has helped us understand how CO_2 behaves and how to safely transport it through pipelines. Today, millions of metric tons of CO_2 are safely transported daily across the country through 5,000+ miles of pipelines. Before a CO_2 storage project ever begins, acceptable routes are identified and evaluated for the new pipelines.

Pipelines are designed to safely operate at pressures typically between 1200-2200 psi for "dense phase" CO_2 transport. Before any CO_2 is transported, pipelines are filled with a liquid or a gas and tested to a pressure at least 125% of their maximum operating pressure to ensure structural integrity.

Pipelines and storage sites have stringent regulations, monitoring, and mitigation requirements. Alaska prioritizes significant planning and research, training, and technology into all aspects of pipeline safety to be prepared for any unexpected scenarios.

QT2. How are underground CO_2 storage sites and pipelines monitored?

Multiple safeguards and protections are put in place for storage sites and pipelines. Safety is ensured through rigorous site selection, extensive monitoring, and regulatory oversight.

Alaska requires extensive review and approval of plans to operate pipelines and storage facilities and inject CO_2. In addition, the US EPA requires a monitoring, reporting, and verification (MRV) plan for sequestered CO_2. Typical project requirements include:

- Class VI well construction with surface casing/ cementing protecting water resources; cementing from the surface to the injection point; and corrosion-resistant materials
- Next-Level Monitoring: multi-layer, multi-protection, multi-action 24/7/365
- Operational monitoring for temperature and pressure changes that could indicate early anomalies
- Leak detection and alerts
- Deep underground monitoring to ensure that the CO_2 remains securely in the storage zone
- Surface and near surface monitoring to ensure no environmental effects
- Surface water, groundwater and soil regular testing
- Automatic shutoff requirements
- Risk assessment and mitigation including comprehensive manuals at each site and control center with actions for various scenarios
- Post injection site care and closure, including continuous monitoring after injection ends, until it is demonstrated that the CO_2 stops moving (at least 10 years)
- Pipeline operators partner with local emergency managers to develop and review emergency response plans, and conduct regular trainings and drills
- Comprehensive financial burden on storage companies to cover the cost of any necessary corrective action, injection well plugging, site care or closure, and emergency or remedial response

From NDIC Brochure: Understanding CO2 Storage and Pipeline Safety

QT3. What happened with the 2020 CO_2 pipeline failure in Satartia, Mississippi?

The 2020 CO_2 pipeline failure in Satartia, Mississippi was a "worst-case scenario," and resulted in several lessons learned. First, the pipeline operator was cited for violating multiple regulations. When federal pipeline regulations are followed, pipelines outperform the safety standards of both rail and truck transit.

Second, the unstable soil where the pipeline was installed was susceptible to movement from the preceding heavy rains (7.5 to 13.5 inches above average), resulting in a landslide that ruptured the pipeline as the ground shifted. Lastly, local weather conditions, lack of wind, and the density and volume of CO_2 released slowed its dissipation; the pipeline operator models underestimated the potential affected area; the operator did not adequately inform local emergency responders; and the pipeline did not contain pure CO_2.

One misconception is that this pipeline "exploded." However, CO_2 is non-flammable and non-explosive. Rather, the pipeline experienced "explosive decompression." This happens when a pipe that carries gas or liquid breaks very quickly – like blowing up a balloon and popping it with a pin. The material escapes quickly, causing a powerful rush and noise, disturbing the ground immediately around the break point.

QT4. What happens if a leak is detected?

Transportation systems are designed with leak detection, alerts, and shutoff requirements. Valves along the length of the pipeline are designed to shut down if a leak is detected, limiting the CO_2 volume released.

While prolonged exposure to high concentrations of CO_2 can cause breathing difficulty, the gas typically quickly evaporates into the air and requires little to no clean-up.

Local emergency responders play a crucial role in ensuring public safety near CO_2 pipelines. Even though a CO_2 pipeline leak is extremely rare, it is important that first responders have the information they need to prepare for and respond to all potential situations.

Pipeline operators are required to work closely with responders to develop and review emergency response plans and conduct regular training and drills.

Carbon Dioxide Geologic Storage

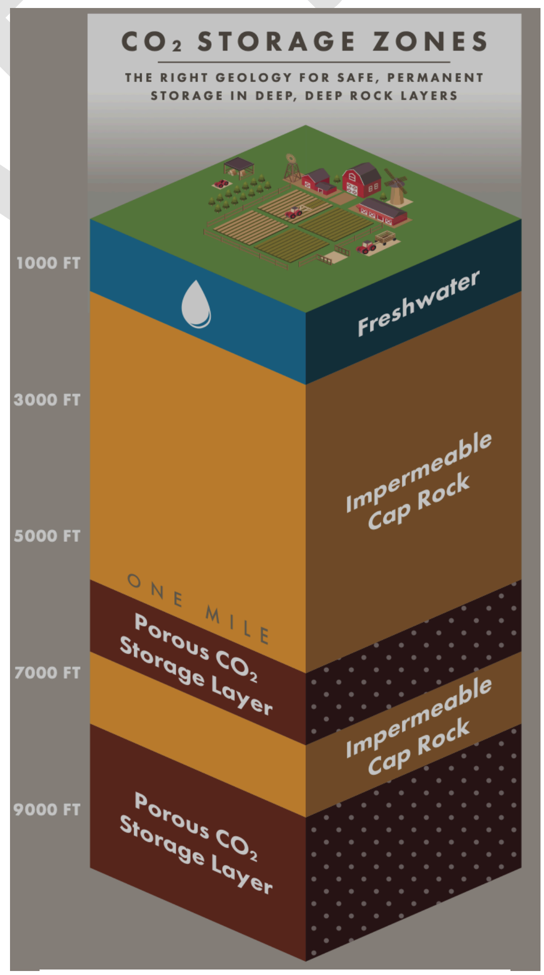
QS1. What is the difference between storage and sequestration?

Storage and sequestration are used interchangeably in terms of CCS. Sequestration means to isolate, per the Oxford dictionary. For CCS, sequestration means permanent carbon dioxide storage underground.

Storage is a simpler word. When used in CCS context, storage means the same thing as sequestration. However, in other applications, storage allows for future extraction. For example, natural gas is stored at the CINGSA facility on the Kenai in the summer and then that gas is produced it back in the winter for use when demand is high.

QS2. What is "cap rock"?

Cap rock is low permeability rock that does not allow gas and liquids to move through it. CO2 is injected in a porous and permeable storage layer and held in place by cap rock, as shown in this figure.



Understanding CO_2 FAQ, NDIC

QS3. What determines the minimum depth of injection underground?

Carbon dioxide is stored underground at depths where the pressure is high enough so it is a liquid rather than a gas, typically 3000' or deeper.

Liquids have higher mass per unit volume (density) than gases, so liquid CO_2 takes up a much smaller space—hundreds of times smaller at under normal conditions. Liquid carbon dioxide has a density around 1,100 kg/m^3 while gaseous carbon dioxide has a density of around 1.98 kg/m^3. In the liquid phase, molecules are much closer together compared to the gaseous phase, resulting in a higher density.

QS4. What happens after carbon dioxide is injected underground?

When CO_2 is injected underground, it flows through the reservoir and interacts with the water and rocks it contacts. Some CO_2 dissolves into the water, like a soda, and is trapped in immobile reservoir water, some is trapped by capillary forces, and some remains mobile. Depending on the reservoir rock minerals, CO_2 can chemically convert into a carbonate rock.

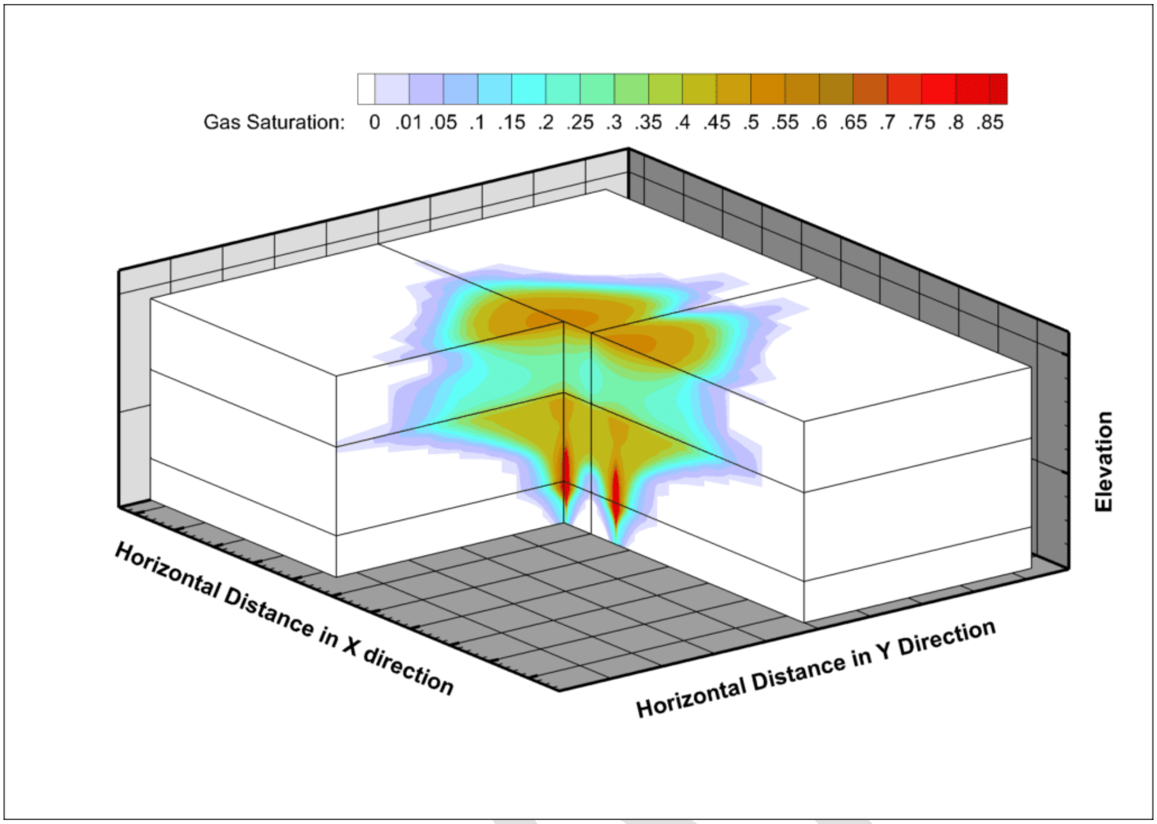
QS5. How is injection controlled to avoid fracturing the cap rock?

Reservoir and cap rock samples are measured or estimated for strength and other properties like porosity and permeability. Injection well and reservoir pressures are managed to maintain injection into the desired target injection reservoir(s).

QS6. How is the interaction of the CO_2 plume predicted/managed to mitigate effects on surrounding earthquake faults?

Advanced geological and physical models are used to predict the vertical and areal movement of CO2 through the reservoir; one example is shown here. This model predicts the pressure and CO2 saturations during and after injection into the reservoir.

Allowable injection pressures are recommended by the operating company based on the modeling and on in-field testing. The Regulator, either the EPA or the AOGCC, sets the maximum injection pressure allowed in a particular reservoir.



CO_2 gas saturation distribution after 30 years of injection in 2 wells located 0.5 miles apart, at a total rate of 1 million tonnes CO_2 per year. Intera modeling for US DOE.
https://www.intera.com/project/delineating-the-extent-of-horizontal-co2-plumes-at-complex-heterogenous-storage-sites/

QS7. What happens if an earthquake fractures the well casing seal?

There are hundreds of wells in the Cook Inlet and Kenai Peninsula, and thousands on the North Slope. All experience earthquakes, and many wells are decades old. If cement cracks, they develop in a cemented zone that is hundreds to thousands of feet high. This provides multiple barriers to flow, and fluids are contained.

QS8. What happens if a leak is detected?

If leaks are detected, the cause is investigated and corrective actions are taken if necessary to ensure the continued safe containment of injected CO2. Corrective actions could include well repairs or changes to operating practices. CO2 storage sites can have subsurface pressure monitoring both in-zone and above the designated storage reservoir.

Since injection is deep underground, advanced monitoring systems are used, including downhole pressure gauges, fiber optical sensors measuring temperature and other parameters, and surface seismic and gravity surveys.

An example of this type of monitoring is at the Sleipner field, Norway, the world's longest running industrial scale storage project:

- https://nora.nerc.ac.uk/id/eprint/508611/1/Sleipner_Chapter_V5_withFigs_singlespace.pdf
- Gasda, S. E., Wangen, M., Bjørnarå, T. I., & Elenius, M. T. (2017). Investigation of Caprock integrity due to pressure build-up during high-volume injection into the utsira formation. *Energy Procedia*, *114*, 3157–3166. https://doi.org/10.1016/j.egypro.2017.03.1444

WHAT CCUS WORK IS UAF DOING?

QU1. Why is UAF INE working on CCUS?

UAF INE strives to support Alaskan engineering needs, focusing on basic and applied research and development, as well as research outreach.

Alaska stands to benefit from carbon storage: from continued operations of existing projects, from new investments, and from payments to the State for carbon dioxide storage as the mineral and pore space owner on State lands. Large sedimentary basins within Alaska have been identified as potential carbon storage sites for either domestically captured or imported carbon dioxide. Some energy companies and utilities are considering carbon storage to reduce the carbon dioxide emissions associated with their activities.

From 2019 through 2024, UAF INE supported the establishment of Alaska's legal and regulatory framework for carbon storage. The Governor, Legislature, and State Agencies including the DNR and AOGCC have established the laws and regulations needed to enable carbon capture and storage in Alaska. The AOGCC is pursuing Class VI primacy with the EPA.

The State of Alaska, energy companies, and power generation companies have identified the need for carbon dioxide storage sites. Owners of existing natural gas power plants and potential coal power plant in Southcentral have a strong interest in having a storage site in the northern part of the Cook Inlet. This is our current focus for the ARCCS project.

QU2. What CCUS studies and projects are UAF INE working on?

With 20+ years of research for injecting carbon and natural gas underground on the North Slope of Alaska, the Institute of Northern Engineering (INE) at the University of Alaska Fairbanks is a leader in CCUS research. Research projects include EOR, corrosion mitigation and inhibition, and CCUS.

Two of INE's current projects — the **Alaska Railbelt Carbon Capture and Storage (ARCCS**) study and the **Alaska CCUS Workgroup** — are advancing efforts to reduce emissions, support energy stability and help prepare Alaska for a future where using CCUS to meet more stringent emissions regulations is commonplace.

In 2019, to deepen its CCUS knowledge, UAF joined the PCOR partnership. PCOR (Plains CarbOn dioxide Reduction) is a regional partnership sponsored by US DOE that spans from Missouri through Alaska including 4 Canadian provinces. PCOR is led by the University of North Dakota's Energy and Environmental Research Center (EERC). PCOR is partnered with UAF and U of Wyoming. PCOR has over 250 members currently and is an international leader in CCUS technology, public policy, and regulatory framework.

QU3. Why is coal-fired power being studied for CCUS in Alaska? Shouldn't we be focusing on renewable energy investments instead?

Like an off-the-grid cabin, Alaska's Railbelt power grid needs to combine diverse power systems to supply reliable power. Wind and solar (along with hydro where available) are supported by batteries for short-term power swings, with natural gas, coal, and/or diesel generators required for long term power supply stability.

Lowering carbon dioxide emissions of these power systems is a research area for UAF INE.

Two recent studies concluded that even with 75% of Railbelt power provided by renewables (requiring massive future infrastructure investments), 80% of existing power generation (coal and natural gas power plants) needs to be retained as firm power available on demand when renewables are not making power. See "***Achieving an 80% Renewable Portfolio in Alaska's Railbelt: Cost Analysis"***. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-85879. Denholm, Paul, Marty Schwarz, and Lauren Streitmatter. 2024. https://www.nrel.gov/docs/fy24osti/85879.pdf.

For more than 70 years, residents in Alaska's Railbelt, from Homer to Fairbanks, have relied primarily on coal and natural gas for industrial and home heating and for making electricity — reliable, affordable and available instantaneously. The impending shortage of natural gas supply (starting in 2027 and estimated to be more than 50% in 2032) leaves a significant shortage of electricity for the Railbelt even with proposed wind and solar farms.

Powering the existing natural gas power plants in Southcentral will require importing LNG, building the gas pipeline from the North Slope, or finding more natural gas in the Cook Inlet quickly. Coal-fired power with CCS provides an alternative using local energy resources with 100-year reserves that are both cost and environmentally competitive.

QU4. Is carbon capture required for existing or new coal-fired power plants in Alaska?

Not for existing coal-fired power plants in Alaska, but CCS (or other abatement) will be needed for new plants to meet applicable EPA rules.

Alaska's existing coal-fired power plants, discontiguous from the lower 48, are exempted from the April 2024 EPA GHG rules that require 90% CCS by 2032 to continue operations after 2039. (For more info see: https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power.)

New coal-fired power plants in Alaska are subject to the 2015 EPA rule requiring emissions to be than 1400 lb. CO_2 per MWh of electricity. This is about 40% carbon dioxide capture from an unabated coal-fired plant.

QU5. Why hasn't UAF implemented CCS at its coal-fired power plant in Fairbanks?

Firstly, carbon dioxide capture is not required at the UAF plant since:

- It was permitted prior to the 2015 EPA rule.
- The UAF plant, and all coal-fired plants in Alaska, are exempt from the 2024 EPA rule specifying 90% capture since Alaska is discontiguous from the lower 48.

Secondly, carbon dioxide captured at the UAF plant would need a sequestration location:

- Finding and proving an excellent storage site for carbon dioxide would be a key enabler for carbon dioxide sequestration in the Interior. A path to this could be a CarbonSAFE Phase I project to find and delineate subsurface reservoirs as carbon dioxide storage sites.
- There is limited subsurface well data in the Interior since not many deep wells have been drilled in the region (due to limited O&G drilling). This lack of subsurface data is an impediment to carbon capture at Interior coal-fired power plants.
- A concern in the Interior is that the seismic activity in the Interior, in some areas, is expressed near the surface. Thus, in addition to good reservoir and seal is finding and proving a site without active faults. See this link to review a statewide screening of seismic hazards for carbon dioxide storage here:
  link: Seismic Hazard Considerations for Carbon Sequestration in Alaska

QU6. What is the Alaska CCUS working group?

A group of Alaskans formed this Workgroup in July 2022 to accelerate commercial carbon capture, use, and storage (CCUS) projects in the State of Alaska. The Workgroup's mission is to attract new investments and create options that enable continued operation of carbon intensive activities vital to the State's economy including power generation, refineries, and oil and gas production.

The Workgroup, co-lead by UAF-INE, the Alaska DNR, and ASRC Energy Services, is comprised of interested parties from diverse organizations including industry, State and Federal government, academia, NGOs, and the Public.

For more information on the Workgroup, see its web site, https://ine.uaf.edu/carbon

For further discussion, see item #6.1, SPE paper 213021, "Alaska CCUS Workgroup and a Roadmap to Commercial Deployment", by Paskvan et. al.

WHAT IS THE ARCCS PROJECT?

QA1. What is the ARCCS Project? Is it dedicated to the West Susitna power plant?

ARCCS is the Alaska Railbelt Carbon Capture and Storage Project. ARCCS is assessing carbon dioxide storage capacity (using the DOE CarbonSAFE Phase II framework) near the Beluga River field, nearby gas fields, and underlying saline aquifers. It is a geologic and engineering assessment including acquiring ~ 20 miles of new 2D seismic in the area to better define underground reservoirs. ARCSS is funded from Sept. 2024–Sept. 2026.

The project evaluates the feasible storage capacity, targeting from 50 to 250 million tonnes of carbon dioxide, and prepares for future storage permit application.

ARCCS is evaluating pipeline transportation options and storage from three potential carbon capture sites: a new Terra Energy Center biomass-coal power plant and two of Chugach Electric's natural gas power plants in Anchorage, the Southcentral Power Plant and the George M. Sullivan power plant near Muldoon Road south of the Glenn Highway.

While ARCCS is an enabler for carbon capture projects, ARCCS storage capacity is not dedicated to any project(s) at this time and is available for storage from any project.

QA2. Who is funding this CCUS work? And who is doing the ARCCS project?

ARCCS is funded by the US DOE and the State of Alaska, ~ 80%/20%.

The University of Alaska Institute of Northern Engineering (UAF-INE) is the primary awardee for ARCCS, with technical support from the University of North Dakota's Energy and Environmental Research Center (UND EERC), Advanced Resources Inc. (ARI) based in Arlington, Virginia, and other sub-awardees and contractors.

QA3. This is an active seismic region. Why are we considering storing CO_2 in this area?

Seismic activity is well known in the Cook Inlet. Development, construction, and operations in the area have safely been ongoing for decades. The presence of many large oil and gas fields in the area proves that large subsurface storage does occur in this area of seismic activity.

Southcentral, while seismically active, typically has deep faults, deeper than 10 km, that do not extend from reservoir depths to the surface. Thus, these reservoirs may be amenable for carbon storage, just as they are for sizeable oil and gas accumulations. Individual storage sites will be screened and seismic hazards evaluated before any injection is considered.

For further information see this link: Seismic Hazard Considerations for Carbon Sequestration in Alaska which states " rupture of these fault cores would likely be blind, meaning that they do not rupture through to the surface but rather cause growth of existing anticlines in the form of broad warping of the seafloor."

QA4. What is the risk of CO_2 being released into the Cook Inlet?

While the ARCCS study is not yet complete, the expected risk of CO_2 release to the Cook Inlet is extremely low. And if significant risks are identified, the storage project concept will be abandoned at this location. That is one reason the area is being studied in detail now.

CO_2 capture, utilization, and storage projects are designed to be safe for people, animals, and the environment. Before a CO_2 storage project ever begins, geoscientists and engineers identify and evaluate acceptable sites to be considered. Permanent CO_2 storage needs porous and permeable (small spaces or holes that are interconnected) rock layers where CO_2 can be injected and stored at pressures low enough to avoid breaking the rock. This porous storage layer must also be capped by an impermeable (or solid) rock where CO_2 can't escape.

The Alaska Oil and Gas Conservation Commission (AOGCC) is expected to be the agency regulating carbon dioxide geologic sequestration in Alaska. The AOGCC plans to apply to the EPA for carbon dioxide injection regulation authority or Primacy. If approved by the

EPA, the AOGCC will review and approve any proposed projects in Alaska, just as they do for oil and gas development. The AOGCC regulatory review will consider seismic hazards.

FEASIBILITY STUDY FOR A WEST SUSITNA PLANT WITH CARBON CAPTURE

QF1. Where can I find this study so I can review it for myself?

The feasibility study can be downloaded from item #9 at https://ine.uaf.edu/carbon along with a PDF and video presentation made to the State Legislature in March of 2024.

Full title and citation: *Cook Inlet Region Low Carbon Power Generation with Carbon Capture, Transport, and Storage Feasibility, UAF-INE, EERC PCOR, February 28, 2024, Paskvan, F., McGuire, T., Strege, J., Hobbs, R., Stevenson, K.*

QF2. Is the West Susitna Access Road required to build or operate a new power plant in West Susitna?

No. In fact, the Beluga River Power Plant was built and has been operating in the West Susitna area for decades off the road system. A new power plant in West Susitna could similarly operate without permanent roads.

Ice roads have historically been built annually in the West Susitna. They can support plant construction and operations, similar to Alpine operations on the North Slope, along with remote airport access.

While a road, such as the proposed West Susitna Access Road Project, would certainly be beneficial for the Plant, its workers, and their families to access the area, a permanent road is not required.

QF3. Who would pay for the new power plant?

Investors pay for initial plant construction. Investors recoup investments from power customers, potentially industrial and residential, over time at rates regulated by the Regulatory Commission of Alaska.

QF4. What are the costs of the major components? Why were the road and transmission line costs excluded?

Study Table 8 (below) shows the 75MW and 300 MW with CCS cost are estimated at $1149 and $3627 million dollars, respectively. The uncertainty range is -30% to +50%, consistent with a Class 5 Conceptual Engineering cost estimate.

Table 8. Combined Project Cost, Low Carbon Biomass-Coal Power Generation with CCS, 30-yr			
	Units	Power Plant with CCS	
Power Plant Generation Net with CCS	MWe net with CCS	75	300
Total Capital: Power Plant, CCS Plant, Pipeline, Well, Storage	Net present US$MM	**1149**	**3627**
Total Operating Capital Cost (30 years, 2.5% plant cost/yr)	Net present US$MM	464	1555
Total Expense Cost (30 years)	Net present US$MM	1657	6129
Power Plant Capital Cost (excluding power transmission)	Net Present US$MM	650	2229
Power Plant Ongoing CAPEX (30 years, 2.5% plant/yr)	Net present US$MM	319	1092
Power Plant OPEX (30 years)	Net present US$MM	1190	4567
Carbon Capture Plant Capital Cost	Net present US$MM	296	944
Carbon Capture Plant Ongoing CAPEX (30 years, 2.5% plant cost/yr)	Net present US$MM	145	463
Carbon Capture Plant OPEX (30 years)	Net present US$MM	389	1410
Pipeline Capital Cost	Net present US$MM	97	133
Pipeline OPEX (30 years)	Net present US$MM	17	17
Well Cost	Net present US$MM	45	186
Storage (monitoring, facility fees, inspection, and testing)	Net present US$MM	61	135

SPE 213051 Table 8, Paskvan et. al.

Transmission line(s) and road costs are excluded as discussed below and in Study section "***Excluded Costs, Tax Structures, Grant Opportunities, and Loan Programs"*** on p.7.

For transmission line(s) costs, the electricity customers are not yet known. Customers may be local to the plant, such as area mines, a new data center, or an AI computer center. Each have expressed interest in low cost, reliable, clean power. Since transmission line costs depend on its length of the line, a reliable cost estimate could not be made.

If the customer is on the Railbelt, potential power connection points include the Beluga River Power Plant or Point MacKenzie. To connect at Beluga, a transmission line cost estimate is ~$250 million dollars, adding 7% for a 300 MW power plant with CCS project. Transmission line costs should be lower for a smaller plant generating less power.

For road costs, the Study assumed the West Susitna Access Road is funded by DOT and/or AIDEA, in which case a toll may be charged for road use. This has yet to be determined. A short access road from WSAR to the power plant site will need to be selected and costed.

QF5. Have the cost assumptions panned out for both the estimated cost of power and the cost of replacement power (imported LNG).

It is difficult to say without redoing the cost estimates.

For imported LNG, Enstar president John Sims stated to the Legislature that imported LNG will cost no less than $16/MMBtu, which is in-line with the Study estimate range of $15 to $25/MMBtu. If the Alaska LNG line is built, it could provide lower cost power, perhaps in the $10/MMBtu or slightly less (TBD). And new Cook Inlet discoveries may occur with an unknown cost of supply.

For capital costs, the Study cost basis was estimated and benchmarked prior to the COVID global supply chain disruption and prior to the EPA mandating CCS on coal-fired plants in the lower 48. Both are expected to drive cost inflation.

Other power options, including Renewables, may also have cost inflation post-COVID.

QF6. What is the status of operating CC systems in North America and their history of operating efficiencies?

Boundary Dam #3 plant in Saskatchewan has captured over 7 million tonnes of CO_2 from coal-fired power plant flue gas, in a first of its kind test project. The Boundary Dam project has an online blog reporting their quarterly performance; Q32024 performance was as expected and captured ~ 86% of flue gas carbon dioxide. The Petro Nova plant in Texas is back online, having been temporarily shut down due to low oil prices; it supplies CO_2 to Hilcorp for an EOR project and when Hilcorp stopped wanting CO_2 the Petro Nova carbon dioxide capture was temporarily halted. The Petro Nova plant operations are nominal. Two coal-fired plants are operating in China, one since 2021, but we've not been able to find operational data for those plants.

QF7. Would the project (i.e. powerplant, carbon capture, pipeline, and injection well/storage site) be publicly or privately funded?

Project partners or investors would pay for the initial plant construction. They recoup their investment from power customers, potentially industrial and residential, over time at rates regulated by the Regulatory Commission of Alaska. Investors may include private, public, and other sources including loans and grants.

QF8. How does the current development timeline compare with that presented in the feasibility study?

An engineering firm estimates 5 years from start of the Front-End Engineering and Design (FEED) to startup. This is faster than the 6.5 years UAF assumed in the study. Starting FEED in 2025 would make a 2030-2031 start possible. This schedule enables qualification within the eligibility time limit for the 45Q tax credit, which is currently available for projects that initiate construction at the site by December 31, 2032.

QF9. How does the project and its anticipated timeline reduce the impact of the projected gas shortfall in Southcentral?

Natural gas for power generation in the Railbelt uses ~ 20 BCF/year of the total 70 BCF/year demand. When other sources of energy, such as coal, are used to generate electricity, natural gas not burned at a power plant can be used to provide heat for homes.

Residential and commercial customers of natural gas will find it difficult to replace natural gas, which is why utilities are pushing for importing LNG—at $16/MMBtu minimum price.

QF10. Why will carbon capture work for this project when others in North America have reportedly struggled?

Petro Nova and Boundary Dam#3, projects that are reportedly struggling, are now performing as expected.

The Petro Nova plant, for example, was designed to supply CO2 for enhanced oil recovery at a specific rate. A portion of a coal-fired power plant's flue gas is processed to extract CO2. That carbon capture process has worked as designed and planned. It was shut-down during COVID's low oil prices, when Hilcorp (the oilfield EOR operator) determined it wasn't economically attractive to buy and inject CO2, but the Petro Nova plant has been restarted and is supplying the target CO2 gas volumes needed by Hilcorp. Petro Nova is a 10X scale-up of prior pilot work and is performing as planned. Critics say it doesn't reduce plant emissions by very much, which is true, but it wasn't designed to process all the flue gas, just a portion. It is performing as designed.

Boundary Dam #3 in Saskatchewan has captured over 7 million tonnes of CO_2 to date, which otherwise would have gone into the air. Its operating efficiency continues to improve with continued operations. Last quarter the plant, in its quarterly blog, captured 86% of the CO_2 emission from the flue gas.

A new coal-fired plant with carbon capture designed as part of the system from day 1 would have higher performance efficiency than either of these two plants. And it would benefit from the learnings from these early pilot/projects.

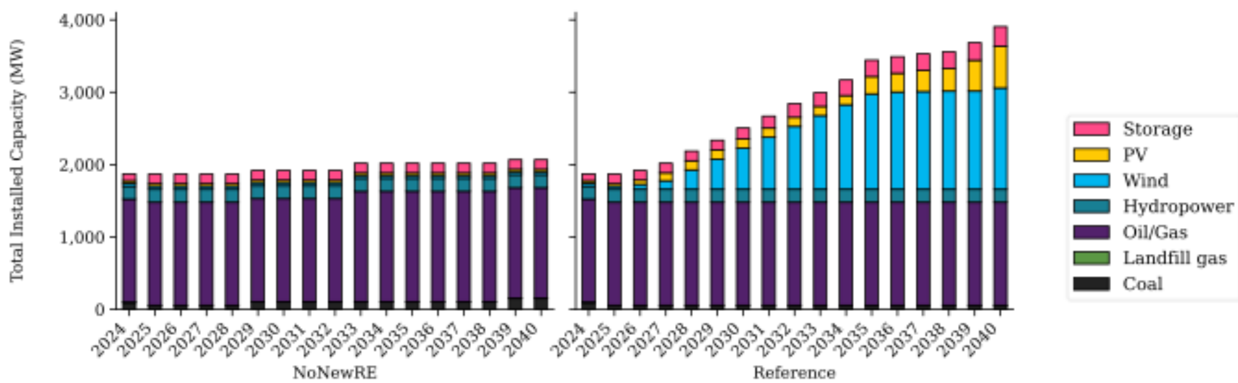
QF11. What is the basis of the anticipated power cost?

Electricity prices are determined by a combination of factors including the cost of generating power (fuel costs, plant operation), transmission and distribution costs, regulatory oversight, market demand, weather conditions, and the type of customer (residential, commercial, industrial), with the final price usually set by a state regulatory agency (the RCA in Alaska) or through a competitive market depending on the region's electricity market structure.

Costs for this project are summarized above, see question QF4.

QF12. Why would we want to build a coal plant considering the 76% — 80% renewable scenarios recommended from the NREL study?

30 years from now, even in the 80% renewables scenario, coal and natural gas power plants are still operational and required for reliable power. This can be seen comparing the NoNewREnewables to the Reference cases' installed capacity charts below. Since these plants are required and operating, wouldn't new, low carbon dioxide emitting plants with lower cost electricity to the consumer be better than existing equipment?



"Achieving an 80% Renewable Portfolio in Alaska's Railbelt: Cost Analysis", Finding #2 p. x

The NREL study, even in the 80% renewables scenario (more wind and solar mainly), finds the grid "*Relying Heavily on Use of Existing Hydro and Fossil-Fueled Generators During Periods of Low Renewable Output*" (Finding #4):

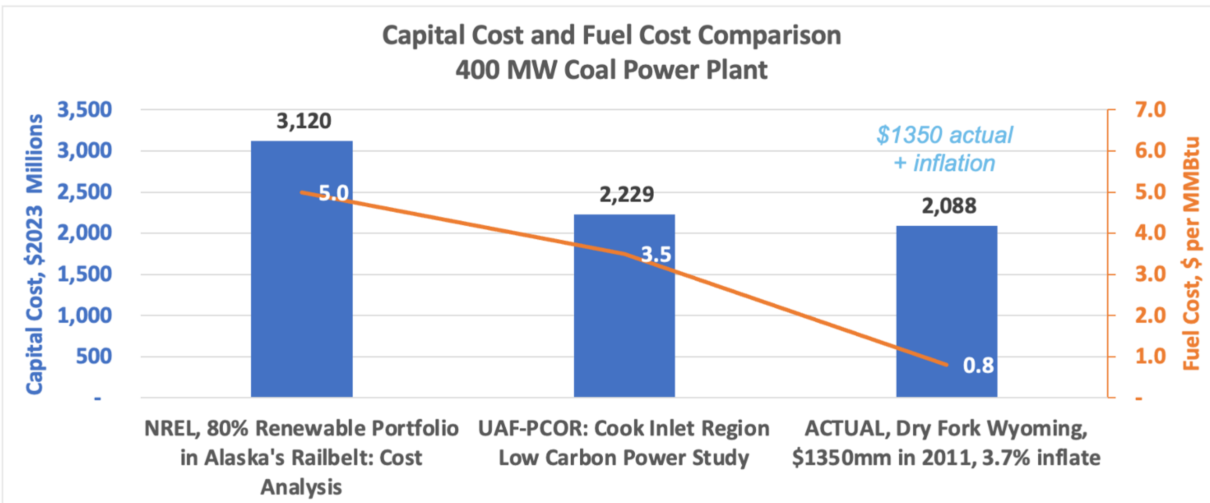
> *"There are many periods of low wind and solar output, and these periods can last for many hours. This demonstrates a fundamental change in how electricity generation is planned, where renewables may provide the majority of the energy requirements on an annual basis, but with fossil resources providing a larger fraction of the capacity requirements."*

The NREL study is an excellent analysis of the Railbelt energy system. It deserves review by anyone wanting to understand the Railbelt grid. Here is a link:

- https://www.nrel.gov/docs/fy24osti/85879.pdf. "***Achieving an 80% Renewable Portfolio in Alaska's Railbelt: Cost Analysis***". Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-85879. Denholm, Paul, Marty Schwarz, and Lauren Streitmatter. 2024.

One issue we raise about the NREL report is, while it did allow adding more coal-fired power, it 1) did not include coal with carbon capture benefits and 2) used capital and fuel costs ~140% of the UAF study basis, i.e. 40% higher. The NREL basis was the 2010 Alaska

Railbelt Regional Integrated Resource Plan (RIRP), which overstates costs compared with actual costs demonstrated at Dry Fork Station, Wyoming. The chart below compares capital and fuel costs from the NREL and UAF-PCOR study to the Dry Fork Wyoming actual costs. Dry Fork cost $1.35 billion in 2011 (a 405 MW design, 485 MW actual plant) with fuel costing $0.80/MMBtu (80 cents per MMBtu). Dry Fork electricity is very low cost (5 to 10 cents per KWh), which is one reason Wyoming has the lowest cost of electricity of any state in the USA. We discussed with NREL staff re-doing their study with the UAF-PCOR cost basis, which they wanted to do, but funding wasn't available for that work.



QF13. What is the benefit to the Railbelt power system from a new powerplant to support Southcentral and potential mining?

A new, low carbon dioxide emitting plant with lower cost electricity to the consumer is better than existing equipment. It expands the power generation capacity enabling and attracting new industrial, commercial, and residential demand with low cost, clean, reliable electricity.

For further information, email CCUSAlaska@gmail.com

For additional FAQs on CCUS, see:

https://carbonnd.com/faqs-north-dakota-carbon-capture/

This link has helpful and informative FAQs from the North Dakota Industrial Council. Their FAQs informed some of our answers provided here.