BECCS LEADERSHIP SUMMIT

OCTOBER 16-18, 2024
BANFF, ALBERTA

BECCS LEADERSHIP SUMMIT PROCEEDINGS

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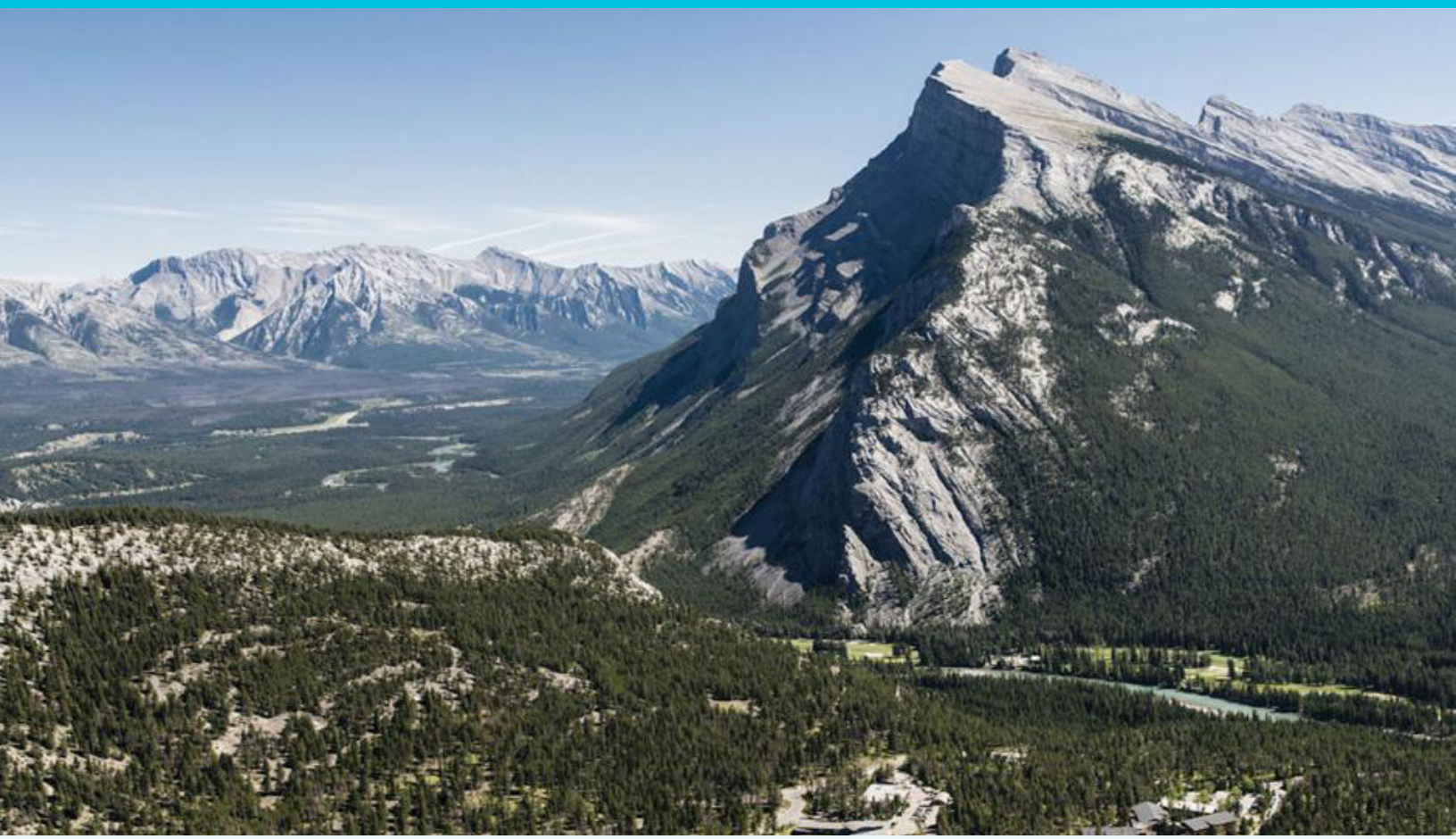

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Emissions Reduction Alberta

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Natural Resources Canada

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Alberta Forest Products Association

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The purpose of this document is to provide an overview of what was discussed by a variety of contributors during the BECCS Leadership Summit. The views and opinions expressed herein do not necessarily reflect those of Emissions Reduction Alberta, Alberta Innovates, the Government of Alberta, or any of the Summit hosts or organizers.

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About the Organizers

About Emissions Reduction Alberta

ERA invests public money from the Government of Alberta's Technology Innovation and Emissions Reduction (TIER) fund to help a diverse range of innovators develop and demonstrate emission reduction technologies. ERA's work is focused on reducing emissions and growing the province's economy. We believe the only way to hit climate targets and achieve economic success is through collaboration, regardless of the sector or size of company.

To date, ERA has committed about $1 billion CAD towards almost 300 projects that will enable the transition to a carbon-neutral world. These projects, valued at over $8 billion, are reducing emissions, lowering costs, attracting investment, and creating jobs in Alberta. ERA's funding ratio is 6.8:1, meaning for every dollar invested, nearly $7 is leveraged from public or private investors. ERA's portfolio is expected to result in cumulative emissions reductions of over 40 million tonnes of CO_2 equivalent by 2030, and 98 million tonnes by 2050.

About Alberta Innovates

Alberta Innovates is a multi-faceted innovation organization that serves as a technology and innovation arm for the province of Alberta. AI invests in and advances the innovation priorities of the province and of Albertans, focusing on the technology readiness level "valley of death".

Within the Alberta Innovates family, there are three organizations: InnoTech Alberta, C-FER Technologies, and Alberta Innovates. Together, they offer a comprehensive and diverse suite of innovation supports with a mission to position Alberta for success economically and environmentally. Between the three organizations, there are 11 locations, with more than a million square feet of lab space and 600 acres of research farmland in the province.

Acknowledgements & Citations

This document should be cited as follows: "Emissions Reduction Alberta and Alberta Innovates, 'Proceedings: BECCS Leadership Summit', November 2024".

Emissions Reduction Alberta, Alberta Innovates, and the Government of Alberta co-hosted this event and led the accompanying efforts to enhance education around BECCS. The event and its outcomes would not have been possible without significant financial and in-kind support provided by TorchLight, the Alberta Forest Products Association, and Natural Resources Canada.

The Summit agenda, attendees, and educational content were developed with oversight by a Steering Committee consisting of key stakeholders representing all aspects of the BECCS industry. The Steering Committee met four times over the course of a year in planning for the event. The organizers would like to recognize the contributions of the Steering Committee members:

- Government of Alberta
- Natural Resources Canada
- TorchLight
- Alberta Forest Products Association
- First Nations Power Coalition
- Carbon Removal Canada
- Hydrogen Naturally
- Varme Energy
- International CCS Knowledge Centre

The organizers would also like to recognize the numerous speakers, facilitators, and attendees who contributed their expertise and perspectives at the Summit. This enabled highly productive presentations and discussions that will help drive this new industry forward.

Communications and media materials from the Summit were produced by Shift Consulting and Sticks + Stones. This includes two educational videos, four podcasts, plenary session recordings, and all design materials associated with the Summit.

The Banff Center staff enabled the event to run smoothly at a beautiful, unique venue nestled the boreal forests of the Rocky Mountains on Treaty 7 territory in Banff National Park.

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Executive Summary

The inaugural BECCS Leadership Summit took place from October 16-18, 2024 in Banff, Alberta. This unique format brought together over 100 leaders and decision makers from diverse stakeholder groups to discuss how to address barriers and accelerate BECCS adoption. Over one and a half days, participants engaged in plenary sessions and interactive workshops covering the spectrum of opportunities and challenges facing this new industry.

This event was timely, given the current status of decarbonization in Alberta and globally. According to the latest IPCC report, there's an imperative for 7-9 billion tonnes of CDRs per year by 2050 to meet Paris Agreement targets. Via BECCS, Alberta is positioned to making a meaningful contribution to achieving these goals. BECCS has advantages over other CDR methods, as well as conventional CCUS, because it leverages the existing forestry sector and co-produces clean energy. This will be needed to meet society's broad energy needs but is especially urgent in the recent advent of data centers and artificial intelligence.

A key theme from the Summit is that Alberta is one of the best places in the world to implement BECCS. Alberta and Canada have abundant, sustainable forest resources, as well as the CCUS experience, geology, and regulatory infrastructure to make it happen. Existing pulp mills are a natural place to start, as they already produce local electricity – contributing around 2% of clean, firm power to the local grid – and have biogenic emissions of approximately 5 $MtCO_2e$/year. The total BECCS opportunity in Alberta is significantly greater than this, given additional opportunities at sawmills, greenfield facilities, and waste-to-energy for applications like power and cement.

Taking place in Banff National Park, the Summit highlighted the critical role that forests play in the energy transition. Canada's growing wildfires create an imperative to work with and manage the forests. However, it was reiterated during the Summit that forest management is extremely complex, involving numerous stakeholders and trade offs. In Alberta, many of the issues are nuanced, and working with the existing, robust forestry expertise and frameworks is essential.

One of the drivers for the unconventional format of the Summit was the fact that BECCS projects involve a diverse group of stakeholders that don't normally work together. Reflecting this, each of the BECCS projects presented at the Summit involved innovative partnerships, ranging from CCUS technology vendors, subsurface experts, pulp mills, First Nations, and more. Given their expertise in CCUS, oil and gas industry workers may also have a role in BECCS.

Financing was raised as a key challenge facing this new industry. Among the key takeaways from the Summit was the need to divide projects in terms of risk and financing into manageable pieces. Participants highlighted that although use of CO_2 for EOR is currently ineligible under most incentive programs for CCUS, this could help finance initial BECCS infrastructure, with the long-term view of transitioning to pure CO_2 sequestration. It was also raised that a "green premium" may ultimately be required on end-products to enable BECCS projects.

A critical component of financing is monetization of CDRs, typically via offtake agreements with buyers from hard-to-abate sectors. More scrutiny on buyer industries around their emissions accountability could drive higher volume purchases and thus greater implementation of BECCS.

In addition to the plenary sessions, the Summit involved interactive workshops that explored emergent topics related to BECCS in greater depth, allowing all participants the opportunity to contribute their expertise to the discussion, by addressing the following questions:

1. **Forest Carbon:** What is the true size of Canada's and Alberta's forest carbon opportunity for BECCS, and how does BECCS compete with other end uses for that feedstock?

In Alberta, sustainable timber harvesting limits are set in alignment with policy, taking into account numerous competing social, economic, and environmental factors. There is currently a differential between potential and actual harvest, due to economics and access constraints. BECCS could incentivize additional harvest within existing policy, as well as tap into forestry residuals currently left as waste. Currently, there is no emissions reduction protocol in Alberta to monetize the benefits of retrieving incremental forestry feedstock for decarbonization projects. Such a protocol could be developed and championed by industry to help advance BECCS.

2. **Projects & Partnerships:** What are some of the unique challenges facing BECCS projects, and what is the best way to structure a BECCS project?

BECCS projects bring unique challenges. Like other CCUS projects, capture technology is the most expensive part. Liquid amines are the proven commercial technology, but there's a role for next generation capture. A key difference between BECCS and other CCUS projects is the variable nature of biogenic flue gas. In terms of infrastructure, existing pulp mills can provide a backbone for the first wave of BECCS projects, but may require changes like waste heat recovery systems, steam generator upgrades, and adjustments to harvesting practices. As for how to set up a project – as evidenced by the different structures present at the Summit – there is no "right" way, but all involve building trust and expertise across multiple industries.

3. **CDR Generation:** What makes a BECCS project truly sustainable for global CDRs, and what protocols and standards are required to help grow the market?

To date, only a few small CDR transactions have occurred, primarily on the voluntary carbon market (VCM). Exponential growth in transaction volume will be needed to meet climate targets. The VCM is reforming to increase credibility and stimulate growth. Long term, the industry is anticipated to move towards compliance markets. Alberta's carbon pricing framework, TIER, is one example. TIER is currently updating its CCS protocol better enable BECCS projects. Strong protocols are essential to generating strong credits, but must be applicable different types of biomass – from forestry, to agriculture, to waste – and involve considerations ranging from prioritization of land use, to water consumption, to biodiversity. It is essential that projects engage standard setters early. The industry should move towards greater alignment and a pragmatic approach to certifying BECCS CDRs.

Overall, the format and content of the Summit was very well-received. Attendees commented on the value of learning about forestry's role in the energy transition; the networking opportunities provided by a targeted, invite-only format; the timing in the broader context of decarbonization, and the secluded, retreat-like setting of Banff to dedicate focus to this exciting new industry for Alberta, Canada, and the world. Numerous public educational materials were provided as outcomes of the Summit, and future events and initiatives are being explored to continue advancing BECCS.

Introduction

This inaugural Summit focused on BECCS as a new industry for Alberta and the world that combines sustainable biomass with carbon capture, utilization, and storage. BECCS is a form of CDR, or negative emissions. It involves the use of biomass for energy, which releases biogenic CO_2. When that biogenic CO_2 is captured and permanently sequestered, it results in a removal from the natural carbon cycle.

CDRs have gained recent traction as necessary to meet climate targets and will play a key role in decarbonizing the global economy. CDRs can offset "hard to abate" emissions from industries like aviation and shipping that aren't reducing emissions quickly enough to reach climate targets. They can also reduce emissions from natural events that are exacerbated by continued global warming, like forest fires.

At a high level, carbon removals can be categorized into three pathways:

1. **Direct air capture (DAC),** using liquid amines, membranes, sorbents, or other means to concentrate CO_2 out of the atmosphere through chemical or physical mechanisms.
2. **Bioenergy with CCS (BECCS),** which combines two established technological processes: bioenergy, i.e. heat or electricity, with carbon capture and storage.

Both DAC and BECCS are sometimes referred to as "engineered solutions", because they ultimately rely on engineered facilities to ensure the carbon removal.

3. **Nature based solutions (NBS)** is a broad category of approaches intended to enhance natural carbon sequestration, including but not limited to:
    - Reforesting lands where forests have been lost
    - Increasing the carbon that's held in soils
    - Increasing the carbon that's held in plant matter and biomass in the oceans
    - Mineralization, whereby naturally occurring minerals like calcium and others form into carbonates through a natural affinity for carbon and oxygen.

BECCS has distinct advantages over both DAC and NBS. Compared to DAC, it's more efficient in both cost and energy, because the CO_2 in the flue gas streams being captured is significantly more concentrated, requiring less energy to sequester. Compared to most NBS, it is more permanent and durable, because the CO_2 is sequestered underground, as opposed to on the surface.

Canada has the potential to become a global leader in BECCS. Not only does it hold the greatest volume of biomass per capita in the world, but it also has on-shore and off-shore geology that is well-suited for carbon sequestration. Within Canada, Alberta is the best place to start. Alberta has all of the ingredients to make BECCS successful:

1. **Sustainable feedstock:** Alberta has a robust forestry sector, and over 80% of Alberta's managed forests have achieved international sustainable forestry certifications.
2. **CCUS expertise:** Alberta's operating commercial infrastructure, natural geology, and regulatory frameworks offer advanced tools to build CCUS projects at scale.

3. **Deregulated electricity market:** The province's competitive power market welcomes new entrants, and bioelectricity from pulp mills is already part of the grid.

To date, the province has made significant investments that lay the groundwork for BECCS. Key examples include:

- More than $2B in public funds have been invested in commercial CCUS infrastructure, including the Alberta Carbon Trunk Line (ACTL) that carries CO_2 between Edmonton and central Alberta from NWR Sturgeon Refinery and other facilities, for use in enhanced oil recovery (EOR), as well as the flagship Shell Quest CO_2 sequestration project.
- More than $160M of TIER funding has gone towards CCUS technology development and engineering work to scale up new CCUS technologies.
- Approximately $40M has been invested through ERA from the TIER fund towards innovations in the forestry sector, including the Mercer Peace River Fiber Procurement Project and the ALPAC Kraft Pulp Mill Flue Gas Recovery Project – these projects are examples of pulp mill upgrades that can lay the groundwork for BECCS.
- More recently, about $20M has been invested through ERA from TIER towards BECCS front-end engineering and design studies.

PLENARY SESSIONS

Session 1 - Making BECCS Happen

The Summit kicked off with a first session focused on how to make major projects happen for the climate and what it will take to accelerate BECCS happen as a carbon removal solution, featuring industry veteran Ian MacGregor, who was essential in standing up Alberta's existing commercial CCUS infrastructure. Several key themes emerged from the discussion:

Alberta's CCUS infrastructure as a case study

- The oil and gas industry in Alberta produces significant CO_2 emissions, and central Alberta has a use for that CO_2 in the form of EOR.
- The NWR Sturgeon Refinery, located near Edmonton, entered operations in 2020. CO_2 is captured from the refinery, transported down the ACTL and used for CO_2-EOR in rural central Alberta. EOR thus helped drive the business case for Alberta's first commercial CCUS infrastructure.
- The ACTL currently transports 500 tCO_2/year, with 5 $MtCO_2e$ sequestered to date. It is undersubscribed, and capable of transporting over 14 $MtCO_2e$/year.
- In the future, we could envision a network of CO_2 pipelines across Alberta, not unlike the current natural gas pipeline network.

The role of the forests in the energy transition

- Trees are nature's direct air capture machine – nothing does this better.
- Canada has a wildfire problem, with wildfires increasing in intensity due to climate change impacts. Not only are forestry residuals being left in the forest right now, but after a forest fire, significant wood remains that serves as a feedstock for the next one. Potentially, these residuals are among the feedstocks that could be leveraged for BECCS projects.

Drivers for BECCS

- Data centers in Canada have projected power needs exceeding all the gas available from LNG Canada. These centers should be carbon neutral, but it's challenging to do with the technology they have. Data centers often need about 50% of their energy from natural gas to maintain reliability and optimize integration with heating and cooling requirements.
- Only Alberta and Texas have deregulated electricity markets – that draws data centers here. In Alberta, most energy comes from natural gas. This creates drivers for BECCS, either as a source of clean energy, or as a source of CDR to offset emissions from other sources.

Why Alberta?

- In Alberta, pore space is owned by the crown; in the US, individual landowners must be consulted, driving CO_2 sequestration offshore, despite the associated higher costs.
- Alberta's emissions management framework, called TIER, is well-established and can be expected to remain in place for the foreseeable future.
- Alberta also has strong regulation due to its history dealing with sour gas. Experience in acid gas injection in pore space translates into expertise for CO_2 injection.

- Between its CCUS and forestry expertise and resources, Alberta is one of the best places in the world to develop a BECCS project.

Advice for investors and project developers

- The need for low carbon, valuable products isn't going away as a driver for emissions reduction and CDR.
- EOR provides more economic options to underpin a CCUS project than pure sequestration.
- For large, vertically integrated projects – it's critical to find a way to break the project, and thus the risk, into manageable pieces, with each partner taking care of their piece and their risk. No one will be willing to manage the entire value chain of risk – it must be allocated.
- The same is true for financing: you may have to break a project apart to finance it. The challenge is balancing differing commercial interests.
- Don't underestimate the power of a small, committed group of individuals to make big projects happen.

Session 2 – Ingredients for BECCS Success

In this session, panelists from forestry, carbon capture tech, and project development discussed key components to enable successful BECCS projects, from technology to financing. Several key themes emerged from the discussion:

State of CCUS technology

- Amine technology has advanced compared to early deployments of MEA solvents. Industry is now in the "second wave" of commercial deployments for post-combustion capture.
- Large projects can be de-risked if they use a standard, proven technology. This will hopefully enable project development times to get down to months instead of years.
- Each CCUS project is different, and there's a need for more proven operational experience.

Challenges & strategies for introducing CCUS to new industries

- Industries outside oil and gas who are new to CCUS (like forestry and cement) face a steep learning curve. There may be opportunities to leverage experience from oil and gas.
- There are limited operational learnings when it comes to CCUS worldwide. Some companies may wish to conduct their own CCUS pilots to build up internal expertise, but this isn't sustainable for everyone to do.
- For international companies, there are opportunities for learnings cross-project.
- There's a need for industries new to CCUS to partner with competent, experienced project developers. Events like the BECCS Summit are one way to form these partnerships.
- Resources like the International CCS Knowledge Center can play a convening role to enable partnerships, as well as funding organizations like Alberta Innovates and ERA.

Challenges for BECCS

- There's a broad need for increased clarity around the regulatory environment for CDR and biogenic vs non-biogenic CO_2 capture.

- There are differing opinions and approaches in policy/regulatory as to how biomass is treated as a feedstock, and not everyone is supportive.
- As a source of feedstock, forestry is complex – it involves long term planning combined with reacting to natural disturbances like wildfires that impact these plans. Forestry expertise should not be taken for granted.
- Material production sectors like forestry and cement ultimately may require a "green premium" to be placed on their products to justify a BECCS project, but there's limited appetite for that in North America.

Comparison of Europe vs. Canada and Alberta

- In Europe, large scale projects are happening due to government support and a "sticks" approach to the energy transition. This creates an environment where everyone, including the public, accepts the need to decarbonize and is willing to pay green premiums.
- From a technical standpoint, BECCS projects in Europe are far more challenging than in Alberta – most notably because CO_2 sequestration happens offshore, which is significantly more complicated and expensive than onshore, as can be done in Alberta.

The starting point for BECCS in Alberta

- There's a need for increased understanding of BECCS and CCUS within the forestry sector by forming partnerships that bring CCUS expertise.
- Alberta has excellent regulations in place for CCUS, but also for forestry – with 10, 20, and 200-year plans informing sustainable harvesting. It's important to recognize that how is the forest fiber used, such as for BECCS or otherwise, feeds into these long-term plans.
- Pulp mills in Alberta are already producing bioelectricity, contributing around 2% to the grid, and could form a source of firm, dispatchable clean power for the future.
- Mills are located in communities that depend on them economically. There is therefore local willpower to sustain the industry and realize local economic growth, and mills already have active consultation and engagement in place that can be leveraged for developing BECCS projects.

Session 3 – BECCS Innovation Showcase

This panel showcased emerging and leading BECCS initiatives in Alberta and across Canada, highlighting the following projects:

Rocky Mountain Carbon

Vault 44.01, along with TorchLight, plans to utilize the Hinton Pulp Mill to increase combustion of biomass that would otherwise be waste, increasing generation of low-carbon electricity to the grid. The project will capture and store biogenic carbon dioxide emissions at the facility, permanently removing 1.3 million metric tonnes of CO_2e per year once operational and helping transform the mill into a negative emissions facility. To learn more about this project, listen to ERA's podcast episode, Carbon Copy Episode 30: Alberta's Bioenergy Advantage.

Bright Green Hydrogen

Hydrogen Naturally is coupling gasification with other technologies in an integrated process that produces hydrogen from biomass with carbon capture and sequestration. It is estimated that each production unit will sequester ~175,000 tCO_2e annually and create additional GHG benefits through the displacement of fossil fuels via the hydrogen produced, totaling GHG benefits per unit of ~200,000 tCO_2e per year. Units could be deployed to power data centers at existing sour gas plants across Alberta and Canada.

Heartland Waste-to-Energy with CCS

Varme Energy, working with Gibson Energy, the City of Edmonton and the Canada Growth Fund, is developing Canada's first industrial-scale waste-to-energy facility with integrated carbon capture and storage to turn municipal waste into clean electricity. This project is expected to provide a sustainable pathway for municipal waste by capturing and storing 185,000 tonnes of biogenic CO_2 annually. It will thus generate BECCS-based carbon removals from organic waste streams.

North Star BECCS

North Star involves a partnership between Meadow Lake Tribal Council (MLTC) and Carbon Alpha, who specializes in CO_2 storage solutions. It is Canada's first majority Indigenous-owned high-impact BECCS CDR project. The project will combine CCS with the existing MLTC Bioenergy Centre that uses sawmill biomass residuals for energy production. North Star will demonstrate how waste from the forestry industry and CCS together can generate sustainable, permanent CDRs for global decarbonization.

The following key themes emerged from the discussion amongst these four projects:

Importance of CO_2 storage

- Figuring out storage is the first question on any BECCS project. There's no vast CO_2 pipeline network yet – so it's important to collocate BECCS opportunities with where storage exists.
- There's a need to emphasize the safety of CO_2 sequestration, as well as durability and permanence, to increase public education. Messaging must be consistent and clear, as this is a new area for most of the public, and an essential underpinning for decarbonization.

Importance of leveraging existing infrastructure

- Co-locating BECCS projects with an existing pulp mill and/or bioelectricity facility is an advantage. Some of the major costs, like boilers, are already in place, and there is already a pipeline of biogenic feedstock available. In the case of Hydrogen Naturally, they're co-locating with sour gas plants to take advantage of their existing infrastructure.
- Engagement is always easier when building off an existing facility and relationships.

Value of partnerships

- Partnerships that leverage different types of expertise are critical to a project's success. As examples, Carbon Alpha is coupling carbon storage expertise with majority Indigenous

ownership. Rocky Mountain Carbon is coupling Vault 44.01's knowledge of the subsurface with TorchLight's expertise in bioresources.

The BECCS Opportunity

- **Data centers:** With astronomically high energy demands, these provide an opportunity to supply carbon negative energy from BECCS to meet their heating and cooling requirements.
- **Forest carbon:** Forests play a key role in the energy transition. The introduction of CDRs is changing the landscape and providing economic opportunities for this sector that could one day exceed those of oil and gas. Finding feedstock is not a problem in Canada, and most forestry feedstock has road access nearby.
- **Waste-to-energy:** As an alternative to forestry feedstock, municipal waste is a pathway for the general public to be an active participant in BECCS through "guilt free garbage".

Common challenges for BECCS projects

- Many projects are in the early stages of engagement. It's important that the public, regulators, and financial institutions all have confidence in these projects.
- BECCS projects are still new and risky, so financing can be a challenge. Financing requires navigating different, potentially conflicting policies and identifying the monetization pathway (i.e., CDR buyers and accompanying CDR offtake agreements).
- Oil from EOR is on average 50% cleaner than the rest of the world, and could help improve project economics, but is not an eligible CO_2 end use for most government incentives.

Lessons learned from the projects to date

- Pilots are essential. It is possible to reach commercial scale without piloting everything together, so long as the fundamental principles have all been demonstrated. Multiple CCS pilots already exist in Alberta and across North America that can help de-risk BECCS.
- How much the cost of carbon is "bearable" varies by different industries and demographics. Some are more willing to bear a green premium than others.
- There's a need to implement BECCS projects in a timely fashion – timing and speed are most important, innovation follows. Even getting one commercial-scale BECCS plant online in North America would make a huge difference to giving investors confidence.
- It's essential to develop a clear commercial structure when allocating risk. BECCS pulls together multiple industries with multiple wheelhouses. There is a lack of willingness for someone to come and fund the entire project/assume all the risk. Divide and conquer.
- Investors are looking for a strong revenue stream and need clarity on carbon pricing.
- Projects need buyers of carbon removals. Carbon registries – through their scrutiny – can give confidence to buyers to come to the market and purchase these credits.

Session 4 - International Perspective on BECCS

The purpose of this session was to discuss BECCS projects and initiatives from around the world. Key themes emerged from the discussion:

BECCS projects are active and underway in Europe

- **Northern Lights** is the world's first cross-border CO_2 transport and storage facility, located in the North Sea off the coast of Norway. It is now complete and ready to receive and store CO_2, co-developed by Equinor, Total, and Shell. Multiple facilities will capture CO_2 and ship it to the Northern Lights terminal to be sequestered offshore. Phase 1 of the project is fully subscribed with CO_2.
- **Stockholm Exergi** is developing a BECCS project by adding CCS to an existing heat and power biomass plant in Stockholm.

Comparison between Alberta and European projects

- CO_2 transport and storage costs are significantly lower in Alberta than in Europe. In Europe, transportation and storage is the largest portion of overall cost; in Alberta, it is the smallest.
- Alberta has large existing facilities (pulp mills) already producing biogenic CO_2 and a stable forestry sector. Regulation and licensing of CO_2 storage is high quality. Pipelines & sequestration know-how for CO_2 shares a lot in common with acid gas disposal wells from the oil & gas industry.

Comparison of international policy tools – Europe, US, and Canada

- European projects are made possible by a variety of policy tools. Denmark has a targeted BECCS subsidy, Norway has direct funding going towards the Northern Lights project, Sweden held a reverse auction ($4.5B CAD) to purchase projects.
- The US has the Inflation Reduction Act (IRA), which offers both investment and production tax credit incentive structures.
- Canada has the Investment Tax Credit (ITC), which focuses on capex, and the Canada Growth Fund, which could help BECCS projects in the form of carbon offtake agreements.

Alberta's positioning within Canada

- Canada's forests make up about 10% of the world's total, and 94% of Canada's forests are under provincial jurisdiction.
- Globally, the pulp and paper sector has declined significantly over the past couple of decades, with many pulp mills closing across the nation (i.e. 13/20 mills have closed in Ontario). Alberta is the only province where the forest sector is still fully subscribed.

US National Lab Perspective

- The US has 17 national laboratories overseen by the US Department of Energy.
- The National Renewable Energy Laboratory (NREL) is the leading laboratory for renewable energy, including bioenergy. Much of their work is "BECCS-adjacent", and they are also looking at biomass for carbon removal and storage (BiCRS).
- It is assumed with in the US lab system that CDR will be necessary, the question is how.
- NREL and other laboratories have conducted technoeconomic (TEA) and lifecycle analysis (LCA) to understand the role of biomass and CDR. NREL has completed a grid analysis looking at the path to 100% clean electricity. Lawrence Livermore completed a Roads to

Removal study that highlighted BECCS as the most promising CDR pathway, due to opportunities to co-produce clean heat, electricity, and CDRs at the same time.

International research collaboration

- Areas of US-Canadian collaboration include piloting, LCA/TEA, and modelling.
- Canada has CANMET laboratories, an analogue to the US national laboratory system, which also has a bioenergy research program.
- Mission Innovation is a forum for collaboration between researchers in Canada and the US.

Session 5- Spotlight on Alberta's Forest and Carbon Management Framework

The purpose of this session was to highlight Alberta's unique carbon and forest management framework that make it an excellent starting point for BECCS projects in Canada and internationally. Key themes emerged from the discussion:

Forest management in Alberta

- Sustainably managed forests cover 38% of Alberta's total land mass. Approximately 80% of Alberta's managed forests have received international sustainability certification.
- The vast majority of Alberta's forests are publicly owned, mostly provincially owned, with federal control over National Parks and reserve lands.
- Alberta's forests are a busy landscape, with many conflicting goals and priorities. The *Forests Act* governs forest management in Alberta. Under this Act, regional plans are set up to help manage trade offs and different demands on the land, including recognition of Treaty rights. There are also sub-regional plans for managing land at a finer scale than regional plans, such as for caribou. Significant consultation goes into these plans.
- Timber harvesting is always planned within sustainable limits.
- Before anything gets harvested, there is a 200-, 20-, 5-, and 1-year plan in place to ensure the rest of the ecosystem can be sustained.
- Under current forest management plans, there is gap between what is available according to policy and what is being harvested, due to economics and access constraints.
- External events also have an impact. 2023 was the worst wildfire season on record, with 2.2 million hectares destroyed. This requires review & reworking of forestry plans.
- Alberta's sustainable forest management system can support investment in BECCS because it is stable while also being designed to enable new economic opportunities.

Carbon management in Alberta

Technology Innovation and Emissions Reduction (TIER)

- Alberta has an emissions management framework in place called the Technology Innovation and Emissions Reduction (TIER) Regulation.
- The TIER regulation implements Alberta's industrial carbon pricing and emissions trading system. TIER helps industrial facilities find innovative ways to reduce emissions and invest in clean technology to stay competitive and save money.
- Facilities with emissions greater than 100,000 tCO_2e/year are subject to TIER.

- TIER creates an offset market, whereby facilities can buy and sell carbon credits to meet emissions targets.
- BECCS projects can be recognized under TIER. TIER provides a compliance backstop for emissions reduction and removal projects.

Management of CO_2 sequestration pore space

- Alberta has a pore space tenure process whereby the province is issuing carbon sequestration rights through a competitive process that enables the development of large-scale carbon storage hubs.
- A hub will be an area of pore space, such as rock formations, managed by a company that can effectively plan and enable sequestration of captured CO_2 from various emissions sources in the surrounding region.
- Facilities not near a formal "hub" may apply for pore space tenure separately via the Small Scale and Remote process.

Incentives

- In addition to ERA and Alberta Innovates that offer grant funding for innovation, Alberta recently launched the Alberta Carbon Capture Incentive Program (ACCIP), to support and accelerate capital costs on commercial scale CCUS deployments.
- This can be combined with existing federal incentives like the Investment Tax Credit and support from organizations like the Canada Growth Fund, as well as innovation agencies funded by the Government of Alberta including ERA and Alberta Innovates.

Session 6 – BECCS as a Carbon Removal Tool

The purpose of this session was to hear from CDR buyers and marketplace innovators on how to establish transparent, permanent carbon removals. Key themes emerged from the discussion:

Allocation of emissions accountability

- Tech companies must work with their suppliers to reduce emissions across the value chain. As with other industries, it's not always clear who's accountable for scope 3 emissions, but these are the largest source and most challenging to abate.
- Some products have the potential to be sold at a "green premium". This could be an option offered to customers in the future to offset costs of emissions reduction/CDR. Tech companies may need to work with suppliers to develop commercial structures around this.
- There's a natural synergy between BECCS and offering a green premium for forest products, like paper and packaging.

Comparing types of CDRs

- The market for nature-based removals is volatile, and purchases carry some reputation risk.
- Engineered removals, like BECCS and DAC, offer permanence and durability. These are anticipated to become the most sought-after types of credits in the long run.
- DAC is very expensive, as it involves capturing CO_2 from a very dilute source – the air. For comparison, many BECCS applications involving capturing CO_2 from a stream that is 15-

20% CO_2, vs. 0.04% for DAC. The former requires significantly less energy. As CO_2 in air is the hardest form to remove, some believe DAC may never become fully scalable. BECCS could be a catalyst for rapidly scaling permanent, durable CDRs.

Value proposition of CDR registries

- CDRs are a relatively new trading commodity, and the market has faced some volatility and uncertainty as it emerges. CDR registries and trading platforms have increased transparency, credibility, and access to CDR-based credits.
- There is some bias against CCUS worldwide, as some consider it an enabler for fossil fuels. There is especially bias against any form of coal – for example, continents like Africa and developing Asia have been shut out from capital formation for this reason.
- Creating a technology-neutral trading platform allows transactions to occur on the basis of the emissions reduction and/or removal, rather than create bias and uncertainty around specific technologies. Thus, all technologies can be treated fairly under the same system.
- CDR trading platforms can also address the issue of CO_2 sequestration permanence. 100 years is generally considered a minimum, and some registries recognize up to 1000 years.

What defines a high quality BECCS project?

- The source of biomass must be sustainable.
- The project must have access to infrastructure/expertise for CO_2 sequestration.
- The project must have access to experience and expertise. It can be expected that many oil and gas people will be involved in creation of the new BECCS industry due to historic expertise in exploring the subsurface and implementing CCUS.

Session 7 - Financing BECCS Industry Growth

The purpose of this session was to hear from financial institutions to understand how to create bankable BECCS projects. Key themes emerged from the discussion:

Best practices for developing a first of a kind BECCS project

- Projects must find a way to do CCUS at the lowest price that can scale. Liquid amines are the most competitive commercially available carbon capture tech today. Existing pulp mills can be leveraged as a starting point for BECCS CDRs.
- CDRs are a completely new industry for the forestry sector; there's interest, but there's a need to align business models across multiple industries.
- The project must be bankable – each piece must work economically on its own.
- Proper management and allocation of risk is essential, and risk must be periodically reassessed – these are still innovative projects, and situations change.
- Any BECCS project ultimately needs a package of contracts to create a whole, bankable project where risk and value are shared across the value chain, and all partners can win.

The role of financial institutions in CDR development

- Banks are playing an increasing role in credit development and improving access to financial tools for emissions reduction and CDR projects.

- Right now, most decarbonization projects are investor driven. As more projects are de-risked and developed, more traditional financial pathways will become available.

Additional advantages for CO_2 sequestration in Alberta

- Alberta has an advantage in terms of the competence to get permits in a reasonable time. In the US, Class 6 permits create significant delays.
- Unlike some jurisdictions, Alberta doesn't face local opposition to pipelines.
- Alberta has significant subsurface experience in EOR and there is some experience in pure sequestration with the Shell Quest project.

Bankability of BECCS projects

- The most important factor is in creating a bankable BECCS project is offtake agreements: someone who's willing to purchase, for example, 200,000 tCO_2e for ten years. There's no such thing as a "standard" offtake contract.
- From the banks' perspective, pilot facilities can help create confidence and reduce risk.
- Comparing the ITC and the IRA, there is a 7-8% difference in rate of return in the US's favor. The Canada Growth Fund is needed to level the playing field.
- The biggest variable cost for a BECCS project is the pipeline between the BECCS facility and sequestration.
- Industry still needs the next generation of technology to help drive down costs of CCS, but the cost of a first of a kind project is still risky.

The future of sustainable financing

- To enable broad decarbonization, financing must eventually shift from a venture capitalist approach to strategic finance focused on long term growth.
- As BECCS projects become more common, risk will be reduced as well as barriers to and cost of financing.
- Banks are encouraged by the growing interest and focus on CDR broadly, and BECCS specifically. They expect another 1-2 years before we start to see transformative growth.

WORKSHOP SESSIONS

In addition to the plenary sessions, the Summit involved interactive workshops that explored emergent topics related to BECCS in greater depth, allowing all participants the opportunity to contribute their expertise to the discussion, across three streams: (1) Forest Carbon, Projects & Partnerships, and (3) CDR Generation.

1. Forest Carbon Stream

This stream involved two facilitated workshops over the two days: "Canada's Forest Carbon Opportunity" and "Best Use Cases of Forest Carbon".

Workshop Session 1 - Canada's Forest Carbon Opportunity

The purpose of this interactive workshop was to discuss the opportunity (and problem) of unlocking carbon from Canada's forests.

Theme 1: Feedstock Availability

This discussion focused on challenges associated with accessing forest feedstocks. While residuals and feedstocks are available in forests and could contribute to forest fires if not otherwise utilized or burned (as otherwise required by legislation), accessing them involves costs, landscape management, biodiversity, and social concerns.

Sometimes, Alberta forests are compared to European forests, where 7x the harvesting takes place because they are very closely managed. This is a challenging comparison – European forestry is more similar to agriculture. Alberta trees generally take 60-80 years for deciduous, 80-100 years for coniferous. South America is the lowest, with rotations of 5-7 years. Europe and South America both use plantation forestry that isn't always being managed for other objectives. In Alberta, trees grow more slowly because of the subarctic climate and the fact they are being managed for multiple purposes. Access can also be a challenge in Western Canada; 2/3 of it is muskeg, making some areas of forest costly to access outside of winter, further complicating the logistics of active management.

Alberta has a robust forest management system in place, specifically tailored to its ecosystem. The Government of Alberta determines total available harvest, taking into account trade offs with other priorities. Currently, there is a differential between total available harvest and what is actually being harvested, due to economics and access constraints. BECCS and other innovations could help create economic drivers to close this differential. Another untapped opportunity is forestry residuals currently left behind as waste.

There is growing competition for forest residues, with some being used in commercial opportunities like wood pellets, and others in the process of scaling up, such as biofuels. This competition can be better managed with clear guidelines on the types of wood required, such as distinctions between softwood and hardwood, or specific tree parts used in different applications.

Anything that is currently sustainable and economic to harvest is already planned for harvesting. However, there is lots of wood still available – fringes and smaller trees that may not be economic for traditional uses. Some material is harder to work with and pelletize, but could still be used for

bioenergy. Slash, or piles of waste wood, is available now for free for those who want to come and get it. An example cost to recover these residuals was provided at ~$70/tonne, and so far, not many players are willing to pay that.

The new opportunity presented by BECCS will further increase competition for forestry residuals and could push the forestry industry into the "edges" of what is currently allowable by forestry policy. This could ultimately lead to policy revisions – noting that if this happens, new environmental trade-offs will need to be made, as well as stakeholder engagement and revisions of forestry plans.

It was flagged that there is currently no "forestry protocol" under TIER in Alberta that incentivizes recovery of biomass for decarbonization projects. Such a protocol could help the economic case for BECCS and increase access to new and uneconomic feedstocks, by monetizing the benefits of retrieving feedstocks beyond "business as usual" to achieve emissions reductions. Protocols are typically developed via a coordinated industry working groups and advocacy.

Theme 2: Role of stakeholders and new project opportunities

The main theme of this discussion was the role of partners and stakeholders in new project opportunities. While new stakeholders and innovation opportunities are welcome, close collaboration with the existing forestry sector framework is essential.

Forest management is highly complex, and requires specialized expertise, as well as long term relationship development & engagement. The cycle time of a forest management plan spans 200 years and is based on scientific principles, with updates every 10 years. These plans consider the entire ecosystem, including soil composition and animal habitats, to ensure sustainable practices, and are built on longstanding stakeholder engagement with many different parties.

The forest industry emphasizes the importance of a comprehensive approach that balances economic, environmental, and social factors. This includes:

1. **Economic Viability:** Ensuring that new projects or stakeholders can operate profitably without disproportionately increasing costs for existing players.
2. **Environmental Sustainability:** Maintaining biodiversity, protecting soil health, and preserving animal habitats are essential components of forest management plans.
3. **Social Responsibility:** Engaging with local communities and stakeholders to ensure that forest management practices benefit all parties involved and do not negatively impact local livelihoods.

Given the complexity of this process, it is challenging to add more partners and planners who do not already have the necessary expertise or stakeholder relationships. This holds back change, rather than driving it forward. However, new stakeholders and innovative project ideas are always welcome to contribute and add perspectives to add forestry planning. The forest industry is concerned with competition and the value proposition of new projects, and has a willingness to work with new stakeholders to understand this better. A clear value proposition and a holistic assessment of new technologies or projects are needed before implementation. It is important to ensure sustainability in the forests, considering the entire ecosystem.

Theme 3: The role of wildfires and natural disturbances

This theme was two-fold: Can we use feedstock leftover from forest fires for BECCS? Do natural events create uncertainty for planning BECCS projects?

The answer to the first question is nuanced. Forest fires do not follow a clear pattern, and much of the burnt wood becomes unusable. Additionally, the logistics of accessing and transporting the usable portions are complex. The unpredictability of forest fires means that relying on forest feedstock after a fire has taken place for carbon removal projects is fraught with challenges. The damaged wood often loses its value for such purposes. The effort and cost required to salvage and transport usable material can be prohibitive.

Regarding the second question, the forest industry is using data management and technology to predict forest fire behavior, which can provide some confidence in planning for BECCS and other major projects. Advanced modeling and real-time data collection help in anticipating fire risks and planning accordingly. However, there was disagreement about whether recent changes, such as climate variations and increased fire frequency, make forecasting more difficult. These changes could potentially create risks for planned BECCS projects, as the reliability of predictions may be compromised, leading to uncertainties in project timelines and outcomes.

Technology advancements remain crucial for improving forest management practices and enhancing predictive capabilities. The discussion highlighted the need for continued research and development to explore new technological solutions that can better address the challenges posed by natural events and improve the feasibility of BECCS projects.

Key takeaways:

- The value of carbon is still unknown. Without knowing its value, it is challenging to inform the supply chain and help stakeholders make informed decisions about what types of feedstocks are economic to recover.
- Policy coherence across Canada and the US is key when trying to access additional value.
- Trade offs are a major consideration in forest management and the use of forest feedstock. Forest management needs to consider sustainability and full ecosystem thinking.
- Additional, sustainable forestry feedstock is available, but logistics, value proposition, type of application, and cost must be considered in accessing it.
- New stakeholders with a clear value proposition are welcome, but new partners lacking the appropriate expertise will create disruptions that are ultimately counter productive.
- Planning CDR projects in the forest industry requires certainty and an understanding of the full ecosystem; but this contrasts with the fact that natural disturbances create challenges and lack of predictability around this.
- Technology and innovation continue to play an important role in forest management.

Workshop Session 2 – Best Use Cases of Forest Carbon

The purpose of this workshop was to discuss different use cases of forest carbon, and what factors may lead to directing more feedstock towards BECCS projects.

Theme 1: Competition and collaboration for forest fiber use

The question of forest feedstock is similar to the first forestry workshop on Canada's forest carbon opportunity but focuses on the perspective of the forest industry and its use in facilities. Several considerations and recent trends were raised when it comes to competing for forest fiber:

- **Competition and costs:** The clean fuel regulation has intensified competition for forest residuals. This competition sometimes forces the industry to use natural gas for power, as the forestry residuals are diverted towards other, higher-value products. This incurs additional expenses and negates some of the carbon reduction benefits of biofuels.
- **Sustainable Aviation Fuel:** This was highlighted as a crucial value-added product with growing momentum worldwide. Unlike other transportation sectors, aviation has limited alternatives to biofuels, making sustainable aviation fuel a key area of focus. However, the commercialization of second-generation biofuel technologies remains a significant hurdle.
- **Lignin utilization:** Lignin, a component of biomass, has potential applications in bio-industrial materials. The primary obstacles are not scientific, but economic, involving the costs and market dynamics associated with scaling up lignin production. Overcoming these challenges requires time and investment.
- **Regulatory and market pressures:** The industry must navigate the pressures of new regulations and market demands, while still ensuring sustainability and economic viability. This includes balancing the use of forest residuals for bioenergy with other potential end-uses and managing the associated costs.

Theme 2: BECCS vs biochar and other alternatives

Continuing the first theme, this discussion reviewed several innovations for end-uses of biomass that can be integrated with a pulp or sawmill, focusing on those with the greatest revenue potential. The discussion specifically focused on biochar, a competing CDR technology to BECCS that involves the forestry sector, and thus a competing end-use for forestry residuals.

Biochar is a charcoal-like substance that sequesters CO_2 and can be used as a soil additive. It is produced via pyrolysis, which can generate heat and electricity at the same time. While pyrolysis is a relatively straightforward, proven technology, both its economic feasibility and the market for biochar present challenges. Biochar is difficult to transport and sell, as is finding a stable market at an acceptable price. The characterization of biochar, which depends on operational conditions and the feedstock used, affects its application and impact on soil.

For a large mill, like a pulp mill, it is likely not feasible to invest in a small, unproven market like biochar. However, the capex barrier to entry for biochar projects is smaller than BECCS. For a smaller sawmill, investing in biochar may be advantageous over BECCS in some cases.

In the near term, most BECCS and/or biochar projects are anticipated to be brownfield projects that leverage existing mill infrastructure, vs greenfield projects. Thus, a major challenge for any new technology is integration with the existing mill. The forest industry relies on a delicate balance of inputs and outputs, and any change can have ripple effects throughout the system. Introducing new technology could disrupt existing processes, posing a challenge for integration.

Finally, economic viability of these technologies is a critical factor. For instance, whereas pyrolysis can produce valuable by-products, the costs associated with setting up and maintaining the technology, as well as the market volatility for biochar, make it a risky investment. The industry needs to see a clear and stable return on investment before committing to such changes.

Theme 3: Integrating carbon capture into the forestry sector

This discussion mainly focused on how to integrate carbon capture technologies for BECCS with existing mill operations.

Capture technology for each project must be selected not only based on the merits of the technology but also its suitability for the forestry industry. For example, amine carbon capture systems are the most proven at scale, but may be challenging due to the many impurities present in mill flue gas that can contaminate the amines and affect performance. Each BECCS project must consider the specific conditions and requirements of the forest industry, ensuring that the chosen technology can handle the challenges posed by the environment and the type of biomass used.

The forest industry is interested in applying CCUS, but does not see a role for itself investing in or contributing to carbon capture technology development. They lack the necessary capabilities and expertise, and the value proposition for them to be involved in this is not supported by financial and regulatory incentives. The industry operates on tight margins, and the high costs associated with developing and implementing CCUS technologies are a significant barrier. Without substantial financial support and clear regulatory frameworks, it is difficult for forest companies to justify these investments. They anticipate relying on other industries and stakeholders to do this work.

Workshop participants highlighted the importance of public funding to absorb the risk and advance new technologies. Public funding can play a crucial role in bridging the gap between research and commercial applications.

Key takeaways:

- Forest feedstock is a public resource and the trade offs need to be sustainably managed by a non-biased entity, such as the government.
- New biomass utilization technologies need to provide a clear value proposition to the industry and be integrated into a system that is already fully utilizing residues in various parts of the operation.
- The increasing cost of feedstock due to competition from the clean fuel regulation can adversely affect the economics and carbon removal potential of the forest industry.
- Adding CCUS is an effective way to reduce carbon emissions at mills; however, the technology must be carefully selected based on the mill's specific operational requirements as well as the broader characteristics of the forestry sector.
- The need for advanced carbon capture technologies represents a source of innovation potential, but this is not something the forestry industry itself expects to invest in.

2. Projects & Partnerships Stream

This stream involved two facilitated workshops over the two days: "Unique Technical Features of BECCS Projects" and "Innovative Partnerships for BECCS Project Delivery".

Workshop Session 1 - Unique Technical Features of BECCS Projects

The purpose of this workshop was to discuss gaps in BECCS technology and infrastructure.

Theme 1: Technical challenges

The main theme of this discussion was to address technical challenges with BECCS projects, focusing on capture, sequestration, and access to sustainable feedstock.

Capture technology for BECCS projects

From a technical perspective, the largest challenge for a BECCS project is capture, primarily tied to cost – at least in places like Alberta that have access to onshore CO_2 sequestration. Due to the high capex nature of capture and the associated business and policy risk, no one wants to test a new technology. They need the technologies to be proven, but not everyone agrees on what "proven" means, and even proven technologies have trade offs.

Amine technologies are currently the only technology operating at full commercial scale. They may not be the best, but they work. It is important that new projects integrate the incremental improvements that have occurred in amines over the last several years.

Other capture technologies include solid sorbents, membranes, cryogenic CCS, but these may not be "proven". There is still a role for carbon capture pilots to help scale up new technologies.

Optimizing energy & resource usage

For amine technologies, optimizing energy use is critical. Parasitic energy loads can range 20-30% or higher. There's a need for innovations in the energy required to take the CO_2 out of the solvent. This is one of the advantages of BECCS compared to conventional CCUS, as there is a sustainable source of feedstock available to power the process. Nonetheless, improvements and optimization of heat and power integration will still be required.

Cryogenic technology is a near-commercially ready alternative avoids the cost of maintaining amines, but requires increased pre-treatment costs. This approach is also more electrically and less heat dependent, which may offer some advantages. Solid sorbents are also a promising approach that could expand in the coming years.

In terms of other resource usage, water is also important. CCUS projects can be either a net consumer or producer of water, based on regional and other factors.

Understanding flue gas characteristics

Biogenic content in CO_2 may influence measurement, monitoring and verification (MMV) requirements and pipeline spec requirements, which ultimately drive the specs of the capture project. Flue gas characteristics for BECCS projects are highly variable and must be understood.

Isotopic analysis is required by Alberta's CCS protocol under TIER, but this type of analysis is currently very limited and time consuming to access.

Access to pore space

CO_2 sequestration proximity plays a significant role in BECCS project economics. While Alberta has an advanced hub tenure process, with 26 approved hubs, hub location does not necessarily align with the location of forests and existing pulp mills. Those mills not located close to hubs may leverage the province's "Small Scale and Remote" sequestration tenure process, but this brings its own challenges and associated MMV and other costs. Contracts and liability between capture, transportation, and sequestration infrastructure must all fit together to make BECCS projects work.

Of note, most existing commercial CCUS infrastructure is built on the basis of using CO_2 for EOR, not pure geological sequestration. The reservoir characterization is different for these two applications, so in some cases, greater understanding of reservoir characteristics and the interactions between projects must now be understood. It was noted that while EOR could improve the business case for BECCS projects, its value is only around \$20-\$30/tCO_2e. While helpful, this alone is not enough to fully justify a ~\$200/tCO_2e BECCS project.

Access to feedstock

Participants discussed how available forestry feedstock can be prioritized for BECCS. Currently, from a regulatory perspective, residuals are the most readily available feedstock to access for BECCS. Land use changes may be required to significantly increase access to feedstock, but this has environmental implications – for example, how do we determine priority between different social, economic, and sustainability objectives?

It was emphasized that all aspects of the environment and ecosystem footprint must be considered when making land use changes, and that geospatial data and technologies like LIDAR can assist in land management and understanding these complex ecosystem interactions.

Theme 2: Infrastructure Requirements to Address Challenges

The main theme of this discussion was to address infrastructure challenges with BECCS projects, focusing on the value of knowledge sharing and pilots, available R&D infrastructure, and differences between new and existing facilities.

Knowledge sharing & technology demonstration

Multiple participants highlighted the need for couple of commercial projects to get up and running, and for their learnings to be widely shared. The challenge is to optimize the use of government dollars – there are issues with spreading government support too thinly. The example given was the Shell Quest project, which received significant Government support, and must now file and publish all their data, forming a blueprint for future CCUS projects.

There is a continued need for pilot demonstrations, but one of the challenges is access to pore space. There isn't a streamlined path to sequestering CO_2 for a pilot project. It follows the same process as a commercial project, which could create significant burden and prevent smaller pilots

from going forward at all. For pilots, “capture and release” is an option – that is, foregoing sequestration altogether – but isn’t a good look and fails to de-risk the full value chain.

R&D infrastructure supporting BECCS

R&D infrastructure exists in Alberta, such as the Alberta Carbon Conversion Technology Center (ACCTC). The ACCTC demonstrates and validates CO_2 capture, conversation/utilization, and methane reduction technology in real-life conditions in a semi-commercial environment. There is also lots of work ongoing across Canada to integrate CCUS R&D facilities. Increased access to flue gas characterization remains a significant R&D gap for BECCS and other types of CCUS.

For commercial projects, it was noted that some EPCs are more open to collaboration and information sharing than others, but there are significant restrictions within capture tech providers on what they are willing to share. Most EPCs are technology agnostic, allowing for cross-pollination of technology between projects.

Using existing vs new infrastructure for BECCS

Existing pulp mills can provide a backbone for the first wave of BECCS projects. But these mills require upgrades to justify the business case for BECCS, such as waste heat recovery systems or steam generator upgrades to maximize power production. They may also need to make changes to their harvesting practices to increase fiber procurement and thus increase feedstock for BECCS. Non-traditional sources of biomass can be “dirty”, containing rocks and soil, which could have significant impacts on operations.

New facilities could take many different forms, not just bioelectricity. This will have new implications for infrastructure needs and best uses of feedstock.

Additional discussion: other challenges & opportunities

While several technical and infrastructure challenges were noted, participants the greatest challenges were “technoeconomic” in nature, involving intersections between technology, policy, financing, and project management. Partnerships and project logistics are especially complex for BECCS projects, involving many facets and types of expertise between subsurface, engineering, operations, and forest management.

Supply chain

There are nowhere near enough EPCs to enable all these projects to go forward. Everyone is competing for the same workforce, and only a limited number of projects can go forward at once. Some are looking at alternatives to amines due to supply chain concerns. Compressors are a potential pinch point in the supply chain.

Prioritizing BECCS vs other types of CCUS

There are fundamental differences in the business case for CCUS vs BECCS: traditional CCUS involves reducing a liability, vs BECCS involves turning a non-liability into an asset – a CDR. Industries with an existing liability are being forced into CCUS, whereas for BECCS projects this is an “option” and must be founded on the revenue opportunity rather than liability reduction.

In some ways, BECCS may be a good place to start proving out broader CCUS adoption because the business case may be easier, due to the high potential value of CDRs – but that value is currently uncertain. To date, CDR purchases have been limited, despite the climate imperative.

Financing

Financing is an enormous challenge to make these projects go forward. The banks are looking for a guaranteed financial stream, and there is still too much fluctuation and uncertainty in the price of carbon and price of carbon removal. CDRs require long term offtake agreements with certainty around price to create a stable revenue stream. Some of these deals have taken place in Europe, but there aren't any significant ones in US or Canada yet.

There are also still big differences in project economics under the IRA (a production tax credit) vs the Investment Tax Credit in Canada, in the IRA's favor. However, there are still some advantages to investing in BECCS projects in Alberta.

Despite these challenges, BECCS is a good option for buyers when they decide to invest in CDRs, due to its permanence and durability, economic viability compared to DAC, and ability to remove emissions at scale. Buyers are looking for new and additional technologies to invest in. Consistency of how these technologies are treated in the market remains a challenge for realizing the full value of BECCS CDRs.

Other factors for consideration

There is a need for increased communication with the general public around topics like forest management and carbon sequestration, the challenge being to translate highly technical and complex processes into digestible messaging.

Data center growth presents both an opportunity and a challenge; as time passes, data developers seem to care less and less about clean energy, threatening climate progress.

Finally, there is currently lag time due to uncertainty around policy and the election. For example, for federal funding agencies, once the election is called, they can't move money for six months.

Workshop Session 2 – Innovative Partnerships for BECCS Project Delivery

The purpose of this workshop was to discuss how projects can be structured to make successful BECCS projects happen, including what it takes to get BECCS projects done, different perspectives on the right way to structure a BECCS project, and how we can learn from best practices in other industries to help grow this emerging market.

Theme 1: Roles & responsibilities in a BECCS project

This theme involved a discussion of the key roles at each stage of the development and execution of BECCS project – including who needs to be involved and when.

The group identified six distinct roles in a BECCS project:

- Host facility
- Technology provider/vendor
- Third-party project developer/consultant

- Engineering, procurement, and construction company
- CO2 offtake/sequestration company
- CDR credit buyer

BECCS projects can be divided into the following stages:

1. Origination/development
2. The three "Fs"/i.e. the "valley of death": FEED, financing, and FID
3. Construction and commissioning
4. Long term ownership & operations

During the discussion, it was identified that the host facility is the main entity that must be involved at every stage of the project. The host facility should be involved early to leverage their existing infrastructure, expertise, and stakeholder relationships.

In terms of project leadership, many participants thought that the project developer should lead most stages of the project lifecycle, as opposed to the host facility. For the host facility, implementing CCUS may be adjacent to their core business, and thus difficult to prioritize. Depending on the industry, having a separate project developer and/or consultant can help get the project to FID, but may not be necessary through every stage of the project. For example, in Europe, project developers Europe typically back out at FID.

There was some disagreement as to when CDR buyers should get involved in a BECCS project. Some felt they should be involved from project origination – for example, Amazon is working on a BECCS project a pulp mill in the US – whereas others felt they should come in later, once the concept is more polished. Buyers will not invest in projects that aren't built on a solid concept that aligns with their values, so there are concerns with going to them too early. On the other hand, there are a lot of assumptions being made about the demand for CDRs that may not be well-founded, but are essential for underpinning the BECCS business case.

The oil and gas sector are an interesting group of stakeholders that could play the role of buyers as well as project developers and/or host facilities, given their existing expertise around CCUS.

Similar to buyers, CO_2 offtake for transportation and sequestration is an essential underpinning for any BECCS project, but challenging to address until the basic project characteristics are mostly figured out, such as capture technology.

Ownership models for the physical assets and operation of BECCS projects may also vary. The capture tech provider will provide a technology guarantee, but may not want to "own" the project.

It was generally felt it wouldn't be unreasonable for all parties to be involved at all stages of the project, and this is part of what makes BECCS projects so complex. At least in Canada, it was also noted that both Government and First Nations are also critical stakeholders to involve through the project lifecycle.

Theme 2 – Structure of a BECCS project

This theme involved a discussion of different BECCS project structures, and their associated pros and cons. The following potential project structures were identified:

- Host facility-led
- Technology vendor-led
- Joint venture
- Third-party project developer-led

The following table provides a summary of the pros and cons identified with each structure:

Structure	Pros	Cons
Host facility-led	- They care about the future of the facility and the surrounding region. They have skin in the game. - They know their facility and their industry intimately. - If they're big enough, they have people to run the CCS plant. - They are ultimately responsible for on-site safety.	- They may not have the necessary skillsets for implementing CCUS. - They may not have the manpower for totally new projects and industries. - They don't know how to sell CDRs. - They may not be set up to lead this type of innovation project. - The project may be outside their traditional business priorities.
Technology vendor-led	- They know how to raise money for first of kind deployments. - They may have been involved in projects with similar challenges. - They know how to build carbon capture facilities.	- They don't always know how to set up projects. They'll need to find a site. - Their perspective on the project is limited to their own technology. - They may not have experience in the host facility's industry.
Joint venture	- A JV one of the best ways to share risk for first-of-a-kind projects. - This could work well between the host facility and the tech provider. - These are often 50/50, but can be scaled based on risk allocation and capital availability. - Having the broad perspective of multiple companies increases expertise, access to financing, and enhances risk mitigation. - This structure is especially valuable in new industries.	- This structure can reduce speed and make it hard to make decisions – more stakeholders, C-suites, and Boards now must get involved. - Similarly, it means adding parties to the negotiations that must occur across a project's lifecycle.
Third-party project developer-led	- Their expertise is the least siloed. - They provide an unbiased view on the business case. - They're technology agnostic and motivated to find the right partner. - They bring subject matter expertise for the specific type of project being developed. - They understand the full value chain and know how to package a project.	- They may not have long term commitment to the host facility region – their view is temporary, based narrowly on the project at hand. - Their involvement is mainly people-dependent, which can change. - There may be a lack of alignment with the other partners on economic objectives and acceptable trade offs for the project.

Embellishing on this further, it was noted that as a comparator, in the oil and gas industry, projects are almost always host-facility led. This is especially true for CCUS. This structure is possible, but more challenging for a BECCS project, especially from a balance sheet perspective.

It was emphasized that every BECCS project is bespoke, and multiple project structures can work. Several were provided as examples, including Svante (tech provider led), CO280 (project developer led), and Carbon Alpha (storage expert led). A third-party project developer could bring the broadest perspective. In some cases, the CDR buyer, like Amazon, might originate its own project.

Across all project structures, trust and understanding of partners' competencies is essential. Also, the lead for the project development and construction phase likely differs from the operator.

Theme 3 - Regional & sectoral differences impacting BECCS project structure

Some regions, such as in Europe, have BECCS-specific incentives. In Sweden, they are doing a reverse auction, which is a "cleverly disguised procurement fund". They announced the fund in August and are expecting bids by the end of November – they are seeking the lowest cost offtake agreements. Once an offtake agreement is signed, the project must be in operations within 36 months, even though 60 months is likely more realistic. This is a space to watch.

More locally, the power sector in Alberta is undergoing rapid transformations and market reforms. This could have implications for BECCS projects, as electricity provides an additional revenue stream that forms the business case for BECCS projects.

Ultimately, CDRs are a globally exportable product that are influenced by policy coherence around the world. At the end of the day, there is no CDR product without policy.

3. CDR Generation Stream

This stream involved two facilitated workshops over the two days: “Evaluating BECCS Projects for Carbon Removal” and “CDR Sustainability Requirements”.

Workshop Session 1 - Evaluating BECCS Projects for Carbon Removal

The purpose of this workshop was to discuss existing and emerging protocols for verification of BECCS-based CDRs.

Theme 1: Voluntary vs. compliance carbon markets

The main theme of this discussion was to address differences between voluntary and compliance markets. Compliance markets are supported by governments, whereas the voluntary carbon market operates independently of government.

The voluntary carbon market (VCM)

Most CDR transactions currently occur on the voluntary market, since CDRs are typically not a requirement set by governments, and are only recently gaining broader traction as a necessary tool to mitigate the impacts of climate change. That makes voluntary markets – their credibility, and the standards they develop – essential in the deployment of CDR projects and monetization of credits.

Unlike markets backed by governments, the VCM must earn its credibility with buyers through establishment of rigorous standards and protocols that define the sustainability, permanence, and other aspects of carbon offset projects. These standards and protocols are typically developed by third-party organizations that are ultimately responsible for certifying voluntary carbon offsets. It is also possible for the VCM to rely on compliance-based protocols and standards.

In the past, the VCM has endured reputational issues, with buyers facing media backlash for misrepresenting the impact of certain carbon offset projects. The industry is now moving past these issues. The VCM is currently transitioning into “VCM 2.0”, a more sophisticated framework with participants who are more informed about opportunities and risks. This is expected to stimulate and increase demand and credibility around VCM transactions. The recent participation of multi-national oil and gas companies, and the resources available to them, is another trend that will help scale the VCM 2.0.

Offtake agreements are an essential component of a well-functioning VCM and will need to clearly identify what the credit can be used for and what it can’t. The terms and conditions of a credit offtake agreement can help create a strong credit.

Compliance markets

In a compliance market, entities are required to meet an emissions reduction target set by a regulatory body. The TIER framework in Alberta is an example of a compliance market. Other examples include the EU ETS and the CARB, both of which are larger than TIER. Compliance markets have inherent credibility compared to the VCM by virtue of being part of the rule of law.

In most compliance markets, including TIER, biogenic CO_2 is tracked, but is not considered part of the overall emissions inventory. Therefore, unlike an emissions reduction project, there is often no imperative to pursue a CDR project under a compliance market.

There are also other challenges with enabling CDR transactions in compliance markets. CDR credits are typically considered higher value than emissions reduction credits, meaning they can seek a higher price on a VCM. Additionally, compliance markets are usually local, whereas CDRs can be traded globally. For CDR transactions to occur within compliance markets on a global scale, there must be ways to reconcile credit generation between different markets.

Theme 2: The role of protocols & standards

The CDR market is emerging, and there is not fully common understanding and awareness of what CDRs are. Even experts can disagree. Biomass is particularly complicated, due to the many different types. Moreover, biogenic emissions are generally considered carbon neutral, but this is not universally the case. Lack of alignment between standards and protocols can create uncertainty and confusion to buyers and impact the bankability of projects. Ultimately, buyer confidence requires common understanding of CDR accounting, which is in turn underpinned by consistency and strength of standards and protocols.

The strength of a carbon credit is directly related to the strength of the protocol or standard it is based on. It is challenging to write a single protocol that covers the full spectrum of projects. There is a lot of diligence that goes into buying carbon now. Buyers want to be convinced that a project will happen and that it is real to ensure the credits are real.

When it comes to standards and protocols, it is possible for compliance and VCM to complement one another. Using compliance protocols in VCM provides comfort for some buyers. A CO_2 credit could be retired in a compliance market, such as TIER, and then traded in a VCM – thus leveraging the credibility of the standards and protocols established under rule of law in the compliance market. In the long term, in order for CDR transactions to occur at the scale required, it is anticipated that the industry will increasingly move towards compliance markets.

Theme 3: Stacking of credits

Currently, there is a mosaic of incentives in Canada which makes developing the business case for a BECCS (or other) type of project very challenging. The “golden rule” when stacking credits is to ensure that each of the crediting mechanism agrees that the credit is allowable. This is not always clear and sometimes requires multi-party conversations. It is challenging for project developers to navigate and can be a barrier to raising capital.

Other considerations

Participants noted that there is more to consider in CDR and sustainability projects than just carbon, such as water and ecological trade-offs. Each project must be evaluated on its own merits, using a pragmatic approach that fully accounts for carbon removals associated with a project.

Workshop Session 2 - CDR Sustainability Requirements

The purpose of this workshop was to discuss what factors make a truly sustainable CDR and BECCS project, using a leading CDR verifier Verra's Voluntary Carbon Standard (VCS), currently in draft form, as a basis for discussion.

It was highlighted that it is very difficult to right standards that work globally. Principles for a successful project include transparency and open dialogue, and a pragmatic approach that allows projects to succeed.

Theme 1 – Sustainability considerations

This theme involved discussing the three prongs of sustainability when it comes to protocol development: emissions accountability, traceability and compliance, and sourcing of renewable biomass.

Understanding and allocating emissions accountability is essential when talking to governments. Governments are key decision makers, but do not always have the expertise to understand the nuances of emergent decarbonization technologies like BECCS and CCUS. For example, use of the term "leakage" is problematic – it is a term in GHG accounting to refer to externalities that aren't being property accounted for, but non-technical audiences assume it means physical leakage of CO_2 from the formation, which is a problematic discrepancy.

The traceability requirement is challenging for some sectors, like agriculture, but the standard needs to cover a wide variety of feedstock types. Traceability requirements differ between different types of feedstocks in Verra's current draft standards. When implementing projects, often a conversation is required between the project and the standard-setter to ensure agreement. This discussion is best to take place during the project's design phase.

The definition of "renewable" biomass is that it must maintain stability or increase carbon stocks over time, with temporary decreases allowed for harvesting. There was some discussion in the workshop around what qualifies as "temporary", and it was noted that decreases also occur due to natural events, like wildfires. It was questioned whether municipal waste can be considered "renewable" under this definition, even though it is an option for sourcing biogenic feedstock for BECCS projects.

Theme 2 – Sustainability risks

This included a discussion of risks and additional considerations when it comes to defining "sustainability" of biomass for BECCS and other types of projects. There are other sustainability considerations besides carbon, ranging from food security to land use and more. Land use changes are complex and challenging. Along this vein, it was flagged that different standards have different treatments for wastes vs primary products being used as biomass feedstock. For example, purpose-grown feedstocks for non-food purposes has been an issue in the past for corn ethanol in the US. Greenfield vs retrofit facility types also has implications.

In the current VCM, there's only a few buyers actively engaging in CDR transactions – so right now, they have all the power to set their conditions. They are acting to manage their own risk, in part based on previous controversies in the VCM. Right now, buyers have the power to set requirements

above and beyond market standards. This creates additional inconsistency and challenges for projects. It was raised that whereas buyers can require CDR projects to trace their projects to the molecule, when by contrast, they don't always take accountability for their own scope 3 emissions. It was also noted that the market focuses completely on risk, but what about reputational reward – i.e., what are buyers risking by *not* doing anything, and what is the value and opportunity cost of the PR benefits they receive from small transactions?

The VCM market is transforming. In the future, hopefully more BECCS and other types of projects will reduce buyers' pricing power and create a more competitive market where buyers do not have all the pricing power.

Theme 3 – Contextualizing Alberta and Canada

It was noted there is no BECCS-specific protocol in Alberta or Canada, but Alberta's current CCS protocol is in the process of being updated to potentially recognize bioenergy and leaving flexibility for BECCS projects to be recognized, forming the necessary building blocks. Federal programs are much further behind.

CONCLUSION & NEXT STEPS

The BECCS Summit was a successful inaugural forum to stimulate this new industry and advance the discussion around its opportunities and challenges. The format and content of the Summit was well-received in the context of many competing events for those attending.

Attendees commented on the value of learning about forestry's role in the energy transition, which is not well understood by those outside the forestry sector. They also appreciated the networking opportunities provided by a targeted, invite-only format and the secluded, retreat-like setting of Banff to dedicate focused time to this exciting new industry. Because of this, the event had virtually zero attrition and the majority of attendees stayed for its entirety, demonstrating the value of this format not only for future BECCS events, as well as events on other emergent topics.

Part of the event's success can be attributed to getting "the right people in the room". This was a significant aspect of the event planning process. The breakdown of the 100 attendees was approximately as follows: 15% from the forestry sector; 15% from the financing and CDR buyer community; 15% from the CCUS technology value chain; 15% from Government, including provincial and federal; 10% from other industries including oil and gas, cement, and power; 3% First Nations; 7% project developers; and 15% market experts including eNGOs, post-secondary institutions, think tanks, research institutions, and consulting firms.

Because of the small nature of the event, it was accompanied by numerous education materials provided as outcomes of the Summit, featured on ERA's BECCS Impact Page. This includes:

- Publicly available recordings of plenary sessions.
- Two videos, including:
    - **The Power of Trees and Technology:** A bite-sized BECCS 101 video.
    - **Alberta's BECCS Advantage:** A short video about why Alberta is one of the best places in the world to invest in BECCS.
- Four podcasts, including:
    - **Carbon Copy Episode 29: Trees, Paper and Pulp.** A discussion with Cal Dakin from Mercer Peace River about sustainability in Alberta forestry.
    - **Carbon Copy Episode 30: Alberta's Bioenergy Advantage.** A discussion with Jamie Stephen from TorchLight on transforming existing pulp mills into large-scale carbon removal projects.
    - **Carbon Copy Episode 31: A New Approach to BECCS.** A discussion with Jonathan Rhone of CO280 about what makes a good CDR project and how CO280 is building partnerships to tackle the hardest part of the journey to net zero.
    - **Carbon Copy Episode 32: Funding BECCS Innovation.** A discussion with Andrew Hall at TD Securities about the world of project financing, carbon credits, green bonds, and how banks like TD are stepping in to support BECCS.

Session presentations and a contact list were also circulated from the Summit.

Finally, given the success of this inaugural forum, future events and further initiatives are being explored to continue advancing BECCS.