ACCELERATING THE ADOPTION OF CCUS IN ALBERTA:

A Systems View

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1.0 Executive Summary

Carbon Capture, Utilization, and Storage (CCUS) is a pivotal avenue to achieving net-zero energy by 2030. However, the effective deployment of CCUS in Alberta and across Canada faces complex challenges. The lack of a shared understanding of these challenges results in fragmented interventions and hampers the growth of the CCUS ecosystem. To address this issue, the Energy Futures Lab (EFL) undertook a project to articulate the most critical pain points faced by actors in Alberta's CCUS ecosystem, and to identify opportunities where the EFL is best positioned to focus collective action. A four-month process was designed and executed by an EFL-led working group to co-determine and stress test stakeholders' key challenges hindering the safe, sustainable, and effective deployment of CCUS projects in Alberta.

Through a series of focused workshops and one-on-one interviews with CCUS ecosystem stakeholders, the working group identified five strategic areas that represent potential opportunities where collective action can help to further CCUS projects in the province.

1. De-risking Investment Amid Carbon Price Uncertainty: The uncertainty in long-term carbon pricing mechanisms within provincial and federal policies reduce investor confidence in CCUS projects. Stable regulatory frameworks and collaboration between governments and industries, both nationally and internationally, can alleviate concerns.

2. Managing Subsurface Dynamics: Ensuring the geology's suitability for CO2 sequestration and effective access management are critical. Alberta's expertise, while significant, will be challenged in addressing issues like reservoir capacity, subsurface risk, and cross-industry conflicts. Robust monitoring and verification programs and cross-industry collaboration can mitigate these challenges.

3. Elevating Utilization: The significance of carbon utilization in emissions reduction sparks debate. Acknowledging carbon's value as a product and recognizing utilization's role is important. Policy adjustments, stakeholder collaboration, and technology commercialization hubs can drive technology development and integration.

4. Managing Risks to Public Confidence: Public support from both Indigenous and non-Indigenous communities is vital for CCUS projects. Long-term public engagement and transparency can bolster public confidence. Addressing environmental concerns, ensuring economic benefits, and fostering public awareness are key.

5. Navigating Competition for Key Assets (Gold Rush): As CCUS projects proliferate, resource competition arises. Anticipating bottlenecks and fostering industry-wide coordination is essential. Sharing technologies, synchronizing labor needs, and facilitating talent mobility can alleviate resource constraints.

2.0 Introduction

Carbon capture, utilization and storage (CCUS) is one of several mutually reinforcing pathways to achieve net-zero energy by 2030, and requires a functioning ecosystem to be successful. The ecosystem consists of all players along the CCUS value chain, from start-up companies developing new technologies around CCUS, to academic institutes providing both knowledge and training programs, to governments and regulators, and to companies implementing carbon capture as a means to reduce their GHG emissions. There is currently limited shared understanding among ecosystem actors of the key challenge areas that are hindering the safe, sustainable and effective deployment of CCUS in Alberta. This makes it difficult to advance and mature the CCUS ecosystem in Alberta, as interventions are ad hoc and often siloed. The result is that CCUS may not ramp up quickly or effectively enough as a solution pathway towards a net-zero future.

Breaking down the challenges around scaling up CCUS will result in individual, actionable statements. While there is importance and value in doing this, the danger is that the sum of these individual challenges does not properly reflect the system challenges. Behavioral

psychology shows us that humans suffer from a status quo bias, meaning we not only prefer current conditions, but we also irrationally assume they will continue; when combined with the fact humans are more likely to disregard information which is complicated, uncertain, and difficult to decipher this results in a very human behavioral condition whereby we only change if we feel an acute pain.

For many businesses today, the pains caused by more immediate pressures such as quarterly performance and profit optimization overshadow the possibility of future pain caused by climate change and subsequent rules and regulations such as carbon taxes. Combined with the mounting uncertainty faced by oil and gas producers over future prices of their commodities and viability of their business models, and the present-day risks and high costs associated with CCUS projects, including uncertainty around carbon pricing, one can understand corporations' reluctance to prioritize capital investment in CCUS projects which do not generate additional value in the form of revenue or profits.

Action is required today in order to meet Canada and Alberta's climate targets. Yet understanding the friction between today's pressures and tomorrow's needs, and the willingness for system players to act and think together lags. This prompted the working group to ask the following question:

How might we ensure that efforts to scale CCUS embrace a systems approach, whereby all components of the value chain are developed in a synchronized way?

Our research project started out with a question asked at an Energy Futures Lab (EFL) event in Banff in early 2022: why aren't there more shovels in the ground on CCUS projects in Alberta? Why is there so much conversation around CCUS, but a lack of actual projects moving forward? This led to two follow-up questions. The first was: Should the EFL do something to help accelerate the deployment of CCUS? The answer to this was a firm "yes." The second question then posed was: What should this entail? The answers to this question were very fragmented and had the potential to lead EFL efforts in multiple directions. It was thus decided before proceeding down a particular solution path to take a step back and perform research to be able to better articulate what pain points are being experienced by system actors currently, and to identify opportunities where the EFL, a social innovation platform, might be best positioned to act.

Based on this, a working group was formed, and a research arc was proposed by the EFL. A four-month process was designed and executed to co-determine and stress test

stakeholders' key challenge areas hindering the safe, sustainable and effective deployment of CCUS in Alberta.

The hypothesis developed by the working group for the project was that: *If* we determine key common challenge areas ('pain points') hindering uptake and deployment of CCUS practices and technologies in Alberta, *then* we can more effectively utilize CCUS as one of several mutually reinforcing pathways to achieve net-zero energy by 2030, *because* key implicated players can - and will - align on a potential trajectory and portfolio of mutually reinforcing interventions to accelerate progress along the CCUS pathway.

Through the arc of the project, the working group conducted a total of three, three-hour workshops. Each workshop was designed to build upon previous event's findings.

- Workshop 1 acted as a foundational or level-setting workshop, with discussion focused on current Alberta and Canada state and value chain mapping to identify strategic issues.
- Workshop 2 then focused on identifying actions and pathways to unlock momentum and solutions to the key strategic issues identified in Workshop 1.
- Finally, Workshop 3 focused on the five strategic issues identified in Workshop 2. These five issues were evaluated by diverse system actors, and who then brought forward proposals for addressing each issue.

Between Workshops 1 and 2, the working group also conducted a series of 30-minute, one-on-one interviews with participants from various organizations or interest groups in the CCUS sector. A total of 17 interviews were conducted. The results of these interviews were anonymized and used for input in future workshops.

Participants in both the workshops and interviews represented system stakeholders such as Alberta Innovates, Emissions Reduction Alberta, the Pembina Institute, Calgary Economic Development, the Government of Alberta, Natural Resources Canada, as well as various end-users. The interviews also included non-profit groups such as the International CCS Knowledge Centre, and other industry groups representing a breadth of players in the CCUS space.

3.0 Key Findings

3.1 What we heard

After initial interviews and discussions in Workshop 1, ideas started to coalesce around several strategic themes. In order to be considered a strategic theme, an issue had to be:

- directly related to the stated project intent of furthering the CCUS ecosystem from a systemic perspective,
- surfaced in multiple discussions from different stakeholders in various parts of the value-chain (i.e., no esoteric or niche issues),
- distinct from other issues identified in terms of stakeholders and potential solutions, and
- capable of unlocking meaningful change if solved.

Based on analysis of raw information and debate, the working group identified five strategic themes (areas) for collective action and 'why' they matter:

1. De-risking Investment Amid Carbon Price Uncertainty: At the outset of the project, the working group had specifically decided to avoid the topic of direct government funding of projects as there is already a significant amount of work and discussion happening in that space, and it had the potential to distract from the next issues we will face as an industry. However, it quickly became clear that the financial discussion was much more nuanced and would have a significant impact well into the future. Rather than immediate monetary support, this theme focuses on the current lack of long-term certainty on carbon pricing.

2. Managing Subsurface Dynamics: This theme received a lot of attention as various players in this space are currently beginning work in this area. This issue deals with both the suitability of the geology to sequester CO2 and the systems put in place to manage access to it, such as the Government of Alberta's CO2 hub framework.

3. Elevating Utilization: This theme saw a lot of spirited debate, garnering both passionate champions and vocal cynics. The issue revolves around carbon utilization often being overlooked as anything meaningful in public discourse and policy. The utilization space is seen to live in the shadow of the storage discussion, and yet it

has a lot to offer in terms of recycling a valuable product, contributing meaningful technology to the broader CCUS ecosystem, and potentially changing the economics of CCUS projects in general.

4. Managing Risks to Public Confidence: CCUS in general is still considered a niche idea when it comes to the public consciousness. Industry is just beginning to test and see the risks associated with this theme. All participants agreed that CCUS projects would only be successful if they had support from surrounding Indigenous and non-Indigenous communities. A lack of foresight and planning on this issue could be disastrous for CCUS' ability to contribute significantly as a transition pathway.

5. Navigating Competition for Key Assets (Gold Rush): There was broad acknowledgment from players in this space that resources were already constrained and that this was expected to get worse. Historically, Alberta has been in a good position in terms of possessing the labor, materials, knowledge and skills required for this work but there is increasing competition for these same resources with the traditional oil and gas sector. As more CCUS projects get underway, it will also create more competition from within that space as well. Information is another resource which will be seen as a competitive advantage to be protected, something which would further hamper rapid progress.

A more detailed description of these strategic themes, their nuances and forward-looking landscape is detailed below.

3.2 Strategic themes and action areas

3.2.1 De-risking Investment amid carbon price uncertainty

Carbon capture and permanent storage (CCS) from industrial emitters will play a critical role in the energy transition and is a significant component of the holistic CCUS ecosystem in Alberta and Canada. Recently, the province has allocated carbon sequestration rights through a competitive process to enable the development of carbon storage hubs. Six potential projects in the heartland region near Edmonton and 19 additional potential projects across the province have been granted carbon sequestration agreements. Project

proponents have begun exploring how to develop these storage hubs across Alberta, however, construction has yet to commence on these large-scale projects.

Our focused interviews and discussions with key players in the CCS ecosystem led to the identification of a common theme around risk and uncertainty of carbon pricing, both provincially and federally. Project developers are looking to provincial and federal regulatory frameworks and carbon pricing mechanisms to understand the potential carbon revenue associated with their projects. This, along with other potential funding mechanisms such as the federal CCS investment tax credit (ITC), discussions around Carbon Contracts for Difference (CCfD), and other programs, has an impact on project developers' ability to move from front-end design to final investment decision.

These discussions and the three strategic workshops allowed for the identification of several key challenges related to de-risking investment in large-scale CCUS projects amid carbon price uncertainty:

1. Low confidence in carbon policy: A lack of long-term certainty on carbon pricing, concurrent with disagreement between provincial and federal government on carbon policy, leads to reduced investor confidence in capital-intensive CCUS projects.

2. Access to investment: Investment risk is closely tied to the uncertainty around carbon pricing and future crediting revenue potential associated with provincial and federal compliance programs.

3. Competition with US: Challenges were identified for Canadian project developers in competing with the US on funding for CCUS. Existing incentive programs in the US amid carbon pricing uncertainty in Canada will result in the siphoning of investment and skilled workers to the US.

4. Gaps for start-ups: Existing mechanisms intended to support CCUS project developers in lieu of (or in excess of) carbon pricing programs, such as the Government of Canada's CCS ITC, are failing to provide meaningful incentives for smaller project proponents without existing cash flow.

5. Funding for new technologies: It is necessary to de-risk investment in CCUS technologies in order to achieve the scale of emissions reductions needed to meet

Canadian climate targets. For new CCUS technologies, a gap in funding exists between early stage and final technology readiness level (TDL) stages.

Action Areas

Discussions in Workshops 2 and 3 identified a number of potential moves that could be undertaken to address these challenges. Participants identified a need for additional clarity around Canada's ITC and how it competes with incentive programs in the US, given the lack of long-term certainty in Canada's carbon pricing framework. Similarly, discussions around the federal funding programs announced in Budget 2023 indicated that accelerating these programs (such as CCfD) could encourage progress in getting major CCUS projects moving toward Final Investment Decision (FID); it was noted however that these contracts do come with some risk to the federal government.

Additional discussions occurred around leveraging learnings from other global jurisdictions where CCUS has progressed further (from both a policy and technology perspective), pointing to an opportunity to collaborate with international accelerators. With respect to the challenge of identifying reliable funding for new technologies midway along the Technology Readiness Level (TRL) journey, workshop participants from Foresight Canada indicated that there is already work underway to establish a collaborative model to facilitate investment for these gaps - work that could be supported by the EFL.

Other potential opportunities that were discussed included the concept of identifying and addressing gaps in carbon offset quantification protocols under the Alberta and federal systems; however, it was determined that this work would likely be conducted by interested project proponents. Additional discussions about establishing an independent climate institution to maintain and oversee a carbon pricing system external to the federal government were had; however, feasibility of actioning this was determined to be too low to be practicable.

3.2.2 Understanding Subsurface Dynamics

Another strategic theme identified during interviews and workshops was the need to manage subsurface dynamics. This theme encompasses both the suitability of the geology to sequester CO2 and the systems put in place to manage access to it, such as the Government of Alberta's CO2 hub framework.

At a high level, there was broad recognition among both workshop and interview participants that Alberta is well positioned for success in this area. Alberta has a talent pool rich in relevant geological expertise through decades of oil and gas activity and acid gas injection. In addition, Alberta is a world leader in CCUS through successes in the Shell Quest, Alberta Carbon Trunk Line, and Enhanced Oil Recovery (EOR) projects. Furthermore, many participants characterized Alberta's CO2 hub framework as a much-needed tool to govern access to the resource. However, despite these positive dynamics, many participants also signaled that subsurface considerations should not be taken for granted. Some major areas of concern included:

1. Reservoir capacity: One participant characterized this as "the biggest barrier" to CCUS and the "only true showstopper" that could prevent CCUS in Canada from realizing its full potential. While Alberta has witnessed success, globally this has been the exception to the rule and not the norm, as many projects struggle to meet their intended sequestration targets.

2. Subsurface risk: Many highlighted subsurface risks such as pressure build up, plume migration, and micro-seismicity as being a problem. While it was understood that governments and industry are well positioned to manage these risks, they emphasized the need for robust measurement, monitoring and verification (MMV) programs.

3. Cross-industry conflict: Many agreed that there was a high potential for conflict among subsurface projects across the CCUS, oil and gas, lithium, and helium industries. Notably, one participant emphasized that this risk may be overstated, and that excessive risk-aversion is slowing regulatory processes. It is unclear whether this claim is warranted, but it is evident that more effort is required to address this issue.

4. Pore space management: Participants generally agreed that Alberta has taken a strong first step to manage pore space access through the sequestration hub process, but identified issues associated with its hasty implementation. Concerns include lack of enforcement provisions surrounding "fair pricing" and "open access" to sequestration hubs and other, still-confidential measures in the Government of Alberta's sequestration agreements. Others also noted that pore space management and access is also not a uniquely Alberta problem. British Columbia.

and Saskatchewan for example, will have to continue to advance systems of their own, and places like Ontario, with a much poorer geological resource, may need to evaluate other options, such as export to the United States.

Action Area

Regarding reservoir capacity and subsurface risk, it is evident that CCUS project proponents need to dedicate the resources required to advance their evaluation and MMV programs and provide customers with the high level of confidence needed to support investment decisions. Participants suggested that increased information sharing between proponents might help address this issue. Some went as far as suggesting that this should be mandated by the government, but agreed that there would be no easy solution to this issue. This is likely to be a major point of tension in the CCUS landscape, as companies race to advance carbon capture projects to meet climate goals, while having to contend with subsurface dynamics that will not move as quickly.

With respect to pore space conflict, participants expressed hope that this could be addressed through the Government of Alberta's hub process and its associated sequestration agreements. However, once again, there is no easy solution here. There is a possibility that multiple subsurface industries will be able to co-exist within one region, but conflict is still likely to arise over fears that one industry's success might hinder that of another.

In terms of pore space management, participants suggested that more regulatory action from the government may be needed. Many agreed that a utility-type model is likely to be most effective at addressing potential pricing and access challenges, but some questioned the feasibility of doing so. They also wondered whether there was any action the government could be taking through sequestration agreements, but this is a relatively opaque process that few are privy to. Overall, most agreed that this is an issue that needs time. The hub process was developed after an effective gold rush for pore space in Alberta, and much of the surrounding policy needed to be developed on an ad hoc basis. More time is needed for these processes to mature, and perhaps there will be learnings from Alberta that could be shared with other jurisdictions to help avoid similar pitfalls.

3.2.3 Elevating utilization - One person's trash is another's treasure

The “U” in CCUS is the subject of much animated debate. On the one hand, skeptics point to the fact that the utilization conversation today is many orders of magnitude from being relevant to any significant impact on global carbon emissions. They state that the global emissions and sequestration discussion is happening in the millions and billions of tons of carbon while utilization is commonly discussed in terms of tens, hundreds and sometimes thousands of tons. On the other hand, players in the utilization space point to the high-value product and opportunities for new growth industries. They also highlight the myriad of technical and long-term sustainability challenges with permanent storage.

Despite this debate, several items were commonly agreed upon throughout our discussions:

- Carbon is and will continue to be a high-value product through 2050,
- the utilization space is currently seeing increased interest and activity, and
- utilization is expected to contribute to the future emissions mitigation toolkit. Lux Research in a 2022 analysis titled, “CO2 Capture & Utilization, The Emergence of a Carbon Economy,” estimates the global CO2 utilization industry will be a USD $550 billion market by 2040, driven largely by the building material sector[1].
- As utilization technologies are proven out and markets developed for end-products, they will play an increasingly important role in large CCUS projects, potentially improving the project business case and positively influencing public perception.

Participants also identified the following challenges for the future of utilization:

1. Sequestration and utilization should go hand in hand: There was broad acknowledgment that sequestration and utilization should not be mutually exclusive. As one participant put it, the utilization ecosystem should be seen as a tremendous opportunity to develop the technologies that the broader CCUS ecosystem needs to thrive. The fact that these discussions are often held separately is seen as a missed opportunity.

2. New technology: Utilization technologies are, overall, at an earlier stage than carbon storage and sequestration technologies, many of which have been in use for decades.

[1] https://www.luxresearchinc.com/wp-content/uploads/2022/07/lux-research-co2-capture-utliziation-the-emergence-of-a-carbon-economy-executive-summary.pdf

3. Policy gaps: Public policy in Canada currently does not do much to incentivize utilization. For example, enhanced oil recovery (EOR), which qualifies for credits under the US Inflation Reduction Act (IRA), does not qualify for Canada's tax credit.

4. Cost: Utilization technologies are typically higher cost with less developed markets than incumbent alternatives, meaning they have a hard time competing on a purely economic basis.

Action Areas

Our discussions surfaced several ideas for moving the utilization space forward. There is common agreement that we need to create optionality in our policy frameworks to incentivize uses of carbon that are not permanent sequestration. As an example, in the US, the Carbon Capture and Utilization Parity Act of 2023 introduced to the senate in February, seeks to do this. In the words of the sponsors, "Our bipartisan Carbon Capture and Utilization Parity Act would bring the value of the tax credits for carbon utilization in line with the incentives for sequestration, while supporting continued investment in carbon-neutral products."

There is also thought to be a need to create a roadmap and commercialization hubs for these nascent technologies. Many startups and players in this space are working in isolation and, according to interview candidates, having a difficult time being taken seriously and getting a seat at the table during the development planning of larger projects and funding allocations.

The single biggest near-term action that would lay the foundation for much of this work is to bring together a strong coalition of the key players in the utilization space, understand their immediate needs and use this group to further the aligned interests of the group with policy makers, regulators, and partners. A robust starting point would be for this group to draft a whitepaper that helps clarify and align sector priorities, and which could then be used to start these discussions with stakeholders.

3.2.4 Risks to Public Confidence

Managing risks to public confidence was also a key strategic issue discussed during interviews and workshops. All participants agreed that CCUS projects would only be

successful if they had support from surrounding Indigenous and non-Indigenous communities. Some key considerations identified during discussions included:

1. Experience in other jurisdictions: Some participants noted that while Alberta has had a strong track record in managing public confidence on CCUS in Alberta, they noted that there are projects in other jurisdictions such as the United States facing growing opposition, and emphasized that project proponents should be prepared to address any similar concerns.

2. Indigenous participation: Participants universally agreed that Indigenous engagement and economic participation are crucial and must be a central component of any CCUS project in Canada.

3. Economic benefit: Some questioned whether CCUS projects would generate the same level of benefit for landowners and other key stakeholders, and therefore questioned whether this would impact public support.

4. Lack of trust: Many suggested that there is a perceived danger associated with CCUS projects (i.e. induced seismicity, pipeline ruptures) and stressed that projects will need to dedicate considerable resources to public education and participation.

5. Relevance: Some acknowledged that there are questions about the need for CCUS, given that many believe the oil and gas sector to be a sunset industry, and wondered whether this would impact public discourse surrounding the issue.

Action Areas

Looking ahead, participants proposed several solutions to manage any potential public confidence issues. One recommendation was to move beyond doing public engagement exclusively as part of environmental assessment and related regulatory processes and move towards long-term monitoring and reporting processes that can involve the public on a continuous basis. Participants also highlighted the need to launch a public awareness campaign that can be combined with simple language to make CCUS something that the public can easily visualize. Lastly, they also recommended that projects set up Indigenous advisory committees and/or be intentional with engagement and providing affected communities with agency in project approvals and decision-making processes.

3.2.5 Navigating Competition for Key Assets (Gold Rush)

Carbon Capture projects are significant in scale, requiring substantial material, labor, engineering, and fiscal resources. To put things into perspective, let's review the projects which have been completed. There are currently three CCUS facilities in operation in Canada. These three facilities collectively capture around 4 million tons per annum (MTPA) and it took on average around 7 years to complete each project from start to finish.

To compare these previous projects with what is required and announced, a scaling factor of 5 to 8 times will have to be applied. There are currently multiple projects announced in Alberta, which collectively would capture around 20 MTPA.

The current federal CCS ITC states that the facility needs to be operational by 2030 in order to claim the 50% credit. If the facility becomes operational past 2030, this credit goes down to 25%. This means that projects which are currently in the early stages are all moving forward at approximately the same stage in order to meet the 2030 deadline. Based on this, participants in the workshops and interviews as well as some EFL Fellows foresee significant bottlenecks as multiple projects seek the same pool of limited resources. In other words, a gold rush effect is anticipated. This will impact labor resources, engineering resources, and the supply chain.

Some key considerations identified during discussions included:

1. Labour resources: Several bottlenecks around labor resources were identified. The most obvious one is the amount of labor required if several large-scale projects start construction at the same time. Companies can only start allocating labor once contracts are in place, so having people on "stand-by" is not realistic. Secondly, while many of the skill sets required for CCUS projects overlap with today's energy industry needs, some new skills are foreseen and a lack of training and training programs could lengthen project timelines and increase cost.

2. Engineering resources: Many traditional academic programs in fields such as petrochemical engineering that impart the skills required for CCUS project development have been cut due to a lack of enrollment. Yet, new programs which would replace the development of those critical skills and knowledge have not yet started. These could take years to see board approval and government funding. This

combination could lead to a shortage of skilled and experienced engineering resources, at least at a local level.

3. Supply chain: To date, projects that have been announced are predominantly large-scale CCUS (one to several million tons of CO2 captured per year). The reasons for this are twofold: to help improve the economics of the project, and to actually help make a significant reduction in scope 1 and 2 emissions. As large-scale CCUS projects are both expensive and carry significant risk, almost all companies are looking to use established amine based CCUS technologies. As there are not many suppliers who have proven technologies with several reference sites running, it means that most companies are looking to purchase a solution from the same handful of suppliers. This will have an impact on pricing (due to supply and demand) and on lead-times.

Action Areas

Looking ahead, participants proposed several solutions to manage the short-term competition for resources to bring CCUS projects online. In Alberta, some activities are already underway to assist. The first is a mapping exercise being undertaken by Foresight Canada, to map out start-up companies working in this space along the value chain. This will make it easier for companies interested in implementing CCUS or DAC projects to identify available technologies and start-ups they could potentially work with. The second activity is being undertaken by the Calgary Economic Development (CED) team. They are mapping the required resources against what is predicted to be available by 2030 with the intention of developing a gap analysis.

The main propositions which were put forward are:

1. Venture to value chain mapping: As mentioned above, the intent is to map what start-up technologies exist along the CCUS value chain.

2. Make open sourcing for project architecture the norm, to support asset planning: Sharing knowledge and insights into CCUS projects will increase know-how, lower risks, lower costs, increase speed of new technology acceptance, and create the ability to forecast labour requirements. Examples of such open sourcing are Tesla and Carbon Engineering.

3. Synchronize labour requirements among industry proponents: There is no single party responsible to synchronize resources (i.e. governments, industry, others), but it was recognized that industry itself is in the best position to have these conversations among peers, with government, and with academic institutions.

4. Work with technical institutions to attract students, increasing the labour and knowledge pool: The creation of new programs are needed. Programs which are attractive to young talent, and which address the pressing needs of energizing a net-zero world. Without the creation of such programs, and the reality that traditional petrochemical programs are struggling, companies will struggle to find skilled employees.

5. Repurpose subsurface petroleum skills towards CCUS: Subsurface petroleum skills will share many requirements with CCUS subsurface skills. Thus, retraining people with these skills and employing them for CCUS projects will ease labour pressures.

6. Ensure a barrier-free labour market and supports to ensure CCUS labour mobility interprovincially and internationally: Acknowledging that Alberta will likely not have enough labour resources for all projects currently announced, it's reasonable to expect that talent from other provinces and internationally will be required. Current provincial regulations around professional engineering licenses make such movement of people more difficult. Similarly, the fact that many engineering or other academic achievements outside Canada are often not recognized within, make it harder to attract and utilize international talent.

4.0 Looking Forward & Next Steps

The intricate interplay between technical, regulatory, economic and social factors in the CCUS ecosystem in Alberta and in Canada leads to challenges in effective deployment of CCUS projects. The findings of this research project have supported an understanding of these key challenge areas hindering the safe, sustainable, and effective deployment of CCUS in the focused jurisdictions.

Through the project's strategic workshops, short and long-term scenarios outlining the desired state of the CCUS ecosystem at a provincial and federal level were outlined with the intention of supporting the process of determining and prioritizing next steps for the EFL.

4.1 Desired State: Short- and Long-Term Outcomes

As part of this framing exercise, desired outcomes were identified as the success factors we are setting out to achieve in the near term (identified as 2035), and in the long term (by 2050), at both a provincial level and federal level.

At a high level, the desired impact was defined as having achieved significant GHG emission reductions (and new economic development opportunities) through a coordinated effort of enabling policies, finance, partnerships, public awareness, R&D and implementation of CCUS technologies.

In each short and long-term scenario, the following desired outcomes were identified:

1. **Near Term (2035) in Alberta:**
    - CCUS has demonstrated some quick early wins economically for various communities and companies, creating support for additional participation in the CCUS ecosystem.
    - Usage has demonstrated little to no harm for the subsurface environment environmentally (proven to not damage subsurface environment).
    - Growing public acceptance and understanding of CCUS as part of the pathway to a prosperous, inclusive and equitable net zero future for the province.
    - The needed labour skills are understood, and training programs to ensure the ongoing development of this needed skilled labour have been established.

2. **Near Term (2035) in Canada:**
    - Improved economics of CCUS projects have helped increase public acceptance/confidence nation-wide.
    - Federal priorities and policies recognize CCUS as part of the pathway to a prosperous, inclusive, and equitable net zero future for the country and funds are flowing toward the most promising technologies.
    - Agreements to collaborate with First Nations communities have been struck which recognize Indigenous Peoples as Rights and Title holders in Canada

and which honour The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

3. **Long Term (2050) in Alberta:**
    - CCUS projects are widely recognized as a driver for job creation as well as economic, social and environmental well being, particularly in rural and remote communities.
    - Next-generation CCUS technologies have proven more efficient, effective and are driving increasing economic growth for Alberta and Albertans.
    - Alberta is recognized as a global center of excellence in CCUS; Alberta-grown utilization technologies have contributed to CO2 reduction globally and are exported around the world as key contributors of decarbonization.
    - Indigenous equity ownership models are commonplace within the CCUS ecosystem.
    - The provincial and federal carbon market programs are complementary and operate seamlessly.
    - Building off of Alberta's oil and gas skills, the necessary, highly skilled CCUS workforce has been established and there is a clear pathway to continue building it into the future.

4. **Long Term (2050) in Canada:**
    - Opportunities to participate in the CCUS ecosystem have been realized across the economy, contributing to socio-economic prosperity for the country as a whole.
    - Canada has become a competitive player in producing low-carbon energy at a global level through CCUS application.
    - Canadian CCUS technologies and practices have made significant contributions to regenerating damaged ecosystems in Canada and abroad.
    - Federal policies and subsidies for CCUS enable equitable and inclusive distribution of prosperity stemming from CCUS activities.

4.2 Actions / Next Steps

Considering the desired state outlined above, and by working through the strategic challenge areas to assess their respective potential to address the challenges and mobilize action, the working group identified a number of possible next steps and pathways

forward. These would contribute to more effective deployment and utilization of CCUS as one of several mutually reinforcing pathways to achieve Canada's emission reduction targets.

Within the five strategic themes are suggested actions that, if taken, can enable the successful scaling of CCUS initiatives:

1. De-risking Investment amid Carbon Price Uncertainty: The unpredictability of carbon pricing was identified as a known barrier to large-scale, capital intensive CCUS projects. The absence of long-term certainty hinders investor confidence, underscoring the need for stable regulatory frameworks and financial incentives.
    a. Suggested action: Advocate for clear guidance on carbon policy and enhanced collaboration with international accelerators.

2. Understanding Subsurface Dynamics: Subsurface considerations, including the suitability of geology for CO2 sequestration and access management, are crucial determinants of CCUS success. While Alberta's expertise and favorable conditions offer advantages, addressing concerns related to reservoir capacity, subsurface risk, and cross-industry conflicts is essential.
    a. Suggested action: Support robust MMV programs, coupled with collaboration among project proponents.

3. Elevating Utilization: The debate surrounding utilization's significance within the CCUS ecosystem underscores the need for a balanced approach. Acknowledging carbon's potential value as a product and recognizing utilization's role in contributing to emissions reduction is essential.
    a. Suggested action: Create flexible policy frameworks, foster collaboration among key players, and establish commercialization hubs to drive the development and adoption of utilization technologies.

4. Risks to Public Confidence: Public support, particularly from Indigenous and non-Indigenous communities, is vital for the success of CCUS projects. Addressing risks related to environmental impact, economic benefits, and overall project relevance requires proactive engagement, transparency, and public awareness campaigns.
    a. Suggested action: Integrate public input into ongoing monitoring and reporting processes.

5. Navigating Competition for Key Assets (Gold Rush): As CCUS projects gain momentum, the potential for resource competition poses challenges. Anticipating a "gold rush" effect, industry-wide coordination and planning are essential to prevent bottlenecks in labor, engineering, and supply chain resources.
    a. Suggested action: Map start-up technologies, open source project architecture, synchronize labor requirements, and promote talent mobility.

To advance the deployment of CCUS in Alberta and across Canada, a strategic and collaborative approach will be needed. Establishing a coalition of key stakeholders in the utilization space, with a focus on policy advocacy and technology commercialization, could drive innovation and industry growth. Additionally, engagement between policy developers and industry participants to provide clarity on carbon pricing, accelerating and optimizing proposed funding mechanisms from Budget 2023, and emphasizing long-term public engagement could contribute to addressing challenges around investment, subsurface dynamics, and public confidence.

By fostering collaboration, incentivizing innovation, and addressing system-level challenges, Canada can position itself as a leader in low-carbon energy and contribute significantly to global emissions reduction targets. The collaborative efforts of industry players, government bodies, research institutions, technology accelerators, and communities are paramount in shaping a successful CCUS ecosystem in the province.